Environment Protection Authority

NSW State of the Environment 2024

Tabled Report

soe.epa.nsw.gov.au

© 2024 State of NSW and the NSW Environment Protection Authority

With the exception of photographs, the State of NSW and the NSW Environment Protection Authority (EPA) are pleased to allow this material to be reproduced in whole or in part for educational and non-commercial use, provided the meaning is unchanged and its source, publisher and authorship are acknowledged. Specific permission is required for the reproduction of photographs.

All content in this publication is owned by the EPA and is protected by Crown Copyright, unless credited otherwise. It is licensed under the Creative Commons Attribution 4.0 International (CC BY 4.0), subject to the exemptions contained in the licence. The legal code for the licence is available at Creative Commons.

The EPA asserts the right to be attributed as author of the original material in the following manner: © State of New South Wales and the NSW Environment Protection Authority 2024.

Front cover: Macquarie Pass National Park. Credit: John Spencer, DCCEEW.

Published by NSW Environment Protection Authority

Visit:
6 Parramatta Square
10 Darcy Street,
Parramatta NSW 2150

Mail:
Locked Bag 5022,
Parramatta NSW 2124

Phone:
+61 2 9995 5000 (switchboard)

TTY users:
Phone 133 677,
then ask for 131 555

Speak and listen users:
Phone 1300 555 727,
then ask for 131 555

Email:
info@epa.nsw.gov.au

Website:
epa.nsw.gov.au

Report pollution and environmental incidents

Environment Line:
131 555 (NSW only) or
info@epa.nsw.gov.au

ISBN 1320-6311
EPA
2025P4583
April 2025

This report has been compiled from extracted content from the **soe.epa.nsw.gov.au** website.

Additional material has been included for publication compliance.

To access dynamic charts, maps and content, we encourage you to visit the website.

Acknowledgement of Country

The NSW Environment Protection Authority acknowledges that Aboriginal people have a spiritual and cultural connection and an inherent right to protect the land, waters, sky and natural resources of NSW. This connection goes deep and has since the Dreaming. The entire landscape, including traditional lands, fresh water and seas, has spiritual and cultural significance to Aboriginal people.

If the cultural and spiritual values of Aboriginal people are sustained by providing protection and respect, then many other components of Aboriginal life will be healthy. By this understanding there is no separation of Country, culture, waters and wellbeing.

The health of the natural environment, fresh waters, land animals, marine animals and people are intimately connected. In compiling this State of Environment report, the EPA recognises that Aboriginal people as the first protectors have continuously cared for Country and been able to live effectively with changing climates for thousands of generations.
Intergenerational knowledge handed down through vibrant cultures has meant Aboriginal peoples have intimate and detailed knowledge of their respective Country.

This knowledge has also resulted in effective understanding and management of place, including seasonal calendars which relate to specific lands and waters that guide Aboriginal people in caring for Country.

The EPA recognises the connection of Aboriginal people to their land, their waters and surrounding communities and acknowledges their history and cultures here on this land.

We also acknowledge our Aboriginal and Torres Strait Islander employees are an integral part of our diverse workforce and recognise the knowledge embedded forever in Aboriginal and Torres Strait Islander custodianship of Country and culture.

EPA's Statement of Commitment to Aboriginal Peoples

The NSW Environment Protection Authority acknowledges Aboriginal peoples as the enduring Custodians of the land, sea, waters and sky of New South Wales.

We recognise the entire NSW landscape, including the lands, waters, plant and animal species and seas, has spiritual and cultural significance to all Aboriginal peoples of NSW. By this understanding there is no separation of nature, wellbeing and culture. The health of the natural environment, and the health of people and culture, are intimately connected.

The EPA is committed to prioritising meaningful relationships with Aboriginal peoples to deepen our understanding of how best to Care for Country. Through our partnership with the EPA Aboriginal Peoples Knowledge Group, we fully acknowledge and embrace the invaluable knowledge they hold and provide to enhance our work as environmental stewards.

The Group comprises members from Rainforest, Desert, Saltwater and Freshwater people, coming together as a unified voice for Country.

We listen to the Group as it guides, advises, nurtures and challenges us to uphold the 12 principles outlined in the EPA's Statement of Commitment to Aboriginal Peoples:

1. Work in respectful partnership with Aboriginal peoples.
2. Actively learn from and listen to Aboriginal voices, cultures and knowledges.
3. Respect Aboriginal peoples' knowledges and science as an equal to western science.
4. Weave Aboriginal knowledges and science with conventional science into the EPA's decision making.
5. Act boldly and bravely to play our part to mend and heal Country together.
6. Ensure Aboriginal knowledges, science and Indigenous Cultural Intellectual Property (ICIP) is protected, and Aboriginal peoples have free, prior informed consent.
7. Address both the tangible and intangible cultural elements of environmental protection.
8. Deliver on results that have direct benefits for Aboriginal communities.
9. Embed consistent, meaningful and trustworthy engagement with Aboriginal communities.
10. Develop Aboriginal cultural competency across the agency.
11. Increase Aboriginal employment across the agency to exceed public sector Aboriginal employment targets, and identify specific occupational gaps.
12. Monitor the impact of this Commitment to Aboriginal peoples, Country, cultures and spirit.

This collaboration ensures our strategic initiatives are firmly grounded in principles of respect and sustainability.

Foreword 2024 report

I am pleased to present the NSW Environment Protection Authority's (EPA) State of the Environment report for 2024. Published every three years, this is the EPA's 12th such report.

This report provides a snapshot of the NSW environment as well as a picture of long-term environmental trends. This detail, alongside previous reports, will continue to inform our role as a steward in caring for and protecting the environment not only today but for generations to come.

I'm particularly proud of the EPA's ongoing collaborative work with Aboriginal people, something that played a huge part in the preparation of this report. The **Aboriginal Peoples Knowledge Group** contributed valuable knowledge and perspectives which worked in tandem with Western science to create a powerful and holistic approach to environmental stewardship and caring for Country.

The benefits of our environment are not infinite. We have aligned the nine planetary boundaries with our report indicators to help identify environmental limits within which we can sustainably live. We will continue to lead in this area by building on it in future reports.

So, what exactly does the *NSW State of the Environment 2024* tell us?

- **Climate change** is already a major factor impacting many environmental trends. In 2021–22, greenhouse gas emissions in NSW were 111 million tonnes of carbon dioxide equivalent per year, which is 27% lower than the annual rate back in 2005.
- In NSW, **sea level** rose by 12cm between 1991 and 2021, and may rise by up to one metre by the end of the 21st century.
- Severe **fire** weather days and hot days (35°C or more) are projected to increase. Average temperatures across the State have already risen 1.4°C since 1910 and sea surface temperatures in the Sydney area have increased by about 0.14–0.2°C per decade since the 1950s.
- The extent of **native vegetation** cover has declined over the past three years. The ability of remaining habitats in NSW to support native plants, animals and ecosystems has dropped to 29% of their original capacity since pre-industrialisation.
- The number of **threatened species** listings in NSW has increased by 36 since December 2020. In 2024, more than 600 plant species and 300 animal species in NSW are threatened and risk extinction.
- NSW **air quality** meets national standards most of the time. In the past three years air quality has been negatively affected during extreme weather events, such as storms and bushfires.
- **River condition** remains poor or very poor for many areas of the Murray–Darling Basin. Coastal rivers are generally in better condition, particularly on the southern coasts.
- Most **soils** in NSW are in a moderate condition, although much of the State's agricultural land is becoming slightly more acidic, with soil pH changing by at least 0.15 in 2006–20.
- Good rainfall in the past three years has helped improve **water quality** in some areas, but may also have been associated with significant fish kill events during that time.
- **Coastal vegetation** and habitats such as saltmarsh, mangroves and seagrass continue to be threatened by development and climate change.
- **Invasive species** continue to exert pressure on native plants and animals. New threats, such as fire ants, will continue to pose a significant biodiversity risk if not eradicated.

The report findings highlight the need to systemically improve our environmental management, with examples of positive recovery showcasing how we can make significant progress in the years ahead. I encourage you to read the report in full for a more detailed analysis of these trends.

Finally, a project of this scale and complexity represents a huge amount of work. I'd like to give a heartfelt vote of thanks to everyone who helped bring the report to life.

Tony Chappel
Chief Executive Officer
NSW Environment Protection Authority

See the **APKG Chairperson foreword** for *State of the Environment 2024*.

APKG Chairperson foreword

I acknowledge the dedication and hard work of the Aboriginal people who have gone before us, who have taken this journey to establish space for Aboriginal ancestral knowledge and wisdom to be heard. I respect the enduring cultural and spiritual relationship Aboriginal people have with the land and sea to ensure Country and people are in a state of wellness and balance.

I acknowledge the members of the Aboriginal Peoples Knowledge Group (APKG); **Greg Griffiths**, **Steven Ahoy**, **Sue Bulger**, **Marcus Ferguson**, **Lawrence Clarke** and **Daniella Chedzey**, for their commitment to working in partnership with the NSW Environment Protection Authority (EPA) for the betterment of our lands, waterways, sky and peoples.

APKG was established as a newly independent advisory committee to the EPA. As the Chairperson, I am proud to bring a collective voice stating our intentions and input into the State of the Environment 2024 Report. The voices of Elders, Knowledge Holders and Custodians will resonate as you read the 2024 State of Environment Report. Aboriginal words, concepts and ideas speak to you throughout these pages. These words are built upon the wisdom of our old people, Elders and ancestors; and our collective lived experiences come to you from our hearts.

APKG elevates traditional practices, values and principles; through sharing of our knowledge and ways of knowing, being and doing. Whilst some APKG members originate from diverse culturally active landscapes and face different environments issues; we speak as a collective in a unified and passionate voice for, and with Country.

Our Country has its own language; the sounds of language come from Country and exists all around us on Country. Language is the vibration of the land, it has the potential to connect us to Country, culture, ancestors and people.

The EPA has been invited to corroborate with language knowledge holders to embed Aboriginal languages in their remit and to support the development of respectful relationships. Prior to invasion, there were 35 languages spoken across NSW, belonging to the Pama-Nyungan family of Australian languages. The surviving languages are referred to as ‘revival’ languages. Language revitalisation enables us to learn, speak and see the languages of the lands we walk upon; it gives us a cultural lens to establish a relationship with the Country and each other.

Developing respectful relationships with Country and each other, allows us to walk together on common ground; to know Country and our connectedness, and find the continuity where we are connected, not separated from one another or Country. Through a reciprocal relationship, we will establish a truth telling platform; with trust we will strategically ensure there are legislative reform, tangible outcomes and viable actions, to conserve and protect our environment and natural resources.

The APKG members are working with the EPA to create better ways of wholistically caring for Country; to ensure it can heal, grow and prosper for all grandchildren, grandchildren’s children and so on.

Throughout the SOE report you will hear the voices of APKG members tell stories, share cultural knowledges, wisdom, make statements and comment on the state of the environment. We invite you *ngarragi* (Gathang language) ‘to listen, learn and remember’ these contributions as we work together to create balance and wellness in our environment and people.

Chairperson
Dr Rhonda Radley (Anjilkurri)
Birrbay/Dhanggati

> To read the NSW EPA's foreword for the 2024 report, please see **Foreword 2024 report**.

This page intentionally
left blank

Contents

This page intentionally
left blank

About the report

soe.epa.nsw.gov.au

This page intentionally left blank

What is SoE?

Introduction to the report

The *NSW State of the Environment 2024* (SoE) has been prepared by the **NSW Environment Protection Authority** (EPA) as required by section 10 of the ***Protection of the Environment Administration Act 1991*** (POEO Act).

The report provides a snapshot of the main environmental issues facing New South Wales (NSW). The SoE report is updated every three years. It compiles data, analysis and information from various NSW Government agencies responsible for managing the state's environmental assets, before it is reviewed by independent expert reviewers.

See the **Acknowledgements** section for more information about contributors to SoE 2024.

The first SoE report was published in 1993 and has since evolved to include more detailed and interactive content. Each SoE report aims to provide credible, robust, statewide environmental information for the NSW Government, industry and the community.

Most Australian states and territories produce their own detailed SoE reports. At a **national level,** SoE reporting is conducted every five years.

Tabled Report

The Tabled Report is a printed copy of the information available on this website at the time of export. This is provided to the Minister and tabled in Parliament.

Topics in this report are maintained in their respective reporting year tabs. A formal addendum is issued if there is any alteration to a Tabled Report's content.

Introduction to the website

The NSW State of the Environment website is designed to offer an accessible and interactive platform for exploring the State's environmental status.

Topics content that matches the Tabled Report can be found in each topic's reporting year tab. Supporting pages, themes and the Current tab may be periodically updated.

Topics prior to 2018 can be found on the **EPA website**.

Acknowledgements

The EPA acknowledges Aboriginal peoples as the enduring Custodians of the land, sea, waters and sky of New South Wales. See the **Statement of Commitment to Aboriginal People** webpage for the full statement.

Aboriginal Peoples Knowledge Group

The EPA Aboriginal Peoples Knowledge Group shared views, values and cultures for introductions to our environmental themes. They further enhanced the report through consultation on images and icons used throughout the report.

See the **Aboriginal Peoples Knowledge Group** page for more information about this group and their contributions to the report.

Advisory Committee

An Advisory Committee comprising academic specialists and representatives of NSW government agencies provides advice on matters such as emerging trends and opportunities, topic content and information gaps.

The EPA acknowledges the contribution of the Advisory Committee members for their suggestions and advice:

- **Dr Stephen Conaty**, Director, Environmental Health Branch, NSW Health
- **Dr Scott Dwyer**, Research Director, Institute for Sustainable Futures, University of Technology Sydney
- **Mr Bhiamie Eckford-Williamson**, Euahalyi man, & Research Fellow, Monash University
- **Bryony Horton**, Director, Science Strategy and Impact, Department of Climate Change, Energy, the Environment and Water
- **Richard Kingswood**, Director, Biodiversity and Ecological Health, National Parks & Wildlife Service
- **Dr Natalie Moltschaniwskyj**, Chief Scientist, Department of Primary Industries and Regional Development
- **Professor Jim Prately**, Research Professor of Agriculture, Gulbali Institute, Sturt University
- **Kathryn Taffs**, Acting Director, Water Science, Department of Climate Change, Energy, the Environment and Water

Agency contributors

The EPA worked closely with NSW Government agencies and subject matter experts from within the EPA in the development of this report.

The EPA is grateful for the assistance of NSW agencies who contributed most of the information and data for the Status and trends section, as well as further guidance for other sections. These agencies include:

- Department of Climate Change, Energy, the Environment and Water
- Department of Planning, Housing and Infrastructure
- Department of Primary Industries and Regional Development
- Forestry Corporation of NSW
- Hunter Water
- Sydney Water
- Transport for NSW
- WaterNSW.

Further assistance and review were provided by The Cabinet Office (NSW) and NSW Health.

Independent expert reviewers

Independent expert review enhances the value and transparency of the report by ensuring that the most up-to-date and appropriate information is included; analysis and interpretation of the material is appropriate; and content adequately covers new and emerging issues.

The EPA acknowledges the contribution of the following experts who reviewed content and data relevant to their expertise:

- **Emeritus Professor Ian Acworth**, UNSW Water Research Laboratory
- **Professor Linda Beaumont**, Macquarie University
- **Professor Andrew Blakers**, Australian National University
- **Associate Professor Mathew Crowther**, University of Sydney
- **Associate Professor Troy Gaston**, University of Newcastle
- **Dr Richard Greene**, Australian National University
- **Joseph Lovie-Toon**, Department of Climate Change, Energy, the Environment and Water
- **Dr Benajmin Madden**, Institute for Sustainable Futures, University of Technology Sydney
- **Dr Chels Marshall** PhD, Gumbaynggirr woman, Deakin University
- **Associate Professor Robert Niven**, University of New South Wales
- **Dr Marie-Chantale Pelletier**, Southern Cross University
- **Professor Andrew Pitman**, University of NSW
- **Associate Professor Daniel Ramp**, Centre for Compassionate Conservation, University of Technology Sydney
- **Dr Michael Reid**, University of New England
- **Dr Aleks Todorovski**, Todorovski Air Science
- **Professor Stuart White**, Institute for Sustainable Futures, University of Technology Sydney
- **Glen Whitehead**, Department of Climate Change, Energy, the Environment and Water
- **Kerryn Wilmot**, Institute for Sustainable Futures, University of Technology Sydney.

Artwork

Artwork throughout this report is created by Gerard Black, Worimi artist and owner of Baiyami Art.

The designs were developed to represent each of the main report themes: Voice of Country, Land, Water, Biodiversity, Air and atmosphere, Drivers, Climate change, People and industry with each piece inspired by the patterns of Country and the spirit all around us.

The designs overarching intent is to promote a greater sense of connection. It is hoped that the viewer can look at the art and transport themselves into the places where the art takes them – whether to the forests or down in the ocean or looking up into the sky to the birds. The aim is for the art to bring the viewer back to that connection level – how we connect to the world around us – the real underlying connection that we should all have.

Learn more about the designs in **Video 1** from Worimi artist, Gerard Black.

Video 1: Hear about the SoE 2024's artworks by Worimi artist, Gerard Black

Source:
NSW EPA 2024

The background page banners background lacing used throughout the report is titled *Butjin Wanggal* ('Dilly bag dance' from the Gathang language). It has been threaded throughout the report to represent the interconnectedness between people and all parts of the environment.

Photo credits

The SoE report features images of Country from across our beautiful state.

The EPA is on a journey to inclusiveness of Aboriginal people and cultures and notes the names of traditional Country assigned to photos may be contestable. These names demonstrate the EPA's commitment, but should not be regarded as fact.

For the SoE website, many photos have been cropped to fit the website's banner format and text overlay. See the **Photo and artistic credits** page for the full list.

How are we reporting?

Global reporting

In the latter half of the 20th century, as environmental damage such as pollution became increasingly obvious, the United Nations hosted international conferences where communities, scientists and governments discussed ways to prevent, limit or reverse environmental harms.

Regular state of the environment (SoE) reporting was one of many **responses to these problems** and today, most states and territories of Australia and some local councils, produce detailed SoE reports.

At a national level, reporting is conducted every five years by the Australian Government under the *Environment Protection and Biodiversity Conservation Act 1999*.

The **Global Reporting Initiative**, set up in 1997, established reporting frameworks, guidelines and sustainability standards to help communities, industries and governments better communicate and demonstrate accountability for impacts on the environment, economy and people.

The **Pressure-State-Response** model was also developed and standardised in the latter half of the 20th century.

See the **Global reporting models** page for more information about the models and the **How to read this report** page to learn how the 2024 report has been structured across themes and within each topic.

Alignment to global models

The SoE report aligns to global models including the United Nation's Sustainable Development Goals and Planetary boundaries.

See the **Global reporting models** page for more information about the models.

Many of our environmental concerns are shared by other Australian states and countries around the world. By aligning the SoE report to these models, we are using a common, global language, allowing comparison of our report with existing data and target outcomes.

See the **Planetary boundaries alignment** and **UN SDG alignment** pages for more information

Explaining indicators

The SoE report uses **environmental indicators** to assess the status and trends of environmental factors. These indicators help to understand the impact of human activities and natural processes on the environment, guiding government policy and management decisions, as well as action by industry and the community.

See the **Indicator guide** page for more information.

Net Zero Plan

In 2021, the NSW EPA was directed by the state Minister for Environment to report on the state's progress towards achieve the ***NSW Net Zero Plan***. This is reported in the State of the Environment reports under the **Net Zero Plan Stage 1: 2020–2030** page.

Linking to other resources

The SoE report is a useful resource for schools, universities and the community. We are currently developing links with the NSW Curriculum and will continue to build on links to other education opportunities. These may include stories, videos, audio or links to specific case studies. Look out for our **resource icons** across the report to learn more.

Global reporting models

Why report on the state of the environment?

The natural environment is essential to our daily lives in many ways – it provides the air we breathe, the water we drink and the soil that sustains our land and agriculture.

Reporting on the long-term condition of our environment helps us assess the effectiveness of actions we have taken to prevent, mitigate or fix damage to the environment and improve our care of it.

Aboriginal peoples have been observing and responding to changes in the environment since deep time, with observations tied to ongoing connections to and care of land, waters and all living beings.

Our reporting framework

The **Pressure-State-Response** framework for environmental reporting was developed and standardised in the latter half of the 20th century.

This model is often expanded or adapted – as it is in this report – to include impacts and other flow-on problems caused by environmental pressures and damage.

This expanded model is called **Pressure-State-Response + Impact**.

For example, a *pressure* such as the number of cars on public roads can affect the *state* of air quality (by increasing pollution) which leads to defined *impacts* on human health, such as an increase in respiratory illness in the population.

Responses include government policies, initiatives and strategies to help improve environmental condition and address pressures and impacts.

This model is used in NSW State of the Environment reports under the following headings:

- **Status and trends (state)** – the condition of the environment and trends in its condition over time
- **Pressures and impacts (pressure)** – what is causing the environmental problems and what this means for human and environmental health
- **Response** – what is being done, or can be done, to address the problems identified under Pressure and Status.

Reporting in this way can help to link the cause-and-effect relationship between environmental pressures and environmental performance, and between our actions and their impacts.

This helps us understand why protecting the environment is important for everyone.

In Australia, State of the Environment reports at Commonwealth, State and jurisdiction levels have only recently started to include Aboriginal and Torres Strait Islander values, perspectives and knowledges.

The *NSW State of the Environment 2021* was the first time that NSW invited Aboriginal peoples to provide advice on the health of Country. Aboriginal voices will be an ongoing feature of NSW State of the Environment reports.

Thinking big for a better future

State of the Environment reporting and the **Pressure-State-Response** model have been useful for measuring and monitoring environmental changes and helping inform decision-making for governments and communities around the world.

However, other emerging approaches are also helping us understand relationships between the environment and human health and wellbeing.

At a time when we face climate and biodiversity crises, a burgeoning waste problem and increasing concerns about health impacts from exposure to pollution on land and in air and water, these approaches offer alternative perspectives on how to measure, report and manage our environment and actions in ways that balance environmental and human needs.

United Nations Sustainable Development Goals (UN SDGs)

The United Nations **2030 Agenda for sustainable development**, outlines how the world could eradicate poverty and help nations develop without continuing environmental harm.

The agenda sets out 17 Sustainable Development Goals that cover global issues such as climate action, clean water, responsible consumption and production, sustainable cities, gender equality and education.

The indicators in *NSW State of the Environment 2024* have been mapped to these goals, targets and indicators to show how our reporting aligns with and supports sustainable development in NSW.

See the UN **Sustainable Development Goals** webpage for more information.

The Global Biodiversity Framework (GBF)

The **Kunming–Montreal Global Biodiversity Framework**, which was adopted by the **United Nations Convention on Biological Diversity** (CBD) in 2022, sets out a global vision for the protection and more sustainable use of nature.

The Framework has four goals for 2050 and 23 targets for 2030 that align with the Sustainable Development Goals.

The 2030 targets include:

- conserving 30% of land, waters and seas (known as the 30x30 target)
- restoring 30% of degraded areas
- enhancing biodiversity and sustainability in agriculture, aquaculture, fisheries, and forestry
- enabling sustainable consumption choices to reduce waste and over-use of resources
- ensuring equitable participation in decision-making that includes Indigenous peoples.

As a party to the CBD, Australia is required to have a national biodiversity strategy and action plan that outlines how it will contribute to the GBF. The Australian Government's **Strategy for Nature 2024–2030** commits to a suite of nationally agreed biodiversity targets that support the GBF targets.

Planetary boundaries

The benefits of our environment are not infinite. Should human activities place extreme pressure on the earth's systems and processes, this will cause catastrophic and enduring damage, such as irreversible climate change, unbreathable air and loss of food and water.

The **planetary boundaries model** was developed to help identify the environmental limits within which we can live safely on earth. It proposes boundaries for nine essential Earth systems (see **Figure GR1.1**).

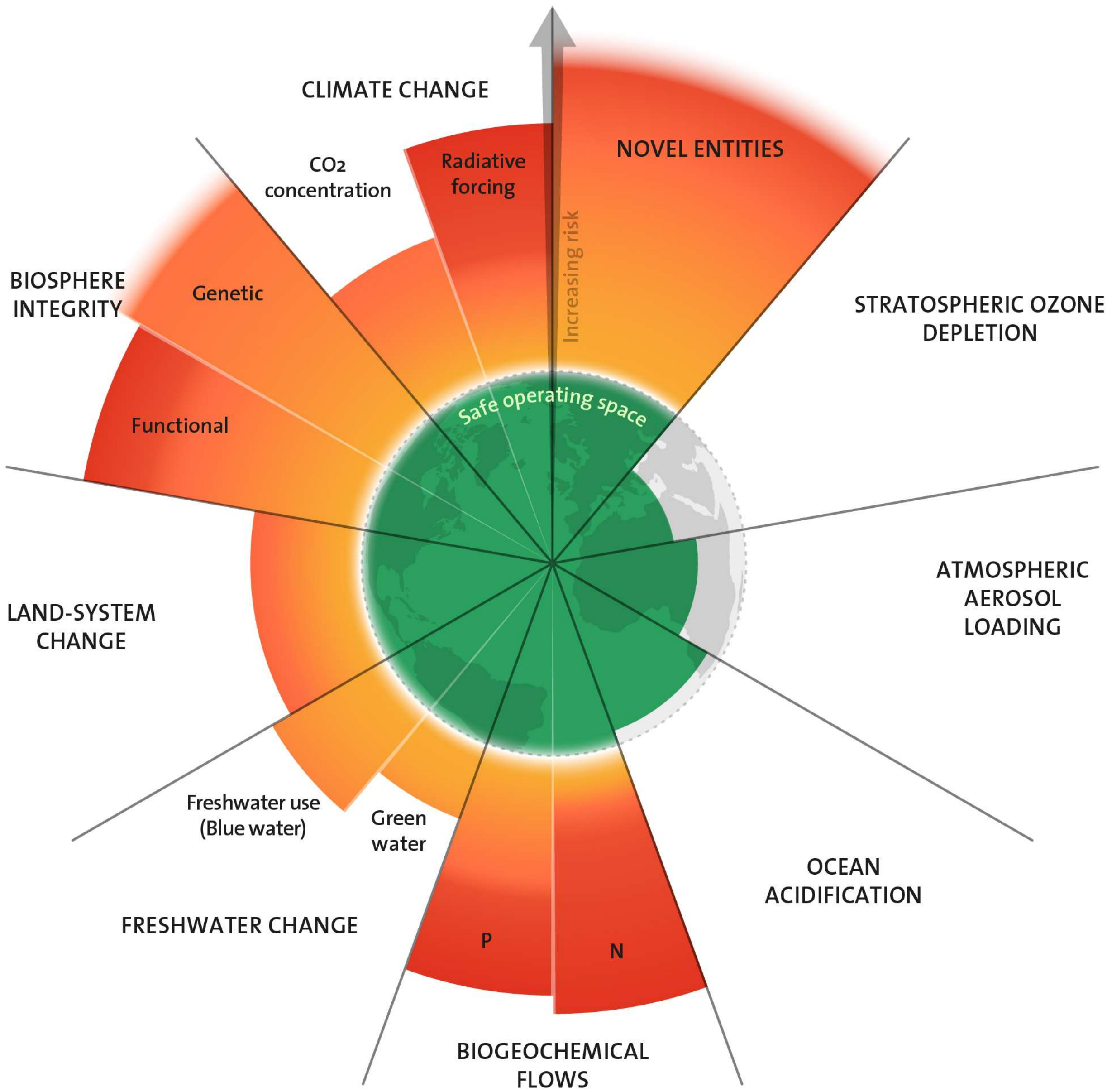
The figure shows that if we go beyond the boundary of the green ('safe') zone, we enter an orange zone of 'uncertainty'.

At this point, it becomes urgent to reverse the trend, because the next boundary, where orange changes to red, represents a danger zone where catastrophic and irreversible changes are much more likely to occur, threatening life on earth.

Since the concept was first developed in 2009, scientists have been 'quantifying' each of the boundaries – that is, deciding how to define or measure where they should be set – and investigating which boundaries have been crossed.

As **Figure GR1.1** shows, all nine boundaries have been identified and six of them have now been crossed – in several cases entering the red danger zone.

Figure GR1.1: Status of the nine planetary boundaries in 2024



Source:
Stockholm Resilience Centre

While the original research was globally focused, since 2009 it has been explored at a smaller scale. For example, the **European Union**, The Netherlands (**Lucas & Wilting 2018**) and **New Zealand** have all 'downscaled' the model to identify what the boundaries should be for their jurisdictions and assess whether any have been crossed.

A privately commissioned report, *Living Within Limits* (**Zyngier et al. 2022**), has assessed five of the planetary boundaries in the Australian context. The researchers found that at the national scale, the boundaries for land system change, biodiversity integrity and biogeochemical flows have been transgressed and climate change and freshwater use are in the orange zone of uncertainty.

Planetary boundaries have not so far been used in any jurisdiction for State of the Environment reporting.

State of the Environment reporting in NSW uses a range of standards that have been established at global or national scales, such as the proposed limits for greenhouse gas emissions at the **Paris Agreement on Climate Change**. The standards used often measure thresholds for impacts on human health rather than environmental integrity, such as air quality standards and safe drinking water guidelines. See, for example, the **Air quality** and **Water use** topics.

Environmental footprint

The environmental footprint approach compares how much humans use and consume resources with nature's capacity to meet these demands.

The most well-known example, **Earth Overshoot Day** estimates the date each year humans are expected to exceed our global environmental budget and how many Earths would be needed after that point to meet our demands.

This is also called 'ecological overshoot'.

When first estimated in 1971, the date was in December. By 2024, it has moved up to 1 August. This means we are using our environmental budget much faster than in previous years.

Earth Overshoot Day can also be explored at **country-level**.

Research by the **Global Footprint Network** shows that richer countries place comparatively more pressure on natural resources, suggesting they have greater responsibility to both prevent environmental damage and to help poorer countries develop without causing harm.

The **footprint calculator** enables this analysis at an individual level and can help identify ways to reduce your environmental impacts and tread more lightly on the earth.

The NSW SoE does not calculate an overall ecological footprint but discusses resource use per capita in the **Population and the environment**, **Economic activity and the environment** and **Energy consumption** topics.

The **ACT State of the Environment** found that the territory's ecological footprint was estimated to be over nine times the size of the ACT land area in 2023, meaning its current resource use was unsustainable.

The report noted that the ecological footprint had been decreasing over time, particularly with the growth in renewable electricity, but not fast enough to be at sustainable levels.

Environmental approaches in economic reporting

Economics provides a framework for how society manages its limited resources.

Up until the early 21st century, consideration of the environment has mostly not been integrated into mainstream economic thinking (**Williams & Taylor 2021**). However, this is changing as societies and governments around the world increasingly recognise that the environment must be included in economic theory and policy so that the benefits it gives us can be protected.

The **Economic activity and the environment** topic in this report outlines how new ways of thinking, such as natural capital accounting, are starting to be implemented in Australia and NSW.

These new economic approaches can also help government better align policies across different departments to ensure a consistent approach to environment protection and restoration across the state.

Doughnut economics

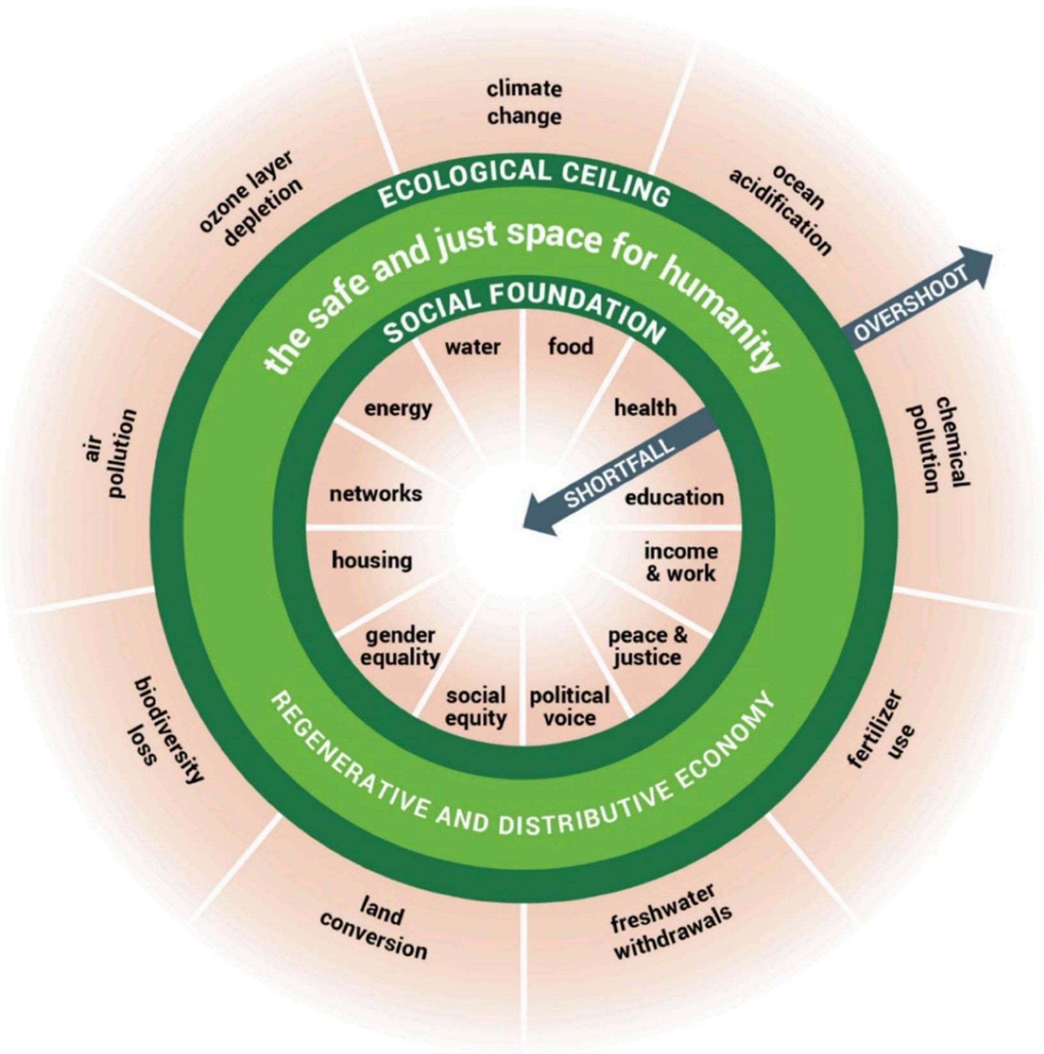
The doughnut economics model combines the planetary boundaries concept with sustainable development goals for economic and social justice to show how the worst-case and best-case scenarios interact (see **Figure GR1.2**).

The model recognises that everyone on the planet should have the resources to ensure they have a safe and comfortable standard of living.

The model includes:

- The ecological ceiling (planetary boundaries): these are the red, white and grey segments of the outermost circle, representing the upper limits on our use of resources.
- A social foundation (based on sustainable development goals): these are the red, white and grey segments of the innermost circle which set the minimum level of resource use to achieve economic and social justice goals.
- The safest place for humanity to thrive: Is between the ecological ceiling and the social foundation, which is in the doughnut-shaped green zone.

Figure GR1.2: Doughnut Economics model



Source:
Kate Raworth (Doughnut Economics Action Lab and the University of Leeds) - Exploring doughnut economics

This theory has been further developed and explored since it was proposed in 2012. For example, **Amsterdam** has downscaled it to city level and a community network in **Sydney** is exploring how the approach can inspire community-based projects such as urban farming.

Where to from here?

With humanity facing significant environmental threats in the 21st century, it is more important than ever to work out how we can be better environmental stewards for the beautiful planet we depend on.

Aboriginal peoples have cared for Country for tens of thousands of years. It is critically important that we listen to Aboriginal knowledges and wisdom from knowledge holders who can speak for Country to heal the environment, restore culture and care for communities through locally relevant and sustainable solutions.

Placing NSW in the global context will help individuals, communities, governments and businesses to develop solutions that also improve everyone's quality of life and create a safer world for future generations to enjoy.

The NSW State of the Environment will continue to report using the **Pressure-State-Response + Impact** model because it aligns best with our legislative reporting requirements.

Further exploration of models like those above can further enhance our reporting.

We encourage you to also keep exploring what you can do as an individual and in your community to value and care for nature in NSW.

References

Lucas P & Wilting H 2018, *Using planetary boundaries to support national implementation of environment-related Sustainable Development Goals*, PBL Netherlands Environmental Assessment Agency, The Hague (PDF 1.5MB)

Williams SJ & Taylor R 2021, *Sustainability and the new economics* (Edition), Springer, Cham

Zyngier R, Archibald C, Hadjikakou M, Shaikh A & Bryan B 2022, *Living within limits: adapting the planetary boundaries to understand Australia's contribution to planetary health*, Climateworks Centre, Docklands VIC

Planetary boundaries alignment

The planetary boundaries model, developed in 2009 by scientists at the **Stockholm Resilience Centre**, helps to identify environmental limits for nine essential Earth systems.

See the **Global reporting models** page for more information on why we report on the state of the environment.

The *NSW State of the Environment 2024* does not report against the criteria used to measure the planetary boundaries. This is because there is currently not sufficient NSW data available.

Table PB1.1 table shows how *NSW State of the Environment 2024* indicators align to the planetary boundaries.

Table PB1.1: Planetary boundaries alignment table

Planetary boundary	How it is measured under the planetary boundaries model	*State of the Environment* indicators
Climate change	• Atmospheric carbon dioxide concentration (350 parts per million) • Increase in top-of-atmosphere radiative forcing • **Globally, this boundary has been crossed**	• The **Greenhouse gas emissions** topic reports on global atmospheric concentrations of greenhouse gases, annual net NSW greenhouse gas emissions and annual NSW per capita greenhouse gas emissions • Tracking radiative forcing is beyond the scope of this report
Novel entities	• Synthetic chemicals and substances, such as microplastics, human-made radioactive materials, such as nuclear waste, and other human interventions, such as genetically modified organisms • **Globally, this boundary has been crossed**	• Reporting on novel entities is beyond the scope of this report
Stratospheric ozone depletion	• Stratospheric ozone concentration (<5% reduction from pre-industrial level) • **Globally, this is within safe levels**	• Reporting on stratospheric ozone is beyond the scope of this report
Atmospheric aerosol loading	• Airborne particles from human activities or natural sources, such as dust or bushfire smoke • **Globally, this is close to crossing the safe boundary**	• Reporting on atmospheric aerosol loading is beyond the scope of this report
Ocean acidification	• Acidity (pH) in ocean water due to the absorption of atmospheric carbon dioxide • **Globally, this is close to crossing the safe boundary**	• Reporting on ocean acidification is beyond the scope of this report
Modification of biogeochemical flows	• Disruption of natural nutrient cycles, such as phosphorous flows from freshwater systems into the ocean or from fertilisers to erodible soils • Industrial and intentional biological fixation of nitrogen (extracting nitrogen from the atmosphere) • **Globally, this is close to crossing the safe boundary**	• Reporting on the modification of biochemical flows differs from the planetary boundary criteria • The **Rivers and wetlands** topic reports on nitrogen and phosphorous levels

Planetary boundary	How it is measured under the planetary boundaries model	*State of the Environment* indicators
Freshwater change	• Alteration of freshwater cycles, such as rivers and groundwater (blue water) and soil moisture (green water) • **Globally, this boundary has been crossed**	• Reporting on freshwater change is beyond the scope of this report
Land system change	• Transformation of landscapes, such as through deforestation and urbanisation • Measured as the area of forested land as a percentage of original forest cover (85% of potential cover maintained for tropical and boreal forests and 50% of potential cover maintained for temperate forests) • **Globally, this boundary has been crossed**	• Reporting on land system change differs from the planetary boundary criteria • The **Plants** topic reports on the extent of native vegetation and the clearing of native vegetation • The **Protected areas and conservation** topic reports on the total area of the NSW terrestrial protected areas network
Biosphere integrity	• Genetic diversity: the maximum extinction rate while preserving ecological complexity (10 extinctions per million species-years) • **Globally, this boundary has been crossed** • Functional diversity: the ability for the biosphere to co-regulate the state of the planet (90% Biodiversity Intactness Index) • **Globally, this boundary has been crossed**	• Reporting on biosphere integrity differs from the planetary boundary criteria • The **Plants** topic reports on the number of threatened species listed • The **Animals** topic reports on the number of threatened species listed • The **Plants** topic reports on the ecological carrying capacity • The **Animals** topic reports on the population and distribution of native mammals and native birds, as well as native fish communities • The **Rivers and wetlands** topic reports on the river condition index for NSW rivers, health of fish communities, wetland extent and condition, and water bird abundance and breeding • The **Coastal and marine** topic reports on the extent of estuarine macrophytes and coastal fish stocks

Source:
Stockholm Resilience Centre (SRC n.d.) | Richardson et al. 2023 | Steffen et al. 2015 | Rockström et al. 2009a | Rockström et al. 2009b

References

Richardson K, Steffen W, Lucht W, Bendtsen J, Cornell SE, Donges J, Druke M, et al. 2023, 'Earth beyond six of nine planetary boundaries', *Science Advances*, vol. 9, no. 37, DOI: 10.1126/sciadv.adh2458

Rockström J, Steffen W, Noone K, Persson Å, Chapin FS III, Lambin EF, Lenton TM, et al. 2009a, 'A safe operating space for humanity', *Nature*, vol. 461, pp.472–5, DOI: 10.1038/461472a

Rockström J, Steffen W, Noone K, Persson Å, Chapin FS III, Lambin EF, Lenton TM, et al. 2009b, 'Planetary Boundaries: Exploring the Safe Operating Space for Humanity', *Ecology and Society*, vol. 14, no. 2, 32

SRC n.d., Planetary boundaries, Stockholm Resilience Centre, accessed 11 December 2024

Steffen W, Richardson K, Rockstrom J, Cornell SE, Fetzer I, Bennett EM, Biggs R, et al. 2015, 'Planetary boundaries: Guiding human development on a changing planet', *Science*, vol. 347, no. 3,223, DOI: 10.1126/science.1259855

UN SDG alignment

Progress towards monitoring UN SDGs relevant to the NSW SoE are tracked by aligning NSW indicators and topics with the UN goals, targets and indicators.

United Nations Sustainable Development Goals (SDGs)

The United Nations **2030 Agenda for sustainable development**, outlined how the world could eradicate poverty and help nations develop without continuing environmental harm.

This page identifies alignment between the **17 sustainable development goals** and the indicators in the SoE report to show how our reporting aligns with and supports sustainable development in NSW. In 2024, the SoE report offers tracking on seven SDGs, including 13 targets and indicators as represented in **Table SDG.1**.

In mapping this alignment, we are using a common, global language and allowing comparison of our report with existing data and target outcomes. See the **Global reporting models** page for more information.

Table SDG.1: SDG alignment with NSW State of Environment current topics

SDG	SDG target	SDG indicator	NSW SoE indicator	NSW SoE topic (2024)
2 ZERO HUNGER	**2.4**: By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality	**2.4.1**: Proportion of agricultural area under productive and sustainable agriculture	Proportion of water extraction covered by water sharing plans	**Water use**
			Environmental share of available water	**Water use**
6 CLEAN WATER AND SANITATION	**6.3**: By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	**6.3.2**: Proportion of bodies of water with good ambient water quality	Nitrogen and phosphorous levels	**Rivers and wetlands**
			Salinity	**Rivers and wetlands**
			Percentage of ocean and estuarine beaches with beach suitability grades for swimming of good or better	**Coastal and marine**
	6.6: By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes	**6.6.1**: Change in the extent of water-related ecosystems over time	Wetland extent	**Rivers and wetlands**
			Wetland condition	**Rivers and wetlands**
7 AFFORDABLE AND CLEAN ENERGY	**7.2**: By 2030, increase substantially the share of renewable energy in the global energy mix	**7.2.1**: Renewable energy share in the total final energy consumption	Total NSW non-renewable energy consumption	**Energy consumption**
	7.3: By 2030, double the global rate of improvement in energy efficiency	**7.3.1**: Energy intensity measured in terms of primary energy and GDP	Per capita residential energy consumption	**Energy consumption**
			Annual NSW per capita greenhouse gas emissions	**Greenhouse gas emissions**
			Emissions intensity of the economy	**Economic activity and the environment**

SDG	SDG target	SDG indicator	NSW SoE indicator	NSW SoE topic (2024)
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	**9.4**: By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities Indicators	**9.4.1**: CO_2 emission per unit of value added	Decoupling of CO_2 emissions from NSW Gross State Product	**Economic activity and the environment**
			Emissions intensity of the economy	**Economic activity and the environment**

SDG	SDG target	SDG indicator	NSW SoE indicator	NSW SoE topic (2024)
11 SUSTAINABLE CITIES AND COMMUNITIES	**11.2**: By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons	**11.2.1**: Proportion of population that has convenient access to public transport, by sex, age and persons with disabilities	Access to 30-minute city	**Transport**
			Access to regional day return	**Transport**
	11.4: Strengthen efforts to protect and safeguard the world's cultural and natural heritage	**11.4.1**: Total per capita expenditure on the preservation, protection and conservation of all cultural and natural heritage, by source of funding (public, private), type of heritage (cultural, natural) and level of government (national, regional, and local/municipal)	Total area of NSW terrestrial protected areas	**Protected areas and conservation**
			Growth in public protected areas	**Protected areas and conservation**
			Growth in private protected areas	**Protected areas and conservation**

SDG	SDG target	SDG indicator	NSW SoE indicator	NSW SoE topic (2024)
	11.6: By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management	**11.6.1**: Proportion of municipal solid waste collected and managed in controlled facilities out of total municipal waste generated, by cities	Per person waste generated	**Waste and recycling**
			Total solid waste recycled	**Waste and recycling**
			Litter items per 1,000m^2	**Waste and recycling**
			Total waste generated	**Waste and recycling**
		11.6.2: Annual mean levels of fine particulate matter (e.g. $PM_{2.5}$ and PM_{10}) in cities (population weighted)	Concentrations of particles (PM_{10})	**Air quality**
			Concentrations of particles ($PM_{2.5}$)	**Air quality**
			Concentrations of carbon monoxide	**Air quality**
			Concentrations of nitrogen dioxide	**Air quality**
			Concentrations of sulfur dioxide	**Air quality**
			Concentrations of lead	**Air quality**
12 RESPONSIBLE CONSUMPTION AND PRODUCTION	**12.5**: By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse	**12.5.1**: National recycling rate, tons of material recycled	Total waste generation	**Waste and recycling**
			Total solid waste recycled	**Waste and recycling**
13 CLIMATE ACTION	**13.2**: Integrate climate change measures into national policies, strategies and planning	**13.2.2**: Total greenhouse gas emissions per year	Global atmospheric concentrations of greenhouse gases	**Greenhouse gas emissions**
			Annual net NSW greenhouse gas emissions	**Greenhouse gas emissions**
			Annual NSW per capita greenhouse gas emissions	**Greenhouse gas emissions**

SDG	SDG target	SDG indicator	NSW SoE indicator	NSW SoE topic (2024)
	14.1: By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution	**14.1.1**: (*a*) Index of coastal eutrophication; and (*b*) plastic debris density	Estuarine water quality (chlorophyll-*a* and turbidity)	**Coastal and marine**
14 LIFE BELOW WATER	**14.4**: By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics	**14.4.1**: Proportion of fish stocks within biologically sustainable levels	Coastal fish stocks	**Coastal and marine**
	14.5: By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information	**14.5.1**: Coverage of protected areas in relation to marine areas	Proportion of marine waters protected in marine parks and reserves	**Coastal and marine**

SDG	SDG target	SDG indicator	NSW SoE indicator	NSW SoE topic (2024)
15 LIFE ON LAND	**15.1**: By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements	**15.1.1**: Forest area as a proportion of total land area	Total area of NSW terrestrial protected areas	**Protected areas and conservation**
			Growth in public protected areas	**Protected areas and conservation**
			Growth in private protected areas	**Protected areas and conservation**
			River Condition Index (RCI) for NSW rivers	**Rivers and wetlands**
			Health of fish assemblages	**Rivers and wetlands**
			Number of threatened species listed	**Plants**
			Invasive plant species numbers, coverage and impact	**Plants**
	15.4: By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development	**15.4.1**: Coverage by protected areas of important sites for mountain biodiversity	Reserve representativeness (infographic)	**Protected areas and conservation**
	15.5: Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species	**15.5.1**: Red List Index	Number of threatened species listed	**Animals**
			Number of threatened species listed	**Plants**
	15.8: By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species	**15.8.1**: Proportion of countries adopting relevant national legislation and adequately resourcing the prevention or control of invasive alien species	Invasive plant species numbers, coverage and impact	**Plants**

Notes:
Explore all 17 goals on the **United Nations website**

How to read this report

Themes

In the *NSW State of the Environment 2024*, topics were grouped into broad themes. These themes can be considered to relate to environmental groupings (**Land**, **Waters**, **Air and atmosphere**, **Biodiversity**) or pressures that are increasing the impact of human activities and natural processes (**Climate**, **People and industry**, **Drivers**).

These themes include:

- statement from the EPA Aboriginal People's Knowledge Group (where relevant)
- high-level introduction to each related topic in a global or Australian context
- key findings for each related topic.

The **Voice of Country** is the first theme in the report. It introduces the **Aboriginal Peoples Knowledge Group**, their collective worldview on the importance of incorporating Aboriginal cultural practices and knowledges in environmental management, and provides specific recommendations for ongoing collaboration. It also describes one member's concerns about exposure of his community to pollution.

Image 1: NSW SoE website homepage showing relationship of themes and topics, 2024

Source:
soe.epa.nsw.gov.au (Dec 2024)

Topics

Each topic will display three tabs:

1. **a current tab –** available to be updated if new data comes in before the next report
2. **a 2024 tab –** exact content as the 2024 Tabled Report
3. **a 2021 tab –** exact content as the 2021 Tabled Report.

Topic structure

In 2024, the structure of each topic will follow a modified **Pressure–State–Response** model: **Overview – Status and trends – Pressures and impacts – Responses.**

- **Overview**: provides a high-level introduction to the topic, what it is, why it's important,
- **Status and trends**: provides as assessment of the topic indicators and relevant data for the current state and the trends over time.
- **Pressures and impacts**: describes how human activities and natural processes influence the environmental condition and the impacts that the environmental condition can then have on ecosystems and human health.
- **Responses**: identifies existing program, projects and initiatives from both government and non-government organisations in response to declining indicators, as well as future opportunities to fill identified gaps in responses or data for assessment under status and trends.

Where relevant, topics include links to **Global reporting models** for alignment of language and to allow for comparison of data and targets.

See the **Executive summary** page for the full list of findings in this report.

Content developed by the **Aboriginal Peoples Knowledge Group** (APKG) is indicated throughout the report where the paperbark colouring is next to the text.

When the above symbol is used, it indicates the content was developed by the whole of the APKG.

Terminology

This report uses technical terminology and commonly used acronyms and abbreviations. See the **Glossary** page for the full list of terminology and the **Abbreviations and acronyms** page for the full list of abbreviations and acronyms.

This report uses various units of measure. See the **Units and measurements** page for the full list.

For information on NSW land and marine bioregions, see the **NSW bioregions** page.

Indicator guide

NSW State of the Environment 2024 assesses the status and trends of each of 77 environmental indicators, along with the reliability of the information used to provide an indicator rating.

See the **Indicator guide** page to learn how terms and symbols are defined in indicator tables.

Executive summary

This page intentionally left blank

Executive summary

Key findings, ongoing challenges and key responses in the NSW State of the Environment 2024.

The NSW *State of the Environment 2024* assesses 20 topics across seven broad themes:

- **Land**
- **Waters**
- **Air and atmosphere**
- **Biodiversity**
- **Climate**
- **People and industry**
- **Drivers**.

The report shows that human activity and climate change continue to impact the environment. The full list of key findings can be found on each theme page.

Voice of Country

Voice of Country is a new section framing the report this year. It introduces the **Aboriginal Peoples Knowledge Group** (APKG) members, describes ways Aboriginal people identify, and mentions aspects of our shared history and worldviews.

The APKG recognise the need to *ngarrangga* 'listen deeply' to each other; walk together, value our differences, acknowledge our strength and have the courage to take action to implement change wherever it is required, for the betterment and care of Country and all peoples.

The APKG was established by the NSW Environment Protection Authority (EPA) to ensure that the perspectives of Aboriginal peoples are heard and considered in matters that relate to Aboriginal cultural values, knowledges and sciences across the EPA.

Key findings

Key findings in this 2024 report include:

Land

- While soil condition is mostly good, soil acidification is increasing.
- The presence of contaminants in soils, including in discrete Aboriginal communities and other communities, remains a significant issue.

Waters

- Coastal swimming sites have water quality that is suitable for swimming.
- Water quality is getting worse for inland rivers and wetlands, particularly areas of the Murray–Darling Basin, significantly affecting fish and waterbird communities.

Air and atmosphere

- NSW air quality is mostly good.
- Air quality has been negatively affected during extreme weather events, such as storms and bushfires, with significant health impacts.

Biodiversity

- The number of threatened plant and animal species listings in NSW continues to increase, with threatened plants increasing by 18 to a total of 675, and animals also increasing by 18 to 343 between December 2020 and June 2024.
- Clearing of native vegetation puts pressure on these species and remains significantly higher than before the regulatory reforms of 2016–17.

Climate

- NSW average surface temperatures over land have risen 1.4°C since national records began in 1910. Sea surface temperatures in the Sydney area have also increased by about 0.14–0.2°C per decade since the 1950s. The impact of the changing climate means there will be more hot days, severe fire weather days and extreme rainfall, increasing the risk of heatwaves, bushfires and floods.
- Net greenhouse gas emissions in NSW in 2021–22 declined to 111 million tonnes of carbon dioxide. This is 27% lower than NSW emissions in 2004–05. This decline is mostly due to the increased proportion of electricity generation from renewable sources.

People and industry

- There has been a major increase in electricity share delivered by renewable energy generation and in 2023 was about 34% of the State’s electricity generation.
- In 2023, vehicles on NSW roads travelled 74.8 billion kilometres, a 12% increase since 2004. Despite an increase in the sale of electric vehicles, transport continues to be one of the biggest sources of greenhouse gas emissions in NSW.
- All but one utility provided 100% of their population with water that met the guidelines for chemicals and contamination with *E. coli* (Inverell achieved 99.9%).
- Total waste generation is increasing faster than our population, rising from 18.7 million tonnes in 2015–16 to 22.4 million tonnes in 2022–23.
- In NSW during 2021–23 the number of regulated contaminated sites remained stable. The EPA regulated about 202 sites per year in that period.

Drivers

- NSW population and economics are decoupling (separating) from some key environmental trends. This means that while population is growing, energy use and greenhouse gas emissions are declining.

Reflections on future opportunities raised by the 2021 APKG

In the *NSW State of the Environment 2021*, the then members of the APKG raised the following as key opportunities:

- Inclusion of Aboriginal peoples in decision making and environmental programs focused on sustaining healthy native vegetation, animals and Country.
- Increased representation of Aboriginal peoples on scientific, biodiversity and conservation committees, with progress tracked through a new SoE indicator.
- Recognition and promotion of Aboriginal knowledges and cultures alongside western sciences.
- Greater collaboration between management authorities and Aboriginal communities to enhance the care and management of the environment.

Progress on these opportunities as of 2024:

- The EPA endorsed a **Statement of Commitment to Aboriginal Peoples** in 2021 as a high-level strategic commitment to work with, learn from, listen to and respect Aboriginal peoples (see **Acknowledging NSW's First Custodians** for more information).
- An ongoing Aboriginal Peoples Knowledge Group was formed to ensure that the perspectives of Aboriginal peoples are heard and considered in matters that relate to Aboriginal cultural values, knowledges and sciences across the EPA.
- Efforts are ongoing to identity data that can be used for a future SoE indicator that measures Aboriginal representation on relevant boards and committees.
- Establishing partnerships with Aboriginal organisations to enable them to support recovery of Country and communities impacted by catastrophic floods and fish kills.

Ongoing challenges

Many of the challenges in previous *State of the Environment* reports continue. Some of the most pressing challenges in 2024 are:

- Climate change is placing increasing pressure on the environment. Land and sea surface temperatures, as well as sea levels, are projected to rise, and rainfall patterns will become more erratic. These changes may result in ecosystem failures.
- The transition to renewable sources of energy needs to accelerate if we are to meet the NSW 2030 net zero targets. In the transport sector, for example, there is a continued reliance on private vehicles, a preference for SUVs, and lack of electric freight vehicles.
- Despite population and economics starting to decouple from environmental impacts, human activities, such as agriculture and urbanisation, can result in soil degradation, poor water quality, air pollution and destruction of ecosystems.
- Clearing of native vegetation continues to fragment habitat and reduce the capacity of land to support native plants, animals and ecosystems.
- Consideration of Aboriginal cultural knowledges and perspectives in holistic planning, management, monitoring and reporting on the state of the environment.
- Data gaps across many topics limit the accuracy of status and trends included in this report. Aspects of the environment lacking an easily accessible data source include: soil nutrient imbalance, aquifer sustainability, groundwater quality, long-term plant species information, land use, vegetation regeneration, invasive plant species, reptiles, amphibians, insects, fungi, indoor air quality, impact of climate change on public infrastructure, climate change resilience metrics, consideration of intergenerational equity, heatwaves, correlation of population and economics with biodiversity, habitat fragmentation, noise and light pollution, recycled water.

Key responses

Significant environmental reforms and initiatives were undertaken during the reporting period. The full list of responses can be found on each topic page.

These responses have been grouped around the biggest environmental issues of our time.

Climate change

- Building on its *Net Zero Plan Stage 1: 2020–30*, the NSW Government is responding to climate change with mitigation and adaptation strategies. The NSW Electricity Infrastructure Roadmap outlines a 20-year plan to integrate renewable energy into the energy-generation mix in NSW, replacing coal-fired generators and enhancing energy reliability through Renewable Energy Zones.
- The *NSW Electric Vehicle Strategy* sets out the NSW Government's plan to accelerate the State's uptake of electric vehicles.

Circular economy

- The *NSW Waste and Sustainable Materials Strategy 2041* sets out a 20-year vision for reducing waste and changing how our economy produces, consumes and recycles products and materials. The strategy has a long-term focus on plastics, organics and residual waste.
- The *NSW Plastics Action Plan* addresses each phase of the plastics life cycle with a three-part approach to reducing harm. This includes removing as many unnecessary plastic items from the economy as possible, improving product design to reduce the risks they pose, and improving the quality of plastic items so they can be recycled at the highest level. The *Plastic Reduction and Circular Economy Act 2021* supports the phasing out of a number of problematic and unnecessary plastic items.

Biodiversity

- The *NSW plan for nature*, released in July 2024, is the NSW Government response to the statutory reviews of the *Biodiversity Conservation Act 2016* and native vegetation provisions of the *Local Land Services Act 2013*. It shifts the Government's policy objective from mitigating decline to restoration and repair. It includes actions to strengthen the Act and reform the Biodiversity Offsets Scheme, develop a NSW nature strategy, and improve biodiversity outcomes through accountability and regulation, use of data and reporting, and increased support for conservation and land management practices. The Act reforms will prioritise Aboriginal cultural values, connecting to Country, cultural practices and opportunities for Aboriginal economic development.
- The Saving our Species program supports management of threatened plant and animal species and ecological communities.
- The Biodiversity Indicator Program collects, monitors and assesses information on the status and trends in biodiversity in NSW to help us understand the impact of current biodiversity management and conservation measures.

Water

- The *NSW Water Strategy* was launched in September 2021. This strategy proposes more than 40 actions across seven priority areas, focused on improving the security, reliability, quality and resilience of the State's water resources. More than $1 billion has been allocated to help local water utilities reduce risks in urban water systems through the Safe and Secure Water Program.

Voice of Country

soe.epa.nsw.gov.au

This page intentionally left blank

Voice of Country

A collective voice of Elders, Knowledge Holders and Custodians.

We invite you to ngarragi* - 'to listen, learn and remember'

The **Voice of Country** introduces the **Aboriginal Peoples Knowledge Group** (APKG) members and describes ways Aboriginal people identify and mentions aspects of our shared history and worldviews.

The United Nations Declaration on the Rights of Indigenous Peoples charter articles give weight to the importance of the rights and self-determination of Aboriginal people to practise and revitalise their culture, maintain and strengthen their relationship with Country and the preservation of Aboriginal cultural values, principles and practices for future generations.

The **Voice of Country** concludes with acknowledging the connectedness, what has come before us, the need to *ngarrangga** 'listen' and recommendations as a way forward.

We invite you to *ngarragi** – 'to listen, learn and remember'.

There are five topics in the **Voice of Country**.

* Gathang language

A Voice of Country

The APKG collective voice - we need to *ngarrangga** 'listen deeply' to each other; walk together, value our differences, acknowledge our strength and have the courage to take action.

Aboriginal Peoples Knowledge Group

Established to ensure that the perspectives of Aboriginal peoples are heard and considered in matters that relate to Aboriginal cultural values, knowledges and sciences across the EPA.

Truth telling

An APKG member provides a first-hand account of living conditions on a discrete Aboriginal community where residents are exposed to contamination and waste.

Recommendations

The APKG has proposed recommendations to solidify a stronger and more meaningful relationship with the EPA and other government bodies.

Videos

Hear from four of the Aboriginal Peoples Knowledge Group members as they share their stories, knowledge and perspectives on how we can work together to care for Country.

This page intentionally
left blank

A Voice of Country

The APKG collective voice – we invite you to ngarrangga 'listen'.

A Voice of Country describes ways Aboriginal people identify and mentions aspects of our shared history and world views. The chapter concludes with acknowledging the connectedness, what has come before us, and the need to *ngarrangga* 'listen' (from the Gathang language).

Identity and terminologies

The key to developing respectful relationships with Aboriginal people is knowing how people identify as an Aboriginal person, and the terminology used for the original people of this Country.

Indigenous Australian peoples are of Aboriginal and Torres Strait Islander descent; who identify as Aboriginal or Torres Strait Islander and are accepted as an Aboriginal or Torres Strait Islander person in the community in which they live or have lived.

It is important to understand that Aboriginal or Torres Strait Islander people may identify with one or more Aboriginal or Torres Strait Islander nations and/or language groups.

The original people who occupied the land now known as New South Wales, are referred to by various terms interchangeably such as: Aboriginal, Australia's First Peoples, First Nation People, Aboriginal people, Indigenous people, Black, Koori, Goori and by their bloodline ancestors (for example, Dhanggati, Birrbay, Gamilaraay, Gomeroi, Bundjalung, Nyangbul, Anaiwan, Wiradjuri, Nguyampaa, Barkindji and Ngiyampaa).

It is respectful to ask what terms are acceptable when referring to a specific Aboriginal group or community.

It is through the knowledge of past historical events in our shared history that people can gain a deeper understanding of the complexities of Aboriginal peoples connection with their culture, Country, Lore and each other.

History

Aboriginal and Torres Strait Islander peoples are recognised as the oldest continuous culture on the planet.

Before colonisation in 1788, there were more than 250 nation groups; each with several different clans and language groups, which formed a diverse tapestry of custodianship of Lore and Country across this continent now known as Australia.

Aboriginal peoples way of life was disrupted by the waves of British invaders. In the quest to colonise, they failed to see the sophisticated societies with people living sustainable lifestyles by using technologies to farm and manage the land and waterways.

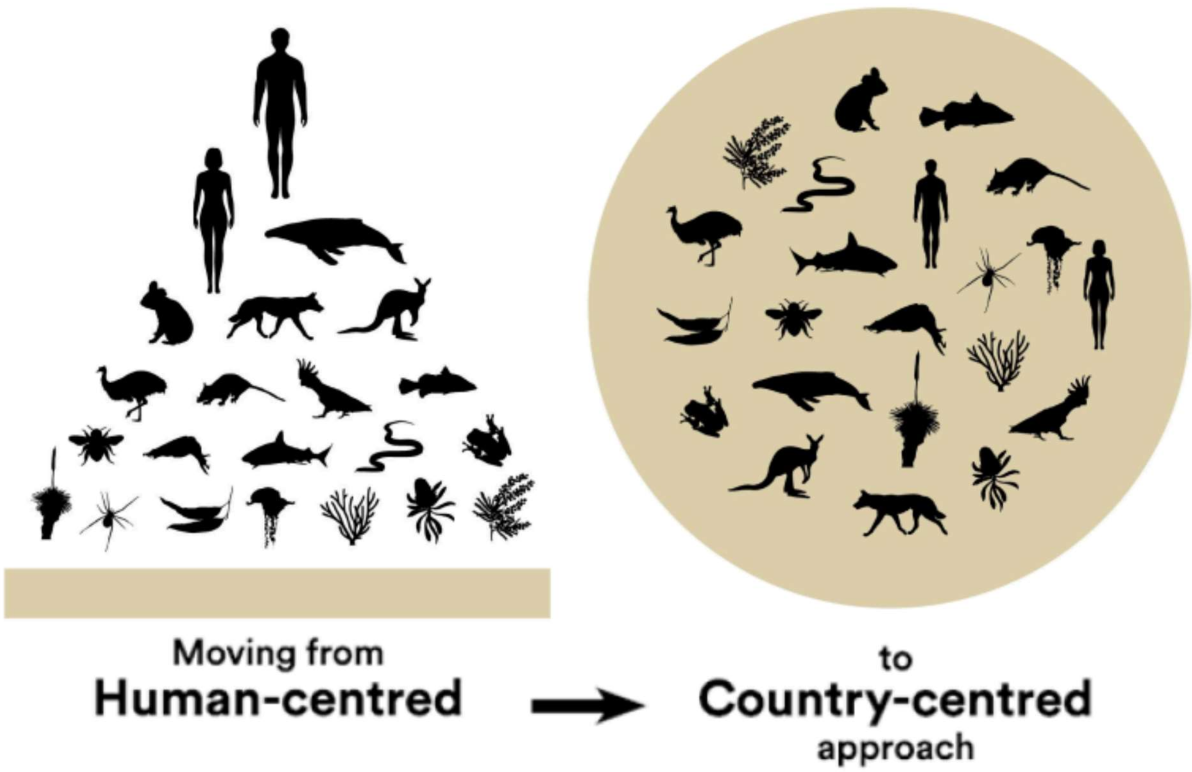
Relationality was and will always be at the forefront of Aboriginal cultural practices and Lore, governing the interaction between all entities, creating a harmonious environment for all to thrive.

Through colonisation, Western industrialisation brought to these shores a system that created an imbalance to the land. The human-centred, hierarchical views of the invaders conflicted with the Country-centred views of the original peoples, and resulted in conflict, trauma and a disruption to people living in harmony with Country.

The Country-centred approach places equal importance on all that Country holds. Aboriginal custodians, as carers of Country, safeguarded the continuation of cultural practices, met cultural obligations and upheld rights to self-determine how to maintain, protect and conserve Country when working with other authorities.

Figure V1.3 is a visual representation of the human-centred approach as opposed to the Country-centred approach. Working in today's reality, Aboriginal people honour their ancestors by safeguarding the continuation of cultural practices; meeting their cultural obligations; upholding their rights as a voice for and with Country; and self-determining how to maintain, protect and conserve Country when working with other authorities.

Figure V1.3: Examples of human-centred and Country-centred approaches



Source:
Reproduced from Government Architect NSW (2023), Connecting with Country. Originally adapted from Lehmann (2010), 'Eco vs Ego' diagram

Self-determination

The following articles speak to self-determination and the rights of indigenous people as a way forward to uphold their cultural practices that includes caring for Country.

The EPA, in respectful relationship and partnership with the APKG, can ensure the **United Nations Declaration on the Rights of Indigenous Peoples** in Australia (New South Wales) are not just words on a page but meaningful interactions between all environmental custodians to protect the rights of Aboriginal people in NSW to:

- practise and revitalise their culture
- maintain and strengthen their distinctive spiritual relationship with their traditionally owned or otherwise occupied and used lands, waters and coastal seas.

In doing so, there is a stronger movement to conserve and protect the natural environment and the preservation of Aboriginal cultural values, principles and practices for all future generations.

After being voted against in 2007, the United Nations Declaration on the Rights of Indigenous Peoples (**UN 2007**) was adopted in 2008 on behalf of Australia by the former Prime Minister, the Hon. Kevin Rudd.

The 46 articles of the Declaration on the Rights of Indigenous Peoples recognise a standard of achievement to be pursued in the true spirit of partnership and mutual respect and detail Indigenous peoples' rights to be distinctly different and have aspirations to self-determine their cultural activities and life aspirations.

Below are five of the 46 articles of note:

Article 3

Indigenous peoples have the right to self-determination. By virtue of that right they freely determine their political status and freely pursue their economic, social and cultural development.

Article 11

1. Indigenous peoples have the right to practise and revitalize their cultural traditions and customs. This includes the right to maintain, protect and develop the past, present and future manifestations of their cultures, such as archaeological and historical sites, artefacts, designs, ceremonies, technologies and visual and performing arts and literature.
2. States shall provide redress through effective mechanisms, which may include restitution, developed in conjunction with indigenous peoples, with respect to their cultural, intellectual, religious and spiritual property taken without their free, prior and informed consent or in violation of their laws, traditions and customs.

Article 25

Indigenous peoples have the right to maintain and strengthen their distinctive spiritual relationship with their traditionally owned or otherwise occupied and used lands, territories, waters and coastal seas and other resources and to uphold their responsibilities to future generations in this regard.

Article 26

1. Indigenous peoples have the right to the lands, territories and resources which they have traditionally owned, occupied or otherwise used or acquired.
2. Indigenous peoples have the right to own, use, develop and control the lands, territories and resources that they possess by reason of traditional ownership or other traditional occupation or use, as well as those which they have otherwise acquired.
3. States shall give legal recognition and protection to these lands, territories and resources. Such recognition shall be conducted with due respect to the customs, traditions and land tenure systems of the indigenous peoples concerned.

Article 33

1. Indigenous peoples have the right to determine their own identity or membership in accordance with their customs and traditions. This does not impair the right of Indigenous individuals to obtain citizenship of the States in which they live.

See the **United Nations Declaration on the Rights of Indigenous Peoples** for more information.

Through mutual respect and actions, we can honour these articles, breathe life into these words and be resolute in preserving the *rich cultural values and principles of our people.* In the present, we create the past and plant the seeds for the future. The time has come for thinking deeply about what we sow for our tomorrow's children and how our legacy of preserving culture and respecting land will support them to *dream, strive and grow into our future leaders*. What do we need to know and understand to move forward?

Moving forward

In spirit of moving forward, we acknowledge the past and present societal structures in which everything is connected and everything is relational.

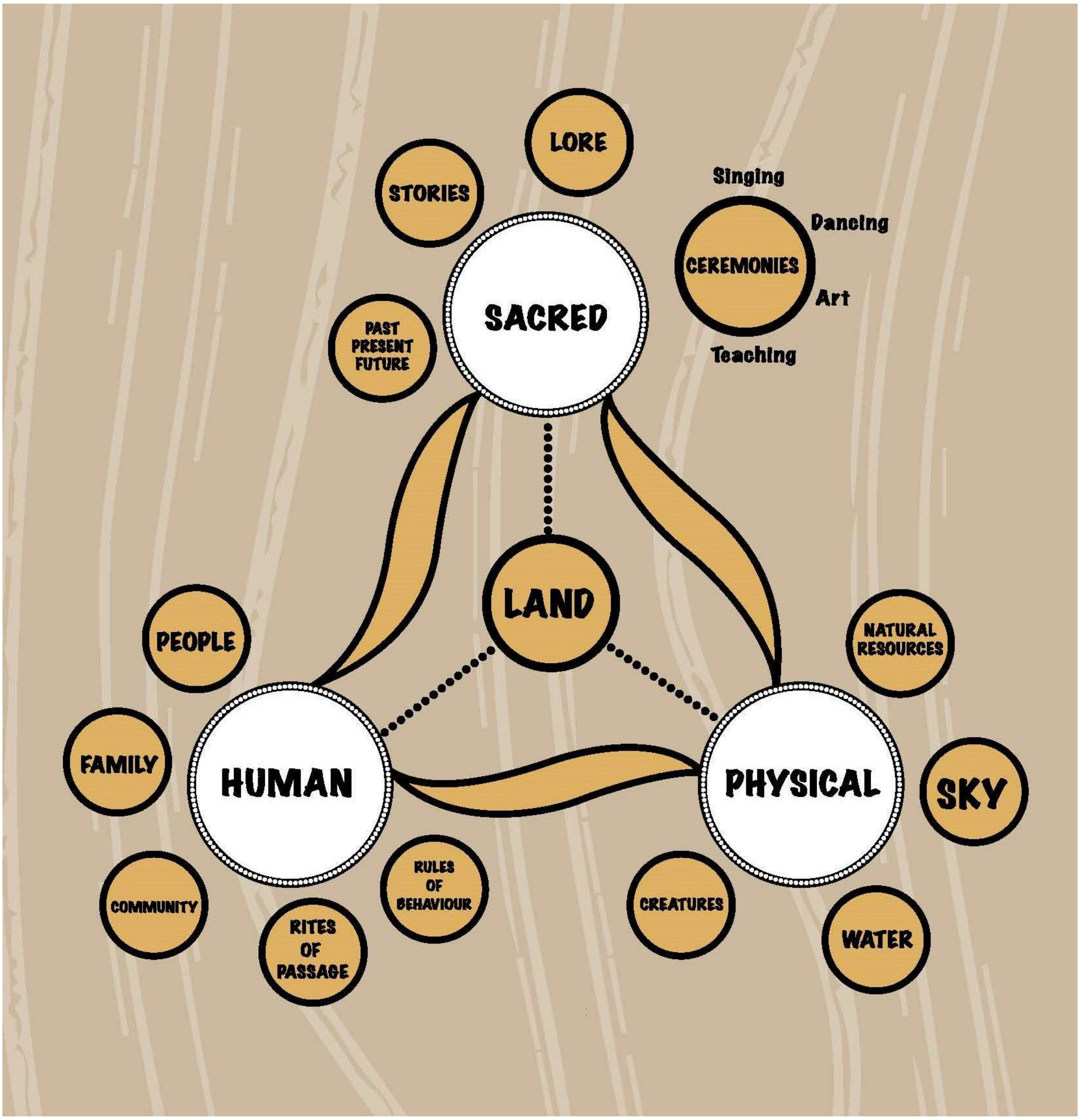
Operating through a set of principles that fostered cooperation rather than competition, our people lived in harmony with nature, which has a natural rhythm and balance to it and humans lived in synergy, protecting Country.

The principles of all nature-based practises recognise spirit and the sacredness of life, through which ceremonies, song and dance reaffirmed our place and identity.

Country was the source of identity and there was a duty to protect and care for it. To maintain it and nurture it for all generations to come. Our role was and is to recognise our place as human beings, to foster a deep sense of connection and belonging to keep things in balance (see **Figure V1.4**).

The APKG invites other stakeholders in the protection of our environment to work with us within a cultural framework that honours our connectedness.

Figure V1.4: Connectedness



Source:
The Gaimaragal Group (2010) Originally adapted from The Dreamtime Chart

In moving forward, we acknowledge the past.

We also acknowledge the collaboration between the Aboriginal and Torres Strait Islander staff of the EPA and the inaugural APKG membership; Department of Planning, Industry and Environment, the NSW Aboriginal Land Council, and two independent members: Wally Stewart, a Walbunja man from the south coast of NSW, and Associate Professor Bradley Moggridge, a Kamilaroi water scientist. it is through working with a shared goal that has led us to where we are today.

The inclusion of Aboriginal voices and cultural views in the *State of Environment 2021 report* allowed the current APKG to have a collective voice to work collaboratively with the EPA to ensure their Statement of Commitment is upheld and enshrined in policy and legislation.

We need to *ngarrangga* 'listen deeply' to each other; walk together, value our differences, acknowledge our strength and have the courage to take action to implement change wherever it is required, for the betterment and care of Country and all peoples.

References

DPE 2023, *Connecting with Country*, NSW Department of Planning and Environment, Sydney

Lehmann S 2023, 'Reconnecting with nature: developing urban spaces in the age of climate change', *Emerald Open Research*, vol. 1, no. 5, DOI: 10.1108/EOR-05-2023-0001

Susan Moylan-Coombs 2024, Connectedness: the three worlds, the Gaimaragal Group

UN 2007, *United Nations Declaration On The Rights Of Indigenous People*, United Nations Department of Economic and Social Affairs

This page intentionally
left blank

Aboriginal Peoples Knowledge Group

The APKG ensures that the perspectives of Aboriginal peoples are heard and considered across NSW.

In June 2023, the EPA Executive committed to enacting the Statement of Commitment to Aboriginal Peoples and approved the re-establishment and expansion for an ongoing Aboriginal Peoples Knowledge Group (APKG) which was first formed in 2021 to assist with the EPA's 2021 State of the Environment report.

The inaugural membership included members of the EPA Aboriginal Initiatives team, Department of Planning, Industry and Environment and NSW Aboriginal Land Council, and two independent members: Wally Stewart, Walbunja man from the south coast of NSW, and Associate Professor Bradley Moggridge, Kamilaroi water scientist.

The ongoing APKG members were formally appointed by the CEO in late 2023; their inaugural meeting was held on 29 February 2024. The membership of the APKG comprises of 7 Aboriginal Knowledge Holders descended from Saltwater, Freshwater, Rainforest and Desert Country of NSW (see **Figure V1.1**).

Figure V1.1: The Aboriginal Peoples Knowledge Group 2024

Notes:
APKG Members are (from top clockwise) **Dr Aunty Rhonda Radley** (Chair) (Birpai and Dhanggati), **Steven Ahoy** (Anaiwan), **Sue Bulger** (Wiradjuri and Walgalu), **Marcus Ferguson** (Bundjalung & Nyangbul), **Greg Griffiths** (Guyinbarray Clan, Gamilaraary, Gomeroi) **Lawrence Clark** (Ngiyampaa & Barkindji), **Daniella Chedzy** (Ngiyimpaa).

Source:
Aboriginal Peoples Knowledge Group and EPA (2024)

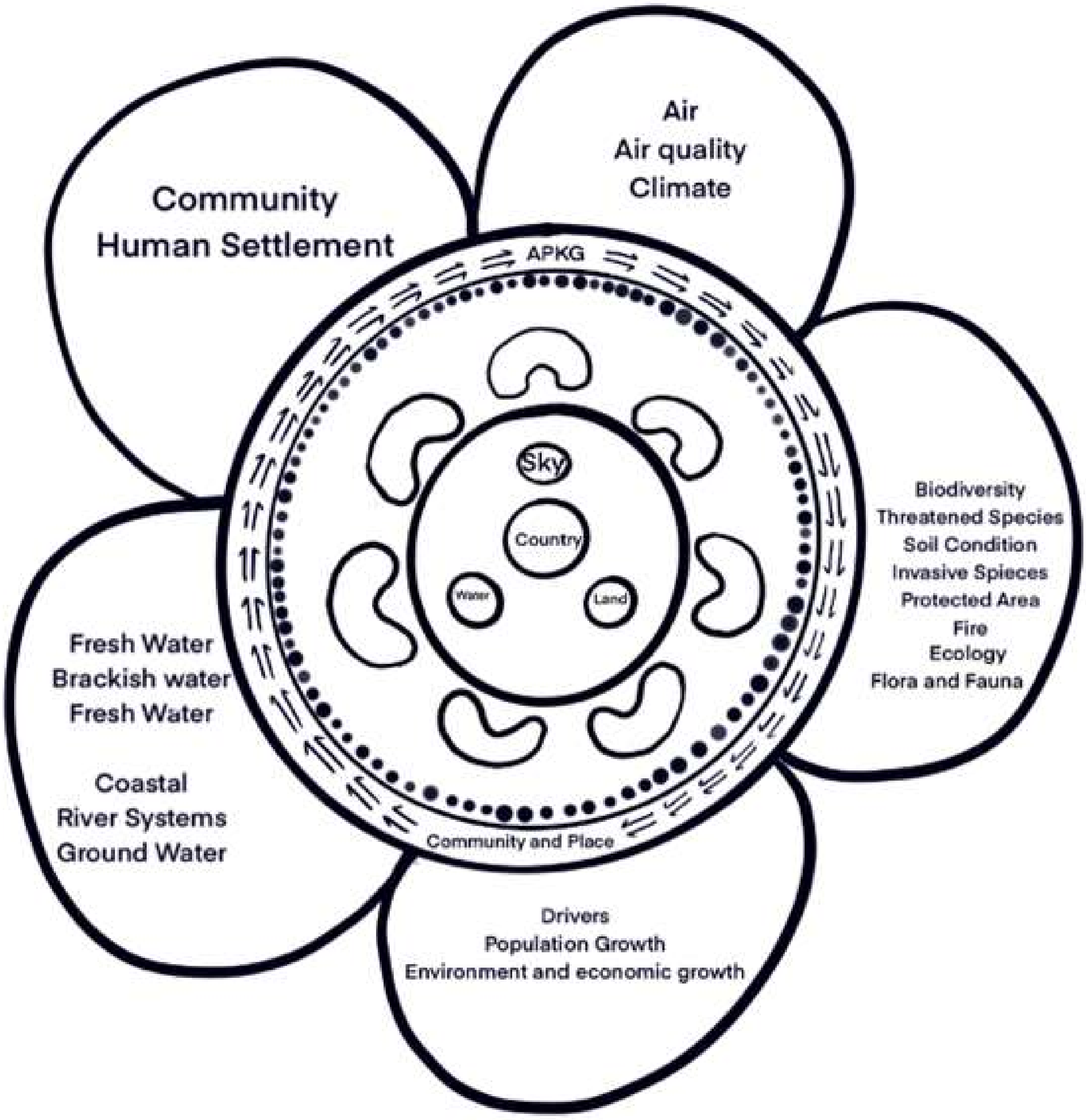
The APKG is an independent body that operates autonomously and is outside the direct control or influence of the EPA. This autonomy ensures the APKG recommendations, guidance, advice, nurturing and challenges provides space for truth telling and the best possible outcomes for Country and the health of the community.

The purpose of the APKG is to ensure the perspectives of Aboriginal peoples will always be heard and considered in matters relating to Aboriginal cultural values, knowledges and sciences across the EPA.

The Advisory Committee will guide, advise, nurture and challenge the EPA to uphold the twelve principles listed in the **Statement of Commitment to Aboriginal Peoples**.

Figure V1.2 represents the APKG collective viewpoint on how State of the Environment reports relate to Country.

Figure V1.2: Representative of APKG collective viewpoint



Source:
Artwork by Susan Moylan-Coombs

References

Susan Moylan-Coombs 2024, Representative of APKG collective viewpoint artwork, the Gaimaragal Group

Truth Telling

Case study: “We’re still living on it. We’re still here.”

An **Aboriginal Peoples Knowledge Group** member provides a first-hand account of living conditions on a discrete Aboriginal community where residents are exposed to contamination and waste.

A Truth Telling story

“In my community's history, we were forced to live on the actual living rubbish tip.

I'm only 43 years of age. I grew up with the rubbish being dumped in our backyards as kids, we didn't know any better and we played in that. There’s medical waste. There’s asbestos. There’s development waste, industrial waste. Everything you could think of was just dumped in our places. None of that has been dealt with.

It has had soil put over soil, put over soil. Now we all know the history of the way the environment works. Soil erodes away over time and all of that contamination just keeps coming up. So right now, we've got asbestos piles. We've got little jars with body parts and everything from medical waste being eroded.

We're not getting anywhere with the Council. We're only just now getting drains put into our mission. So we’re all alone dealing with chemical waste and all that, our Land Council is not equipped to deal with this. We've got nobody who is qualified to deal with the asbestos, which is the main contamination.

It's been left up to us living today as community members to deal with it, we have to be proactive, we have to go around and try and figure all this out for ourselves because we’ve gotten no help.

Nobody's being accountable. It's a pass the buck to everybody, like the Land Council saying it’s Council’s responsibility and Council saying it's Land Council’s responsibility, and now I'm hearing it’s the Aboriginal Housing Office’s responsibility. We’re just stuck in limbo and have to live with this.

My father is dying of cancer right now. My grandmother died of cancer. My grandfather died of cancer Probably 90% of my uncles and aunties, they’ve all got cancers. We know it can't be genetic. It just can't be because it's not affecting all of my genetic family who live elsewhere. It's only affecting my genetic family that's living in Armidale now and has been raised in Armidale.

The Council produced a community garden here and done an investigation and through that investigation, the report states that the soil is highly contaminated, and it's not fit for human consumption or cultivation of foods for human consumption. But to this day, they still maintain their community garden.

No Aboriginal people eat off of it anymore. because we know this, but they still maintain it. They still out there growing the foods and it has been a bit of a publicity stunt. But all we're asking for is, can we just please get our soil officially tested, see what's going on with it? If there's a problem, help us rectify the situation.

We don't know who's going to take responsibility. We can't find any help for it at the moment. We just beg everybody for advice and guidance.

Armidale is the highest city in Australia and all our rivers flow down to the sea. We’ve got the Gara River, Salisbury River and Bakers Creek that come together to create the Macleay River, with a further 26 tributaries joining the Macleay as it stretches from the top of the Great Dividing Range to the sea.

It is one of the largest rivers in the northern New England Tablelands and considered one of the most Culturally significant rivers to our people and environment.

Everything we do to the river up here, affects the environment and people living downstream.

Now, we had an arsenic leak at one of the mines 15 years ago and that destroyed the fish, the turtles, the eels and everything where we traditionally fish in those waterways. In one year we turned up and then all the fish had pink rashes and sores. And then the next years we just seen a more depleting size of the fish and a fatigue in nature, then with some of the floods, there is a cleaning out of some of the rivers naturally and they're coming back.

You know, that’s correction. That's true nature.

500 metres off our mission, we've done an investigation for the RTA on the foam, which the Fire Brigade was spraying because our mission again is the Fire Brigades practice place because it was the tip, so all that foam they were spraying around went into our soil. Now we've just proven that it's 8 metres deep contaminated.

We're still living on it. We're still here. It's leaked into the water system. So now all of that is going and spreading down to the Macleay River and valleys to Tamworth, valleys to a western side down to Tinga and everywhere they're all being affected by the gold mining the phosphorus in the farming industries. These are all killing our river systems, encouraging the algae blooms and all of those sorts of things.

My people talk about the black fish they use to eat up here. What black fish? In my lifetime, there's none. We still eat the eels. We still eat the mussels. We still eat the turtles up here. The fish, we have to go off our mountain now to get some.

But then can we eat them?

We are eating them again. Is that a reason why we were dying of cancer?

These are the big concerns that we have. But it's not just concerns, it's actual physical evidence to justify some of those concerns, but we just haven't got the scientific investigation and background to cement that in and make it, you know, legit for Australia to see and really take action.”

Steven Ahoy
Anaiwan
Freshwater
APKG Member

> Consistent with the NSW Environment Protection Authority (EPA) **Statement of Commitment to Aboriginal peoples**, the EPA is committed to actively learn from, and listen to, Aboriginal voices, cultures and knowledge. Part of this learning and listening includes welcoming Truth Telling and engaging in the practice of Truth Listening.
>
> To read the response to this **Truth Telling**, see the **Truth Listening** section in the **Contaminated sites** topic.

This page intentionally
left blank

Recommendations

Recommendations from the Aboriginal Peoples Knowledge Group for the EPA and other government bodies.

The Aboriginal Peoples Knowledge Group (APKG) has proposed the following recommendations to solidify a stronger and more meaningful relationship with the EPA and other government bodies:

Recommendations

- The APKG and EPA to work in partnership to develop legislative reform to commit government to implement real change, to ensure the protection of Country and people, and Aboriginal sacred sites.
- Inclusion of Aboriginal people in decision-making and the development of programs that aim to sustain healthy biosystems.
- Ensure Aboriginal knowledges and cultures are valued and promoted alongside western sciences by the inclusion of representation of Aboriginal people on scientific, biodiversity and conservation (environmental management) committees.
- Increase the allocation of funding for healthy Country programs.
- Initiate community consultation, through public forums lead by the APKG, to amplify the voice of Aboriginal people to drive systemic reform and hold governments and services accountable for the health and protection of Country.
- Design a reporting framework for the APKG, outlining the actions and deliverables on the work being undertaken by government bodies and stakeholders in the sustainability and protection of the environment.

It is with great honour that we, the members of the **Aboriginal Peoples Knowledge Group** have contributed our voices and truths to the State of the Environment report 2024. We look forward to continually building our relationship and partnership with the EPA to uphold the **Statement of Commitment to Aboriginal Peoples**.

Videos

Hear four of our APKG members share their insights on the health of Country and their reason for joining the APKG.

Hear from four of the Aboriginal Peoples Knowledge Group members as they share their stories, knowledge and perspectives on how we can work together to care for Country in **Video V1** series below**.**

Video V1.1: Dr Aunty Rhonda Radley – Knowledge Holder & APKG Chairperson

Video V1.2: Marcus Ferguson – Knowledge Holder & APKG member

Video V1.3: Aunty Sue Bulger – Knowledge Holder & APKG member

Video V1.4: Daniella Chedzey – Knowledge Holder & APKG member

Land

soe.epa.nsw.gov.au

This page intentionally left blank

Land

How our land is used and managed is the main determinant of its condition and the health of native species and ecosystems.

The topics in this theme describe **soil condition** and **protected areas and conservation**.

Soil condition

Healthy soil provides the foundation for life on Earth. Human activities are affecting soil condition, impacting its ability to support natural ecosystems effectively.

Protected areas and conservation

Protected areas preserve habitats for our plants and animals and maintain essential ecosystem services. Australia has committed internationally to halting biodiversity loss by 2030.

Soil organic carbon stocks declined by

3.1%

between 2006 and 2020

The protected areas network covered

10.4%

of NSW as at
30 December 2023

Introduction to land

All the elements have Lore, cultural Lore, right LORE.

It's so important to know where you belong, mountains, desert, plains, rainforest, rivers, sea. The land provides so much for us, all the things that we need to survive, our food, livelihood, shelter, water, air. We look after the land so that there will be those things that are necessary for survival for generations to come.

So many of our native creatures are becoming endangered or extinct. We need to be able to look after them, so the generations of the future will know how to look after them.

What we give back is at the core of who we are and our relationship with the land and the water is at the heart of our very existence. If we're not connected to that, then we might as well be zombies walking around.

It's really important that we bring younger people along with us so that they understand how important it is to be connected to the land and Country. Our young men and women now, are being involved in natural resource management, they go to our special places on Country, connecting them will connect their children to what needs to be done.

Soil condition

Soil covers most land. This living material, made up of inorganic particles and organic matter, provides the foundation for life on earth.

Soil condition is critical to a variety of ecological and human activities.

Healthy soil is home to a complex web of organisms, including bacteria, invertebrates and insects. They facilitate nutrient cycling and maintain soil structure. Healthy soil provides a variety of ecosystem services. It filters water, acts as a carbon sink and supports flood regulation.

Land and soils have cultural and spiritual significance to Aboriginal peoples, and these values have been diminished due to development and unsustainable land use associated with colonisation.

Modern agricultural practices or land use change are affecting soil conditions. Soil sealing and soil compaction can reduce water filtration and carbon storage of soils. Industry and agriculture can contaminate soils with pollutants, such as metals and chemicals.

Key findings from the 2024 report

- Much of the changes in soil condition began after European colonisation. Aboriginal peoples' practices for caring for Country, which included sustainable management of soils, were detrimentally impacted under European practices.
- Most soils in NSW are in a moderate condition.
- About 12.6% of the original soil organic carbon levels has been lost from the top 30cm of soil since European colonisation.
- Much of the State's agricultural land is becoming slightly more acidic. Soil pH changed by at least 0.15 units of pH between 2006 and 2020.

Protected areas and conservation

Protected areas are regions established to protect the natural environment and cultural heritage. These areas of land are havens for biodiversity as they preserve habitats for our plants and animals. They provide many ecosystem services that are critical to ecological health and human wellbeing.

Importantly, protected areas aim to provide opportunities for Aboriginal peoples to access and connect with Country and joint management agreements give Aboriginal Custodians a say in how Country is cared for.

Post-colonisation human activity has transformed landscapes and continues to place ecosystems under pressure through agriculture, urban development, forestry, industry and resource extraction.

As our climate changes, impacts such as rising temperatures and altered rainfall patterns will increase the vulnerability of these protected ecosystems. Loss of protected areas would have significant and far-reaching impacts on both the environment and human society.

It is estimated that globally one third of all land is degraded or degrading. This is causing continued biodiversity loss. It is also impacting essential ecosystem services including water availability and carbon storage.

Australia is a signatory to international protocols and frameworks, including the **Convention on Biological Diversity** and the **Kunming-Montreal Global Biodiversity Framework**. This framework establishes four long-term goals to 2050 and 23 action-oriented targets to 2030.

Under the **Kunming-Montreal Global Biodiversity Framework**, Australia is obliged to have a national biodiversity strategy and action plan, including national targets. The national **Strategy for Nature 2024–2030** outlines how Australia will contribute to the framework's long-term goals and action-oriented targets.

Key findings from the 2024 report

- About 10.4% (or 8.3 million hectares) of NSW are formal protected areas that contribute to Australia's National Reserve System.
- Most protected areas fall within the public reserve system (almost 7.7 million hectares or 9.7% of NSW). Much of the remaining area is protected through private conservation agreements managed by the Biodiversity Conservation Trust (about 536,000 hectares or 0.7% of NSW).
- About 30% of the National Parks and Wildlife Service estate is jointly managed with Aboriginal custodians under 34 agreements.
- Pressures on, and threats to, protected areas continue to include climate change, inappropriate fire regimes, invasive species, and fragmentation and habitat loss from land use changes and clearing.
- This topic's 'total area of the NSW terrestrial protected areas network' indicator aligns to the 'Land system change' planetary boundary. Globally, this boundary has been crossed (see **Planetary boundaries alignment**).

This page intentionally
left blank

Soil condition

Soil is central to all life. Soil health is threatened by intensive land use, population growth and an increasingly extreme climate.

Overview

In 2023, the hillslope erosion rate decreased to

0.7t/ha/yr

(tonnes per hectare per year)

Read more

Soil organic carbon stocks declined by

3.1%

between 2006 and 2020

Read more

Beneath our feet, soil quietly sustains the web of life on earth.

It's a living material, connected to everything that plants, animals and humans need, including eating, drinking and breathing.

Soil is central to the function and health of the environment. This material:

- stores, regulates and supplies water
- stores, regulates and supplies nutrients so plants can grow
- provides habitat for plants, animals and microbes
- delivers other ecosystem services, such as mitigating greenhouse gases and supporting biodiversity (**Baer & Birgé 2018**).

Soil is also essential for human health and wellbeing. It provides food, fibre and water, and underpins our economic activity.

Aboriginal peoples sustainably managed soils for millennia and continue to hold knowledge of soils and their role in maintaining healthy ecosystems.

Australia's soils contribute:

- about $63 billion each year to the economy through agricultural production (**SSA 2019**)
- about $930 billion per year across all functions and services (**McBratney et al. 2017**).

Ecosystems are communities of plants, animals, invertebrates, and the microorganisms that rely on each other for food, habitat, breeding and survival. Sustainable soil management helps to maintain ecosystem health and prevents them from degrading.

Soil is a non-renewable resource, as it forms over billions of years (**Bui et al. 2010**; **Stockmann et al. 2014**). Although some soil properties can be managed and restored, when soil degrades, it is generally a permanent change. This is why it is important to preserve soil's natural qualities.

There are many layers of soil, including topsoil, subsoil and bedrock. The topsoil is usually responsible for the majority of nutrient cycling (including carbon) and microbial activity, but subsoil function is also important.

Living soil

Soil is one of the most biodiverse habitats on earth and it has been estimated that 59% of all terrestrial species inhabit the soil (**Anthony et al. 2023**).

Soil is a dynamic and biologically active layer of the earth's surface with a complex community of microorganisms including fungi, bacteria and archaea, and soil macrofauna including insects and other invertebrates, interacting with organic matter and minerals.

A healthy soil, in good condition, will have millions of microscopic and larger organisms carrying out various environmental functions. These key functions include nutrient cycles, decomposition that leads to soil aggregation, as well as suppression of pests and pathogens and supporting other flora and fauna. Everything works together to supply the water, oxygen, nutrients and soil physical condition that plants need to grow and thrive (**Hartmann & Six 2022**).

Recent global scientific interest, including the United Nations Convention on Biodiversity, has highlighted the vital role of microbes, including fungi in soils, in:

- helping to reduce the effects of climate change by storing carbon through plant growth and through regulating the carbon cycle (**Averill & Hawkes 2016**).
- sustaining agricultural productivity and promoting healthy plant growth and resilience against pests and diseases (**Jayaraman et al. 2021**).

In NSW and Australia, our understanding of the soil microbiome and its roles and functions in soil health is currently being developed. This encompasses:

- improving our understanding of the composition of the microbiome of different soils and their functions in different areas.
- improving knowledge to inform management and conservation strategies that maintain soil biological and ecosystem health, and productivity in diverse Australian landscapes.

Soil health

Soil condition, also referred to as soil health, assesses how well soil performs all its functions and ways in which those functions are being preserved for future use (**USDA n.d.**).

These functions include healthy natural or managed ecosystems that:

- sustain plants and animals in both the broader environment and in production landscapes
- maintain or enhance water and air quality and promote plant and animal health (**Doran 2002**).

The health of a soil can be assessed by comparing it with an ideal soil for a given purpose or land use, or with a natural soil with its original vegetation. This comparison informs how a soil's health can be improved or maintained by changing management practices to:

- increase acidity or alkalinity, depending on what is needed
- increase nutrients
- improve texture, structure and water holding capacity through addition of organic matter.

For the purposes of maintaining natural ecosystems, a soil is healthy if it exists in natural conditions with its original native vegetation. When land is cleared for cropping or grazing, the condition of the soil will change in ways which can be measured and compared with a soil in original condition.

Most soils in NSW are in a moderate condition.

Much of the changes in soil condition began after European colonisation. Aboriginal peoples cared for the land and maintained healthy ecosystems for millennia (**Mawson 2021**).

Development, such as housing, infrastructure, cities and industrial activities, have significantly impacted soil health, including through soil sealing and compaction, pollution, topsoil removal, salinity and disruption of natural processes.

Urbanisation leads to soil sealing, where the soil is covered with concrete and asphalt. This can:

- reduce water infiltration
- disrupt natural drainage
- limit the soil's ability to store carbon and support plant life.

Construction compacts the soil by:

- degrading its structure
- reducing its capacity to retain water and nutrients
- restricting its activity to grow healthy plants.

Industrial and urban activities may:

- contaminate soils with pollutants, such as metals and other chemicals
- further damage soils
- risk damaging ecosystems and harming human.

Soil degradation

Soil degradation refers to changes that are largely due to human activities, including undesirable changes brought about by development, agriculture or other land uses. Soil degradation can reduce both its quantity and quality, limiting or removing its ability to:

- supply nutrients for healthy plant growth and the invertebrates that live in it
- regulate water
- store carbon.

Land and soil also have spiritual and cultural significance, particularly for Aboriginal peoples, and these values have also been diminished in many areas through land and soil degradation.

As Australia's soils form slowly, soil erosion can be a more serious problem in Australia than globally (**Metcalfe & Bui 2017**).

Erosion is a natural process, but its impacts are often increased by development, urbanisation and farming. Around the world, the nutrient loss in agricultural land from soil erosion is between:

- 23 and 42 million tonnes of nitrogen
- 15 and 26 million tonnes of phosphorus (**Kopittke et al. 2019**).

Some consequences of soil degradation can be irreversible or expensive to rectify, including:

- accelerated erosion
- salinity
- soil acidification due to agriculture and fertiliser use.

Some forms of degradation, such as decline in nutrients and soil acidification in surface and subsoils, can be improved if resolved early when degradation is minor. Although restoration can be expensive (**Lockwood et al. 2003**), when done appropriately and at the correct rates it can lead to economically viable functional improvements.

Industrial and urban land activities may lead to soil pollution, where harmful pollutants, such as metals, chemicals and waste, are introduced into the soil.

See the **Contaminated sites** topic for more information.

The NSW Enviro Pulse survey provides quarterly responses from a structured random sample of the NSW population.

For NSW residents, pesticides and soil pollution remain environmental concerns for about a quarter of the population (see **Table L1.1**).

Table L1.1: Concern about pesticides and soil pollution in NSW (March 2021 to March 2024)

Concern	Mar 21	Sep 21	Mar 22	Sep 22	Mar 23	Sep 23	Mar 24
Pesticides	31%	29%	29%	29%	28%	25%	27%
Soil pollution	30%	26%	31%	27%	24%	21%	25%
Sample (n)	1,002	1,017	1,015	998	1,008	1,011	992

Notes:
Enviro Pulse survey is ongoing

Source:
DCCEEW 2024

Soils and climate change

Climate change is caused by emissions of carbon dioxide and other greenhouse gases into the atmosphere by human activities.

Storing carbon in soil can help to slow down climate change. Soil is part of the natural carbon cycle, contributing to the land carbon sink. As plants die or shed leaves, microorganisms break down the organic matter and turn it into more stable forms of carbon that remain in soil.

Levels of soil carbon depend on:

- the balance between decomposition by microorganisms and soil fauna and vegetation harvesting
- the amount of erosion – the higher the rate of erosion, the lower the amount of carbon in the soil (**ATSE 2021**).

Soil organic carbon fluctuates over time, mainly due to rainfall and land management practices. Revegetation and improved land management practices can help to increase soil organic carbon and other soil benefits. However, there are limits to the amount of carbon that soils can store.

See the **Climate change** topic for more information about carbon sinks.

Soil management

NSW is a signatory to the ***National Soil Strategy*** which provides a framework for coordinated action on soil by governments, industry and communities.

Soil is regulated and overseen by several government agencies in states and territories, and locally (see **Table L1.2**).

In NSW:

- **Department of Climate Change, Energy, the Environment and Water (DCCEEW)** collects, manages and provides information about NSW soils and landscapes, and advises on sustainable soil management
- **Department of Primary Industries and Regional Development (DPIRD)** advises and supports primary industries on soil management, including the Soil Conservation Service
- **Local Land Services (LLS)** administers Part 5A of the *Local Land Services Act 2013* (land management framework) and provides natural resource management services and advice to landholders.

Table L1.2: Current key legislation and policies relevant to soil management in NSW

Legislation or policy	Purpose
Contaminated Land Management Act 1997	Regulates the identification, management and remediation of significantly contaminated land in NSW
Local Land Services Act 2013	Governs management of natural resources, biosecurity and agricultural production on private rural land
Soil Conservation Act 1938	Provides rules to support the conservation of soil and farm water, and reduce erosion
State Environmental Planning Policy (Biodiversity and Conservation) 2021	Regulates clearing of native vegetation in towns and cities, and land zoned for environment protection (chapter 2)
State Environmental Planning Policy (Resources and Energy) 2021	Aims to balance the needs of agriculture and mining, petroleum production and extractive industries and to protect strategic agricultural land
State Environmental Planning Policy (Rural Lands) 2008	Aims to promote the proper management, development and protection of rural lands and to reduce land use conflicts that may arise from use of rural lands

Notes:
See the **Responses** section for more information about how **Soil condition** is managed in NSW.

Related topics: **Animals** | **Climate change** | **Contaminated sites** | **Extreme climate and weather** | **Groundwater** | **Plants**

Status and trends

NSW indicators

This section describes changes in soil condition that have happened over the past 10–15 years. Soil condition in NSW is assessed through remote sensing and modelling.

This assessment considers five main indicators of soil condition recorded in NSW (see **Table L1.3**).

- **Hillslope erosion** is stable, with the impact of increases in rainfall balanced by the restoration of vegetation cover following the 2019–20 bushfires (see **Hillslope erosion**).
- **Soil pH (acidification)** is increasing, with the biggest impacts seen in the Riverina, Murray and Central West regions (see **Soil pH (acidification)**).
- **Organic carbon** is decreasing, with projections for continued reduction likely to impact soil quality (see **Soil organic carbon**).
- **Wind erosion** is stable, with recent wet weather reducing erosion levels seen in previous reporting periods (see **Wind erosion**).
- **Salinisation** is stable, with changes in rainfall patterns and evaporation due to climate change likely to impact this in the future (see **Salinisation**).

Table L1.3: Soil condition indicator status and trends

Indicator	Environmental status	Environmental trend	Information reliability
Hillslope erosion	MODERATE	Stable	Reasonable
Soil pH (acidification)	MODERATE	Getting worse	Reasonable
Organic carbon	MODERATE	Getting worse	Reasonable
Wind erosion	POOR	Stable	Limited
Salinisation	MODERATE	Stable	Reasonable

Notes:
Indicator table scales:
- **Environmental status**: Good, moderate, poor, unknown
- **Environmental trend**: Getting better, stable, getting worse
- **Information reliability**: Good, reasonable, limited.

See **Indicator guide** to learn how terms and symbols are defined.

The condition of soils is assessed through the degradation impacts by land use practices and prevailing climate conditions, such as extreme rainfall (see **Table L1.4**).

Table L1.4: Indicators of soil condition and associated degradation processes

Indicator of soil condition	Degradation process
Hillslope erosion: when soil is washed down hillsides due to rain, erosion and landslides.	**Loss of topsoil:** leads to a loss of soil productivity and biodiversity. It is exacerbated by vegetation clearing and lack of groundcover. Subsequent sedimentation and nutrient loss may decrease environmental and water quality (**Erizon 2024**).
Soil pH: a measure of how acidic or alkaline the soil is. A pH below 7 is acidic. A pH above 7 is alkaline.	**Acidification:** most plant growth and yield is reduced below a pH of 5 (**Gazey & Alt 2013**). Acidification is increasing in NSW due to nitrate leaching, removal of large amounts of agricultural products such as grain, hay or silage, and use of ammonium nitrogen fertilisers, for example, urea (**DPI 2000**).
Soil organic carbon: includes all organic material, such as decomposing plants and animals. Ideally, soil organic carbon is at least 60% of soil organic matter.	**Loss of soil organic carbon:** increases vulnerability to erosion and degradation mainly due to land clearing, intensive agricultural land use, drought and climate change
Wind erosion: A natural process that moves soil from one location to another by wind power (**NSW Government 2020**).	**Loss of topsoil:** Many areas have been damaged due to wind erosion. Some recover naturally, but others are damaged permanently due to insufficient groundcover, particularly in western areas of NSW and in drought conditions.
Salinisation: When salt content in soil increases, it is known as salinisation. There are four types: dryland, irrigation, urban and industrial salinity.	**Increased salinity:** Land clearing, polluted groundwater or unsound irrigation bring salts to the surface. Increased salinity in soil decreases its quality, resulting in loss of productivity, soil erosion, stunting or death of vegetation and damage to building foundations and infrastructure.

Notes:
In 2021–23, updated data compared to 2018–20 was only available for hillslope erosion and wind erosion. For other indicators, the modelling is from 2020 and was also presented in the *State of the Environment 2021 report.*

Hillslope erosion

Hillslope erosion continues to be stable. Rates fluctuated between 2021 and 2023 with both higher and lower rates of hillslope erosion than the baseline period average (between 2001 and 2020).

Historically, hillslope erosion has contributed to extensive soil loss and an associated decline in ecosystem function.

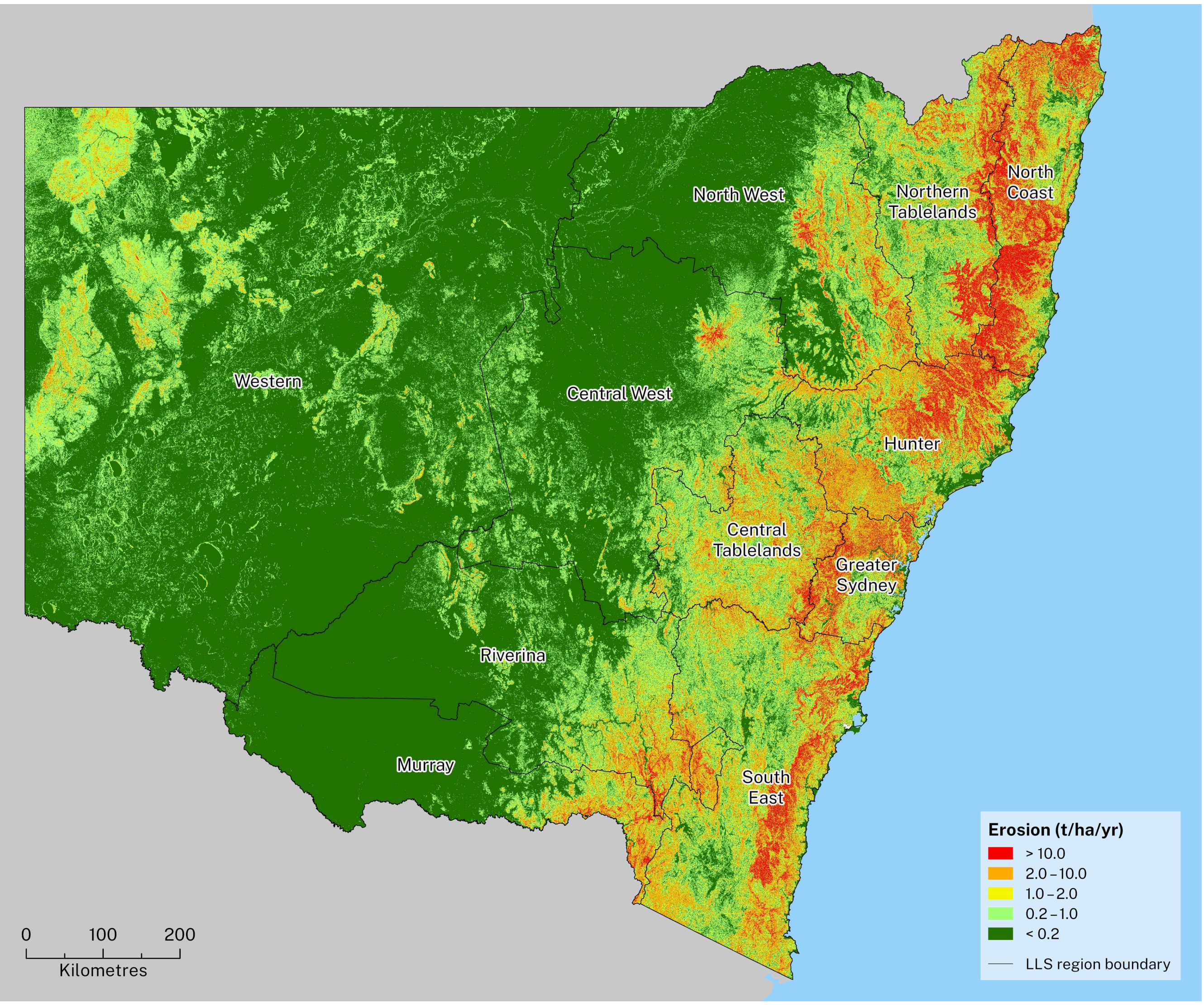
During the current reporting period (2021–23) there is variation in the status of hillslope erosion in NSW.

- The average rate of hillslope erosion for the baseline period (2001–20) was 1.0 tonnes per hectare per year (t/ha/yr).
- Hillslope erosion rates increased significantly after the 2019–20 bushfires and rainstorms that followed.
- Hillslope erosion rates in 2021 and 2022 reduced slightly from a high of 1.8t/ha/yr in 2020 but were still above the baseline rate.
- The erosion rate in 2023 decreased to 0.7t/ha/yr
- Typical rates of soil formation in NSW are between 0.04–0.4t/ha/yr (**DPI 2009**).

The increase in hillslope erosion was mainly due to the increase of rainfall from 500 millimetres (mm) a year in 2001–20 to 692mm a year in 2021–23. This 38% increase subsequently resulted in a 43% increase of erosion in 2021–23 from the 2001–20.

The average annual rate of hillslope erosion across NSW for 2021–23 (see **Map L1.1**) was calculated from modelling based on the **Revised Universal Soil Loss Equation** (**Renard et al. 1997**).

Map L1.1: Annual mean hillslope erosion, 2021–23



Notes:

Access the interactive version of this map.

Modelling is based on the **Revised Universal Soil Loss Equation**.

Source:

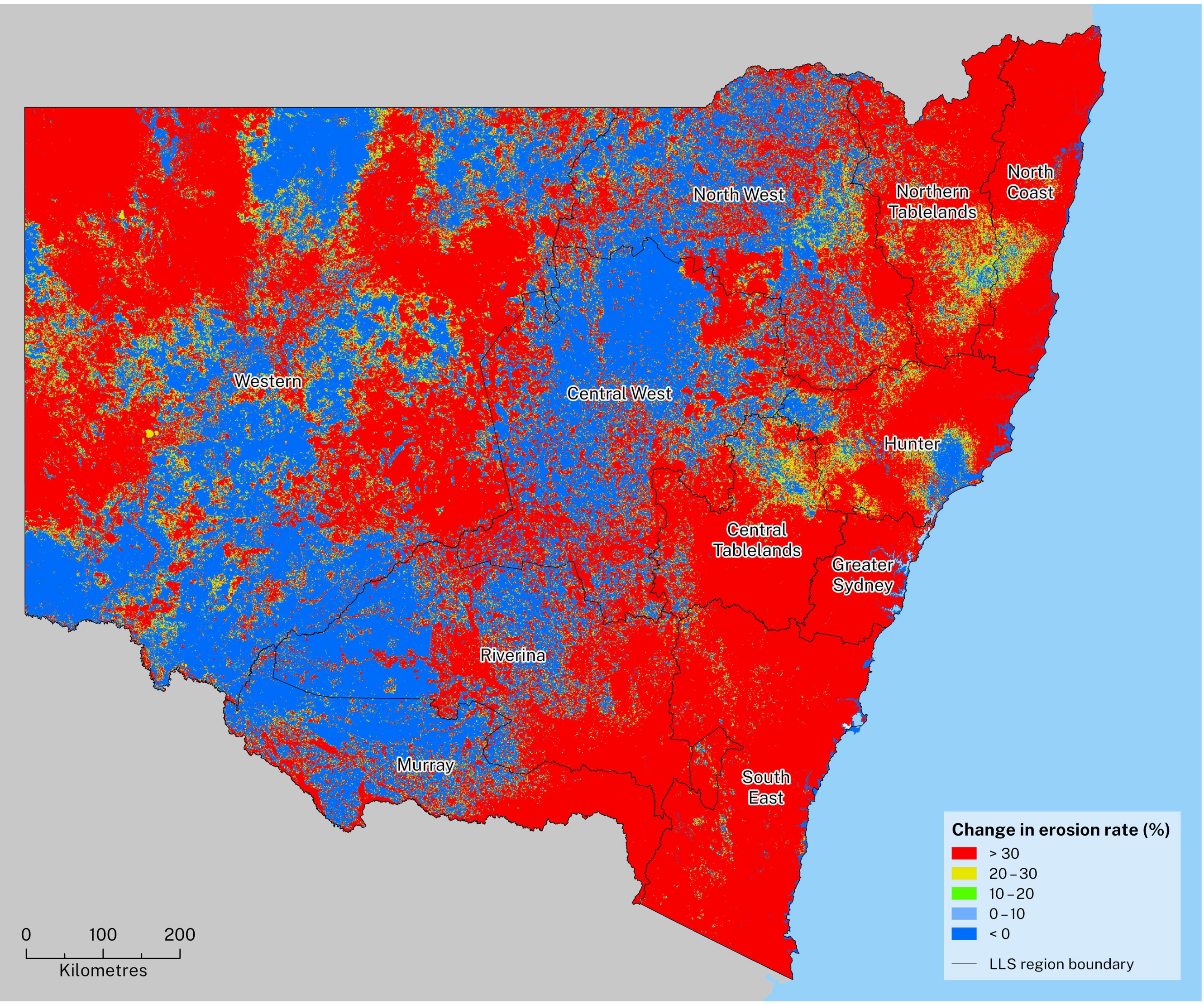
Modelling by DCCEEW April 2024

The areas of highest erosion for 2021–23 were unchanged from previous years (see **Map L1.2**). These areas were:

- North Coast region
- Hunter region
- Greater Sydney region.

The Western region has the lowest levels of erosion, as it is mainly flat.

Map L1.2: Change in annual mean hillslope erosion, from 2001–20 to 2021–23



Notes:
Access the interactive version of this map.
Modelling is based on the **Revised Universal Soil Loss Equation**.

Source:
Modelling by DCCEEW April 2024

The variation in erosion rates was due mainly to:

- the 2019–20 bushfires
- the subsequent loss of vegetation cover
- storms in 2020 across eastern NSW (North Coast, Greater Sydney).

Modelled changes in hillslope erosion between 2001 and 2020 and the current reporting period are presented in **Table L1.5** for all Local Land Services (LLS) regions in NSW.

Table L1.5: Modelled mean hillslope erosion (t/ha/yr) by region and the changes

LLS Region	Baseline (2001–20)	Last period (2018–20)	Current period (2021–23)	Hillslope erosion (% change)
Central Tablelands	1.38	1.51	1.83	32.18
Central West	0.30	0.31	0.34	15.92
Greater Sydney	3.27	4.21	5.07	55.08
Hunter	3.67	3.14	4.54	23.61
Murray	0.34	0.28	0.54	58.68
North Coast	5.44	4.76	7.28	33.98
North West	0.64	0.55	0.73	15.19
Northern Tablelands	3.07	2.40	3.71	20.66
Riverina	0.46	0.40	0.65	40.46
South East	1.69	1.93	2.68	58.93
Western	0.17	0.13	0.20	22.76
NSW	**0.95**	**0.88**	**1.26**	**32.62**

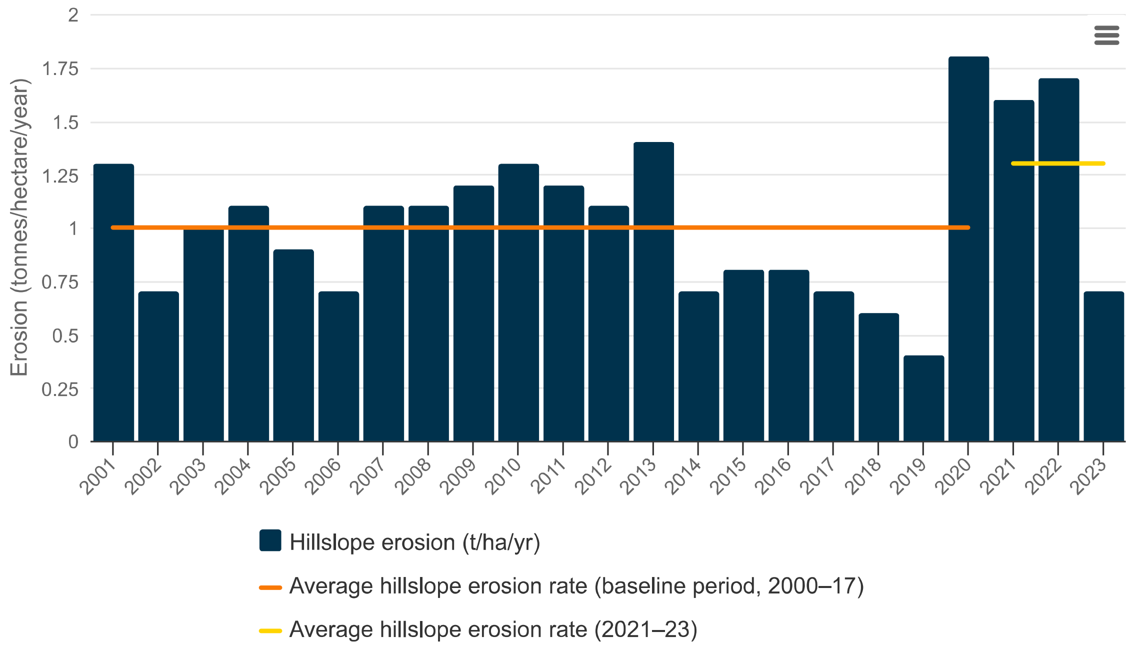
Notes:
The value for all NSW is not the simple average of the Local Land Services regions, due to their differing areas.
t/ha/yr is tonnes per hectare per year.

Source:
Modelling by DCCEEW, April 2024

The yearly averages for rates of hillslope erosion between 2001 and 2023 across NSW are presented in **Figure L1.1**, which shows:

- the average erosion rate for 2021–23 was 1.32 tonnes per hectare per year (t/ha/yr)
- the average hillslope erosion rate for the baseline period (2001–20) was 1.0t/ha/yr
- hillslope erosion over 2021–23 increased by about 32% compared with 2001–20, while the highest overall erosion rate for the past 20 years was in 2020 (1.80t/ha/yr)
- most (86.1%) of NSW had an erosion rate of less than 0.5t/ha/yr (arguably the tolerable erosion rate, the maximum level of soil loss without significant degradation), while 13.9% of NSW had an erosion rate of more than 0.5t/ha/yr.

Figure L1.1: Hillslope erosion in NSW, from 2001 to 2023



Source:
DCCEEW modelling, 2024

Soil pH (acidification)

Soil acidification is moderate, and available data shows it has been worsening over time.

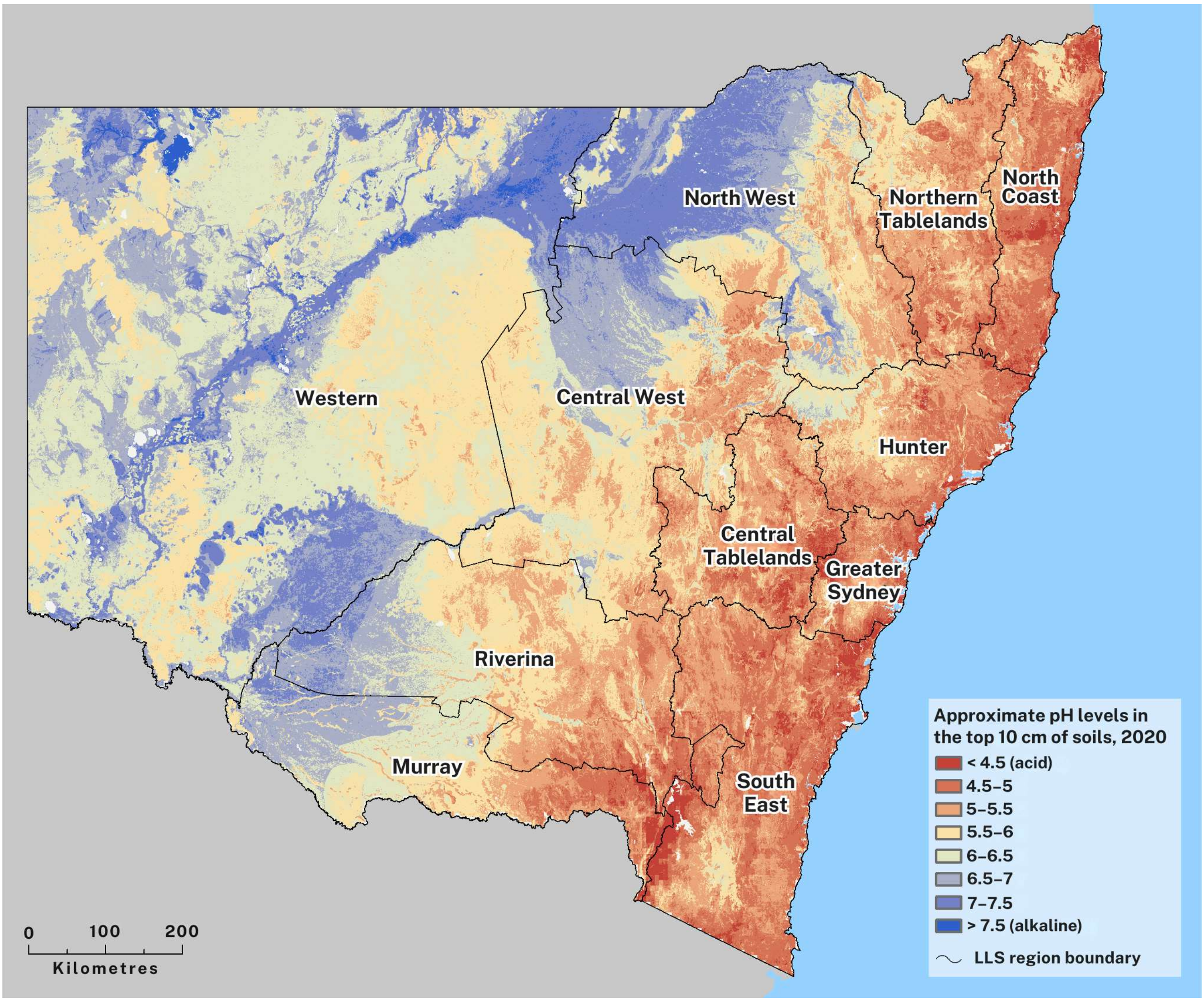
All plants, whether natural or grown for agriculture, function within different ranges of soil pH (**AdaptNSW n.d.-a**).

Soil pH indicates whether a soil is acidic or alkaline. The pH scale is from 0 (most acid) to 14 (most alkaline) and the level 7 is neutral. Acidic soils, particularly with pH levels below 4.5, pose challenges for agricultural crop growth due to associated toxicities (**Hazelton & Murphy 2016**).

Modelling has predicted that soils in NSW will become slightly more alkaline over time. The influence of farming on soils, however, can make them more acidic (**AdaptNSW n.d.-a**). Ammonium-based fertilisers increase nitrate levels through a process called nitrification, where ammonium is converted into nitrate by soil bacteria. This process releases hydrogen ions into the soil, which lowers the pH, making the soil more acidic.

Modelling of pH levels in the top 10cm of soil shows that soils with higher acidity occur along the east coast and Central Tablelands regions, while more alkaline soils are in the drier western regions of the State (see **Map L1.3**).

Map L1.3: pH levels in the top 10 centimetres of soils in NSW, 2020



Notes:

[Access the interactive version of this map].

All pH measurements refer to laboratory analysis by the CaCl method, the standard method for measuring pH in soil in Australia. pH measured in CaCl is normally between 0.5 and 0.9 units lower than pH measured in water, and more accurately reflects the conditions experienced by plants in soil (**NSW Agriculture 2000**; **Hazelton & Murphy 2016**).

Source:

Modelling by DPIE, April 2021

The changes in soil pH levels from 2006–20 in **Map L1.3** should be compared to data on current pH levels shown in **Map L1.4**.

Modelling of pH levels in the top 10cm of soil agricultural areas of NSW suggests that much of the State's agricultural land is becoming slightly more acidic, with soil pH declining by 0.15 or more from 2006–20 (see **Map L1.4**).

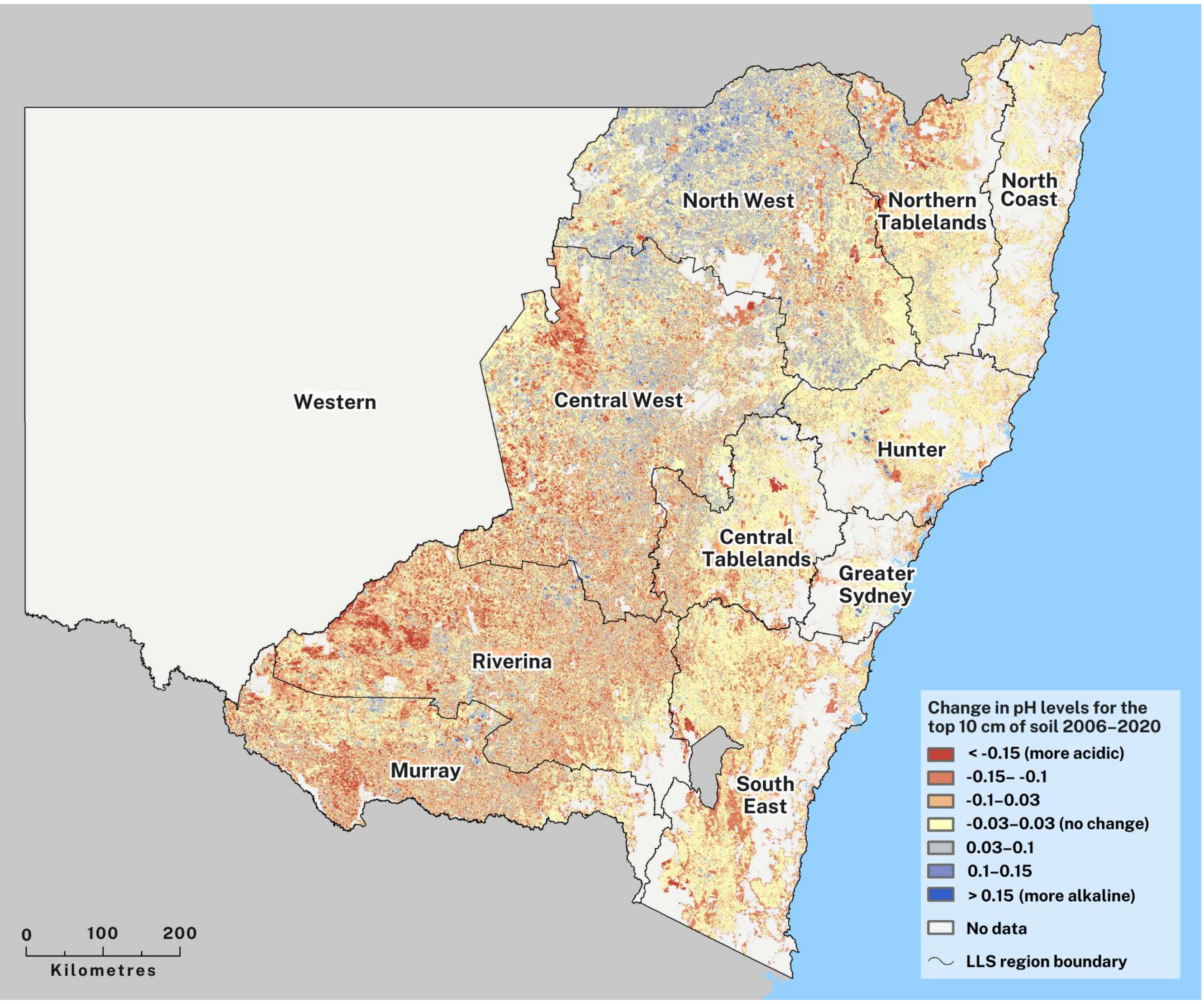
This trend towards acidification is most evident in the Riverina, Murray and Central West Local Land Services regions.

Agricultural land mapping excludes:

- nature conservation reserves and national parks
- private land set aside for conservation
- State forests and private forests used for logging
- the rangelands of the western Local Land Services region.

This modelling incorporated changes in land use and groundcover but did not consider the application of lime, which is often used by farmers to raise soil pH levels (to make it less acidic). Exclusion of the use of lime means that the data on acidification is likely to be the worst-case scenario. Therefore, with the use of lime, some acidic soils may be improved for agriculture and other uses.

Map L1.4: Modelled change in pH levels for the top 10cm of soil, from 2006–20



Notes:

[Access the interactive version of this map].

All pH measurements refer to laboratory analysis by the CaCl method, the standard method for measuring pH in soil in Australia. Soil pH measured in CaCl is normally between 0.5 and 0.9 units lower than pH measured in water and more accurately reflects the conditions experienced by plants in soil (**NSW Agriculture 2000**; **Hazelton & Murphy 2016**).

Source:
Modelling by DPIE, April 2021

Even slight pH decreases can affect crop and pasture growth, especially acid-sensitive crops like canola and lucerne.

Increases in pH levels leading to soil alkalinity of more than 0.1 have been found in some central and northern regions, affecting about 3% of NSW agricultural land.

Areas with very low soil pH that are getting even lower soil pH are of particular concern for acidification, especially where subsoil acidity is present. Subsoil acidity can increase the effects of topsoil acidification, making it harder for plant roots to get essential nutrients and water.

Modelled changes in pH levels between 2006 and 2020 for the top 10 and 30cm of soil are presented in **Table L1.6** for all Local Land Services regions in NSW.

The highest average reductions in soil pH levels are in the Riverina and Murray regions, with reductions of 0.05 and 0.04 pH units, respectively.

Table L1.6: Modelled changes in mean pH levels, between 2006 and 2020

LLS region	Change in pH level (0–10cm)	Change in pH level (0–30cm)
Central Tablelands	-0.02	-0.01
Central West	-0.03	-0.01
Greater Sydney	-0.02	-0.01
Hunter	-0.02	-0.01
Murray	-0.04	-0.02
North Coast	-0.03	-0.02
North West	-0.01	0.00
Northern Tablelands	-0.02	-0.01
Riverina	-0.05	-0.02
South East	-0.04	-0.02
Western	-	-
NSW	**-0.03**	**-0.01**

Notes:
Changes in pH are between 2006 and 2020.
pH change is modelled only over agricultural lands and excludes the western Local Land Services region. The value for all NSW is not the simple average of the Local Land Services regions, due to their differing areas.

Source:
Modelling by DPIE, April 2021

Soil organic carbon

Soil organic carbon is moderate, and available data shows it has been worsening over time.

NSW is projected to experience a reduction in soil organic carbon in the near (2030) and far (2070) future (**Gray & Bishop 2018**; **AdaptNSW n.d.-a**). This means a reduction in soil quality.

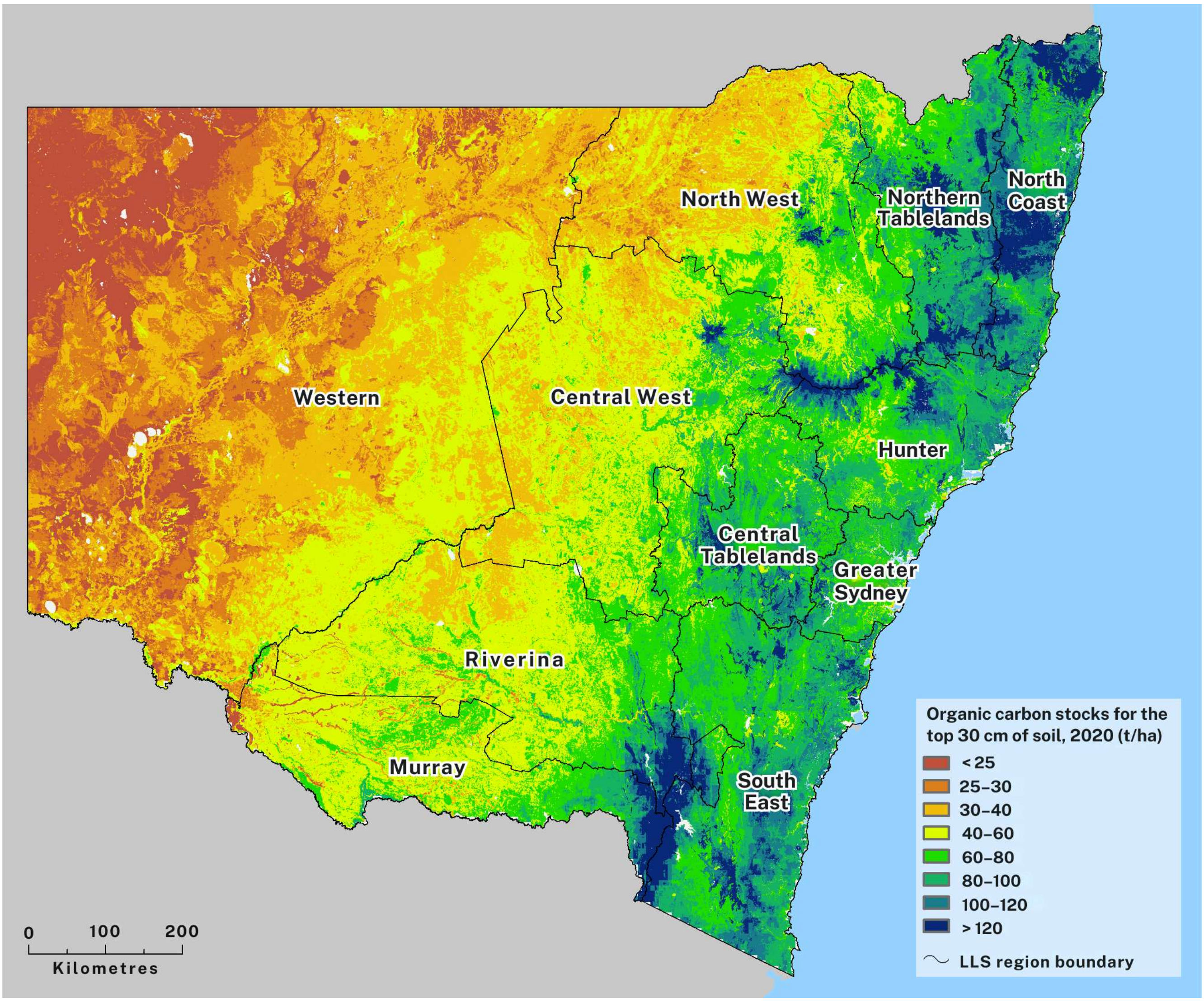
High soil organic carbon levels indicate:

- more nutrient availability
- higher biological activity
- better soil physical structure
- better water-holding capacity
- more aeration.

About 530 million tonnes of soil organic carbon, or 12.6% of the original levels, has been lost from the top 30cm of soil since European colonisation (**Gray et al. 2016**). The greatest losses have been in regularly cropped, high-fertility soils.

Modelling of organic carbon levels in the top 30cm of soil shows high variation across NSW (see **Map L1.5**). Lower levels in western regions of the state are due to their drier climate (**Gray et al. 2016**).

Map L1.5: Soil organic carbon levels in the top 30cm of soil in NSW, 2020



Notes:

Access the interactive version of this map.

Source:

Modelling by DPIE, April 2021

The soil organic carbon condition of soils across NSW is moderate but getting worse (see **Map L1.6**).

The condition is based on the change in current levels from natural levels before European colonisation. The change in soil organic carbon levels over the 15 years to 2020 was calculated from:

- data on changes in land use and groundcover
- the past 10 years of rainfall and temperature records.

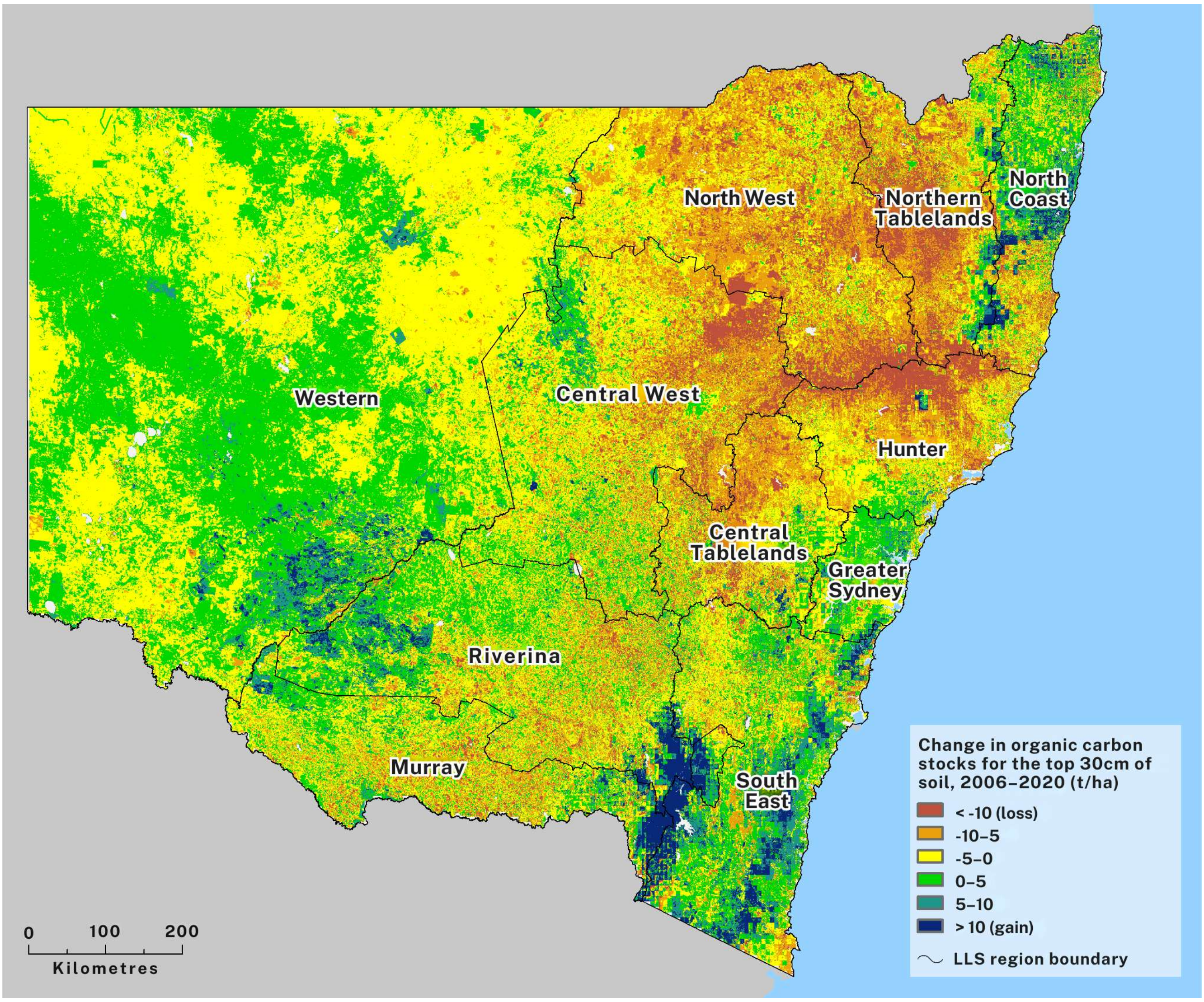
According to modelling in 2021, most of NSW had experienced at least a 2.7 tonnes per hectare (t/ha) decline in soil organic carbon stocks from 2006–20 (see **Table L1.7**). This is a 3.1% decline.

The largest declines in levels in Local Land Services regions were:

- 6.6t/ha in the North West region
- 6.4t/ha on the Northern Tablelands region
- 6.3t/ha in the Hunter region.

Only the Greater Sydney and North Coast regions have slight increases in soil organic carbon levels.

Map L1.6: Change in NSW soil organic carbon levels, between 2006 and 2020



Notes:
Access the interactive version of this map.

Source:
Modelling by DPIE, April 2021

Land use changes can decrease soil organic carbon levels. A NSW study reported that soil organic carbon levels in the top 30cm of soil were lower on agricultural sites than in areas of native vegetation (**Singh & Whelan 2020**). Extreme weather, such as prolonged droughts, also decreases soil organic carbon levels (**Singh & Whelan 2020**).

The decline in soil organic carbon levels in NSW is due to:

- drier conditions, with higher temperatures and lower rainfall
- the move to more intensive farming with less vegetation, for example the move from grazing to cropping.

Projections suggest climate change will lead to substantial future losses in soil organic carbon, particularly in highland areas.

Table L1.7: Change in NSW soil organic carbon levels, between 2006 and 2020

LLS region	Change in soil organic carbon – t/ha* in the top 0–30cm of soil
Central Tablelands	-4.8
Central West	-4.0
Greater Sydney	1.4
Hunter	-6.3
Murray	-1.0
North Coast	0.89
North West	-6.6
Northern Tablelands	-6.4
Riverina	-0.6
South East	-2.1
Western	0.0
NSW	**-2.7**

Notes:
Changes in soil organic carbon levels are over the period 2006–20.
The value for all NSW is not the simple average of the Local Land Services regions, due to their differing areas.
*t/ha is tonnes per hectare.

Source:
Modelling by DPIE, April 2021

Wind erosion

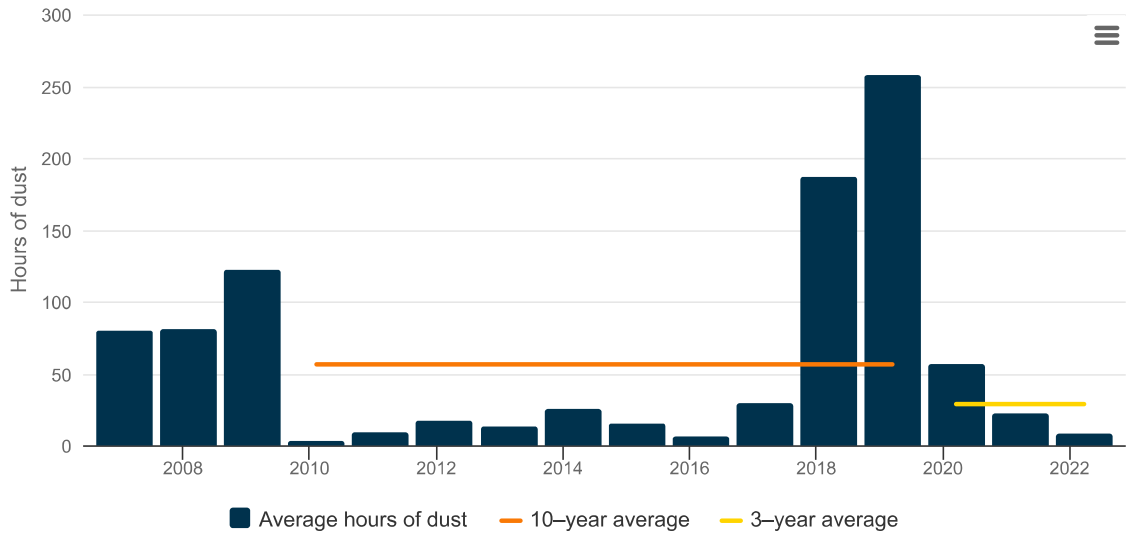
Wind erosion, like hillslope erosion, has led to extensive soil loss and the decline of soil condition throughout NSW, especially in the drier western regions. Recent wet weather has reduced the level of wind erosion seen during the 2017–20 drought.

Dust in the air is an indicator of wind erosion degrading soils upwind of the area where the dust is falling. Dust activity is measured by the number of hours per year that the average dust concentration exceeds 25 micrograms per cubic metre (μg/m^3).

Figure L1.2 plots average dust hours recorded at NSW DustWatch stations, 2007–08 to 2022–23.

See the **Community DustWatch program** website for additional background and data from 21 individual monitoring stations west of the Great Dividing Range.

Figure L1.2: Average dust hours recorded at NSW DustWatch stations, 2007–08 to 2022–23



Notes:
The red horizontal line is the average of the baseline (2010–11 to 2019–20) and the green line is the average for the reporting period 2020–21 to 2022–23.

Source:
DustWatch publications, 2023

Improved land management changes in south-western NSW have reduced wind erosion in cropping areas (**Leys et al. 2023**). Despite this, drought conditions can exacerbate wind erosion, such as in 2017–20 when an extreme drought with 'no clear historical precedent' (**BOM n.d.**) led to large areas of the sheep and wheat belt in central NSW being affected by wind erosion.

Salinisation

Salinisation, the process of salts being brought to the surface, is currently moderate and stable (see **Table L1.1** for process).

A general salinity hazard map for most of NSW has been compiled from:

- salinity hazard assessments of water quality from **NSW Water Resource Plans** 2017–18
- previous **Hydrogeological Landscape** hazard assessments from 2008–20
- **salinity hazard assessments for catchment action plans** in 2012.

Salinity hazard ratings are based on whether salinity is likely to happen and what its impacts might be. Salinity assessments are based on:

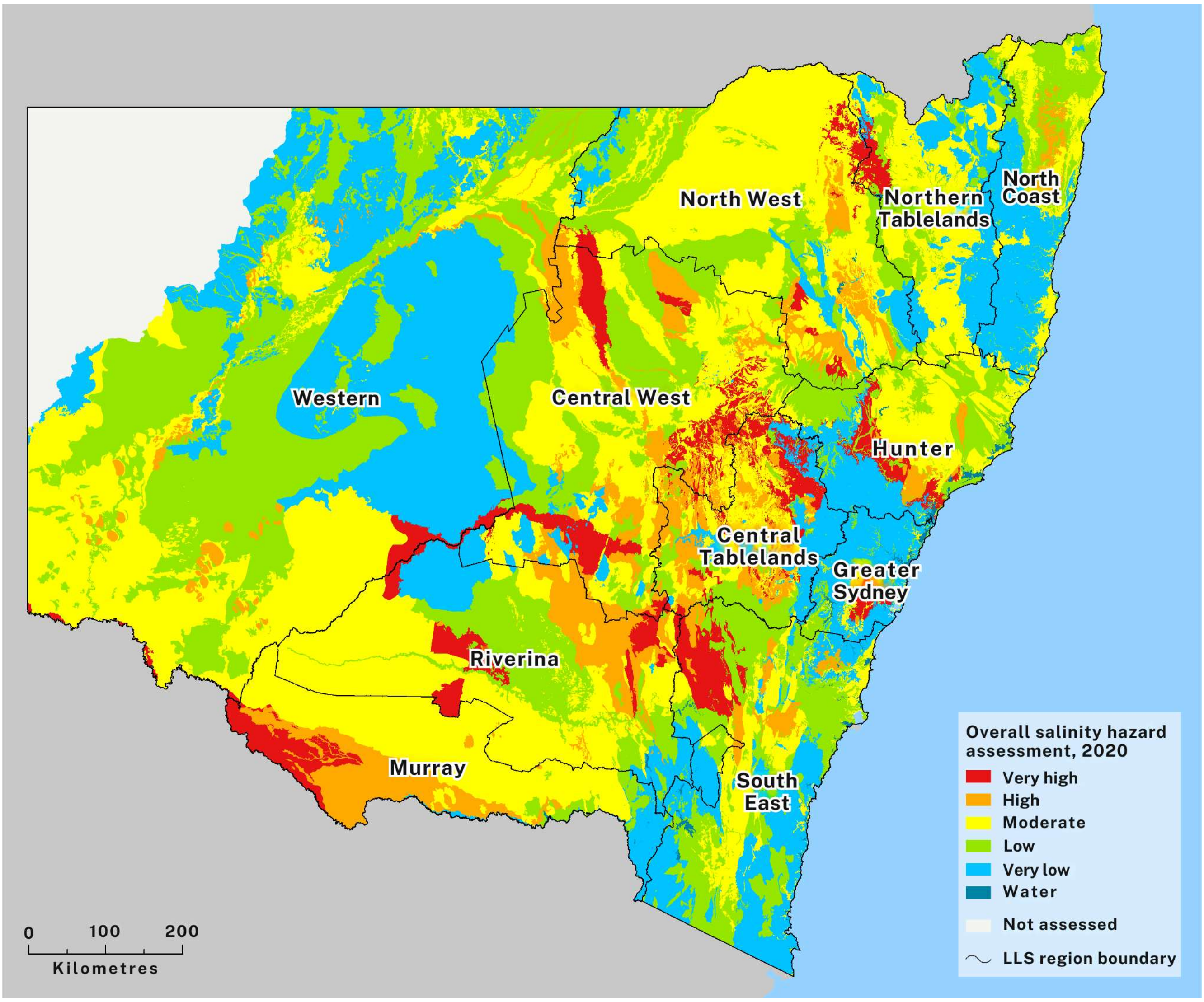
- the impacts of salinity on the land
- the impacts of salt concentrations and loads in streams near the land.

The severity of each of these will vary depending on local factors that influence how salt and water move through the landscape of the area affected.

Areas with high or very high salinity hazards cover about 12% of NSW (see **Map L1.7**). Areas of concern include:

- the Hunter, Greater Sydney and Central West regions
- the Yass and Boorowa areas
- the Mid and Lower Murray and Murrumbidgee irrigation areas.

Map L1.7: Overall salinity hazard assessment for NSW, 2020



Notes:

Access the interactive version of this map.

Source:

NSW Hydrogeological Landscapes 2020

In areas with high saline rates, soils can contain excessive sodium ions (sodic soils) which negatively affects soil structure by causing clay particles to disperse. Sodic soils may have poor aggregation, reduced permeability and decreased infiltration rates, resulting in waterlogging and poor plant growth.

NSW Water Resource Plans have assessed areas in the Murray–Darling Basin for salinity hazards. The Murray–Darling Basin Authority keeps a register of salinity credits and debits that records actions that affect salinity in the basin.

Future changes in rainfall patterns and evaporation in all regions (**Littleboy et al. 2015**) will reduce the balance between:

- agricultural runoff and natural overland flows
- shallow and deep drainage.

These changes will affect the movement and concentration of salts.

See the **Climate change** topic for more information.

Pressures and impacts

Intensive land use and clearing

While land management has improved, the pressure on soil condition continues due to land use changes and increasing intensity of use. There is more need to ensure that soils and land are managed sustainably to handle some disturbance or use. This will help ensure the long-term productive use of NSW soils.

The overuse of cultivation, fertilisation, irrigation and pesticides have historically also contributed to soil functional decline (**Fraiture et al. 2007**).

Residential, commercial, and industrial land uses also threaten soil health. Industrial activities can contaminate soil and reduce its capacity to support ecosystems or agriculture. Constructing roads and buildings often results in topsoil removal, degrading soil quality.

Extreme climate and weather events

Climate change will increase soil degradation through wind erosion and associated loss of soil carbon bound up with dust particles (**AdaptNSW n.d.-a**; **Rengel 2011**).

Climate change may lead to:

- increased risk of extreme weather events, such as drought, bushfires and storms
- broader changes in weather patterns, such as increasing temperatures and fluctuations in rainfall (**AdaptNSW n.d.-b**).

See the **Climate change** topic for more information.

Changed rainfall patterns

While soil management is relatively uncomplicated in normal weather conditions, the unpredictability and variability of severe weather can rapidly reduce the capacity of soils to resist disturbance and stay productive.

Severe weather may result in:

- loss of carbon from the soil, meaning it will be returned to the atmosphere
- depletion of microorganisms and soil fauna
- soil erosion.

One of the measures of soil erosivity is the ability for rainfall to cause erosion, based on rainfall amount and intensity.

While significant uncertainty remains around rainfall projections, it is likely that some parts of NSW will experience an increase in extreme rainfall events, which can affect rainfall erosivity (see the **Extreme climate and weather** topic).

The projected seasonal changes in rainfall erosivity alone could cause a sevenfold increase in soil loss, even if the total rainfall amount and intensity are the same (**OEH 2015**). This loss of soil could then affect water quality, agricultural productivity, forestry and biodiversity.

The areas most affected will include mountainous regions of the Great Dividing Range especially in the high-risk Central Coast, North Coast and Hunter regions. To manage erosion risk, it will be important to maintain good groundcover in these areas (**OEH 2015**).

Bushfires

The effects of fire on soil health relate to fire severity, types of ecosystems on the land and soil properties. While low to moderate intensity fires can improve soil fertility, structure and organic carbon, severe fires can damage soil health due to:

- loss of nutrients and organic matter (**Clark et al. 2019**)
- soil erosion following decreased ground cover
- microbes in the soil decreasing or changing, affecting nutrient cycling and decomposition
- altered soil pH

- loss of native vegetation and invasion by weeds.

Soil health improved during the 2020–22 period as there were fewer bushfires due to high rainfall and mild temperatures associated with La Niña conditions.

Climate change projections suggest that severe fire weather conditions will increase across most ecosystems, including in NSW (**Sayedi et al. 2024**). If this results in increased fire activity, this will damage soil health and increase erosion (**Murramarang Country et al. 2024**).

See the **Extreme climate and weather** topic for more information.

Invasive species

Invasive plant and animal species can lead to soil erosion and compaction, reduced nutrient cycling and microbial activity.

- Invasive weeds like lantana and African olive grow densely, often forming an impenetrable mass of vegetation. Their shallow root systems and ability to release chemicals that stop growth of native vegetation mean they spread fast.
- European rabbit digging behaviour and grazing can lead to soil erosion and hillslope erosion, deplete native vegetation, degrade ecosystems and damage habitat for native plants and animals.
- Feral pigs root and dig into the soil in search of food which can expose bare soil. They can also create new openings in the ground, making it easier for weeds to spread.
- Feral horses, particularly in Australia's alpine regions like **Kosciuszko National Park**, contribute to soil erosion, compaction and degradation, which can significantly affect vegetation, water flow and overall ecosystem health.

See the **Plants** and **Animals** topics for more information.

Responses

Agricultural land use

The **Local Land Services Agricultural Services Framework 2021–26** aims to increase agricultural productivity in a sustainable way that:

- enhances farm natural assets without deteriorating natural assets including soils
- manages risks associated with climate change and market disruption.

Through the framework, Local Land Services helps landholders to:

- assess soil health and take measures to improve it by controlling erosion, reducing sediment loss and increasing ground cover, and other safeguards, such as maintaining riparian (where water meets land) buffers
- maximise the water bearing properties of soils and factors impacting water use efficiency
- understand soil nutrient interactions, capabilities and constraints
- plan fertiliser investment and land management strategies.

The **Farming Forward Project**, initiated through the framework, aims to boost farm productivity, resilience and sustainability. Local Land Services tests soils to:

- improve soil health
- manage soil constraints
- match nutrient requirements to production goals
- manage soil moisture
- optimise pasture and crop growth and yield.

Protecting soils during drought

Local Land Services leads the **Saving Our Soils During Drought project**. This is a federally funded project delivered in partnership with six farming system groups, the Southern NSW Drought Hub and the Soil Knowledge Network.

The project helps farmers improve land management by:

- increasing and improving their drought resilient land management practices
- strengthening collaboration between farmers and other land managers
- demonstrating sustainable land management practices for improving drought resilience.

Various programs contribute to achieving project metrics (see **Table L1.8**).

Table L1.8 Key Local Land Services metrics for improving soil condition through the Saving our Soils During Drought project

Metric	Total area of land (hectares) (2021–22 to 2023–24)	Top contributing programs
Area (in hectares) of land managed for improved soil condition	492,596	• Sustainable Agriculture – Farming Forward • Sustainable Agriculture Program 22–23 • Healthy Soil and Land (NRM Services)
Area (in hectares) of land managed for improved agricultural production	2,104,648	• Sustainable Agriculture Program 22–23 • Western LLS Land Services Program • Northern Tablelands Sustainable Agriculture Extension Programs

Notes:
To find your Local Land Services region, visit this **map**. Select your region to explore projects and programs.

Source:
LLS 2024

Regenerative agriculture

Regenerative agriculture focuses on restoring soil health, improving biodiversity and improving ecosystem resilience. Soil health improvement strategies emphasise practices that rebuild soil organic matter and promote natural processes, such as reduced tillage to minimise soil disturbance and rotational grazing (**Schreefel et al. 2020**).

This approach aims to regenerate the land, leading to better water retention, increased carbon sequestration (as a carbon sink) and enhanced productivity.

Urban development and infrastructure

Water Sensitive Urban Design principles can help minimise the impacts of sealed urban areas on waterways and water-dependent ecosystems. These principles include:

- managing water runoff, pollution and salinity
- rehabilitating and maintaining riverbank and wetland ecosystems
- using natural features such as biofiltration and permeable surfaces to improve water quality.

Properly managed water sensitive urban design aims to develop clean stormwater infrastructure and a functioning urban ecosystem. Implementing such design helps to retain wildlife corridors and benefit soil and water health.

National Soil Strategy

The Australian Government's ***National Soil Strategy***, released in May 2021, sets out how Australia will manage and improve its soil over the next 20 years.

The ***National Soil Action Plan 2023–2028*** sits under the strategy. The NSW Department of Primary Industries will work with other NSW agencies on actions to:

- use innovation and the latest science to improve soil health
- improve knowledge of sustainable soils and good soil management.

Fire and soil health

Following the **2020 NSW Bushfire Inquiry**, the National Parks and Wildlife Service is investigating the effects of 'cooler' fires - hazard reduction burns and cultural burns - on soil health. The project will report on:

- the effects of hazard reduction burns on 21 sites in NSW national parks and reserves
- soil properties before and after hazard reduction burns.

The **Applied Bushfire Science Program** is addressing key recommendations from the 2020 NSW Bushfire Inquiry relating to ecosystems, recognition of Aboriginal cultural knowledge and impacts of fire on Aboriginal cultural values.

As part of the program, the NSW Department of Climate Change, Energy, the Environment and Water (DCCEEW) is establishing a long-term monitoring network in south-eastern NSW. Sites will be monitored for several factors, including soil health before and after bushfires, hazard reduction burns and cultural burns.

DCCEEW and LLS are also working with Aboriginal knowledge holders to understand fire impacts on cultural values and empower Aboriginal peoples' input to the fire planning process.

Additional responses

Other responses for managing and improving soil condition are as follows.

- The **National Committee on Soil and Terrain** advises on soil and land assessment standards and policy. The committee has published national protocols for monitoring soil acidification and soil organic carbon.
- The NSW **Community DustWatch program** has been monitoring the extent and magnitude of dust pollution across NSW for the past 13 years.
- NSW Government agencies lead the national assessment of wind erosion and the use of remote-sensing to assess the extent of groundcover.
- The Department of Primary Industries and Regional Development **soil research and development program** develops, assesses and promotes technologies and management systems that improve soil quality and protect it from degradation.
- The NSW Natural Resources Commission has identified baselines, drivers and trends for soil stability and health in forest catchments across the **NSW Regional Forest Agreement areas**.
- The Department of Primary Industries and Regional Development provides an **information series** on microbes, nematodes, bacteria and fungi for landholders who wish to enrich soil nutrients for natural ecosystems or agriculture.
- Local Land Services have provided a **fungi guide** for landholders in the Central Tablelands and Central West regions, with 96 species from hundreds, possibly thousands, that grow in the diverse habitats of these regions.

Pest animals and weeds

National Parks and Wildlife Service is responsible for managing national parks and nature reserves for the protection and conservation of biodiversity in NSW. This includes the **control of pest animals and weeds** that affect soils within national parks. The Australian Government's ***Australian Pest Management Strategy 2017–2027*** outlines measures for controlling invasive species while considering both environmental and cultural factors.

See the **Animals** and **Plants** topics for more information.

Future opportunities

Modelling of soil condition in NSW

Further and systematic monitoring of soil condition would improve our understanding of current condition and change in NSW landscapes and soils and also improve the ability to anticipate or react to developing issues caused by changes in environmental conditions or alterations in land management practice.

The adoption of a universally agreed definition of soil health has had limited success (**Lichtenberg 2024**). Across NSW there is no consistent monitoring of physical, chemical and biological factors that relate to soil health, apart from the federal government's **National Soil Action Plan.**

Recent localised studies have highlighted the value of:

- native tree planting (specifically *Acacia pendula* and *Eucalyptus camaldulensis*) to increase soil microbial activity and nutrient content, particularly in the upper soil layers and under the tree canopy (**Amarasinghe et al. 2020**)
- fungi and bacteria in breaking down complex, resistant carbon sources like ryegrass litter, especially during drought (**Ullah et al. 2023**).

Landscape Function Analysis

Landscape Function Analysis can be a useful tool for assessing and monitoring the health and functionality of landscapes, especially in arid and semi-arid environments (**Ludwig et al. 2024**). This method focuses on evaluating essential ecological functions of landscapes, such as capturing and retaining resources like water and nutrients. The analysis can be useful to assess effectiveness of land management practices and to develop strategies to enhance ecosystem resilience.

Soil ecosystems

Soil microbial ecosystems are key in maintaining soil health as well as dependant ecosystems, such as fauna and flora. Therefore, quantifying the importance of these interactions and developing metrics that include microbial communities and functions in setting soil and biodiversity indicators for the state of environment reporting will be key in the future. Potential for impacts of existing contaminants from industrial, urban and pesticide use in considering soil ecosystem health are also key to ensure soil and health and resilience is maintained.

Fungi

Australia's unique environmental conditions and ancient soils offer a promising opportunity to enhance our understanding of soil fungi including symbiotic mycorrhizal fungi, which play crucial roles in plant nutrient uptake, soil health and ecosystem functions (**Frew & Aguilar-Trigueros 2023**).

Despite their global significance and presence across diverse ecosystems, Australian fungal ecology is poorly understood, particularly biogeographical distribution and adaptation to local conditions. Understanding soil fungi, and the soil microbiome is essential for improving conservation, restoration and sustainable agricultural practices in the face of environmental changes.

Acid sulfate soils

There are opportunities to explore this area further. Improved mapping techniques, including remote sensing methods such as LiDAR (Light Detection and Ranging), will improve our understanding of acid sulfate soil extent.

Additional research on acid sulfate soils could focus on the impacts of extreme drought and subsequent rewetting on soil acidification and sulfuric material formation (**Fitzpatrick et al. 2017**). The Millennium Drought (2007–10) in the Lower Murray River demonstrated how deep oxidation of sulfides and formation of acid sulfate soils occurred in both irrigated areas and natural wetlands.

Understanding how water table management, such as through irrigation and drainage, affects the development of deep sulfuric materials and their persistence can help in developing strategies to mitigate long-term soil degradation and manage water resources more effectively.

References

AdaptNSW n.d.-a, Climate change impacts on our soils, AdaptNSW, accessed 17 July 2024

AdaptNSW n.d.-b, Climate change in my region, AdaptNSW, accessed 17 July 2024

Amarasinghe A, Fyfe C, Knox OGG, Lobry de Bruyn LA, Kristiansen P & Wilson BR 2020, 'Spatial distribution of soil microbial activity and soil properties associated with Eucalyptus and Acacia plantings in NSW, Australia', *Soil Research*, vol. 59, no. 6, pp. 609–18, DOI: 10.1071/SR19393

Anthony MA, Bender FS & van der Heijden MGA 2023, 'Enumerating soil biodiversity', *Proceedings of the National Academy of Sciences of the United States of America*, vol. 120, no. 33, e2304663120, DOI: 10.1073/pnas.2304663120

ATSE 2021, *Australia's soil carbon opportunities and risks*, Australian Academy of Technological Sciences & Engineering

Averill C & Hawkes CV 2016, 'Ectomycorrhizal fungi slow soil carbon cycling', *Ecology Letters*, vol. 19, no. 8, pp. 937–47, DOI: 10.1111/ele.12631

Baer S & Birgé HE 2018, 'Soil ecosystem services: an overview', *Managing Soil Health for Sustainable Agriculture*, vol. 1, pp. 17–38, DOI:10.19103/AS.2017.0033.02

BOM n.d., Previous drought, Bureau of Meteorology, accessed 18 September 2024

Bui EN, Hancock GJ, Chappell A & Gregory LJ 2010, *Evaluation of Tolerable Erosion Rates and Time to Critical Topsoil Loss in Australia*, CSIRO, Canberra

Clark CM, Richkus J, Jones PW, Phelan J, Burns DA, de Vries W, Du E, Fenn ME, Jones L & Watmough SA 2019, 'A synthesis of ecosystem management strategies for forests in the face of chronic nitrogen deposition', *Environmental Pollution*, vol. 248, pp. 1,046–58, DOI: 10.1016/j.envpol.2019.02.006

Condon J, Burns H & Li G 2020, 'The extent, significance and amelioration of subsurface acidity in southern New South Wales, Australia', *Soil Research*, vol. 59, no. 1, pp. 1–11, DOI: 10.1071/SR20079

DCCEEW 2024, *Enviro Pulse Survey*, NSW Department of Climate Change, Energy, the Environment and Water, Sydney

DPI 2000, *Acid soil management in low rainfall farming systems of Central Western New South Wales*, NSW Department of Primary Industries, Sydney

Doran JW 2002, 'Soil health and global sustainability: translating science into practice', *Agriculture, Ecosystems & Environment*, vol. 88, no. 2, pp. 119–27, DOI: 10.1016/S0167-8809(01)00246-8

Erizon 2024, The Impact of Loss of Topsoil in Australian Industries and the Role of Revegetation, Erizon, accessed 18 September 2024

Fitzpatrick RW, Shand P & Mosley LM 2017, 'Acid sulfate soil evolution models and pedogenic pathways during drought and reflooding cycles in irrigated areas and adjacent natural wetlands', *Geoderma*, vol. 308, pp. 270–90, DOI: 10.1016/j.geoderma.2017.08.016

Fraiture CD, Wichelns D, Rosktrom J, Kemp-Benedict E, Eriyagama N, Gordon LJ, Hanjra MA, Hoogeveen J, Huber-Lee A & Karlberg L 2007, 'Looking ahead to 2050: scenarios of alternative investment approaches', *Water for Food Water for Life*, 1st Edition, pp. 91–145, DOI: 10.22004/ag.econ.157926

Frew A & Aguilar-Trigueros CA 2023, 'Australia offers unique insight into the ecology of arbuscular mycorrhizal fungi: An opportunity not to be lost', *Special Issue: Australian Freshwater Turtle*, vol. 48, no. 8, pp. 1713–20, DOI: 10.1111/aec.13451

Gazey P & Alt S 2013, Soil Acidity – New South Wales, NSW Department of Primary Industries, accessed 18 September 2024

Gray JM, Bishop TFA & Wilson BR 2016, 'Factors Controlling Soil Organic Carbon Stocks with Depth in Eastern Australia', *Soil Science Society of America Journal*, vol. 79, no. 6, pp. 1,741–51, DOI: 10.2136/sssaj2015.06.0224

Gray JM & Bishop TFA 2018, *Climate Change Impacts on Three Key Soil Properties in New South Wales (2nd edition)*, NSW Office of Environment and Heritage, Sydney (PDF 4.2MB)

Hartmann M & Six J 2022, 'Soil structure and microbiome functions in agroecosystems', *Nature Reviews Earth & Environment*, vol. 4, pp. 4–18, DOI: 10.1038/s43017-022-00366-w

Hazelton P & Murphy BW 2016, *Interpreting Soil Test Results. What do all the numbers mean?*, 3rd edition, CSIRO Publishing, Melbourne

Jayaraman S, Naorem A, Lal R, Dalal RC, Sinha NK, Patra AK & Chaudhari SK 2021, 'Disease-Suppressive Soils—Beyond Food Production: a Critical Review', *Journal of Soil Science and Plant Nutrition*, vol. 21, pp. 1,437–65, DOI: 10.1007/s42729-021-00451-x

Kopittke PM, Menzies NW, Wang P, McKenna BA & Lombi E 2019, 'Soil and the intensification of agriculture for global food security', *Environment International*, vol. 132, 105078, DOI: 10.1016/j.envint.2019.105078

Leys JF, Shields T, Murphy SR & Koen T 2023, 'Changes in land management practices have reduced wind erosion in the cropping areas of far south-western NSW, Australia', *The Rangeland Journal*, vol. 44, pp. 303–19, DOI: 10.1071/RJ22028

Lichtenberg E 2024, 'Thinking about soil health: A conceptual framework', *Soil Security*, vol. 14, 100130, DOI: 10.1016/j.soisec.2024.100130

Lines-Kelly R 1992, *Plant nutrients in the soil*, Soil Sense Leaflet 8/92

Littleboy M, Young J & Raman J 2015, *Climate Change Impacts on Surface Runoff and Recharge to Groundwater*, Office of Environment & Heritage, Sydney

Lockwood P, Wilson BR, Daniel H & Jones M 2003, *Soil Acidification and Natural Resource Management: Directions for the Future*, NSW Department of Agriculture (NSW Agriculture), Acid Soil Action Program,

Ludwig JA, Tongway DJ & Hindley N 2024, 'Can simple, on-ground vegetation and soil measures reliably indicate the health of rangelands? An application in Australia's semi-arid woodlands', *The Rangeland Journal*, vol. 45, no. 6, pp. 235–45, DOI: 10.1071/RJ24004

McBratney AB, Morgan CLS & Jarrett L 2017, 'The Value of Soil's Contributions to Ecosystem Services' in DJ Morgan, CLS McBratney and AB (eds), *Global Soil Security, Progress in Soil Science*, Springer, Cham, Switzerland, pp. 227–35, DOI: 10.1007/978-3-319-43394-3_20

Metcalfe DJ & Bui EN 2017, *Australia: State of the Environment 2016: Land*, Independent report to the Australian Government Minister for the Environment and Energy, Australian Government Department of the Environment and Energy, Canberra (PDF 6.3MB)

Murramarang Country, Davis J, Simmons J, Snelson S, Channell V, Haynes K, Deutscher N, Brook L & Dosseto A 2024, 'Quantitative Assessment of the Effect of Agency-Led Prescribed Burns and Cultural Burns on Soil Properties in Southeastern Australia', *Fire*, vol. 7, no. 3, pp. 75, DOI: 10.3390/fire7030075

NSW Agriculture 2000, Understanding Soil pH. Leaflet No.2, NSW Agriculture, Orange (PDF 181KB)

NSW Government 2020, Wind erosion, Environment and Heritage, accessed 16 October 2024

OEH 2012, *The land and soil capability assessment scheme – Second approximation*, NSW Office of Environment and Heritage, Sydney

OEH 2015, *Soil Erosion Climate Change Impact Snapshot*, NSW Office of Environment and Heritage, Sydney

Renard KG, Foster GR, Weesies GA, McCool DK & Yoder DC 1997, *Predicting Soil Erosion by Water: A guide to conservation planning with the Revised Universal Soil Loss Equation (RUSLE), Agricultural Handbook*, vol. 703, US Department of Agriculture, Washington, DC, pp. 1–251 (PDF 7.4MB)

Rengel Z 2011, 'Soil pH, soil health and climate change' in Singh BP, Cowie AL & Chan KY (eds), *Soil Health and Climate Change, Soil Biology vol.28*, Springer-Verlag GmbH, Berlin, pp. 69–85, DOI: 10.1007/978-3-642-20256-8_4

Sayedi SS, Abbott BW, Vannière B, Leys B, Colombarli et al. 2024, 'Assessing changes in global fire regimes', *Fire Ecology*, vol. 20, 18, DOI: 10.1186/s42408-023-00237-9

Schreefel L, Schulte RPO, de Boer IJM, Pas Schrijver A & van Zanten HHE 2020, 'Regenerative agriculture – the soil is the base', *Global Food Security*, vol. 26, 100404, DOI: 10.1016/j.gfs.2020.100404

Singh K & Whelan B 2020, 'Soil carbon change across ten New South Wales farms under different farm management regimes in Australia', *Soil Use and Management*, vol. 36, no. 4, pp. 616–32, DOI: 10.1111/sum.12590

SSA 2019, SOS value and services of Australia's soils, Soil Science Australia, accessed 17 July 2024

Stockmann U, Minasny B & McBratney AB 2014, 'How fast does soil grow?', *Geoderma, 216*, pp. 48–61, DOI: 10.1016/j.geoderma.2013.10.007

Ullah MR, Carrillo Y & Dijkstra F 2023, 'Relative contributions of fungi and bacteria to litter decomposition under low and high soil moisture in an Australian grassland', *Applied Soil Ecology*, vol. 182, 104737, DOI: 10.1016/j.apsoil.2022.104737

USDA n.d., Soil Health, U.S. Department of Agriculture, accessed 17 July 2024

This page intentionally
left blank

Protected areas and conservation

Building a network of terrestrial protected areas across NSW is key to securing and conserving our diverse ecosystems and the plants and animals they support.

Overview

The protected areas network covered

10.4%

of NSW as at 30 December 2023

Read more

Public protected areas made up

93%

of the protected areas network in NSW as at 30 December 2023

Read more

Protected areas are clearly defined areas of land or ocean, formally managed to achieve the long-term conservation of nature with associated ecosystem services and cultural values (**IUCN 2008**).

Conservation refers to the planned management of natural resources and protection of biological diversity (biodiversity) across landscapes. It includes measures to prevent biodiversity loss and to restore damaged habitats and ecosystems.

Why protected areas are important

Protected areas are a key component of conservation strategies and are managed to:

- safeguard biodiversity
- maintain ecosystems
- preserve and restore important habitats
- protect natural and cultural heritage
- build resilience to climate change.

Protected areas provide safe and healthy ecosystems for our native plants and animals. They also provide essential ecosystem services such as clean water, clean air, pollination and carbon storage. Ecosystem services have important social, economic and health benefits for human wellbeing.

Importantly, in NSW, protected areas also aim to provide opportunities for Aboriginal custodianship, access and connection with Country, and cultural practice. Joint management agreements give Aboriginal custodians a say in how Country is cared for through collaborative management of parks.

Networks of terrestrial (land-based) and marine (sea-based) protected areas aim to address biodiversity loss and ecosystem degradation at international, national and sub-national levels.

The information in this topic focuses on land-based protected areas and conservation in NSW.

See the **Coastal and marine** topic for more information on marine protected areas in NSW.

See the **Plants** and **Animals** topics for information on threats to native plants and animals in NSW, and monitoring and conservation programs.

Global and national frameworks and targets

The **International Union for Conservation of Nature** (IUCN) provides an internationally recognised framework for protected areas which includes:

- six management categories, applied to a protected area on the basis of management objectives
- four broad governance types, recognising that different decision-making authorities and owners can be responsible for the management of protected areas (**IUCN 2008**).

The IUCN framework and guidelines underpin the four governance types for protected areas in Australia's National Reserve System (**Commonwealth of Australia 2009**). These are:

- public protected areas (government owned)
- Indigenous Protected Areas
- private protected areas
- shared management reserves.

Australia is a signatory to international protocols and frameworks, including the **Convention on Biological Diversity** and the **Kunming–Montreal Global Biodiversity Framework**. Aligning to these, Australian state and territory governments have agreed to support six new national biodiversity targets under Australia's ***Strategy for Nature 2024–2030***:

- Ensure no new extinctions of native species and support the recovery of threatened species.
- Protect and conserve 30% of Australia's landmass and 30% of Australia's marine areas by 2030 (**National 30 by 30 Roadmap**).
- Prioritise degraded areas under effective restoration by 2030 to recover biodiversity and improve ecosystem functions and services, ecological integrity and connectivity.
- Minimise the impact of climate change on biodiversity and increase its resilience.
- Eradicate or control invasive species in priority landscapes and minimise their introduction by 2030.
- Increase Australia's circularity rate (by ensuring products are designed to be reused, repaired, recycled and repurposed) and reduce pollution and its impacts on biodiversity by 2030.

States and territories will implement measures and improve current programs to support efforts to meet these national targets.

National Reserve System

Australia has a network of formally protected terrestrial areas that make up the **National Reserve System** (NRS). Only areas that fall within the IUCN definition of a protected area form part of the NRS. These areas are protected through legal or other effective means and are managed in perpetuity (this means either permanently or for more than 99 years).

The NRS aims to conserve examples of our unique landscapes, plants, animals and important environmental values for future generations. By ensuring effective management of landscapes, a natural safety net is formed against some of our biggest environmental challenges, namely climate change and declining water resources.

See the **Pressures and impacts** section of this topic for more information.

Indigenous Protected Areas

Indigenous people have been protecting habitats, species and ecological functions for thousands of years. Formal recognition of these efforts by governments and the inclusion of **Indigenous Protected Areas** (IPAs) within the NRS began in 1997.

More than 50% of the NRS is made up of IPAs, but only 0.5% of the NSW NRS. Aboriginal communities voluntarily dedicate and manage their land as protected areas under a program jointly administered by the Australian Government and the National Indigenous Australians Agency. These areas hold deep cultural significance for Aboriginal peoples, who manage IPAs with the goal of protecting the environment and their cultural heritage.

By protecting habitats for threatened species and ecological communities, IPAs are making a significant contribution to Australia's biodiversity conservation efforts (**Little et al. 2023**).

See the **Health of Country** topic for more information.

Bioregions

The NRS rests on the **Interim Biogeographic Regionalisation for Australia (IBRA) framework** of bioregions. These are large, geographically distinct areas of land with distinguishing characteristics, such as climate, ecological features and plant and animal communities.

The Australian land mass is divided into 89 bioregions and 419 subregions. Subregions are used to provide more detailed information about landscapes and are used for finer, regional-scale planning of protected areas and conservation.

See **NSW bioregions** for information.

'Comprehensive, adequate and representative' system

Underpinning the NRS is the scientific framework, the '**comprehensive, adequate and representative**' (CAR) system of protected areas. The system aims to protect examples of all regional ecosystems within the bioregions through both public and private land conservation.

- ***Comprehensive:*** refers to the inclusion in the protected areas network of examples of the full range of regional-scale ecosystems in each bioregion.
- ***Adequate:*** refers to the inclusion of enough of each regional ecosystem within the protected areas network to provide ecological viability and maintain the integrity of animal and plant populations, species and communities.
- ***Representative:*** builds on the principle of comprehensiveness to cover the variability within regional ecosystems across each bioregion.

See the **Status and trends** section of this topic for more information.

Collaborative Australian Protected Areas Database

The **Collaborative Australian Protected Areas Database** (CAPAD) holds information on protected areas that are part of the NRS and offers an interactive dashboard. It is maintained by the Australian Government and is updated every two years, most recently in 2022.

As at 30 June 2022, the total land area of Australia was 768,828,859 hectares (ha), of which 169,941,262ha, or 22.1%, was reserved within protected areas.

Currently, less than 6% of Australia's protected areas are on private land.

> See the interactive **Australian Protected Areas Dashboard, as at 30 June 2022** for more information.

Protected areas system in NSW

The main land area of NSW includes all or part of 18 bioregions and 131 subregions of the IBRA framework, with Lord Howe Island contributing an additional bioregion and subregion.

The bioregions cover a diversity of landscapes, including sandy deserts, riverine plains, wetlands, rolling slopes and rocky ranges, rugged mountains, alpine environs, fragile wooded grasslands, rainforests, and coastal areas (**NPWS 2003**).

The terrestrial protected area network (also called the protected areas system) on public and private lands throughout NSW includes a range of habitats and ecosystems, a diversity of plant and animal species, significant geological features and landforms, Aboriginal cultural heritage sites and landscapes, heritage buildings and historic sites.

Protected areas and Aboriginal access to Country

For Aboriginal peoples, colonisation has caused dispossession of their traditional lands and prevented access to Country, especially on private lands. Opportunities are now emerging for Aboriginal peoples and communities to access, protect and manage Country through formal and informal agreements on both public and private lands.

This includes through Aboriginal joint management agreements and partnerships with government agencies and non-government conservation organisations, and also through the establishment of Indigenous Protected Areas in NSW.

Public protected areas

Conservation in NSW is centred on public protected areas, in particular the national parks system and flora reserves, and relies on a mixture of biodiversity, conservation and land protection legislation. **National parks and reserves**, and **flora reserves** in State forests, currently make up almost 93% of the protected areas in NSW.

The **NSW National Parks Establishment Plan 2008** sets out how new parks are established, and the conservation priorities for acquiring new land and enhancing the parks system. It is currently being reviewed, and a revised plan is under development by the NSW National Parks and Wildlife Service (NPWS).

The NPWS Aboriginal joint management program started in 1998 and, at 30 June 2024, around 30% of the national parks estate is jointly managed with Aboriginal peoples. There are also a number of joint management arrangements for areas of State forests.

Private protected areas

Many threatened ecosystems, plants, animals and cultural sites are found on privately owned land outside the protection of public protected areas.

With more than 70% of NSW's land managed privately (**BCT n.d.**), private land conservation is increasingly important in NSW to improve biodiversity conservation outcomes. Policies and programs have been established to increase the area of private land, including land leased from the Crown, that is managed as part of the formal protected areas network.

The ***Biodiversity Conservation Investment Strategy*** sets the NSW Government's priorities and targets for private land conservation. It maps areas of the State into five Priority Investment Areas, guiding the investment priorities of the **NSW Biodiversity Conservation Trust** (BCT). The strategy explains the criteria and data used for the identification of priority investment areas.

To help to address the issue of dispossession of Aboriginal peoples from their traditional lands, especially from private lands, the BCT has developed 'respect and recognition' guidance to provide support for private landowners to meet and learn from local Aboriginal communities and knowledge holders about the cultural values of their properties. This is aimed at strengthening relationships between local Aboriginal communities and landowners and improving access to Country and a better understanding of how to care for Country.

See the **Health of Country** topic for more information.

Many **non-government organisations** play an important role in private land conservation. They also partner with Aboriginal peoples to manage private protected areas and for conservation purposes. Some have long-standing relationships with Aboriginal communities.

Other areas managed for conservation

Areas of public and private land that do not meet the protected areas definition and requirements can still be managed for conservation purposes. They contribute to the overall aim of improving biodiversity conservation in NSW but do not count towards the formal network or targets. They include public land such as Crown land and State forest, private land under BCT agreements that are not permanent (term agreements), and other land owned by private individuals and business or non-government conservation organisations. Some may be eligible to become part of a proposed conserved areas network.

Conserved areas

Under the **National Other Effective Area-based Conservation Measures (OECM) Framework**, agreed to by the Australian, state and territory governments in June 2024, additional areas of high biodiversity value may now be eligible to become **conserved areas**.

Known as OECMs internationally, and conserved areas in Australia, they are lands which are recognised as providing ongoing suitable conditions for nature conservation although this is not their primary goal. This means they are places where formal protection is not possible, appropriate or supported.

Alongside the protected areas network, the conserved areas network will contribute to **national and global targets** to protect and conserve 30% of land by 2030.

Key legislation for the development of formally protected areas and biodiversity conservation in NSW, on both public and private land, is described in **Table L2.1**.

Table L2.1: Current key legislation and policies relevant to protected areas

Legislation or Policy	Summary
Aboriginal Land Rights Act 1983	Provides for land rights for Aboriginal persons in NSW. Provides for the creation of Aboriginal Land Councils, and for land to be vested in those Councils.
Biodiversity Conservation Act 2016	Aims to protect biodiversity and foster a productive, resilient environment while enabling ecologically sustainable development. Provides for private land conservation arrangements and funding in NSW.
Biosecurity Act 2015 (Commonwealth)	Manages biosecurity threats to plans, animal and human health in Australia and Australian territories
Crown Land Management Act 2016	Allows for Crown reserves to be set aside for public purposes, including environmental and heritage protection. Facilitates the use of Crown land by Aboriginal peoples and enables co-management of dedicated or reserved Crown land.
Forestry Act 2012	Provides for the dedication, management and sustainable use of State forests and other Crown-timber land for forestry and other purposes. All Flora Reserves contribute towards the **National Reserve System**.
Greater Sydney Parklands Trust Act 2022	Provides for the management of the Greater Sydney Parklands Trust estate. Ensures the conservation of the natural and cultural heritage values, and the protection of the environment, within the parklands estate.
Local Land Services Act 2013	Governs the management of natural resources, biosecurity and agricultural production in NSW. Private land with suitable types of property vegetation plans contribute towards the **National Reserve System**.
National Parks and Wildlife Act 1974	Aims to conserve the natural and cultural heritage of the state of New South Wales through the establishment of national parks and reserves. Parks and reserves under this Act contribute to the **National Reserve System**.
Native Title (NSW) Act 1994	Sets out how native title rights must be recognised and protected. Section 211 preserves native title holders' rights to hunt, fish, gather resources and undertake cultural activities.
Commonwealth Acts bringing effect to Indigenous Protected Areas	**Indigenous Protected Areas** are dedicated reserves formed by agreement between the Australian Government and Indigenous Australians. They are recognised as contributing to the **National Reserve System**.
Biodiversity Conservation Investment Strategy 2018	Guides the NSW Government's investment to deliver private land conservation programs in NSW. All permanent (in perpetuity) agreements administered by the **Biodiversity Conservation Trust** are recognised as contributing to the **National Reserve System**.

Notes:
See the **Responses** section for more information about about how **Protected areas and conservation** is managed in NSW

Related topics: **Animals** | **Climate change** | **Coastal and marine** | **Extreme climate and weather** | **Health of Country** | **Plants** | **Rivers and wetlands**

Status and trends

Protected areas and conservation indicators

This report uses five indicators to assess the status of protected areas and conservation in NSW (see **Table L2.2**):

- **Total area of the NSW terrestrial protected areas network** measures the total of public and private land areas in the NSW protected areas network. It includes land that is permanently and securely protected under legal mechanisms (in perpetuity). There has been stable growth in the total area protected over recent years, but there is a need for this to accelerate to improve the 'comprehensive, adequate and representative' system in NSW, and to contribute to national targets under the ***Strategy for Nature 2024–2030*** NRS targets for 2030. The indicator status is assessed as moderate (see the **Total area of NSW protected areas system** section in this topic for more information).
This indicator aligns to the 'land system change' planetary boundary. Globally, this boundary has been crossed. See **Planetary boundaries alignment**.
- **Growth in public protected areas** has stabilised at levels similar to the previous three years for national parks and reserves. The overall status of the indicator is assessed as moderate and the trend stable. Three large properties were purchased by the NSW Government during this period but not yet formally added to the national parks estate. When included, about 11.1% of NSW will be in public protected areas (see the **Growth in national parks and reserves** section in this topic for more information).
- **Growth in private protected areas** is assessed as moderate, showing a stable trend over the past three years in the growth of private land protected in-perpetuity under agreements administered by the BCT. Less than 1% of NSW is protected under permanent agreements on private land (see the **Private protected areas in NSW** section in this topic for more information).
- **Protected areas owned or jointly managed by Aboriginal peoples** remained stable over the past three years. The overall status of this indicator remains moderate and stable (see the **Indigenous Protected Areas** and **joint management** sections in this topic for more information).
- **Coverage of regional ecosystems in the NSW protected areas network** is assessed as poor. This new indicator considers current information on the progress towards a 'comprehensive, adequate and representative' protected areas system in NSW. While the trend is considered stable as there have been improvements in the proportion of regional ecosystems sampled at bioregion and subregion levels, progress is well below targets and there are still many ecosystems that are poorly protected, or not sampled at all, in the protected areas system (see the **'Comprehensive, adequate and representative' protection** section in this topic for more information).

Table L2.2: Protected areas and conservation indicators

Indicator	Environmental status	Environmental trend	Information reliability
Total area of the NSW terrestrial protected areas network	MODERATE	Stable	Good
Growth in public protected areas	MODERATE	Stable	Good
Growth in private protected areas	MODERATE	Stable	Good
Protected areas owned or jointly managed by Aboriginal peoples	MODERATE	Stable	Good
Coverage of regional ecosystems in NSW protected areas network	POOR	Stable	Reasonable

Notes:
Indicator table scales:
- **Environmental status**: Good, moderate, poor, unknown
- **Environmental trend**: Getting better, stable, getting worse
- **Information reliability**: Good, reasonable, limited.

See **Indicator guide** to learn how terms and symbols are defined.

See the **Planetary boundaries alignment** page for more information about how indicators align.

Total area of NSW protected areas system

NSW has a total land area of 80,115,000 hectares. As at 31 December 2023, the protected areas network in NSW covered more than 8.3 million hectares, about 10.4% of the State (**NPWS unpub.**). This included:

- 7.7 million hectares of public protected areas in the national parks system and flora reserves
- 37,940 hectares of Indigenous Protected Areas
- 513,500 hectares of private protected areas administered under permanent BCT agreements
- 79,500 hectares in the Southern Mallee Reserves and eligible private property vegetation plans
- 1,270 hectares protected in the Lord Howe Island group.

The total has grown since 2018, when public protected areas were estimated as 7.2 million hectares (9%) and private protected areas as 0.4% (OEH 2018).

Public protected areas account for almost 93% of the NSW protected areas network.

Public protected areas in NSW

Public lands that meet formal reserve standards under the International Union for Conservation of Nature (IUCN) categories are a core component of the NSW protected areas network (see **Map L2.1**).

The public reserve system conserves native plants and animals, a broad range of ecosystems, threatened species and habitats, and protects Aboriginal cultural and archaeological values.

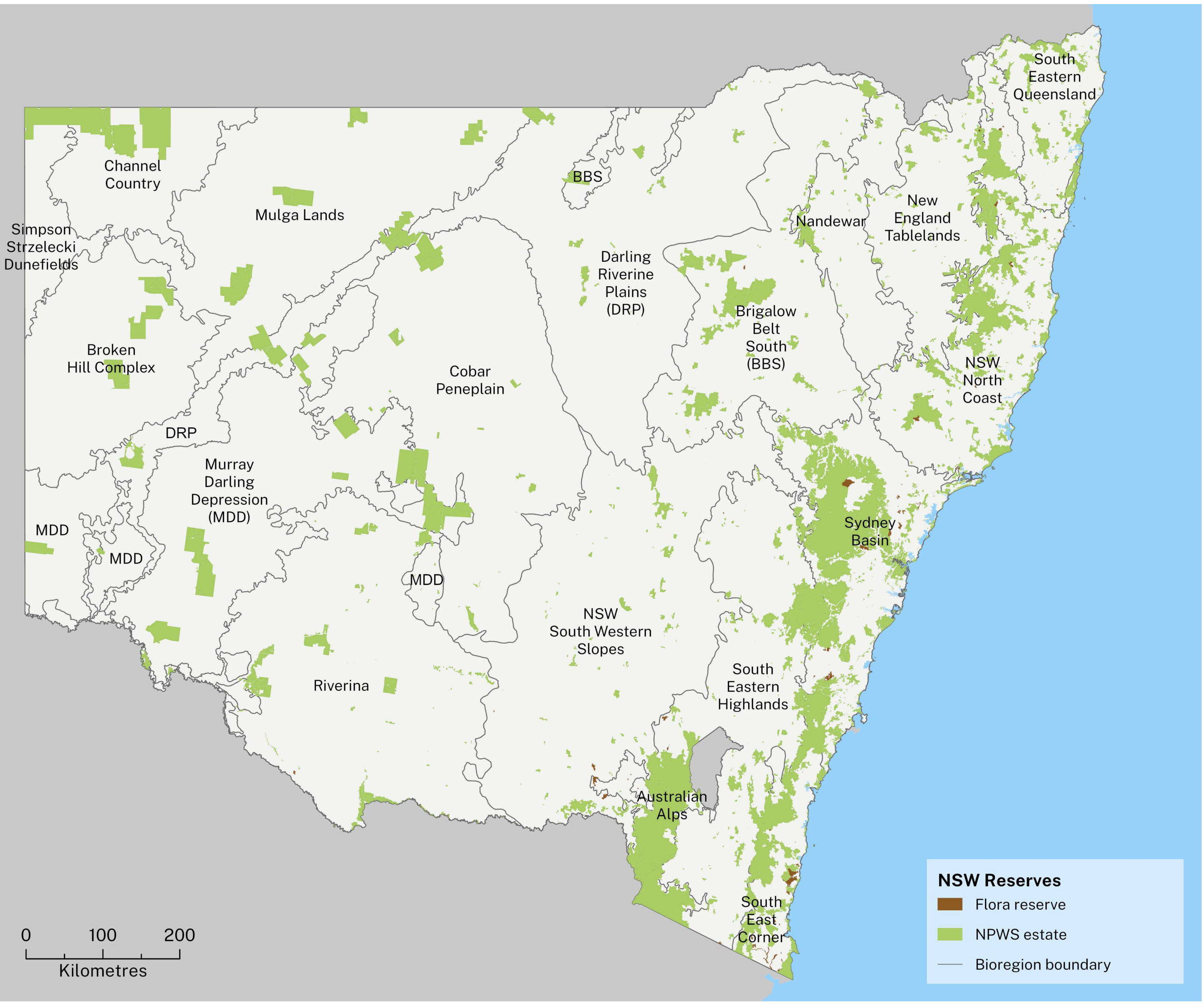
National parks and reserves (national parks estate):

- 7,634 million hectares (9.5% of the State)
- includes national parks, regional parks, nature reserves, state conservation areas, karst conservation reserves, historic sites and Aboriginal areas
- established under the ***National Parks and Wildlife Act 1974*** and managed by the NSW National Parks and Wildlife Service (NPWS).

Flora reserves:

- 65,848 hectares of NSW State forest lands (almost 0.1% of the State):
  - 27,478 hectares managed by the Forestry Corporation of NSW (65 reserves)
  - 38,370 hectares managed by the NPWS (23 reserves)
- declared under the provisions of the ***Forestry Act 2012***
- flora reserves under NPWS management do not form part of the national parks estate.

Map L2.1: National parks and flora reserves in NSW, December 2023



Notes:

View the interactive version of this map.

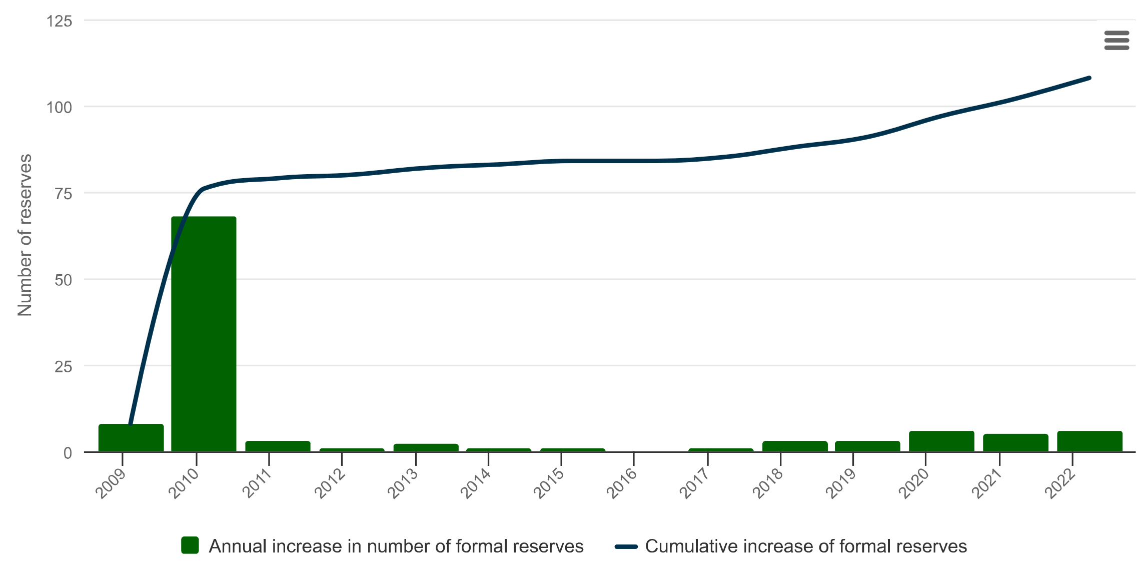
Source:

NPWS data December 2023

Growth in national parks and reserves

Since the *NSW State of the Environment 2021*, there have been 45 additions to existing NPWS parks and reserves, and 11 new NPWS reserves (**Figure L2.1**).

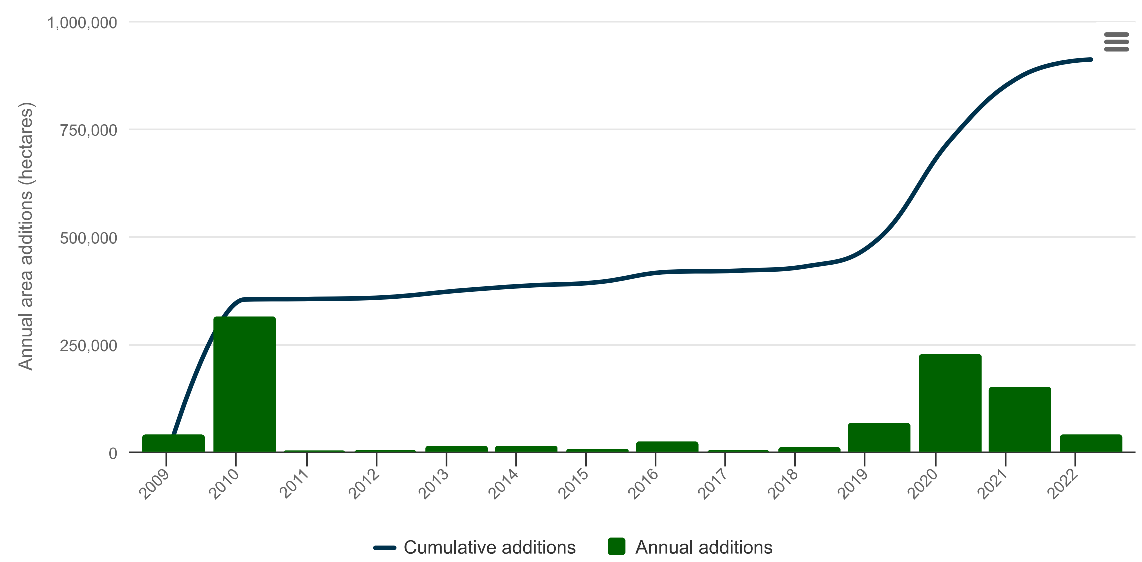
Figure L2.1: Annual additions to national parks in NSW since 2009, by number (new reserves)



Source:
NPWS data 2024

The additions and new reserves during 2021–22 and 2022–23 added a total of 187,192 hectares to the national parks estate (**Figure L2.2**).

Figure L2.2: Annual additions to national parks in NSW since 2009, by area (ha)



Source:
NPWS data 2024

The three largest additions during this time contributed about 140,000 hectares of the 187,192 hectares total.

Table L2.3 shows how the additions contribute to improvements in the 'comprehensive, adequate and representative' (CAR) reserve system.

Table L2.3: Contribution of additions to the CAR reserve system				
Reserve	Area (ha)	Comprehensive	Adequate	Representative
Langidoon–Metford State Conservation Area	60,416	Broken Hill Complex C now 54%	Increasing the area under reservation for four poorly reserved and five previously unsampled, regional ecosystems	Barrier Range R now 85.7%; Barrier Range Outwash now 42.9%
Koonaburra National Park	45,534	Cobar Peneplain C now 55.6%; Murray Darling Depression C now 81.6%	Increasing the area under reservation for eight poorly reserved and four previously unsampled regional ecosystems	Barnato Downs R now 61.9%; Darling Depression R now 66.7%
Brindingabba National Park	33,904	[no change]	Increasing the area under reservation for two poorly reserved and one previously unsampled regional ecosystems	West Warrego R now 50%

Notes:
Comprehensiveness (C) – the proportion of the range of regional ecosystems that have been sampled by the reserve system in each respective IBRA bioregion.
Adequacy – increases in the area of a regional ecosystem under reservation within an IBRA subregion.
Representativeness (R) – the proportion of the range of regional ecosystems that have been sampled by the reserve system in each respective IBRA subregions.

IBRA = Interim Biogeographic Regionalisation for Australia

Source:
NPWS data 2024

Other key contributions to the growth in reserves:

- 28,322 hectares – the new Gardens of Stone State Conservation Area, in the South-Eastern Highlands and Sydney Basin bioregions
- 4,561 hectares – additions to Oxley Wild Rivers National Park, in the NSW North Coast bioregion
- 2,411hectares – additions to Culgoa National Park, in the Darling Riverine Plains and Mulga Lands bioregions.

Public land acquired but not yet formally reserved

Three further properties acquired by the NSW Government over recent years are in the process of being formally reserved (gazetted) as part of the national parks system for inclusion in the NSW protected areas network.

These properties total 596,200 hectares and contribute significantly to the CAR reserve system in the bioregions:

- 437,390 hectares – Thurloo Downs (Channel Country, Mulga Lands)
- 121,390 hectares – Avenel Station (Simpson Strzelecki Dunefields, Broken Hill Complex)
- 37,420 hectares – Comeroo Station (Mulga Lands).

Once they are added, the protected areas network will increase from 10.4% to about 11.1% of NSW.

Aboriginal joint management

Aboriginal joint management in NSW formally recognises the connection of Aboriginal people to Country and facilitates involvement in management and decision-making, particularly for national parks and reserves.

At 30 June 2024 almost 2,335,000 hectares (30%) of the NSW national parks estate is managed under 34 **joint management agreements** with Aboriginal peoples (see **Map L2.2**):

- **17 Memoranda of Understanding** totalling 1,572,778 hectares cover agreements between Aboriginal communities and the Department of Climate Change, Energy, the Environment and Water over access to and management of a park or reserve.
- **10 Indigenous Land Use Agreements** totalling 588,997 hectares allow traditional owners who are native title holders or claimants to negotiate and establish a joint management partnership for a national park or reserve with the NSW Government under the *Native Title Act 1993*.
- **7 Aboriginal ownership and lease-back** agreements totalling 173,794 hectares allow land to be returned to local Aboriginal land councils to hold on behalf of Aboriginal owners and lease back to the NSW Government under Part 4A of the *National Parks and Wildlife Act 1974* and the *Aboriginal Land Rights Act 1983*.

Joint management arrangements also exist for other types of public lands such as State forests and Crown reserves although not all are within the protected areas network.

Aboriginal peoples hold freehold title to 2.3% of the national park estate. Following determinations in 2024, **Native title** has been formally recognised in more than 6% of the NSW national park estate.

Indigenous Protected Areas

Aboriginal people manage Indigenous Protected Areas (IPAs) for biodiversity conservation under voluntary agreements with the Australian Government.

There are 11 IPAs in NSW with a total land area of 37,939 hectares (0.5% of NSW protected areas). They are listed in **Table L2.4** with their subregions and are shown in **Map L2.2**.

Table L2.4: Indigenous Protected Areas in NSW

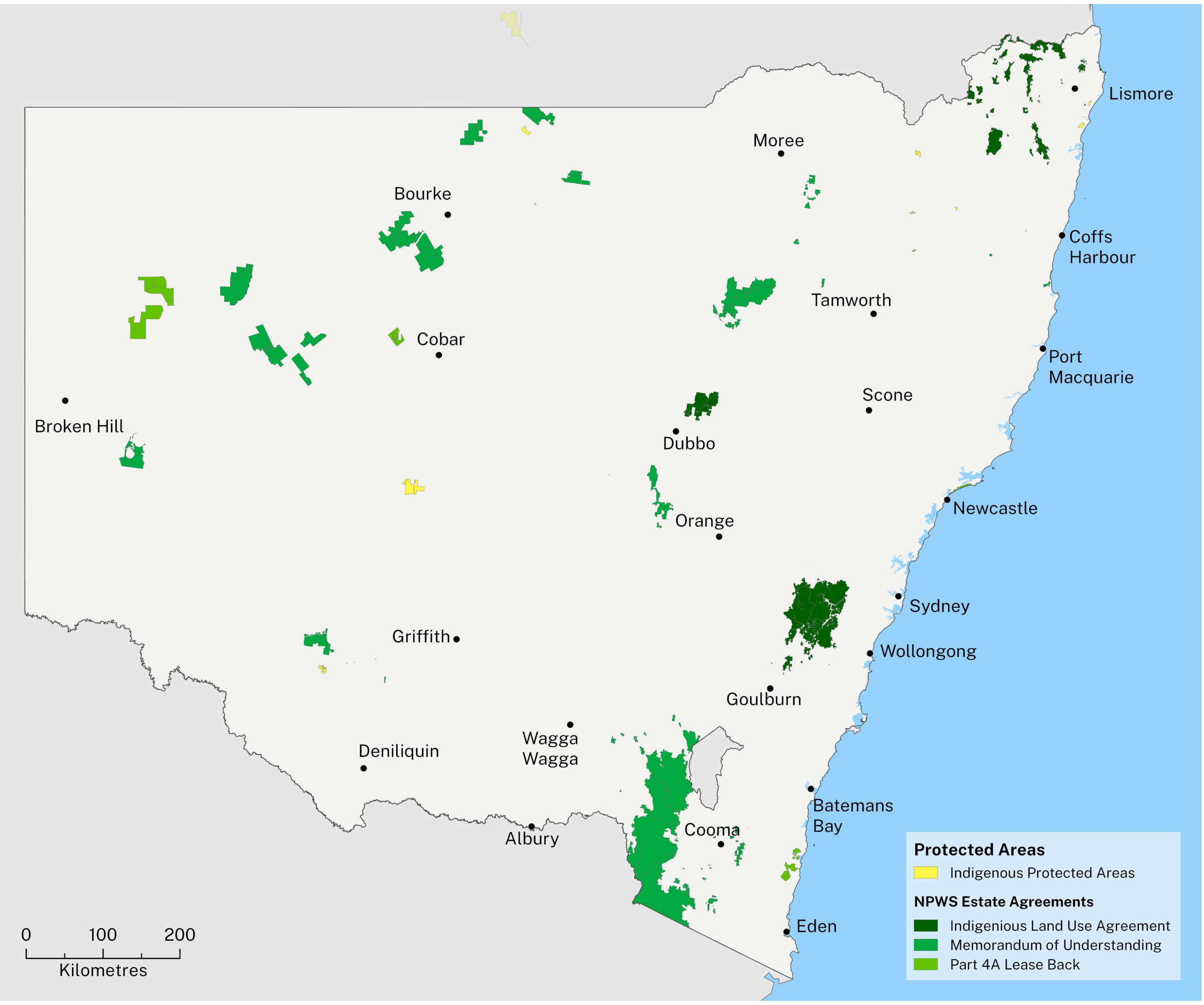
Name	Area (ha)	IBRA regions
Boorabee and The Willows	2,712	New England Tablelands
Brewarrina Ngemba Billabong	261	Darling Riverine Plains
Dorodong	85	NSW North Coast
Gumma	111	NSW North Coast
Mawonga	21,987	Cobar Peneplain, Murray Darling Depression
Minyumai	2,160	South Eastern Queensland (NSW area)
Ngunya Jargoon	861	South Eastern Queensland (NSW area)
Tarriwa Kurrukun	929	New England Tablelands
Toogimbie	4,114	Riverina
Wattleridge	645	New England Tablelands
Weilmoringle	4,073	Darling Riverine Plains, Mulga Lands
Total	**37,939**	

Notes:
About 21,000 hectares of land in IPAs are managed under BCT agreements.
IBRA = Interim Biogeographic Regionalisation for Australia.

Source:
DCCEEW-Aus 2022

Map L2.2 shows Indigenous Protected Areas in NSW and also areas where joint management agreements exist for areas of the national parks estate (but not joint management agreements with other government agencies or on private protected areas).

Map L2.2: Indigenous Protected Areas and joint management



Source:
DCCEEW data 2024, DCCEEW-Aus

Private protected areas in NSW

With more than 70% of the State under private ownership or Crown lease, private land conservation has the potential to play a vital role in conserving biodiversity in NSW.

As at 30 June 2024, approximately 0.8% of NSW is private land that is included in the protected areas network, this includes:

- 536,000 hectares managed under permanent agreements with the BCT
- 79,500 hectares in the **Southern Mallee Reserves** and in-perpetuity property vegetation plans (to conserve biodiversity).

A further 1,525,000 hectares (2% of NSW) is managed for conservation purposes under the BCT time-bound (term) or revocable agreements, but as these are not held in perpetuity, they do not contribute to the formal protected areas network.

Private land conservation agreements

As at 30 June 2024, the BCT was responsible for managing 2,426 **private land conservation** agreements with landholders. These agreements cover more than 530,000 hectares that contribute to the NSW protected areas network and the **National Reserve System** (NRS).

Since 2018, 536 landholders have entered or plan to enter into a conservation agreement with the BCT, conserving private land across about 319,000 hectares (see **Figure L2.4**).

The BCT is investing more than $290 million to support these agreements (**BCT 2024**). This investment is split 71% for in-perpetuity (permanent) agreements and 29% for term agreements (minimum of 15 years). The permanent agreements are recognised as contributing to the formal protected areas network in NSW.

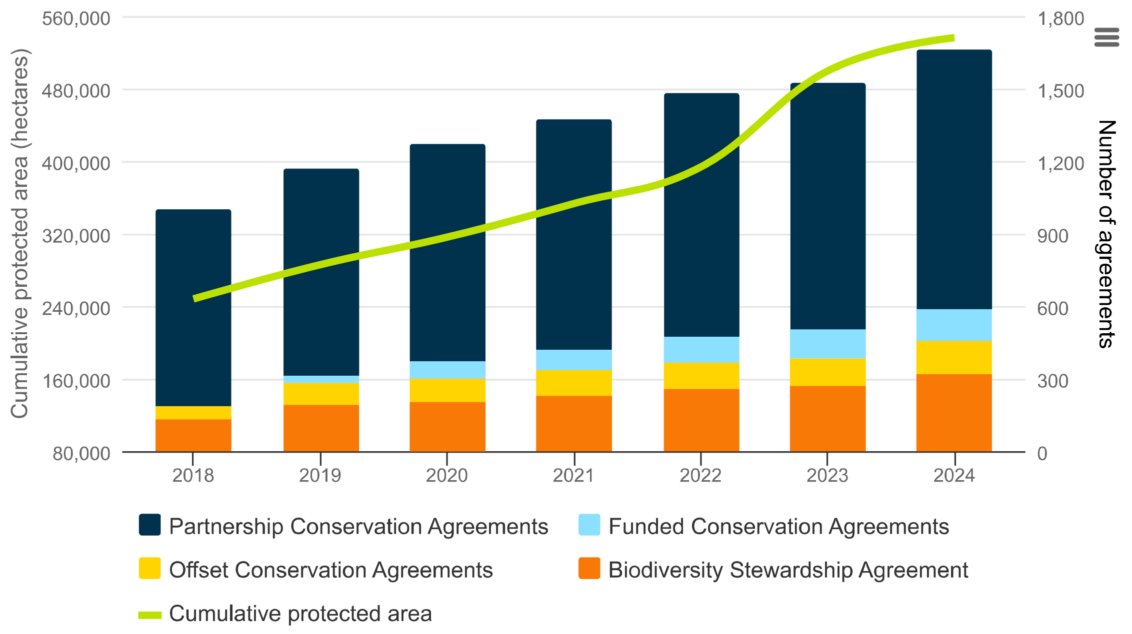
As at 30 June 2024, BCT was administering 1,662 permanent agreements representing a total of 536,310 hectares that are part of the NSW protected areas network and contribute to the NRS.

Four main categories of permanent agreements contribute to the NSW protected areas network:

- Partnership Conservation Agreements
- Funded Conservation Agreements (in perpetuity)
- Offset Conservation Agreements
- Biodiversity Stewardship Agreements.

These are shown in **Figure L2.3** and **Table L2.5**.

Figure L2.3: Private protected areas in NSW, June 2024



Source:
BCT data June 2024

A further 764 agreements administered by BCT, covering a combined total area of 1,525,716 hectares, are being managed for conservation purposes but are not part of the formal protected area network.

The breakdown of all agreements is shown in **Table L2.5** and in **Map L2.3**.

Table L2.5: Private land conservation agreements and area in NSW (administered by the BCT)

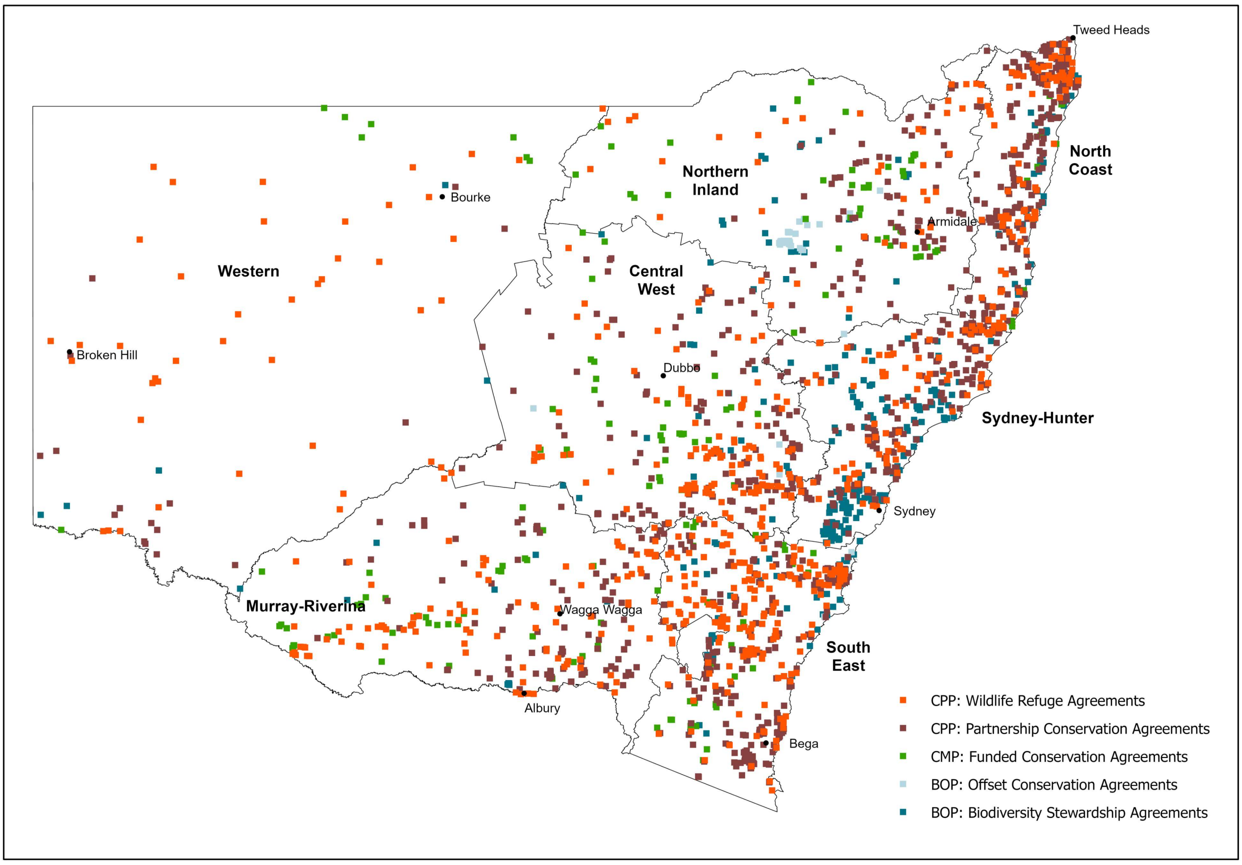
Agreement type	No.	Area (ha)
In-perpetuity Registered Property Agreements (pre-BCT)	243	12,399
Trust Agreements (pre-BCT)	118	54,273
Conservation Agreements (pre-BCT) (eligible for grants only)	427	147,655
Conservation Agreements (BCT)	288	50,895
Funded, in-perpetuity Conservation Agreements (BCT)	129	143,325
Offset Conservation Agreements (pre-BCT)	56	10,384
Offset Conservation Agreements (BCT)	82	35,824
Biodiversity Stewardship Agreements (pre-BCT)	187	22,682
Biodiversity Stewardship Agreements (BCT)	132	58,872
Agreements contributing to the protected area network/NRS	**1,662**	**536,310**
Wildlife Refuges (pre-BCT)	646	1,465,212
Wildlife Refuge Agreements (BCT)	20	905
Registered Property Agreements (pre-BCT)	46	4,325
Funded, term Conservation Agreements (BCT)	52	55,274
Other agreements (non NRS)	**764**	**1,525,716**
All agreements managed by the BCT	**2,426**	**2,062,027**

Notes:
The BCT commenced operating in August 2017. The table splits data on agreements into those entered into with the BCT and past agreements ('pre-BCT').

Source:
BCT data June 2024

The distribution of private land under conservation agreements managed by the BCT is shown in **Map L2.3**. The map shows land under permanent agreements that contribute to the protected areas system, as well as land under non-permanent agreements.

Map L2.3: All private land conservation agreements managed by the BCT



Notes:
The map includes private land under permanent agreements that contributes to the NSW protected areas network, and other land managed for conservation under non-permanent agreements that does not contribute.

Source:
BCT data June 2024

Through these agreements with the BCT, unique landscapes, threatened ecosystems and habitats for threatened native plant and animal species and ecological communities are protected and managed for conservation by private landholders, Aboriginal peoples and non-government organisations.

In 2018, the BCT met the first target under the ***Biodiversity Conservation Investment Strategy*** to protect 30 landscapes not represented, or inadequately represented, across other protected areas (**BCT 2021**). In 2024 it met its four-year business plan target to secure 200,000 hectares of private land under a BCT agreement (**BCT 2024**).

It is estimated that the current agreements protect at least 216 unique threatened species and at least 32 threatened ecological communities.

See the **Private land conservation outcomes** for more information.

Cultural land management practices on Country

In 2023, the Nari Nari Tribal Council signed a Conservation Agreement with the BCT to fund cultural land management practices and conservation efforts across the 55,220 hectare Gayini Conservation Area, located between Hay and Balranald, in south-western NSW.

> The agreement embeds the role of traditional custodians in managing land for current and future generations and is the largest private land holding to be funded, in perpetuity, by the NSW Government. This conservation demonstrates the NSW Government's commitment to caring for Country obligations of Aboriginal landholders
>
> **Source: BCT media release**

Non-government organisations (NGOs) establish and manage land for the purpose of conservation, including areas that contribute to the protected areas network and 'comprehensive, adequate and representative' system in NSW. In addition to purchasing properties, some NGOs also manage other areas for restoration, protection and conservation for private landholders and government.

NGOs own or manage a total of about 106,760 hectares of land for the purpose of nature conservation and are included in CAPAD (2022) as part of the protected areas network in NSW and the NRS (**DCCEEW-Aus 2022**). Many of these areas are managed under permanent conservation agreements administered by the BCT.

'Comprehensive, adequate and representative' protection

The NSW Government monitors the development of the 'comprehensive, adequate and representative' (CAR) system of protected areas across both public and private lands, and assesses progress against national targets.

The purpose of a CAR protected area system is to conserve samples of all regional ecosystems across the range of environments in which they occur. Protecting an 'example' of a regional ecosystem means that part of the ecosystem is protected under a permanent legal mechanism, for example, a national park or a permanent BCT conservation agreement. The NPWS uses the term 'sampled' in this context.

The following describes the CAR protected area system in NSW as of December 2023 (excluding Lord Howe Island). It includes both public and private protected areas that are permanently and securely protected for nature conservation. It also takes into consideration areas acquired for the national parks system but not yet formally gazetted.

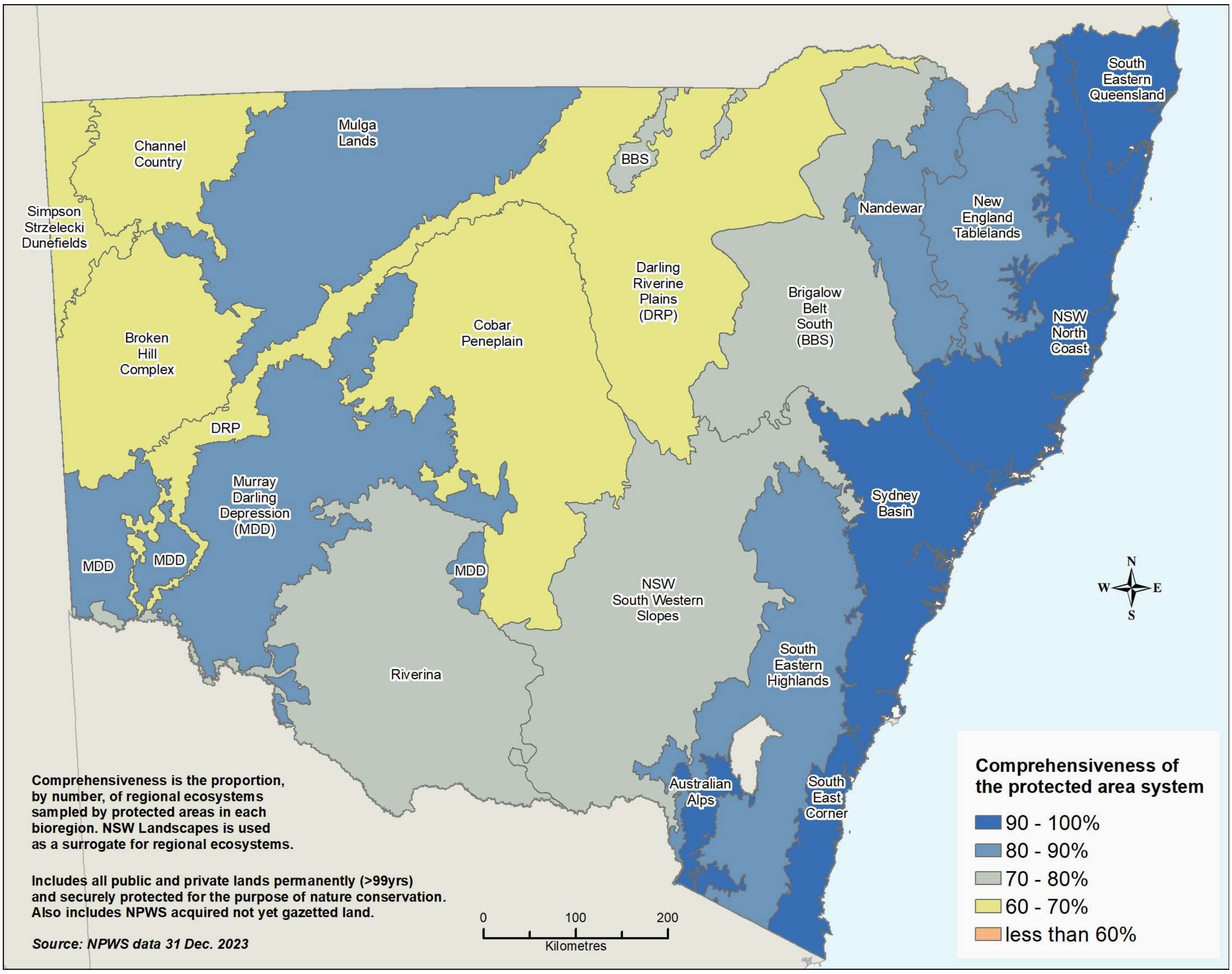
Comprehensiveness – measured at bioregion level

NSW has 794 regional ecosystems by IBRA bioregion. Of these, 653 (82%) have been sampled in the protected area system.

The comprehensiveness target of 80% (of regional ecosystems sampled) has been achieved in 10 of the 18 bioregions. The Darling Riverine Plains has the lowest score, at 61% (see **Map L2.4**). Of the 18 bioregions:

- 5 have a score of 90%–100% (dark blue areas)
- 5 have a score of 80%–90% (mid-blue areas)
- 3 have a score of 70%–80% (grey-green areas)
- 5 have a score of 60%–70% (yellow areas).

Map L2.4: Comprehensiveness of the public and private protected area system in NSW bioregions



Notes:

'NSW Landscapes' is used to represent regional ecosystems. NSW Landscapes are based on patterns in rainfall, temperature, topography (shape and features of the land), drainage patterns, geology, soil and vegetation. There are 570 NSW Landscapes (Mitchell 2002).

IBRA = Interim Biogeographic Regionalisation for Australia.

Source:
NPWS December 2023

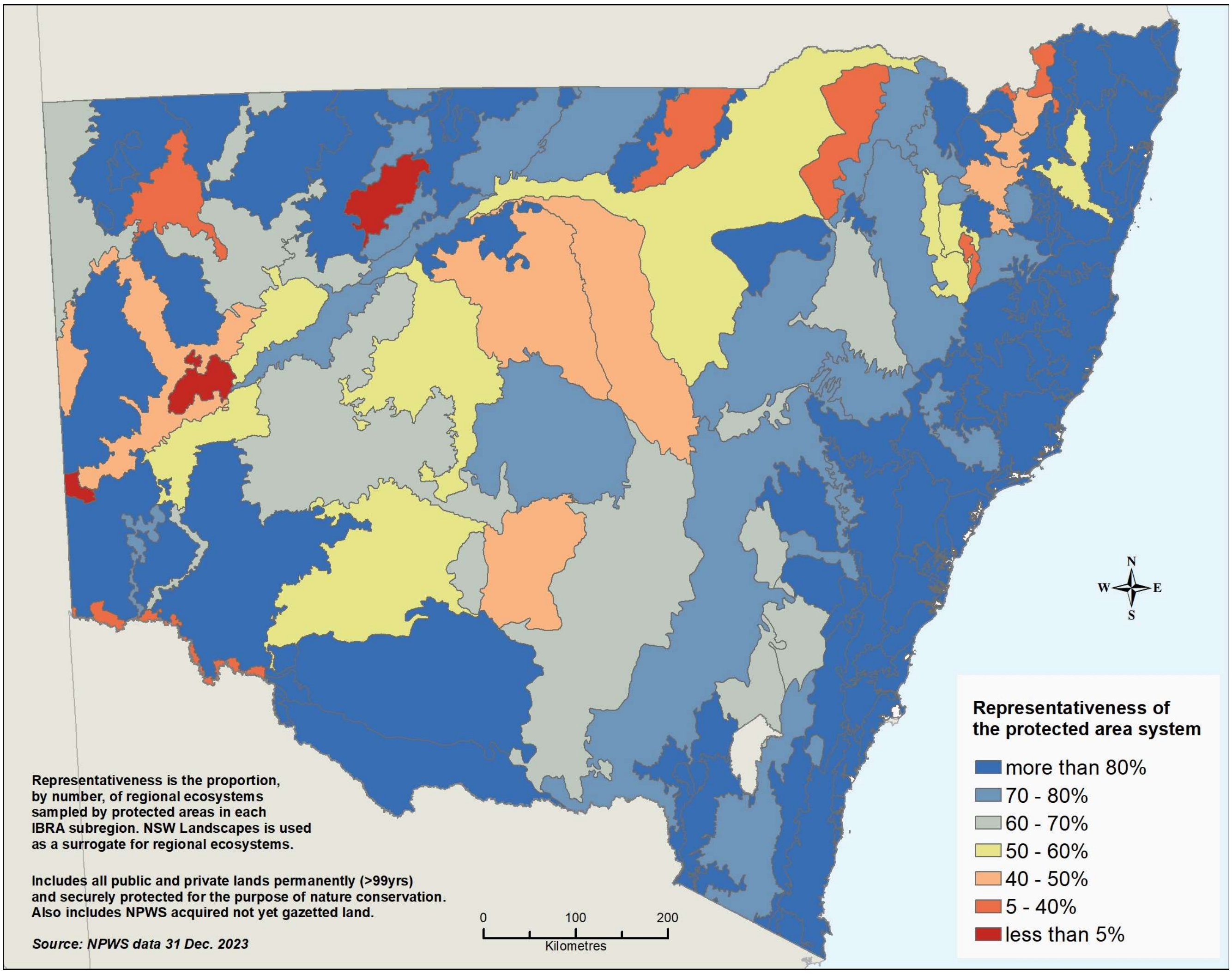
Representativeness – measured at subregion level

NSW has 1,221 regional ecosystems by IBRA subregion. Of these, 962 (79%) have been sampled in the protected area system.

The representativeness target of 80% (of regional ecosystems sampled) has been achieved in only 75 of the 131 subregions (see **Map L2.5**). Of these 131 subregions:

- 70 have a score of more than 80% (dark blue areas)
- 22 have a score of 70%–80% (mid-blue areas)
- 13 have a score of 60%–70% (grey-green areas)
- 8 have a score of 50%–60% (yellow areas)
- 15 have a score of less than or equal to 50% (orange areas, two shades)
- 3 have a score of 0% (red areas – shown on the map as <5%).

Map L2.5: Representativeness of the public and private protected area system in NSW IBRA subregions



Notes:

'NSW Landscapes' is used to represent regional ecosystems. NSW Landscapes are based on patterns in rainfall, temperature, topography (shape and features of the land), drainage patterns, geology, soil and vegetation. There are 570 NSW Landscapes (Mitchell 2002).

IBRA = Interim Biogeographic Regionalisation for Australia.

Source:
NPWS December 2023

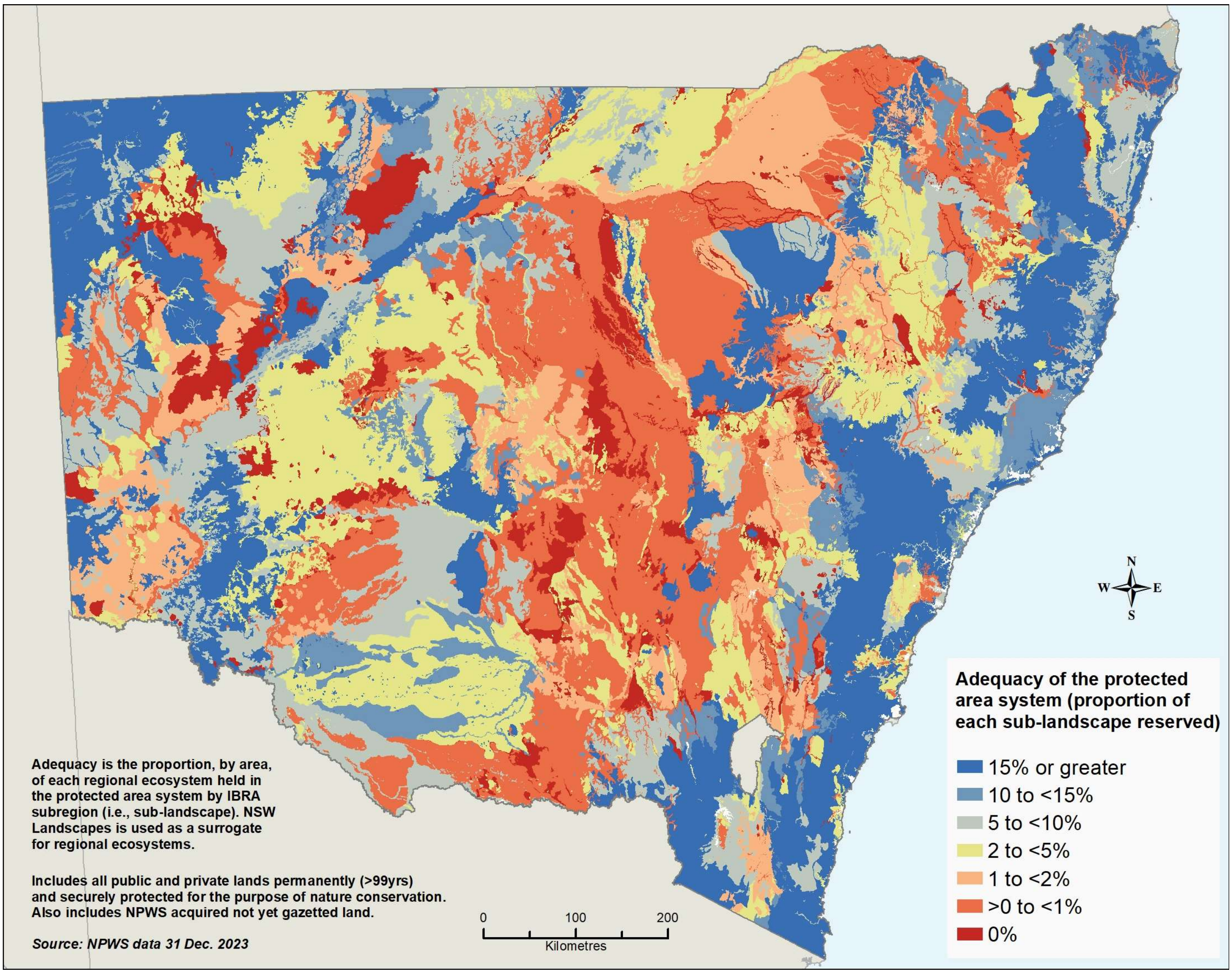
Adequacy – ecological viability of sampled regional ecosystems

Adequacy considers the viability of each sampled regional ecosystem by IBRA subregion (also known as sub-landscapes) and measures the proportion of each held within protected areas.

The adequacy target of 15% (of each sub-landscape being sampled within the protected areas system) has been achieved in 31% of sub-landscapes (see **Map L2.6**).

- The best protected ecosystems are those on the steep ranges of eastern NSW, parts of the coast and the Australian Alps (dark blue areas).
- Additions to the protected area system in recent years have led to substantial improvements in adequacy in the north-west of the NSW (dark blue areas).
- There remain many poorly protected ecosystems in Far Western NSW, the Northern and Central tablelands and the Western Slopes (dark orange and red areas).
- Much of the land under-represented in protected areas is heavily fragmented agricultural land, particularly in the Central West. Significant rehabilitation and revegetation is required to halt species loss.

Map L2.6: Adequacy of the public and private protected area system in NSW



Notes:

'NSW Landscapes' is used to represent regional ecosystems. NSW Landscapes are based on patterns in rainfall, temperature, topography (shape and features of the land), drainage patterns, geology, soil and vegetation. There are 570 NSW Landscapes (Mitchell 2002).

IBRA = Interim Biogeographic Regionalisation for Australia.

Source:
NPWS December 2023

Many regional ecosystems are highly fragmented by other land uses, with remnants often too small to retain viability. Ongoing development of a CAR protected area system across a combination of public and private lands will require rehabilitation and revegetation of some areas in order to achieve targets.

The NSW Government is continuing to explore adding new, large areas of land in under-represented areas to the public reserve system when opportunities arise. Private land conservation agreements also have an important part in expanding areas under permanent conservation that contribute to the CAR protected area system.

This is particularly important given future threats from climate change, such as fire and drought, which could reduce the amount of viable land.

Other areas managed for conservation in NSW

Other areas of land are managed for conservation in NSW that do not meet the requirements for inclusion in the formal protected areas system. These include areas of State forests, Crown land and private land. Some of these areas may meet the requirements to be conserved areas under the OECM Framework.

Areas managed for conservation can supplement protected areas by providing vegetation corridors linking larger public reserves and protecting natural ecosystems that are under-represented or not present in the NSW protected areas network.

State forest management zones

Forestry Corporation of NSW manages more than 2 million hectares of State forests, including:

- 1.85 million hectares of native forest
- 34,000 hectares of hardwood plantation
- 230,000 hectares of softwood plantation.

A system of forest management zones is used to categorise management intent in State forests. Through this zoning system:

- at least 65,848 hectares of State forests is formally protected in **flora reserves** and contributes to the NSW protected areas network
- 279,643 hectares of State forests is protected in informal reserves
- 198,577 hectares of State forests is protected by special prescription.

These forests contribute, in varying degrees, to the protection of forest ecosystems and native species habitat and the conservation of natural and cultural values.

Native forests in remaining State forest areas are harvested in accordance with ecologically sustainable forest management principles. The ***Forestry Act 2012*** and **Integrated Forestry Operations Approvals** set rules to protect environmental values during native forestry operations on public land and require harvested forests to be regrown.

See the Forestry Corporation website for further information on NSW **State forests**, access to **maps and spatial data**, and **environmental reporting**.

Aboriginal partnerships on State forests

Forestry Corporation partners with Aboriginal communities in a number of ways including for economic, cultural, community wellbeing and conservation.

It has Indigenous Land Use Agreements with Aboriginal groups that cover over 343,000 hectares of State forests.

See Forestry Corporation's **Aboriginal Heritage and Partnerships** website for further information.

Crown lands

Crown land includes many parks, reserves, roads, cemeteries and infrastructure. Held by the NSW Government on behalf of the public under the ***Crown Land Management Act 2016*** it is diverse and can be used in many ways.

About 38% of NSW is Crown land and includes rangelands, forests, grasslands, mountainous terrain as well as waterways, stretches of coastline and the marine estate.

Protecting environmental assets on Crown land is a key priority under ***Crown Land 2031: State Strategic Plan for Crown Lands*** (**DPIE 2021**). One of the primary ways this is achieved is by reserving land for protection and conservation purposes.

As at June 2024:

- 30 Crown land sites, covering over 137,000 hectares, have established biodiversity conservation agreements in place to conserve and protect areas of high environmental value
- 749 Crown reserves that cover around 128,000 hectares have been reserved for environmental protection and conservation purposes; they are not part of the protected areas network but contribute to conservation efforts.

Greater Sydney Parklands

Greater Sydney Parklands has five estates covering over 6,000 hectares of public open space spread out across various parts of the greater metropolitan area. These include Centennial Parklands, Callan Park, Parramatta Park, Western Sydney Parklands and Fernhill Estate. The parklands are managed for the purpose of connecting communities to open spaces for recreation and enjoyment.

Established under the ***Greater Sydney Parklands Trust Act 2022*** the parks must be managed in a way that ensures no net loss in natural environment including areas that provide an ecological function, and also areas that have been restored to a natural state or have naturalised, for example, bushland corridors or abandoned farm dams that have naturalised as wetlands.

Key aspects of the Greater Sydney Parklands estate and programs include:

- 2,000 hectare bushland corridor in Western Sydney Parklands that is, or will be restored to, natural environment. It is the most significant of the five estates and is Australia's largest urban park
- 583 hectare Western Sydney Regional Park which is part of the NPWS estate. It is managed under the Greater Sydney Parklands Trust as part of the Western Sydney Parklands
- 7 Biobank / Biodiversity Stewardship Agreement sites under the Biodiversity Conservation Act administered by the BCT conserved in perpetuity
- small areas of vegetation managed for protection of ecological communities including parts of Eastern Suburbs Banksia Scrub in Centennial Parklands and plant communities on Callan Point
- various areas of recreational bushland that provide refuge and links for wildlife
- recognising and conserving Aboriginal cultural heritage and values, and establishing mutual long-term partnerships with Traditional Custodians, Local Aboriginal Land Councils and the First Nations communities of Greater Sydney.

Travelling stock reserves

Travelling stock reserves (TSRs) are authorised thoroughfares on Crown land for moving stock from one location to another. There are more than 6,500 TSRs on Crown land in NSW, covering about 2 million hectares. Almost 1.5 million hectares (75%) of the TSR network is in the **Western Division** of NSW.

Most land in the Western Division is held under **Western lands leases**, which are used for grazing, agriculture, homes and businesses. The leaseholders manage the care and control of the western TSRs. The bulk of the TSR network in the Western Division are not fenced and are grazed in the same way as the surrounding land.

Although narrow and modified by roads and farm infrastructure, such as fences and gates, many TSRs are well vegetated and in better condition than the surrounding land, particularly those in the Central and Eastern divisions.

Local Land Services (LLS) controls and manages about 530,000 hectares of TSR land, concentrated mainly in the Central and Eastern divisions (see **Table L2.6**).

The TSR network contains areas of high environmental value, including habitat for threatened plant and animal species and ecological communities. It provides habitat connectivity through often highly cleared and fragmented landscapes.

Table L2.6: Travelling stock reserves in NSW managed by Local Land Services

Region	Area (hectares)	Bioregion (hectares)	% of bioregion in a TSR
Australian Alps	272	464,298	0.06
Brigalow Belt South	63,449	5,624,738	1.13
Broken Hill Complex	28,708	3,763,318	0.76
Channel Country	9,280	2,340,662	0.40
Cobar Peneplain	45,776	7,377,221	0.62
Darling Riverine Plains	133,067	9,419,258	1.41
Mulga Lands	28,311	6,591,283	0.43
Murray Darling Depression	57,040	7,935,881	0.72
Nandewar	20,847	2,074,882	1.00
New England Tableland	27,863	2,860,298	0.97
NSW North Coast	8,753	3,962,538	0.22
NSW South-Western Slopes	48,582	8,103,373	0.60
Riverina	92,359	7,022,692	1.32
Simpson–Strzelecki Dunefields	0	1,095,797	0.00
South-East Corner	2	1,153,601	0.00
South-Eastern Highlands	6,474	4,989,020	0.13
South-Eastern Queensland (NSW area)	4,734	1,647,041	0.29
Sydney Basin	2,091	3,573,566	0.06
Total and average percentage	**577,606**	**79,999,467**	**0.72**

Source:
LLS 2024

See the **TSR State Classification Map** for reserves managed by LLS.

About 335,000 hectares of travelling stock reserves managed by LLS are considered to be of high value. This means that they are actively managed to maintain or improve biodiversity conservation or cultural values. These may be considered for inclusion as **National Other Effective Area-based Conservation Measures** in the conserved areas network for NSW.

Further information on the conservation value of NSW travelling stock reserves can be found on the NSW Government's **SEED database** and on the **LLS website**.

Pressures and impacts

Lack of custodian access to Country

Interruptions to cultural landscapes

Cultural landscapes reflect the traditional relationships Aboriginal peoples have with different parts of Country. From a cultural heritage perspective they are important as they bring together living patterns, land management, traditional knowledge and dreamtime stories in the land. Cultural landscapes have been interrupted and fragmented by loss of access to Country for Aboriginal peoples due to land ownership and land use changes across NSW.

Land use and human activities

Reduced landscape connectivity

Land use changes, such as development for housing or clearing for agriculture and infrastructure, can make maintaining habitat connectivity difficult. Improving connectivity is particularly important in over-cleared landscapes where ecosystems may be under significant pressure owing to a history of clearing and fragmentation.

Habitat and species isolation can occur when there are limited vegetation corridors or natural areas between reserves and other key habitats. This can impede dispersal of plants and movement of animals across landscapes, reducing reproduction and genetic diversity.

Visitor use and infrastructure

Growing levels of visitation and associated infrastructure may increase pressures on the environmental values of public protected areas if not appropriately managed.

Fostering public appreciation and enjoyment of nature, cultural heritage and conservation is a key objective in managing the public reserve system. Increased public appreciation and enjoyment in turn fosters greater care and stewardship of parks.

National parks remain important to the NSW public, as shown by an increase in the percentage of surveyed people visiting them since 2015 (see **Table L2.7**).

Table L2.7: Survey of national park visits in the last 12 months

Response	2015 (%)	2022 (%)	2023 (%)	2024 (%)
1 to 5 times	47	48	55	56
6 to 12 times	13	14	11	12
More than 12 times	10	6	6	5
0 times	30	26	24	23
Don’t know / can’t recall	0	5	4	4
Sample size (*n*)	2,000	1,901	2,063	2,060

Notes:
Question: In the last 12 months how many times have you visited a National Park?

Source:
Community Appreciation of Biodiversity 2015–24 (DCCEEW)

An increase in visitation must be balanced with conservation objectives and ecologically sustainable forest management principles.

Illegal activities

As at May 2021, the most widely reported illegal activities threatening NSW national parks were:

- damage caused by clearing and firewood collection
- dumping of waste
- antisocial behaviour
- arson
- collecting of native plants.

These activities reduce natural and cultural heritage values and the capacity of the NPWS to maintain these values.

Illegal activities threaten visitors' enjoyment and safety, harm native animals and plants, and damage cultural heritage sites and park assets.

Invasive species and diseases

Invasive species and diseases cause some of the most significant problems for native plants and animals and threatens biodiversity. As such, their impact and management are high priorities for public and private protected areas and other land managed for conservation.

See the ***Biodiversity Conservation Act 2016*** for a full list of invasive plants and animals.

Invasive species and diseases affect threatened species and ecological communities by damaging habitats and outcompeting native plants and animals for resources. They can also damage community infrastructure and public amenity and affect Aboriginal cultural relics, such as rock engravings and grinding grooves.

The most significant widespread invasive animals threatening environmental values in reserves include foxes, feral cats, feral goats, rabbits, deer, wild horses and feral pigs.

See the **Animals** topic for more information.

Of the more than 350 invasive plant species affecting environmental values in NSW in April 2021, the following were some of the most pervasive in reserves:

- bitou bush (*Chrysanthemoides monilifera rotundata*)
- lantana (*Lantana*)
- African olive (*Olea europaea cuspidata*)
- Scotch broom (*Cytisus scoparius scoparius*)
- introduced perennial grasses, such as serrated tussock (*Nassella trichotoma*)
- exotic vines, such as Madeira vine (*Anredera cordifolia*).

See the **Plants** topic for more information.

Pathogens and diseases

Pathogens are organisms, such as viruses, bacteria and fungi, that cause disease. They threaten the integrity of ecosystems, animals and plants within protected areas.

The NSW *Biodiversity Conservation Act 2016* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* identify pathogens that are considered key threatening processes, including:

- Myrtle rust (*Puccinia psidii*) – a fungal disease which affects plants
- root-rot fungus (Phytophthora cinnamomi) – a water mould.

See the **Plants** topic for more information.

Climate change

The effects of climate change are already being felt, particularly in protected areas. Effects include:

- loss of plants, animals and their communities, restriction of their ranges and reduced capacity to adapt to climate change
- increased risk of extreme weather events, including extreme rainfall and severe fire weather
- increased impacts on coastal reserves from sea level rise

- increased weed invasion and spread due to changes in temperature and rainfall
- loss of tangible and intangible Aboriginal cultural heritage.

While it is likely that all natural systems will be affected by climate change, some systems particularly likely to be affected include:

- rainforests
- subalpine habitats
- saltmarshes
- freshwater lagoons
- sand dunes
- threatened seabird habitats
- water-dependent ecosystems
- threatened and endangered species
- ecological communities.

Fire management

Inadequate bushfire management exacerbates the threats to biodiversity.

Over the past 50 years, the risks associated with managing bushfires across the landscape, particularly in forested areas, have been steadily rising owing to a range of factors, including climate change. As temperatures increase, so too do the number of severe fire weather days and the length of the fire season over much of NSW.

See the **Extreme climate and weather** topic for more information.

Protected areas have been particularly affected by extreme climate and weather in recent years. For example, the NPWS estimated that 2.7 million hectares of the NSW national park estate (about 38%) was impacted during the **Black Summer bushfires** in 2019–20.

Improved risk mitigation and hazard reduction burning practices can reduce the risks to and impacts on biodiversity.

The **Final Report of the NSW Bushfire Inquiry** (July 2020) recommended increasing the use of traditional Aboriginal burning practices (recommendations 25 and 26).

In response, the NSW Government has committed to adopting cultural burning as one component of a broader practice of traditional Aboriginal land management and recognising it as an important cultural practice, not simply another technique of hazard reduction burning.

Responses

Aboriginal involvement in conservation

The NSW Government increasingly recognises Aboriginal peoples' obligations to care for Country and has been introducing and expanding programs that partner with Aboriginal peoples in land and water conservation and management. See the **Health of Country** topic for more information.

Aboriginal joint management of NSW national parks

The NPWS is developing a new model for joint management of the State's national parks and reserves to support the expansion of joint management under the ***National Parks and Wildlife Act 1974***.

Joint management involves Aboriginal peoples who have a cultural association with a national park or reserve being involved in, or advising on, its management. It enables them to have input to conservation measures including invasive animal and weed management and cultural fire management.

The new model proposes the continued management of national parks for the public to enjoy while enhancing conservation initiatives and visitor experiences through greater involvement of Aboriginal peoples. It is being developed through engagement with Aboriginal communities, the NSW Coalition of Aboriginal Peak Organisations, national park stakeholder groups and the public.

Cultural fire management

Cultural Burning is an integral part of connection to Country for Aboriginal communities. Australia's native plants and animals evolved to live with fire, and many species rely on small, managed fires as part of their natural lifecycle.

The use of Cultural Fire management practices in NSW has increased in recent years across public and private lands.

The NSW Cultural Fire Management Strategy, currently under development, will help guide NSW Government departments to support Aboriginal communities in cultural fire management activities.

See the **Health of Country**topic for more information.

In response to the **Statutory Review** of the *Local Land Services Act 2013*, Local Land Services (LLS) is working with the **Cultural Fire Management Unit** to explore potential opportunities with Aboriginal peoples and landowners to facilitate Cultural Fire management across differing land tenures. The focus is to develop respectful ways to work with Aboriginal stakeholders to expand the use of Cultural Fire management and to develop community-led monitoring and evaluation indicators.

Forestry Corporation of NSW is co-funding a $3 million partnership **cultural burning program** looking at the use cultural burns to reduce bushfire risk on State forests. The project, part funded through the Australian Government **Disaster Ready Fund**, is establishing partnerships with Aboriginal communities and organisations to reduce the risk, harm and severity of major and catastrophic bushfire events and other natural hazards. It involves traditional mapping and cultural knowledge, Aboriginal and other stakeholder co-design, Aboriginal employment, contracting and skills development.

Crown Lands (within the Department of Planning, Housing and Infrastructure) has a **Cultural Burn Program** that facilitates and supports the Aboriginal community, including Traditional Owners and Local Aboriginal Land Councils, to undertake cultural fire management on Crown land. The program aims to:

- provide an opportunity for Aboriginal communities to further develop and enhance their skills in caring for Country, including opportunities to be reimbursed for their time and knowledge
- partner with Traditional Owners across NSW to support and undertake cultural fire management
- facilitate Cultural Fire management with the objective of getting community out onto Country, which contributes to a wide-ranging benefits.

Aboriginal peoples and travelling stock reserves

It is believed that TSRs follow pathways used traditionally by Aboriginal peoples to travel across country. Many are next to or follow tracks and rivers. TSRs are important to Aboriginal peoples for access and connection to Country, cultural practices and cultural heritage protection.

Many TSRs are the subject of Aboriginal land claims (***NSW Aboriginal Land Rights Act 1983***) or Native Title determination (Commonwealth ***Native Title Act 1993***). These claims may eventually lead to a transfer of land or management agreements with Aboriginal peoples (**LLS 2019**).

LLS is investigating ways to better enable traditional land management practices to heal Country and restore endemic natural systems, especially native vegetation and ecosystems, through the use of traditional knowledge and contemporary approaches to propagation and planting. One example is an **Aboriginal cultural burn at Top Gobarralong**.

Expansion of protected and conserved areas

The **Kunming–Montreal Global Biodiversity Framework** calls for the conservation of at least 30% of land and sea areas, globally, by 2030. As a signatory, the Australian Government has set a **30 by 30** target to be delivered through a combination of formally protected areas and other conservation measures.

The NSW Government has agreed to implement measures and improve current programs, including the growth of public and private protected areas, to support efforts to meet the national target.

Conserved areas network

In June 2024, environment ministers in Australia agreed to the **National Other Effective Area-based Conservation Measures (OECMs) Framework** to enable the recognition of high biodiversity value land-based 'conserved areas'. The purpose being to provide conservation in places where formal protection within the protected areas network is not possible, appropriate or supported.

The aim is for a conserved areas network to complement the protected areas network and contribute to achieving the national **target to protect 30% of land by 2030**. Future assessment of progress towards a CAR protected areas system is expected to include conserved areas when they have been defined and implemented for NSW.

Increasing and conserving koala habitat

The ***NSW Koala Strategy 2021–26*** aims to double the number of koalas in NSW by 2050. It sets out actions and targets to work towards protecting, restoring and conserving koala habitat, improving koala health and safety, expanding our knowledge of them, and supporting communities to conserve them.

More than 15,000 hectares of koala habitat has been purchased, across 17 parcels of land, for inclusion in the national parks system. This meets the target set in the strategy.

From July 2021 to June 2024, the BCT entered into 161 new conservation agreements with private landholders, permanently protecting 10,838 hectares of koala habitat. This exceeded the 7,000 hectares five-year target set under the strategy.

Private land conservation support

Biodiversity Conservation Investment Strategy

The ***Biodiversity Conservation Investment Strategy*** guides conservation investments to advance a CAR protected area system. It targets funding to areas that have not met the CAR targets, or that have met the targets but require in-perpetuity agreements.

Biodiversity Conservation Trust

Through its programs, the BCT is investing more than $290 million to deliver private land conservation outcomes and are seeking partnerships to accelerate their efforts to protect, connect and restore biodiversity in NSW.

Investment in private land conservation is essential for meeting national and international obligations for the growth of protected areas and the long-term conservation of biodiversity.

This investment is split 71% for in-perpetuity (permanent) agreements and 29% for term agreements (minimum of 15 years). Many unique landscapes, threatened ecosystems and habitats for our threatened native plant and animal species, are now protected and are being managed by private landholders.

Biodiversity Offsets Scheme

Legislated under the *Biodiversity Conservation Act 2016*, the **Biodiversity Offsets Scheme** provides a mechanism to avoid, minimise and offset the impacts of development, and some types of clearing, on biodiversity in NSW.

Government initiatives in response to legislative reviews

In July 2024, in its response to the reviews of the *Biodiversity Conservation Act 2016* and native vegetation provisions of the *Local Land Services Act 2016*, the **NSW plan for nature**, the NSW Government proposed actions to expand private land conservation initiatives, including:

- strengthening the BCT's private land conservation program
- introducing stronger private land conservation agreements that protect sites of high biodiversity value from incompatible land uses
- broadening private land conservation agreements to recognise and protect Aboriginal cultural values and traditional ecological knowledge
- improving the management, funding and reporting of private land conservation agreements and biodiversity credits.

NSW plan for nature

In accordance with the **NSW plan for nature**, LLS is supporting landholders to evaluate opportunities in environmental and natural capital markets, some of which may encourage biodiversity conservation.

Support and incentives also help landholders to implement land management practices that benefit biodiversity, threatened species, soils and waterways. Actions include preserving and enhancing natural habitats and provision of technical advice on how to manage lands to improve biodiversity values.

Travelling stock reserves for biodiversity credit generation

LLS is responsible for the care, control and management of about 30% of travelling stock reserves (TSRs) in NSW, covering around than 578,000 hectares. Some of the TSRs are underused for stock movement and recreation purposes, have significant biodiversity values and contain priority vegetation communities currently sought under the **Credit Supply Taskforce**.

There is potential for TSRs to generate biodiversity credits under the **Biodiversity Offset Scheme** and provide a source of income that can be used to conserve and improve the biodiversity value of these sites.

The Credit Supply Taskforce and LLS have developed a pilot project to investigate the credit potential of a selection of TSRs, starting with sites in the Central West region. The Credit Supply Taskforce has engaged accredited assessors to calculate the number and type of biodiversity credits that could be generated on each TSR, determine whether these credits are currently in demand and assess the feasibility of each site as a Biodiversity Stewardship Agreement (BSA) site.

Establishment of BSA's over parts of LLS's TSR network would enable better management of the environmental and cultural values of these sites, such as improved fire management, invasive animals and weed control, fencing, replanting, facilitation of natural regeneration of native vegetation and conservation of significant sites and places.

Non-government contributors to conservation

In addition to government initiatives and support, non-government organisations (NGOs) and land trusts, and corporate and philanthropic investment are contributing to the increase in private protected areas and conservation efforts in NSW. They work individually and also through partnerships and in cooperation with other organisations, Aboriginal landholders and communities, individual landholders and government agencies.

An example of organised collaboration is the emergence over the past decade of the **Australian Land Conservation Alliance** , a member–based national body representing organisations that work to conserve, manage and restore nature on private land. Members include NGOs and land trusts operating in NSW, environment groups and natural resource managers.

Protected areas management

Appropriate management of existing and emerging invasive animals, weeds and diseases before they start to threaten native plants, animals, ecosystems and cultural sites is crucial to effective conservation.

Invasive animal and weed management

In NSW weed management is prioritised based on risk as evaluated through the **NSW Weeds Risk Management system**. The risk for each weed is assessed based on the potential impacts if it becomes more established and/or more widespread. **Regional Strategic Weed Management Plans** also use risk to prioritise weed management in the 11 Local Land Services (LLS) regions.

See the **Plants** topic for more information.

LLS coordinates and leads programs to control invasive animals. Its coverage expanded from 46.8 million hectares in 2021 to 54.7 million hectares in 2024. Invasive animal control programs include ground and aerial baiting, trapping and aerial ground shooting. In the same period, LLS also facilitated weed management of 141,100 hectares of private rural land for improved biosecurity, biodiversity outcomes and agricultural productivity.

Crown Lands invests in biosecurity and control of invasive species. The **Crown Reserves Improvement Fund Program** provides financial support for the maintenance, improvement or development of Crown reserves. It funds projects and works that enhance environmental assets by supporting conservation initiatives and the control of invasive animals and weeds. In 2023–24, it invested about $4 million in invasive animals and weed control.

To support this work, a new spatial database, developed by Crown Lands for planning and recording work to meet its biosecurity duty under the ***Biosecurity Act 2015***, came into use in 2023–24. It enables Crown Lands staff to spatially view invasive animal and weed control, helping to align efforts with other land managers where statewide priorities are identified and shared.

Controlling invasive animals in national parks

NPWS has been delivering record levels of feral animal control since 2019–20, including the largest aerial shooting program in its history. The NPWS aerial shooting and baiting programs have been increasing since 2020 to address invasive animals, including foxes, feral cats, wild dogs, goats, pigs, feral horses and deer. These efforts:

- mean there is more habitat and food available for native animals
- prevent the spread of diseases that native animals have no resistance to
- protect threatened species, native plants, animals, landscapes and catchment values

- limit the impact of invasive animals on neighbouring properties.

Invasive predator-free areas

The NPWS is establishing a network of **predator-free areas** within NSW national parks. At the time of writing, the network contains ten sites where locally extinct and threatened native mammals are being reintroduced and ecosystem functions are being restored.

Protected areas monitoring

Ecological monitoring on private land

The **Ecological Monitoring Module** has been established under the BCT Monitoring, Evaluation, Reporting Framework with the purpose of measuring change in biodiversity across all types of private land conservation agreements administered by the BCT.

More than 1,500 baseline monitoring plots have been established to date at both agreement and control sites. Data will be used in program evaluation, reporting and improvement, as well as in the evaluation and adaptive management of agreements.

The BCT also has established baseline monitoring on legacy biobanking sites where no monitoring was in place.

Monitoring of NSW national parks and reserves

The NPWS **Ecological Health Performance Scorecards** program is an initiative that aims to improve the ecological health of NSW national parks by providing data-based metrics to track key ecological indicators, informing park management decision-making and securing improved conservation outcomes.

Scorecards will be published annually, reporting on ecological health, management activities and expenditure, and enabling adaptive management of NSW national parks. This initiative will enable the NPWS, for the first time in its history, to systematically collect and apply the critical information required to design and deliver effective park management.

The pilot program measures the health of our national parks in eight sites across NSW by monitoring environmental indicators related to:

- the health of native plants and animals
- threats to ecological health, such as invasive animals and weeds
- important ecological processes, such as soil chemistry and water quality
- fire patterns.

Each site represents a major ecosystem within the national park estate. Most of the scorecards should become available in 2025.

See the **Plants** and **Animals** topics for more information of monitoring of specific species on the NSW national parks estate.

Monitoring programs on State forests

Forestry Corporation of NSW is undertaking a biodiversity monitoring program across eastern NSW state forests in collaboration with the NSW Natural Resources Commission. The purpose is to evaluate the wildlife protection effectiveness of the **Coastal Integrated Forestry Operations Approval**.

This complements long-standing, species-specific monitoring for animals such as the southern brown bandicoot, smoky mouse and large forest owls. The program tracks occupancy trends in focal species such as koalas, gliders and ground mammals through sightings and interactions across 600 baited sites using remote cameras and sound recorders.

Call recognisers developed by the NSW Department of Primary Industry and Regional Development detect species like koalas, owls, gliders and glossy black-cockatoos, with more in progress. Seasonal surveys capture variations, such as powerful owls being vocal in autumn and koalas in spring. Validated data includes images of bandicoots with babies, spotted-tail quolls and detections of species like sugar gliders and glossy black-cockatoos.

Climate change adaptation and Net Zero

The ***NSW Climate Change Adaptation Strategy***, released in 2022, lays out the NSW Government's approach to making the State more resilient and adapted to climate change. It is supported by the **NSW Climate Change Adaptation Action Plan 2025-2029** which complements other major government initiatives including the **State Disaster Mitigation Plan**.

The strategy and plan build on the principles of previous policies and plans, such as the **NSW Climate Change Policy Framework (PDF 2.4MB)** of 2016 and the **Net Zero Plan Stage 1: 2020–2030** of 2020.

The **Net Zero Plan Stage 1: 2020–2030** topic provides an update on progress towards the plan.

Future opportunities

Comprehensive and transparent information

The **Collaborative Australian Protected Areas Database**, maintained by the Australian Government, collates data on protected areas on a state and national basis. It is updated every two years.

There is a need to bring together information and data on the NSW protected area network and make it publicly accessible and clear. Doing so would require:

- data on public, private, Aboriginal and other areas included in the protected and conserved areas networks
- a dashboard to show progress against key targets and progress against CAR targets
- comprehensive and individual maps on the protected areas network and bioregion CAR attributes
- coordination and collation through one NSW Government department or agency.

Information related to areas protected or conserved in NSW under both NSW and Commonwealth legislation and mechanisms, should be reported on the dashboard. While SEED (the Central Resource for Sharing and Enabling Environmental Data in NSW) is an appropriate repository for access by government agencies, academics and scientists, it is not an appropriate information, communication and reporting portal for a broader audience.

It would be beneficial if information on both terrestrial protected (and conserved) areas and marine protected areas were made available through the same reporting mechanism.

Strategic direction

In 2023, the International Union for Conservation of Nature (IUCN) noted that the creation of new protected areas; the expansion of existing ones; maintaining and establishing conservation corridors that connect these areas; and better management of them, are the most effective policy tools to address the twin crises of biodiversity loss and climate change.

New protected areas, the expansion of existing ones and support for OECMs (conserved areas) can target places where carbon richness and high biodiversity overlap to create 'carbon stabilization' areas (**Smith & Young 2023**).

With substantial areas of NSW under private ownership, it is important that the NSW Government, in consultation with Australian Government, further boosts permanent private land conservation, filling gaps in the public protected areas system. Effectively progressing the introduction of conserved areas is one step to help meet the national **'30 by 30' target** and NSW's progression towards net zero by 2050, but further initiatives may well be needed.

References

BCT 2021, *Business Plan 2021–22 to 2024–25*, NSW Biodiversity Conservation Trust, Parramatta

BCT 2024, *Annual Report: Financial Year 2023–2024*, NSW Biodiversity Conservation Trust, Department of Climate Change, Energy, the Environment and Water, Parramatta

BCT n.d., Private land conservation in NSW, Biodiversity Conservation Trust, accessed 16 July 2024

Commonwealth of Australia 2009, *Australia's Strategy for the National Reserve System 2009–2030*, Australian Government, Canberra

DCCEEW-Aus 2022, *Collaborative Australian Protected Areas Database 2022 (CAPAD 2022)*, Australian Government Department of Climate Change, Energy, the Environment and Water, Canberra

DPE 2022, *Development of a new Aboriginal joint management model for NSW national parks*, NSW Department of Planning and Environment, Sydney

DPIE 2021, *Crown land 2031 – State Strategic Plan for Crown lands*, NSW Department of Planning, Industry and Environment, Sydney

IUCN 2008, *Guidelines for Applying Protected Area Management Categories*, International Union for Conservation of Nature, Gland, Switzerland, (PDF 3.0MB)

Little R, Pethie L, Woodward E, Jarvis D, Abbott T, Hill R, Maloney K, Braedon P, Pert P Reeve R & Bubb A 2023, *Indigenous Protected Areas (IPA) Program Evaluation: Final Evaluation Report*, National Indigenous Australians Agency, Canberra

LLS 2019, *Travelling Stock Reserves: State-wide Plan of Management*, Local Land Services, Orange

Mitchell P 2002, *NSW Landscapes Mapping: Background and Methodology*, report prepared for the NSW National Parks and Wildlife Service, Sydney, (PDF 1.1MB)

NPWS 2003, *The Bioregions of New South Wales: their biodiversity, conservation and history*, NSW National Parks and Wildlife Service, Hurstville, Sydney

NPWS unpub., *Data on protected areas in NSW* (unpublished), National Parks and Wildlife Service

OEH 2018, *Biodiversity Conservation Investment Strategy 2018*, NSW Office of Environment and Heritage, Sydney

Smith R & Young V 2023, *Role of Protected Areas in Climate Change Mitigation and Biodiversity Conservation*, Technical Note Series No. 8, Updated, Gland, Switzerland

This page intentionally
left blank

Waters

www.soe.epa.nsw.gov.au

This page intentionally left blank

Waters

Water is essential to all aspects of life on earth. Our management of water resources must improve as our climate changes and our population grows.

The topics in this theme describe **rivers and wetlands**, **coastal and marine** and **groundwater**, their importance and their condition.

Rivers and wetlands

Freshwater is essential to all life. Declining health of waterways impacts the environment, Country, society and industry.

Groundwater

Coastlines have incredible environmental, economic, social and cultural significance to Australians. The condition of these ecosystems is threatened by climate change and urbanisation.

Coastal and marine

Coastlines have incredible environmental, economic, social and cultural significance to Australians. The condition of these ecosystems is threatened by climate change and urbanisation.

Only

12%

of inland wetlands in NSW are protected

Agriculture accounts for

75%

of groundwater used in NSW

Swimming site graded 'very good' or 'good' declined to

73%

in 2022–23

Introduction to waters

All the elements have Lore, cultural Lore, right LORE.

Water is sacred in a number of different contexts. It sustains life and our spiritual health.

In water ceremonies we honour the reciprocal relationship that exists between water and people.

Water gives us so much. Water nurtures land, it's an interwoven relationship with all that is so there is no separation. Water is life.

We need to look after the health of all water systems. Water is influenced by vibration, land, air, people, our language is vibrational and comes from the sounds of Country. So, when we speak in our languages, we connect all things.

Australia, with its diverse and sometimes harsh landscape, relies heavily on water resources to support both people and the environment.

Water supports a diverse array of ecosystems that are rich with biodiversity. Along with habitat for our plants and animals, these ecosystems provide valuable natural resources and services, such as drinking water, food and timber, recreational opportunities and cultural practices. For Aboriginal peoples, water is a living thing and is intrinsic to Aboriginal cultures.

Water resources are not endless.

Many of our key economic contributors rely on regular access to water resources. These include agriculture, food processing and mining, as well as our fisheries and tourism industries.

Climate change, population growth, restricting Aboriginal peoples access to Country, freshwater mismanagement, environmental degradation and aging infrastructure all contribute to a decline in water indicators in NSW. Communities, Aboriginal cultures, ecosystems and industries that rely on water will be impacted by this decline. Cultural, biodiversity and economic losses may follow.

Rivers and wetlands

Rivers and wetlands are lifelines for both ecosystems and human societies. They serve important roles as freshwater sources, biodiversity hotspots and natural flood buffers.

NSW rivers are generally in fair condition. As the climate becomes hotter and drier, wetlands and the species that depend on them will continue to be negatively impacted.

Water quality indicators are getting worse for inland rivers and wetlands, significantly affecting fish and waterbird communities.

Key findings from the 2024 report

Many areas of the Murray–Darling Basin have a poor to very poor river condition in terms of water quality (nutrients and salinity), vegetation cover, catchment disturbance and hydrological stress (changes to natural flow regimes). Coastal rivers are generally in better condition, particularly on the southern coasts.

- Loss of river connectivity and access to water significantly impacts Aboriginal communities' mental and physical health.

- Fish, turtle and frog populations respond to rainfall levels differently depending on the species. Good rainfall in the last three years has helped improve outcomes for water quality, vegetation and waterbirds in some areas.
- More fish kill events have occurred in the last five years, with an average of 69 per year between 2019–23, up from an average of 21 between 2009–18.
- During 2021–23 there was an increase in the number of sites exceeding to 2018–20. This is most likely due to increased runoff from wetter weather.
- Long-term trends in total waterbird abundance and number of breeding species show a decline overall. The abundance of ducks, herbivores, large wading birds and over the 1983–2023 survey period by about two-thirds. This broadly corresponds with inundated area in spring.
- This topic's 'nitrogen and phosphorous levels' indicator aligns to the 'modification of biochemical flows' planetary boundary. Globally, this boundary has been crossed (see **Planetary boundaries alignment**).
- This topic's 'river condition index for NSW rivers', 'health of fish communities', 'wetland extent', 'wetland condition' and 'waterbird abundance and breeding' indicators align to the 'biosphere integrity' planetary boundary. Globally, this boundary has been crossed (see **Planetary boundaries alignment**).

Groundwater

Globally, groundwater is an increasingly important source of water. It supports the day-to-day water needs of one-third of the world's population.

Most (97.3%) of the water on earth's surface is sea water. Only the remaining 2.7% of water freshwater. It is found in ice caps and glaciers, groundwater, lakes and rivers and in the atmosphere. In many areas of the world groundwater is the only source of freshwater.

Groundwater with a low dissolved salt content accounts for most of the usable low-salinity water available globally, with a small amount stored in closed saline lakes.

Groundwater holds deep cultural significance for Aboriginal peoples. For over 65,000 years, Aboriginal knowledge of groundwater sources has been crucial for survival in Australia's arid regions.

The changing climate is predicted to negatively impact water availability. To support their water needs, communities will increasingly turn to other sources of water than surface water, including groundwater.

Significant gaps remain in groundwater data. This means that determining the status and trends is difficult and unreliable. This has led to two indicators (aquifer sustainability and groundwater quality) being updated to a status of 'unknown'.

Key findings from the 2024 report

- Over the past three years, there were no exceedances of groundwater extraction limits, with a reduction in groundwater use overall due to good rainfall, reducing dependence groundwater.
- More than 250 regional towns in NSW are now reliant on groundwater for most of their everyday water needs.
- Although monitoring across NSW indicates that groundwater-dependent ecosystems are in moderate condition and stable, information on the extent and condition of them is still lacking. More work is being done to address these shortfalls.

Coastal and marine

Coastal, estuarine and marine ecosystems are vital for biodiversity, providing habitat for countless species and playing a role as marine life nurseries.

For Aboriginal peoples, the marine environment is not just a resource, but a fundamental part of identity, culture and wellbeing.

Coastlines have incredible environmental, economic, social and cultural significance to Australians, with coastal towns and cities being home to roughly 85% of the State's population.

The water quality and overall health of the State's coastal and marine ecosystems are stable, yet these ecosystems are increasingly vulnerable to loss of saltmarsh and catchment disturbance.

Key findings from the 2024 report

- Most estuaries and coastal swimming sites have water quality that is suitable for swimming, but this varies, especially after heavy rainfall.
- Coastal vegetation and habitats (saltmarsh, mangroves and seagrass) continue to be threatened by coastal development and climate change. While in some locations they are declining, in others coverage has improved due to good management.
- Kelp forest area declined in all sampled locations between 2019 and 2023, from 25% to 60%.
- Despite limited data for assessing statewide trends of coastal fish species, current monitoring of fisheries suggests fish stocks are stable, although some species are under threat.
- This topic's 'extent of estuarine macrophytes' and 'coastal fish stocks' indicators align to the 'biosphere integrity' planetary boundary. Globally, this boundary has been crossed (see **Planetary boundaries alignment**).

Rivers and wetlands

Declines in river and wetland health are reducing biodiversity of water-dependent plants and animals, including waterbirds, fish, frogs and turtles.

Overview

The NSW Government has investigated more than

190

fish death events since 2021

Read more

In NSW,

12%

of inland wetlands are protected

Read more

> ‘For First Peoples, water is a sacred source of life. The natural flow of water sustains aquatic ecosystems that are central to our spirituality, our social and cultural economy and wellbeing. The rivers are the veins of Country, carrying water to sustain all parts of our sacred landscape. The wetlands are the kidneys, filtering the water as it passes through the land’ (**MLDRIN et al. 2017**).

Rivers and wetlands are critical components of a healthy environment. They support our cities and towns, as well as irrigation, grazing and many industries. They provide the ecosystem services needed for good water quality and supply, and habitats for a wide range of plants and animals, including threatened species.

Rivers and wetlands are intrinsically connected to each other, by groundwater or surface water. The systems include the rivers themselves, the riparian zones (where water meets land), floodplains, billabongs, lakes, swamps, marshes and bogs.

Rivers and wetlands provide each other with water, sediments and nutrients. Wetlands can act as filters and improve the quality of water in rivers.

The plants and animals making up the ecosystems of rivers and wetlands have adapted to the natural cycles in water flow. Disruption of these cycles – for example by drought or human activity – harms them.

Rivers and wetlands can recover from infrequent drought. But they struggle to recover if droughts become more frequent or if human activity disrupts water flow.

See the **Coastal and marine** topic for information on coastal wetlands, including saltmarsh and mangroves.

Rivers and wetlands in NSW

Rivers

There are 58,000km of rivers and major streams in NSW (**NLWRA 2002**).

The Great Dividing Range separates NSW into east and west. The coastal strip to the east of the Range has rivers that flow to the East Coast. This includes the large catchments of the Clarence River on the North Coast, the Hunter River flowing to the coast at Newcastle, and the Hawkesbury–Nepean River, which almost encircles the Sydney Basin.

To the west of the Divide are the rivers of the Murray–Darling Basin. In the south of the basin, the Lachlan and Murrumbidgee rivers flow into the Murray River under high flow conditions. Rivers in the north of the basin flow into the Darling–Baaka, which then joins the Murray River in the far south-west of the State.

Wetlands

Wetlands are areas of land covered or saturated with fresh, brackish or salt water that is generally still or slow moving. The water can also sit just below the surface.

An area doesn't need to be permanently wet to qualify as a wetland. Flooding or saturation can happen cyclically or intermittently. The area just needs to be wet for long enough for its plants and animals to be adapted to – or even dependent on – wet conditions for at least part of their life cycle.

There are more than 20,000 wetlands across NSW.

Based on Landsat (satellite) imagery, wetlands covered about 4.5 million hectares of NSW, or about 6% of the State (**Kingsford et al. 2003**).

Our biggest wetlands are in the Murray–Darling Basin and include the **Ramsar-listed wetlands**, such as the Macquarie Marshes. Many wetlands are coastal and include estuaries, coastal lakes and lagoons. NSW also has a few freshwater wetlands on the Tablelands and in the high Alpine regions.

NSW protects wetlands by:

- including them within the National Parks and Wildlife Service reserve system (see **NPWS parks**)
- listing them in the ***Directory of Important Wetlands of Australia*** (DIWA) (**DCCEEW-Aus 2021**)
- protecting them under the **Convention on Wetlands of International Importance** (Ramsar convention).

NSW has 13 Ramsar-listed wetlands. All of them overlap with DIWA-listed wetlands.

Why river and wetland health matters

In the driest inhabited continent on earth, Australia, the rivers and wetlands of NSW have been central to human life for tens of thousands of years (**Nelson et al. 2018**). They are highly valuable ecosystems that provide clean water and extensive habitats for fish, waterbirds and vegetation (**DPIRD n.d.-a**). In many areas of NSW, connection between rivers, wetlands and groundwater is fundamental to ecosystem health and clean water.

People in NSW use waterways for many purposes. They are a source of water for drinking and other domestic purposes, and a place for recreation and tourism, including fishing, swimming and boating. Rivers are essential for agriculture and all types of industry, including mining and electricity generation.

Rivers and wetlands can increase personal wellbeing and create a sense of place, belonging and community.

Clean water is necessary for a healthy planet. Changes to freshwater use may result in abrupt unacceptable changes to Earth's environment (**Rockström et al. 2009**). In their recent planetary health check, **Caesar et al. 2024** assessed global use of freshwater as operating beyond the safe zone. This increases the risk of environmental change that reduces liveability on the planet.

Maintaining river and wetland ecosystems is vital for the health and wellbeing of Aboriginal communities. Flowing rivers are central to the identity, health and cultural continuity of Aboriginal peoples, underpinning their connection to Country and their duty to care for downstream communities (**DCCEEW 2024b**).

For Aboriginal peoples, water is a living thing and intrinsic to culture. Flowing rivers are central to community health and wellbeing, food security, cultural education and employment opportunities (**DCCEEW 2024b**).

'First Nations Peoples have rights and a moral obligation to care for water under their law and customs. These obligations connect across communities and language groups, extending to downstream communities, throughout catchments and over connected aquifer and groundwater systems' (**MLDRIN et al. 2017**).

The rivers and wetlands of NSW are vital to the continued existence of many of its unique animals, plants and ecological communities.

Wetlands perform multiple environmental functions, including:

- helping to reduce the impacts from storm damage and flooding
- maintaining good water quality in rivers
- recharging groundwater
- storing carbon
- helping to stabilise climatic conditions
- controlling pests
- acting as important refuge sites for animals and plants.

Condition of NSW rivers and wetlands

Rivers

Nearly all (97%) of the State's rivers and major streams have been substantially modified by land use change, extraction of water and damage to bordering vegetation (**NLWRA 2002**).

The **River Condition Index** is assessed across NSW. It measures river condition using water quality and flow, and biological and geomorphological data. The 2023 update shows that coastal rivers and those in the Far West of the State were in good or moderate condition. Rivers through the middle of the State rate as poor or very poor.

Wet weather in the last few years has increased nutrient loads in rivers. More than 80% of the 140 monitoring sites recorded high nutrient loads in more than a quarter of their samples.

Salinity within NSW river systems is good: 135 of the 140 sites were rated 'good' during 2021–23.

Fish provide an indication of the health of rivers. Healthy rivers have plenty of fish of different species. Mass deaths of fish (fish deaths) indicate poor river health. Since January 2021, 190 fish death events have been investigated. A significant **event** occurred on the Darling–Baaka in March 2023 and was declared a state emergency (**OCSE 2023**).

See the **Fish kills** section of this topic for more information.

Wetlands

Wetland health is indicated by the variety of plants and animals within them, and the area that is inundated.

Assessment of wetland vegetation rated 17 of 28 inland wetlands as 'poor', but only 4 of 19 coastal wetlands as 'poor'.

The annual **Eastern Australian Waterbird Survey** provides information on both the area inundated and the number of waterbirds in each of 50 species. The survey in 2023 found inundation in the surveyed areas was below the long-term median.

Waterbird abundance showed more birds than usual following the past two wet springs. Both the number of species nesting and overall breeding numbers were near median (middle) values for the years since 1983.

Surveys of frogs found good conditions for breeding in the Gwydir, Macquarie and Lowbidgee wetland systems.

NSW has seven native species of turtles, three of them listed as threatened. Recent surveys found high abundance of six of the species but listed the other as rare.

See **Wetland animals** section of this topic for more information.

Key threats

Since colonisation, river and wetland health has been threatened by changes to water flow, increased sediment, release of water at the wrong temperature or the wrong time, and pollution from urban runoff, agriculture and industry.

Due to dispossession, many Aboriginal peoples have lost their ability to fulfill their roles as caretakers of the waters to sustain their traditional life, culture, languages and knowledges (**DCCEEW 2024b**). This harms the health of rivers and wetlands.

Rivers and wetlands in NSW are under pressure from:

- regulation of river flows by dams and weirs
- extraction of water from rivers and groundwater
- clearing of riverside and wetland vegetation

- floodplain harvesting that interferes with natural flow patterns
- diffuse-source water pollution, including agricultural runoff and urban stormwater
- sedimentation from runoff and the erosion of land and riverbanks
- invasive plant and animal species
- stock access and grazing
- climate variability and the impacts of climate change.

Wetlands are also particularly threatened by development, such as housing, industry and roads.

Management and regulation

Addressing the declining health of river and wetland ecosystems is a global concern.

Some jurisdictions have given rivers human rights to help to improve their protection. Examples include the Whanganui River in New Zealand and the Ganga (Ganges) and Yamuna rivers in India.

Rivers and wetlands are managed in NSW by a variety of government agencies and organisations. These include:

- the NSW Department of Climate Change, Energy, the Environment and Water (NSW DCCEEW), through the:
  - DCCEEW Water Group – research, policy and management
  - DCCEEW BCS Group (Biodiversity, Conservation and Science) – 'water for the environment' management, policy and research, including:
    - programs relating to flows and connectivity, wetland vegetation, waterbirds, and other animals such as fish, frogs and turtles
    - programs for the NSW portion of the Murray–Darling Basin
  - National Parks and Wildlife Service (NPWS) – management of rivers and wetlands within the National Parks estate, and research
- Water NSW – the operator of most dams and weirs in the State
- NSW Department of Primary Industries and Regional Development (DPIRD) – research and policy on improving native fish populations and key aquatic habitats.

NSW also has an extensive regulatory framework to manage the extraction of water from our rivers under the ***NSW Water Management Act 2000***.

Under this Act, the entire State is covered by **Water Sharing Plans**. These plans allocate water among users – agriculture, industry, towns and the environment. Water extraction under these plans requires an appropriate licence and metering equipment so the volumes of water taken can be measured.

The NSW Environment Protection Authority (EPA) regulates activities that may pollute water entering rivers and wetlands.

Table W1.1 lists current legislation and policies that contribute to the management of our river and wetland ecosystems.

Table W1.1: Current legislation and policies for rivers and wetlands in NSW

Legislation or policy	Summary
NSW Water Management Act 2000	Recognises the need for allocation and provision of water for environmental health of rivers and groundwater, and provides water licence holders with secure access and trade opportunities
NSW Coastal Management Act 2016	Establishes the framework and overarching objects for coastal management. Its purpose is to manage the use and development of the coastal environment in an ecologically sustainable way for the social, cultural and economic wellbeing of the people of NSW
Protection of the Environment Operations Act 1997	Part 5.3 prohibits the pollution of waters
Murray–Darling Basin Plan	Sets the amount of water that can be taken from the Murray–Darling Basin while leaving enough to maintain the environmental health of the river
NSW Long-Term Water Plans	Guides and informs water management (including water for the environment) for environmental outcomes by setting objectives, targets and water requirements for plants, waterbirds, fish and other species, such as frogs, over 5-, 10- and 20-year timeframes
NSW Water Strategy 2021	Sets the overarching vision for 12 regional and two metropolitan water strategies, tailored to the individual needs of each region in NSW
State Environmental Planning Policy (Resilience and Hazards) 2021	Chapter 2 covers how development proposals are assessed if they are in a coastal zone. It is supported by detailed mapping
Water Resource Plans	Outlines how each water resource area aims to achieve community, environmental, economic and cultural outcomes and ensure that State water management rules meet the Murray–Darling Basin Plan objectives. The plans reflect current arrangements that are working and incorporate new arrangements that strengthen water management at a local level.
Water Sharing Plans	Provides rules for the allocation and sharing of water between water users and environmental needs. They are provided for different regions and water sources within NSW

Notes:
See the **Responses** section of this topic for more information about how **rivers and wetlands** are managed in NSW.

Water for the environment

Water is set aside specifically to support the health of rivers, wetlands and floodplains across NSW. More information is available in the **Water use** topic.

Related topics: **Climate change** | **Coastal and marine** | **Groundwater**

Status and trends

Rivers and wetlands indicators

Four indicators are used to assess the status and trends of rivers (see **Table W1.2**), and three indicators to assess the status and trends of wetlands (see **Table W1.3**).

Rivers

- **River condition index for NSW rivers** measures the overall health of rivers using six datasets: riparian vegetation cover, hydrological stress, biodiversity condition, geomorphic condition, catchment disturbance and water quality index. This indicator is assessed as moderate status and trend of getting worse with values in the Murray–Darling Basin scoring particularly poorly (see **River health**).
  This indicator aligns to the 'biosphere integrity' planetary boundary. Globally, this boundary has been crossed (see **Planetary boundaries alignment**).
- **Nitrogen and phosphorus levels** measures water quality by the levels of these nutrients in rivers. They are used to indicate river health as excessive nutrients can reduce oxygen levels or contaminate drinking water. This indicator is assessed as moderate status and stable trend (see **Nutrients**).
  This indicator aligns to the 'modification of biochemical flows' planetary boundary. Globally, this boundary has been crossed (see **Planetary boundaries alignment**).
- **Salinity** measures the concentration of dissolved salts in water. This indicator is assessed as good status and stable trend (see **Salinity**).
- **Health of fish communities** measures the number of juvenile fish developing into adults, the distribution of fish species, and the total number and mass of fish in river systems. It is used as an indicator of river health as fish communities need the right water flow and quality to live. This indicator is assessed as poor status and trend of getting worse, with poor outcomes across all measures, and an increase in fish kill events (see **Health of fish communities**).
  This indicator aligns to the 'biosphere integrity' planetary boundary. Globally, this boundary has been crossed (see **Planetary boundaries alignment**).

Table W1.2: NSW indicators (rivers)

Indicator	Environmental status	Environmental trend	Information reliability
River condition index for NSW rivers	MODERATE	Getting worse	Reasonable
Nitrogen and phosphorus levels	MODERATE	Stable	Reasonable
Salinity	GOOD	Stable	Reasonable
Health of fish communities	POOR	Unknown	Reasonable

Notes:
Indicator table scales:
- **Environmental status**: Good, moderate, poor, unknown
- **Environmental trend**: Getting better, stable, getting worse
- **Information reliability**: Good, reasonable, limited.

See **Indicator guide** to learn how terms and symbols are defined.

Wetlands

- **Wetland extent** measures the area of wetlands that are inundated, and the total area of wetlands in the public and private protected area system. This indicator is assessed as moderate status and trend of getting worse due to decreasing areas of inundation. Significant area was recently added to the protected area system (see **Extent**).
- **Wetland condition** measures wetland and riparian vegetation to indicate the ecological function of the wetlands. This indicator is assessed as moderate status and trend of getting worse, with many surveyed plant communities declining, particularly in the Murray–Darling Basin (see **Condition**).
- **Waterbird abundance and breeding** measures the total number of waterbirds, species diversity and nesting using data from the Eastern Australian Waterbird Survey. This indicator is assessed as poor status and trend of getting worse due to ongoing reduction in suitable inundated wetland habitat (see **Waterbirds**).

These indicators align to the 'biosphere integrity' planetary boundary. Globally, this boundary has been crossed. See the **Planetary boundaries alignment** page for more information.

Table W1.3: NSW indicators (wetlands)

Indicator	Environmental status	Environmental trend	Information reliability
Wetland extent	MODERATE	Getting worse	Limited
Wetland condition	MODERATE	Getting worse	Limited
Waterbird abundance and breeding	POOR	Getting worse	Good

Notes:
Indicator table scales:
- **Environmental status**: Good, moderate, poor, unknown
- **Environmental trend**: Getting better, stable, getting worse
- **Information reliability**: Good, reasonable, limited.

See **Indicator guide** to learn how terms and symbols are defined.

River health

River health is measured by the condition of various ecological indicators, including water quality, biodiversity, and habitat availability.

River condition

The **River Condition Index** provides a readily available assessment of river condition in NSW and applies to all rivers in the State.

This index assesses the health of NSW rivers using a combination of:

- **riparian vegetation cover** – condition of vegetation along river channels
- **hydrological stress** – level of stress caused by changes in flows due to dams, weirs and other infrastructure
- **biodiversity condition** – condition of aquatic communities
- **geomorphic condition** – condition of stream channels and banks
- **catchment disturbance** – indicative level of land use change in a catchment
- **water quality index** – relative indicator of long-term water quality.

The 2023 index update shows that river conditions tend to be worse in the southern and central western regions of NSW than in the far western region (see **Map W1.1**). Index values are lower in many areas than the assessment in 2018 (**NSW EPA 2022**).

Many areas within the Murray–Darling Basin are in 'poor' or 'very poor' condition, whereas coastal areas generally range from 'moderate' to 'very good' condition.

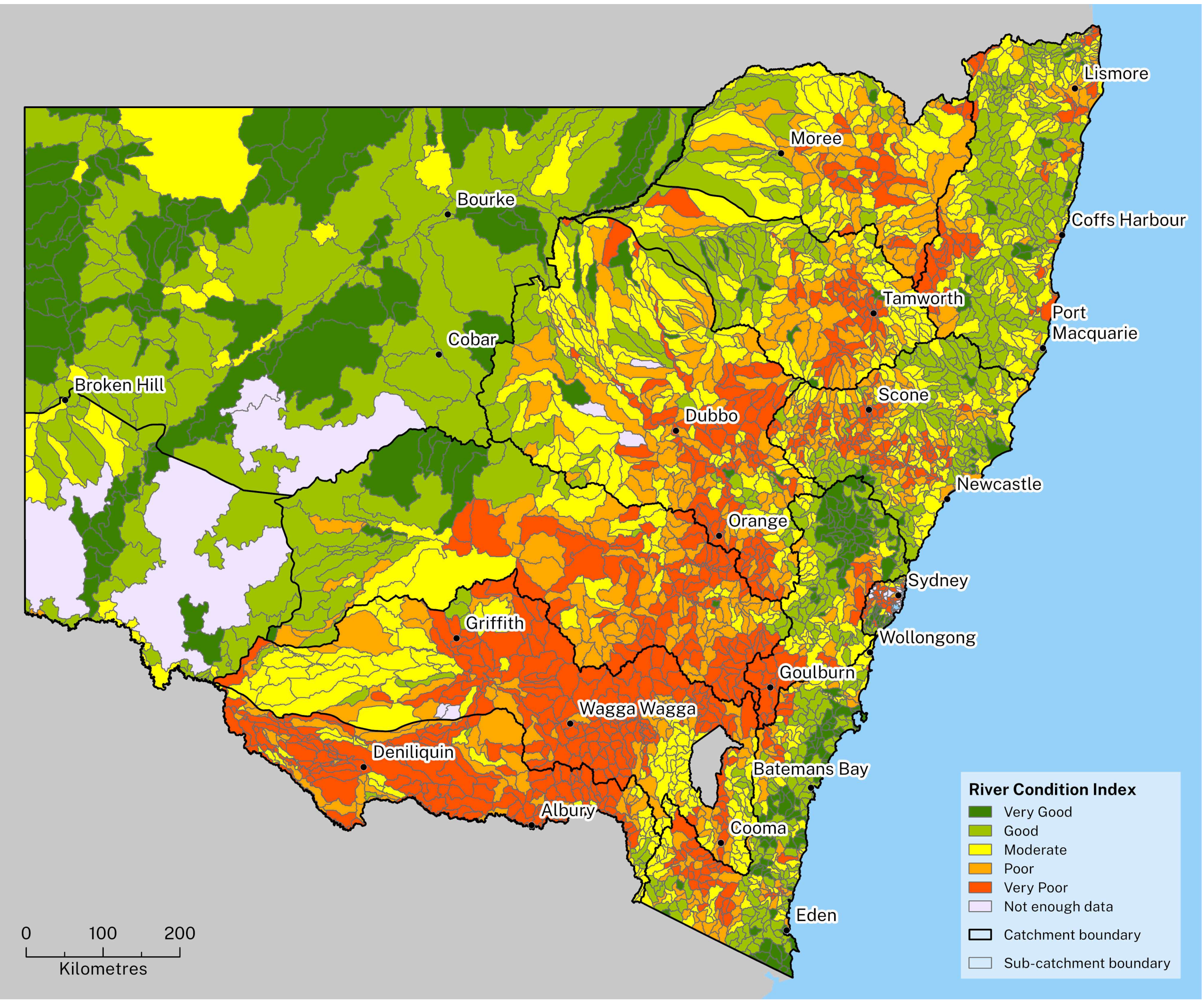
The index focuses on western measures of environmental health and does not include Aboriginal cultural indicators of the health of Freshwater Country.

A shared language of water management is often absent between Aboriginal communities and water authorities. Technical jargon can hinder effective communication and understanding of Indigenous knowledge and values (**Moggridge & Thompson 2021**).

The **[Aboriginal Waterways Assessment tool](#)** provides a method to assess the cultural value and cultural health of waterways (**MLDRIN 2015**). It has not yet been widely applied in NSW.

See the **[NSW River Condition Index](#)** for more information.

Map W1.1: River Condition Index value in NSW catchments



Notes:
River Condition Index scores are not comparable between the 2012 and 2023 versions, as some datasets used in 2012 were no longer collected or available for the 2023 update. Some of the new sub-indices may perform as better indicators of change. This second iteration sees changes in the rating of conditions since 2012, as well as the introduction of the Water Quality Index.

Source:
NSW DCCEEW Water Group 2022

Water quality

Two important measures of water quality in rivers are the amount of nutrients and the salinity (amount of salt).

Regular monitoring helps identify sources, track trends over time, and inform management strategies so they can reduce harms to both ecosystems and communities (**McNamara 2023**). Monitoring is conducted at 141 sites.

Water quality is assessed using different measures depending on location. Coastal sites use the **National Guidelines for Fresh and Marine Water Quality ()**. Inland sites use the Murray–Darling Basin Plan water quality targets (**Basin Plan 2012, Schedule 11**).

Nutrients

Excessive nutrients can lead to algal blooms (eutrophication), which deplete oxygen levels in water and harm aquatic life. High nutrient levels can also contaminate drinking water supplies, posing risks to human health.

Nutrient load is assessed using the concentrations of nitrogen and phosphorus. The current target for water quality is that at each site, fewer than 75% of samples exceed the guideline concentration for that site. **Guideline** concentrations are generated based on local conditions. See **NSW Water Quality and River Flow Objectives** for information on these guidelines.

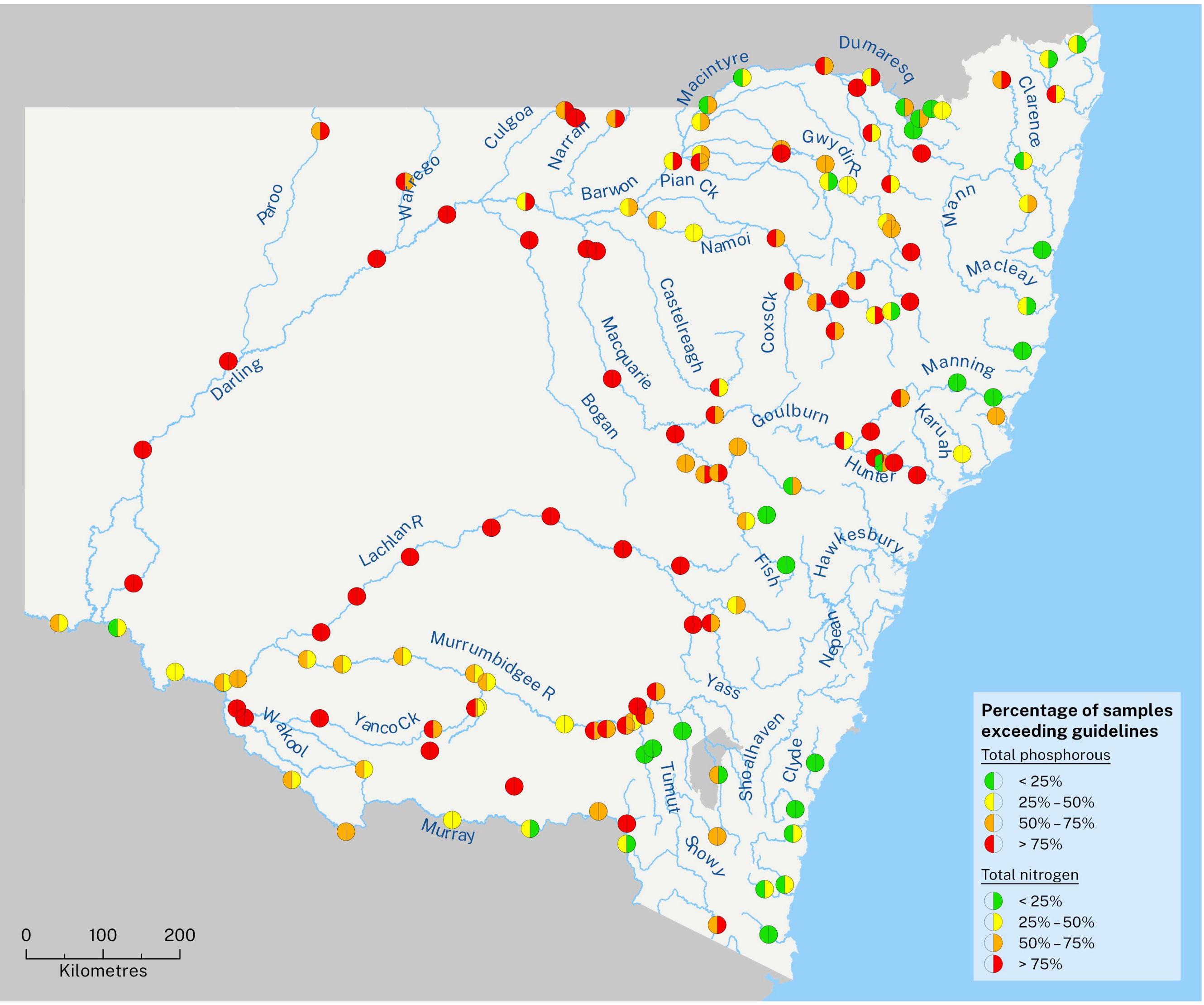
Monitoring sites have been given a rating based on the proportion of samples reporting an exceedence. The ratings are 'good' (fewer than 25% of observations), 'moderate' (25% to 50%), 'poor' (50% to 75%) and 'very poor' (more than 75%).

Water quality ratings from 2021 to 2023 were generally better at sites on the coast (see **Map W1.2**). Those on the North and South coasts had better water quality than those in the Hunter region and inland.

The target of fewer than 75% of observations exceeding guideline concentrations was not met at 50 sites (36%) for nitrogen and 58 sites (41%) for phosphorus.

See the **Coastal and marine** topic for more information on coastal catchment water quality.

Map W1.2: Exceedance of water quality targets for total nitrogen and total phosphorus, 2021–23



Notes:
Data show the percentage of water samples from NSW streams with nitrogen and phosphorus concentrations that exceeded water quality targets from 2021 to 2023 (that is, they were above accepted targets).

Access the interactive version of this map.

Source:
NSW DCCEEW Water Group 2024

Nutrient concentrations are generally higher in wetter years owing to more runoff (**WMIS 2024**). Major flooding resulted in high nutrient concentrations at sites in:

- the lower Lachlan River

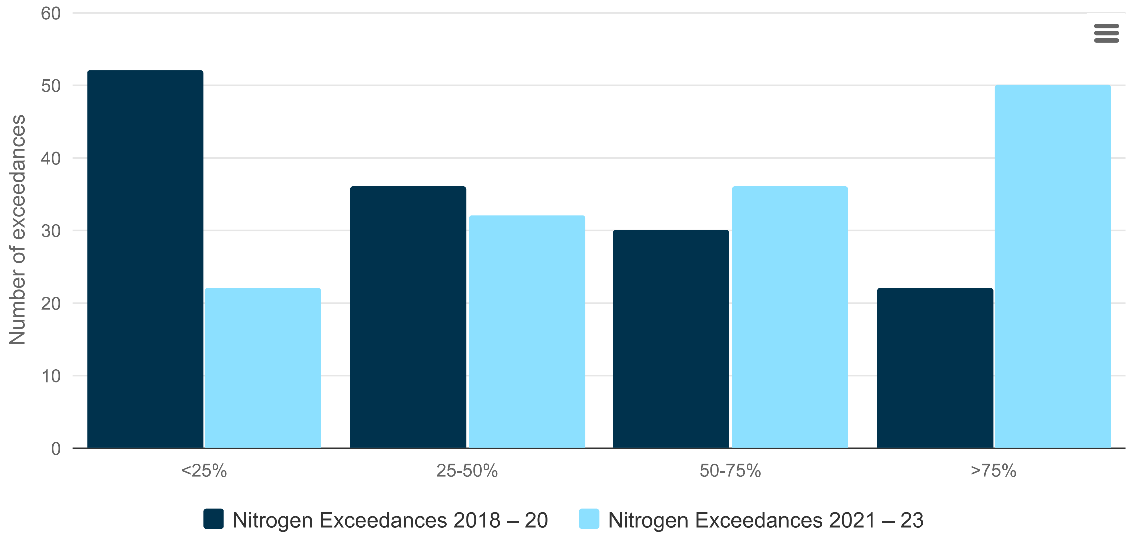
- the lower Macquarie River
- the Hunter River
- Billabong Creek
- the middle and lower Darling–Baaka River.

Higher nutrient levels were also recorded in the upper Murray River catchment. This was due to heavy rainfall following the 2019–20 Black Summer bushfires. The high rainfall carried ash as well as soil into waterways in this region (**DCCEEW 2024a**).

More sites exceeded the nitrogen and phosphorus targets in 2021–23 than in 2018–20 (see **Figure W1.1**).

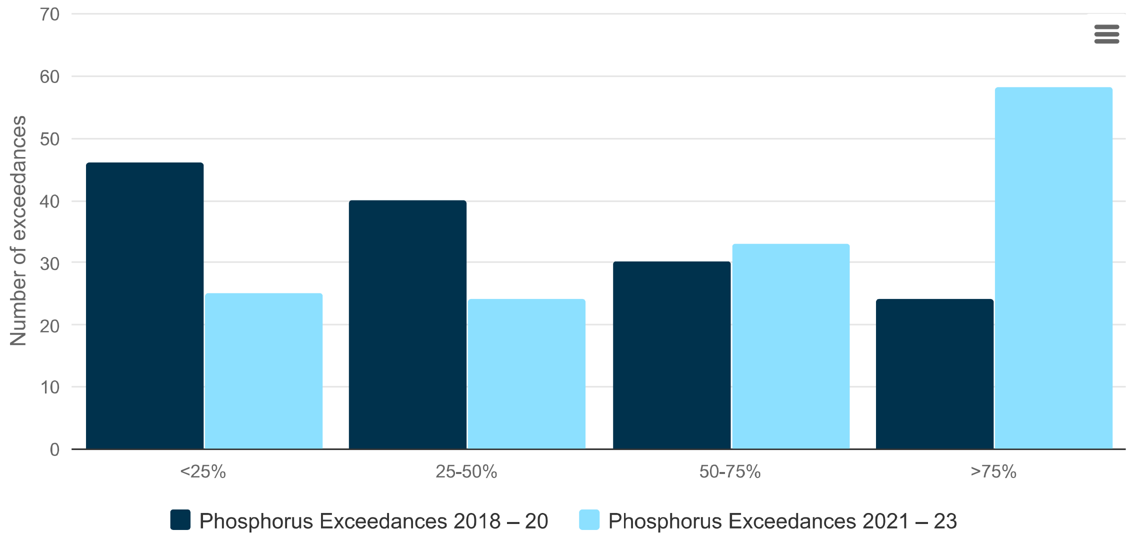
- There were increases in the numbers of sites rated very poor (red segment) for both nitrogen (from 22 to 50 sites) and phosphorus (from 24 to 58 sites).
- There was a decrease in the number of sites rated good (green segment) for nitrogen (from 52 to 22 sites).
- Across NSW, 76 sites (54%) had a worse rating for total nitrogen and 78 sites (56%) had a worse rating for total phosphorus than in the previous reporting period.
- There were improvements at only 14 sites in total nitrogen and 3 sites in total phosphorus.

Figure W1.1a: Rating of exceedances in nitrogen targets for 2018–20 and 2021–23



Source:
DCCEEW 2024a

Figure W1.1b: Rating of exceedances in phosphorous targets for 2018–20 and 2021–23



Source:
DCCEEW 2024a

Salinity

Salinity refers to the concentration of dissolved salts in water. It is expressed as parts per thousand (ppt) or Practical Salinity Units. Practical Salinity Units is measured using electrical conductivity and reported as microsiemens per centimetre (µS/cm) or converted to grams per litre (g/L) (**Bal et al. 2021**).

Salinity levels in NSW waterways remain generally stable, although they rise and fall depending on the season.

River salinity is caused when water laden with salt is discharged from areas suffering from dryland or irrigation salinity, or when salty water is discharged by mining or industry. This is particularly of concern in the Murray and Murrumbidgee catchments and the Hunter River.

Salinity influences the distribution and abundance of species because different organisms have differing tolerances to salinity levels. Changes in salinity can disrupt breeding and feeding patterns, resulting in fewer organisms. This results in reduced ecosystem stability and poorer biodiversity.

Increased salinity can also threaten freshwater resources and harm agriculture by reducing soil fertility.

Monitoring salinity is essential for managing water quality and making sure that human activities and natural ecosystems that depend on freshwater can be maintained (**US EPA 2024**; **NWQMS n.d.**).

Salinity is continuously monitored at many sites in the Murray–Darling Basin to determine long-term salinity trends. Salinity levels are assessed against targets in the Australian Government's ***Salinity Management Strategy***.

The NSW Government also sets a target for the overall salinity in a river system, against which salinity is assessed.

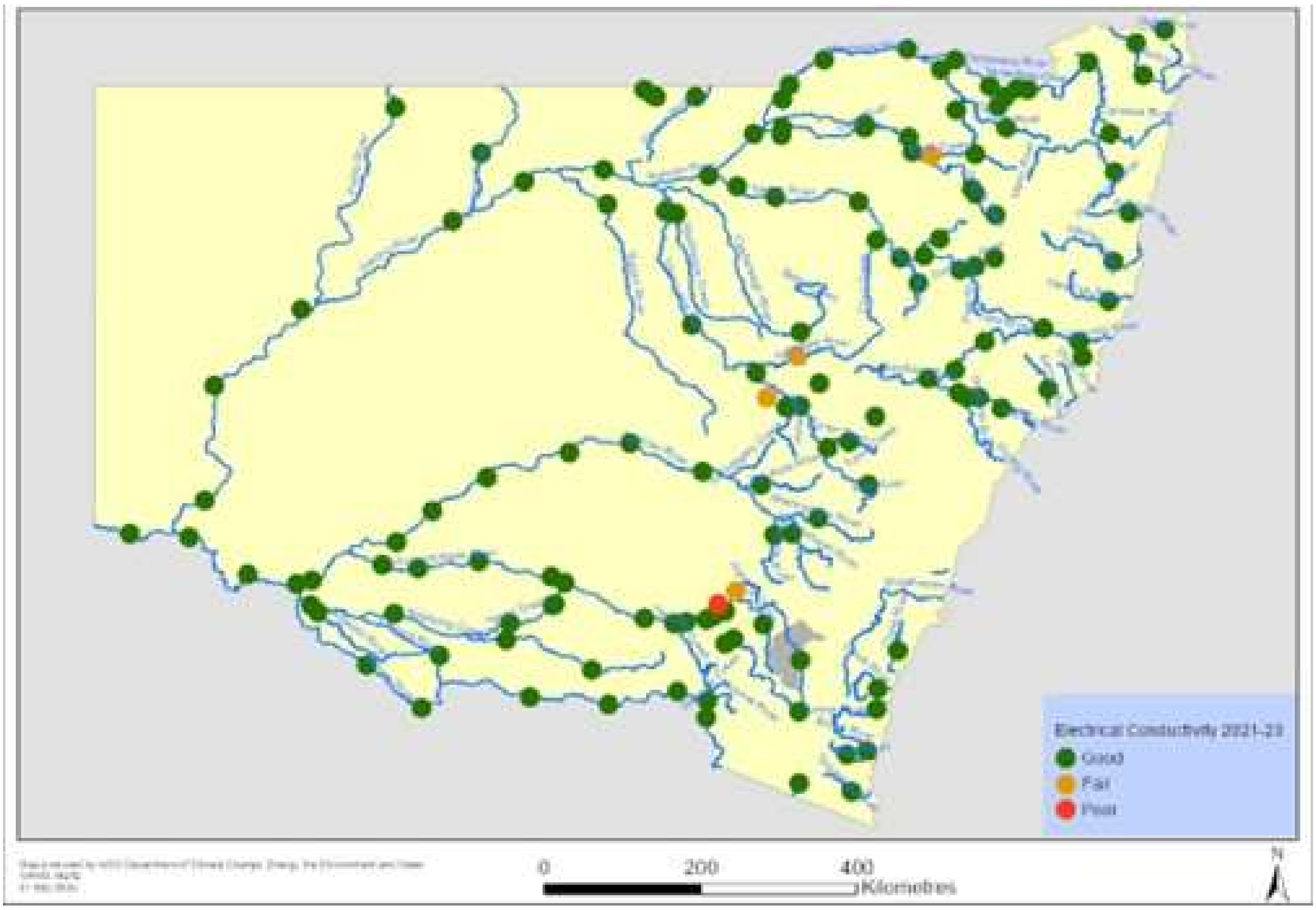
Most of the 141 sites assessed for electrical conductivity against the **Australian drinking water guidelines** (**NHMRC 2011**) were rated as good (see **Map W1.3**).

The five monitoring sites that did not receive a good rating are in catchments with known salinity issues due to high salt loads stored in the soil and underlying geology.

Four of these were rated as fair – Myall Creek in the Gwydir Valley, the Little and Talbragar rivers in the Macquarie Valley, and Jugiong Creek in the Murrumbidgee Valley). Muttama Creek in the Murrumbidgee Valley was rated as poor.

Salinity in the Hunter River is managed through the **Hunter River Salinity Trading Scheme**.

Map W1.3: Salinity rating targets 2021–23



Notes:
Electrical conductivity measured in microsiemens per centimetre (µS/cm):

Good = 0–938 µS/cm
Fair = 939–1406 µS/cm
Poor = 1407–1875 µS/cm
Very poor = 1876 µS/cm or greater

Source:
DCCEEW 2024a

Salinity levels in most streams remain relatively stable (see **Table W1.4**). Variations are generally attributable to changes in flow conditions.

In Chile, drought increased salinity in rivers through both increased evaporation and decreased dilution of saltier inflows (**Peña-Guerrero et al. 2020**). Both slower flows and drier weather increased salinity because the salt in the river is dissolved in less water. With less water in rivers, the naturally saltier groundwater entering rivers is diluted less.

In NSW, saline inflow occurs from the use of groundwater and from mining.

Increased streamflow and major flooding across NSW in 2021–23 flushed accumulated salts from waterways and diluted saline inflows, resulting in a return to lower salinity (**DPE 2023a**).

Table W1.4: Comparison of salinity ratings across State of the Environment reporting periods

Rating	2015–17	2018–20	2021–23
Good	130	126	135
Fair	5	9	4
Poor	4	4	1
Very poor	1	1	0

Source:
Compiled by the EPA from data supplied by NSW DCCEEW

Health of fish communities

The health of fish communities is an important indicator of the health and function of rivers (**Schinegger et al. 2016**). Fish communities need the right flows of water to support in-stream habitat and to provide them with food. Without the right flows, they suffer, as rivers and catchments are not functioning as they should (**Bunn & Arthington 2002**; **Jargal et al. 2023**).

The health of freshwater fish is measured by the long-term trends for fish species in:

- **recruitment** – how many juvenile fish develop into adults
- **distribution** – spatial spread of fish species through river network
- **abundance and biomass** – how many fish there are and their total mass in river systems; abundance and biomass are related, but increased abundance after spawning events may not significantly influence biomass until fish mature.

Floods can trigger large recruitment events, while droughts reduce abundance. There is naturally large variation in abundance between species and across regions because of the high variability of the State's climate. Long-term data is needed to show trends in health.

The health of freshwater fish communities is poor. Relative abundance of key species in the Murray-Darling basin is stable but there has been a marked increase in fish kill events. The trend in health is assessed as uncertain.

The number of fish kill events has increased significantly since 2019, from an average of 21 for the years 2009–18 to an average of 69 for the years 2019–2023.

Fish health in the Murray–Darling Basin

Freshwater fish communities across the NSW Murray–Darling Basin have been monitored using standardised methods since the mid-1990s. Key programs currently collecting data include the NSW Government's **Murray–Darling Basin Plan Environmental Outcomes Monitoring – Fish program** (**DPIRD n.d.-b**) and the Murray–Darling Basin Authority's **Fish Survey program**.

The NSW **Murray–Darling Basin Plan** intends to ensure that the rivers, wetlands and floodplains are restored to a healthy and resilient state. The ***Basin-wide environmental watering strategy*** sets targets to measure progress on this goal. Some of these targets relate to fish health.

The most recent **assessment** shows that only 83 of the 193 targets had been achieved (**DCCEEW 2024c**)

Distribution

Overall distributions of many species in the NSW Murray–Darling Basin have remained stable over the past 30 years (**DCCEEW 2024c**). The distribution of both silver perch and trout cod has decreased.

Silver perch is now restricted to isolated locations in the southern basin and upper reaches of some northern tributaries. This change likely occurred before 2018.

Trout cod now appears restricted to the Murrumbidgee and Murray systems. It has not been recorded in the Macquarie catchment since 2018.

Abundance and biomass

Standardised monitoring for abundance and biomass of key freshwater fish species began in the mid-1990s (**Crook et al. 2023**). There is substantial variation both between species and within species in different regions.

Most species were in a significantly depleted state at the time and there has been no clear change in the overall status of native fish populations over recent decades.

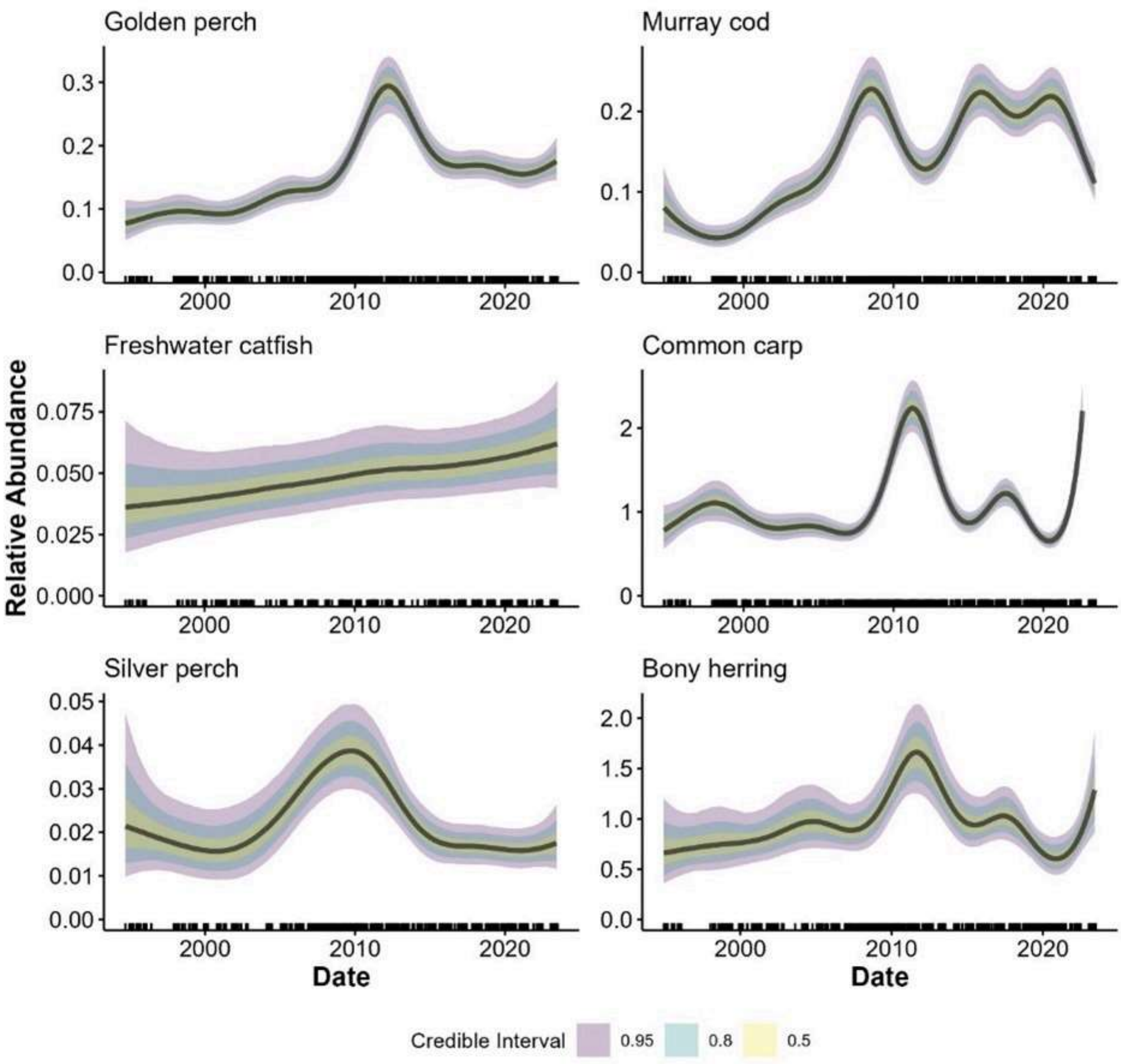
It is difficult to estimate the abundances and biomass of native fish that can be supported under current conditions due to the degraded state of rivers in the Murray–Darling Basin compared to pre-colonisation conditions.

See the **NSW DPIRD Fish Monitoring Reports** website for specific trends in biomass for key species. A full summary on fish outcomes can be found in the NSW Basin Plan Matter 8 report (**DCCEEW 2024c**).

Abundance

Long-term abundance trends for many of the key species in the Murray–Darling Basin remain relatively stable (see **Figure W1.2**). Widespread flooding in 2022 promoted large spawning events and a large abundance of juvenile carp. These are unlikely to survive in the longer term.

Figure W1.2: Relative abundance of key species in the NSW Murray–Darling Basin, 1994–2023



Notes:
Graphs show relative abundance of species across time.
Colours show various levels of confidence around the biomass estimates.

Source:
Figure adapted from Crook et al. 2023

Biomass

Increased abundance of golden perch and freshwater catfish species (see **Figure W1.2**) contrasts with decreases in biomass (see **Figure W1.3**): there are more fish, but they are smaller, indicating that conditions do not support them in growing to adulthood.

Long-term biomass trends for many of the key species in the Murray–Darling Basin remain relatively stable (see **Figure W1.3**). Murray cod biomass has increased since the 1990s.

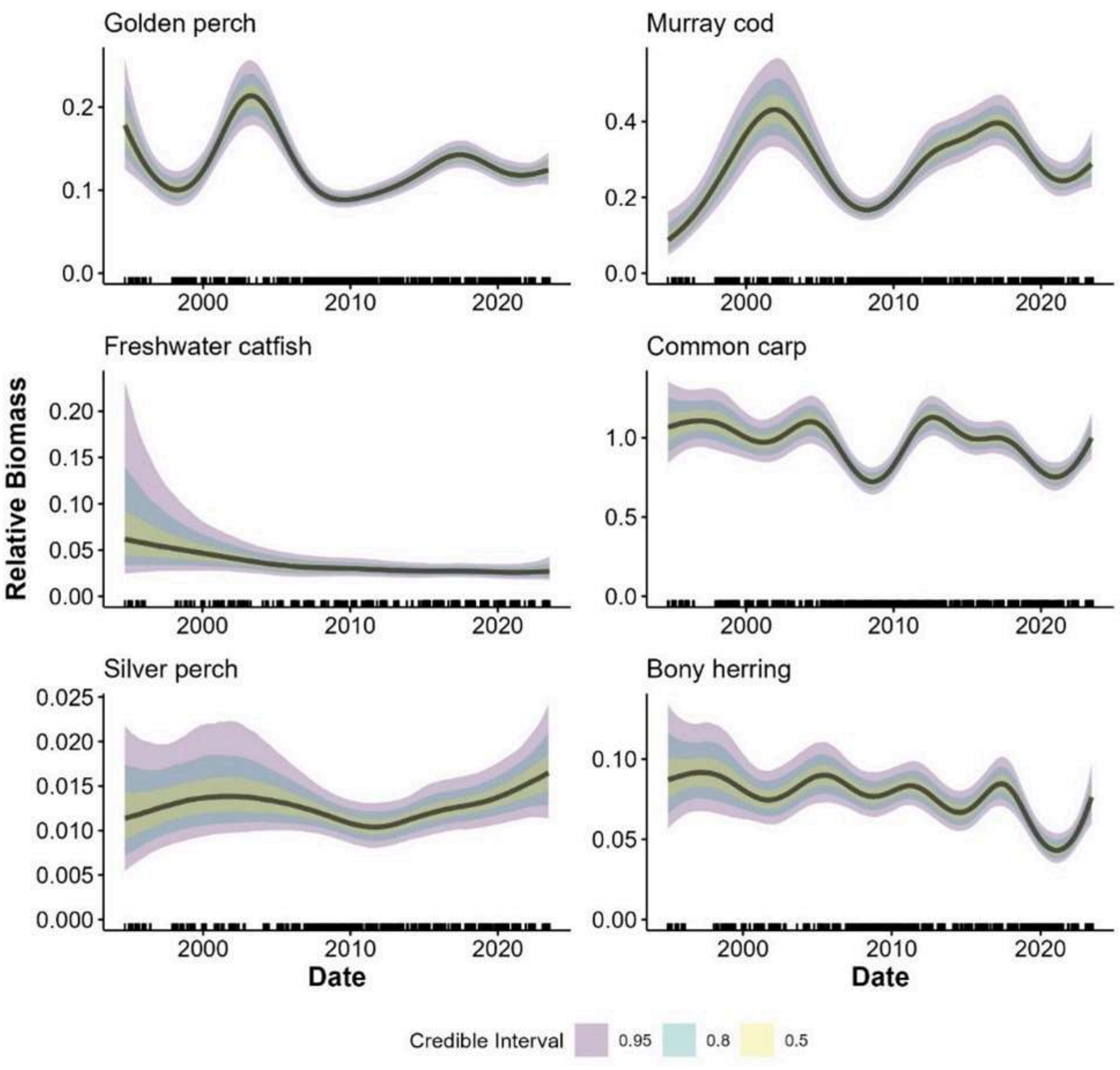
Increases in biomass tend to occur in years following significant freshwater flows.

Common carp are an established invasive species in most inland waterways. Overall, biomass has been relatively stable since the 1990s and the species has likely reached carrying capacity in most areas of the NSW Murray–Darling Basin.

The average proportion of total fish biomass made up by common carp across sites in this area is about 57%, although there are locations where common carp contributes close to 100% (**Schilling et al. 2024**).

Large numbers of common carp juveniles are often produced in response to flooding events, but these do not seem to substantially alter the overall biomass in the longer term.

Figure W1.3: Relative biomass of key species in the NSW Murray–Darling Basin, 1994–2023



Notes:

Numbers are unitless and show relative biomass of species across time.

Species biomass cannot be compared between species using these charts.

Colours show various levels of confidence around the biomass estimates.

Source:

Figure adapted from Crook et al. 2023

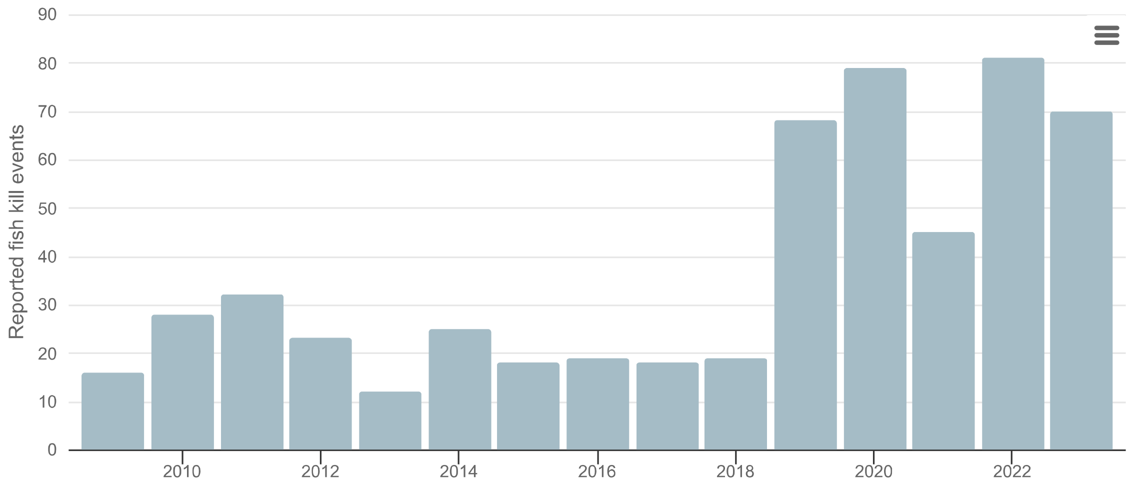
Fish kills

Fish mortality events, also known as fish kills, can occur at any time. They are most likely in summer or following sudden changes in temperature and river flows. These changes can reduce the amount of oxygen dissolved in the water and thus kill fish.

The DPIRD maintains a statewide database of reported fish kill events in NSW (see **Figure W1.4**), holding more than 1,600 records dating back to the early 1970s. It is the lead agency for coordinating responses to such events.

There has been a marked increase in fish kill events since 2019. From 2009 to 2018, the number of fish kill events each year was between 12 and 32 with an average of 21. The years 2019–23 ranged from 45 to 81 with an average of 69.

Figure W1.4: Freshwater fish kill events reported, 2009–23



Source:
DPIRD – Fisheries data 2024

Flows and water volumes vastly improved across most of NSW from 2021 to 2023. This followed intense drought conditions that covered most of the State from 2017 to 2020. The improved conditions provided opportunities for native fish recovery across most of NSW.

Recent fish kill events

Despite these improvements, significant fish deaths occurred in key areas.

Since January 2021, the NSW Government has investigated more than 190 fish death events. This included 80 events in coastal locations and more than 70 in inland river systems.

In March 2023, a large-scale fish death occurred in the 40-kilometre reach of the Darling–Baaka River between Menindee Main Weir and Weir 32, next to Menindee. The incident was declared a formal state emergency and associated emergency management protocols were followed (**OCSE 2023**).

The NSW Government responded to the fish death event through its emergency management arrangements. The NSW Environment Protection Authority (EPA) led the Environmental Services Functional Area (EnvSFA) incident response.

Between March and July 2023, the EPA worked closely with NSW DCCEEW, Science and Insights Division to conduct water quality monitoring in the Darling–Baaka River near Menindee.

It is estimated that tens of millions of fish died during the **event** (**OCSE 2023**).

The bony herring, an important totemic species along the Darling–Baaka River, was the main species affected during this event. It is a short-lived, fast-growing species that booms in times of floods and can die off in large numbers as river flows return to normal (**OCSE 2023**).

The fish kill area overlaps the area affected during 2018–19.

A secondary fish death event affected adult golden perch within the Menindee Weir 32 pool in February 2024. It is estimated more than 100 fish died during the event.

Water quality parameters that typically affect fish health were within or near normal range during this period, including dissolved oxygen, temperature, salinity and pH (acidity).

Testing for pesticide residue and other toxins completed in early February by NSW DCCEEW and EPA found no adverse results. Government agencies are continuing to test for other toxins and are taking more sediment samples.

See the **Climate change** and **Extreme climate and weather** topics for more information.

The recent fish deaths affecting the Darling–Baaka River have been devastating to the Barkandji people, for whom the Baaka River has served as a cultural, spiritual and economic lifeline for tens of thousands of years (**Jackson 2021**).

Their deep connection to the river is evidenced by the creation of intricate fish trap systems, which have supported their livelihoods and cultural practices (**Jackson 2021**). These structures represent a sophisticated understanding of hydrology and ecology, far predating modern water management practices (**Bates et al. 2024**).

The Barkandji people continue to maintain these ancestral fishing practices in Wilcannia and Menindee to this day, manipulating the riverbed with rocks to control water flow and create fish enclosures (**Bates et al. 2024**).

Wetland health

Wetland health is indicated by the variety of plants and animals within them and the area that is inundated.

Natural rainfall and flooding events are beneficial for both coastal and inland wetland vegetation.

The present condition and extent of inland wetlands reflects more than a century of unsustainable land and water management practices (**Salimi et al. 2021**; **DCCEEW-Aus 2024a**). The reduction in both health and area reduces the resilience of our wetlands to increasing climate extremes.

Many areas are losing their ecological function owing to increased pressures from cropping and grazing over the past century, and increased demands on water usage and the structures to meet them (**Kingsford 2001**; **DECCW 2011**; **CSIRO 2015**). This means that they are no longer able to support the plants and animals that rely on them to survive.

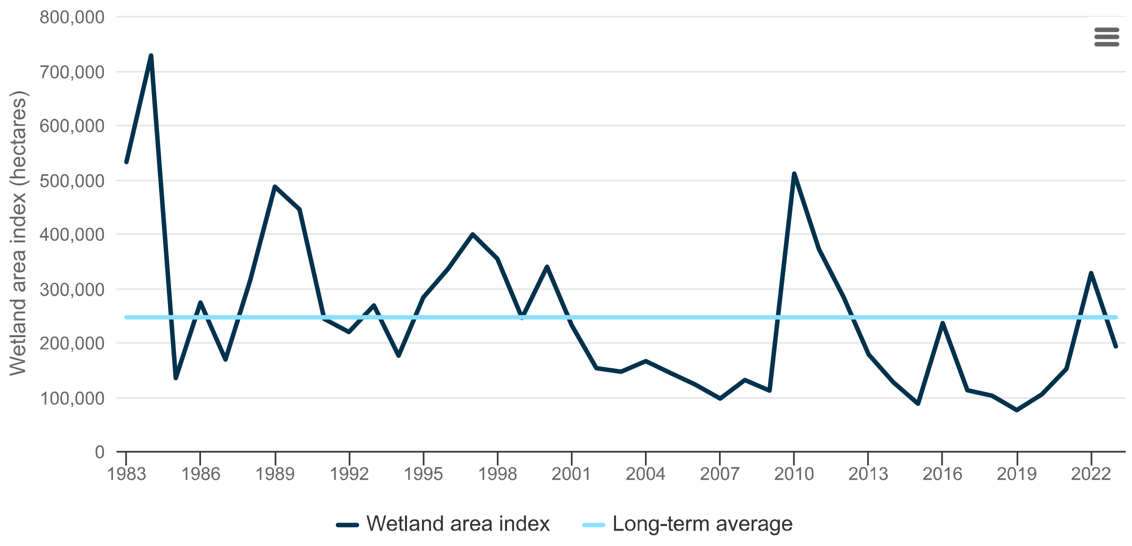
An important resource for assessing trends is the **Eastern Australian Waterbird Survey**. The survey has been conducted since 1983. Information presented here is from the 2023 report (**Porter et al. 2023**).

In October each year, 10 aerial surveys monitor up to 200 wetlands (**Kingsford et al. 2020**; **Porter et al. 2023**). These surveys cover areas 30 kilometres (km) wide, at every 2 degrees of latitude across eastern Australia.

They cover all water bodies larger than 1 hectare (ha), including estuaries, coastal lakes, rivers, swamps, floodplain wetlands, saline lakes, dams, reservoirs and impoundments.

The inundated area has been decreasing since 1983. Only two of the last 10 years had inundation greater than the median value for the period (see **Figure W1.5**).

Figure W1.5: Inundated wetland area (h in eastern Australia, 1983–2023



Notes:
Total wetland area inundated (in hectares) in annual survey transects.
Data derive from annual aerial survey in 10 aerial survey bands in eastern Australia, 1983–2023.

Source:
Eastern Australian Waterbird Survey (Porter et al., 2023)

The NSW DCCEEW's Murray–Darling Basin Monitoring, Evaluation and Reporting program monitors inundation area in selected Murray–Darling Basin wetlands using satellite images. The wetlands monitored are the Gwydir Wetlands, Lowbidgee floodplain, Lower Lachlan Wetlands, Macquarie Marshes, Barmah–Millewa Forest and Narran Lakes.

The satellite imagery can provide information every five days. It complements information from the Eastern Australian Waterbird Survey by providing information throughout the year.

In 2022–23, more than 1 million hectares was inundated across these wetlands.

Wetland extent

Wetland extent has grown with significant additions to protected areas. A little over 12% of wetland is protected (see **Table W1.5**).

In 2021–24, 186,536ha of wetland was added to the combined public and private protected area system in NSW. This included 150,103ha reserved or acquired under the NSW *National Parks and Wildlife Act 1974*.

Many of these wetland additions, both coastal and inland, include areas listed in the **Directory of Important Wetlands in Australia**.

Inland wetlands

In 2021–24, inland wetland areas in the public and private protected area system in NSW increased by 186,162ha (see **Table W1.5**). This included 149,738ha reserved or acquired by the NSW National Parks and Wildlife Services (NPWS) for the reserve system in:

- Brindingabba National Park
- Culgoa National Park
- Doodle Comer Swamp Nature Reserve
- Paroo–Darling National Park
- Comeroo Station (recently acquired)
- Thurloo Downs Station (recently acquired).

Table W1.5: Extent of inland (west of the Great Dividing Range) wetland types and their inclusion in NSW protected areas in 2024

Wetland type	Total area (ha)	% in protected areas (as at end of March 2024)	Protected area	Area in protected areas (ha) (June 2021)	Area in protected areas (ha) (March 2024)	Reserved or acquired from June 2021 to March 2024
Floodplain wetland	4,008,881	13%	NPWS reserves	329,602	478,077	A
			Other	7,296	42,974	–
Freshwater lake	296,071	8%	NPWS reserves	21,205	22,434	B
			Other	251	996	–
Reservoir	84,645	4%	NPWS reserves	3,402	3,429	–
			Other	16	18	–
Saline wetland	18,542	4%	NPWS reserves	0	6	–
			Other	745	751	–
Total	**4,408,139**	**12%**	**NPWS reserves**	**354,208**	**503,946**	–
			Other	**8,219**	**44,733**	**–**

Notes:
A: Brindingabba National Park, Culgoa National Park, Doodle Comer Swamp Nature Reserve*,Cuttaburra Nature Reserve, Thurloo Downs Station* (recently acquired).
B: Paroo–Darling National Park, Thurloo Downs Station*.
*NPWS acquired but not yet reserved (included in both protected area categories).
Other = public or private protected areas.
Protected areas = lands protected securely and in perpetuity.

Information on wetlands is available from DCCEEW n.d. and NPWS n.d.

Source:
Unpublished data from DCCEEW and NPWS

Coastal wetlands

In 2021–24, coastal wetlands in the public and private protected area system in NSW increased by 374ha (see **Table W1.6**). This included 365ha reserved or acquired for the national park system in:

- Killalea Regional Park
- Lake Innes Nature Reserve
- Clybucca Aboriginal Area
- Yuraygir National Park
- Seven Mile Beach National Park.

Table W1.6: Extent of coastal (east of the Great Dividing Range) wetland types and their inclusion in NSW protected areas in 2024						
Wetland type	Total area (ha)	% in protected areas (as at end of March 2024)	Protected area	Area in protected areas (ha) (June 2021)	Area in protected areas (ha) (March 2024)	Reserved or acquired from June 2021 to March 2024
Coastal lagoons and lakes	66,589	28%	NPWS reserves	18,775	18,796	A
			Other	77	79	–
Estuarine Wetland	111,527	14%	NPWS reserves only	14,918	15,210	B
			Other	283	284	–
Floodplain Wetland	15,429	30%	NPWS reserves only	4,546	4,595	C
			Other	37	39	–
Freshwater Lake	2,095	11%	NPWS reserves only	235	235	–
			Other	5	5	–
Reservoir	38,098	2%	NPWS reserves only	601	604	–
			Other	6	9	–
TOTAL	**233,738**	**17%**	**NPWS reserves only**	**39,075**	**39,440**	–
			Other	**407**	**416**	–

Notes:
A: Killalea Regional Park, Lake Innes Nature Reserve, Clybucca Aboriginal Area*.B: Killalea Regional Park, Yuraygir National Park.
C: Seven Mile Beach National Park*.
*NPWS acquired but not yet reserved (included in both protected area categories).
Other = public or private protected areas.
Protected areas = lands protected securely and in perpetuity.

Wetland plants

Environmental flows provide benefits for wetlands, reduce the impact of dry and drought conditions and increase vegetation resilience to extreme climate or weather.

Murray–Darling Basin

Across the NSW Murray–Darling Basin, tree community conditions change in response to wet and dry periods. Different species reflect changes in wetland conditions over varying periods of time.

Non woody vegetation refers to wetlands with shrubs and grasses, including water couch marsh grassland or sedgeland. These plants respond quickly to changing conditions and reflect short-term weather conditions. Prolonged dry weather replaces these wetland species with grasses and shrubs that prefer drier conditions.

Woody vegetation refers to trees, including the coolabah and the river red gum. These species respond slowly to environmental conditions and reflect longer-term changes. Their deeper roots can support them during dry periods and drought.

See the **Plants** topic for more information.

Floodplain vegetation condition has been assessed in the State's inland water management areas (**Map W1.4**). The map shows conditions in 2023–24 and, where condition in 2020–21 is available, whether they have improved, stayed the same or declined (**Bowen et al. in press**).

Woody vegetation has been assessed at 16 sites, four in the south of the basin (Murray, Murrumbidgee, Lachlan) and 12 in the north of the basin (Northern streams, Barwon–Darling, Border Rivers, Gwydir, Namoi, Macquarie). Eight of these had a previous assessment.

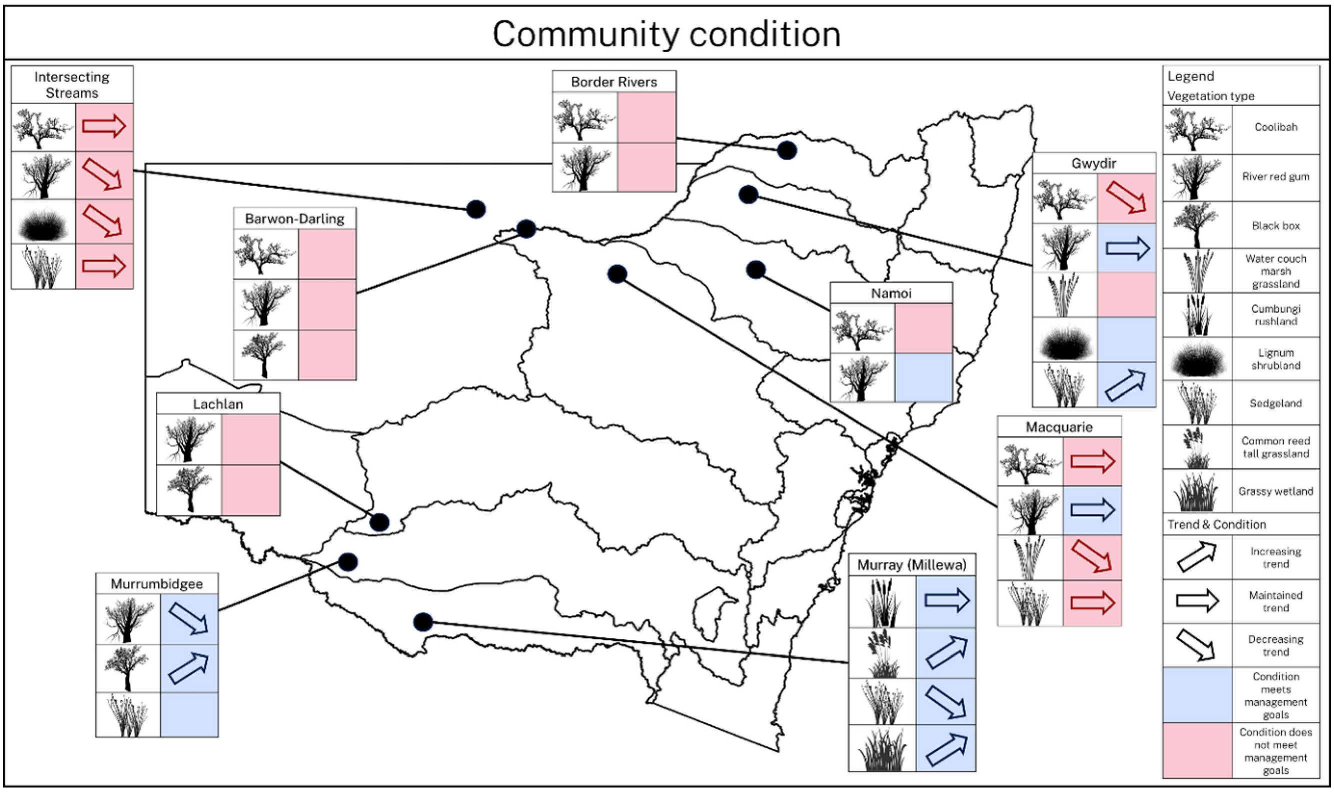
Non woody vegetation was assessed at 10 sites, five in each of the south and the north.

Woody vegetation was assessed as poor at 11 of the 16 sites. Four sites had the same assessment, three were worse and one was better.

Non woody vegetation had better overall condition than woody vegetation. Five of the 12 sites were assessed as poor. Three had the same assessment, three were worse and two were better.

The vegetation condition is markedly worse in the northern Murray–Darling Basin than in the south. For non woody vegetation, two of the seven in the north were assessed as good while all five in the south were good. For woody vegetation, 9 of the 12 in the north were poor while two in the south were poor and two were good.

Map W1.4: Community conditions of surveyed plant community types across the NSW inland water management areas



Notes:
Arrows indicate trends based on available data from 2020–21 to 2023–24. Absence of an arrow indicates data were available for only one of these years.
Colour indicates the most recently assessed community condition.
Pink: a condition of intermediate/poor or below does not meet the management goals.
Blue: a condition of intermediate or above does meet the management goals.

Source:
Bowen et al. in press

The viability of tree populations across the State establishes whether there are enough young trees to replace older trees as they die. If there are not enough young trees (called recruits), these populations are considered not viable.

Semi-arid eucalypts, including river red gum (*Eucalyptus camaldulensis*), coolabah (*Eucalyptus Coolabah*) and black box (*Eucalyptus Largiflorens*), are extremely long-lived, living from decades to centuries. If enough recruits survive to the first adult size class, then these populations will remain viable as long as their water needs are met.

Many communities appeared to have viable population structures but insufficient recruitment between 2021 and 2023 (**Bowen et al. in press**).

See the **DCCEEW website** for more information on woody vegetation viability in NSW.

Coastal riparian areas

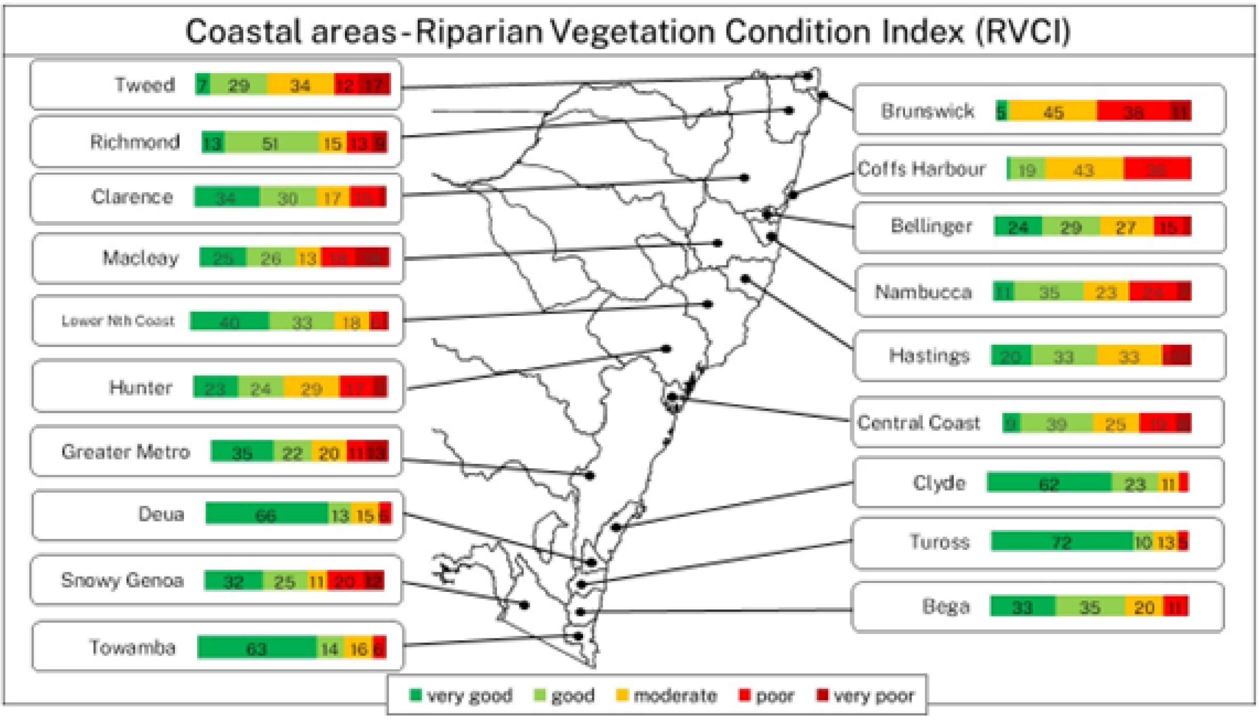
Coastal riparian vegetation is assessed by the Riparian Vegetation Condition Index, a component of the 2023 River Condition Index (**DPE 2023b**). The index is a scale of 0 to 100 based on:

- structural type (woody or non woody)
- naturalness (native or non-native)
- landscape connectivity (fragmentation and patch size).

The index has a 5-point category: 'very poor' (0–20), 'poor' (21–40), 'moderate' (41–60), 'good' (61–80) 'very good' (81–100) (see **Map W1.5**).

Riparian (riverside) vegetation was generally better along the rivers and streams of the NSW South Coast and poorer in the northern areas around the Tweed, Brunswick and Richmond rivers and in the Coffs Harbour catchment.

Map W1.5: Riparian vegetation condition in coastal areas by Water Sharing Plan boundary areas



Notes:
Bar charts indicate the total area of each condition category within each boundary area, shown as a percentage of the total area.

While the index is effective at estimating and indicating condition at a statewide scale, it has limitations.

The scores do not reflect species composition, structural integrity, tree health or community condition. In addition, they are calculated only for a 30-metre-wide buffer zone on either side of streams and do not consider vegetation further away, even though it can contribute to river and wetland health.

See the **Coastal and marine** topic for more information.

Wetland animals

Wetland health is shown by the abundance and diversity of its animals. Pressures adversely affecting a wetland's overall function will be seen in changes to animal abundance.

Wetlands are rich in biodiversity. This report provides data on three representative wetland animal species: waterbirds, frogs and turtles.

Waterbirds

The **Eastern Australian Waterbird Survey** has revealed a long-term decline in waterbirds since 1983 (**Porter et al. 2023**).

While the total waterbird abundance increased over the last three years, long-term trends indicate a decline overall.

Data on waterbirds collected by the survey include:

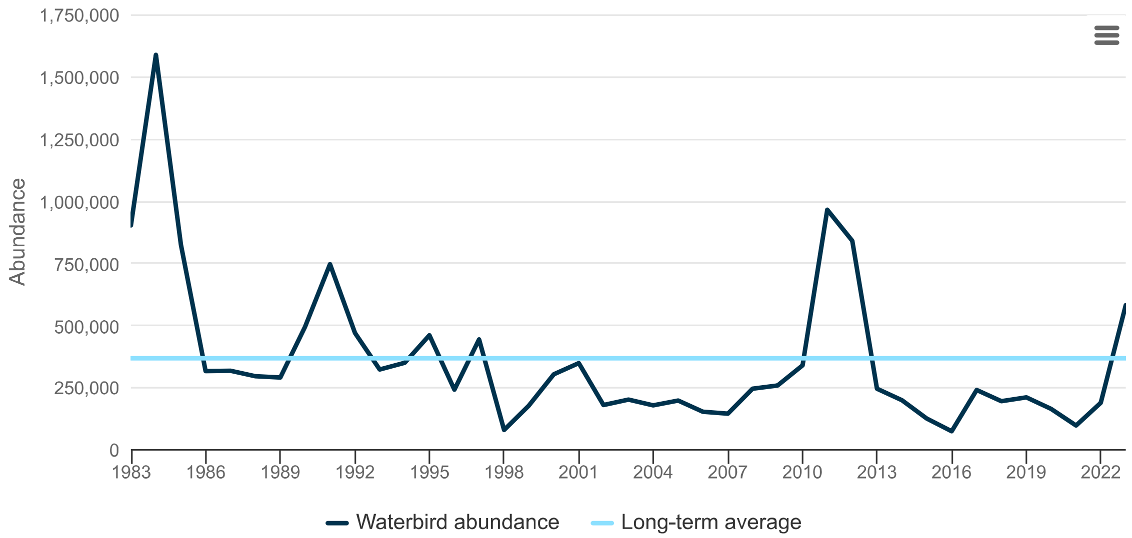
- abundance – total number of waterbirds
- breeding species diversity – number of breeding species
- breeding index – counts of nests and broods of breeding species.

Abundance

Total waterbird abundance increased from 162,824 waterbirds in 2020 to 579,641 in 2023 (see **Figure W1.6**). This is above the long-term median of 256,094 and is the 7th highest record in 41 years.

Long-term trends in total waterbird abundance and number of breeding species show a decline overall, notably in the abundance of ducks, herbivores, large wading birds and shorebirds (**Porter et al. 2023**).

Figure W1.6: Waterbird abundance in eastern Australia, 1983–2023



Notes:
Abundance is the total number of waterbirds counted in the spring aerial surveys (100,000).

Source:
Eastern Australian Waterbird Survey

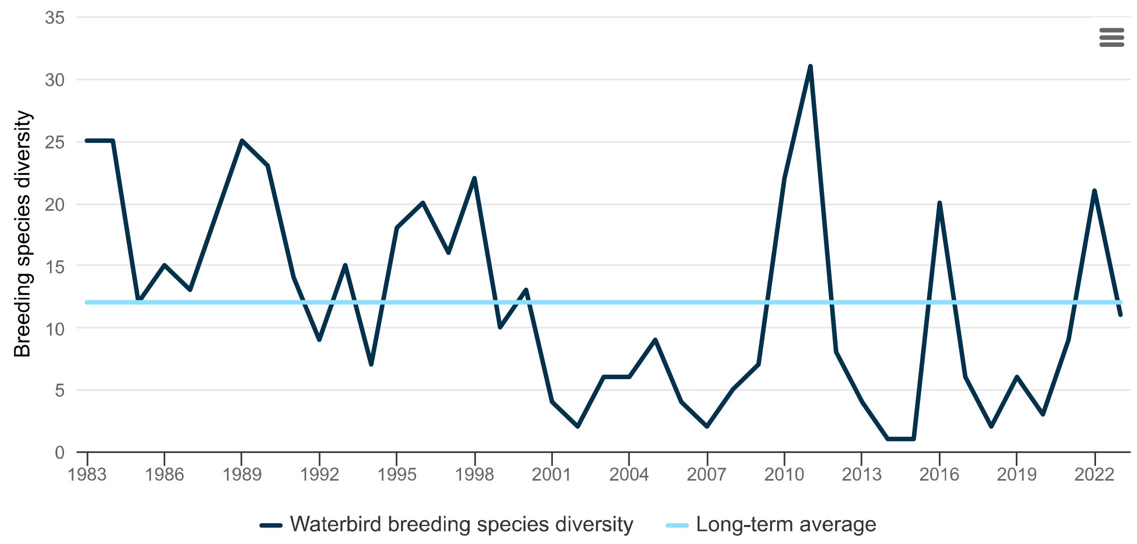
The long-term decline in waterbird abundance reflects the reduction in suitable inundated wetland habitat due to alteration of flows in regulated rivers in the Murray–Darling Basin (**Kingsford et al. 2017**).

Availability of wetland habitat is a major driver of waterbird abundance, breeding and diversity. Reductions in habitat area and persistence due to climate change, river regulation and water extraction have resulted in long-term declines, particularly in the Murray–Darling Basin. Purchases and timed releases of environmental water to support breeding or habitat condition may offset some the impacts of regulation (**Porter et al. 2023**).

Breeding species diversity and breeding index

Waterbird breeding species diversity and the breeding index were above the long-term median in spring 2023 but had significantly decreased from 2022, when large breeding events were recorded in the NSW Murray–Darling Basin (see **Figures W1.7** and **W1.8**).

Figure W1.7: Waterbird breeding species diversity in eastern Australia, 1983–2023

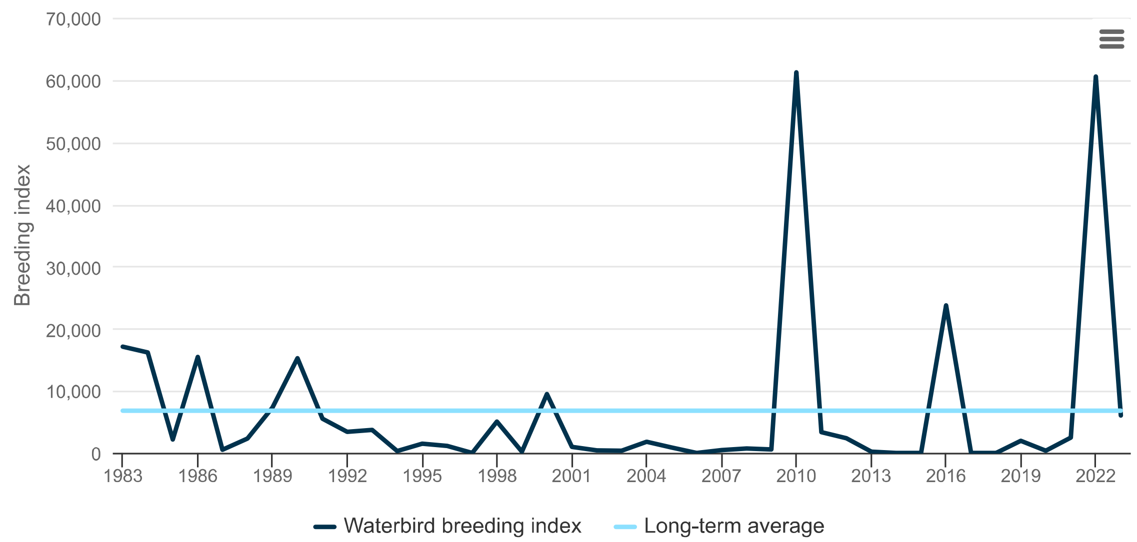


Notes:
Species diversity is the number of species breeding counted in the spring aerial surveys.

Source:
Eastern Australian Waterbird Survey

The waterbird breeding index relates to the estimated number of nests and broods. (A brood is a family of chicks cared for at the same time.)

Figure W1.8: Waterbird breeding index in eastern Australia, 1983–2023



Notes:
Breeding index is the estimated number of nests or broods counted in hundreds of thousands in the spring aerial surveys.

Source:
Eastern Australian Waterbird Survey

Frogs

The presence of these species and their breeding activity have been monitored across three inland wetland regions from 2014 to 2022 (see **Figure W1.9**). The detection of flow-dependent frog species and breeding activity were stable over this period (**DCCEEW 2024d**).

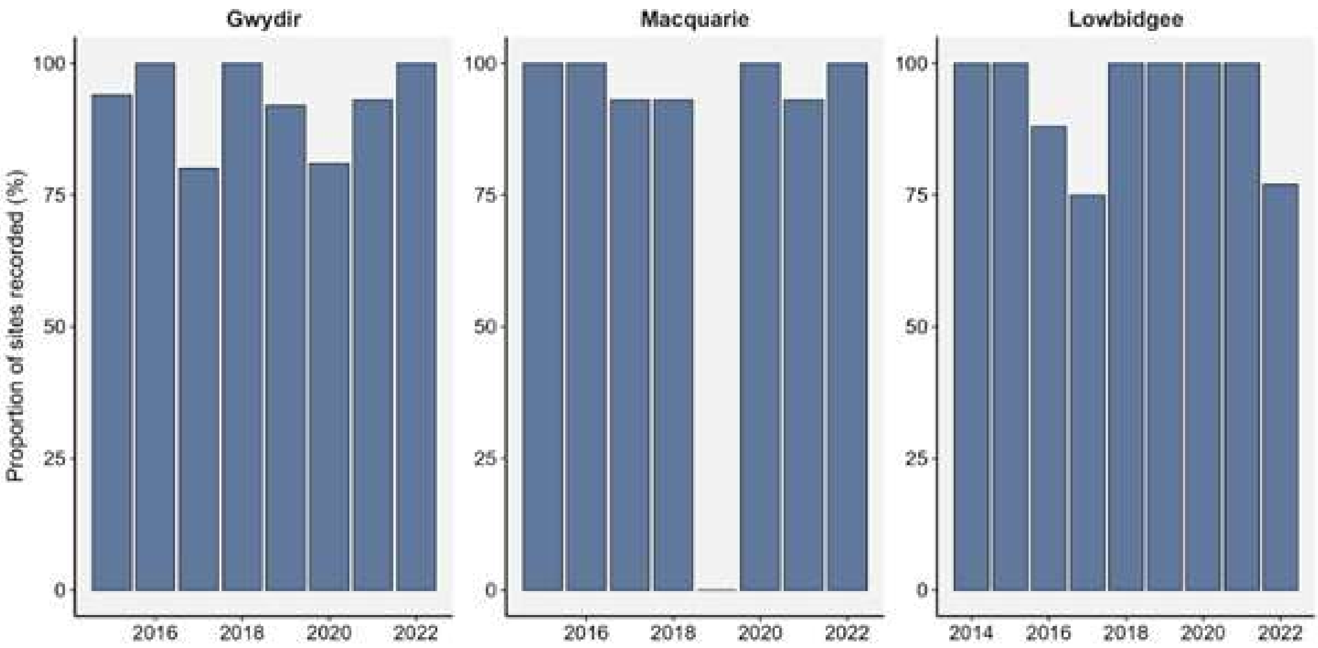
Flow-dependent frog species are those known to breed in response to wetland filling, regardless of rainfall. Breeding activity includes male calling, egg masses, tadpoles and recently changed (metamorphosed) juvenile frogs.

In recent years, delivery of water for the environment to inland wetland systems has supported frog breeding by providing refuge habitat during dry times and enhancing inundation extent and duration at key sites during wetter periods.

One species that has benefited from widespread flooding in spring-summer 2016, 2021 and 2022, and delivery of water for the environment is the nationally vulnerable southern bell frog (*Litoria raniformis*). This species has expanded into new wetland sites in the Lachlan, Murrumbidgee and Murray catchments in recent years (**Waudby et al. 2020**; **Waudby et al. 2021**; **Waudby et al. 2022**).

The presence of these species and breeding activity have been monitored across three inland wetland regions from 2014 to 2022 (see **Figure W1.9**).

Figure W1.9: Proportion of surveyed sites that supported frog breeding activity, 2014–22



Notes:
Flow-dependent frog species: species known to breed in response to wetland filling, regardless of rainfall, and therefore of particular interest for environmental water management.
Breeding activity: includes male calling, egg masses, tadpoles and recently metamorphosed juvenile frogs.
Gwydir and Macquarie: collected through the NSW DCCEEW Biodiversity, Conservation and Science Group for the Water for the Environment program.
Lowbidgee data: collected by Charles Sturt University funded by the Commonwealth Environmental Water Holder Long-Term Intervention Monitoring and Flow Monitoring, Evaluation and Research programs.

NSW Long-Term Water Plans set out the ecological objectives and targets for flow-dependent frog species that were developed as part of the 'Other species' theme. Baselines for flow-dependent frog targets were developed using available data and expert opinion (DPE 2023).

Source:
DCCEEW 2024c

Freshwater turtle populations

NSW has seven freshwater turtle species and one subspecies. Three of these are currently listed as threatened.

Freshwater turtles hold significant cultural, spiritual and ecological value for Aboriginal peoples. Turtles are deeply embedded in Aboriginal traditions such as Dreamtime stories, artworks, ceremonial practices and traditional food sources (**De Oliveira Ferronato & Georges 2023**). This is evident from the more extensive motifs of turtles in rock art than of other fauna.

The specific importance of freshwater turtles varies across different Aboriginal communities (**Petrov et al. 2023**).

Targeted, species-specific monitoring is undertaken by universities and partnerships between the NSW Government and freshwater turtle ecologists. The assessment of turtle species health draws upon recent conservation, advice documents, monitoring reports and scientific literature published within the last six years (see **Table W1.7**).

Freshwater turtle populations are unlikely to be subject to major fluctuations in abundance or distribution within short timeframes, because of their slow maturation, longevity, and high egg and hatchling mortality (**DCCEEW-Aus 2023a**; **DCCEEW-Aus 2023b**).

The assessment of freshwater turtle populations in NSW uses four key metrics (**DCCEEW-Aus 2022**; **DCCEEW-Aus 2023a**; **DCCEEW-Aus 2023b**):

- **abundance status** – graded as uncertain, moderate to high, low or rare
- **abundance trend** – graded as uncertain, stable, increasing or decreasing
- **distribution status** – graded as uncertain, widespread, fragmented or confined
- **distribution trend** – graded as uncertain, stable, increasing or decreasing.

The abundance status of seven of the species or subspecies is graded as moderate to high in most valleys (see **Table W1.7**). The critically endangered Bellinger River helmeted turtle is graded as rare, primarily owing to a rapid disease-related population crash in 2015 (**Petrov 2021**).

The abundance trend of most species was either uncertain, owing to a lack of information, or decreasing, owing to a range of perceived threats, including fox predation, novel viruses and drought.

The distribution status of most species is widespread, with trends either uncertain or decreasing. The endangered Manning River helmeted turtle is graded as fragmented and uncertain. The endangered Bellinger River helmeted turtle is graded as confined but stable.

Table W1.7: Freshwater turtle population status before and during reporting period, 2024

Turtle species	Relevant valleys	Abundance status; trend	Distribution status; trend	Confidence	Source(s)
Broad-shelled turtle (*Chelodina expansa*)	Northern NSW Murray–Darling Basin catchments	moderate to high; uncertain	widespread; uncertain	low	(1)
	Southern NSW Murray–Darling Basin catchments	uncertain	uncertain	not applicable	not applicable
Eastern long-necked turtle (*Chelodina longicollis*)	All NSW Murray–Darling Basin catchments	moderate to high; uncertain	widespread; uncertain	medium	(1), (2), (3)
	All coastal NSW catchments	moderate to high; uncertain	widespread; uncertain	low	(2), (3)
Murray River turtle (*Emydura macquarii*)	All NSW Murray–Darling Basin catchments	moderate to high; uncertain	widespread; uncertain	low	(1), (3)
	Clarence	moderate to high; uncertain	widespread; uncertain	low	(6)
	Bellinger ****Introduced***	moderate to high and increasing	widespread; stable	medium	(6), (7), (8)
	Manning ****Introduced***	low abundance but increasing	confined but increasing	low	(6)
	Hunter	moderate to high and stable	widespread; stable	medium	(1), (4), (5)
	Sydney ****Introduced***	moderate to high; increasing	fragmented; uncertain	low	(9)
	Richmond, Tweed, Brunswick, Macleay, Hastings, Hawkesbury, Macquarie–Tuggerah Lakes, Wollongong coast	uncertain	uncertain	not applicable	not applicable
Western sawshell turtle (*Myuchelys bellii*) ***Endangered**	NSW Border Rivers, Namoi, Gwydir	moderate to high; stable	widespread; stable	high	(1), (10), (11)

Turtle species	Relevant valleys	Abundance status; trend	Distribution status; trend	Confidence	Source(s)
Bellinger River helmeted turtle (*Myuchelys georgesi*) ***Critically endangered**	Bellinger	rare; stable	confined; stable	high	(1), (7), (8), (12)
Common sawshell turtle (*Myuchelys latisternum*)	Richmond, Tweed, Brunswick	moderate to high; uncertain	widespread; uncertain	low	(1)
Manning River helmeted turtle (*Myuchelys purvisi*) ***Endangered**	Manning	moderate to high; uncertain	widespread; uncertain	medium	(1), (13)

Source:
(1) Petrov et al. 2020 | (2) DCCEEW-Aus 2023a | (3) Chessman 2024a | (4) NWES 2021 | (5) DAWE 2020 | (6) Chessman 2021 | (7) Petrov 2021 | (8) Chessman et al. 2020 | (9) Chessman 2024b | (10) DCCEEW 2023b | (11) Chessman et al. 2023a | (12) DCCEEW-Aus 2024b | (13) Chessman et al. 2023b

Threats to freshwater turtle populations

Freshwater turtle populations are under pressure from a combination of known and potential threats, including:

- dams, weirs and other built structures, which prevent movement up and down streams
- removal of large logs and other instream habitats
- trampling of nests by stock and predation of eggs by foxes
- reduced permanency of wetlands and water bodies through water extraction and climate change
- degradation of the riparian (riverside) zone and invasive weeds.

Some threats affect specific life stages. For example, predation or damage of turtle nests affects eggs and hatchlings. Drying of aquatic refuges because of drought and water extraction may affect all life stages.

Adult mortality is particularly concerning, as it takes many years for freshwater turtles to reach maturity and they have low rates of reproductive success. This makes the survival of mature adults extremely important for population persistence.

The likelihood and severity of threats may vary with time or location, with some risks more evident in specific areas (for example, road kills near development).

Most recorded turtle deaths reported by **TurtleSAT** between 2012 and 2023 were road kills of eastern long-neck turtles, particularly during the nesting season, when females seek nesting sites (**Santori et al. 2018**), and around areas with significant development, such as Sydney.

Greater awareness and delivery of targeted conservation measures may reduce these threats. This is particularly important during specific times, such as nesting periods, and in certain locations.

Effective conservation efforts must also prioritise collaboration with Aboriginal peoples, incorporating their knowledge and perspectives to ensure the long-term protection of these culturally and ecologically important species (**Petrov et al. 2023**).

Pressures and impacts

Changes to river flows

The way that water flows in a river system (known as the river flow regime) plays an important role in creating and maintaining the physical habitat of river channels. These channels are being altered by regulation, extraction and climate change.

Installation of dams, weirs, diversion channels and offtakes allows us to move water within river systems for extraction by communities and industry. Such alteration of natural flow patterns can have significant impacts on the health of river, floodplain, wetland and estuarine ecosystems.

Changes to flow can affect the health of Country, including the health and wellbeing of Aboriginal peoples. Recent surveys of Aboriginal communities in Western NSW revealed that loss of river connectivity and access to water significantly harms their mental and physical health (**DCCEEW 2024b**).

Decreasing the volume of water flowing down rivers can harm the function of rivers and wetlands, favour invasive species such as carp, and reduce native plant, fish and waterbird numbers by:

- reducing water levels
- changing the transport of sediments and nutrients
- reducing the connectivity of the river with floodplains and wetlands.

It can also change the composition of these communities, increasing vulnerability and making species more susceptible to climate change and invasive species (**Whipple & Viers 2019**; **Cid et al. 2017**).

Waterway infrastructure

Built structures, such as dams and weirs, present a physical barrier that prevents the safe migration of many fish up and down river systems and the flow of sediments downstream.

All Australian native fish need to migrate to spawn, seek food and shelter, and avoid predators and other threats, such as poor water quality and drying habitats.

The ability of native fish to migrate in NSW has been significantly constrained by the construction of **more than 300 dams and weirs** that help manage the State's water resources.

As barriers to fish, these structures have contributed to a 90% decline in native fish populations since colonisation. Without specific, targeted intervention to restore fish passage, native fish populations will continue to decline towards extinction.

Dams permit cold water pollution, which has significant ecological, social, cultural and economic consequences. Cold water pollution occurs when the bottom cold layer of water from large, stratified (layered) storage dams is released downstream, resulting in detrimental effects over distances of up to 400 kilometres. The artificial drop in water temperature can disrupt the natural thermal regime that many aquatic species rely on for reproduction, feeding and growth.

This disruption can lead to reduced recruitment (breeding) and survival rates of fish and macroinvertebrates, ultimately harming biodiversity and the health of aquatic ecosystems (**Lugg & Copeland 2014**). These can have flow-on effects for local communities that depend on these ecosystems for cultural practices, recreation and economic activities, such as fishing.

Native fish may also be drawn into water pumps and diverted into channels, becoming injured or killed.

In the NSW part of the Murray–Darling Basin alone, more than 450 water pumps are operated for irrigation. This operation could lead to tens of millions of native fish being harmed by water extraction practices annually – estimated at 3.5 native fish per megalitre of water extracted (**Boys et al. 2021**).

Catchment development

The development of catchments for urban and agricultural land use reduces wetland extent and changes the quality of surface water runoff that enters rivers and wetlands.

This has affected native fish populations throughout the freshwater environments of NSW. Nearly two-thirds of species and populations are listed as threatened under State or Commonwealth legislation.

Land clearing

Riparian (riverside) and aquatic habitats of NSW have suffered serious declines in quality and quantity since colonisation.

Reductions in areas of vegetation and native groundcover reduce water infiltration, increase runoff and increase soil erosion. The resulting larger volumes of sediment entering waterways reduces water quality. This is particularly an issue where clearing of riparian vegetation leads to:

- widening of river channels
- erosion at the headwaters of a stream
- increased sediment loads, which can smother aquatic habitats (**Brierley & Fryirs 2005**) and accelerate infilling of deep waterholes in rivers (**Pearson et al. 2020**).

Riparian land acts as the last line of defence for waterways, helping to stabilise banks, improve water quality, drive food webs and provide habitat. Protecting riparian vegetation is vital to support healthy population structures of native fish and for the recovery of threatened aquatic species.

Clearing for developments such as cropping, intensive agriculture and housing leads to a deterioration of water quality in rivers.

Livestock can disrupt wetland ecosystems when they are not constrained. The destruction of plants can increase erosion and interrupt the life cycles of aquatic animals.

Modification of water flow via levees and channels has major impacts on wetland extent and condition. See **Changes to river flows** above for more information.

Pollutants

The use of fertilisers, herbicides and insecticides in intensive agriculture has increased the loads of nutrients entering rivers and wetland areas. This can result in algal blooms, which can smother native macrophyte (large plant) and aquatic invertebrate communities.

Urban development has increased the concentrations of nutrients in rivers and wetlands. This is predominantly due to the release by sewage treatment plants of large volumes of water into rivers, and to high concentrations of heavy metals and chemicals in urban runoff.

Surface waters may also be contaminated with human-made chemicals. A notable example is the presence PFAS (per- and poly-fluoroalkyl substances) in some rivers and reservoirs. PFAS are particularly resistant to heat and chemicals. They have been widely used in fire-fighting foams and as waterproofing and stain protection in fabrics. Their chemical resistance means they persist in the environment for a long time. More information regarding these chemicals is available on the **EPA website**.

Invasive species

Invasive plants and animals put pressure on native populations, competing for resources and space.

Wetland degradation facilitates the establishment and spread of weed and pest species.

Weed species may compromise wetland biodiversity and habitat value, ecosystem function and water quality. Significant wetland weeds include *Lippia*, *Salvinia* and water hyacinth (**Luque et al. 2014**; **Whalley et al. 2011**).

Introduced domestic and feral animals may compete with, or prey upon, native wetland animals. These include foxes, goats and pigs. They can also reduce water quality and plant biomass and increase sedimentation and water turbidity (murkiness).

Introduced fish are a significant issue within NSW waterways, preying on fish and frog eggs, tadpoles and juvenile fish, and fundamentally altering food webs and habitats.

Common carp can exacerbate erosion in rivers when feeding near cleared banks in large numbers. They have become one of the dominant fish species and are found throughout most of the Murray–Darling Basin. Their abundance and biomass fluctuate widely, possibly in relation to recruitment waves associated with flood conditions.

Climate change

Increasing temperatures associated with climate change are exacerbating existing pressures on rivers and wetlands, changing water flows and harming catchment and riparian conditions.

Recent projections by the NSW Government indicate a warmer future, with an increase in mean temperature, potentially exceeding 4°C during this century under a high-emissions scenario (**AdaptNSW 2024**).

Increased temperatures will lead to increased evapotranspiration and demand by industry, reducing the availability and flow of water in rivers.

Uncertainty remains around the impact of climate change on rainfall patterns (**AdaptNSW 2024**). Projections suggest that NSW may experience overall reductions in precipitation.

Reduced water availability will mean that the flows that support ecosystems will be less likely to occur. Water for the environment is particularly important in supporting ecosystems when water availability is low.

Changes in water flow durations can affect the life cycle and distribution of many water-dependent species.

Changes in water availability affect the wetland inundation patterns that support vegetation. These may cause significant contraction of inland wetlands and change their ecological functions.

Reduced streamflow is expected to reduce habitat quality and quantity, limit interconnectivity, and limit movement of fish to seek out suitable habitat and spawn.

Coastal freshwater wetlands that rely on rainfall are also likely to be harmed by climate change under the projected drier conditions.

Estuaries will be further affected by projected sea level rise, which will alter tidal ranges and salinity distribution (**Khojasteh et al. 2021**), and by increases in sea surface temperatures. Possible impacts include:

- local collapse of fish populations
- declines in species distribution (as survival of species in their original ranges depends on their ability to migrate throughout river systems to maintain genetic diversity)
- disrupted breeding cues (especially from increases in water temperatures)
- altered competition and symbiotic relationships
- spread of disease
- altered fitness of fish across all life stages.

Understanding the climate change risks and impacts for aquatic animals, such as native fish, waterbirds, frogs and turtles, and their habitats will help support the development of appropriate adaptation and management actions.

This will increase resilience in populations and guide management actions. Actions such as relaxing constraints to ensure that water for the environment can be delivered when and where it is needed are crucial.

See the **Climate change** topic for more information.

Extreme climate and weather

Drought

The Australian landscape is adapted to natural drought conditions, with many species' life cycles relying on natural variability in river flows.

However, prolonged or severe drought causes major disturbance to rivers and wetlands, reducing water availability for vegetation and refuge habitats for animals, and compounding the impacts on already stressed aquatic ecosystems.

Where the combined effects of drought conditions and water extraction build up over extended periods, they may exceed critical thresholds in the life cycles of some aquatic species. This threatens the resilience and recovery of populations of aquatic animals such as fish, frogs and birds.

Long-term changes to river conditions have already reduced native fish and waterbird populations, making them less resilient to further changes, such as those imposed by the decade-long Millennium Drought of the 2000s.

These changes to river conditions will also affect vegetation populations. Assessment of the viability of woody vegetation communities in the lower Namoi and lower Gwydir found too few juvenile trees (**DPE 2023c**).

Large areas of NSW faced severe water shortages owing to drought from 2017 to early 2020, although since then, there has been a series of La Niña years that were wetter than average.

Water shortages are projected to become more frequent and severe as our climate changes (**AdaptNSW 2024**).

Bushfires

After a bushfire, ash, burnt material, soil and organic matter are washed into waterways. The impact on water quality can occur straight away and may persist for years after the fire. The severity of impacts varies depending on catchment conditions and rainfall intensity.

Materials washed into rivers and streams can change water chemistry, harming aquatic animals, such as fish and platypus, while also compromising town water supplies.

Fire affects other components of river condition for many years through changing habitat, removing plants along riverbanks, which allows more erosion, altering the shape of the river and reducing biodiversity.

Since the NSW bushfires in 2019–20, research has been undertaken into the **impacts of bushfires on freshwater ecosystems and potential water management options.**

See the **Extreme climate and weather** topic for more information.

Responses

Licensing and regulation

The NSW Government has implemented and improved water licensing and regulatory measures since the NSW *State of the Environment 2021*. These measures are intended to improve water sharing equity between users and water for the environment.

Floodplain harvesting

Floodplain harvesting activities, such as the unlicensed taking of water from floodplain runoff, were integrated into the water licensing framework.

Licensing limits now provide regulatory certainty for users and regulate the take of water and the development of water storage infrastructure on floodplains in NSW. This ensures that water resources are now measured and managed within appropriate rules and limits.

Licensing and measurement of floodplain harvesting will return significant volumes of water to floodplains, rivers and creeks. The additional floodplain flows will benefit waterbirds, native fish and vegetation, particularly in the internationally recognised Gwydir Wetlands.

See the **Licensing floodplain harvesting** website for more information.

Long-term water strategies

NSW Water Strategy

The NSW Government has established the ***NSW Water Strategy***, which outlines a plan to achieve sustainable water resources for people, places and ecosystems. The plan states seven priorities:

- Priority 1: Build community confidence and capacity through engagement, transparency and accountability.
- Priority 2: Recognise Aboriginal peoples' rights and values and increase access to and ownership of water for cultural and economic purposes.
- Priority 3: Improve river, floodplain and aquifer ecosystem health and system connectivity.
- Priority 4: Increase resilience to changes in water availability.
- Priority 5: Support economic growth and resilient industries within a capped system.
- Priority 6: Support resilient, prosperous and liveable cities and towns.
- Priority 7: Enable a future-focused, capable and innovative water sector.

The **2021–22 Annual Progress Report on Water Strategy Implementation** reports that of the 123 actions in the **2021–22 NSW Water Strategy Implementation Plan**:

- 55% were complete or ongoing (have no end date)
- 26% were in progress with a revised timeline
- 15% were in progress
- 2% had closed
- 2% had not started.

The 2022–23 Annual Report Progress on Water Strategy Implementation updates progress but does not provide a progress summary.

The **2021–22 NSW Water Strategy Implementation Plan** builds on the progress made since 2021 and identifies 42 actions to be taken over the next 2 years.

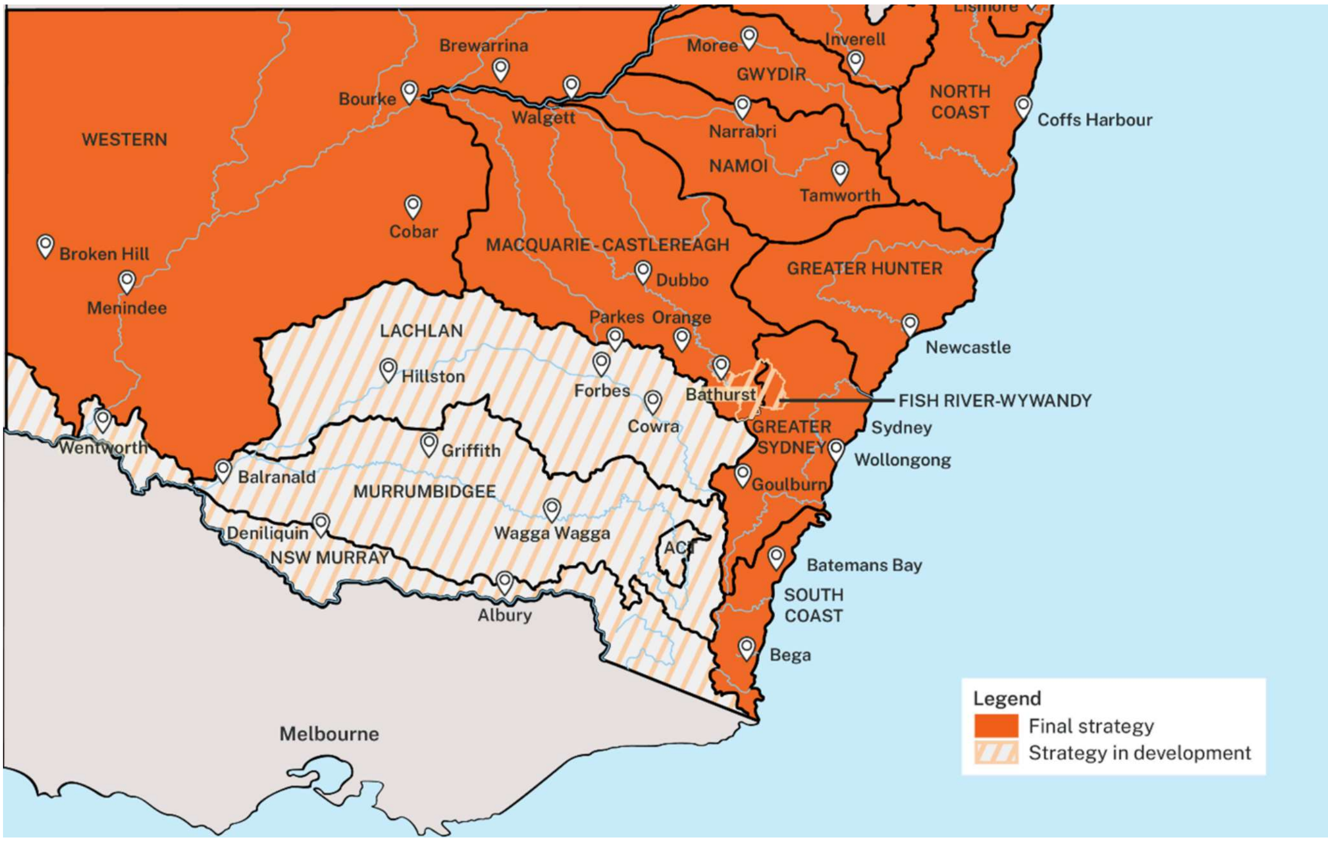
The first formal review of the *NSW Water Strategy* is due in 2026.

Regional and metropolitan water strategies

Regional and metropolitan water strategies work alongside the NSW Water Strategy to help prepare specific regions for a changing climate.

Most of these strategies have been finalised and are now being implemented (see **Map W1.6**). The final four regional water strategies are currently under development (**NSW Water n.d.**).

Map W1.6: Regional and metropolitan water strategy program status as of 2023



Source:
NSW Water n.d.

Working with Aboriginal peoples

Aboriginal Water Program

The **Aboriginal Water Program** encapsulates how the NSW DCCEEW is embedding Aboriginal peoples in the planning and management of water in NSW.

NSW Aboriginal Water Strategy

The NSW Government is working with Aboriginal peoples to develop and implement a ***NSW Aboriginal Water Strategy*** to address the ***NSW Water Strategy*** Priority 2.

The strategy identifies opportunities to increase Aboriginal water rights and ensure that Aboriginal peoples are empowered to contribute to water management and planning decisions.

The strategy is underpinned by six principles relating to water that Aboriginal peoples identified as important:

- culture – water is central to Aboriginal culture and practices
- health and wellbeing
- caring for Country
- meaningful engagement
- economic benefit
- shared cultural and environmental benefits.

Cultural Watering Plans

Cultural Watering Plans aim to increase Aboriginal ownership of water for cultural and economic purposes.

The NSW Government will create an environment of two-way knowledge sharing. It will also investigate barriers to using **Aboriginal Cultural Specific Purpose Access Licences** and promote awareness of existing water access avenues.

Other NSW Government programs

The NSW Government is working with Aboriginal peoples to apply the processes developed in **A Pathway to Cultural Flows in Australia**.

Existing government strategies provide the principles and commitments for effective engagement and shared decision making, including:

- the Australian Government's **Closing the Gap**
- the NSW Government's **OCHRE Plan**
- the NSW Government's ***Aboriginal Outcomes Strategy 2022–25***.

Incident response programs

The **Aboriginal Lands Flood Recovery Program** provides support to managers of Aboriginal land in recovering from the 2022 floods through clean-up and restoration works. Assistance is currently being provided to three Local Aboriginal Land Councils in the Central West and the Riverina.

A joint **Darling–Baaka water quality monitoring program** commenced in mid-2023 following floods and the mass fish deaths in Menindee. The Program will run until June 2025 in three local government areas in partnership with the NSW DCCEEW and the Barkandji Native Title Group Aboriginal Corporation. The **NSW Government's full response** to the Office of the Chief Scientist and Engineer's review of this incident is available.

See the **Environmental incidents** section below for more information.

Environmental water

Water for the environment

Water that is allocated and managed specifically to improve the health of rivers, wetlands and floodplains is known as **water for the environment**.

Water for the environment is allocated to allow plants and animals to feed, breed, grow and remain resilient.

Over the past three years, water for the environment has been managed to restore a more natural flow regime in the regulated catchments of the NSW portion of the Murray–Darling Basin. This includes the Gwydir, Macquarie, Lachlan, Murrumbidgee and Murray rivers. The more natural flows have supported the waterbirds of large floodplain wetlands to breed during wet periods.

These flows enable fish to move up and down the rivers, inundate feeding habitat, and provide refuge habitat during dry periods for other wetland-dependent species, such as frogs and freshwater turtles.

Water for the environment is especially important during dry periods as it is often the only water available to plants and animals.

As part of the **NSW Water for the Environment Program**, the DCCEEW Biodiversity, Conservation and Science Group continues long-term monitoring of the priority indicators of wetland health related to environmental flow requirements: inundation patterns, vegetation, waterbirds and frogs.

Trends in environmental outcomes are assessed to evaluate the progress towards the targets of indicator objectives outlined in the **NSW Long-Term Water Plans**. The Murray–Darling Basin Plan requires reporting on ecological outcomes every five years. The most recent was released in October 2024. These reports are available on the **Murray–Darling Basin Authority website**.

Since 2020–21, water for the environment has been extended to other river catchments in the NSW portion of the Murray–Darling Basin: Lower Darling–Baaka, Namoi, Barwon–Darling and intersecting streams.

Outside of the Murray–Darling Basin, water for the environment is managed in the Snowy River and Hunter River catchments.

When implementing environmental flows, it is important to consider the cultural values of waterways (**Moggridge & Thompson 2021**).

Although there is extensive Aboriginal knowledge of environmental flows, it has been largely overlooked. This can lead to unintended harms to cultural heritage, such as disturbing sacred sites or harming culturally significant species (**Moggridge & Thompson 2021**).

In contrast, cultural water flows recognise the intricate relationship between people and Country, often involving precise timing and location of water delivery. Protection of culture requires that these considerations be included in managing environmental flows.

Reconnecting River Country Program

The **Reconnecting River Country Program** proposes to enable more flexible use of water for the environment and to increase the frequency and extent of inundation connecting rivers to their wetlands and floodplains. It works with Aboriginal peoples, landholders, public land managers and local communities.

Gwydir Reconnecting Watercourse Country Program

The **Gwydir Reconnecting Watercourse Country Program** seeks to increase the effectiveness of environmental water deliveries by working with watercourse landholders, water licence holders and the broader community to establish water corridors.

The program has three project areas:

- Gingham Watercourse
- Lower Gwydir Watercourse
- Lower Mehi River.

It is funded through the **Northern Basin Toolkit** and is currently in implementation phase.

Saving our Species program

The **Saving our Species program** develops conservation strategies for all threatened species and ecological communities in NSW. The strategies identify the critical threats affecting each target's viability and the actions needed to secure them in the long term.

Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands has been identified as a critical threat to 29 plants, 22 animals and 12 threatened ecological communities. Of these, 35 are currently under management through the Saving our Species program (**NSW Government 2002**).

Improving water quality

NSW Water Quality Governance Roadmap

The **NSW Water Quality Governance Roadmap** identifies initiatives to support continual improvement of water quality governance and broader reforms to it.

The development of the roadmap included research into arrangements and frameworks for water quality management and monitoring across NSW to better understand the challenges and opportunities for improvement. The research focused on better understanding of the regulatory framework and policy context, roles and responsibilities and existing programs.

Recognising the challenges of shared management of water quality across NSW, the roadmap presents a pathway for better integrating the management of land, water and natural resources in NSW to improve water quality management.

NSW Water Quality Monitoring Framework

The water quality framework project is a 12-month initiative to develop and implement a statewide system for collecting, managing, sharing, and accessing water quality data across government agencies.

The project aims to address the gaps and challenges identified by the Office of the Chief Scientist and Engineer's **report on fish deaths**, and improve the environmental outcomes and public awareness of water quality issues. It involves collaboration and consultation with key stakeholders and will use existing tools and platforms, such as **SEED** and **Water Insights**.

Diffuse source water pollution governance framework

The **Diffuse source water pollution governance framework** will allow NSW Government agencies to work together to improve water quality by clarifying roles and responsibilities of each agency, and identifying strategies for managing pollution.

Improving river and catchment habitats

Fish passage and screening improvements

The ***NSW Fish Passage Strategy***, developed in 2018, sets out a coordinated, 20-year plan to restore and improve native fish access to critical mainstem river and off-channel habitats below all major storage dams in NSW.

Since it started, it has helped attract more than $184 million in funding for fish passage amendments at more than 50 barriers.

Over the past three years, fishways have been constructed at four high-priority sites in NSW:

- Homestead Weir on the Warrego River
- Boera Weir on the Warrego River
- Walgett Weir on the Barwon River
- Seaham Weir on the Williams River in the Hunter catchment.

These significant works have reinstated fish passage to more than 360km of upstream habitat and have been complemented by smaller works at other structures, such as causeways, crossings and smaller weirs.

In NSW, **modern fish-protection screens are being installed** at pumping sites across more than 120km of waterway along the Macquarie, Mehi and Barwon rivers.

A total of 52 pumps have been upgraded complementing other efforts over recent years. Installation started in early 2024 and is expected to continue into 2026.

Screening these sites is projected to protect 252,000 native fish annually and deliver up to 800 million litres per day of cleaner water.

Habitat mapping

In the past three years, the NSW DPIRD has mapped 1,317km of stream length and 14,524ha of riparian area in the:

- Lachlan River
- Murrumbidgee River
- Capertee River
- Turon River
- Darling River
- Dungowan Creek
- Billabong Creek.

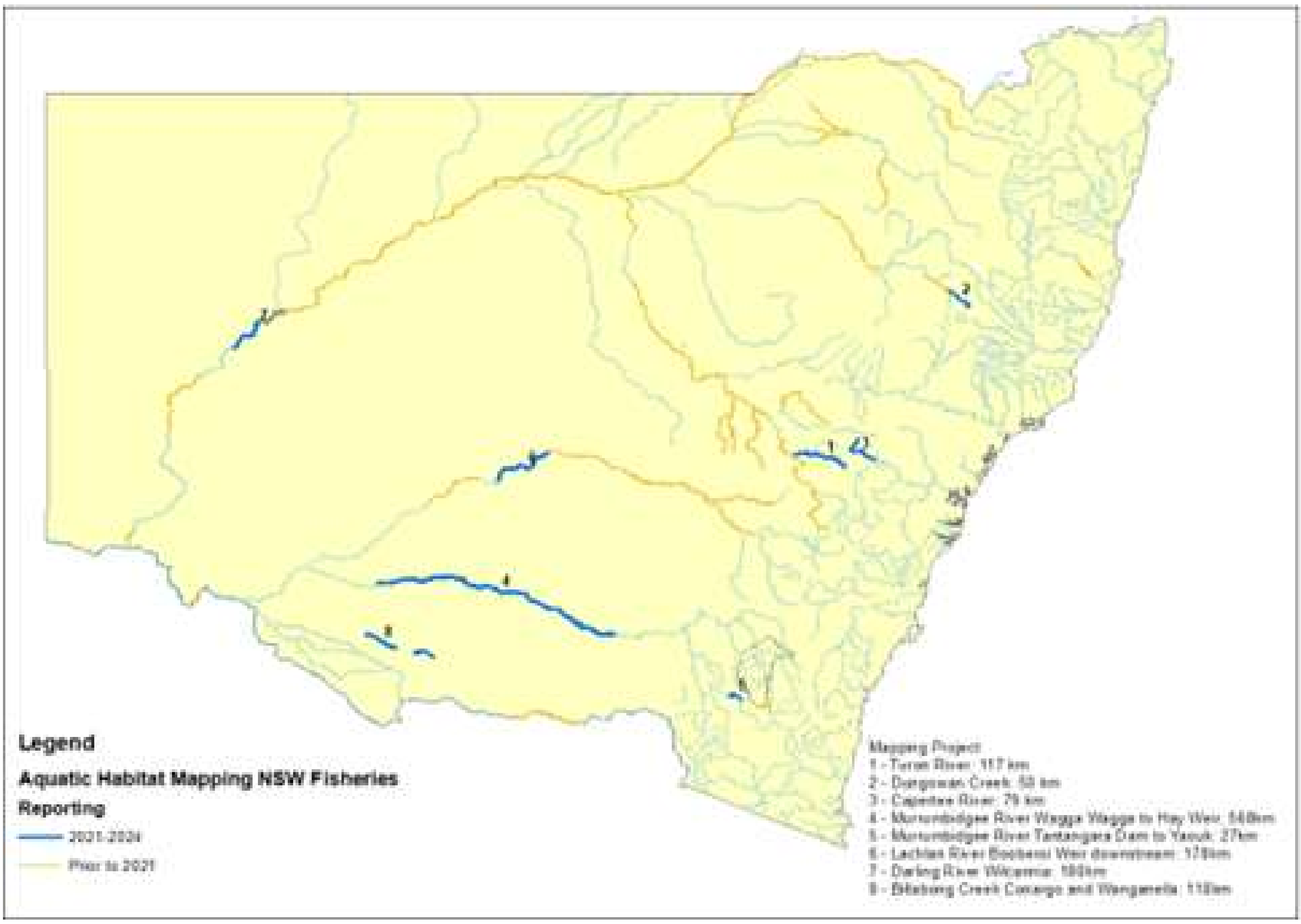
The mapping establishes baseline measurements for the physical features related to the needs of aquatic species and river management. Future remapping will show trends and guide rehabilitation priorities.

Mapping data were used to identify relationships between river flow height and habitat availability to inform water management decisions and flow hydrograph design.

This builds on previous mapping, bringing the total to 6,558km of stream length and 66,934ha within riparian zones (see **Map W1.7**).

As at 2023, 3.69% of the NSW total area has been mapped.

Map W1.7 Total area of mapped aquatic and riparian habitats since 2009



Source:
Unpublished data, DPIRD

Local Land Services Natural Resource Management Framework

The **Natural Resource Management Framework 2021–26** sets statewide priorities for Local Land Services (LLS) planning and programs. Objective 3 of the framework is to act on the top threats to the health and resilience of NSW landscapes and catchments.

One of the expected outcomes is that waterways and riparian zones will be rehabilitated in high-priority catchment areas. Projects include:

- the **Hexham Swamp Rehabilitation Project (PDF 0.44MB)**
- the **Ramsar Wetlands Project**
- the **Restoring Clybucca Tidal Wetlands Project (PDF 0.85MB)**.

LLS support the rehabilitation and protection of wetlands and waterways by providing advice to landholders on:

- revegetating around waterways
- managing riverbank and gully erosion
- stock exclusion
- delivery of on-ground projects.

See the **LLS website** for more information.

NSW Recreational Fishing Trust Habitat Action Grant Program

During the current reporting timeframe, more than 90 projects have been undertaken by local governments and community supported by the Recreational Fishing Trust to protect and rehabilitate fish habitats.

Over 96,000 plantings covering an area of 115.8ha and 59.2km of riparian corridors and foreshores were completed. 139.3ha of weed control was undertaken extending along over 98km of riparian frontage and 2,300 metres of erosion control was undertaken. Instream, 100 large woody habitat (snags) and eight rock structures were reinstated, 42 fish hotels/engineered log jams were installed, and two barriers were removed opening up 29km of fish passage.

Aquatic habitat mapping

The **Aquatic Habitat Mapping Program**:

- develops riverine mapping projects to identify instream and riparian habitats
- provides information to assess environmental impacts
- introduces restoration and rehabilitation actions to improve aquatic environments and manage river flows.

Breeding threatened species

The Department of Primary Industries and Rural Development (DPIRD) is involved in many research, conservation management and habitat restoration projects to support threatened species. This includes captive breeding and release. See the list of **current threatened species projects** on the DPIRD website.

Between 2020 and 2023, 13 threatened fish species were bred in captivity. More than 375,000 fish were released into suitable habitats in rivers and streams.

Weed management

In NSW weed management is prioritised based on risk as evaluated through the **NSW Weed Risk Management system**.

The risk for each weed is assessed based on the potential impacts if it becomes more established or more widespread.

Weeds that are considered a State biosecurity risk are managed using instruments such as Control Orders and Biosecurity Zones under the ***Biosecurity Act 2015*** and the **Biosecurity Regulation 2017 – Weeds**.

These include, rubber vine (*Cryptostegia grandiflora*) and mouse-ear hawkweed (*Pilosella officinarum*), both listed as Prohibited Matter under the *Biosecurity Act 2015*. Both are on track for eradication in NSW by the DPIRD.

The **Regional Strategic Weed Management Plans** also use risk to prioritise weed management in the 11 Local Land Services (LLS) regions.

The plans play a critical role in the early detection and eradication of priority weed species and the containment and management of those that are more widespread.

They list 64 weed species that have been assessed as regional priority weeds for conservation and environmental land use areas in NSW.

Of these,13 are managed with the goal of preventing their spread in at least one LLS region. These include weeds such as leaf cactus (*Pereskia aculeata*) and horsetails (*Equisetum* spp.).

A further 38 regional weed species are being managed with the goal of eradication in at least one region. These include a wide range of priority species, such as:

- bridal creeper (*Asparagus asparagoides*)
- Hudson pear (*Cylindropuntia pallida*)
- sea spurge (*Euphorbia paralias*).

Another 34 species are managed for containment and asset protection in at least one LLS region.

These include opuntioid cacti, such as the prickly pears (*Opuntioid* spp.), and Hudson pear (*Cylindropuntia pallida*), which are being managed successfully through biocontrol programs and targeted on ground management (**McConnachie et al. 2022**).

Other widespread species, including blackberry (*Rubus fruticosus* species aggregate), *Lantana camara* and serrated tussock (*Nassella trichotoma*), are managed using an asset protection approach through programs such as **Saving our Species**, which manage weeds and other threats to native species holistically. These programs aim to reduce weed impact at specific affected locations (**DCCEEW 2024b**).

LLS supports rural landholders to fulfil their responsibilities to manage weeds in accordance with Australian and NSW biosecurity legislation and Regional Strategic Weed Management Plans.

For example, from 2021 to 2024, LLS helped manage weeds on 141,100ha of private rural land for improved biosecurity, agricultural productivity and biodiversity.

Invasive species

Carp

Released in 2022, the **National Carp Control Plan** uses a virus to kill introduced carp. Scientists are determining if the virus is safe, effective and feasible so it can be released in waterways where carp live.

Environmental incidents

Fish kill responses

The extent and severity of mass fish deaths across NSW have increased over the past five years.

In 2023, the NSW Government released the 30-year ***Native Fish Recovery Strategy***. The strategy identifies four key outcomes:

- Recovery and persistence of native fish
- Identification and mitigation of threats to native fish
- Active involvement of communities in native fish recovery
- Informing of recovery actions by best available knowledge.

This work is undertaken by recovery coordinators in 'recovery reaches'.

The Office of the Chief Scientist and Engineer undertook an **independent review** following the mass fish death event in the Lower Darling–Baaka during March 2023.

The review makes four major recommendations, each with multiple sub-components (24 recommendations in total):

- Recommendation 1: Regulatory environmental protections must be enforced.
- Recommendation 2: Obtain better data to support better decisions.
- Recommendation 3: Effective emergency management.
- Recommendation 4: Interventions to mitigate against future mass fish deaths.

The NSW Government released an initial response in November 2023. The **final response** was released in June 2024. See the **NSW Government Response to Menindee 2023 Fish Deaths (PDF 13.9MB)** for more information.

The initial response committed the NSW Government to 10 immediate, on-ground actions that were under way or were planned to be completed during the 2023–24 summer. These actions are intended to mitigate the risk of further fish deaths at Menindee and in the Lower Darling–Baaka during peak summer, and include:

- managing flows from the Menindee Lakes to maintain sufficient dissolved oxygen levels for fish
- appointing a Menindee-based Senior Water Implementation Officer to improve local communication
- upgrading water quality monitoring
- undertaking surveys to estimate fish numbers
- scoping options to allow fish passage and enhance river connectivity
- developing an interim Mass Fish Death Sub-Plan to respond to mass fish deaths at Menindee.

The NSW Government continues to work on reducing the risk of further mass fish deaths at Menindee. It is developing initiatives to improve water quality and fish health in the Barwon–Darling catchment and enhancing its emergency response and communication capabilities.

Flood recovery programs

The NSW EPA led **flood recovery programs** following intense flooding across the State in 2022 and 2023. A range of agencies and contractors carried out the programs.

The programs included:

- a land-based clean-up program that removed 150 tonnes of large and hazardous flood debris from 835 sites across 41 local government areas
- partnering with the Barkandji Native Title Group Aboriginal Corporation and NSW DCCEEW to monitor water quality and river health in the Darling–Baaka from mid-2023 following floods and the fish kill
- additional projects for agricultural chemical clean-up, contaminated land assessments and clearing illegal waste dumps and flood waste
- extensive water quality monitoring under the **East Coast flood project**.

Future opportunities

The ***NSW Fish Passage Strategy*** will significantly enhance the ability of native fish to reach key habitat. Additional infrastructure management actions are needed to mitigate cold water pollution downstream of impoundments, and to protect fish from pumps and diversion channels. A statewide strategy to mitigate cold water pollution is being revised and a strategy for diversion screening is being developed.

A more holistic approach is needed in water management, incorporating cultural values and the wellbeing of Aboriginal peoples in addition to ecological outcomes (**Costanza-van den Belt et al. 2022**). This requires a deep understanding of the complex relationship between Aboriginal cultures and water values (**Moggridge & Thompson 2021**).

Research and collaboration with Aboriginal communities are essential to understanding the cultural values associated with water and to determining the specific water requirements needed to uphold these values (**Moggridge & Thompson 2021**). Through a focus on Aboriginal knowledges and practices, it is possible to develop water management strategies that benefit both ecosystems and communities.

Cultural flows recognise the unique water rights and management systems of Aboriginal peoples. These flows are dedicated to supporting cultural, spiritual and economic benefits for Aboriginal communities (**Nelson et al. 2018**). Implementing cultural flows requires meaningful partnerships between Aboriginal groups, government agencies and water managers to place Aboriginal voices central to decision-making (**Duncan 2022**).

References

AdaptNSW 2024, NSW Climate Change Snapshot, AdaptNSW, accessed 28 August 2024

Bal A, Panda F, Pati SG, Das K, Agrawal PK & Paital B 2021, 'Modulation of physiological oxidative stress and antioxidant status by abiotic factors especially salinity in aquatic organisms', *Comparative Biochemistry and Physiology Part C: Toxicology & Pharmacology*, vol. 241, 108971, DOI: 10.1016/j.cbpc.2020.108971

Bates WB, Chu L, Claire H, Colloff MJ, Cotton R, Davies R, Larsen L, Loughrey G, Manero A, Marshall V, Martin S, Nguyen, N-M, Nikolakis W, Poelina A, Schulz D, Taylor KS, Willliams J, WyrWoll P & Grafton RQ 2024, 'A tale of two rivers – Baaka and Martuwarra, Australia: Shared voices and art towards water justice', *The Anthropocene Review*, vol. 11, no. 1, pp. 228–61, DOI: 10.11177/20530196231186962

Bowen S, O'Hea Miller S, Helfensdorfer A, Van Den Broek J, Roberts I, Cox B, et al. (in press), *Water-dependent native vegetation, Environmental Outcomes Monitoring and Research Program Technical Report 2021–2024*, NSW Water, Sydney

Boys CA, Rayner TS, Baumgartner LJ & Doyle KE 2021, 'Native fish losses due to water extraction in Australian rivers: Evidence, impacts and a solution in modern fish- and farm-friendly screens', *Ecological Management & Restoration*, vol. 22, no. 2, pp. 134–44, DOI: 10.1111/emr.12483

Brierley GJ & Fryirs KA 2005, *Geomorphology and River Management: Applications of the River Styles Framework*, Blackwell Publications, Oxford, UK

Bunn S & Arthington A 2002, 'Basic Principles and Ecological Consequences of Altered Flow Regimes for Aquatic Biodiversity', *Environmental Management*, vol. 30, pp. 492–507, DOI: 10.1007/s00267-002-2737-0

Caesar L, Sakschewski L, Andersen S, Beringer T, Braun D, Dennis D, Gerten D, Heilemann A, Kaisar J, Kitzmann NH, Loriani S, Lucht W, Ludescher J, Martin M, Mathesius S, Paolucci A, te Wierik S & Rockström J 2024, *Planetary Health Check: A scientific assessment of the state of the planet*, Potsdam Institute for Climate Impact Research, Potsdam, Germany

Chessman BC, McGilvray G, Ruming S, Jones HA, Petrov K, Fielder DP, et al. 2020, 'On a razor's edge: Status and prospects of the critically endangered Bellinger River snapping turtle, *Myuchelys georgesi*', *Aquatic Conservation: Marine and Freshwater Ecosystems*, vol. 30, no. 3, pp. 586–600, DOI: 10.1002/aqc.3258

Chessman BC 2021, '*A creeping threat? Introduced Macquarie turtles and the future of endangered helmeted turtles in southern Australia*', Aquatic Conservation: Marine and Freshwater Ecosystems, vol. 31, no. 12, pp. 3,429–36, DOI: 10.1002/aqc.3723

Chessman BC, Dillon ML, Fielder DP, Spark PH & Streeting LM 2023a, 'Juvenile proportion as a predictor of freshwater turtle population change', *Austral Ecology*, vol. 48, no. 8, pp. 1,588–602, DOI: 10.1111/aec.13406

Chessman BC 2024a, Personal Communication – 4 May 2024, advice from DCCEEW-Water Group representatives

Chessman BC 2024b, 'A misconstrued alien: the freshwater turtle Emydura macquarii in the Greater Sydney region', Australian Zoologist, vol. 43, no. 3, pp. 443–54, DOI: 10.7882/AZ.2024.006, https://doi.org/10.7882/AZ.2024.006

Cid N, Bonada N, Carlson SM, Grantham TE, Gasith A & Resh VH 2017, 'High variability is a defining component of Mediterranean-climate rivers and their biota', *Water*, vol. 9, no. 1, 52, DOI: 10.3390/w9010052

Costanza-van den Belt M, Rao R, Colloff MJ, Pittock J & Moggridge B 2022, 'Watering of indifenous country in the Murray–Darling basin, Australia', *Marine and Freshwater Research*, vol. 73, no. 12, pp1,413–25, DOI: 10.1071/MF22155

Crook DA, Schilling HT, Gilligan DM, Asmus M, Boys CA, Butler GL, Cameron LM, et al. 2023, 'Multi-decadal trends in large-bodied fish populations in the New South Wales Murray–Darling Basin, Australia', *Marine and Freshwater Research*, vol. 74, no. 11, pp. 899–916, DOI: 10.1071/MF23046

CSIRO 2015, A long view of ecosystem health in the Murray–Darling Basin, Commonwealth Scientific and Industrial Research Organisation, accessed 24 September 2024

DCCEEW-Aus 2021, Directory of Important Wetlands in Australia, Australian Government Department of Climate Change, Energy, the Environment and Water, Canberra, accessed 25 October 2024

DCCEEW-Aus 2022, *Conservation Advice for Myuchelys purvisi (Manning River saw-shelled turtle)*, Australian Government Department of Climate Change, Energy, the Environment and Water, Canberra (PDF 2.4MB)

DCCEEW-Aus 2023a, *Conservation Advice for Chelodina longicollis (eastern long-necked turtle)*, Australian Government Department of Climate Change, Energy, the Environment and Water, Canberra

DCCEEW-Aus 2023b, *Conservation Advice for Myuchelys belli (western saw-shelled turtle)*, Australian Government Department of Climate Change, Energy, the Environment and Water, Canberra

DCCEEW-Aus 2024a, Wetlands climate change resources, Australian Government Department of Climate Change, Energy, the Environment and Water, accessed 24 September 2024

DCCEEW-Aus 2024b, *Conservation Advice for Wollumbinia georgesi (Bellinger River saw-shell turtle)*, Australian Government Department of Agriculture, Water and the Environment, Canberra (PDF 0.78MB)

DCCEEW 2024a, *Impacts of bushfires on freshwater ecosystems and potential water management options: A literature review*, NSW Department of Climate Change, Energy, the Environment and Water, Sydney

DCCEEW 2024b, *Connectivity Expert Panel Final Report*, the Connectivity Expert Panel for the NSW government

DCCEEW 2024c, *NSW Basin Plan Matter 8 Report 2024*, NSW Department of Climate Change, Energy, Environment and Water, Sydney, ISSN 978-1-76058-796-3

DCCEEW 2024d, *Evaluation of flow-dependent frog objectives and targets: Technical report supporting the NSW Basin Plan Matter 8 Reporting 2019–24 (draft)*, NSW Department of Climate Change, Energy, the Environment and Water, Sydney

DECCW 2011, *Gwydir Wetlands Adaptive Environmental Management Plan: Synthesis of information projects and actions*, NSW Department of Environment, Climate Change and Water, Sydney

De Oliveira Ferronato B & Georges A 2023, ‘Distribution of Freshwater Turtle Rock Art and Archaeological Sites in Australia: a Glimpse into Aboriginal Use of Chelonians’, *Herpetological Conservation and Biology*, vol 18, no. 2, pp 374–91

DPE 2023a, *NSW BSM2030 Comprehensive Report 2021/2022 – 2022/2023*, NSW Department of Planning and Environment, Sydney

DPE 2023b, *River Condition Index*, NSW Department of Planning and Environment, Sydney

DPE 2023c, *Water dependent native vegetation: Environmental Outcomes Monitoring and Research Program Annual Report 2021–2022*, NSW Department of Planning and Environment, Sydney

DPIRD n.d.-a, Freshwater habitats, NSW Department of Primary Industries and Regional Development, accessed 27 September 2024

DPIRD n.d.-b, Basin Plan Environmental Outcomes Monitoring, NSW Department of Primary Industries and Regional Development, accessed 12 December 2024

Duncan P 2022, Cultural water knowledge key to adapting to climate change, Alluvium, accessed 13 December 2024

Jackson S 2021, ‘Enacting multiple river realities in the performance of an environmental flow in Australia’s Murray–Darling Basin’, *Geographical Research*, vol. 60, pp463–79, DOI: 10.1111/1745-5871.12513

Jargal N, Kim JE & An KG 2023, ‘New interactive functional indicator approach for river health assessment in an Asian temperate river: Comprehensive analysis of water chemistry, physical habitat, land use, and the biological disturbance of invasive alien species’, *Ecological Indicators*, vol. 157, 111212, DOI: 10.1016/j.ecolind.2023.111212

Kingsford RT 2001, ‘Ecological impacts of dams, water diversions and river management on floodplain wetlands in Australia’, *Austral Ecology*, vol. 25, no. 2, pp. 109–27, DOI: 10.1046/j.1442-9993.2000.01036.x

Kingsford RT, Brandis K, Thomas R, Crighton P, Knowles E & Gale E 2003, *The Distribution of Wetlands in New South Wales*, Natural Heritage Trust, National Parks and Wild life Service, Murray-Darling Basin Commission, Sydney (PDF 0.56MB)

Kingsford RT, Bino G & Porter JL 2017, ‘Continental impacts of water development on waterbirds, contrasting two Australian river basins: Global implications for sustainable water use’, *Global Change Biology*, vol. 23, no. 11, pp. 4,958–69, DOI: 10.1111/gcb.13743

Kingsford RT, Porter JL, Brandis K & Ryall S 2020, ‘Aerial surveys of waterbirds in Australia’, *Scientific Data*, vol. 7, 172, DOI: 10.1038/s41597-020-0512-9

Khojasteh D, Glamore W, Heimhuber V & Felder S 2021, ‘Sea level rise impacts on estuarine dynamics: A review’, *Science of The Total Environment*, vol. 780,146470, DOI: 10.1016/j.scitotenv.2021.146470

Lugg A & Copeland C 2014, 'Review of cold water pollution in the Murray–Darling Basin and the impacts on fish communities', *Ecological Management & Restoration*, vol. 15, no. 1, pp. 71–9, DOI: 10.1111/emr.12074

Luque GM, Bellard C, Bertelsmeier C, Bonnaud E, Genovesi P, Simperloff D & Courchamn F 2014, ‘The 100th of the world’s worst invasive alien species’, *Biological Invasions*, vol. 16, pp 981–5, DOI: 10.1007/s10530-013-0561-5

McConnachie A, Jones P, Fletcher A, Savage M, Patterson A, Holtkamp R, Snow L, Taylor T, Skewes J, Dawson P, Bergin C, Harvey K, Turner P, Shilpakar R & Nawaz M 2022, *A thorny tale: Cylindropuntia pallida (Hudson pear) biocontrol in New South Wales, Australia*, 2022 Australasian Weeds Conference paper (PDF 0.16MB)

McNamara T 2023, The importance of river monitoring, FreeUP, accessed 10 September 2024

MLDRIN 2015, *Aboriginal Waterways Assessment program*, The Murray Lower Darling Rivers Indigenous Nations

MLDRIN, NBAN & NAILSMA 2017, *Dhungala Baaka: Rethinking the future of water management in Australia*, Murray Lower Darling Rivers Indigenous Nations (MLDRIN), Northern Basin Aboriginal Nations (NBAN), and North Australian Indigenous Land and Sea Management Alliance (NAILSMA)

Moggridge BJ & Thompson RM 2021, ‘Cultural value of water and western water management: An Australian Indigenous perspective’, *Australasian Journal of Water Resources*, vol. 25, no. 1, pp. 4–14, DOI: 10.1080/13241583.2021.1897926

Nelson R, Godden L & Lindsay B 2018, *A pathway to cultural flows in Australia*, Murray Lower Darling Rivers Indigenous Nations (MLDRIN), Northern Basin Aboriginal Nations (NBAN), North Australian Indigenous Land and Sea Management Alliance (NAILSMA), North Melbourne (PDF 1.26MB)

NHMRC 2011, *Australian Drinking Water Guidelines 6*, version 3.8, updated September 2022, National Health and Medical Research Council

NLWRA 2002, *Australian Catchment, River and Estuary Assessment 2002: Volume 1*, National Land and Water Resources Audit, Canberra

NSW EPA 2022, NSW State of the Environment report 2021: River health, NSW Environment Protection Authority, accessed 27 August 2024

NSW Government 2002, Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands - key threatening process listing, Environment and Heritage, accessed 13 December 2024

NSW Water n.d., 2022–2023 Progress report region snapshots, NSW Water, accessed 13 December 2024

NWES 2021, *Summary of Hunter River catchment turtle survey results for Hunter Local Land Services*, North West Ecological Services, Tamworth (PDF 14.5MB)

NWQMS n.d., Salinity and water quality, National Water Quality Management Strategy, accessed 02 October 2024

OCSE 2023, *Independent review into the 2023 fish deaths in the Darling-Baaka River at Menindee*, Office of the NSW Chief Scientist & Engineer, Sydney

Pearson MR, Reid MA, Miller C & Ryder D 2020, 'Comparison of historical and modern river surveys reveal changes to waterhole characteristics in an Australian dryland river', *Geomorphology*, vol. 356, 107089, DOI: 10.1016/j.geomorph.2020.107089

Peña-Guerrero MD, Nauditt A, Muñoz-Robles C, Ribbe L & Meza F 2020, 'Drought impacts on water quality and potential implications for agricultural production in the Maipo River Basin, Central Chile', *Hydrological Sciences Journal*, vol. 65, no. 6, pp. 1,005–21, DOI: 10.1080/02626667.2020.1711911

Petrov K 2021, *Decline and recovery of the Bellinger River turtle, Myuchelys georgesi*, Western Sydney University, Sydney (PDF 3.0MB)

Petrov K, Sutcliffe S, Truscott H, Kutay C, Eisemberg CC, Spencer RJ, et al. 2023, 'Turtles in trouble. Conservation ecology and priorities for Australian freshwater turtles', *Austral Ecology*, vol. 48, no. 8, pp. 1,603–56, DOI: 10.1111/aec.13418 (**https://doi.org/10.1111/aec.13418)**

Porter JL, Kingsford RT, Francis R, Brandis K & Ahern A 2023, *Aerial Survey of Wetland Birds in Eastern Australia: October 2023 Annual Summary Report*, Centre for Ecosystem Science, School of Biological, Earth and Environmental Sciences, University of NSW, Sydney and NSW Department of Planning & Environment

Rockström J, Steffen W, Noone K, Persson Å, Chapin FS III, Lambin EF, Lenton TM, et al. 2009, 'A safe operating space for humanity', *Nature*, vol. 461, pp.472–5, DOI: 10.1038/461472a

Salimi S, Almuktar SAAAN & Scholz M 2021, 'Impact of climate change on wetland ecosystems: A critical review of experimental wetlands', *Journal of Environmental Management*, vol. 286, 112160, DOI: 10.1016/j.jenvman.2021.112160

Santori C, Spencer RJ, Dyke JUV & Thompson MB 2018, 'Road mortality of the eastern long-necked turtle (*Chelodina longicollis*) along the Murray River, Australia: an assessment using citizen science', *Australian Journal of Zoology*, vol. 66, no. 1, pp. 41–9, DOI: 10.1071/ZO17065

Schilling H, Butler G, Cheshire K, Gilligan D, Stocks J, Thiem J & Crook D 2024, 'Contribution of invasive carp (*Cyprinus carpio*) to fish biomass in rivers of the Murray–Darling Basin, Australia', *Biological Invasions*, vol. 26, pp. 2955–71, DOI: 10.1007/s10530-024-03362-x

Schinegger R, Palt M, Segurado P & Schmutz S 2016, 'Untangling the effects of multiple human stressors and their impacts on fish assemblages in European running waters', *Science of the Total Environment*, vol. 573, pp. 1,079–88 , DOI: 10.1016/j.scitotenv.2016.08.143

US EPA 2024, Indicators: Salinity, United States Environmental Protection Agency, accessed 2 October 2024

Waudby HP, Amos C, Healy S, Dyer J, McGrath N, Maguire J, Conallin A & Childs P 2020, *Saving the Southern Bell Frog (Litoria raniformis): 2018–19 monitoring report*, NSW Department of Planning, Industry and Environment, Albury, NSW (internal report)

Waudby HP, Healy S, Dyer J, Amos C, Maguire J, Conallin A & Childs P 2021, *Saving the Southern Bell Frog (Litoria raniformis): 2019–20 monitoring report*, NSW Department of Planning, Industry and Environment, Albury, NSW (internal report)

Waudby HP, McGrath N & Lenehan J 2022, *Evaluating the distribution of the threatened southern bell frog (Litoria raniformis) in the Lower Lachlan*, NSW Department of Planning and Environment, Albury, NSW (internal report)

Whalley RDB, Price JN, Macdonald MJ & Berney PJ 2011, 'Drivers of change in the social-ecological systems of the Gwydir Wetlands and Macquarie Marshes in northern New South Wales, Australia', *Rangeland Journal*, vol. 33, no. 2, pp. 109–19, DOI: 10.1071/RJ11002

Whipple AA & Viers JH 2019, 'Coupling landscapes and river flows to restore highly modified rivers', *Water Resources Research*, vol. 55, no. 6, pp. 4,512–32, DOI: 10.1029/2018WR022783

WMIS 2024, What influences water quality, VIC Water Measurement Information System, accessed 23 September 2024

Groundwater

Groundwater is a valuable resource in NSW. It supports a wide range of plants and animals in many diverse environments, and can be extracted for use in agriculture, industry and households.

Overview

Agriculture accounts for

75%

of groundwater use in NSW.

Read more

More than

250

regional towns are now reliant on groundwater for most of their everyday water needs.

Read more

Groundwater is an invisible but vital resource that supports unique ecosystems, industries and many rural towns.

Groundwater holds deep cultural significance for Aboriginal peoples. For more than 65,000 years, Aboriginal knowledge of groundwater sources has been crucial for survival in Australia's arid regions.

Groundwater that is suitable for drinking and other human uses is limited. Not all groundwater is accessible or usable (**DPE 2023b**).

Only about 30% of Australia's groundwater is drinkable, with the remainder containing dissolved minerals, such as sodium or magnesium bicarbonates and, less commonly, sodium chloride (salt).

There is increasing demand for reliable supplies of safe, accessible drinking water to support Australia's growing population.

The rate of groundwater extraction in NSW has fallen over the past three years due to increased rainfall, with no groundwater source exceeding limits set for sustainability. Extraction has declined as more surface water and runoff has been used to meet water needs, reducing dependence on groundwater.

Groundwater conditions remain difficult to monitor at a statewide level. While there is some monitoring of groundwater salinity and an awareness of emerging contamination issues (for example, PFAS), there is no comprehensive statewide assessment for groundwater quality.

Similarly, the condition of groundwater-dependent ecosystems is available only for limited areas across the State. However, a comprehensive mapping of groundwater-dependent ecosystems has been done, with sites categorised based on their ecological value to help prioritise planning and management.

What is groundwater

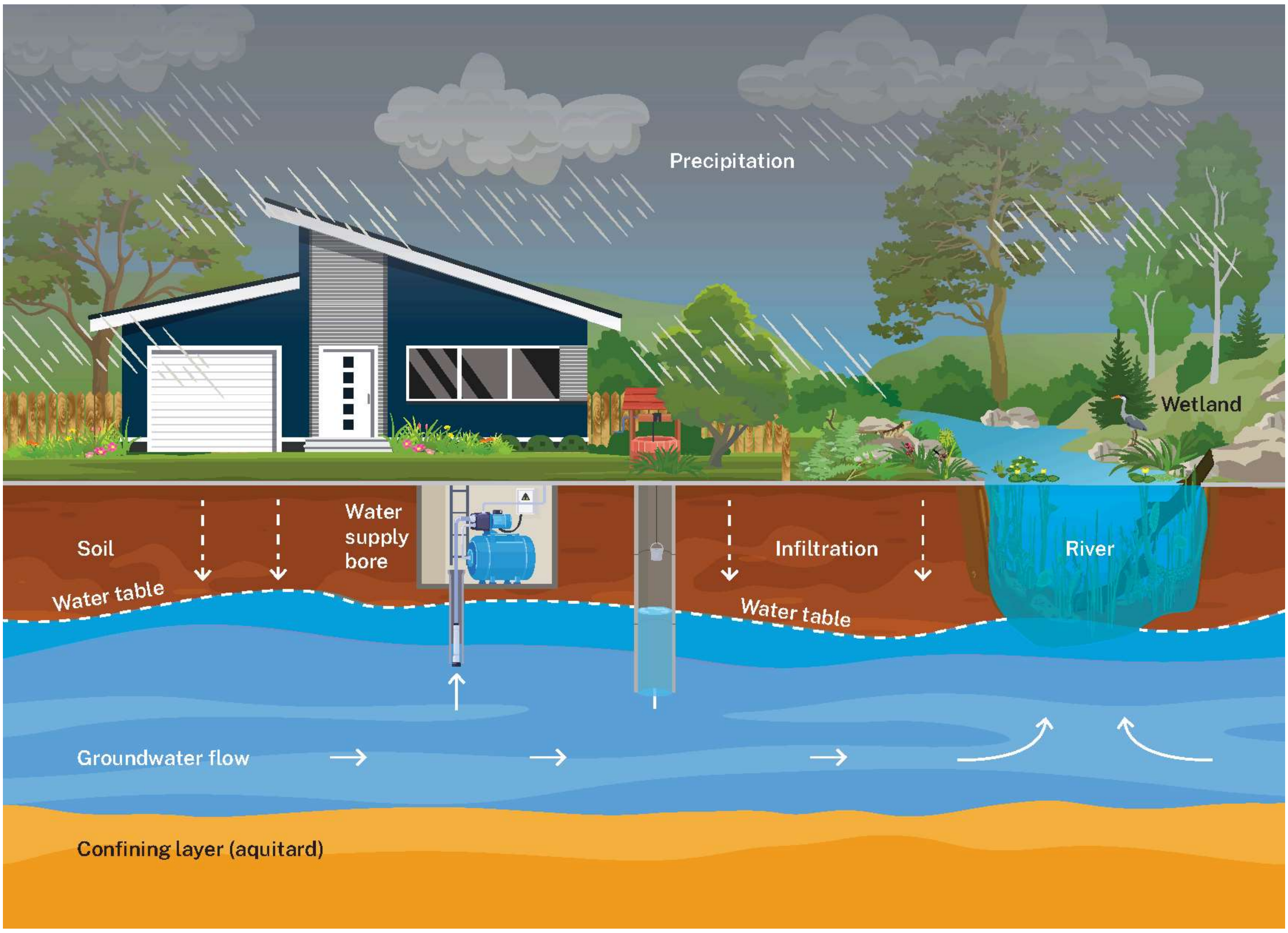
Groundwater is found beneath the ground in aquifers. Aquifers are layers of saturated rock or sediments (such as sand or gravel) that store water in rock cracks and sediment spaces (pores). It has a permeability that allows water to flow through it easily.

NSW has more than 500 groundwater sources, with an estimated 5,110 million megalitres (or 5,110,000 gigalitres) of groundwater stored in aquifers across NSW. Most of this is contained in confined aquifers (**DPE 2023a**).

Confined aquifers are those fully underground and contained between aquitards (described below). Water stored within confined aquifers is pressurised, causing the water level to rise above the saturated zone.

Unconfined aquifers (such as the one shown in **Image W2.1**) are exposed at the surface, with the top of the saturated zone represented by the water table. The water table can rise and fall as water moves into and out of the aquifer.

Image W2.1: Conceptual model of groundwater occurrence



Source:
NSW EPA 2024

Formations containing groundwater are characterised by:

- **Porosity** – the measure of the total volume of rock or sediment that is open space (expressed in the percentage of the formation volume). It indicates the maximum volume that is available to hold water underground.
- **Permeability** – the capacity that an aquifer has to transmit water (expressed in metres per day). It varies greatly and depends on the shape and connectedness of the pores in the aquifer. It is not a measure of the speed at which groundwater flows.
- **Storage** – the volume of water per square metre that is released from an aquifer for each drop in water level of 1 metre.

An aquitard (see **Image W2.1**) is a body of rock or sediments with low permeability (for example, clay or poorly fractured rock). This means only a relatively small quantity of water can move through an aquitard.

The difference in storage between unconfined and confined is significant. The impact of taking water from a confined aquifer is greater than taking the same amount of water from an unconfined aquifer.

The impacts of pumping from an unconfined aquifer are generally local – probably confined to a single land holding. By contrast, the impact on a confined aquifer will extend, in most cases, onto adjacent properties, which in a rural setting could be many kilometres. This is why groundwater must be managed as if it is a ‘common good’ not a ‘private good’.

Groundwater can return to the surface via:

- baseflow, which adds water to a river channel
- water flowing to the surface through a spring
- pumping groundwater up from an aquifer.

Recharge rate is the rate at which an aquifer is replenished. This rate is impacted by:

- the type of aquifer
- the amount and intensity of rainfall
- soil and vegetation types
- geology
- topography
- land use.

Recharge rates cannot be directly measured and are highly variable (**Luetkemeier et al. 2022**). This means it is very difficult to determine the amount of recharge, particularly in the arid and semi-arid areas of western NSW.

Groundwater yields differ (**Acworth 2019**) based on the type of groundwater system:

- **Unconsolidated sediments in alluvial floodplains and coastal sand beds** provide most groundwater supplies. This is because their greater porosity makes them more permeable.
- **Consolidated porous rocks in sedimentary basins** have varying groundwater yields and salinity, ranging from freshwater in coastal sand dunes to higher salinity groundwater in some coal basins.
- **Fractured rock groundwater systems** typically have low groundwater yields. Fractured basalt rocks on the north coast of NSW are an exception.

Connectivity of surface and groundwater

Groundwater systems often connect to surface water systems and water is transferred between them. Removal of large amounts of groundwater will reduce the water it provides to connected surface waters. This includes water in springs, and baseflow – flow of water from an aquifer into a river.

Similarly, removing large amounts surface water reduces the water available to recharge the aquifer and hence the amount of water in the aquifer.

Groundwater recharge occurs when surface water in the environment soaks through the soil to the water table. Recharge is difficult to measure accurately because it can't be observed directly and is impacted by many factors, such as rainfall, soil type, type and extent of vegetation, urban development and water table depth.

Where groundwater discharges to the surface it supports a wide variety of ecosystems. Plants and animals can also directly access the water, often from subsurface water just above the water table and groundwater-fed springs.

These are referred to as groundwater-dependent ecosystems. They support many unique floral species, including 69 threatened plant types in NSW and the animals that depend on these plants (**DPE 2022**).

Aboriginal sacred sites and culturally important sites on land are also often linked to groundwater-dependent ecosystems. These sites include trees, bush foods and soaks – where groundwater can be collected by digging down less than a metre.

The significance of groundwater for Aboriginal peoples

Groundwater holds deep cultural significance for Aboriginal peoples.

For more than 65,000 years, Aboriginal knowledge of groundwater sources has been crucial for survival in Australia's arid regions. Passed down through generations, traditional knowledges emphasise not just finding water, but also managing it sustainably and protecting it (**Moggridge et al. 2022**).

It is an important part of Dreaming stories and a source of spiritual meaning (**Wardle 2022**). For example, accessing groundwater deep within the earth links Aboriginal people to deep time (**Smithers & Hopson 2024**). There is an understanding that groundwater is intimately connected with surface waters, the lands and the sky (**Moggridge & Thompson 2021**).

Groundwater-dependent ecosystems

Groundwater-dependent ecosystems require access to groundwater to maintain a diversity of species and ecological processes.

These ecosystems are found in a wide range of environments with biological and physical characteristics that make them uniquely different from other ecosystems (**Hose et al. 2023**).

Groundwater-dependent ecosystems are grouped into three broad types:

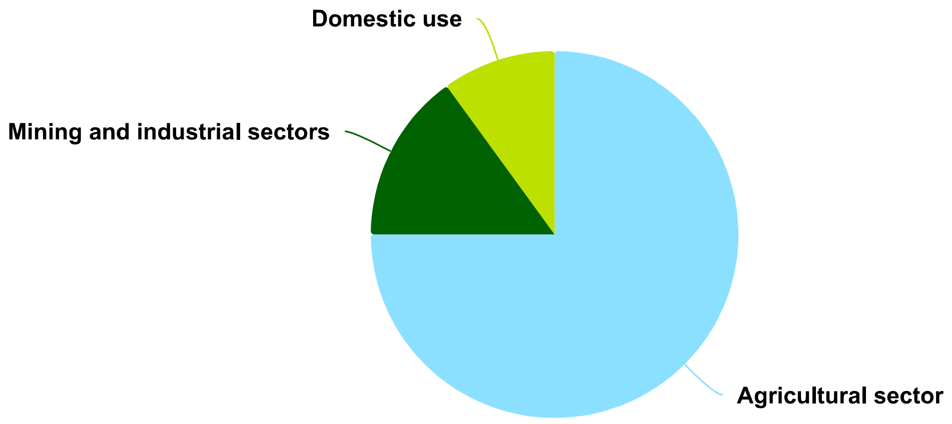
- subterranean – those in aquifers and caves
- aquatic – where groundwater meets surface (such as river and stream baseflow)
- terrestrial vegetation – those dependent on the subsurface presence of groundwater (**Eamus & Froend 2006**).

Terrestrial vegetation and wetland across more than 6.5 million hectares of NSW (about 8% of the land surface) have been identified as having a high probability of being groundwater-dependent (**DPE 2022**).

How groundwater is used

In NSW, groundwater is used for agriculture, mining, town water supplies and domestic use (see **Figure W2.1**).

Figure W2.1: Groundwater extraction in NSW by major users, 2022



Notes:
Agriculture = 75%, Industry = 15%, Domestic = 10%

Source:
DCCEEW 2022

Agriculture remains the dominant use for groundwater in NSW, accounting for 75% of the State's usage in the past eight years (**ABS 2023**). Water from high-quality alluvial groundwater systems supports highly productive food and fibre industries.

Groundwater is also used in some mining operations, such as for dust control. Sometimes mining cannot proceed until hazardous groundwater is controlled, usually by removal and disposal.

Groundwater systems are used to supplement or replace surface water supplies when surface water is less available. During drought, this provides a buffer for agricultural businesses, businesses that depend on them, and regional economies in general, and ensures faster recovery.

Some groundwater is set aside as **water for the environment** through water sharing rules and water licences. Water that is earmarked for the environment cannot be taken or used for any other purpose (**DPE 2023a**).

In NSW, groundwater-related activities directly generate close to $1 billion (**DPE 2023b**). It's also an important source for communities' water supply, especially during droughts.

More than 250 regional towns (with a combined population of nearly 300,000) depend on groundwater – either completely or partially – for farming, irrigation and domestic use (**DPIRD n.d.).**

Managing groundwater

Aboriginal knowledge and cultural practice and Lore traditionally ensured sustainable groundwater management. Aboriginal loss of access to Country has resulted in significant impacts to water quality and supply.

Historically, surface water and groundwater have been managed as two independent resources.

However, where they are interconnected, activities that impact one are likely to impact the other – often with a significant time delay.

Reductions in aquifer flow by heavy extraction may not be noticeable immediately. The effects may be visible within days or not be visible for decades. The timeframe depends on the aquifer type, extraction depth and distance between the bores and the river.

Heavy pumping of groundwater can reduce or eliminate the flow in a connected river during drought times. This occurs because the extracted groundwater would have otherwise moved from the aquifer into the surface water channel as baseflow.

Extraction of large amounts of water from rivers can also reduce groundwater recharge. This occurs when the river height is no longer high enough to cause downward flow or when the height of the nearby water table has been reduced.

Water-management mechanisms that recognise connectivity

Modern water-management mechanisms are moving towards overseeing these resources in a way that recognises the close relationship of groundwater and surface water, such as the connectivity between rivers and aquifers.

For example, Action 1.2 under Strategic Priority 1 of the ***NSW Groundwater Strategy*** is to improve protection of groundwater-dependent ecosystems and the baseflow to streams. The action identifies the need to develop a framework for protecting these assets (**DCCEEW n.d.-a**).

The ***Water Management Act 2000*** is the primary tool for the management of surface and groundwater resources in NSW. **Water sharing plans** apply to all surface and groundwater sources in NSW.

The purpose of a water sharing plan is to:

- define the volume of water that can be extracted from a groundwater system and share it among groundwater users, which include the environment
- give water users information about when and how water is available for use
- protect the environmental health of a water source
- ensure the water source is sustainable in the long term.

Together with other water policies, these water sharing plans manage this interconnected relationship through:

- rules for shared water resources
- setback distances for groundwater extraction works from highly connected surface waters and groundwater-dependent ecosystems
- approval conditions that may adjust rates of groundwater extraction in certain circumstances (**DCCEEW n.d.-b**).

Applications for new production bores undergo hydrogeological impact assessments where relevant. This includes consideration of impacts on surface water connections and groundwater-dependent ecosystems.

Where a hydrogeological impact assessment has been performed, actions to mitigate these impacts may be recommended. They include extraction limits and construction conditions.

Tracking extraction levels

Groundwater extraction is managed to protect the availability and long-term sustainability of groundwater resources (**DCCEEW 2023**).

The ***Water Management Act 2000*** and the **Murray-Darling Basin Plan** set rules and limits for how much groundwater can be taken, while ensuring that the plants and animals that rely on groundwater are not adversely impacted (**DCCEEW 2023**).

Water users can only extract a limited amount from a groundwater source.

Average extraction levels are assessed annually to ensure the long-term average annual extraction limit is not exceeded (**DCCEEW n.d.-d**).

If this is exceeded, groundwater access may be temporarily restricted by reducing the amount of water going into accounts (known as an allocation or available water determination) or reducing the amount of water that can be taken or traded from accounts (known as a maximum water account debit).

Managing groundwater extraction is challenging and complex. This is mainly because:

- gathering data and monitoring activities is more difficult underground than on the surface (**Acworth 2019**)
- each of the many aquifers in NSW is unique in composition, size and the many factors that determine how they function. This means they cannot be managed the same way.

The State's groundwater management framework is made up of a combination of legislation and policies that govern the use and protection of groundwater resources, and the activities that may have an impact on these resources (see **Table W2.1**).

Table W2.1: Current legislation and policies relevant to groundwater management

Legislation or policy	Summary
Protection of the Environment Operations Act 1997	Manages contamination at a point source (single, identifiable location of contamination, such as a pipe) and protects groundwater quality in NSW.
Water Management Act 2000	Establishes principles to manage groundwater resources in NSW.
Murray-Darling Basin Plan	Sets the amount of water that can be taken from the Murray-Darling Basin while leaving enough volume to maintain the environmental health of the river.
Non-urban water metering framework	Outlines regulations to enforce metering consistently across the State, inclusive of reporting of metered usage.
NSW Aquifer Interference Policy	Sets out impact assessment requirements and limits for aquifer interference activities in NSW.
NSW Groundwater Strategy	Sets out a statewide 20-year strategy to protect groundwater resources and dependent ecosystems, support water-dependent aspirations of Aboriginal people, improve water resilience for urban populations and better improve groundwater management and investment decisions.
Water sharing plans	Outlines water sharing processes and operational rules for water users and the environment in NSW.

Notes:
See the **Responses** section for more information about how protection of native animals is managed in NSW.

Related topics: **Population and the environment** | **Rivers and wetlands** | **Water use**

Status and trends

Groundwater indicators

Four indicators are used to assess groundwater status and trends in NSW (see **Table W2.2**). These indicators relate to trends that can impact groundwater availability and quality for both humans and the environment.

The indicators are:

- **Long-term extraction limit: exceedances** reports on trends in annual groundwater extraction in metered systems (see **Long-term extraction limit: exceedences**).
- **Aquifer sustainability** looks at factors that impact an aquifer's ability to continue being used for groundwater extraction. This indicator is listed as unknown due to lack of data. Further information will be required to assess status and trends in future reports (see **Aquifer sustainability**).
- **Groundwater quality** assesses the quality of the water extracted from groundwater sources. This indicator is listed as unknown due to lack of data. Further information will be required to assess status and trends in future reports (see **Groundwater quality**).
- **Condition of groundwater-dependent ecosystems** looks at the health and extent of groundwater-dependent ecosystems (see **Condition of groundwater-dependent ecosystems**).

Table W2.2: Groundwater indicators

Indicator	Environmental status	Environmental trend	Information reliability
Long-term extraction limit: exceedences	GOOD	Stable***	Reasonable
Aquifer sustainability*	UNKNOWN	Unknown	n/a
Groundwater quality**	UNKNOWN	Stable	Reasonable
Condition of groundwater-dependent ecosystems	MODERATE	Unknown	Reasonable

Notes:
* The previous indicator for 'aquifer sustainability' was changed from 'aquifer integrity' to better reflect data informing the indicator.
** Not enough data exists to indicate a statewide trend (DCCEEW n.d.-f).
***Short-term improvements have been seen in the current reporting period coinciding with prevailing wet weather conditions. Long-term trends remain stable.

Indicator table scales:

- **Environmental status**: Good, moderate, poor, unknown
- **Environmental trend**: Getting better, stable, getting worse
- **Information reliability**: Good, reasonable, limited, n/a (no data available)

See **Indicator guide** to learn how terms and symbols are defined.

Long-term extraction limit: exceedences

Water Sharing Plans outline the amount of groundwater available for extraction from a groundwater source and how it is to be shared between water users.

These users include access licence holders. A water access licence allows the licence holder to take water from a groundwater source.

Each water year commences on 1 July. At the start of each water year a determination is made regarding the water available in each groundwater source. This allows for allocation to licence holders.

Allocations can be varied from year to year based on historic extraction patterns. Before the start of each water year, the total extraction in a groundwater source is reviewed by checking extraction data recorded by water meters at bores. Total extraction should be within the plan's extraction limit.

If extraction in a groundwater source is close to or exceeds the plan's limit, it may trigger a reduced available water determination. Managing the extraction of groundwater in this way ensures it is available now and into the future.

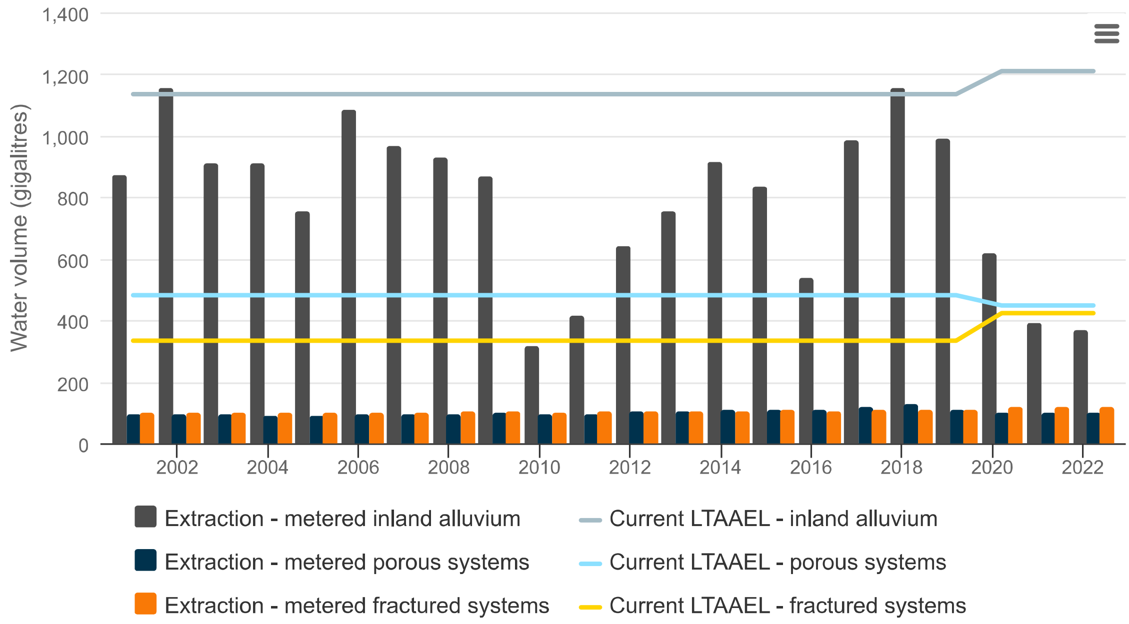
Extraction

Agriculture remains the dominant use for groundwater in NSW, accounting for 75% or more of take. Extraction by industries (including mining) accounts for 15%, while domestic and town water supplies use 10% (**DPE 2022**).

Groundwater extraction often reflects weather patterns, with higher levels of extraction in drier years. The years 2021 to 2023 saw above-average levels of state-averaged annual rainfall in NSW, with some of the highest levels on record (since 1900) (**NSW EPA n.d.**).

On average, groundwater extraction decreased or remained mostly stable across metered systems during that time (see **Figure W2.2**).

Figure W2.2: Annual groundwater extraction (GL) from metered systems by type, 2001–02 to 2022–23



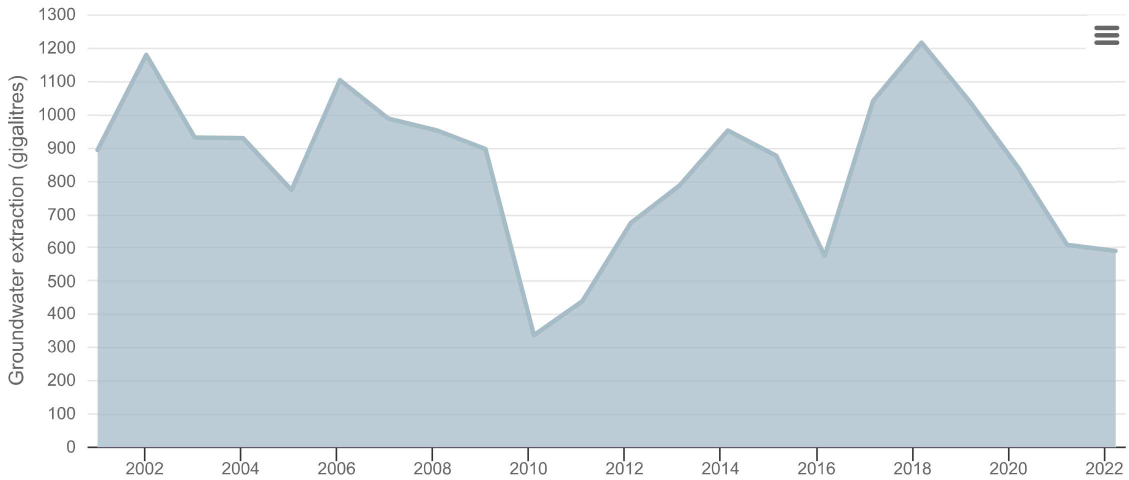
Notes:
LTAAEL = Long-Term Average Annual Extraction Limits. The change in LTAAELs in 2020–21 is due to updates to the relevant water sharing plans.

Source:
DCCEEW 2024

During times of drought, groundwater can provide up to 70% of the total water usage by agriculture.

Between 2017–18 and 2019–20, NSW experienced an extended, severe drought. Conditions were hotter and drier than any in the previous 120 years (**DCCEEW n.d.-c**). In that period, groundwater extraction levels in NSW increased significantly to reflect this (see **Figure W2.3**).

Figure W2.3: Annual total metered groundwater extraction, 2001–02 to 2022–23



Source:
DCCEEW 2024

On average, annual groundwater extraction levels decreased each year between 2019–20 and 2022–23. This reflects the higher-than-average patterns of rainfall experienced across the State during that period.

Since 2021, the overall level of groundwater extracted from all metered groundwater sources in NSW is lower than the cumulative sustainable extraction limits. This is likely because higher-than-average rainfall levels have reduced the need to pump groundwater.

Aquifer sustainability

Aquifer sustainability in NSW has remained stable. This is largely the result of the wetter than average years in this reporting period.

The sustainability of an aquifer is impacted by several factors. These include extraction activities and the aquifer's structure and water quality.

Since the *State of the Environment 2021* (**NSW EPA 2022**), aquifer sustainability in NSW has remained stable. This is largely the result of the wetter than average years in this period, as reported above.

Sustainable yield

Groundwater extraction across NSW is currently within sustainable yield limits.

To protect future groundwater availability within aquifers, sustainable yields are determined for groundwater sources. These are called Long-Term Annual Average Extraction Limits (LTAAELs).

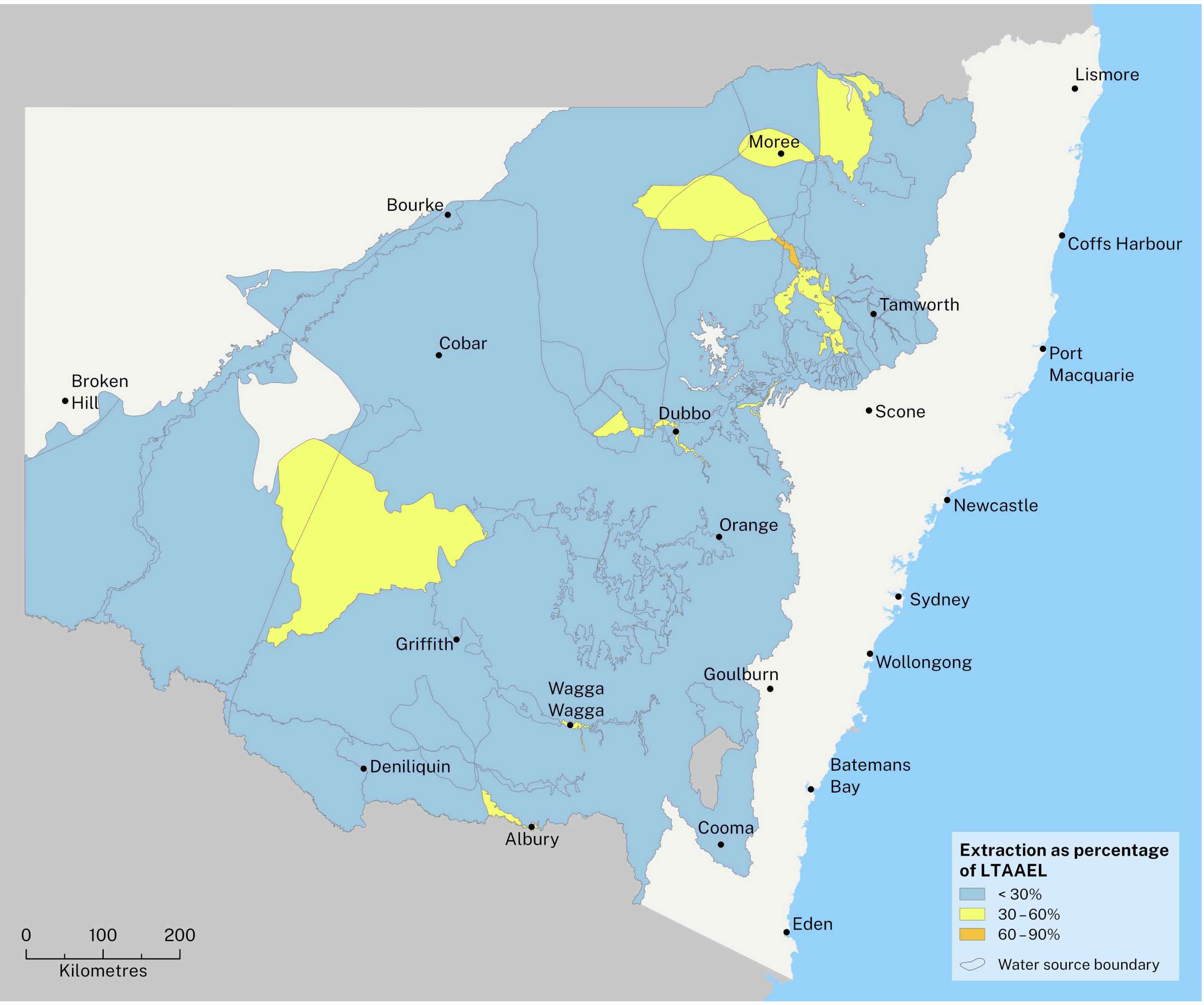
The LTAAEL is the amount of water able to be taken from a groundwater source over a specified timeframe that allows for acceptable levels of stress and protects dependent economic, social and environmental values.

LTAAELs are different for each water source. These values are determined using different methods, depending on the groundwater source. They include:

- use of numerical models
- estimations of recharge
- analysis of the physical parameters of the groundwater source.

Between 2021 and 2024, there was no over-extraction of surface groundwater in any groundwater source relative to the LTAAEL set in each area (see **Map W2.1**). Only one area had an average extraction above 60% of its LTAAEL: the Namoi Valley Zone 5 area (orange section of **Map W2.1**).

Map W2.1: Groundwater extraction per water source relative to LTAAELs (%), 2021–22 to 2023–24



Notes:
Groundwater extraction as a percentage of the Long Term Annual Average Extraction Limit (LTAAEL) of each water source was calculated using the average extraction of groundwater across period of three financial years, 2021–22, 2022–23 and 2023–24.

Water accounting years are aligned to financial years.

This map and analysis is for surface groundwater sources.

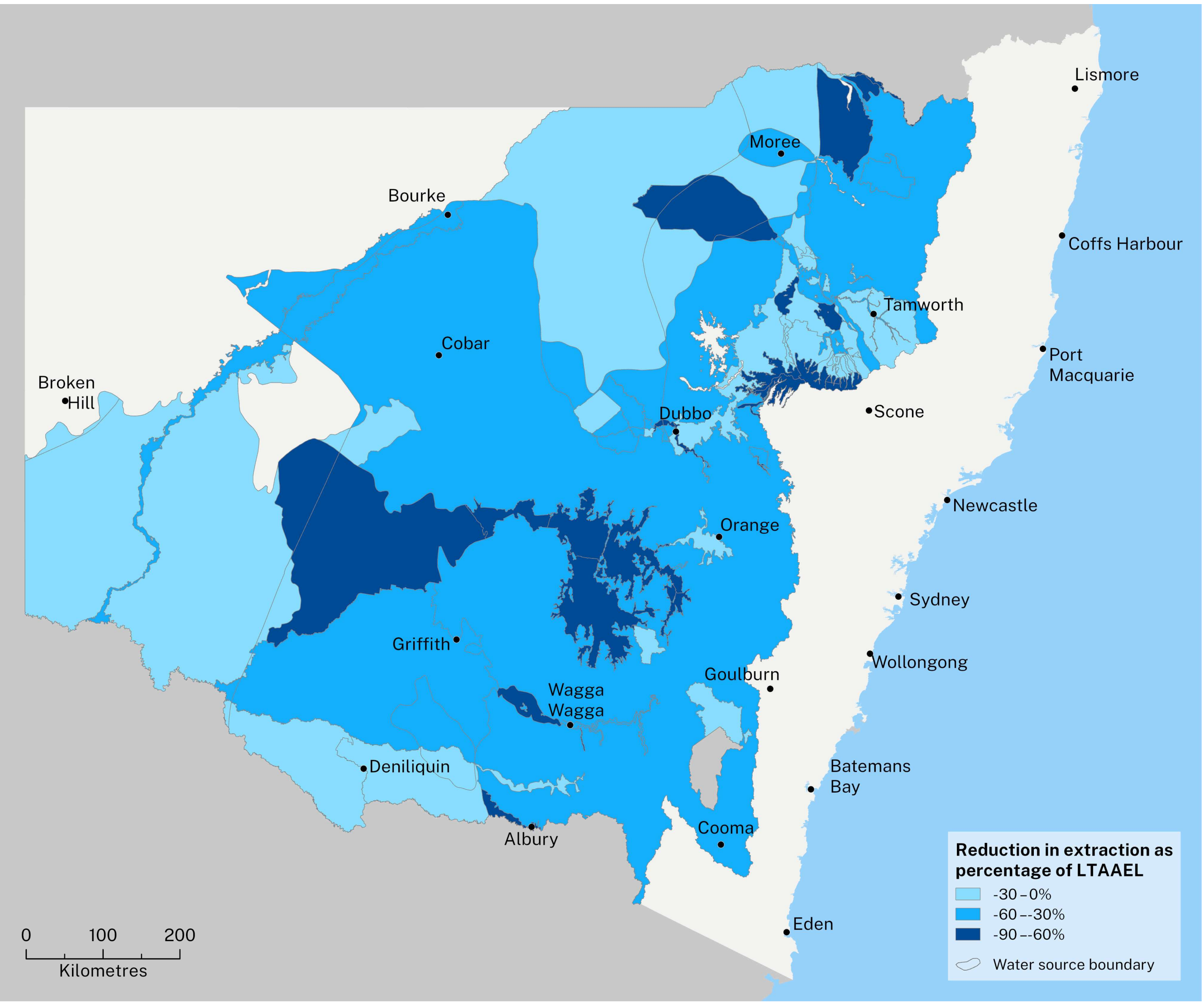
Access the interactive version of this map.

Source:
DCCEEW 2024

Groundwater extraction over the past three years has not exceeded groundwater extraction limits, in part due to good rainfall across the State.

Map W2.2 shows the change in the percentage of groundwater extraction relative to the LTAAEL for each water source between 2017–21 and 2021–24. There were declines in relative LTAAEL extraction in all water sources.

Map W2.2: Groundwater extraction per water source relative to LTAAELs (%), 2017–21 to 2021–24



Notes:
Change in groundwater extraction as a percentage of the Long-Term Annual Average Extraction Limit (LTAAEL) of each water source was calculated using the difference between average extraction of groundwater across 2017–18, 2018–19, 2019–20 and 2020–21 (the period shown in the previous *State of the Environment 2021*) and the period of the three most recent financial years, 2021–22, 2022–23 and 2023–24.
For example, between 2017–21 the Liverpool Ranges Basalt water source had an average of 85% LTAAEL extraction, while in 2021–24, only 1% of its LTAAEL was extracted, meaning there was a change in extraction relative to the LTAAEL of 84% (not an 84% reduction in extraction).

Water accounting years are aligned to financial years.

This map and analysis is for surface groundwater sources.

Access the interactive version of this map.

Source:
DCCEEW 2024

Structural sustainability

While an aquifer's geology does not change significantly over time, some extraction activities can impact the aquifer's structure and reduce its storage capacity.

Groundwater fills the tiny pore spaces in and around the sediment within an aquifer. This helps it to maintain its structure and stability. If groundwater is extracted too quickly and for too long, the pore spaces can collapse. This causes sediment compaction.

When sediment compaction occurs over a large area it permanently lowers the amount of available space for groundwater storage in an aquifer.

In rare cases, compaction can also cause the land surface to sink. This is known as land subsidence or ground displacement.

Studies have been undertaken to investigate and understand the impacts of groundwater extraction on land subsidence. Data was taken from locations in the Lower Namoi groundwater source and southern inland NSW groundwater sources, including the Murray, Murrumbidgee and Lachlan (**Castellazzi et al. 2021**).

This data included surveyed benchmarks, historical groundwater levels and remote sensing radar imagery (Interferometric Synthetic Aperture Radar, or InSAR).

In the Lower Namoi it was found that land subsidence was the result of a natural and periodic process of clay shrinking and swelling. In the southern inland areas, groundwater extraction was found to contribute to land subsidence in some isolated locations.

These studies will be the benchmark for future studies into aquifer integrity and land subsidence in NSW (**DCCEEW n.d.-e**).

Groundwater quality

There is limited in-depth knowledge of groundwater quality across NSW.

Current monitoring activities provide only a 'picture in time' of water quality and cannot provide information regarding trends over time.

Water quality in the context of the NSW resource management framework refers essentially to the level of salt contained in groundwater. Water quality ranges from fresh to saline.

Groundwater is considered fresh when it holds low salt levels and can be used for town water, stock and domestic supply, or for commercial purposes, such as farming and irrigation.

Many factors, usually related to human activities, impact groundwater quality. The quality affects the people, plants and animals that depend on groundwater systems.

Groundwater quality is degraded by:

- dissolved salts entering groundwater due to mineral weathering in the surrounding aquifer
- pollutants entering groundwater with surface waters in recharge areas.

For more information, see the Australian Government's **guidelines (PDF 1.36MB)** for protecting the quality of groundwater (Australian Government 2013); and its **online water quality management framework** (**Australian Government 2018**).

Monitoring water quality

A statewide groundwater sampling program was undertaken in 2021 to assess groundwater quality across many NSW sites. During this exercise 588 bores at more than 332 locations were visited, with 957 samples taken (**DCCEEW n.d.-f**).

Localised baseline datasets exist for groundwater quality in three high-extraction groundwater sources in NSW: the Lower Naomi, Lower Murray and Lower Murrumbidgee. An analysis of the data from these locations indicates there is no change in water quality associated with beneficial groundwater extraction (**DCCEEW n.d.-f**).

The limited number of sites regularly monitored over time means there is insufficient data to represent the impacts of groundwater extraction on water quality statewide.

Saline intrusion

The movement of saltwater into freshwater aquifers is known as saline intrusion. While it can be a natural process, the intrusion of saltwater into aquifers has detrimental effects on extracted groundwater quality and related uses.

There can be a high risk of saline intrusion where:

- groundwater extraction is high
- the aquifer is overlain or underlain by saline aquifers
- the aquifer is near the coast.

Water quality in coastal areas of NSW is at particular risk of saline intrusion from seawater. Bore-monitoring sites have been constructed in some areas to monitor for changes. Some bores use automatic data loggers to collect hourly salinity data and include specific triggers linked to response procedures.

Seawater is not the only cause of high salinity. Studies of high-volume groundwater extraction in inland alluvial aquifers have identified localised areas of water quality decline due to salinity. This decline is associated with changing groundwater flow patterns due to the extraction. Strategies are being developed to address these risks.

Contamination

Groundwater can become contaminated by sources of pollution, including:

- industrial sites
- fuel storage tanks
- septic systems
- landfill sites.

There is no statewide comprehensive record of groundwater contamination, though there are localised monitoring projects.

Groundwater contamination can cause significant animal and human health risks. In some cases, it can render a groundwater source unusable.

Pollutants can move over a large area, including deep underground. Leakage of pollutants into aquifers poses a particular risk to water quality.

It is extremely difficult and expensive to remediate contaminated groundwater sources.

An emerging groundwater quality issue in NSW is contamination by PFAS (per- and poly-fluoroalkyl substances).

Groundwater contamination has been reported in a number of locations across NSW as a legacy of the use of foams containing PFAS for firefighting until 2007. The chemical characteristics of PFAS make them highly resistant to degradation (**NSW EPA 2022**).

See the **Responses** section for more information about how the NSW Environment Protection Authroity (EPA) is managing PFAS.

Condition of groundwater-dependent ecosystems

Groundwater-dependent ecosystems (GDEs) require access to groundwater to maintain a diversity of species and ecological processes.

GDEs are found in a wide range of environments with biological and physical characteristics that make them distinct from other ecosystems (**Hose et al. 2023**).

GDEs are grouped into three broad types:

- subterranean – those in aquifers (stygofauna) and caves
- aquatic – where groundwater meets surface-expressed groundwater or aquatic ecosystems (for example, river baseflow)
- terrestrial vegetation – those dependent on the subsurface presence of groundwater (**Eamus & Froend 2006**).

In NSW, examples of GDEs include:

- aquifer ecosystems
- cave and karst ecosystems
- river and stream baseflow ecosystems
- groundwater-dependent terrestrial vegetation (phreatophytes)
- groundwater-dependent wetlands
- Great Artesian Basin springs
- estuarine and near-shore marine ecosystems (**DCCEEW n.d.-g**).

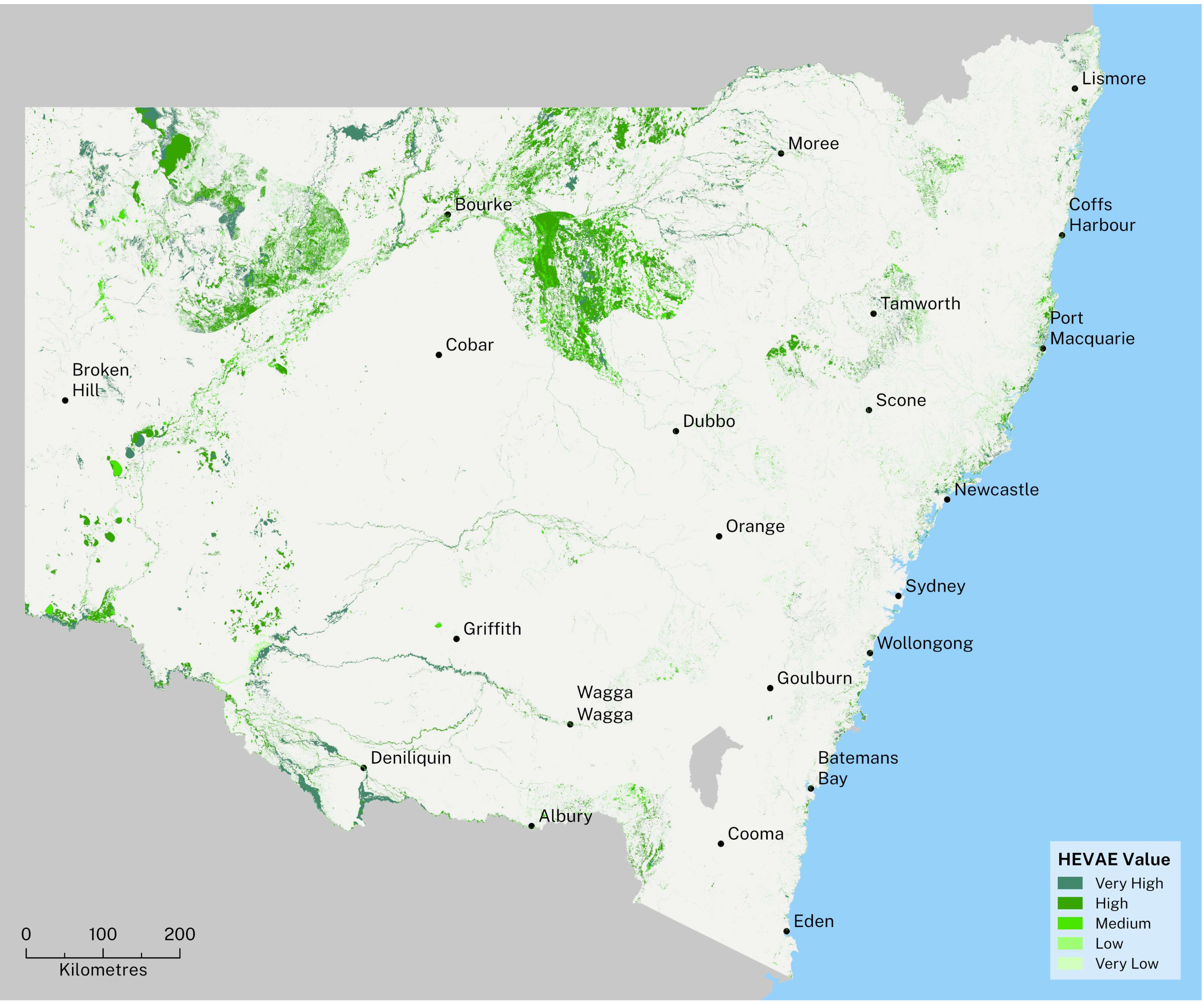
Terrestrial vegetation and wetland across more than 6.5 million hectares of NSW (about 8% of the land surface) have been identified as having a high probability of being groundwater-dependent (**DPE 2022**) (see **Map W2.3**).

Information on the condition of all GDEs in NSW is not comprehensive.

However, relative ecological value of GDEs has been assigned to help inform management actions. These values are based on the High Ecological Value Aquatic Ecosystems approach (**Dabovic et al. 2019**).

Understanding the location, extent and condition of groundwater-dependent ecosystems is vital for planning and management of surface water and groundwater. This information allows resource management decisions to consider the needs of the ecosystems and how to protect them.

Map W2.3: Location of groundwater-dependent ecosystems in NSW



Notes:
Map created using Spatial Layer of HEVAE Vegetation Groundwater Dependent Ecosystems Value in NSW.
Access the interactive version of this map.

Source:
DCCEEW 2024

Pressures and impacts

High demand

It's not sustainable to consistently extract groundwater faster than it can recharge. This removes it as a resource and has permanent consequences for dependent ecosystems.

In NSW, 54 groundwater sources are fully committed. This means if each entitlement share was assigned a value of 1 megalitre, the sum of the entitlement shares plus unlicensed rights to take groundwater would meet or exceed the groundwater source extraction limit (**DPE 2022**).

While the groundwater Available Water Determination (AWD) mechanism ensures the extraction limit is not exceeded, this indicates there is a strong demand for groundwater and a need to ensure its sustainability.

Development

The volume and quality of groundwater is threatened by land clearing, diverted runoff and contaminants.

Urbanisation

Rainfall on hard surfaces is often channelled into drains, rather than contributing to soil moisture. This can reduce the potential for recharge to the local water table.

Exposure to contaminants can pose direct short- and long-term threats to the ecology of groundwater-dependent ecosystems. Contaminants might include:

- nutrients from fertilisers and septic tank effluent
- agricultural pesticides
- metals and hydrocarbons from commercial and urban land uses (for example, leakage from underground petroleum storage systems).

Land use changes and vegetation clearing

Intensive agriculture and land clearing can increase surface water runoff and drainage erosion. This, in turn, can impact the water table through reduced recharge and increased aquifer drainage.

Activities that can impact the integrity of an aquifer are known as aquifer interference activities (**DPI 2012**). They can include anything that:

- penetrates an aquifer
- interferes with groundwater in an aquifer
- changes or obstructs groundwater flow in an aquifer
- takes groundwater from an aquifer
- disposes of water taken from an aquifer.

See the **Population and the environment**topic for more information.

Poor water quality

Poor water quality can negatively impact people and the environment.

Factors affecting groundwater quality and availability can be naturally occurring (seasonal weather, natural distribution of salts) but also affected by disruptions, including:

- excessive demand and extraction
- changes in land use
- changes in climate conditions
- pathogens
- chemical contamination and microbiological contamination
- lack of protection of aquifer recharge areas
- lack of local planning rules and borefield capture zone protection for town water supply borefields.

Chemical contamination of groundwater can reduce the value for water users and even prevent some types of water use. It also increases water treatment costs.

Once contaminated, an aquifer is extremely difficult and expensive to restore (**NSW EPA 2022**).

Cultural heritage

Groundwater is a vital resource for many remote and arid Aboriginal communities. Low availability and poor quality are serious issues in many areas (**Ross & Williams 2023**; **Lyons et al. 2023**).

Competition from agricultural and mining activities and the logistical challenges of accessing water in remote areas contributes to the risk of insufficient water quantity and quality for Aboriginal people (**Moggridge 2020**; **Ross & Williams 2023**).

The low quality of the groundwater in bores can have serious health consequences for communities that depend on them (**Lyons et al. 2023**).

A larger percentage of the population in remote and arid regions of NSW are Aboriginal. This means they are disproportionately impacted where groundwater availability is reduced due to competition from agricultural use and mining (**Ross & Williams 2023**).

Groundwater decline impacts extend beyond environmental values. They also pose a significant threat to cultural heritage.

Groundwater-fed ecosystems may include sacred sites with special trees and bush foods. Lowering the water table means these sites may be destroyed, jeopardising the cultural traditions that depend on them. For example, a scarred tree, a living testament to cultural history, might rely on groundwater to survive.

Dreaming tracks also rely on water sources for navigation and cultural knowledge. Protecting these cultural values means protecting the groundwater itself (**Moggridge et al. 2019**).

Informed management of surface water, which can directly impact groundwater supplies, is crucial (Caron et al. 2021). An example of this is the Boobera Lagoon in Moree Plains Shire. The loss of Aboriginal access and management disrupted the delicate balance between surface and groundwater in the lagoon, resulting in a decline in water quality (**Moggridge et al. 2022**).

Climate change

Climate change is expected to directly affect groundwater resources. Impacts may include:

- an increase in groundwater extraction due to decreased surface water availability
- changes to groundwater recharge (**AdaptNSW n.d.**)
- changes to the relative pressure between fresh and saline water, potentially affecting the distribution of fresh water in aquifers (**CWI 2009**).

For groundwater recharge, it is important to distinguish shallow, unconfined aquifers from deeper, semi-confined to confined aquifers. Their recharge processes are different, and the timing of an effect on recharge variation will also be largely different.

The main mechanisms of groundwater recharge of unconfined aquifers (or water table aquifers) include:

- flow from other aquifers
- rainfall infiltration
- river losses to the underlying aquifer
- aquifer recharge during floods.

Semi-confined and confined aquifers are generally recharged where the aquifer materials are exposed to the surface. Recharge to confined aquifers may take decades or even hundreds of years.

Climate change may increase the demand for groundwater due to reduced access to surface water.

Changes in surface water characteristics and rainfall frequency and intensity due to climate change may also influence groundwater quality and recharge.

Climate modelling predicts an increase in the frequency and intensity of extreme rainfall events (**Myhre et al. 2019**).

While rainfall (and the associated stream flows and flooding) is a major source of recharge for many groundwater systems, more rain may not always mean greater recharge.

A 10-year study conducted in the arid zones of western NSW has shown that during high-intensity rainfall events, water is often lost through runoff before it can soak into aquifers. This shows that the relationship between rainfall and aquifer recharge is far more complex than previously thought, and predictive modelling for recharge may need to be re-examined (**Myhre et al. 2019**).

See the **Climate change** topic for more information.

Extreme weather events

Groundwater is managed using long-term averages. This approach ensures groundwater systems, with their large storage capacities, provide a buffer to supply water in times of drought.

Climate variations affect how much groundwater people use. During droughts, groundwater extraction may increase to offset the low availability of surface water. This results in declining groundwater levels (**NSW EPA 2022**).

Rising sea levels

Rising sea levels have the potential to increase the salinity of land and coastal aquifers This results from increased pressure of the saline water against the freshwater groundwater flow.

See the **Extreme climate and weather** topic for more information.

Knowledge gaps

Connections

Connectivity, as it relates to groundwater, refers to the degree of hydraulic interaction between:

- different aquifers
- different parts of the same aquifer
- groundwater and surface water systems.

These connections are generally not well understood across NSW.

Where connectivity between water resources is high, water transfers readily. This means that extracting water from one source may also impact groundwater resources in a connected area.

Recharge

Recharge occurs when surface water in the environment soaks through the soil to the water table. Recharge is difficult to measure accurately. This is because it cannot be observed directly and is impacted by many factors, such as rainfall rates, soil type, vegetation cover and type, urban development and water table depth.

As reliance on groundwater increases, so does the importance of understanding aquifer recharge and the factors that impact it. Current understanding of recharge mechanisms and rates is poor.

Responses

Increasing recharge

In February 2022, the NSW Government published reports on how groundwater levels have changed since monitoring began in the 1970s and 1980s across 29 inland alluvial groundwater systems. Department hydrogeologists reviewed and analysed data from 1,300 groundwater monitoring sites.

They looked at how deep the groundwater levels fall during the summer irrigation season and the level to which they recover when the bore pumps are turned off during winter.

The report found that:

- Groundwater levels have generally fluctuated within acceptable levels of decline and recovery. In some localities, with concentrated areas of pumping, groundwater levels are not able to fully recover before the following irrigation season starts.
- Lower Gwydir, Lower Namoi and Upper Lachlan alluvial groundwater sources were identified as at most risk. Local management solutions have been put in place and work is underway to achieve the ***NSW Groundwater Strategy*** objective to manage these groundwater systems sustainably.
- There may be opportunities to enhance groundwater recharge and then contribute to increased storage. DCCEEW is working on a policy that will allow 'artificial' groundwater recharge, such as managed aquifer recharge.

Adapting to climate change

The effect of climate change on groundwater availability in NSW is largely unknown.

The ***NSW Groundwater Strategy*** will address how climate change is expected to influence groundwater availability and management, and inform the development of adaptation tools.

A program of work is under development in line with the **NSW Groundwater Strategy Implementation Plan 2023 to 25**. It will look at better characterising current groundwater recharge mechanisms and the impact of a future climate on groundwater availability.

Groundwater recharge is a slow process in most aquifers. The timeline of impact to the availability of water depends on the type of aquifer. For instance, a deep confined aquifer won't feel the impact of a reduced recharge for hundreds of years.

The program of work is expected to also look at groundwater quality changes, usage behaviours and management options.

Managing groundwater quality

A baseline of groundwater quality characterisation has been collected over the past few years. This is the first statewide program of groundwater quality status in NSW.

In line with the ***NSW Groundwater Strategy***, the NSW Government is preparing a groundwater quality monitoring strategy and a program of monitoring.

The program will set the frequency and locations of monitoring using the:

- risk exposure of groundwater systems
- speed of potential groundwater quality changes.

Groundwater contamination via chemical release remains largely controlled under the regulation of the EPA.

An emerging groundwater quality issue in NSW is contamination by PFAS (per- and poly-fluoroalkyl substances).

Various levels of groundwater contamination have been reported in several locations across NSW as a legacy of the use of foams containing PFAS for firefighting until 2007. The chemical characteristics of PFAS make them highly resistant to degradation (**NSW EPA 2022**).

The EPA leads the **NSW Government PFAS Investigation Program**. This program assesses legacy sites where it is likely that large quantities of PFAS have been used.

See the **Australian Government website** for more information about the PFAS National Environment Management Plan.

Protecting ecosystems

Knowledge of groundwater-dependent ecosystems in NSW has improved. There is still uncertainty around their extent, health and ability to respond to variations in groundwater availability.

The NSW Government implemented the **Groundwater dependent ecosystems program** to improve understanding of these ecosystems.

Research projects are currently being undertaken to better understand how groundwater-dependent ecosystems respond to variations in groundwater levels, and to allow for better detection of groundwater-reliant vegetation (**DCCEEW n.d.-h**).

These projects include:

- evaluation of vegetation health with groundwater level changes using remote sensing indices and field vegetation health indicators
- establishing the links between groundwater ecosystem health, groundwater-dependent vegetation and wetland health use in the Murray–Darling Basin
- using eDNA in groundwater to detect tree water use
- predicting the impacts of groundwater drawdown on groundwater ecosystems
- re-analysis of groundwater health in alluvial aquifers in the Murray–Darling Basin and associated thresholds for groundwater-dependent ecosystems
- establishing the links between groundwater ecosystem health, groundwater-dependent vegetation and wetland health in coastal catchments

- using a predictive stressor-response model for the ecosystem health of coastal aquifers.

Future opportunities

Listening to Aboriginal knowledges

Traditional knowledge about managing this precious resource can be valuable for informing sustainable water management practices (**Moggridge & Thompson 2021**).

Governments at all levels need to recognise and consider these knowledges when making decisions that impact groundwater. By collaborating with Aboriginal communities and respecting their knowledge, we can ensure a future where Australia's groundwater sustains us all (**Moggridge 2020**).

Unassigned water

Some groundwater sources have unassigned water available. This means that the level of commitment under basic landholder rights and access licences is less than the water sharing plan extraction limit. In these systems, the Minister for Water can make water available under a controlled allocation process.

Metered take

Most extraction from coastal groundwater sources isn't metered. Non-metered take of groundwater also presents opportunities for better measuring, modelling and monitoring. Under the NSW **Non-Urban Water Metering policy** (PDF 648KB), meter coverage will improve across the State. Better monitoring of water extracted will improve understanding of how groundwater systems respond to climatic and pumping stresses.

Knowledge gaps

Under the ***NSW Groundwater Strategy***, responses to several knowledge gaps critical to groundwater management and impact management are being developed.

The responses will:

- provide better documentation of groundwater-dependent ecosystems across NSW
- address risks to high-value groundwater-dependent ecosystems from increased constraint on a supporting aquifer
- provide better information on connectivity between surface water and groundwater.

This information will support water planning and management.

With such a strong Aboriginal connection to groundwater, NSW water managers must protect the cultural values of groundwater. This can be done by protecting groundwater quality and quantity from:

- impactful drawdown
- prolonged over-extraction
- pollution from industry, mining and agriculture.

Water quality

Groundwater quality in NSW is monitored infrequently and at few sites, though is improving. This means there is not yet sufficient data to develop a bigger picture of the impacts of groundwater extraction on water quality statewide.

Microfauna

Groundwater ecosystems contain numerous habitats that support a diverse array of microfauna biodiversity. These species, their roles and the impact of their presence, or absence, within their ecosystem are a poorly understood field of study.

Recharge

Further research is needed to inform updated prediction models to continue managing NSW groundwater resources sustainably. This is especially important as demand continues to grow and climate change impacts rainfall events.

Groundwater-dependent ecosystems

Knowledge of groundwater-dependent ecosystems in NSW is an ongoing area of improvement. The priorities set by the *NSW Groundwater Strategy* will further contribute to characterise all types of groundwater-dependent ecosystems and inform management responses.

Knowledge of groundwater-dependent ecosystems is still emerging. Better understanding of their location, characteristics and levels of dependency on groundwater is needed.

Little is known about plants and animals living in, or dependent on, groundwater aquifers. These knowledge gaps make it difficult to manage groundwater systems in ways that will ensure their protection.

Community education

Increasing community understanding of groundwater processes through education is part of the response to managing risks and pressures. The NSW Government has published a number of **short videos** to explain groundwater processes.

References

ABS 2023, Water account, Australia, Australian Bureau of Statistics, accessed 8 July 2024

Acworth I 2019, 'Investigating Groundwater', *International Contributions to Hydrogeology*, vol. 29, CRC Press

AdaptNSW n.d., Climate change impacts on our water resource, AdaptNSW, accessed 27 August 2024

Australian Government 2013, Guidelines for groundwater quality protection in Australia, Australian Government Initiative, accessed 5 July 2024

Australian Government 2018, Australian and New Zealand guidelines for fresh and marine water quality, Australian Government Initiative, accessed 5 July 2024

Castellazzi P, Schmid W & Fu G 2021, *Ground displacements over alluvial aquifers in southern Inland New South Wales*, prepared by Commonwealth Scientific and Industrial Research Organisation, NSW Department of Planning, Industry and Environment, Sydney

CWI 2009, Potential impacts of sea-level rise and climate change on coastal aquifers, UNSW Connected Waters Initiative, accessed 27 August 2024

Dabovic J, Dobbs L, Byrne G & Raine A 2019, 'A new approach to prioritising groundwater dependent vegetation communities to inform groundwater management in New South Wales, Australia', *Australian Journal of Botany*, vol. 67, no. 5, pp. 397–413, DOI: 10.1071/BT1821

DCCEEW 2023, *Groundwater-dependent Ecosystems: Environmental Outcomes Monitoring and Research Program Annual Report 2021–2022*, NSW Department of Climate Change, Energy, the Environment and Water, Sydney

DCCEEW n.d.-a, NSW Groundwater strategic priorities and actions, NSW Department of Climate Change, Energy, the Environment and Water, accessed 05 July 2024

DCCEEW n.d.-b, Managing groundwater in NSW, NSW Department of Climate Change, Energy, the Environment and Water, accessed 05 July 2024

DCCEEW n.d.-c, The 2017–20 drought, NSW Department of Climate Change, Energy, the Environment and Water, accessed 05 July 2024

DCCEEW n.d.-d, Tracking groundwater extraction against extraction limits, NSW Department of Climate Change, Energy, the Environment and Water, accessed 05 July 2024

DCCEEW n.d.-e, Groundwater projects and schemes, NSW Department of Climate Change, Energy, the Environment and Water, accessed 05 July 2024

DCCEEW n.d.-f, Groundwater quality, NSW Department of Climate Change, Energy, the Environment and Water, accessed 05 July 2024

DCCEEW n.d.-g, Groundwater and the environment, NSW Department of Climate Change, Energy, the Environment and Water, accessed 26 April 2024

DCCEEW n.d.-h, Groundwater-dependent ecosystems (GDEs), NSW Department of Climate Change, Energy, the Environment and Water, accessed 05 July 2024

DPE 2022, *NSW Groundwater Strategy*, NSW Department of Planning and Environment, Sydney

DPE 2023a, *Guide to Groundwater Resources in NSW*, NSW Department of Planning and Environment, Sydney (PDF 28.5MB)

DPE 2023b, *Guide to Groundwater Management in NSW*, NSW Department of Planning and Environment, Sydney (PDF 7.4MB)

DPI 2012, *NSW Aquifer Interference Policy*, Department of Primary Industries, Sydney (PDF 0.49MB)

DPIRD n.d., *NSW Groundwater Strategy*, NSW Department of Primary Industries and Regional Development, Orange

Eamus D & Froend R 2006, 'Groundwater-dependent ecosystems: The where, what and why of GDEs', *Australian Journal of Botany*, vol. 54, no. 2, pp. 91–6, DOI:10.1071/BT06029

Hose GC, Lorenzo TD, Fillinger L, Galassi DMP, Griebler C, Hahn HJ, Handley KM, Korbel K, Reboleira AS, Siemensmeyer T, Spengler C, Weaver L & Weigand A 2023, 'Chapter 22 – Assessing groundwater ecosystem health, status, and services' in F Malard, C Griebler and S Rétaux (eds), *Groundwater Ecology and Evolution*, (2nd edn), Elsevier, pp. 501–24, DOI: 10.1016/B978-0-12-819119-4.00022-6

Lyons I, Barber M, Fisher K & Braedon P 2023, *Indigenous water values, rights, interests and development goals in the Roper catchment - A technical report from the CSIRO Roper River Water Resource Assessment for the National Water Grid*, Commonwealth Scientific and Industry Research Organisation (CSIRO)

Luetkemeier R, Söller L & Frick-Trzebitzky F 2022, 'Anthropogenic pressures on groundwater', *Encyclopedia of Inland Waters (Second Edition)*, vol. 3, pp. 548–59, DOI: 10.1016/B978-0-12-819166-8.00183-3

Moggridge BJ, Betterridge L & Thompson RM 2019, 'Integrating Aboriginal cultural values into water planning: A case study from New South Wales, Australia', *Australasian Journal of Environmental Management*, vol. 26, no. 3, pp. 273–86, DOI: 10.1080/14486563.2019.1650837

Moggridge BJ 2020, 'Aboriginal people and groundwater', *The Proceedings of the Royal Society of Queensland*, vol. 126, pp. 11–27, DOI: 10.5962/p.357835

Moggridge BJ & Thompson RM 2021, 'Cultural value of water and western water management: An Australian Indigenous perspective', *Australasian Journal of Water Resources*, vol. 25, no. 1, pp. 4–14, DOI: 10.1080/13241583.2021.1897926

Moggridge BJ, Thompson RM & Radoll 2022, 'Indigenous research methodologies in water management: Learning from Australia and New Zealand for application on Kamilaroi country', *Wetlands Ecology and Management*, vol. 30, pp. 853–68, DOI: 10.1007/s11273-022-09866-4

Myhre G, Alterskjær K, Stjern CW, Hodnebrog Ø, Marelle L, Samset BH, Sillmann J, Schaller N, Fischer E, Schulz M & Stohl A 2019, 'Frequency of extreme precipitation increases extensively with event rareness under global warming', *Scientific Reports*, vol. 9, 16063, DOI: 10.1038/s41598-019-52277-4

NSW EPA n.d.-a, NSW State of Environment map viewer, NSW Environment Protection Authority, accessed 05 July 2024

NSW EPA n.d.-b, NSW State of the Environment report 2021: Groundwater, NSW Environment Protection Authority, accessed 27 August 2024

Ross A & Williams J 2023, *A thriving Murray-Darling Basin: Actions in the face of climate change, Essay 3: Surface water and groundwater connectivity in the Murray–Darling Basin: Integrated management of connected resources*, Australian Academy of Technological Sciences and Engineering, Canberra

Smithers G & Hopson S 2024, 'Rainbow Serpents and Boiling Springs: Indigenous sovereignty and the fight for groundwater in the United States and Australia', *Journal of American Studies*, vol. 58, no. 1, pp.1–38, DOI: 10.1017/S0021875824000148

Wardle D 2022, 'Sustainable groundwater stories: From disasters to epical narration', *The Journal for Thematic Dialogue*, vol. 21, DOI: 10.34074/junc.21022

This page intentionally
left blank

Coastal and marine

Ongoing declines in all coastal and marine indicators show that these environments are increasingly at risk. This will continue as our population grows and our climate changes.

Overview

Swimming sites graded very good or good declined to

73%

in 2022–23

Read more

Fish stocks listed as depleted have increased by

6%

since 2020

Read more

NSW has about 1,750 kilometres (km) of coastline, 826 beaches and 185 estuaries and coastal lakes (**NSW Marine Estate n.d.**).

Coastal and marine environments provide important habitats for animals and plants, as well as places for recreation and fishing.

For Aboriginal peoples, the marine environment is not just a resource, but a fundamental part of identity, culture and wellbeing.

As our population grows and our climate changes, coastal and marine environments are coming under increasing risk.

Condition

The area of NSW marine protected areas has remained stable at 35% of the NSW marine estate.

The proportion of marine and estuarine beaches suitable and useful for swimming declined: 73% of the 225 monitored sites were rated as very good or good in 2022–23, a decline from the previous year's 80%.

The water quality of NSW estuaries has remained stable in recent years. Data on estuarine turbidity and chlorophyll-*a* from July 2007 to April 2024 rated the water quality of 66% of estuaries as good.

The extent of estuarine macrophytes (large aquatic plants) in NSW showed an overall increase in mangrove area but a decrease in saltmarsh area. Change in area varied among the 18 estuaries that were remapped in the past 3 years. Over these estuaries, mangrove area increased by 624ha (12%), but saltmarsh decreased by 76ha (4%).

Fifteen of the 18 remapped estuaries reported an increase in mangrove area. Eight reported a decrease in saltmarsh area.

Estuarine catchments have become more susceptible to external factors in recent years, with 94 of the 184 estuaries identified as vulnerable.

The overall relative abundance of fish species along the NSW coast was also relatively stable. Fish abundance declined in 2011 but reached newly observed highs in 2022.

Why our coasts are important

Coastal ecosystems have long been deeply treasured by human cultures and societies. We have, and still do, live, swim, fish, farm, trade, celebrate and camp all along our coasts.

These ecosystems are formed by a combination of terrestrial (land), freshwater and marine (sea) processes and contain unique habitats and species, and comprise beaches, bays, estuaries, harbours, islands, sand dunes, coastal floodplains and wetlands.

For millennia, the marine environment has been deeply connected to the lives of Aboriginal peoples (**Gaylard et al. 2020**). The cultural significance of the ocean in Aboriginal cultures is evident in stories, songlines and spiritual beliefs interconnected with the marine environment (**Parsons & Taylor 2021**). Middens – mounds of shell and bone remains – are evidence of the long history of Aboriginal peoples' relationship with the marine environment (**Rowland & Ulm 2012**).

The coastal, estuarine and marine waters of NSW contain high biodiversity (variety of animal and plant species) owing to their diverse range of habitats and the influence of subtropical and temperate ocean currents.

These varied environments:

- prevent coastal and seabed erosion
- maintain coastal water quality and healthy aquatic ecosystems
- act as key habitats for fish and other marine life
- provide recreation, visual amenity and food production.

The health of coastal and nearshore marine environments is closely linked to the health and activities of coastal river catchments, the flow of water through these catchments and marine processes.

The health of and access to our coastal environments are fundamental to human health and wellbeing, particularly for Aboriginal peoples (**DPI & Ipsos ATSIRU 2022**; **DPI & Ipsos 2022a**; **DPI & Ipsos 2022b**; **DPI & Ipsos 2022c**).

There is no separation between the land and sea for Aboriginal peoples, the health of the marine environment is intrinsically tied to the wellbeing of the land and all living things (**Parsons & Taylor 2021**). This deep connection forms a sense of identity for coastal Aboriginal communities. The ocean contributes to their physical and mental health through sustenance, cultural practices and the connection it provides to their ancestral lands (**Marshall 2023**). Ultimately, the marine environment is not just a resource for Aboriginal peoples, but a fundamental part of their identity, culture and wellbeing.

NSW marine estate

The NSW marine estate covers the ocean and coastal areas of NSW, along with their natural resources and ecosystems.

Resources and ecosystems include marine biodiversity, fishery resources, coral reefs and seagrass beds, as well as economic, cultural and environmental values (**NSW Marine Estate n.d.**).

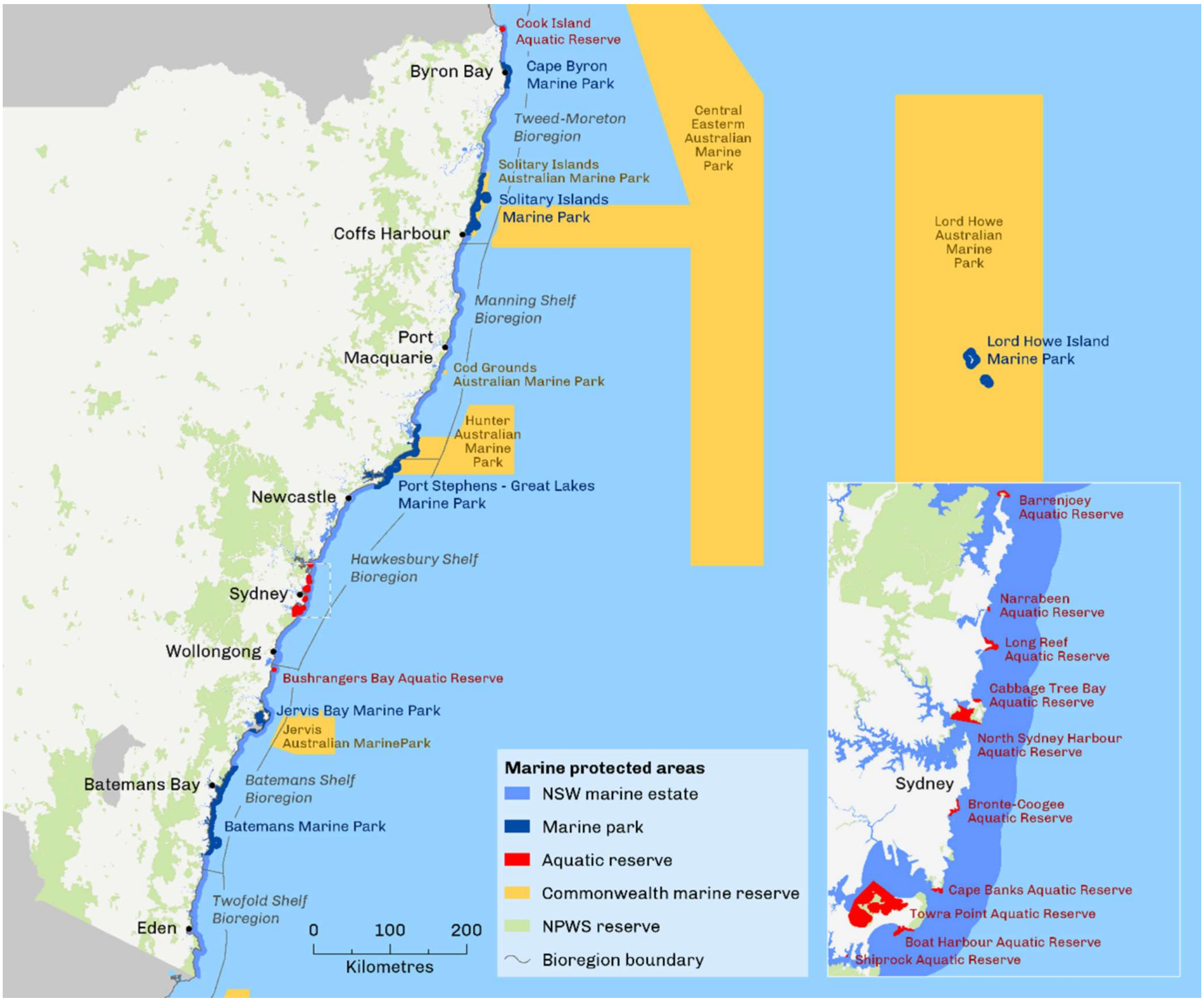
The NSW marine estate extends from the Queensland border to the Victorian border and encompasses:

- the ocean – out to three nautical miles (5.46km) from the mainland coast and around islands such as Lord Howe and the Solitary Islands
- estuaries – to the tidal limit (where the high tide reaches upstream)
- the coastline – beaches, dunes and headlands
- coastal wetlands – saltmarsh, mangroves and seagrass beds
- coastal lakes and lagoons connected to the ocean.

The NSW marine estate can be divided into six marine bioregions (see **Map W3.1**). Each of these bioregions is ecologically distinct, with different temperature conditions, habitat types and resident species.

Five of these bioregions are adjacent to the coast and one surrounds Lord Howe Island.

Map W3.1: Marine parks and aquatic reserves along the NSW coast



Source:
Department of Primary Industries and Regional Development (DPIRD) data 2014; Geoscience Australia data 2014

Threats to the NSW marine estate

Much of the NSW coastline is highly populated.

The activities that occur in coastal catchments and the marine estate put significant pressure on the health of our coasts and nearshore marine waters. A statewide threat and risk assessment identified the priority threats to the health of the coast, estuaries, marine waters and local culture (**BMT WBM 2017**).

The top ten environmental threats and risks are:

1. urban stormwater discharge
2. estuary entrance modifications
3. diffuse-source agricultural runoff (in estuaries)
4. clearing of riparian (riverside) vegetation along waterways and adjacent habitat, including wetland drainage
5. climate change stressors (sea level rise, land and sea surface temperature increases, altered ocean currents and nutrient inputs)
6. modified freshwater flows (in estuaries)
7. foreshore development
8. boating infrastructure and recreational and tourism boating (in estuaries)
9. navigation and entrance management, navigation and entrance modification and harbour maintenance (in estuaries)

10. sewage effluent and septic runoff.

The greatest threats to the social, cultural and economic benefits were primarily associated with:

- water pollution
- limited social, cultural and economic information
- lack of compliance with regulations
- lack of access to the marine estate.

Estuaries are at higher risk than the coast and ocean, mainly due to their high level of use and lower resilience to threats. Marine invasive species are also an issue along the NSW coast, outcompeting native species and degrading habitats.

Coastal development has also damaged Aboriginal cultural sites and restricted access to important places and animals and plants used for food and medicine.

Management of the NSW coast

Rehabilitation and protection will improve our coastal and estuarine environments.

Actions include adaptation to the effects of climate change – such as sea level rise and increases in sea surface temperatures – and building resilience to potential extreme weather events, such as storms and cyclones.

NSW has a suite of management frameworks and legislation to manage the marine estate. These encompass objectives for coastal management, coastal land use planning, environment protection, and the conservation and management of fisheries and aquatic ecosystems.

Key strategies include:

- the ***Marine Estate Management Strategy***
- the **Marine Water Quality Objectives for NSW Ocean Waters**
- the **Risk-based Frameworks for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions**
- **Coastal Management Plans**
- **NSW State Environmental Planning Policies**.

Table W3.1 lists current legislation and policies that support the management of our coast and marine ecosystems.

Table W3.1: Current legislation and policies relevant to coastal and marine ecosystems

Legislation or policy	Summary
Coastal Management Act 2016	Establishes the coastal zone and objectives to manage the use and development of the coastal environment in an ecologically sustainable way.
Fisheries Management Act 1994	Legislates the management of fishery resources and their habitats in New South Wales. It also legislates that the fishing needs and traditions of Aboriginal people are appropriately considered in the management of fisheries resources.
Marine Estate Management Act 2014 (MEM Act)	Provides for the strategic and integrated management of the whole marine estate – marine waters, coast and estuaries – consistent with the principles of ecologically sustainable development. It also provides for the management of marine parks and aquatic reserves.
NSW Marine Estate Management Strategy 2018–28	Outlines how the NSW Government will address priority statewide threats to the marine estate, such as climate change, water quality and pollution, and protection of threatened and protected species. See the **Responses** section of this topic for more information.
State Environmental Planning Policy (Resilience and Hazards) 2021	Promotes an integrated and coordinated approach to land use planning for the coastal zone, consistent with objectives of the *Coastal Management Act 2016*.

Notes:
See the **Responses** section for more information about how coastal and marine ecosystems are managed in NSW.

Related topics: **Climate change** | **Extreme climate and weather** | **Population and the environment** | **Protected areas and conservation** | **Rivers and wetlands** | **Waste and recycling**

Status and trends

Coastal and marine indicators

This report uses six indicators to assess the status and trends of coastal and marine environments in NSW (see **Table W3.2**):

- **Proportion of marine waters protected in marine parks or reserves** measures the area of the marine parks and reserves in NSW. Since 2018, there have been no changes to the area of marine parks and aquatic reserves. They are 35% of the NSW marine estate. This indicator is assessed as moderate (see **Marine parks and reserves**).
- **Percentage of ocean and estuarine beaches with beach suitability grades for swimming of good or better** assessed as good, because 73% of the 225 monitored sites were rated as very good or good for swimming in 2022–23 (see **Swimming sites**).
- **Estuarine water quality (chlorophyll-*a* and turbidity)** measures estuarine water quality. Based on data from July 2007 to April 2024, the water quality in 66% of NSW estuaries was rated as good. The indicator is assessed as moderate (see **Estuarine water quality**).
- **Extent of estuarine macrophytes (including seagrasses)** is assessed as moderate, because 39% of remapped saltmarsh habitats in NSW estuaries have lost areas of saltmarsh since the 2000s, while 71% have seen an increase in mangroves areas. Several species of seagrass are less abundant (see **Estuarine macrophytes** and **Subtidal habitats**). This indicator aligns to the 'biosphere integrity' planetary boundary. Globally, this boundary has been crossed (see **Planetary boundaries alignment**).
- **Levels of estuarine catchment disturbance** status is unknown, but it is getting worse. In the last major statewide study of catchment disturbance in 2017, 94 of the 184 estuarine catchments in NSW were identified as vulnerable. It is likely that

the proportion has increased with urban and agricultural development in the past seven years (see **Catchment disturbance**).

- **Coastal fish stocks** measures coastal fish community health using different metrics, such as fish diversity, abundance and fisheries stocks, in three coastal regions of NSW. From 2010 to 2022, both coastal fish diversity and abundance have remained stable. This indicator is assessed as moderate (see **Coastal fish communities**).
  This indicator aligns to the 'biosphere integrity' planetary boundary. Globally, this boundary has been crossed (see **Planetary boundaries alignment**).

Table W3.2: Coastal and marine indicators

Indicator	Environmental status	Environmental trend	Information reliability
Proportion of marine waters protected in marine parks or reserves	MODERATE	Stable	Good
Percentage of ocean and estuarine beaches with beach suitability grades for swimming of good or better	GOOD	Stable	Good
Estuarine water quality (chlorophyll-*a* and turbidity)*	MODERATE	Stable	Good
Extent of estuarine macrophytes	MODERATE	Stable**	Reasonable
Levels of estuarine catchment disturbance	UNKNOWN	Getting worse	Limited
Coastal fish stocks	MODERATE	Stable	Reasonable

Notes:
*Water quality by algae (chlorophyll-*a*) and water clarity (turbidity)

**Stable reflects a variable result with extent decreasing in some areas and increasing in others

Indicator table scales:
- **Environmental status**: Good, moderate, poor, unknown
- **Environmental trend**: Getting better, stable, getting worse
- **Information reliability**: Good, reasonable, limited.

See **Indicator guide** to learn how terms and symbols are defined.

See the **Planetary boundaries alignment** page for more information about how indicators align.

Marine parks and reserves

The network of marine protected areas shown in **Map W3.1** includes:

- six multiple-use marine parks, which cover about 35% (about 345,000 hectares) of the NSW marine estate
- 12 aquatic reserves covering about 2,000 hectares of the estate
- national park and nature reserve areas below the high tide level, accounting for about 20,000 hectares of the estate.

There have been no increases to the area of marine parks and aquatic reserves in NSW since the *State of the Environment 2021*.

The total area of sanctuary zones, the highest level of protection for marine life and habitats, is about 65,630 hectares, or about 6.5% of the total marine estate.

These parks and reserves aim to conserve biodiversity and maintain ecosystem integrity and function (see **Map W3.1**).

Marine parks and aquatic reserves provide additional legislative protections to those in place for the broader NSW marine estate.

Secondary purposes of marine parks and aquatic reserves include other community benefits, such as:

- recreation and enjoyment
- Aboriginal cultural uses
- ecologically sustainable resource use
- conservation, research and education.

Indigenous Protected Areas

Aboriginal peoples have a deep connection to Australia's coastal and marine environments. However, their involvement in marine governance remains limited (**Marshall 2023**).

One Indigenous Protected Area project is designated on the NSW coast: Ngiyambandigay Gaagal (**Ngiyambandigay Wajaarr Aboriginal Corporation n.d,**), near Coffs Harbour.

Indigenous Protected Areas (IPAs) are voluntary, non-legal agreements between the Australian Government and traditional owners. They are facilitated by an international framework for managing protected areas, which allows IPA designation on Indigenous-owned lands and other tenures, including Sea Country.

The program is funded by the Australian Government and is a crucial part of Australia's National Reserve System. This system includes all formally recognized parks, reserves and protected areas across the country.

While IPAs represent a positive step forward, the number of coastal and marine IPAs is small, and Aboriginal people have minimal formal roles in managing Marine Protected Areas (**Shamsi et al. 2020**; **Marshall 2023**). Despite holding invaluable Traditional Knowledge, its integration into broader marine management strategies remains insufficient (**Shamsi et al. 2020**).

Swimming sites

The NSW Government's **Beachwatch program** monitors 240 swimming sites at ocean beaches and in estuarine areas, lakes, lagoons, freshwater swimming sites and ocean baths.

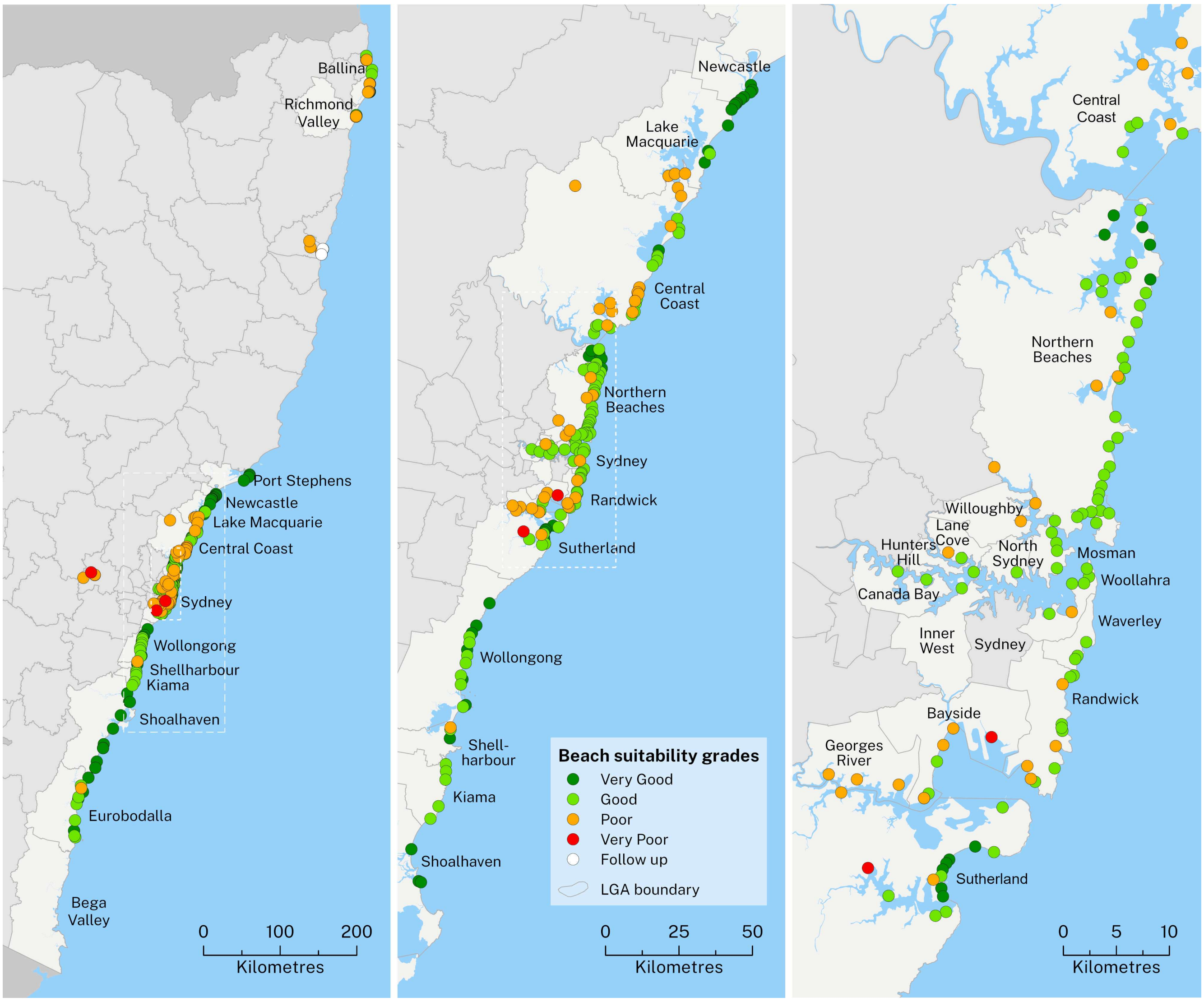
Swimming sites in NSW are assigned a suitability grade, ranging from very good to very poor. Grades relate to the Microbial Assessment Category, which detects levels of enterococcal bacteria in the water to assess the risk of illness, determined in accordance with the *Guidelines for Managing Risks in Recreational Water* (**NHMRC 2008**).

In 2022, the program expanded to include some inland waterways and freshwater swimming sites (for example, Penrith Lakes).

While coastal swimming sites continue to achieve high ratings, freshwater sites and lagoons perform poorly (see **Map W3.2**).

See the **Beachwatch** website for live water quality maps.

Map W3.2: Swimming site suitability grades



Source:
NSW Beachwatch Program 2023

In 2022–23, 73% (165 of 225) of NSW swimming sites monitored were graded as very good or good overall. This is a decline from 80% in 2021–22.

The decline reflects changes in water quality over time. It may also be influenced by changes in the number of sites monitored each year.

All ocean baths and 96% of ocean beaches achieved very good or good ratings in 2022–23.

About 56% of estuarine swimming sites achieved these ratings in 2022–23, a significant decline from 65% in 2021–22. Only 6% of lakes and lagoons were rated as very good or good. There is currently no comparative data for these sites as they were added to the program in 2022.

Rainfall is a major driver of pollution to waterways through stormwater runoff.

Untreated discharges from the wastewater treatment and transport systems can occasionally also pollute waterways if sewerage systems are overwhelmed during extreme rainfall.

Estuarine water quality

Estuarine water quality has been relatively stable overall since the *State of the Environment 2021*.

The NSW Government's **Estuary monitoring program** monitors water quality in 164 estuaries. The program takes three years to complete. The results of the chlorophyll-*a* and turbidity levels are combined into an overall score from A (good) to E (poor) for each estuary in each year, **DCCEEW 2024a** presented in **Map W3.3**.

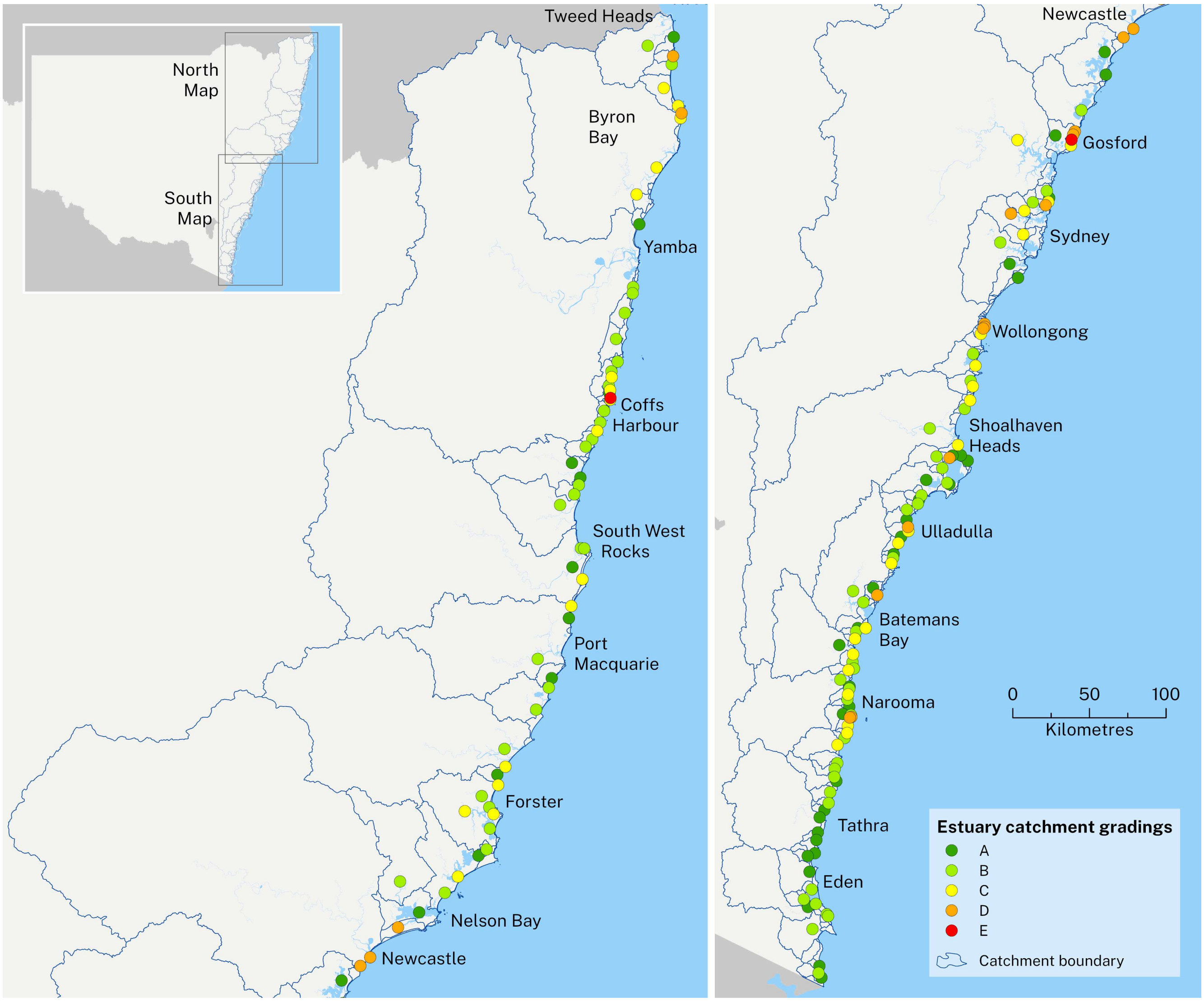
The extent of algae (chlorophyll-*a*) and water clarity (turbidity) in estuaries provides a good indication of the water quality of the ecosystem and therefore its overall health.

In NSW in 2021–23:

- 66% of estuaries were graded as good (27% Grade A, 39% Grade B), down from 71% in 2016–21
- 23% of estuaries were graded as fair (23% Grade C), up from 19% in 2016–21
- 11% of estuaries were graded as poor (10% Grade D and 1% Grade E), up from 10% in 2016–21.

See the **Real-time water quality monitoring website** for water quality in your area.

Map W3.3: Estuarine water quality gradings, 2021–23



Notes:
Access the interactive version of this map.

Statewide monitoring of estuaries is completed over a 3-year cycle.

Source:
Unpublished data, DCCEEW

Some estuaries continue to be graded as poor or very poor owing to impacts of significant urban development nearby. These include the estuaries of the Hunter River, Terrigal Lagoon, Avoca Lake, Manly Lagoon, Parramatta River, Cooks River, Towradgi Creek and Fairy Creek.

Estuarine macrophytes

Estuarine macrophytes are the aquatic plants of coastal rivers, including mangroves, saltmarshes, seagrasses and kelp.

They are key components of estuarine systems and provide a range of ecosystem services, including habitat, food, sediment stabilisation and water quality.

The NSW Department of Primary Industry and Regional Development (DPIRD) ***Marine Estate Management Strategy*** maps estuarine macrophytes on a rolling cycle using high-resolution aerial images, remapping most estuaries every five to ten years.

This report includes only 18 of the 184 estuaries, those remapped between 2021 and 2024 (the period of this *State of the Environment 2024*).

Changes in the extent of each macrophyte habitat in those 18 estuaries are presented below for mangroves (see **Figure W3.1**), saltmarsh (see **Figure W3.2**) and seagrasses (see **Figure W3.3**).

Maps of estuarine macrophytes for all available years (including the original mapping project from the 1980s) can be viewed on the **DPIRD Fisheries Estuarine Habitat Dashboard.**

Intertidal habitats

Mangroves

Mangroves in NSW are dominated by two species:

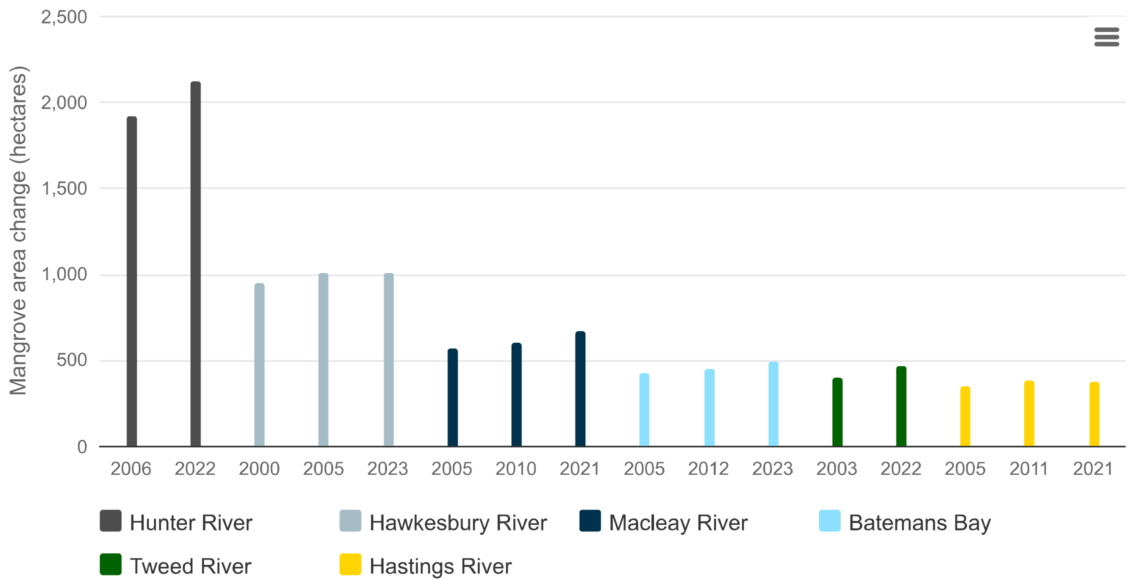
- *Avicennia marina* (grey or white mangrove)
- *Aegiceras corniculatum* (black mangrove).

Mangroves have been mapped in 86 NSW estuaries since the 1980s and remapped in 18 of these since 2020 (see **Figure W3.1**). Of these 18 estuaries, 14 have shown an increase in mangrove area since they were last mapped and three have shown a decline.

The largest increases in area occurred in the Hunter and Macleay rivers and in Batemans Bay, and the largest increases in percentage occurred in Twofold Bay, Merimbula Lake and Mooball Creek.

In the remapped estuaries, mangroves increased in area by 624 hectares.

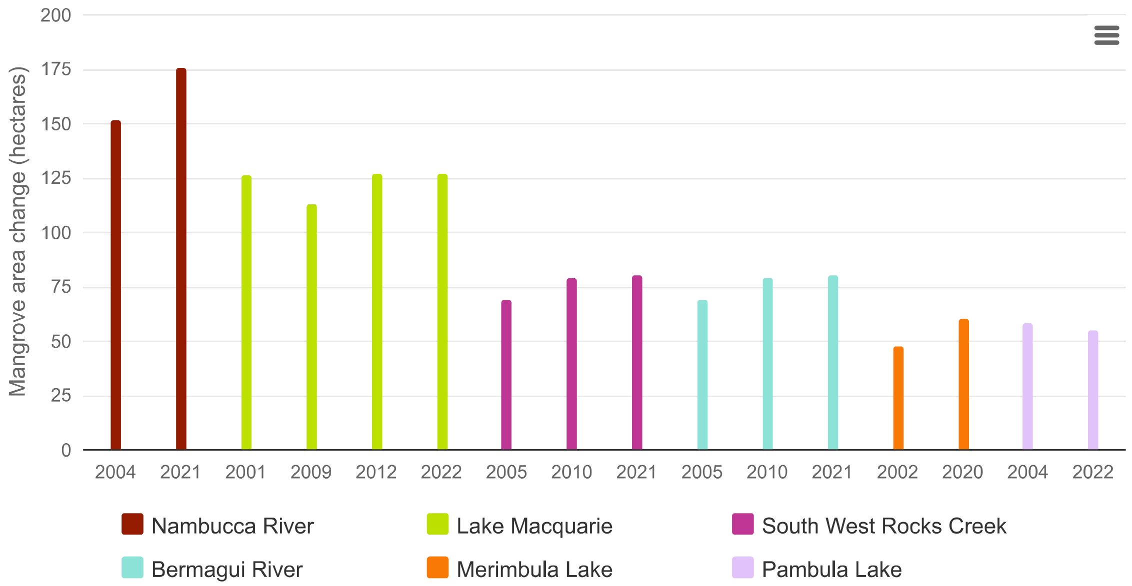
Figure W3.1a: Mangrove area (ha) in NSW estuaries remapped within the past three years



Notes:
Only estuaries remapped since 2020 are presented.
Data from tributaries of Batemans Bay are amalgamated here.

Source:
DPIRD data 2024

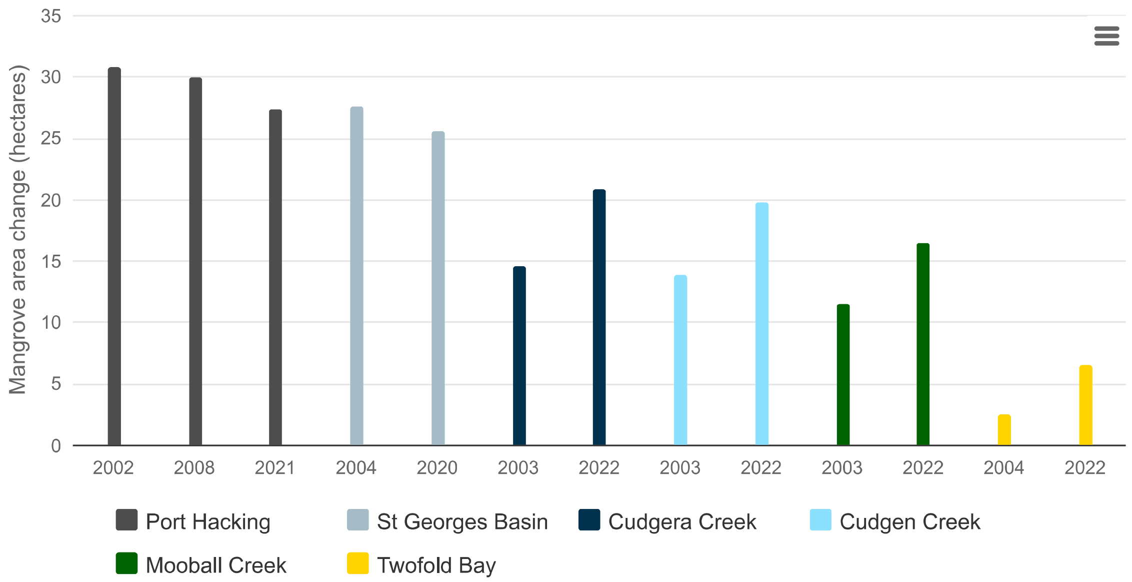
Figure W3.1b: Mangrove area (ha) in NSW estuaries remapped within the past three years



Notes:
Only estuaries remapped since 2020 are presented.

Source:
DPIRD data 2024

Figure W3.1c: Mangrove area (ha) in NSW estuaries remapped within the past three years



Notes:
Only estuaries remapped since 2020 are presented.
Data from tributaries of Twofold Bay are amalgamated here.

Source:
DPIRD data 2024

Saltmarsh

NSW saltmarsh includes three major species:

- *Sarcocornia quinqueflora* (samphire)
- *Suaeda australis* (seablite)
- *Sporobolus virginicus* and *Paspalum vaginatum* (salt-couch).

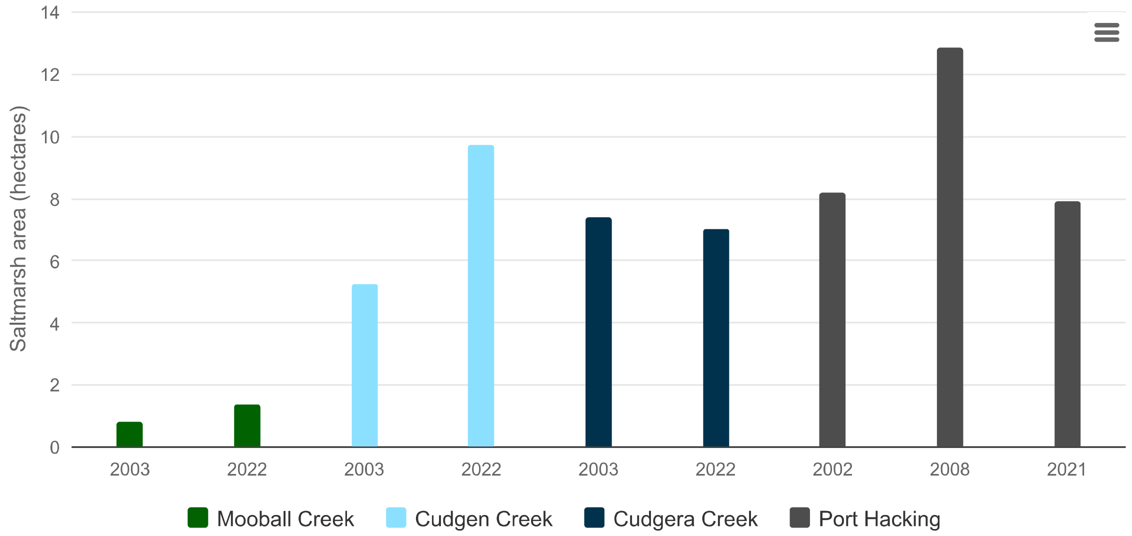
Of the 18 estuaries mapped in this reporting period, eight show a decline in areas of saltmarsh since the 2000s, two rated moderate to severe (>20% loss), including:

- a substantial decline in the Tweed River (45% loss), some related to residential development around Terranora Broadwater and mangrove encroachment
- declines in Lake Macquarie (28%), Macleay River (16%), the Hawkesbury River (14%) and Merimbula Lake (12%)
- a decline in the Hunter River (6%) despite major restoration activities (**Glamore et al. 2021**).

Saltmarsh has increased in Cudgen Creek (86% gain) and Mooball Creek (70%), and in Twofold Bay (65%) and South West Rocks Creek (56%) potentially driven by intermittent opening and closing of the river mouths.

In the 18 remapped estuaries, saltmarsh area decreased by 76 hectares.

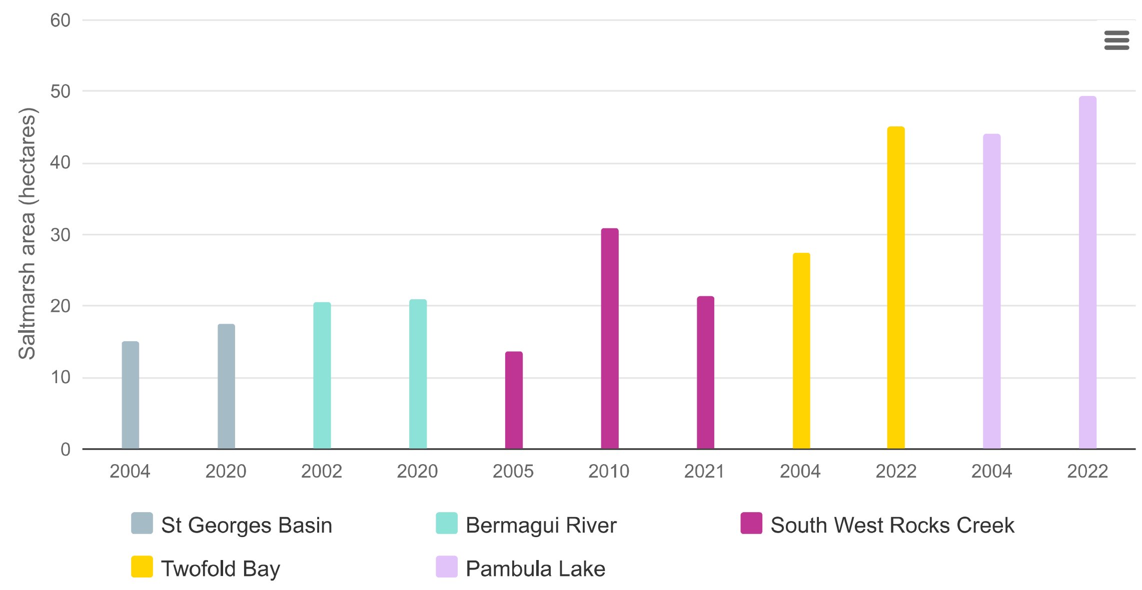
Figure W3.2a: Saltmarsh area (ha) in NSW estuaries remapped within the past three years



Notes:
Only estuaries remapped since 2020 are presented.

Source:
DPIRD data 2024

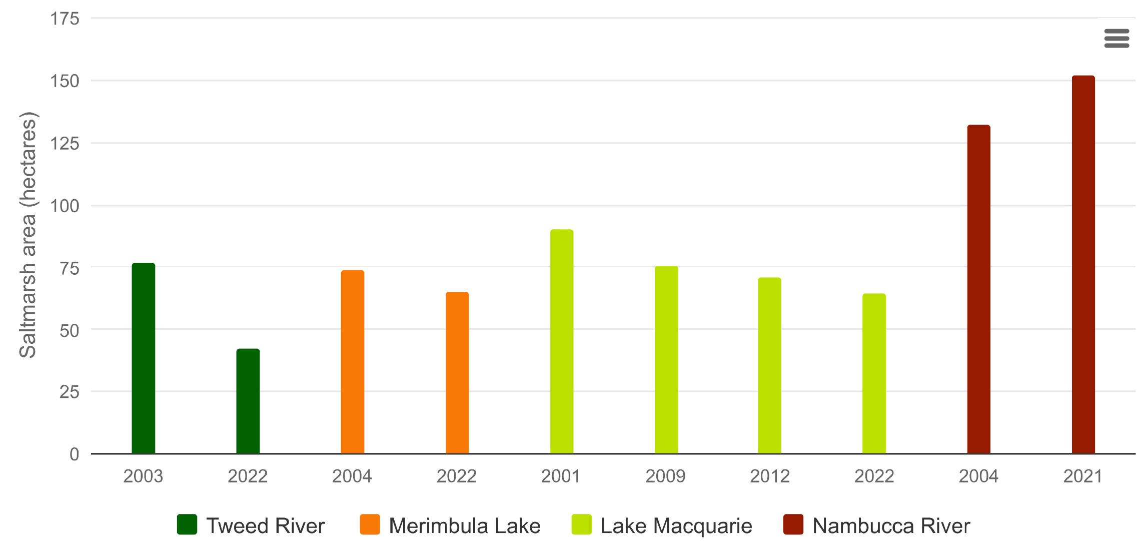
Figure W3.2b Saltmarsh area (ha) in NSW estuaries remapped within the past three years



Notes:
Only estuaries remapped since 2020 are presented.
Data from tributaries of Twofold Bay have been amalgamated here.

Source:
DPIRD data 2024

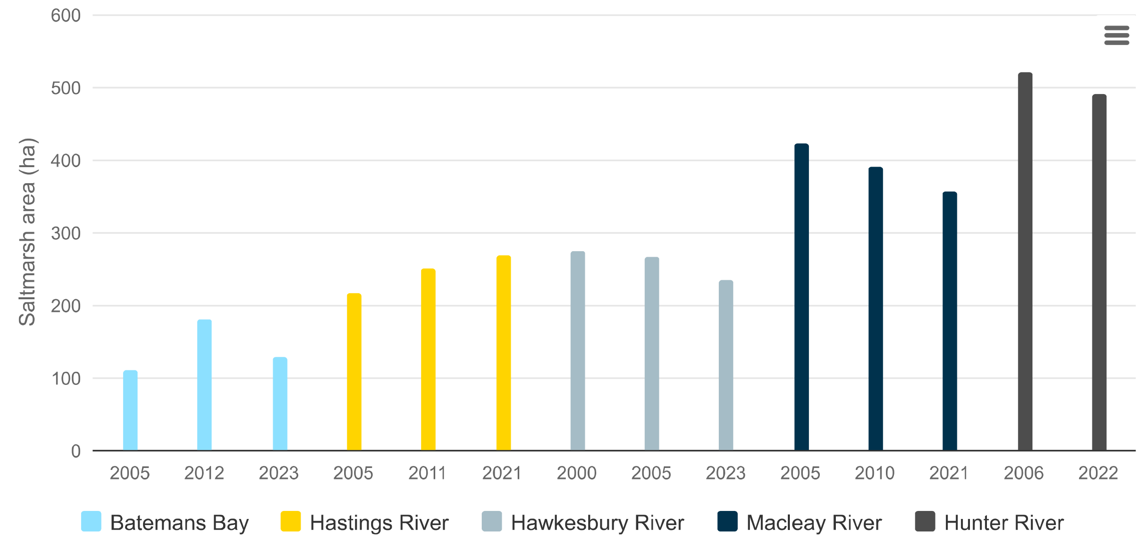
Figure W3.2c Saltmarsh area (ha) in NSW estuaries remapped within the past three years



Notes:
Only estuaries remapped since 2020 are presented.

Source:
DPIRD data 2024

Figure W3.2d Saltmarsh area (ha) in NSW estuaries remapped within the past three years



Notes:
Only estuaries remapped since 2020 are presented.
Data from tributaries of Batemans Bay have been amalgamated here.

Source:
DPIRD data 2024

Drivers of intertidal habitat change

Causes of saltmarsh and mangrove losses include (**Saintilan et al. 2022**; **Wen et al. 2023**):

- urban development
- flooding and the opening or closing of lagoons
- pollution
- damage from offroad vehicles
- sea level rise.

Fluctuations in saltmarsh and mangrove coverage are common in intermittently opened lakes and lagoons because the extent of opening affects inundation of wetlands (**Hughes et al. 2019**). For example, changes in saltmarsh and mangroves declined in 2020 in Cabbage Tree Basin, in Port Hacking, apparently owing to freshwater inundation related to the closure of the narrow entrance at Deeban Spit (**Asbridge et al. 2024**).

Mangrove encroachment is also a contributor to declines in saltmarsh in many estuaries (**Saintilan & Williams 1999**; **Saintilan et al. 2014**). This may be due to a variety of reasons, including landward encroachment associated with sea level rise (**Wen & Hughes 2022**; **Kumbier et al. 2022**). Mangroves have encroached into saltmarshes at various sites in Port Hacking and in the Hunter River, the latter being the only central region estuary to show moderate mangrove increases since the 2000s (see **Figure W3.2**).

Large areas of saltmarsh and mangrove were also burnt in the 2019–20 Black Summer bushfires, reducing coverage in some places. Signs of recovery are present in saltmarsh but not mangroves (**Glasby et al. 2023**).

Subtidal habitats

Soft Corals

Aggregations of cauliflower soft corals form habitat for a large range of marine species. Extreme weather events, such as floods, are becoming more frequent and pose a substantial threat to nearshore marine communities.

The reduction in salinity associated with these events has substantially impacted shallow reef communities, including an endangered soft coral species, *Dendronephthya australis,* endemic to the south-east coast of Australia. Large volumes of freshwater ingress to marine systems through successive flood events between 2021 and 2022 has caused a major decline in the areal extent of cauliflower soft coral to the point of localised extinction in the Port Stephens estuary.

Before the floods, aggregations of colonies were persisting, and individuals were growing at two of the four monitored sites in the estuary. However, flooding in March 2021 caused a 91% decline in the remaining areal extent of *D. australis*.

Seagrasses

Seagrasses are marine plants that occur predominantly in subtidal (permanently submerged) sand or mud. They provide habitats and nursery grounds for many marine animals and act as substrate and sediment stabilisers (**AIMS n.d.**).

Many of the seagrass species in NSW are transient. In contrast, *Posidonia australis* (strapweed) typically forms relatively stable meadows when not subjected to human impacts (**West & Glasby 2021**). It occurs in 17 estuaries from Wallis Lake down to Twofold Bay, and in some sheltered open coast locations (**Williams et al. 2013**).

Posidonia australis

Posidonia australis (strapweed) is used to map seagrass extent in NSW because it is abundant and forms stable meadows. Maps of the extent of the different seagrass species can be viewed on the **NSW DPIRD Estuarine Habitat Dashboard**.

Populations of *Posidonia australis* are listed as endangered under State legislation in several areas, including:

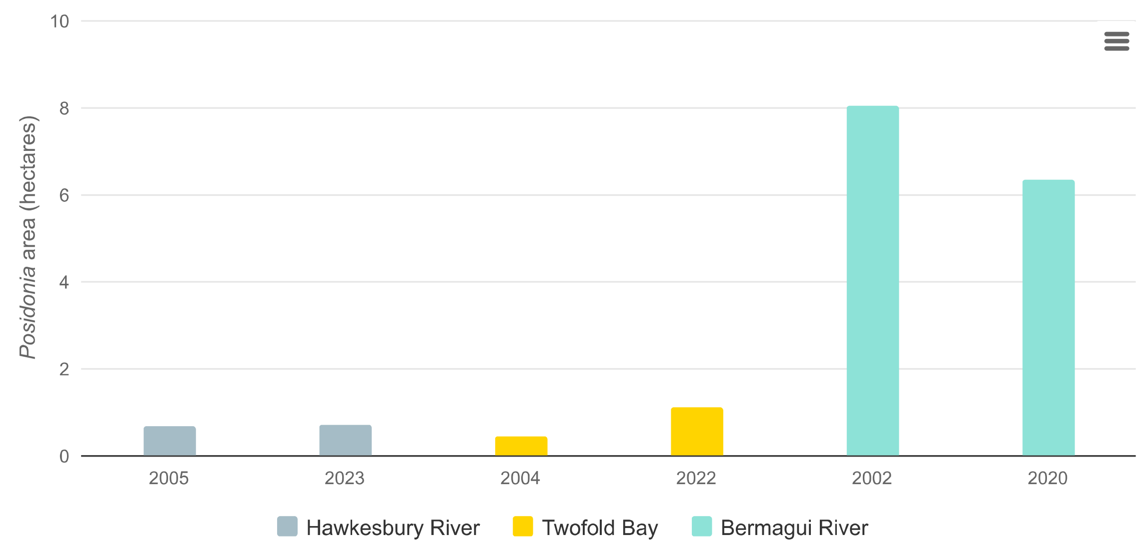
- Botany Bay
- Brisbane Water
- Lake Macquarie
- Pittwater
- Port Hacking
- Port Jackson.

Nine estuaries have been remapped since 2020 (see **Figure W3.3**).

Batemans Bay, Bermagui River and Pambula Lake show moderate to severe declines in seagrass extent since the 2000s. More work is needed to understand why this has occurred. Large scale sand movement may have contributed at Bermagui River.

Increase in area was seen in St George, Merimbula, Twofold Bay and Port Hacking. Despite overall increases across many estuaries, losses were still apparent in many urbanised estuaries. Further, losses occurred at individual sites from localised impacts.

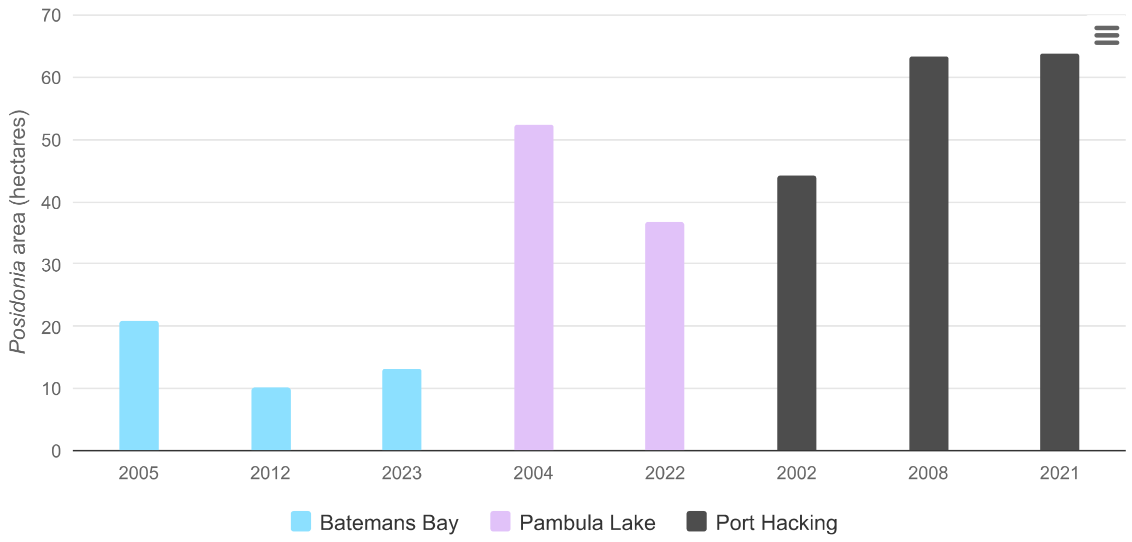
Figure W3.3a: Area (ha) of Posidonia australis in NSW estuaries remapped within the past five years



Notes:
Only estuaries remapped since 2020 are presented.
Data from tributaries of Twofold Bay have been amalgamated here.
Areas for any mapping times since 2000 are included to enable an assessment of longer-term trends.

Source:
DPIRD data 2024

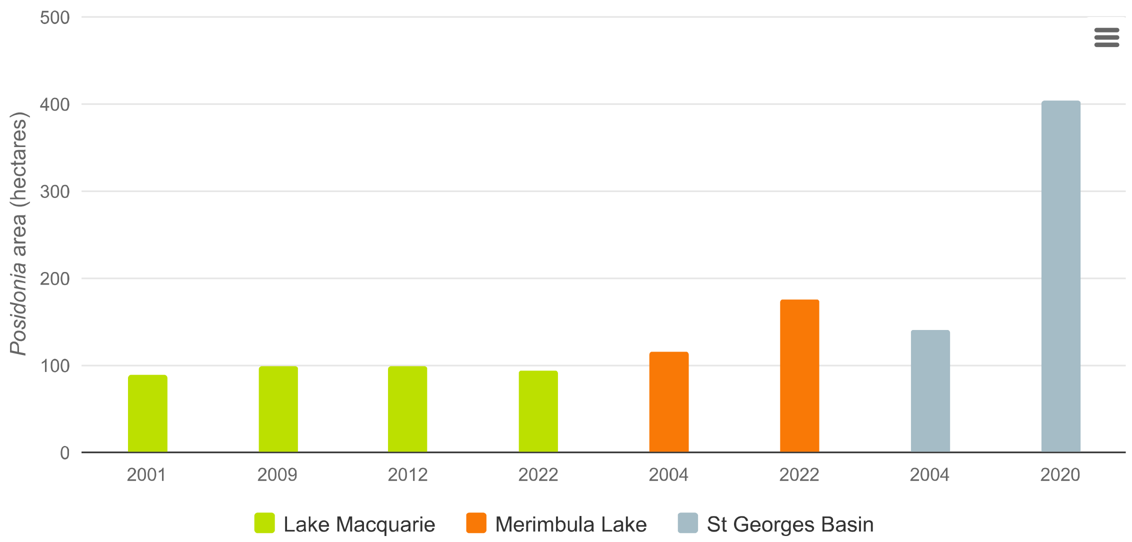
Figure W3.3b: Area (ha) of Posidonia australis in NSW estuaries remapped within the past five years



Notes:
Only estuaries remapped since 2020 are presented.
Data from tributaries of Batemans Bay have been amalgamated here.
Areas for any mapping times since 2000 are included to enable an assessment of longer-term trends.

Source:
DPIRD data 2024

Figure W3.3c: Area (ha) of Posidonia australis in NSW estuaries remapped within the past five years



Notes:
Only estuaries remapped since 2020 are presented.
Areas for any mapping times since 2000 are included to enable an assessment of longer-term trends.

Source:
DPIRD data 2024

Transient seagrasses

Transient seagrasses are not as stable as *Posidonia australis.* They include:

- *Zostera capricorni* subspecies *muelleri* (eelgrass), common in most estuaries
- *Halophila* species (paddle weed)
- *Ruppia* species (tassel weed or widgeon grass).

Large changes in the extent of transient seagrasses (dominated by *Zostera*) over short time periods complicate determining long-term changes (**West & Glasby 2021**).

Remapping since 2020 in 18 estuaries (see **Figure W3.4**) reveal substantial declines in transient seagrass area since the early 2000s in area or percentage:

- Smiths Lake (loss of 278ha or 94%), Lake Macquarie (220ha, 16%) and the Hastings River (113ha, 78%)
- Mooball Creek (2ha, 98%), Cudgera Creek (3ha, 97%) and Cudgen Creek (1ha, 92%).

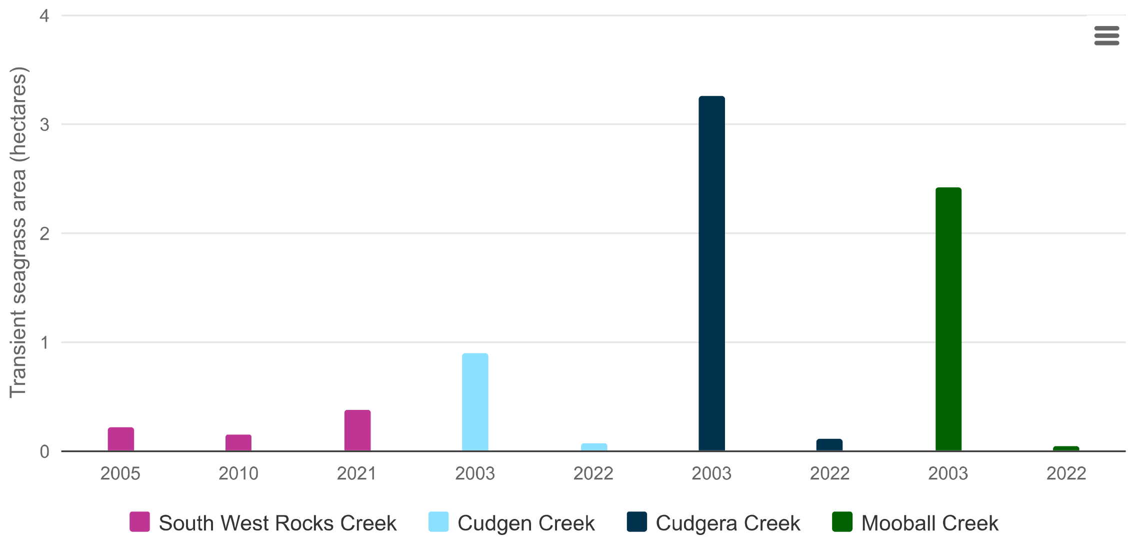
Smiths Lake and Cudgera Creek have fluctuating environmental conditions that correlate to large variations in *Zostera* abundance (**West & Glasby 2021**). Work is currently underway to assess whether other declines might be related to heavy rainfall which typically has disproportionately large effects in mature barrier river estuaries (**West & Glasby 2021**).

Coverage has increased in six of the mapped estuaries:

- Hawkesbury River (30ha, 77%)
- St Georges Basin (28ha,16%)
- Port Hacking (23ha, 62%)
- Pambula Lake (7ha, 40%)
- Merimbula Lake (4ha, 7%)
- Bermagui River (1ha, 5%).

The extent of seagrasses has declined by nearly 25% from 2,604ha in the early 2000s to 1968ha when remapped over the last 4 years.

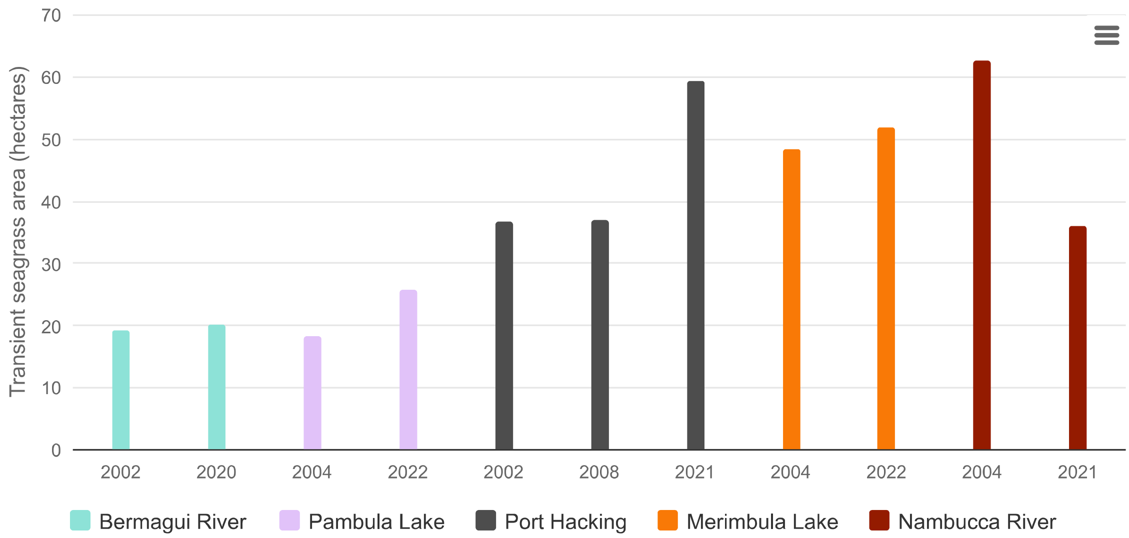
Figure W3.4a: Area (ha) of transient seagrasses in NSW estuaries remapped within the past five years



Notes:
Transient seagrasses (non-stable seagrass population) are dominated by *Zostera*.
Only estuaries remapped since 2020 are presented.

Source:
DPIRD data 2024

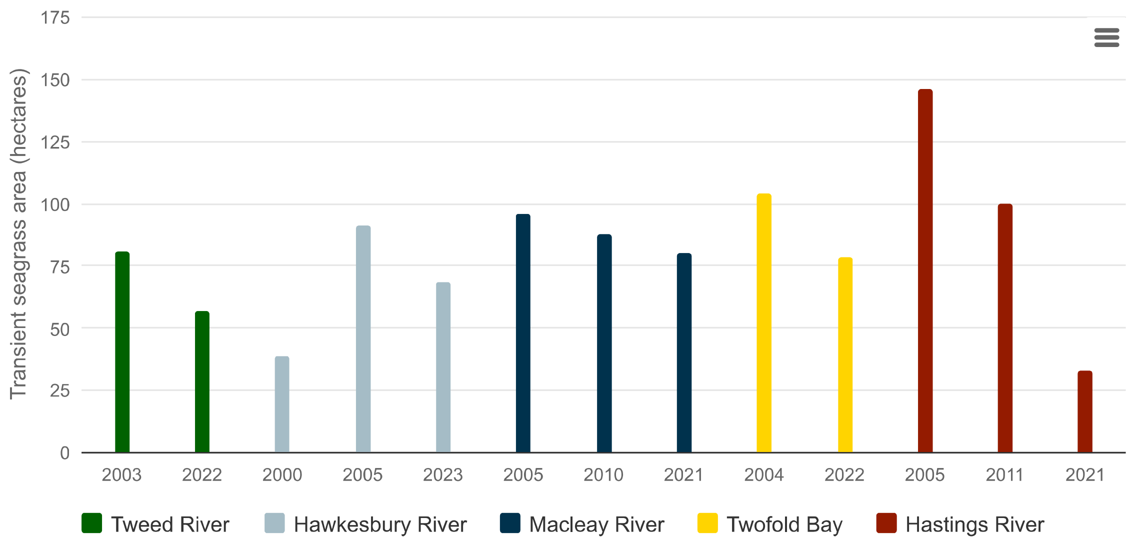
Figure W3.4b: Area (ha) of transient seagrasses in NSW estuaries remapped within the past five years



Notes:
Transient seagrasses (non-stable seagrass population) are dominated by *Zostera*.
Only estuaries remapped since 2020 are presented.

Source:
DPIRD data 2024

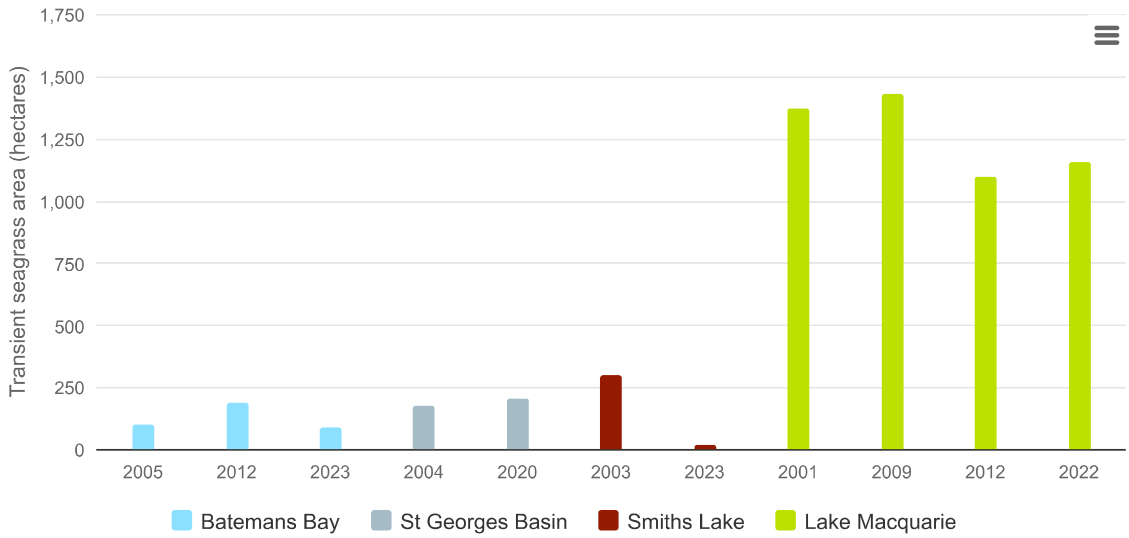
Figure W3.4c: Area (ha) of transient seagrasses in NSW estuaries remapped within the past five years



Notes:
Transient seagrasses (non-stable seagrass population) are dominated by *Zostera*.
Only estuaries remapped since 2020 are presented.
Data from tributaries of Twofold Bay are amalgamated here.

Source:
DPIRD data 2024

Figure W3.4d: Area (ha) of transient seagrasses in NSW estuaries remapped within the last 5 years



Notes:
Transient seagrasses (non-stable seagrass population) are dominated by *Zostera*.
Only estuaries remapped since 2020 are presented.
Data from tributaries of Batemans Bay are amalgamated here.

Source:
DPIRD data 2024

Drivers of seagrass habitat loss

There are many causes of local losses of *Posidonia australis* (**Swadling et al. 2023a**).

Recent declines in seagrass coverage were most strongly associated with:

- the presence of large areas of artificial structures in estuaries (jetties and pontoons)
- distance from the ocean (greater losses were more common in the upper reaches of estuaries)
- boating and fishing activities
- combined effects of the above stressors and contamination (**Rees et al. 2023**).

Increased numbers of boat moorings, jetties, pontoons and aquaculture leases are associated with increased fragmentation (breaking apart) of *Posidonia australis* meadows across NSW estuaries (**Swadling et al. 2023b**).

Once a meadow becomes fragmented it is more likely to shrink in area and become less connected. This fragmentation then influences ecological processes and the movement of marine animals. Fragmentation of meadows is greatest in Port Jackson, Botany Bay, Brisbane Water and Lake Macquarie (**Swadling et al. 2023b**).

Losses of transient seagrasses in estuaries have been related to flood events, which can reduce seagrass density. Floods and other environmental changes can also trigger reproduction of *Zostera* (**Lekammudiyanse et al. 2024**).

Research by DPIRD is investigating whether these declines in *Zostera* indicate sustained losses or short-term declines with longer-term fluctuations.

Kelp and seaweeds

Kelp coverage has declined in NSW.

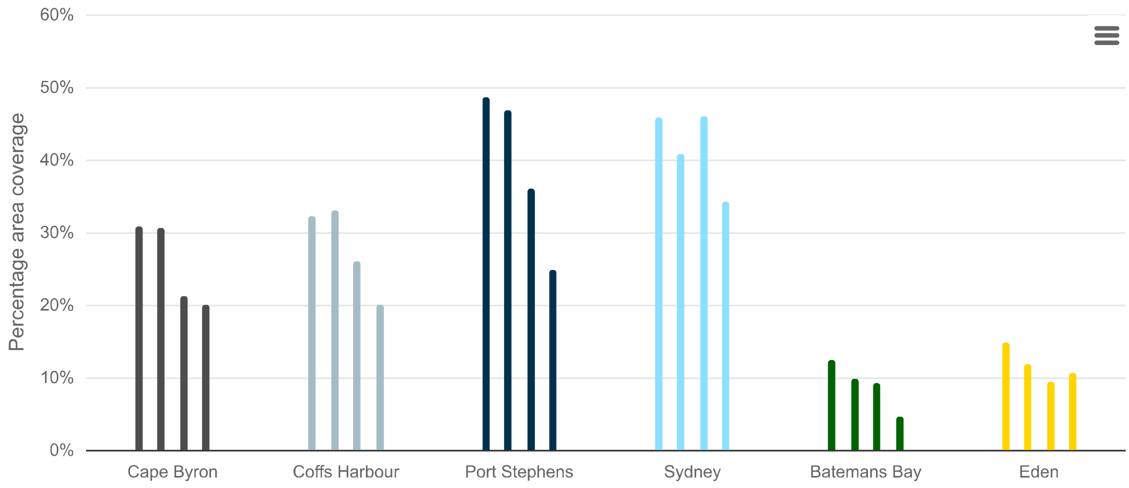
Kelp forests are important marine habitats that provide food and shelter for many rocky reef species. They are threatened by a range of stressors, including marine heatwaves, ocean warming, ocean acidification and pollution (**Coleman et al. 2008**; **Coleman & Wernberg 2017**; **Verges et al. 2016**).

When kelp and seaweeds (also known as macroalgae) are removed from rocky reefs, areas of rock encrusted with coralline algae (with flat crusts) can remain – called barrens – or areas transition into low lying algal turfs.

Trends in the abundance and condition of macroalgae have only been monitored systematically across NSW by DPIRD – Fisheries since 2019. Trends are preliminary and data over longer periods is needed to understand kelp forest condition.

Kelp cover has been mapped at six sites (see **Figure W3.5**). All sites have shown a decline in the percentage coverage of kelp since 2019, the largest being seen in Batemans Bay and Port Stephens.

Figure W3.5: Kelp cover (%) at NSW monitoring sites, 2019–23



Notes:
Based on average across six fixed 200-metre-long towed video transects at three sites at each location.
Surveys conducted on inshore reefs at depths from 5m to 30m.

Source:
DPIRD data 2024

Drivers of change in kelp and seaweeds

Previous video surveys have identified losses of kelp from offshore reefs on the Mid North Coast. These losses correlate with warming and increasing abundance of tropical herbivorous fishes (**Verges et al. 2016**). Recent kelp losses within estuaries have been linked to flooding caused by severe weather events (**Davis et al. 2022**).

Research is investigating the reasons for these changes, focusing on linking them to recent La Niña conditions and identifying possible refugia (places of safety) for kelp as oceans warm (**Davis et al. 2021a**).

When large macroalgae are removed from a rocky reef and sea urchins dominate, the reef is called a barren. This usually occurs from increased predation on seaweed, storm activity, reduced salinity or pollution (**Wright et al. 2005**). Barrens occur across most NSW rocky reefs, but they tend to be larger and more numerous along the South Coast (**Przeslawski et al. 2023**).

No significant changes in the extent of barrens have been observed (**Glasby & Gibson 2020**).

Catchment disturbance

The level of coastal catchment disturbance in NSW was assessed most comprehensively in 2017 by the statewide threat and risk assessment for the NSW marine estate. No statewide assessment has been completed since, though risks will have increased in the past seven years with the increases in population, development and climate change.

This work identified that 93 of the 185 estuaries in NSW as sensitive to impacts from land use and potential changes (**MEMA 2017**). The biggest risks were associated with population density (40% of catchments) and nutrient increase (37% of catchments) (**Roper et al. 2011**).

Most coastal catchments in NSW have some level of land use activity or development. The causes of coastal catchment disturbance include population growth, agricultural expansion, and industrial and commercial activities (**NSW Planning n.d.**; **Wu & Barrett 2022**).

Estuaries with more catchment disturbance have also had poorer chlorophyll-*a* and turbidity results. See the **Estuarine water quality (coastal-and-marine#estuarine-water-quality-status-and-trends)** section.

Understanding these disturbances is crucial because they can degrade water quality, disrupt ecosystems, and reduce the resilience of coastal environments to climate change impacts (**Wu & Barrett 2022**).

Further research is required to establish the status of catchment disturbance and its impacts.

Coastal fish communities

Subtidal reef fish

The abundance and diversity of subtidal reef fish in NSW has been relatively stable in the past decade since systematic sampling has been done. Longer-term data will help us better understand these trends.

Subtidal reef fish inhabit the areas of a reef located below the low tide mark, which are constantly submerged. These fish include many endemic, or culturally and socially valued, species, such as pink snapper (*Chrysophrys auratus*), grey morwong (*Nemadactylus douglasii*), eastern blue groper (*Achoerodus viridis*) and southern Maori wrasse (*Ophthalmolepis lineolatus*).

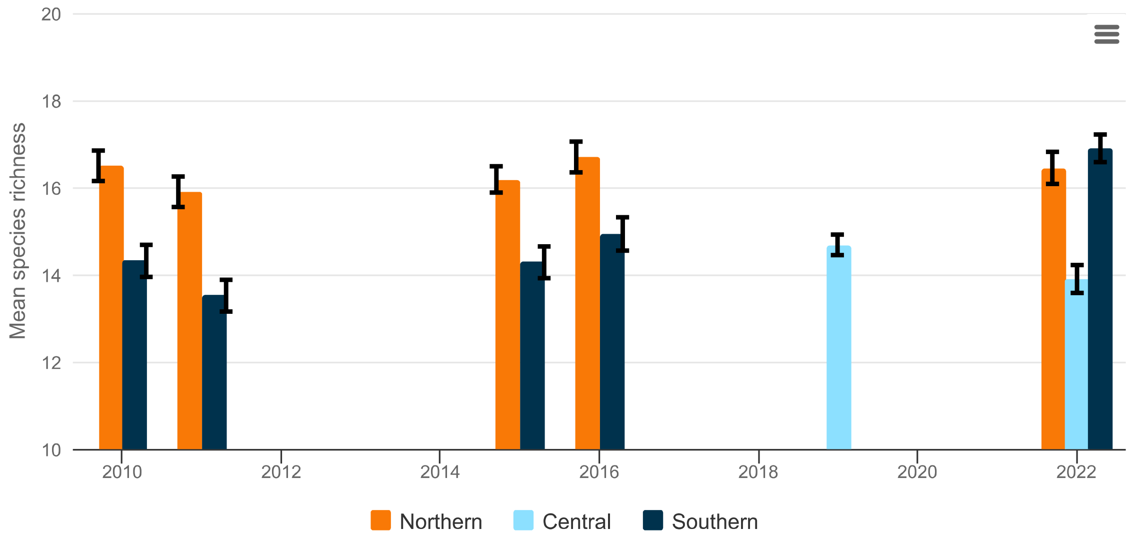
DPIRD monitors the diversity and abundance of rocky reef fishes using baited remote underwater video.

Find out more about **subtidal reef monitoring**.

Fish abundances and diversity have been systematically sampled in the Tweed–Moreton, Manning and Batemans bioregions since late 2010 and in the Hawkesbury bioregion since 2019. Fish are observed at numerous sites in each bioregion to provide a representative selection (**Knott et al. 2021**; **Rees et al. 2021**).

Coastal fish diversity, measured as species richness (the number of species per sample), has been relatively stable through time in all bioregions (see **Figure W3.6**). Generally, species richness has been higher in the Northern region (Port Stephens to the Queensland border) than in the Central or Southern regions. Fish diversity increased sharply in the Southern region in 2022.

Figure W3.6: NSW coastal fish diversity, 2010–22

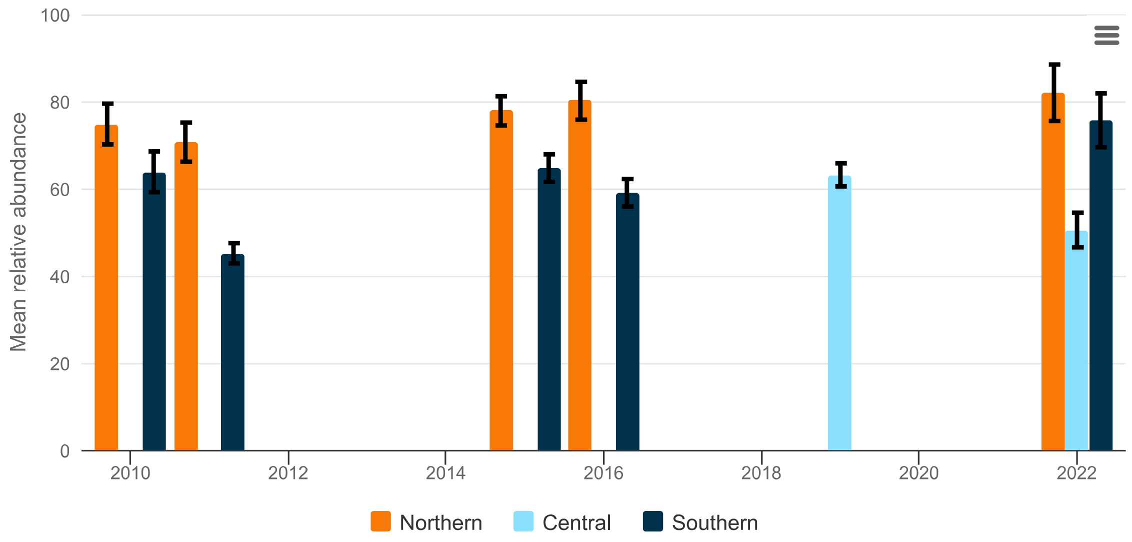


Notes:
Northern, Central and Southern regions correspond with definitions of the *Marine Estate Management Strategy*.

Source:
Marine Integrated Monitoring program, Statewide BRUV Program

The total relative abundance of coastal fish (measured by total maximum number) was also relatively stable over time (see **Figure W3.7**). Abundance was consistently higher in the Northern region than in the Central or Southern regions. Abundance increased sharply in the Southern region in 2022, mirroring the increase in species richness in the same area. Analyses of future data will provide an indication of whether this increase in the Southern region was a fluctuation or is part of a long-term trend.

Figure W3.7: NSW coastal fish abundance, 2010–22



Notes:
Northern, Central and Southern regions correspond with definitions of the *Marine Estate Management Strategy*.

Source:
Marine Integrated Monitoring program, Statewide BRUV Program

Fisheries stocks

There is limited data available to assess the statewide trends of coastal fish species, but the **Status of Australian Fish Stocks reports** provide an indication of the population health of many of the key recreational and commercial fisheries species.

In 2023, the report included stock numbers for 92 freshwater and marine species (see **Figure W3.8**), an increase on the 85 assessed in 2020. Since then, there has been a:

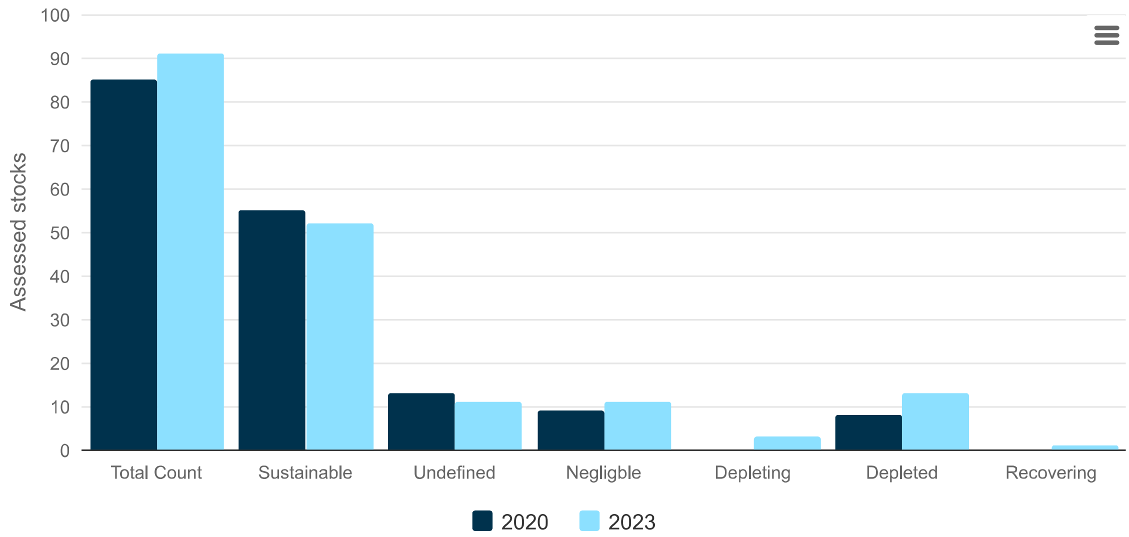
- 6% increase in stocks assessed as depleted
- 3% decline in stocks assessed as sustainable
- 2% decline in undefined stocks
- 2% increase in the number of stocks showing negligible change.

The slight increase in the proportion of stocks assessed as depleted is the result of several undefined populations such as abalone, Murray cod and golden perch classified as depleted due to more detailed stock assessments being completed for these species. The following are examples of species in each stock status:

- **Sustainable:** eastern rock lobster (*Sagmariasus verreauxi*), dusky flathead (*Platycephalus fuscus*), eastern school whiting (*Sillago flindersi*)
- **Depleted:** Spanish mackerel (*Scomberomorus commerson*), grey morwong (*Nemadactylus douglasii*), redfish (*Centroberyx affinis*)
- **Depleting:** blue swimmer crab (*Portunus armatus*)
- **Recovering:** mulloway (*Argyrosomus japonicus*)
- **Undefined:** black bream (*Acanthopagrus butcheri*), estuary cobbler (*Cnidoglanis macrocephalus*), hapuku (*Polyprion oxygeneios*)
- **Negligible:** bastard trumpeter (*Latridopsis forsteri*), pale octopus (*Octopus pallidus*).

The status of blacklip abalone (*Halotis rubra rubra*) is complex. It is described as depleted in one Spatial Management Unit, depleting in two Spatial Management Units and sustainable in another. The sustainable area is about 75% of total stock (**SAFS 2023**).

Figure W3.8: Status of Australian fish stocks in NSW, 2020–23



Source:
Fisheries Research and Development Corporation, Status of Australian Fish Stocks, 2020, 2024

Community concerns with water quality

The NSW Enviro Pulse survey provides quarterly responses from a structured random sample of the NSW population.

Results of the most recent Enviro Pulse survey indicate that fewer NSW residents feel that water pollution is an environmental concern for NSW than they did in March 2021 (see **Table W3.3**).

Table W3.3 Concern about water pollution in NSW, March 2021 to September 2024

	Mar 21	Sep 21	Mar 22	Sep 22	Mar 23	Sep 23	Mar 24
Water pollution	59%	55%	57%	52%	53%	48%	47%
Number surveyed	1,002	1,017	1,015	998	1,008	1,011	992

Notes:
Enviro Pulse survey is ongoing.

Source:
DCCEEW 2024b

Residents were also asked to rate satisfaction with water quality and cleanliness near where they live. Since March 2021 there has been an increase in satisfaction with water quality of rivers and lakes, and with cleanliness of beaches and oceans (**Table W3.4**).

Table W3.4: Satisfied or very satisfied with the water quality and cleanliness in NSW, March 2021 to September 2024

	Mar 21	Sep 21	Mar 22	Sep 22	Mar 23	Sep 23	Mar 24
Cleanliness of beaches and oceans near me	58%	58%	50%	57%	60%	62%	61%
Water quality of rivers or lakes in my local area	54%	54%	49%	54%	55%	57%	59%
Number surveyed	1,002	1,017	1,015	998	1,008	1,011	992

Notes:
Enviro Pulse survey is ongoing.

Source:
DCCEEW 2024b

Pressures and impacts

Development and recreation

As 85% of our population lives within 50km of the coast (**AdaptNSW n.d.**), development of our catchments, coastlines and offshore areas continues to put significant pressure on the environment.

Increasing land use intensification (increased urban and agricultural development), water pollution (urban and agricultural runoff), and shoreline infrastructure and related recreational activities (jetties, pontoons, piers and boating) due to a growing population all pose continued risks to the health of our coast and estuaries.

See the **Threats to the NSW marine estate** section of this topic for the top 10 environmental threats.

These threats will continue to increase as our population grows.

See the **Population and the environment** topic for more information about projected growth.

Catchments

Urban and agricultural development in coastal catchments can result in:

- habitat alteration and fragmentation of ecosystems
- eutrophication and algal blooms
- increased bacterial concentrations and pollutants in coastal waterways.

Changes in tidal levels from modifications to estuary entrances have also had major consequences for critical marine habitats, including beaches, saltmarsh, mangroves, seagrasses and mudflats (**MEMA 2017**). This creates flow-on consequences for the plants and animals that rely on these habitats.

Sea level rise will further increase the impact of changes in tidal levels.

See the **Climate change** topic for more information about sea level rise.

Coastlines

Coastline and foreshore development, such as housing, parklands and break walls, alter sand dunes. This can result in:

- increased coastal erosion
- changes in beach sand dynamics
- removal of important coastal vegetation
- changes in or loss of animal habitats.

These developments can alter the flow of water, changing the transportation of sediments, nutrients and food resources necessary for estuarine habitat maintenance and life cycles of vegetation and animals. This can affect the whole ecology of an area, decreasing:

- water quality
- habitat coverage
- capacity to support plants and animals
- ecosystem health.

Coastal development, particularly street lighting, recreational activity and agriculture, can alter behaviour and harm habitats for migratory seabirds, shorebirds and fish breeding (**Taylor 2017**; **Truscott et al. 2017**; **Umwelt 2017**; **DEC 2006**).

Commercial and recreational fishing have potential cumulative impacts on fish groups and coastal food webs (**BMT WBM 2017**). These impacts, including overfishing of certain species, may reduce the abundance and diversity of fish communities.

Commercial fisheries operate in 76 of the 184 estuaries along the NSW coast (**DPIRD n.d.**).

Offshore

Offshore development, through offshore wind farms proposed to meet renewable energy needs, has the potential to harm the marine environment through:

- increased noise levels
- pollution risk during construction
- increased marine traffic
- development of associated land-based infrastructure
- alteration to seafloor habitats.

Offshore windfarms may also pose a significant risk to the seabird species that breed on our offshore islands. Further research is required to determine the likely impacts of any future offshore developments.

Pollution

Water pollution from runoff, litter and debris continue to threaten coastal and marine environmental, social, cultural and economic values (**BMT WBM 2017**; **MEMA 2018**).

The impacts of water pollution can be devastating for the environment, communities and culture.

Runoff

Pollutants can enter coastal and marine environments through stormwater and agricultural and sewage runoff during periods of higher rainfall.

Runoff from these sources can carry a range of nutrients, heavy metals and contaminants that are transported to coastal ecosystems.

Nutrients

Increased nutrient loads from urban stormwater discharge and diffuse agricultural runoff into estuarine waters can result in algal blooms, particularly of harmful or toxic cyanobacteria (**Ajani et al. 2018**). These events lower the water quality, affecting recreational and swimming areas and reducing seafood quality, as seen following bloom events in the Hawkesbury River (**Ajani et al. 2018**).

Large algal blooms can also reduce the amount of oxygen in the water and kill large numbers of fish. One of the most significant water pollution events attributed to an algal bloom occurred in Newcastle in February 1993, resulting in significant fish kills (**Rasmussen et al. 2024**).

While fish kills caused by algal blooms are less common in coastal areas than in inland waterways, they are becoming common in many estuaries, and eutrophication (enrichment of nutrients) poses a serious threat to estuarine ecosystems (**NSW Government 2024**).

Heavy metals

Pollution from mercury, lead, copper and other heavy metals, and by pesticides is a localised problem in some areas, including Lake Macquarie, Sydney Harbour and the Hunter River (**NSW Government 2024**). Other sources include metals mobilised by acidic runoff from oxidised acid sulfate soil landscapes, such as drained coastal floodplains.

Elevated metal and organic chemical concentrations in sediments have been linked to significant risk to aquatic organisms (**BMT WBM 2017**). For example, heavy metal pollution can disrupt respiratory, cardiovascular and reproductive systems in fish (**Shahjahan et al. 2022**).

Sediment

Excessive sediment transport can change the characteristics of streambeds and shorelines and alter habitats. Sediments can carry pollutants in them, including heavy metals and organic compounds which are harmful to humans, plants and animals.

Sediment can smother aquatic habitats and limit light penetration impacting seagrasses and other aquatic plants.

See the **Seagrasses** section of this topic for more information about the decline in seagrasses.

Licensed discharges

Discharges, including nutrients, heavy metals and sediments, can originate from point or diffuse sources.

Point sources of pollution include urban stormwater and licensed discharge points.

Diffuse sources include runoff from a broader area; for example, agricultural, urban or industrial areas.

The EPA regulates point source discharges from industry through the **Load-based licensing scheme**. Monitoring covers loads of total nitrogen, total phosphorus and total suspended solids discharged into open marine waters and estuaries.

Loads discharged into estuarine environments have generally decreased since 2011–12, with fluctuations in the discharge of suspended solids tending to reflect wet and dry periods.

See the **Extreme climate and weather** topic for more information about these cycles.

Marine litter and debris

Marine litter is human-generated or processed material that is intentionally or accidentally disposed of, abandoned or transported into coastal and marine environments.

In NSW, microplastics, fishing lines and nets, ropes, fibres and plastic fragments pose some of the greatest threats to our coastal and marine environments (**DPE 2023**).

Entanglement in and ingestion of debris are key threats to marine species, particularly threatened species, such as seabirds, turtles and whales (**BMT WBM 2017**). The recovery of populations of threatened species, such as humpback whales, is likely to result in more accidental entanglements (**NOAA Fisheries 2024**).

See the **Waste and recycling** topic for more details on plastic waste.

Cigarettes are the most littered item on beaches, while glass fragments, polystyrene, and soft and hard plastics are common in NSW estuaries (**DPE 2023**). Monitoring as a part of the **Key Littered Items Study** shows significant decreases in targeted items such as single-use plastic bags (74% reduction) and beverage containers thanks to the **Return and Earn** container deposit scheme (61% reduction) (**DPE 2023**; **NSW EPA 2024**).

Threats to Aboriginal peoples' cultural connection to Sea Country

Significant issues threaten Aboriginal people's connection to Sea Country, including:

- restricted access to Sea Country resources and culturally significant sites
- natural habitat damage and loss
- overcrowding and development of cultural sites

- poor water quality
- climate change.

These threats reduce the amount and quality of seafood, and diminish totemic or culturally significant wildlife.

They affect emotional and mental health, cultural identity, cultural practices, traditional food collection practices, and Aboriginal people's ability to pass down traditional teachings to future generations (**DPI & Ipsos ATSIRU 2022**).

Actions being taken in response to these concerns are part of Initiative 4 – protecting the Aboriginal cultural values of the marine estate as part of the *Marine Estate Management Strategy*.

Cultural fishing is important in the lives of coastal Aboriginal peoples, forming part of their connection to Sea Country and culture (**Gollan & Curley 2023**). Aboriginal peoples view fishing as a way to honour their ancestors and connect spiritually to the marine world (**Cubillo et al. 2023**).

As custodians of the sea, Aboriginal communities see themselves as responsible for its protection and ensuring its continued sustainability for future generations (**Gollan & Barclay 2020**). This responsibility is reflected in traditional fishing practices that are based on the principle of taking only what is needed and respecting the delicate balance of the marine ecosystem (**Shamsi et al. 2020**). The act of fishing also serves in the transmission of cultural knowledge and traditions from generation to generation (**Smyth et al. 2018**). Sharing the catch strengthens social bonds and reinforces the importance of community within Aboriginal cultures (**Cubillo et al. 2023**).

This essential connection is challenged by contemporary regulations (**Gollan & Barclay 2020**).

Restrictions, such as permit requirements for fishing in no-take zones, can hinder traditional practices and limit the ability of Aboriginal people to maintain their cultural heritage (**Gollan & Barclay 2020**).

In addition, significant portions of Aboriginal cultural heritage exist underwater, having been submerged by sea level rise 8,000 years ago (**Ward et al. 2022**). There is currently a lack of awareness and protection of these underwater cultural sites (**Marshall 2023**).

Currently, protections of Sea Country are focused primarily on biodiversity and shipwreck conservation, with limited recognition of the importance of Aboriginal cultural heritage (**Benjamin et al. 2021**). The absence of frameworks for protecting culturally important marine ecosystems leaves these submerged sites vulnerable to the increasing pressures of human activities and climate change (**Marshall 2023**; **Benjamin et al. 2021**).

Diseases and invasives

Monitoring and management of aquatic animal diseases is important, as they can threaten the biodiversity of our marine estate.

Introduced pathogens and parasites, or the amplification of endemic diseases, can have devastating impacts on native species, aquatic industries and the safety of seafood.

Diseases

Several diseases are currently of concern in NSW marine and estuarine environments:

White spot is a highly contagious viral disease of prawns and other farmed crustaceans that can result in high mortality. It has recently been detected in the Evans Head and Richmond River areas.

See the **White Spot** website for more information.

Epizootic ulcerative syndrome, also known as 'red spot', causes ulcers in fish species such as bream, mullet and whiting. In early 2021 it was reported in fish from the estuaries of the Macleay, Brunswick, Richmond, Clarence and Hastings rivers. In 2022 it was detected in samples from the Myall River, the Hastings River and waterways near Grafton following reports of ulcerated fish to DPIRD.

Queensland unknown (QX) disease can cause mass mortality in Sydney rock oysters. First found in south-east Queensland, QX has caused the near collapse of the Sydney rock oyster industry in various estuaries, including the Hawkesbury River in 2004 and the Port Stephens estuary in 2021.

Surveillance in 2022 determined that the Port Stephens area was at high risk for this disease, and **clause 49 of the Biosecurity Regulation 2017** was updated in response.

See the **QX disease** website for more information.

Avian influenza (H5N1 and variants) has affected wild birds (and mammals) on several continents but has yet to reach Australia. Its short incubation period means that no migratory seabirds or shorebirds that are infected in other parts of the world reach our region alive. These diseases may eventually occur here.

Marine invasive species

Marine invasive species include plants, algae, invertebrates and animals, often introduced from overseas. They can take over habitats, directly compete with native species for food, and introduce viruses and disease.

Some of these are native to other regions of Australia but have been brought into NSW on ships or via the aquarium trade.

The following marine invasive species have been detected in NSW, with varying degrees of impact and spread:

- green macroalga (*Caulerpa taxifolia)*
- green shore crab (*Carcinus maenas*)
- **European fan worm** *(Sabella spallanzanii*)
- **Japanese goby** (*Tridentiger trigonocephalus*)
- **New Zealand screw shell** (*Maoricolpus roseus)*
- *wild Pacific oyster (Magallana gigas)*
- *striped barnacle (Amphibalanus amphitrite)*
- yellowfin goby (*Acanthogobius flavimanus*)
- non-native sea squirt (*Botrylloides giganteus*)
- devil's tongue weed (*Grateloupia turuturu*)
- *red macroalga (Pachymeniopsis lanceolata)*
- lightbulb sea squirt (*Clavelina lepadiformis)*
- vase tunicate *(Ciona intestinalis)*
- dead man's fingers (*Codium fragile fragile)*
- pleated sea squirt (*Styela plicata).*

The State's offshore islands are now free of vertebrate pest species, though their impacts remain in some cases; notably, species driven extinct by them cannot be recovered.

Many islands remain threatened by invasive weed species.

Invasive weeds on islands can significantly modify habitat and compete with endemic species (**Mack & Lonsdale 2002**). Unchecked, they can also have significant impacts on the structure of vegetation, with consequent impacts on nesting habitats for seabirds (**Rippey et al. 2002**).

Climate change

Climate change has the potential to significantly alter our coasts and marine environments through:

- altered ocean currents and nutrient levels
- sea level rise
- warmer sea surface water including marine heatwaves
- ocean acidification
- altered weather patterns, such as storm and cyclone activity (**BMT WBM 2017**)
- localised impacts on salinity caused by freshwater ingress.

Changes in the movement and flow intensity of the East Australian Current could greatly affect future species distributions in NSW (**Davis et al. 2023**; **Champion et al. 2022**), potentially affecting:

- seafood nutritional properties (**Shalders et al. 2023a**; **Shalders et al. 2023b**)
- species interactions (**Davis et al. 2021b**)

- patterns of connectivity and settlement of organisms (**Cetina-Heredia et al. 2019**; **Coleman & Wernberg 2017**).

Sea level rise presents significant challenges for communities along the coast and around our tidal waterways, including:

- changes to the coastal processes that move sand around beaches and dunes
- exacerbated impacts of major storms and floods (**AdaptNSW n.d.**)
- increased impacts on cultural sites on dunes and foreshores, including erosion of middens and burial sites
- inundation of coastal floodplains and/or impairment of existing drainage viability impacting current land uses
- loss of sand from beaches, and other changes due to sea level rise, storm surges and inundation.

Increasing sea surface temperatures, often known as 'marine heatwaves', have consequences for the species range of marine and estuarine animals and plants (**Castro et al. 2024**; **Shalders et al. 2023c**). Some plants and animals along the NSW coastline are already moving south, such as the green moon wrasse (*Thalassoma lutescens*) (**NSW Marine Estate 2024**).

Climate change will exacerbate impacts on the NSW marine environment. Significant effects are expected to occur across south-eastern Australia (**Hobday et al. 2006**; **Wernberg et al. 2011**; **Verges et al. 2016**), including changes to:

- the distribution and abundance of marine species (**Davis et al. 2020**)
- variations in and timing of life-cycle events
- physiology, morphology and behaviour (such as rates of metabolism, reproduction and development)
- biological communities via altered species interactions.

Ocean acidification is already affecting calcifying animals, such as snails, oysters, zooplankton and corals (**Parker et al. 2013**; **Ross et al. 2011**; **Havenhand et al. 2008**; **Cetina-Heredia et al. 2015**). Marine molluscs (oysters, abalone and whelks) are particularly vulnerable to these effects during their reproductive stages (**Parker et al. 2010**; **Scanes et al. 2014**).

Acidification has reduced the rate of successful fertilisation in Sydney rock oysters, resulting in a smaller size, longer time to develop and increased abnormality of larval stages (**Parker et al. 2010**). Combined with other stressors this has the potential to limit survival (**Scanes et al. 2017**).

See the **Climate change** topic for more details.

Bushfire impacts on coastal water quality

Bushfires have the potential to increase erosion and decrease water quality in NSW waterways.

Bushfire impacts are strongly related to waterway type, fire severity and post-fire conditions, particularly the intensity and frequency of post-fire rainfall.

Intermittently closed and open lakes and lagoons are most susceptible to significant water quality impacts, as they are less frequently flushed by seawater than estuaries that remain open to the ocean (**Smyth 2020**).

Declines in water quality are most significant immediately following the first rainfall events that occur after fire and can remain for up to two years.

During the 2019–20 Black Summer bushfires, nearly every catchment in coastal NSW suffered, as fires burned into wetter environments that are reported to 'not normally burn.' Overall, 30% of the total area of all coastal catchments in NSW was burned, totalling 5,507,400 hectares, with significant implications for erosion and water quality (**Fryirs et al. 2022**).

Water quality monitoring data from 22 NSW estuaries revealed sudden and severe declines in estuary water quality following heavy rainfall in the first one to two years after fire, owing to elevated erosion rates and the transport of ash, debris, sediment and nutrients into waterways, reservoirs and estuaries.

The breakdown of organic matter can reduce dissolved oxygen concentrations in receiving waters for up to a month. When combined with elevated sediment, nutrient and dissolved carbon loads, this can trigger potentially hazardous algal blooms and fish kills (**Smyth 2020**).

Responses

Strategic management

Marine Estate Management Strategy

The ***Marine Estate Management Strategy 2018–28*** outlines how the NSW Government will address priority threats to the marine estate, including threats to environmental assets and protect their benefits to our community, Aboriginal peoples and the economy.

More than $285m is being invested in meeting the following nine management initiatives over the 10-year lifetime of the strategy to:

- improve water quality and reduce litter
- deliver healthy coastal habitats with sustainable use and development
- plan for climate change
- protect Aboriginal cultural values of the marine estate
- reduce impacts on threatened species
- ensure sustainable fishing and aquaculture
- enable safe and sustainable boating
- enhance social, cultural and economic benefits
- deliver effective governance.

Implementation of the 53 management actions in the strategy involves partnerships with agencies, industry, key stakeholders and community to collectively address social, cultural, economic and environmental threats to the marine estate in a coordinated approach.

Management of Sea Country by Aboriginal people is embedded in the strategy to ensure that traditional knowledge and cultural practices be considered, be shared and influence decision-making.

NSW marine protected areas

Marine protected areas play an important role in conserving marine biodiversity and ecosystems while delivering a range of benefits to the community.

Statutory management planning for marine parks has seen the development of a draft network management plan for the five mainland marine parks and preliminary work to inform a management plan for Lord Howe Island.

See the **Overview (coastal-and-marine#overview)**section of this topic for more information.

Coastal Management Programs

Coastal Management Programs (CMPs) are prepared by local councils in consultation with their communities and public authorities to set long-term strategies for the coordinated management of the coast and estuaries.

Several councils are developing CMPs to manage their coastal zones where waterways and coastal zones are shared, such as the **Hawkesbury–Nepean River system**.

Management actions are often supported by funding from the **Coastal and Estuary Grant Program**.

At the end of 2023, 11 CMPs had been certified and are being implemented. A further 50 are being prepared by councils with financial and technical support from the NSW Government.

NSW Blue Carbon Strategy 2022–2027

The ***NSW Blue Carbon Strategy 2022–2027*** supports the restoration of coastal biodiversity and ecosystems while simultaneously working towards reducing emissions.

‘Blue carbon’ is the term used to describe the carbon captured and stored by marine and coastal ecosystems.

Blue carbon ecosystems, which include seagrasses, mangroves and saltmarsh, can store substantially more carbon per area than land-based forests and, if undisturbed, can store it in soils for many years.

Projects that restore blue carbon ecosystems, such as the reintroduction of tidal flows to restore coastal wetlands, can reduce emissions significantly and may enable carbon credits to be earned.

Fisheries Management Strategies

NSW DPIRD have prepared **strategies** for each of the major fisheries and activities they manage to ensure the sustainable use of fisheries resources and limit the impacts on the environment. Where fisheries resources have become depleted, recovery plans are put in place to ensure rebuilding of the stocks of these species in an appropriate time period.

A key component of updating these strategies is the development of Harvest Strategies containing pre-defined rules agreed to by fishers that enact management before fish stocks become depleted.

Monitoring our coasts

Marine Integrated Monitoring Program

The **Marine Integrated Monitoring Program**, which began in 2018:

- monitors the conditions and trends of environmental assets and the community benefits derived from the NSW marine estate
- evaluates the effectiveness of actions aimed at reducing priority threats and risks
- fills knowledge gaps (social, cultural, economic, and environmental) identified in the 2017 **NSW Marine Estate Threat and Risk Assessment.**

Marine Debris Threat and Risk Assessment

Published in 2023, the *Marine Debris Threat and Risk Assessment* comprehensively evaluates the impact of marine debris on the marine estate of NSW.

It identifies the sources, distribution and types of marine debris to explain the associated risks to environmental and social values. It provides tools and knowledge to help stakeholders and managers better manage the risk of marine debris.

Working with Traditional Owners

Coastal monitoring

A new community wellbeing monitoring program under the Marine Integrated Management Program includes the **Connections to Sea Country – Aboriginal Peoples of Coastal NSW** survey. The survey themes include interactions with Sea Country, importance of Sea Country to quality of life, cultural connections to Sea Country, community perceptions of environmental health, impact of key threats on cultural connections, perceptions of and attitudes to Sea Country management, employment related to Sea Country, and involvement and interest in government-led Sea Country programs (for example, Ngiyambandigay Gaagal Indigenous Protected Area)

DCCEEW has developed **guidelines** for engaging Aboriginal communities, knowledge holders, and Aboriginal-led organisations when preparing coastal management programs under the *Coastal Management Act 2016*.

The **Coastal Management: Creating culturally safe opportunities when engaging First Nations people guide** supports engagement with First Nations people through approaches that are culturally safe, respectful and reciprocal.

Pest surveillance and removal

The **5-year Marine Pest Surveillance Plan (2022–2026)** developed by DPIRD Aquatic Biosecurity directs biannual surveillance of 23 priority marine pest species at the six largest ports in NSW. It focuses on early detection and response.

Environmental incidents

The EPA, LLS and DPIRD led **Flood Recovery Programs** following the 2021–22 periods of intense flooding on NSW coast, particularly in the Northern Rivers. Programs included:

EPA Water Quality Monitoring Program (concluded):

- removing 24,438 cubic metres of debris from affected waterways from the Shoalhaven to the Tweed rivers
- water quality monitoring in recovering systems, collecting 11,000 samples across 29 local government areas
- an Aboriginal knowledge project on Bundjalung Country sharing perspectives and weaving together water quality knowledge

- additional agricultural chemical clean-up, contaminated land assessments, and illegal dumping and flood waste recovery projects (**NSW EPA unpub.**).

DPIRD Estuary Asset Protection Program (ongoing)

An action plan to protect and support the recovery of estuarine ecosystems and reinstate their resilience to future disasters including assessment, prioritisation and on-ground works in the areas of:

- Aboriginal Cultural Heritage protection
- Riverbank resilience
- Instream obstructions
- Key habitat and threatened species resilience
- Estuarine infrastructure
- Monitoring and research

LLS Riverbank Rehabilitation Program (ongoing)

A program to assist longer-term rehabilitation and future-proofing of flood damaged riverbanks through targeted on-ground works and support for flood impacted land managers.

Future opportunities

The NSW Government needs to continue to develop and implement strategies to plan for climate change and prevent a decline in the quality of coastal, estuarine and marine environments.

The poor water quality in some highly urbanised estuaries suggests that stormwater runoff and new urban development can be managed better to maintain the health of estuaries and coastal lakes and the desirability of coastal lifestyles.

A molecular database is being generated for NSW estuaries to help assess biodiversity in estuaries and allow assessment of the occurrence and range shifts of finfish, crustaceans and molluscs statewide.

While trends in aquatic vegetation have been monitored systematically, understanding coastal vegetation, such as dune grasses, coastal heath and woodland, and back-beach swamps, is also important for the overall health of coastal environments.

Vulnerability to inundation and coastal erosion should be a significant consideration in the location and planning of future developments for an expanding population.

Other areas for further improvement are possible:

- Improved collaboration between community, governments and research institutions to further enhance the shared management of the marine estate and its resources.
- Creation of opportunities to listen to Aboriginal peoples in decision-making roles in inclusive and respectful settings.
- Enhancement of indicators of water health by including additional water monitoring datasets, such as harvest area classifications and analysis of historic data trends within the NSW Shellfish Program dataset (faecal coliforms, *E. coli*, phytoplankton, salinity, temperature and water level monitors).
- Improved communication and education opportunities in all aspects of estuarine, coastal and marine management to raise awareness, enhance community stewardship and influence positive behaviours.
- Strengthening ecosystem health monitoring programs and sharing data to provide sound scientific input into decision-making.
- Boosting social, cultural and economic research and monitoring capabilities within government to ensure that decisions be comprehensively based, to achieve holistic management of estuaries, coasts and oceans.
- Further development and expansion of risk assessment methods to help protect and rehabilitate the environment in the most resource-efficient manner.
- Re-evaluation of emerging threats and accelerating risks from known threats, such as those threats posed by climate change in the near term.
- Consistent application of the **risk-based framework** for urban and rural waterway health (**Dela-Cruz et al. 2017**) across NSW as a best-practice protocol for managing the impacts of land-use change on waterway health.

- Clarification of agency roles and responsibilities in relation to diffuse-source water pollution in NSW.
- Sentinel monitoring to detect reinvasion of offshore islands by pests.
- Baseline monitoring of seabird populations and their breeding success on offshore islands to track changes supporting research into the marine biodiversity of NSW.

There is scope to introduce qualitative information on coastal, estuarine and marine species and ecosystems of significance to Aboriginal people, to understand how they are faring and ways to care for coastal, marine and estuarine species and their habitats.

Qualitative data collection includes oral stories and knowledge about Aboriginal culture and practices. The 2021 EPA Aboriginal Peoples Knowledge Group identified a need for management authorities to apply Aboriginal cultures and practices in the care, protection and management of species, habitats and the overall environment. The group identified this emerging research as being essential for understanding and managing all aspects of environmental and ecosystem health.

References

AdaptNSW n.d., Climate change impacts on sea level rise, AdaptNSW, accessed 18 July 2024

Ajani PA, Larsson ME, Woodcock S, Rubio A, Farrell H, Brett S & Murray SA 2018, 'Bloom drivers of the potentially harmful dinoflagellate *Procentrum mimum* (Pavillard) Schiller in a south eastern temperate Australian estuary', *Estuarine, Coastal and Shelf Science*, vol. 215, pp161–71, DOI: 10.1016/j.ecss.2018.09.029

AIMS n.d., Seagrasses, Australian Institute of Marine Science, accessed 13 September 2024

Asbridge E, Clark R, Denham P, Hughes MG, James M, Mclaughlin D, Turner C, Whitton T, Wilde T & Rogers K 2024, 'Tidal Impoundment and Mangrove Dieback at Cabbage Tree Basin, NSW: Drivers of Change and Tailored Management for the Future', *Estuaries and Coasts*, vol. 47, pp. 2,190–208, DOI: 10.1007/s12237-024-01426-8

Benjamin J, Wiseman C, McCarthy J, Jeffries P & Ulm S 2021, Australia's coastal waters are rich in indigenous cultural heritage, but it remains hidden and under threat, The Conversation, accessed 18 December 2024

BMT WBM 2017, *New South Wales Marine Estate Threat and Risk Assessment Report: Final Report*, NSW Marine Estate Management Authority, BMT WBM, Sydney

Castro LC, Verges A, Straub S, Campbell AH, Coleman MA, Wernberg T, Steinberg PD, Thomas T, Dworjanyn S, Cetina Heredia P, Roughan M & Marzinelli EM 2024, 'Effect of marine heatwaves and warming on kelp microbiota influence trophic interactions', *Molecular Ecology*, vol. 33, no. 5, e17267, DOI: 10.1111/mec.17267

Cetina-Heredia P, Roughan M, Liggins G, Coleman MA & Jeffs A 2019, 'Mesoscale circulation determines broad spatio-temporal settlement patterns of lobster', *PlosOne*, vol. 14, no. 4, e0214996, DOI: 10.1371/journal.pone.0214996

Champion C, Hobday AJ, Zhang X & Coleman MA 2022, 'Climate change alters the temporal persistence of coastal-pelagic fishes off eastern Australia', *ICES Journal of Marine Science*, vol. 79, no. 4, pp. 1,083–97, DOI: 10.1093/icesjms/fsac025

Coleman MA, Kelaher BP, Steinberg PD & Millar AJK 2008, 'Absence of a large brown macroalga on urbanized rocky reefs around Sydney, Australia, and evidence for historical decline 1', *Journal of Phycology*, vol. 44, no. 4, pp. 897–901, DOI: 10.1111/j.1529-8817.2008.00541.x

Coleman MA & Wernberg T 2017, 'Forgotten underwater forests: The key role of fucoids on Australian temperate reefs', *Ecology and Evolution*, vol. 7, no. 20, pp. 8,406–18, DOI: 10.1002/ece3.3279

Cubillo B, Stacey N & Brimblcombe J 2023, 'How is nutrition, health and wellbeing conceptualised in connection with seafood for coastal Indigenous Peoples'', *Food Policy*, vol. 116, 102434, DOI: 10.1016/j.foodpol.2023.102434

Davis TR, Cadiou G, Champion C & Coleman MA 2020, 'Environmental drivers and indicators of change in habitat and fish assemblages within a climate change hotspot', *Regional Studies in Marine Science*, vol. 36, 101295, DOI: 10.1016/j.rsma.2020.101295

Davis TR, Champion C & Coleman MA 2021a, 'Climate refugia for kelp within an ocean warming hotspot revealed by stacked species distribution modelling', *Marine Environmental Research*, vol. 166, 105267, DOI: 10.1016/j.marenvres.2021.105267

Davis TR, Champion C & Coleman MA 2021b, 'Ecological interactions mediate projected loss of kelp biomass under climate change', *Diversity and Distributions*, vol. 28, no. 2, pp. 306–17, DOI: 10.1111/ddi.13462

Davis TR, Larkin MF, Forbes A, Veenhof RJ, Scott A & Coleman MA 2022, 'Extreme flooding and reduced salinity causes mass mortality of nearshore kelp forests', Estuarine, Coastal and Shelf Science, vol. 275, 107960, DOI: 10.1016/j.ecss.2022.107960

Davis TR, Champion C, Dalton S & Coleman MA 2023, 'Are corals coming to a reef near you? Projected extension of suitable thermal habitat for hard coral communities along the east Australian coast', *Austral Ecology*, vol. 48, no. 5, pp. 885–92, DOI: 10.1111/aec.13327

DCCEEW 2016, *Coastal wetlands – Mangroves and salt marshes*, NSW Department of Climate Change, Energy, the Environment and Water, Sydney

DCCEEW 2024a, Search NSW estuary profiles, NSW Department of Climate Change, Energy, the Environment and Water, Sydney, accessed 21 January 2025

DCCEEW 2024b, *Enviro Pulse Survey*, NSW Department of Climate Change, Energy, the Environment and Water, Sydney

DEC 2006, *Threatened migratory shorebird habitat mapping project, prepared by Avifauna Research and Services*, NSW Department of Environment and Conservation, Sydney (PDF 0.79MB)

Dela-Cruz J, Pik A & Wearne P 2017, *Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions*, NSW Office of Environment and Heritage and the Environment Protection Authority, Sydney

DPE 2023, *Marine Debris Threat and Risk Assessment Summary Report*, NSW Department of Planning and Environment, Sydney

DPIRD n.d., Estuary General Fishery, NSW Department of Primary Industries and Regional Development, accessed 16 September 2024

DPI & Ipsos ATSIRU 2022, *NSW marine estate community wellbeing report: Connections to Sea Country – Aboriginal People of Coastal NSW Wave 1*, NSW Department of Primary Industries, Sydney (PDF 4.0MB)

DPI & Ipsos 2022a, *NSW marine estate community wellbeing survey report: Coastal residents of NSW Summary Report (Wave 1)*, NSW Department of Primary Industries

DPI & Ipsos 2022b, *NSW marine estate community wellbeing survey report: Visitors to Coastal NSW (Wave 1)*, NSW Department of Primary Industries, Sydney

DPI & Ipsos 2022c, *NSW marine estate community wellbeing survey report: Coastal Youth of NSW (Wave 1)*, NSW Department of Primary Industries, Sydney,

Fryirs KA, Zhang N, Duxbury E & Ralph T 2022, 'Rivers up in smoke: impacts of Australia's 2019–2020 megafires on riparian systems', *International Journal of Wildland Fire*, vol. 37, no. 7, pp. 720–7, DOI: 10.1071/WF22046

Gaylard S, Waycott M & Lavery P 2020, 'Review of coast and marine ecosystems in temperate Australia demonstrates a wealth of ecosystem services', *Frontiers in Marine Science*, vol. 7, DOI: 10.3389/fmars.2020.00453

Glamore W, Rayner D, Ruprecht J, Sadat-Noori M & Khojasteh D 2021, 'Eco-hydrology as a driver for tidal restoration: Observations from a Ramsar wetland in eastern Australia', *PLOS ONE*, vol. 16, no. 8, e0254701, DOI: 10.1371/journal.pone.0254701

Glasby TM & Gibson PT 2020, 'Decadal dynamics of subtidal barrens habitat', *Marine Environmental Research*, vol. 154, 104869, DOI: 10.1016/j.marenvres.2019.104869

Glasby TM, Gibson PT, Laird R, Swadling DS & West G 2023, 'Black summer bushfires caused extensive damage to estuarine wetlands in New South Wales, Australia', *Ecological Management & Restoration*, vol. 24, no. 1, pp. 27–35, DOI: 10.1111/emr.12572

Gollan N & Barclay K 2020, ''It's not just about fish': Assessing the social impacts of marine protected areas on the wellbeing of coastal communities in New South Wales', *Plos one*, vol. 15, no. 12, e0244605

Gollan N & Curley B 2023, *NSW Marine Estate Community Wellbeing Framework*, NSW Marine Estate

Havenhand J, Fenina-Raphaela B, Thorndyke M & Williamson JE 2008, 'Near-future levels of ocean acidification reduce fertilization success in a sea urchin', *Current Biology*, vol. 18, no. 15, pp. PR651–2, DOI: 10.1016/j.cub.2008.06.015

Hobday AJ, Okey TA, Poloczanska ES, Kunz TJ & Richardson AJ 2006, *Impacts of Climate Change on Australian Marine Life: Part B Technical Report*, CSIRO Marine and Atmospheric Research report to the Australian Greenhouse Office, Department of the Environment and Heritage, Canberra (PDF 2.9 MB)

Hughes MG, Rogers K & Wen L 2019, 'Saline wetland extents and tidal inundation regimes on a micro-tidal coast, New South Wales, Australia', *Estuarine, Coastal and Shelf Science*, vol. 227, 106297, DOI: 10.1016/j.ecss.2019.106297

Lekammudiyanse MU, Saunders MI, Flint N, Irving A, Aiken C, Clark DE, Berthelsen A, Hindmarsh B, Hooks R, Connolly RM, Sievers M, Rasheed MA, Smith TM, Glasby TM, Sherman CDH & Jackson EL 2024, 'Environmental drivers of flowering in the genus Zostera and spatio-temporal variability of Zostera muelleri flowering in Australasia', *Aquatic Conservation: Marine and Freshwater Ecosystems*, vol. 34, no. 2, e4068, DOI: 10.1002/aqc.4068

Knott NA, Williams J, Harasti D, Malcolm HA, Coleman MA, Kelaher BP, Rees MJ, Schultz A & Jordan A 2021, 'A coherent, representative, and bioregional marine reserve network shows consistent change in rocky reef fish assemblages', *Ecosphere*, vol. 12, no. 4, e03447, DOI: 10.1002/ecs2.3447

Kumbier K, Rogers K, Hughes MG, Lal KK, Mogensen LA & Woodroffe CD 2022, 'An Eco-Morphodynamic Modelling Approach to Estuarine Hydrodynamics & Wetlands in Response to Sea-Level Rise', *Frontiers in Marine Science*, vol. 9, 860910, DOI: 10.3389/fmars.2022.860910

Mack RN & Lonsdale WM 2002, 'Eradicating invasive plants: Hard-won lessons for islands' in CR Veitch and MN Clout (eds), *Turning the tide: the eradication of invasive species*, IUCN SSC Invasive Species Specialist Group, IUCN, Gland, Switzerland and Cambridge, UK, pp. 164–72 (PDF 0.06MB)

Marshall CA 2023, 'The Importance of Aboriginal Marine Park Management Concepts for Australia' in P Darcy & D Dakasi Da-Wei Kuan (eds), *Islands of Hope: Indigenous Resource Management in a Changing Pacific*, pp. 123–42, ANU Press, Canberra, DOI: 10.22459/IH.2023

MEMA 2017, *NSW Marine Estate Threat and Risk Assessment: Background environmental information*, NSW Marine Estate Management Authority, Sydney (PDF 9.1MB)

MEMA 2018, *NSW Marine Estate Management Strategy 2018–2028*, NSW Marine Estate Management Authority, Sydney (PDF 12.3MB)

NHMRC 2008, *Guidelines for Managing Risks in Recreational Water*, National Health and Medical Research Council, Canberra **(nhmrc.gov.au/about-us/publications/guidelines-managing-risks-recreational-water)**

Ngiyambandigay Wajaarr Aboriginal Corporation n.d, *Sea Country IPA*, Ngiyambandigay Wajaarr Aboriginal Corporation, Coffs Harbour

NOAA Fisheries 2024, *Humpback Whale*, National Oceanic and Atmospheric Administration, the National Marine Fisheries Service, accessed 16 September 2024

NSW EPA 2024, Container deposit scheme: beverage container litter, NSW Environmental Protection Agency, accessed 12 September 2024

NSW EPA unpub., *Flood Recovery Program Data* (unpublished), NSW Environmental Protection Agency, Sydney

NSW Government 2024, Threats to estuaries, Environment and Heritage, accessed 16 September 2024

NSW Marine Estate 2024, Climate change citizen science, NSW Marine Estate, accessed 16 September 2024

NSW Marine Estate n.d., Your marine estate, NSW Marine Estate, accessed 11 September 2024

NSW Planning n.d., Coastal management, NSW Planning, accessed 20 September 2024

Parker LM, Ross PM & O'Connor WA 2010, 'Comparing the effect of elevated *p*CO_2 and temperature on the fertilization and early development of two species of oysters', *Marine Biology*, vol. 157, pp. 2,435–52, DOI: 10.1007/s00227-010-1508-3

Parker LM, Ross PM, O'Connor WA, Pörtner HO, Scanes E & Wright JM 2013, 'Predicting the response of molluscs to the impact of ocean acidification', *Biology*, vol. 2, no. 2, pp. 651–92, DOI: 10.3390/biology2020651

Parsons M & Taylor L 2021, Why indigenous knowledge should be an essential part of how we govern the world's oceans, The Conversation, accessed 18 December 2024

Przeslawski R, Chick R, Day J, Glasby T & Knott N 2023, *Research Summary – New South Wales Barrens*, NSW Department of Primary Industries, Sydney (PDF 10MB)

Rasmussen JA, Ingleton T, Bennett WW, Pearson RM, McAneney CA, Foulsham E, Hanslow D, Scanes PR & Connolly RM 2024, 'The effects of estuarine outflows on coastal marine ecosystems in New South Wales, Australia', *Marine Pollution Bulletin*, vol. 208, 116915, DOI: 10.1016/j.marpolbul.2024.116915

Rees MJ, Knott NA, Davis TR, Davis AR, Gudge S, Neilson JM, Fetterplace LC & Jordan A 2021, 'Temporal stability in a protected and isolated fish community within marine parks surrounding lord howe island', *Regional Studies in Marine Science*, vol. 48, 102038, DOI: 10.1016/j.rsma.2021.102038

Rees MJ, Knott NA, Astles K, Swadling DS, West GJ, Ferguson A, Delamont J, Gibson PT, Neilson J, Birch G & Glasby TM 2023, 'Cumulative effects of multiple stressors impact an endangered seagrass population and fish communities', *Science of the Total Environment*, vol. 904, 166706, DOI: 10.1016/j.scitotenv.2023.166706

Rippey E, Rippey JJ & Dunlop JN 2002, 'Increasing numbers of Pied Cormorants breeding on the islands of Perth, western Australia and Consequences for the vegetation', *Corella*, vol. 26, no. 3, pp. 61–4, (PDF 1.65MB)

Roper T, Creese B, Scanes P, Stephens K, Williams R, Dela-Cruz J, Coade G, Coates B & Fraser M 2011, *Assessing the condition of estuaries and coastal lake ecosystems in NSW, Monitoring, evaluation and reporting program, Technical Report Series*, NSW Office of Environment and Heritage, Sydney

Ross PM, Parker L, O'Conner WA & Bailey EA 2011, 'The Impact of Ocean Acidification on Reproduction, Early Development and Settlement of Marine Organisms', *Water*, vol. 3, no. 4, pp. 1,005–30, DOI: 10.3390/w3041005

Rowland MJ & Ulm S 2012, 'Key issues in the conservation of the Australian coastal and archaeological record: natural and human impacts', *Journal of Coastal Conservation*, vol. 16, no. 2, pp. 159–71, DOI: 10.1007/s11852-010-0112-5

SAFS 2023, Blacklip Abalone 2023, Status of Australian Fish Stocks Reports, accessed 16 December 2024

Saintilan N & Williams RJ 1999, 'Mangrove transgression into saltmarsh environments in south-east Australia', *Global Ecology and Biogeography*, vol. 8, no. 2, pp. 117–24, DOI: 10.1046/j.1365-2699.1999.00133.x

Saintilan N, Wilson NC, Rogers K, Rajkaran A & Krauss KW 2014, 'Mangrove expansion and salt marsh decline at mangrove poleward limits', *Global Change Biology*, vol. 20, no. 1, pp. 147–57, DOI: 10.1111/gcb.12341

Saintilan N, Kovalenko KE, Guntenspergen G, Rogers K, Lynch JC, Cahoon DR, Lovelock CE, et al. 2022, 'Constraints on the adjustment of tidal marshes to accelerating sea level rise', *Science*, vol. 377, no. 6,605, pp. 523–7, DOI: 10.1126/science.abo7872

Scanes E, Parker LM, O'Connor WA & Ross PM 2014, 'Mixed effects of elevated pCO2 on fertilisation, larval and juvenile development and adult responses in the mobile subtidal scallop *Mimichlamys asperrima* (Lamarck, 1819)', *Plos One*, vol. 9, no. 4, e93649, DOI: 10.1371/journal.pone.0093649

Scanes E, Parker LM, O'Connor WA, Stapp LS & Ross PM 2017, 'Intertidal oysters reach their physiological limit in a future high-CO2 world', *Journal of Experimental Biology*, vol. 220, no. 5, pp. 765–74, DOI: 10.1242/jeb.151365

Shahjahan M, Taslima K, Rahman MS, Al-Emran M, Alam SI & Faggio C 2022, 'Effects of heavy metals on fish physiology–a review', *Chemosphere*, vol. 300, 134519, DOI: 10.1016/j.chemosphere.2022.134519

Shalders TC, Champion C, Coleman MA, Butcherine P, Broadhurst MK, Benkendorff, K 2023a, 'Impacts of seasonal temperatures, ocean warming and marine heatwaves on the nutritional quality of eastern school prawns (*Metapenaeus macleayi*)', *Science of the Total Environment*, vol. 876, 162778, DOI: 10.1016/j.scitotenv.2023.162778

Shalders TC, Champion C, Benkendorff K, Coleman MA, Cooling K & Hall K 2023b, 'Nutritional quality of eastern school whiting (*Sillago flindersi*) under contemporary and future environmental conditions', *Fisheries Oceanography*, vol. 33, no. 2, e12659, DOI: 10.1111/fog.12659

Shalders TC, Champion C, Benkendorff K, Davis T, Wernberg T, Morris S & Coleman MA 2023c, 'Changing nutritional seascapes of kelp forests', *Frontiers in Marine Science*, vol. 10, DOI: 10.3389/fmars.2023.1197468

Shamsi S, Williams M & Mansourian Y 2020, 'An Introduction to Aboriginal Fishing Cultures and Legacies in Seafood Sustainability', *Sustainability*, vol. 12, no. 22, 9724, DOI: 10.3390/su12229724

Smyth C 2020, *The impacts of bushfires on coastal and marine environments: A review and recommendations for change*, Australian Marine Conservation Society, Brisbane

Smyth L, Egan H & Kennett R 2018, *Livelihood values of indigenous customary fishing: Final report to the Fisheries Research and Development Corporation*, Australian Institute of Aboriginal and Torres Strait Islander Studies, Canberra (PDF 3.0MB)

Swadling DS, West GJ, Gibson PT, Laird RJ & Glasby TM 2023a, 'Multi-scale assessments reveal changes in the distribution of the endangered seagrass *Posidonia australis* and the role of disturbances', *Marine Biology*, vol. 170, 147, DOI: 10.1007/s00227-023-04279-0

Swadling DS, West GJ, Gibson PT, Laird RJ & Glasby TM 2023b, 'Don't go breaking apart: Anthropogenic disturbances predict meadow fragmentation of an endangered seagrass', *Aquatic Conservation: Marine and Freshwater Ecosystems*, vol. 33, no. 1, pp.56–69, DOI: 10.1002/aqc.3905

Taylor M 2017, *Change in ecological character of the Towra Pont Nature Reserve RAMSAR site – Statement of Reasons*, Commonwealth Environmental Water Office, Canberra (0.38MB)

Truscott Z, Booth DT & Limpus CJ 2017, 'The effect of on-shore light pollution on sea-turtle hatchlings commencing their off-shore swim', *Wildlife Research*, vol. 44, no. 2, pp. 127–34, DOI: 10.1071/WR16143

Umwelt 2017, *Towra Point Nature Reserve Ramsar Site: Ecological character description*, NSW Department of Environment, Climate Change and Water, Sydney (PDF 4.33MB)

Vergés A, Doropoulos C, Malcolm HA, Skye M, Garcia-Pizá M, Marzinelli EM, Campbell AH, Ballesteros E, Hoey AS, Vila-Concejo A, Bozec YM & Steinberg PD 2016, 'Long-term empirical evidence of ocean warming leading to tropicalization of fish communities, increased herbivory, and loss of kelp', *Proceedings of the National Academy of Sciences*, vol. 113, no. 48, pp. 13,791–6, DOI: 10.1073/pnas.1610725113

Ward I, Bastos A, Carabias D, Cawtha H, Farr H, Green A & Sturt F 2022, 'Submerged Paleolandscapes of the Southern Hemisphere (SPLOSH) – What is emerging from the Southern Hemisphere', *World Archaeology*, vol. 54, no. 1, pp. 6–28, DOI: 10.1080/00438243.2022.2077822

Wen L & Hughes MG 2022, 'Coastal Wetland Responses to Sea Level Rise: The Losers and Winners Based on Hydro-Geomorphological Settings', *Remote Sensing*, vol. 14, no. 8, 1888, DOI: 10.3390/rs14081888

Wernberg T, Russell BD, Moore PJ, Ling SD, Smale DA, Campbell A, Coleman MA, Steinberg PD, Kendrick GA & Connell SD 2011, 'Impacts of climate change in a global hotspot for temperate marine biodiversity and ocean warming', *Journal of Experimental Marine Biology and Ecology*, vol. 400, no. 1–2, pp. 7–16, DOI: 10.1016/j.jembe.2011.02.021

West GJ & Glasby TM 2021, 'Interpreting Long-Term Patterns of Seagrasses Abundance: How Seagrass Variability Is Dependent on Genus and Estuary Type', *Estuaries and Coasts*, vol. 45, pp. 1,393–408, DOI: 10.1007/s12237-021-01026-w

Williams RJ, Scanes PR & Udy J 2013, *Chapter 3.3 - Seagrasses of southeastern Australia*, WET eBook.indd, (PDF 1.1MB)

Wright JT, Dworjanyn SA, Rogers CN, Steinberg PD, Williamson JE & Poore AGB 2005, 'Density-dependent sea urchin grazing: differential removal of species, changes in community composition and alternative community states', *Marine Ecology Progress Series*, vol. 298, pp. 143–56, DOI: 10.3354/meps298143

Wu T & Barrett J 2022, 'Coastal Land Use Management Methodologies under Pressure from Climate Change and Population Growth', *Environmental Management*, vol. 70, pp. 827–39, DOI: 10.1007/s00267-022-01705-9

This page intentionally left blank

Air and atmosphere

www.soe.epa.nsw.gov.au

This page intentionally left blank

Air and atmosphere

The emissions we release into the atmosphere affect the quality of the air we breathe. These may build up in the atmosphere, contributing to climate change.

The topics in this theme describe **air quality** in NSW and human-made **greenhouse gas emissions** in the atmosphere.

Air quality

Air free from harmful substances, such as bushfire smoke or chemicals from fossil fuel combustion, is vital for human health and the environment. We monitor to maintain good air quality.

Air quality standards for one or more pollutants were exceeded on

47 days

in 2023

Greenhouse gas emissions

Burning of fossil fuels and other human activities are leading to a build-up of greenhouse gases in the atmosphere This is changing our climate with serious consequences.

In 2021–22, NSW greenhouse gas emissions were

27%

lower than in 2005

Introduction to air and atmosphere

All the elements have Lore, cultural Lore, right LORE.

Air is crucial to the ecology. The trees, flora they breathe for us, for us to exist.

Trees breathe in carbon dioxide and give out oxygen. They breathe for us, and we breathe for them. It is so important to look after something that feeds your lifeforce.

A big responsibility exists to look after our air, all plant forms, Country, this is all connected to our wellbeing.

Air quality

NSW air quality is generally good.

This means the air is free of harmful substances, or pollutants. We monitor air quality because human health may be impacted by short or long-term exposure to pollutants.

In NSW, the major air pollutants monitored are particles and ozone. These mostly come from bushfire smoke, dust, and fossil fuel combustion from motor vehicles and industry.

Key findings from the 2024 report

- NSW air quality met national standards most of the time.
- The number of days exceeding these standards varies greatly each year depending on natural climate variations and local weather.
- Without addressing air pollution, health impacts will continue to increase as our population grows and becomes denser.

Greenhouse gas emissions

Global concentrations of greenhouse gases from human activities have been increasing since the pre-industrial era (before 1750) with a large increase of 42% occurring between 1990 and 2019.

In NSW, greenhouse gas emissions mostly come from burning fossil fuels to produce energy.

These gases (mostly carbon dioxide, methane and nitrous oxide) build up in the atmosphere. This is causing the earth to warm up and our climate to change, with serious consequences.

See the **Climate change** and **Extreme climate and weather** topics for more information about the impact that increased greenhouse gas emissions is having on the earth.

Key findings from the 2024 report

- Global net greenhouse gas emissions and atmospheric concentrations of carbon dioxide, methane and nitrous oxide continue to increase.
- Australian and NSW net greenhouse gas emissions are slowly decreasing.
- NSW net greenhouse gas emissions in 2021–22 were 111 million tonnes of carbon dioxide equivalent (CO_2-e) per annum, which is 27% lower than the rate of emissions in 2004–05.
- The electricity generation sector was the highest contributor, followed by transport and agriculture.
- Emissions from the electricity generation sector, have been slowly decreasing due to the uptake of renewable energy.
- The transport sector is the second highest contributor. It decreased marginally since 2005 and expected to increase by 2030.
- The land use, land use change and forestry sector has shifted from a carbon emitter to a sink since 1993.
- Annual emissions continue to decouple (separate) from both population and economic drivers.
- This topic's 'global concentrations of greenhouse gases' indicator aligns to the 'climate change' planetary boundary. Globally, this boundary has been crossed (see **Planetary boundaries alignment**).

This page intentionally
left blank

Air quality

Clean air is essential for the health of humans and the environment. Monitoring air pollutants helps us maintain our good air quality in NSW.

Overview

Air quality standards for one or more pollutants were exceeded on

47 days

in 2023

Read more

Sydney exceeded air quality standards on

12 days

for PM_{10} in 2023

Read more

Air quality measures the amount of pollutants in the air we breathe relative to their potential impacts on our health. Good air quality means that while some substances and pollutants could still be found in air, they are not considered to be harmful. Harmful airborne pollutants can come directly from emissions sources or through chemical reactions in the air. They can be found both outdoors and indoors.

Health impacts may occur because of short- or long-term exposure to air pollutants. Children, the elderly, pregnant women and people with pre-existing health conditions are the most vulnerable to these impacts. For many air pollutants, such as particulate matter, some degree of health impact is possible at any level of exposure. As a result, criteria for the level of acceptable impact are applied when assessing air quality.

Consideration of air quality in the development of environmental and urban management programs and initiatives is crucial to improving outcomes for human health and the environment.

Find out more about **managing air quality**.

Prominent pollutants in NSW

Air pollutants in NSW mostly come from:

- natural sources, such as bushfires, dust storms, sea salt, and volatile natural chemicals released from vegetation
- human-generated sources, including domestic wood heaters, hazard reduction burning, motor vehicles, commercial activities, industries, such as coal mining, energy production, construction, manufacturing and manufactured products.

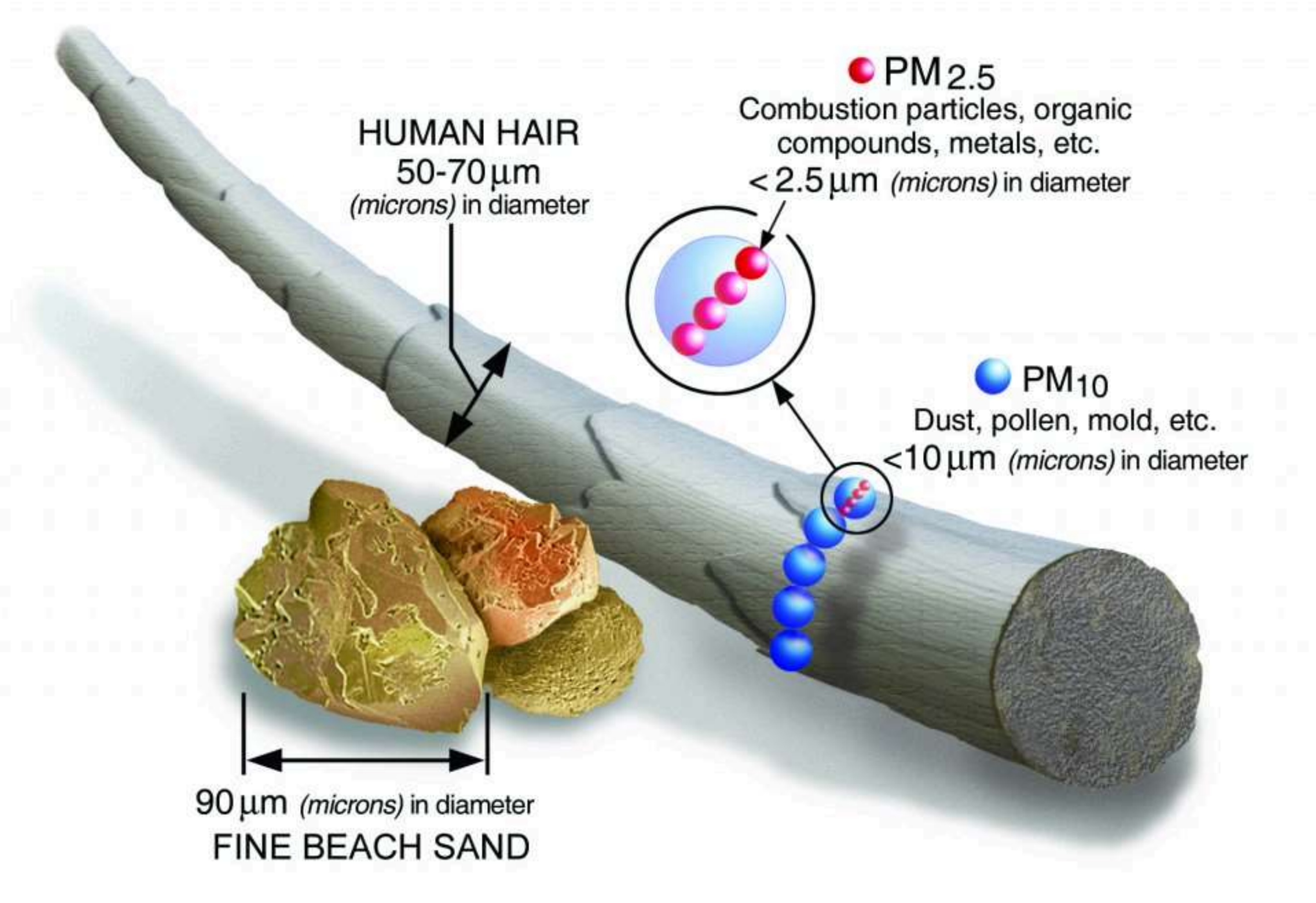
Particulate matter and ozone are the major pollutants monitored and reported on by the NSW Department of Climate Change, Energy, the Environment and Water (NSW DCCEEW).

Particulate matter pollutants, or PM, come in various sizes: PM_{10} are relatively coarse particles up to 10 micrometres (μm) in diameter, while fine $PM_{2.5}$ particles are less than 2.5μm. See size comparison for particulate matter in **Image A1.1** (**US EPA 2024**).

The smaller the particles, the more easily they can be inhaled into the lungs, with some small enough to pass into the bloodstream. Once there, even at relatively low levels, they can trigger heart attacks in people with health conditions and severely affect children and the elderly (**WHO 2013a**). $PM_{2.5}$ has the greatest impacts on human health. The **National Environment Protection (Ambient Air Quality) Measure 1998** (AAQ NEPM) is periodically updated to reflect current health evidence.

Particulate matter pollution varies greatly with weather conditions, changes in the seasons, climate and human activities. These factors affect the concentration and type of particle pollution present in the air.

Image A1.1: Size comparisons for particulate matter (PM) particles



Source:
US EPA 2024

Unlike particulate matter, ozone is a gas that can be found in both the upper atmosphere (stratosphere) and at ground level (troposphere). Tropospheric ozone is formed when oxides of nitrogen (NOx) and volatile organic compounds (VOCs) react in the presence of sunlight. Fossil fuel combustion is a primary human-generated source of these components, making ozone a particular concern in heavily populated areas. Vegetation is also a natural source of VOCs.

Pollutants monitored in NSW can have several impacts on human health when the community is exposed to high concentrations. These predominantly include a range of respiratory and cardiovascular impacts. To help combat the health impacts of air pollution, the NSW Government reports publicly available data against one of five air quality categories. This is supported by an **activity guide** that supports the community to protect itself from air pollution.

Monitoring air quality in NSW

NSW DCCEEW monitors the criteria air pollutants identified in the standards set by the **AAQ NEPM** (see **Table A1.1**).

The practical objective of monitoring air quality is to protect human health by managing activities to reduce pollutants.

In NSW the main exceedances of the AAQ NEPM standards occur:

- in winter due to $PM_{2.5}$ from domestic wood heating
- in areas surrounding mining and industry (PM_{10})

- during bushfires and hazard reduction burning, which generate both $PM_{2.5}$ and PM_{10}
- during the warmer months, especially summer (ozone formation).

Find out more about these and other air pollutants monitored by the NSW Government on the **Air quality website**.

Table A1.1: National Environment Protection (Ambient Air Quality) Measure standards

Pollutant	Averaging period	Standard (maximum concentration)
Carbon monoxide	8-hour rolling average	9.0ppm*
Nitrogen dioxide	1-hour average	0.080ppm
	1-year average	0.015ppm
Photochemical oxidants (as ozone)	8-hour rolling average	0.065ppm
Sulfur dioxide	1-hour average	0.100ppm
	24-hour average	0.020ppm
Particles as PM_{10}	24-hour average	$50.0\mu g/m^3$**
	1-year average	$25.0\mu g/m^3$
Particles as $PM_{2.5}$	24-hour average	$25.0\mu g/m^3$
	1-year average	$8.0\mu g/m^3$
Lead	1-year average	$0.50\mu g/m^3$

Notes:
* ppm = parts per million
** µg/m = micrograms per cubic metre
This table is a compilation of the AAQ NEPM and accompanying provision.

In 2021, the standards for ozone were revised from 1-hour and 4-hour rolling averages to an 8-hour rolling average and from allowing one exceedance day per year to no exceedances, unless determined as an exceptional event. Information about **averaging periods** is available on the NSW DCCEEW website.

Source:
AAQ NEPM

While air quality in NSW is generally good, ongoing monitoring and temporary responses assist in reducing the impact of air pollution.

NSW DCCEEW operates Australia's most comprehensive **air quality monitoring network**, with more than 90 long-term monitoring stations in operation in 2024. These monitoring stations provide the community with accurate, near-real time data on an hourly basis (see **NSW DCCEEW website** for latest data). This includes:

- 56 standard, long-term monitoring stations that use National Association of Testing Authorities (NATA)-compliant monitoring methods to sample pollutants as per Australian standards
- 39 rural stations that use indicative monitoring methods in rural and remote areas of the state as an early warning for dust storm activity, including some in remote parts of Victoria and South Australia
- several low-cost sensors that enhance monitoring and assess air quality trends in a simplified, more accessible way for the public than standard monitoring instruments.

In 2021, a new long-term station at Alexandria was commissioned and incorporated into NSW DCCEEW's network. Since 2021, existing stations at Bradfield Highway, Port Macquarie, and Coffs Harbour have also been incorporated into the Department's network of long-term monitoring stations. Two new air quality monitoring sites are proposed for Narrabeen and Sutherland.

The Chullora station was decommissioned in 2022 and replaced by the Lidcombe station, which has been operational since 2020.

During 2023, permanent ozone monitoring began at the Wagga Wagga North, Tamworth, Albury, Orange and Bathurst stations. Permanent nitrogen dioxide monitoring has also began at Wagga Wagga North, Albury and Tamworth during 2023.

See the **NSW Annual Air Quality Statement 2023** for more information about the air quality monitoring network.

The NSW Environment Protection Authority (EPA) also requires premises licensed under the ***Protection of the Environment Operations Act 1997*** to monitor and report on air pollution emissions. These include emissions to air according to each facility's environment protection licence.

See the **licensing** and **industrial emissions** pages on the EPA website for more information.

Special air quality monitoring projects are also established in response to major areas of concern. For example, temporary research monitoring stations are operating at the **Cadia gold mine** and **Warringah freeway upgrade** in response to community concerns over air quality.

Air quality is regulated at both the federal (Australian Department of Climate Change, Energy, the Environment and Water (DCCEEW)) and state level (NSW EPA). **Table A1.2** lists the main current instruments related to air quality in NSW.

Table A1.2: Current legislation and policies relevant to air quality in NSW

Legislation or policy	Description
Protection of the Environment Operations Act 1997	Sets the statutory framework for managing air quality in NSW. It contains provisions for the operation of industrial plant to prevent air pollution that exceeds regulatory standards; the prohibition of burning to reduce smoke pollution during certain weather conditions; and the management of smoke from domestic premises.
Protection of the Environment Operations (Clean Air) Regulation 2022	Aims to reduce emissions of harmful air pollutants through requirements such as standards for domestic wood heaters; provisions for controls on open burning of vegetation and domestic waste; obligations to prevent or minimise emissions; anti-pollution devices for certain motor vehicles; standards on the supply of petrol; requirements for petrol vapour recovery at service stations in the greater metropolitan area; standards for industry air impurity emissions; and controls on the storage and transport of volatile organic liquids.
Protection of the Environment Operations (General) Regulation 2022	Establishes the licensing fee scheme for major industrial premises and provides economic incentives for licensed businesses and industry to reduce pollution, including emissions to air. It also established the **Upper Hunter** and **Newcastle Local** air quality monitoring networks and gives effect to the requirements of the National Pollutant Inventory in NSW (see below).
NSW Clean Air Strategy 2021–2030 (**DPE 2022a**)	Sets out a whole-of-government approach to achieve ongoing reductions in the adverse effects of air pollution, including five areas to mitigate community exposure to poor air quality: better preparedness for pollution events; cleaner industry; cleaner transport, engines, and fuels; healthier households; and better places.
National Clean Air Agreement	Sets a framework for national collaboration on air quality issues to deliver health, environmental and economic outcomes, allowing the Commonwealth, the states and territories to coordinate cooperative actions at national, state and local levels.
National Environment Protection (Air Toxics) Measure 2004	Specifies national-level standards for ambient air toxics and associated monitoring and reporting procedures to protect human health and wellbeing.
National Environment Protection (Ambient Air Quality) Measure 1998 (AAQ NEPM)	Specifies standards for ambient air quality and associated monitoring and reporting procedures for listed air pollutants to minimise the risk of adverse health impacts from exposure to air pollution. The NEPM's environment protection goals aim to meet standards for carbon monoxide, nitrogen dioxide, photochemical oxidants (as ozone), lead, particles (as PM_{10} and $PM_{2.5}$) and sulfur dioxide. The NEPM was updated in 2021 with a further review scheduled to commence in 2025.
National Environment Protection (National Pollutant Inventory) Measure 1998	Requires reporting of emissions from industrial facilities. The national environmental protection goals for this measure include maintenance and improvement in ambient air quality and marine, estuarine and freshwater quality, as well as minimising environmental impacts associated with hazardous wastes and improving the sustainable use of resources.

Notes:
See the **Responses** section for more information about how **Air quality** is managed in NSW.

Indoor air quality

Data gaps for indoor air quality exist due to limited monitoring at the state and national level. This is of particular concern as Australians spend on average 90% of their time indoors (**DCCEEW-Aus 2022**). The health impacts from poor indoor air quality are estimated to cost Australia up to $12 billion per year (**DCCEEW-Aus 2022**).

See the **Future opportunities** section of this topic for more information.

Indoor air pollution often has other sources and exceeds levels of outdoor air pollution (**Molloy et al. 2012**). They may also present in homes and buildings as by-products from domestic wood heaters, gas stoves and cooking and chemical cleaning products, as well as particulates shed by homewares and other products and in secondary tobacco smoke, dust and mould.

Find out more about the harmful impacts of **wood smoke pollution** on the EPA website.

> **Related topics**: **Climate change** | **Extreme climate and weather** | **Greenhouse gas emissions** | **Population and the environment** | **Soil condition** | **Transport**

Status and trends

Air quality indicators

The NSW DCCEEW monitors six of the seven criteria pollutants under the **AAQ NEPM** as indicators of the state of air quality in NSW. Ambient monitoring of lead (the last of the criteria pollutants) ceased in NSW in 2004 following the introduction of unleaded motor fuel.

- **Particles as PM_{10}** are stable, with 21 days exceeding the national standards in 2023 (see **Particles as PM_{10}**).
- **Particles as $PM_{2.5}$** are stable, with 13 days exceeding the national standards in 2023 (see **Particles as $PM_{2.5}$**).
- **Ozone** is stable, with 3 days exceeding the national standards in 2023 (see **Ozone**).

As concentrations of carbon monoxide (CO), nitrogen dioxide (NO_2) and sulfur dioxide (SO_2) are generally well below the AAQ NEPM standards, detailed graphs of their long-term trends are not included in this report.

Air quality continues to be stable in NSW (see **Table A1.3**). The number of days exceeding national standards has been lower over the past three years due to wetter than average weather. Particulate matter and ozone pollution indicators remain at 'moderate' due to a return to the trend of increased exceedances in 2023.

Table A1.3: Air quality indicators

Indicator	Environmental status	Environmental trend	Information reliability
Particles (PM_{10}*)	MODERATE	Stable	Good
Particles ($PM_{2.5}$)**	MODERATE	Stable	Good
Ozone (O_3)	MODERATE	Stable	Good
Carbon monoxide (CO)	GOOD	Stable	Good
Nitrogen dioxide (NO_2)	GOOD	Stable	Good
Sulfur dioxide (SO_2)	GOOD	Stable	Good

Notes:
PM refers to particles which are 10 micrometres (10µm) or less in diameter.
PM refers to particles which are 2.5 micrometres (2.5µm) or less across.

Indicator table scales:
- **Environmental status**: Good, moderate, poor, unknown
- **Environmental trend**: Getting better, stable, getting worse
- **Information reliability**: Good, reasonable, limited.

See **Indicator guide** to learn how terms and symbols are defined.

NSW generally experiences good air quality. From 2021 to 2023, air quality in NSW met AAQ NEPM standards between 84% and 100% of the time.

In 2023, most of NSW met national air quality standards 96% of the time with Newcastle local region the exception, achieving the standards 84% of the time. During 2023, exceedances of the AAQ NEPM standard for one or more pollutants occurred on 47 days, compared to 19 in 2022 and 53 in 2021.

Particles as PM_{10} and $PM_{2.5}$ and ozone (O_3) are of most concern as these pollutants exceed their AAQ NEPM standards most often. Since the 2019–20 bushfire season, successive La niña events and subsequent drought recovery saw a sharp decline in exceedances of these pollutants through to 2023. Air quality exceedances for PM_{10} and O_3 in 2022 were observed at record low levels due in part to well above-average rainfall across NSW.

Air quality in 2022 was overall the best on record. From 2021 onwards, trends in PM_{10}, $PM_{2.5}$ and O_3 have reverted to levels consistent with observations before the 2019–20 bushfire season. During this period, levels of CO, NO_2 and SO_2 remained stable.

Particulate matter pollutants

Particle concentrations are monitored across the NSW Greater Metropolitan Region (NSW GMR) (Sydney, the Lower and Upper Hunter, Central Coast, Lake Macquarie and the Illawarra) to measure compliance with national standards. This takes in about 75% of the NSW population, including some regional centres. Levels recorded in regional centres are generally representative of the air quality in surrounding regions. Concentrations around NSW vary according to the source of the pollution and season.

Between 2021 and 2023, particle ($PM_{2.5}$ and PM_{10}) concentrations in NSW exceeded the national air quality standards on from 19 (2022) to 42 days in 2023. In Sydney, particles exceeded the national standards from zero (2021, 2022) to 15 days in 2023.

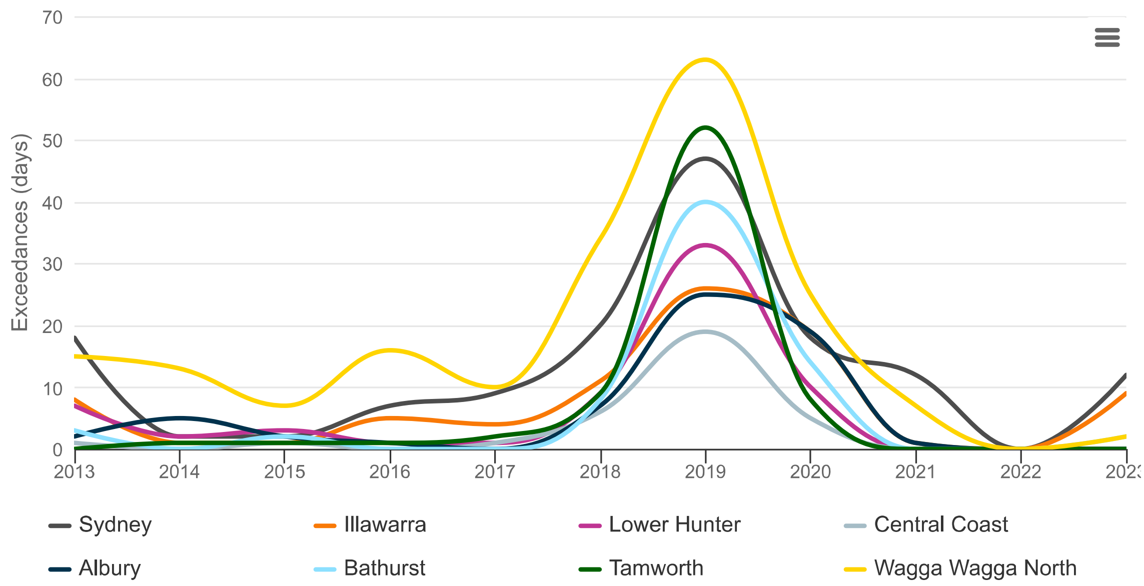
Exceedances of the particle standards between 2021 and 2023 were most often caused by the burning of biomass (organic matter), including bushfires, hazard reduction burns and local agricultural burning, wood smoke from domestic heaters and airborne dust.

Particles as PM_{10}

While levels of PM_{10} particulate matter pollution are generally good, they can become elevated and result in poor air quality during hazard reduction burns, bushfires and dust storms. The greatest number of days with PM_{10} levels above the 24-hour standard in NSW occurred during the severe drought between 2017 and 2020 and concurrent with bushfires in 2019 and 2020 (see **Figure A1.1**).

More recently, exceedances increased in the Illawarra and Sydney regions in 2023 following fewer exceedances in 2021 and no exceedances in 2022.

Figure A1.1: Number of days exceeding AAQ NEPM 24-hour standard for particles (PM_{10}) in NSW, 2013–23



Notes:
To ensure consistency in presenting trends, all exceedances, including those due to exceptional events, are presented.

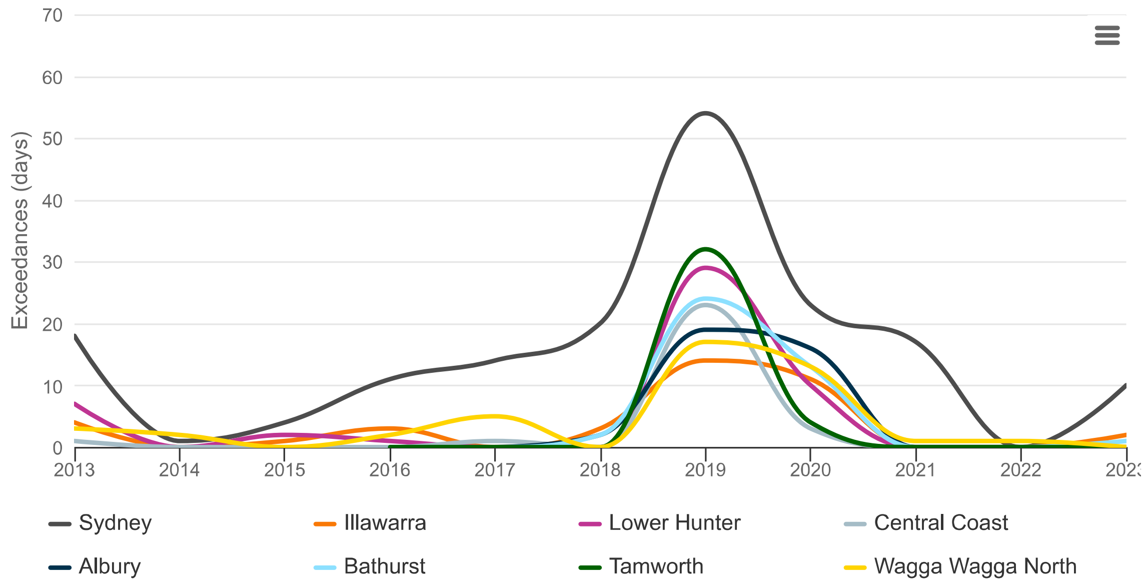
Source:
NSW DCCEEW air quality monitoring

Particles as $PM_{2.5}$

$PM_{2.5}$ particulate matter pollution has a greater potential to cause detrimental health impacts by inhalation than PM_{10}. These small particles also peak during specific events, including bushfires and droughts.

After the Black Summer bushfires, fewer exceedances were observed in 2021. In 2022 only one exceedance was recorded, which is the fewest on record. However, exceedances of $PM_{2.5}$ have begun to increase again in 2023 (see **Figure A1.2**).

Figure A1.2: Number of days exceeding AAQ NEPM 24-hour standard for particles ($PM_{2.5M}$) in NSW, 2013–23



Notes:
To ensure consistency in presenting trends, all exceedances, including those due to exceptional events, are presented.

Source:
DCCEEW air quality monitoring

Seasonal exceedances in particulate matter pollution also occur in cooler months due to:

- hazard reduction burning
- smoke from domestic wood heaters
- agricultural burning.

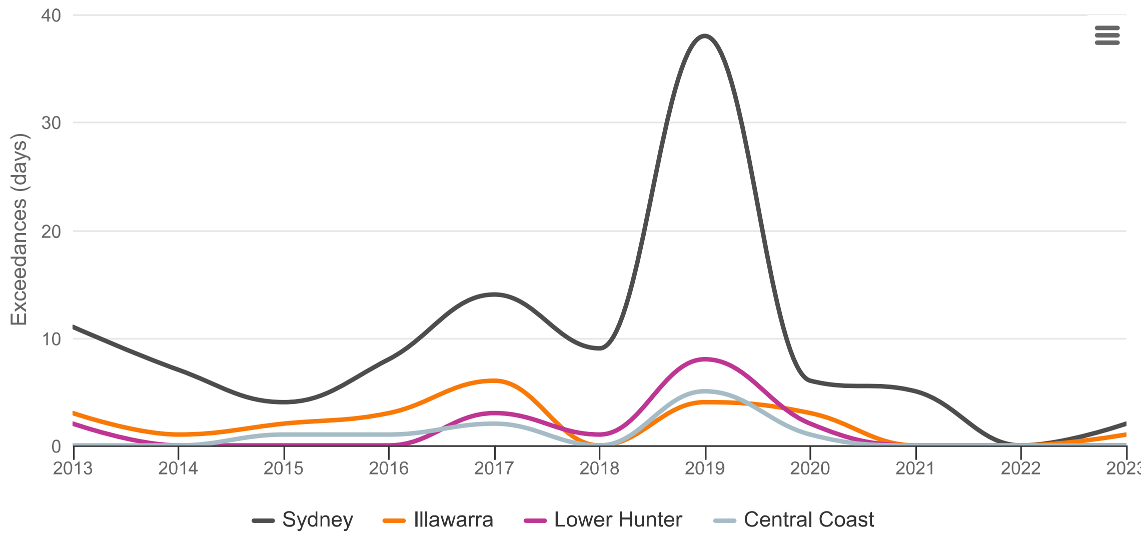
Ozone pollution

Exceedances of O_3 show geographical differences and trends over many years. In 2021, a revised 8-hour rolling ozone average standard was introduced. All exceedances before that date were retrospectively calculated to indicate how O_3 levels in previous years compared with the new standard.

Figure A1.3 shows O_3 exceedance days in the NSW GMR, with the highest occurring during drought years (2017–20) and the 2019–20 bushfire season. O_3 exceedances increased in 2023 following a record low of no exceedances in 2022. Most O_3 exceedances occur in Sydney.

Reduced exceedances recorded in the NSW GMR in recent years may reflect fewer warm and sunny days during summer when successive La Niña events prevented the optimal meteorological conditions for O_3 formation.

Figure A1.3: Number of days exceeding the new 8-hour AAQ NEPM standard for ozone (O_3) in NSW GMR, 2013–23



Notes:
A day is counted only once per region, even if exceedances occur at multiple monitoring sites on that particular day.

Source:
DCCEEW air quality monitoring

Monitoring of O_3 was extended to regional locations in Gunnedah (2018), Goulburn (2019) and Merriwa (2020). Five additional regional centres were also monitored for O_3 during the 2020–21 summer for comparison against the revised 8-hour ozone standard. Apart from exceedances due to bushfire smoke, there were no other recordings of O_3 levels above the previous or revised standards in regional areas.

In 2023, permanent O_3 monitoring began in the regional locations of Wagga Wagga North, Tamworth, Albury, Orange and Bathurst.

Community perceptions of air quality

The NSW Enviro Pulse survey provides quarterly responses from a structured random sample of the NSW population.

Results from the NSW DCCEEW Enviro Pulse survey found that NSW residents feel less environmental concern about air pollution in 2024 than they did in 2021 (see **Table A1.4**).

Table A1.4: Concern about air pollution in NSW, March 2021 to March 2024

Data type	Mar 21	Sep 21	Mar 22	Sep 22	Mar 23	Sep 23	Mar 24
Air pollution	57%	54%	54%	50%	48%	48%	49%
Sample (n)	1,002	1,017	1,015	998	1,008	1,011	992

Notes:
Enviro Pulse survey is ongoing.

Source:
DCCEEW 2024

Enviro Pulse found most NSW residents (84%) identified local air pollution as a concern for their local area in 2024 (see **Table A1.5**). Residents considered road traffic, trucks, and bushfire and hazard reduction burns as the most concerning sources of air pollution in their local area.

Table A1.5: Sources of air pollution of concern in local area, March 2021 to March 2024			
Source	Mar 23	Sep 23	Mar 24
Road traffic	58%	53%	52%
Trucks	46%	37%	44%
Bushfire smoke or hazard reduction burns	44%	55%	39%
Industrial sources	29%	26%	28%
Diesel equipment (for example construction equipment)	27%	24%	25%
Smoke from wood heaters or fireplaces	21%	25%	21%
Coal mines	18%	16%	18%
Rail	13%	12%	15%
Smoke from fire pits, pizza ovens or other outdoor domestic sources	12%	13%	15%
Power generation plants	15%	13%	14%
Total with any air pollution concerns	**84%**	**87%**	**84%**
Total with no air pollution concerns	**16%**	**13%**	**16%**
Sample size (n)	1,008	1,011	992

Notes:
Enviro Pulse survey is ongoing.

Source:
DCCEEW 2024

On days of poor air quality, NSW residents adopt a range of behaviours to protect their health (see **Table A1.6**). The most common action has been to close all windows and doors. There has been a growth (twice as many) in those purchasing or using air purifiers and in researching what to do. These increases are despite five times as many people not taking any action as the air quality is good.

Table A1.6: Actions taken by people the last time they experienced a day with poor air quality, March 2021 to March 2024

Source	Mar 21	Sep 21	Mar 22	Sep 22	Mar 23	Sep 23	Mar 24
Closed all windows and doors	74%	79%	76%	74%	75%	58%	55%
Used my air purifier	12%	12%	13%	15%	17%	15%	21%
Used personal protective equipment, for example a face mask when going outside	16%	12%	18%	17%	20%	16%	19%
Bought an air purifier	8%	5%	8%	9%	12%	12%	14%
Researched what to do	8%	7%	7%	7%	10%	11%	13%
Went to a public building with better air quality than my home	7%	4%	6%	7%	8%	8%	10%
Kept or brought my children home from school	6%	5%	7%	8%	9%	8%	9%
Not applicable, air quality has been good	3%	3%	4%	4%	3%	17%	15%
Sample (n)	**1,002**	**1,017**	**1,015**	**998**	**1,008**	**1,011**	**992**

Source:
DCCEEW 2024

Pressures and impacts

Human health impacts

The World Health Organization (WHO) estimates that air pollution is on a par with other major global health risks, such as exposure to tobacco smoke and an unhealthy diet (**WHO 2021**). Without addressing air pollution, long-term exposure will increase the risk of chronic respiratory and cardiovascular disease and mortality and permanently affect lung development in children (**WHO 2013b**).

In the NSW GMR, it is estimated that 5,900 years of life are lost each year due to long-term exposure to fine particles ($PM_{2.5}$), equating to the equivalent of 420 premature deaths (**Broome et al. 2020**).

The NSW population is projected to reach more than 8.9 million people by 2031 (**DPHI 2022**). Increased population densities will raise the community's exposure to air pollution, resulting in public health impacts and costs, even where air pollution concentrations remain the same. This is particularly relevant for growth areas in parts of western Sydney and along major road transport corridors due to exposure to traffic emissions.

See the **Population and the environment** and **Transport** topics for more information.

Transport emissions

In the Sydney region, motor vehicles are a significant source of O_3 precursor emissions (NOx and VOCs) and particulate matter pollutants ($PM_{2.5}$ and PM_{10}).

Results from the ***Sydney Air Quality Study Stage 2*** (**DCCEEW 2023**) show that human activities account for 48% of $PM_{2.5}$ exposure across the NSW GMR. Of these emissions, on-road motor vehicle exhausts contribute 13% and on-road vehicles non-exhaust (tyre and break wear) accounts for 4%.

In terms of the impact on mortality and the associated annual health costs from premature death or years of life lost, this equates $614 million from motor vehicle exhaust and $218 million from non-exhaust sources (2021 Australian dollar values) (**DCCEEW 2023**).

Without a significant decrease in the use of fossil fuels for private and public transport, air quality may decline as the population grows. This could create negative impacts on the environment and poorer human health outcomes for the people of NSW.

See the **Greenhouse gas emissions**, **Population and the environment**, **Transport** and **Net Zero Plan Stage 1: 2020–2030** topics for more information.

Smoke from bushfires and hazard reduction burns

The impact of bushfire smoke on populations over large areas depends on a variety of factors, including the nature of the fire and weather conditions. With severe fire weather projected to increase over coming decades, days of poor or worse air quality due to bushfire smoke are likely to increase.

The number of severe fire weather days varies significantly from year to year. A series of successive La Niña events over the 2021 to 2023 period likely limited the development of severe fire weather, reducing the number of large bushfires and reducing particulate matter pollution from smoke.

The $PM_{2.5}$ component of smoke provides the greatest health risk to communities. While exposure to smoke is usually short-term over hours or days, concentrations can be extremely high. This contributes to increases in premature deaths and hospital presentations due to the effect of $PM_{2.5}$ exposure on lung and heart conditions.

$PM_{2.5}$ particles associated with the 2019–20 bushfire season contributed to 219 excess deaths, 1,050 hospital admissions for respiratory conditions and 577 hospital admissions for cardiovascular conditions in NSW (**Borchers-Arriagada et al. 2020**).

See the **Extreme climate and weather** topic for more information.

Wood heaters

Smoke from wood heaters is a significant source of exposure to $PM_{2.5}$ and other pollutants that are detrimental to human health in both metropolitan and regional areas of NSW. Wood heaters are responsible for more human health impacts in NSW than any other single source of human-generated air pollution.

Smoke from wood heaters accounts for 42% of $PM_{2.5}$ emissions generated each year on average (**DCCEEW 2023**). This results in an estimated 269 premature deaths and over $2.2 billion in health costs every year, across the NSW GMR (**DCCEEW 2023**).

Climate change

The relationship between climate change and air pollution is complex and knowledge is limited, especially about how it might affect regional air quality. Climate change is impacting health through extreme weather events, increased air pollution from bushfire smoke and dust and through human sources, such as air conditioning (**Keswani et al. 2022**).

The emergence of acute asthma presentations after thunderstorms is likely to become more frequent and severe due to climate change (**Price et al. 2021**).

This is happening already. See the **Extreme climate and weather** topic for more information.

An understanding of the future projections of meteorological variables (such as temperature, precipitation and cloud cover) and changes in the frequency and severity of bushfires and dust storms, are as important to air quality projections as they are to the projections of greenhouse gas emissions.

See the **Climate change** and **Greenhouse gas emissions** topics.

Responses

Prioritising air quality

National Clean Air Agreement Work Plan

The **National Clean Air Agreement** is an agreement between the Commonwealth, the states and territories that sets a framework for national collaboration on air quality issues and delivery of a program of activities to respond to air quality priorities.

Under the agreement, Australia's environment ministers determine rolling three-year work plans. The **2021–23 Work Plan** was implemented collaboratively by all participant jurisdictions and built on the achievements of the previous work plans. It includes a range of projects across the four strategic approaches set out by the agreement which are:

1. better knowledge, education and awareness
2. emissions reduction measures to reduce air pollution and population exposure to air pollution
3. building and advancing partnerships and cooperation
4. improved standards for reporting and monitoring air pollution.

A work plan for 2024–26 is under development.

NSW Clean Air Strategy

The ***NSW Clean Air Strategy 2021–2030*** (**DPE 2022a**) presents a cohesive, whole-of-government set of priorities and actions to support liveable communities, healthy environments and the NSW economy by reducing the adverse effects of air pollution on NSW communities. The priority areas are:

- better preparedness for pollution events – improve information and how it is communicated to help reduce health impacts of air pollution on NSW communities, including from bushfires, hazard reduction burns and dust storms
- cleaner industry – drive improved management of air emissions by industry
- cleaner transport, engines and fuels – further reduce air emissions and impacts from vehicles, fuels and non-road diesel sources
- healthier households – support reducing air emissions from household activities, with the main priority being wood heater emissions
- better places – reduce the impacts of air pollution on communities through better planning and design of places and buildings.

The strategy integrates with the ***Net Zero Plan Stage 1: 2020–2030*** (**DPIE 2020**) and other key energy, transport and planning strategies. Annual reports on how the NSW Government is tracking in implementing the strategy form part of the **NSW annual air quality statements**.

NSW Clean Air Regulation remake

The revised **Protection of the Environment Operations (Clean Air) Regulation 2022** took effect in December 2022. Key changes include:

- requiring cleaner, lower volatility petrol to be supplied for an extra month over summer to reduce ozone
- stricter emission limits and controls on volatile organic liquids in storage tanks, loading plant and tank vehicles
- requiring older industrial activities and plant, which began operating or were upgraded between 1979 and 1997, to comply with more stringent air emission standards.

Updating standards and air quality criteria

Changes to national standards

Nationally consistent air quality standards are set out under the *National Environment Protection (Ambient Air Quality) Measure* (**AAQ NEPM**) which help to guide jurisdictional policy on air pollution. These standards are periodically reviewed by the **National Environment Protection Council** (NEPC).

In May 2021, the AAQ NEPM was updated by the Commonwealth to introduce more stringent national air quality standards for ozone (O_3), nitrogen dioxide (NO_2) and sulfur dioxide (SO_2). Introduced on the back of recent health evidence and a desire for consistency with other international jurisdictions, the changes included:

- reducing the hourly NO_2 standard from 0.120 parts per million (ppm) to 0.080ppm
- replacing the hourly and rolling 4-hour O_3 standards with a rolling 8-hour ozone standard of 0.065ppm
- removing the annual standard for SO_2 and reducing the hourly standard from 0.200ppm to 0.100ppm and reducing the 24-hour standard from 0.080ppm to 0.020ppm
- removing allowable maximum exceedances
- extending the application of the exceptional event rule to the new 8-hour rolling O_3 standard.

The hourly standard for SO_2 will be further reduced to 0.075ppm from 2025. For $PM_{2.5}$, new goals of 20 micrograms per cubic metre (μg/m^3) (24-hour) and 7μg/m^3 (annual) are being introduced from 2025. A further review of the standards is scheduled to commence in 2025.

The Environmental Health Standing Committee of the Australian Health Protection Committee (enHealth) produced two new guideline documents:

- **Guidance for public health agencies** – managing prolonged smoke from landscape fires
- **$PM_{2.5}$ air quality categories and public health advice** – provides guidance to public agencies for health advice during fluctuations in air pollution from fine particle matter.

Improving regulations

Actions by the NSW EPA

The EPA is one of the agencies responsible for the regulation of air quality in NSW. It uses a comprehensive and robust framework for managing air quality, including the regulation of air pollution emissions from scheduled industrial premises.

This regulatory framework was set up and is maintained by the ***Protection of the Environment Operations Act 1997*** (POEO Act), the **Protection of the Environment Operations (Clean Air) Regulation 2022** and the **Protection of the Environment Operations (General) Regulation 2022** (see **Table A1.2**).

The EPA actively promotes compliance with the relevant legislation to deliver improved environmental outcomes and requires licensed industry operators to work to reduce emissions and improve their environmental performance in the long-term.

Between 2021 and 2024, the EPA implemented and worked to improve the regulations for air quality by:

- continuing to monitor and regulate licensed industrial facilities, including for air emissions, and enforcing regulations where necessary
- reviewing and remaking the POEO (General) Regulation 2022 and POEO (Clean Air) Regulation 2022
- updating the **Approved methods for the sampling and analysis of air pollutants** (**NSW EPA 2022a**) and the **Approved methods for the modelling and assessment of air pollutants** (**NSW EPA 2022b**).

The EPA's **Public Register** is regularly updated to provide information about environment protection licences and other regulatory requirements under the POEO Act.

Programs and resources

Local Government Air Quality Toolkit

The NSW DCCEEW has completed a major update of the **Local Government Air Quality Toolkit** based on extensive consultation with the NSW EPA and local councils.

The toolkit contains a comprehensive set of guidance materials to assist councils to meet their regulatory responsibilities to effectively manage air quality issues in their local government areas. Upgrading the toolkit was a priority action under the ***NSW Clean Air Strategy 2021–2030*** (**DPE 2022a**).

The revised toolkit contains new guidance material on climate change impacts, land use planning and emissions from crematoriums. It also includes new practical visual guides and a resource pack to assist council officers with air quality-related inspections.

Bust the Dust campaign

Dust from mining activity in the Hunter Valley is a key concern for the local community. The EPA runs Bust the Dust campaigns to regulate air quality at mine sites and implement procedures to reduce dust from their operations.

Between 2020 and 2022, the Upper Hunter experienced above-average rainfall, a result of multi-year La Niña weather events. During this period, the EPA's Environment Line received few reports of poor air quality. The prevailing wetter conditions at the time are believed to have aided dust suppression and reduced particulate emissions from the land and Upper Hunter coal mines. Consequently, the EPA did not run any compliance campaigns in 2021 or 2022.

In 2023, long-range weather forecasts predicted a return to El Nino conditions of hot dry periods. In light of the seasonal forecast, the EPA resumed the Bust the Dust campaign, examining Upper Hunter coal mine operations and monitoring the effectiveness of their dust control measures.

Between August and December 2023, the campaign used various resources, including drones, to help EPA officers better identify the source of dust plumes and observe their impacts on air quality. Coal mines were generally observed to be implementing appropriate dust management controls.

The results from this latest campaign revealed improved performance by local mines compared with previous years, including increased measures for dust suppression and several instances where operations were suspended in response to dust risks. While dust from mining activity in the Hunter Valley remains a key concern for the community, the EPA will continue its campaigns and routine inspections to ensure the mines are maintaining good air quality in the region.

National Pollutant Inventory

As required by the **National Environment Protection (National Pollutant Inventory) Measure** (NPI NEPM), the EPA requires about 1,000 industry facilities in NSW to publicly report their emissions of listed pollutants, including emissions to air.

NPI data is searchable by state, destination (such as air) and substance emitted.

Load-based licensing

The EPA administers the **Load-Based Licensing (LBL) scheme** which aims to encourage cleaner production through a 'polluter pays' principle that requires some environment protection licensees to pay part of their licence fees based on the load of pollutants their activities release to the environment.

By linking the fees payable to pollutant loads, LBL aims to provide an ongoing economic incentive for licensees to improve their environmental performance beyond the levels required by regulation or licence conditions alone. For more information see **the EPA website**.

Petrol vapours and vehicle emissions

The EPA leads the following programs to reduce air quality pollutants from petrol vapour and vehicle emissions:

- The **summer low-volatility petrol program** manages ozone formation in the NSW GMR from 1 November to 31 March each year. Regulatory requirements limit petrol volatility, which is a contributor to the development of ozone, to a maximum of 64 kilopascals, a measure of vapour pressure indicating how easily the fuel can give off fumes. Petrol importers and blenders are required to test and report to the EPA on batch volatility each month.
- The **vapour recovery at service stations program** captures displaced vapours from storage tanks when fuel is delivered to a service station as well as when motorists refuel at the bowser.
- The **smoky vehicle enforcement program** aims to reduce vehicle emissions to air by ensuring owners properly maintain their vehicles. A smoky vehicle is any motor vehicle that emits visible smoke continuously for over 10 seconds.

NSW Electric Vehicle Strategy

Launched in June 2021, the ***NSW Electric Vehicle Strategy*** (**DPIE 2021b**) commits to increasing the uptake of electric vehicles. The NSW Government has set targets of 52% of new vehicles sold to be electric by 2030 and 100% of new passenger fleet vehicle procurement also to be electric by the same date. These targets, as well as other incentives, investments and programs will support the reduction in transport emissions in NSW.

Transport for NSW

In 2023, Transport for NSW released its **Net Zero and Climate Change Policy** with a range of emissions targets including:

- 100% renewable energy for the rail, light rail and metro train network by 2025
- net zero operational and fleet emissions by 2035
- net zero embodied emissions by 2045
- net zero transport sector emissions by 2050.

The **Zero Emissions Buses** program commits to transitioning the state's public transport buses to zero emissions technology. Completion targets are 2035 for Greater Sydney; 2040 in outer metropolitan regions; and 2047 in regional NSW.

The **Towards Net Zero Emissions Freight Policy**, published in 2023, sets out a road map to support the road and rail freight transport industry to transition to low and zero emission vehicles and technologies.

The 30-minute city

The ***Greater Sydney Region Plan*** sets an objective for achieving a **'30-minute city'**, in which most residents are within half an hour of their nearest metropolitan centre, using public and active transport. About 61% of homes across Greater Sydney met this objective in December 2023.

See the **Transport** topic for more information on programs to reduce motor vehicle emissions.

Programs in NSW schools

In 2023, the NSW Department of Education implemented a two-year **Clean Air Schools** pilot program in collaboration with the University of NSW. This non-invasive air quality monitoring program aims to improve the overall learning environment for schools. Low-cost air quality sensors to monitor air pollution for two years have been installed at indoor and outdoor locations in 100 schools across NSW.

Design Framework: Sustainability (**DoE 2023**) requires that all new NSW public school buildings valued at over $10 million and at least 1,000 square metres in size are certified as Green Star Buildings. There is a minimum requirement for projects in metropolitan areas to be fossil fuel-free from 2023 for 5 Star ratings and from 2026 for 4 Star ratings in regional areas.

The ***Sustainable Buildings SEPP*** (**DPE 2022b**) will also require NSW schools to measure and report embodied emissions and verify energy performance of buildings with a view to them being fully electric or able to be converted to fully electric by 2035.

Wood heaters

Particulate matter pollution from indoor wood heaters continues to be the number one human-generated air pollution issue in NSW, despite being a seasonal occurrence. Wood heaters were specifically included in the ***NSW Clean Air Strategy 2021–2030*** (**DPE 2022a**), in addition to already existing regulations, to deliver long-term and widespread wood smoke emission reductions and public health benefits.

The **EPA website** provides educational materials to raise public awareness about the health impacts of wood smoke and how to properly operate wood heaters. A fact sheet on wood heaters and health is available on the **NSW Health website**. The EPA also provides a **resource kit** to help local councils run community education campaigns. The NSW Government is continuing to lead and support research into the health impacts of wood heaters and the effectiveness of different types of interventions.

Monitoring and research

Review of Monitoring Plan

The ***NSW Air Quality Monitoring Plan 2021–2025*** (**DPIE 2021a**) aligns the NSW monitoring network with the national monitoring framework; proposes an expansion of the network through the use of low-cost sensors to improve monitoring coverage for particulate matter pollution; and focuses on ensuring NSW meets its obligations to the AAQ NEPM.

Future opportunities

Review of AAQ NEPM national standards 2025

In May 2021, the National Environment Protection Council (NEPC) amended the National Environment Protection (Ambient Air Quality) Measure (**AAQ NEPM**) to tighten national standards for nitrogen dioxide, sulfur dioxide and ozone. NEPC also agreed to further tighten the sulfur dioxide 1-hour standard and update the goal for the $PM_{2.5}$ 24-hour and annual averaging periods from 2025.

The Australian Government is scheduled to commence a further review of the national standards in 2025, creating an opportunity to review the standards against the latest available evidence and World Health Organization Guidelines.

Standards Australia review of wood heater emissions standard

The **Protection of the Environment Operations (Clean Air) Regulation 2022** requires all domestic solid-fuel heaters sold in NSW to comply with the current Australian Standards for efficiency (AS 4012) and particulate matter emissions (AS 4013).

The NSW Government is currently supporting a proposal by Standards Australia to review these standards with a proposed stricter emission limit for wood heaters. The review expected in 2024–25 will include a period for public comment.

Non-road diesel engine emissions

Currently there are no national standards or approaches to manage emissions from non-road diesel engines in Australia. However, evaluations of the potential for a national approach to manage non-road diesel engine emissions have commenced under the **National Clean Air Agreement**.

The Australian and NSW Governments worked on this project across 2022 and 2023. A cost-benefit analysis report was published in early 2023 and, based on the findings, the Commonwealth progressed a Regulatory Impact Analysis process. Public consultation of the draft Impact Analysis occurred in mid-2023 and the Commonwealth is now considering national regulation.

Further information on the project can be found on the **National Clean Air Agreement** website

Updated fuel and vehicle emission standards

The Australian Government is responsible for setting fuel quality and vehicle emission standards for new on-road vehicles in Australia. The following **new fuel quality standards** will come into effect from December 2025:

- The level of aromatic hydrocarbons in 95 RON (research octane number) petrol will be reduced to a maximum of 35% to enable the introduction of stricter noxious emissions standards for light vehicles.
- The level of sulfur allowed in all petrol grades (91 RON, 95 RON and 98 RON) and E85 will be reduced to 10 parts per million.

The Commonwealth Government is also implementing more stringent (Euro 6d equivalent) noxious emissions standards for new light vehicles (passenger and commercial vehicles with gross vehicle mass up to 3.5 tonnes). These standards will set stricter limits on the levels of noxious emissions (such as carbon monoxide, hydrocarbons, oxides of nitrogen and particles) produced by new road vehicles supplied to Australia. The new vehicle standards commence from 1 December 2025 for all new model vehicles and from 1 July 2028 for all new vehicles.

Further information on the new vehicle standards is available on the **Australian Department of Infrastructure** website.

Transport emissions trends

Despite these more stringent emission standards and the ***NSW Electric Vehicle Strategy*** (**DPIE 2021b**), transport emissions are projected to only fall marginally as 2030 approaches. NSW transport greenhouse gas emissions are projected to reduce decline by 5% in 2030 compared to the baseline 2005 level.

Emission reductions from the uptake of battery electric and plug-in hybrid vehicles are also offset by record sales of new vehicles, a large proportion of which are classified as SUVs or light commercial vehicles, such as utes (**FCAI 2024**) that are high fuel consumers. This trend has been encouraged by tax incentives for businesses in recent years, such as the exemption from fringe benefits tax (**ATO 2023**) that apply for vehicles able to carry more than one tonne.

Transport for NSW annual fleet registration data also shows an ongoing increase in the percentage of diesel vehicles in the NSW on-road vehicle fleet:

- 17.3% at 30 June 2014 (**NEPC 2015**)
- 22.68% at 30 June 2023
- 23.18% at 30 June 2024.

This average increase of greater than 0.5% per year is significant, as diesel vehicles contribute disproportionately to the amount of air pollution produced by on-road vehicles (**NSW EPA 2019**).

The latest data from the **Australian Infrastructure and Transport Statistics Yearbook 2023** (**BITRE 2024**) shows that the total vehicle kilometres travelled in NSW increased by approximately 9% in 2022–23 compared to 2021–22.

The total vehicle distance travelled also continues to increase for light goods vehicles and heavy vehicle categories, which are predominantly diesel vehicles.

Considerations

Increased greenhouse gas emissions

Moving freight over long distances (long haul) by rail has significantly lower environmental impacts than transporting it by road. This is mainly due to rail's greater efficiency in hauling larger volumes of goods. Rail freight produces 16 times less greenhouse gas emissions and is four times more fuel efficient compared to road freight (**TfNSW 2023**).

Population density

Implementation of a 30-minute city may reduce transport emissions but will require work to develop sound planning approaches which minimise the impact on air quality when increasing population density near sources of pollution.

Indoor air quality data gaps

Further exploration of the use of low-cost sensor technology would help to establish baseline monitoring for indoor air quality. Further investment in innovative technologies would support improved functionality of these sensors.

Further exploration could address growing concerns in ultrafine particulate matter (particles with a diameter of 0.1 micrometres or less) and airborne microplastics (particularly polyester microfibres from clothing).

Utilising AI and machine learning

Exploration of the role that artificial intelligence (AI) and machine learning could play in better managing and monitoring air quality. Machine learning techniques have the potential to support air quality monitoring and projections, as they are currently being incorporated into weather forecasting.

References

ATO 2023, Exempt use of eligible vehicles, Australian Tax Office, accessed February 2024

BITRE 2024, *Australian Infrastructure and Transport Statistics Yearbook 2023*, Bureau of Infrastructure and Transport Research Economics, Department of Infrastructure, Transport, Regional Development, Communications and the Arts, Canberra

Borchers-Arriagada N, Palmer A, Bowman D, Morgan G, Jalaludin B & Johnston F 2020, 'Unprecedented smoke-related health burden associated with the 2019–20 bushfires in eastern Australia', *The Medical Journal of Australia*, vol. 213, no. 6, pp. 282–3, DOI: 10.5694/mja2.50545

Broome RA, Powel J, Cope ME & Morgan GG 2020, 'The mortality effect of $PM_{2.5}$ sources in the Greater metropolitan Region of Sydney, Australia', *Environment International* vol. 137, 105429

DCCEEW-Aus 2021, Indoor air, Australian Government Department of Climate Change, Energy, the Environment and Water, Canberra, accessed 15 February 2024

DCCEEW 2023, *Sydney Air Quality Study: Stage 2*, Department of Climate Change, Energy, the Environment and Water, Sydney

DCCEEW 2024, *Enviro Pulse Survey*, NSW Department of Climate Change, Energy, the Environment and Water, Sydney

DoE 2023, Design framework: sustainability, NSW Department of Education, accessed 27 February 2024

DPE 2022a, *NSW Clean Air Strategy 2021–2030*, NSW Department of Planning and Environment, Sydney

DPE 2022b, *Sustainable Buildings SEPP*, NSW Department of Planning and Environment, Sydney

DPHI 2022, Population projections, NSW Department of Planning, Housing and Infrastructure, accessed 15 February 2024

DPIE 2020, *Net Zero Plan Stage 1: 2020–2030*, NSW Department of Planning, Industry and Environment, Sydney

DPIE 2021a, *NSW Air Quality Monitoring Plan 2021–2025*, NSW Department of Planning, Industry and Environment, Sydney

DPIE 2021b, *NSW Electric Vehicle Strategy*, NSW Department of Planning, Industry and Environment, Sydney

FCAI 2024, *Australia breaks all-time new vehicle sales in 2023*, Federal Chamber of Automotive Industries, Kingston

Keswani A, Akselrod H & Anenberg SC 2022, 'Health and clinical impacts of air pollution and linkages with climate change', *NEJM Evidence 2022*, vol. 1, no. 7, DOI: 10.1056/EVIDra2200068

Molloy SB, Cheng M, Galbally IE, Keywood MD, Lawson SJ, Powell JC, Gillett R, Dunne E& Selleck PW 2012, 'Indoor air quality in typical temperate zone Australian dwellings', *Atmospheric Environment*, vol. 54, pp. 400–7, DOI:10.1016/j.atmosenv.2012.02.031

NEPC 2015, *National Environment Protection Council Annual Report 2013-2014*, Commonwealth of Australia, Canberra

NSW EPA 2019, *Air Emissions Inventory for the Greater Metropolitan Region in NSW (2013 Calendar Year)*, NSW Environment Protection Authority, Sydney

NSW EPA 2022a, *Approved Methods for the Sampling and Analysis of Air Pollutants in NSW*, NSW Environment Protection Authority, Sydney

NSW EPA 2022b, *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW*, NSW Environment Protection Authority, Sydney

Price D, Hughes KM, Thien F & Suphioglu C 2021, 'Epidemic thunderstorm asthma: lessons learned from the storm down-under', *The Journal of Allergy and Clinical Immunology: In Practice*, vol. 9, no. 4, pp. 1,510–5, DOI: 10.1016/j.jaip.2020.10.022

TfNSW 2023, *Towards Net Zero Emissions – Freight Policy*, Transport for NSW, Sydney

US EPA 2024, Particulate matter (PM) pollution, US Environmental Protection Agency, accessed 15 July 2024

WHO 2013a, *Media Release No. 221, IARC: Outdoor air pollution a leading environmental cause of cancer deaths*, International Agency for Research on Cancer, World Health Organization, Lyon, France

WHO 2013b *Review of evidence on health aspects of air pollution – REVIHAAP project: Final technical report*, World Health Organization, WHO Regional Office for Europe, Copenhagen

WHO 2021, *WHO Global Air Quality Guidelines: Particulate Matter ($PM_{2.5}$ and PM_{10}), Ozone, Nitrogen Dioxide, Sulfur Dioxide and Carbon Monoxide*, World Health Organization

Greenhouse gas emissions

Human activities release excessive greenhouse gases into our atmosphere, leading to increased temperatures and climate change.

Overview

In 2021–22, NSW greenhouse gas emissions were

27%

lower than in 2005

Read more

Stationary energy (electricity generation) in 2021–22 remained as the highest emitter, contributing

39%

of NSW emissions

Read more

Greenhouse gases trap heat in earth's atmosphere.

Though most are crucial to life on earth, their concentrations in the atmosphere have increased rapidly since the pre-industrial (before 1750) times (**WMO 2024**). A significant increase – 42% – has occurred over a relatively short period, from 1990 to 2019 (**IPCC 2023**).

These increases are due to human activities and are driving global temperature increases and climate change (**IPCC 2021**).

Among the anthropogenic (caused or influenced by human activity) greenhouse gases, carbon dioxide (CO_2) has the highest atmospheric concentration followed by methane (CH_4) and nitrous oxide (N_2O) (**BOM & CSIRO 2022**; **WMO 2024**).

Most of the carbon dioxide emissions in NSW come from burning of fossil fuels and industrial processes.

Methane emissions in NSW arise mostly from agricultural practices (mainly sheep and cattle digestive processes) and fugitive emissions from the extraction and transport of coal, oil and natural gas. The global warming potential of methane is 28 times that of carbon dioxide over a period of 100 years (**IPCC 2014**).

In NSW, nitrous oxide comes mainly from pastures and crops using nitrogen fertilisers. Its global warming potential is 265 times that of carbon dioxide over 100 years (**IPCC 2014**).

> **Watch a short video about why methane emissions matter** (1 min 50 s)

The greenhouse effect

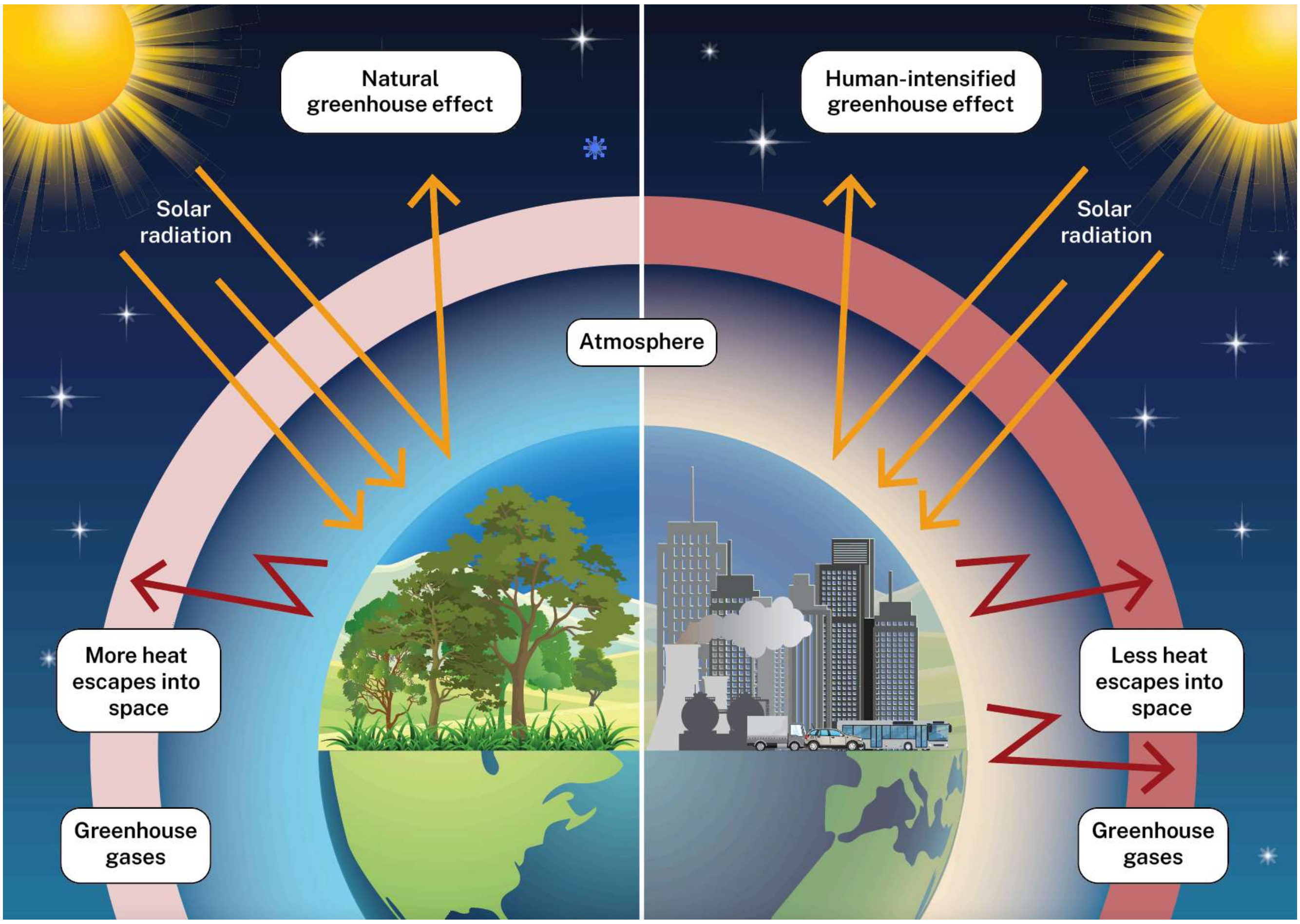
The 'greenhouse effect' refers to how heat from the sun is trapped in earth's atmosphere and influences temperatures.

Earth naturally absorbs energy from the sun in the oceans, soils and vegetation. As the surface warms up, most of this energy is re-radiated back into the atmosphere as infrared radiation (heat).

Greenhouse gases in the atmosphere trap some of this heat, preventing it from escaping into space. This trapped heat warms earth's surface and lower atmosphere, creating a stable climate that supports life.

Human activities have intensified this effect by increasing the levels of greenhouse gases in the atmosphere. This leads to global warming and its associated impacts (see **Image A2.1**).

Image A2.1: Human activities intensify the greenhouse effect



Source:
Bespoke image prepared by NSW EPA

The last time earth experienced carbon dioxide levels in the atmosphere as high as today was about 3 million years ago (**IPCC 2021**). At that time, temperatures were 2.5 to 4°C higher, and sea levels were 5 to 25 metres higher, than in 1850 (**IPCC 2021**).

Global temperatures over land and oceans in 2014–23 were 1.06–1.30°C above pre-industrial levels in 1850–1900 (**Forster et al. 2024**).

Australia's average temperature is now 1.51 ± 0.23°C warmer than in 1910 (**BOM & CSIRO 2022**), when the earliest national data became available.

The increase in overall temperature has been accompanied by variations in Australia's rainfall patterns as well as by heightened frequencies and intensities of extreme weather-related events (**BOM & CSIRO 2024**). These have implications for ecosystems, livelihoods and the economy.

The rate of global sea levels rise have significantly increased since 1901 (**IPCC 2021**). They are now rising at three times the rate in the early to mid-1900s. This increase in the past 100 years have been:

- 1.3 millimetres per year between 1901 and 1971 (71 years)
- 1.9 millimetres per year between 1971 and 2006 (35 years)
- 3.7 millimetres per year between 2006 and 2018 (13 years) (**IPCC 2021**).

See **Climate change** and **Extreme climate and weather** for more information on the impacts of changing climate on NSW.

Carbon sources

Under the **Paris Agreement** – the international treaty on climate change – Australia reports greenhouse gas emissions and removals according to defined sectors and sub-sectors. These sectors and sub-sectors encompass related processes and activities defined by the classification system of the United Nations Framework Convention on Climate Change (UNFCCC).

This standardised reporting enables comparison of emissions between countries and over time.

A major source of greenhouse gas emissions is the burning of fossil fuels, including coal, oil and natural gas, for electricity generation, manufacturing and transport. There are also fugitive emissions generated during processing and distribution of fossil fuels.

The greenhouse gas emissions sectors are defined in **Table A2.1**.

Table A2.1: United Nations Framework Convention on Climate Change (UNFCCC) classification system for sources of greenhouse gas emissions

Sector	Definition
Stationary energy (electricity generation)	Emissions from fuel combustion in public thermal power stations
Stationary energy (excluding electricity generation)	Emissions released from on-site fuel combustion (other than for electricity generation) in manufacturing and primary industries, as well as in the commercial and residential building sectors
Transport	Emissions from fuel combustion in road, domestic aviation, rail, domestic shipping, off-road recreational vehicle activity and gas pipeline transport. (Emissions from the supply of the electricity that powers rail and electric vehicles are accounted for above, in 'Stationary energy (including electricity generation)')
Fugitive emissions	By-products of coal mining and natural gas extraction, processing, storage, transmission and distribution. Emissions (mostly methane) can be intentional or unintentional releases (for example, leaks) from coal mines, gas fields and industrial equipment
Agriculture	Dominated by methane produced by livestock due to the fermentation of plant matter in their stomachs and the way manure is managed
Industrial processes (sometimes referred to as industrial processes and product use)	Emissions resulting from industrial processes, including steel and steel production; the use of gases in products, such as refrigerant gases in imported equipment; and the use of fossil fuels as feedstocks for manufacturing
Waste	Emissions from solid waste disposal and treatment, and from domestic, commercial and industrial wastewater treatment and discharge. Most of the emissions are methane from anaerobic (in the absence of oxygen) decomposition of organic matter
Land use, land use change and forestry (LULUCF)	Emissions and removals associated with land management practices that affect the carbon stored in vegetation and soils

Source:
Based on the classification system in the IPCC Fifth Assessment Report (IPCC 2014)

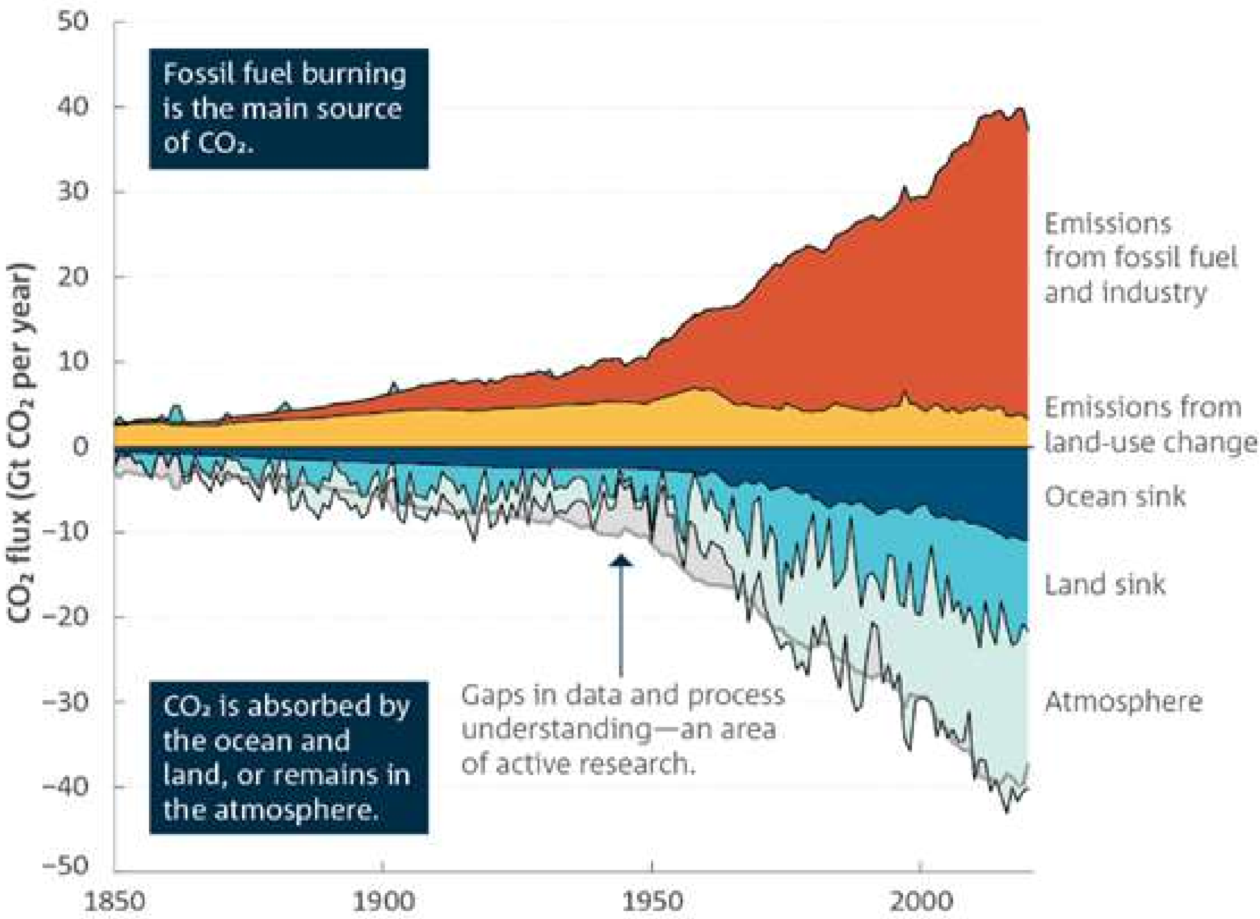
Carbon sinks

Natural processes that absorb greenhouses gases as part of the carbon cycle are known as carbon sinks.

Although land (soils and plants) and oceans can absorb carbon dioxide from the atmosphere, serving as natural carbon sinks, human activities produce more carbon dioxide than nature can absorb.

More than half (about 56%) of global anthropogenic carbon dioxide emissions are absorbed by natural carbon sinks (**IPCC 2023**). The rest builds up in the atmosphere (see **Figure A2.1**).

Figure A2.1: Global greenhouse gas emissions of CO_2 from fossil fuels and land usage change, 1850–2021



Source:
BOM & CSIRO 2022

Reducing emissions

There is an urgent need to radically reduce emissions in order to slow down global warming and mitigate the worst impacts of climate change (**IPCC 2023**).

When comparing different greenhouses gas emissions, the amounts are expressed in terms of a common unit called carbon dioxide-equivalent (CO_2-e). This accounts for the global warming potential of each gas compared with carbon dioxide. In this report, 'carbon emissions' or simply 'emissions' is used as shorthand to refer to 'carbon dioxide equivalent emissions'.

Australia, along with all parties to the **Paris Agreement**, aims to hold the increase in global average temperatures to well below 2°C above pre-industrial levels and to try hard to limit the temperature increase to 1.5°C.

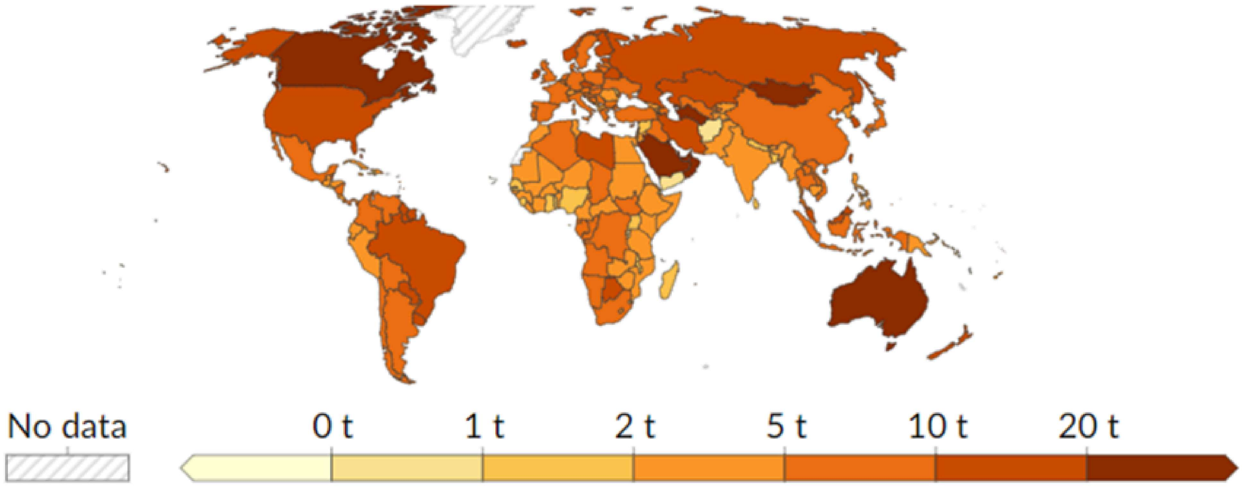
Under the Paris Agreement and the **Australian *Climate Change Act 2022***, Australia has committed to reduce its emissions to 43% below 2005 levels by 2030 and to reach net zero by 2050 (**DCCEEW-Aus 2023**).

See the **Net Zero Plan Stage 1: 2020–2030** topic for more information about what the NSW Government is doing to achieve these targets.

This is a challenging task, because while Australia makes a relatively small contribution to global emissions, it has one the highest per capita emissions in the world (see **Map A2.1**). This rate, almost three times the global average, is due to a heavy reliance on non-renewable energy sources and transport powered by fossil fuels (**IEA 2020**).

As the most populated state, NSW contributes about one quarter of Australia's total greenhouse gas emissions.

Map A2.1: Global per capita greenhouse gas emissions, 2022



Notes:
Australia was the tenth largest emitter per capita in 2022.

The emissions shown in this map are based on global warming potentials from the IPCC Sixth Assessment Report.

Source:
Ritchie et al. 2023 (data page: Per-capita greenhouse gas emissions)

Status of NSW emissions

Greenhouse gas emissions in NSW continue to slowly decline.

NSW net emissions in 2021–22 were 111 Mt CO_2-e, 27% lower than in 2004–05 (153 Mt CO_2-e) (**DCCEEW-Aus 2024**). Although it has been 'decarbonising' or reducing emissions from fossil fuel combustion, the stationary energy (electricity generation) sector remained the biggest contributor to NSW emissions.

Consistent with national goals, NSW has set emission reduction targets through the ***Climate Change (Net Zero Future) Act 2023***. This and other key legislation and policies that influence NSW emissions are detailed in **Table A2.2**.

See the **Net Zero Plan Stage 1: 2020–2030** topic to see the progress of emission reduction initiatives in NSW.

Table A2.2: Current key legislation and policies related to greenhouse gas emissions in NSW

Legislation or policy	Purpose
Climate Change (Net Zero Future) Act 2023	The main features of the Act are: • providing guiding principles for actions to address climate change that consider impacts, opportunities and the need for action in NSW • setting emissions reduction targets • setting an objective for NSW to be more resilient to a changing climate • setting 50% emissions reduction on 2005 levels by 2030, 70% reduction on 2005 levels by 2035, and net zero by 2050 • establishing an independent **Net Zero Commission** to monitor, review, report on and advise on progress towards these targets.
Protection of the Environment Operations Act 1997	Sets the statutory framework for managing air quality in NSW. It contains provisions for the operation of industrial plant to prevent air pollution that exceeds regulatory standards; the prohibition of burning to reduce smoke pollution during certain weather conditions; and the management of smoke from domestic premises.
EPA's Climate Change Policy and Climate Change Action Plan 2023–26	Outline a comprehensive regulatory approach and set of actions to address the causes and consequences of climate change in NSW. They include actions to support licenced industries to decarbonise and build resilience to climate change.
Net Zero Plan Stage 1: 2020–2030	Sets the foundation for NSW action on climate change. It outlines policies and actions for NSW to achieve net zero emissions by 2030.
NSW Climate Change Policy Framework	Maximises the economic, social and environmental wellbeing of NSW in the context of a changing climate and of current and emerging international and national policy settings and actions to address climate change. It also defines the NSW Government's role in reducing carbon emissions and adapting to the impacts of climate change.
NSW Climate Change Fund	Supports activities that reduce the impacts of climate change, including reductions in energy consumption and carbon emissions. It was established in 2007 under the *Energy and Utilities Administration Act 1987*.

Notes:
See the **Responses** section for more information about how **Greenhouse gas emissions** is being addressed in NSW.

Other federal legislative frameworks also affect emission reduction in NSW:

- The **Safeguard Mechanism** requires Australia's highest emitters, including the mining, manufacturing, oil and gas production, transport, waste industries, to reduce the emissions they directly emit to the atmosphere. This is enacted through the ***National Greenhouse and Energy Reporting Act 2007*** and other legislation, and is administered by the Clean Energy Regulator.
- The ***Fuel Quality Standards Act 2000*** regulates the quality of fuel supplied in Australia to reduce the level of pollutants and emissions, facilitate adoption of better technology and allow the more effective operation of engines.

Related topics: **Air quality** | **Climate change** | **Energy consumption** | **Net Zero Plan Stage 1: 2020–2030** | **Population and the environment** | **Transport**

Status and trends

Greenhouse gas indicators

Greenhouse gas indicators include (see **Table A2.3**):

- **Global atmospheric concentrations of greenhouse gases** are increasing (getting worse). Levels of carbon dioxide, methane and nitrous oxide have all increased significantly since 1850. In Australia, as globally, these emissions come mostly from the burning of fossil fuels (see **Global atmospheric concentrations of greenhouse gases**).
- **Annual net NSW greenhouse gas emissions** are decreasing (getting better), owing to decarbonisation of the stationary energy (electricity generation) sector. Decarbonisation means reducing greenhouse gas emissions produced by the combustion of fossil fuels. Despite this decrease, projections show that NSW is not guaranteed to meet its emissions reductions target by 2030 (see **NSW greenhouse gas emissions**).
  See the **Net Zero Plan Stage 1: 2020–2030** topic for more information on NSW's progress to its emissions reduction targets.
- **Annual NSW per capita greenhouse gas emissions** are decreasing (getting better), mostly owing to the decoupling of emissions from population and economic drivers. Decoupling means that an increase in population (or gross state product) does not automatically equal an increase in emissions per capita (or gross state product). Despite this decrease, our per capita emissions are still far higher than the global average (see **NSW emissions per capita and gross state product**).

These indicators aligns to the 'climate change' planetary boundary. Globally, this boundary has been crossed (see **Planetary boundaries alignment**).

Table A2.3: Greenhouse gas emissions indicators

Indicator	Environmental status	Environmental trend	Information reliability
Global atmospheric concentrations of greenhouse gases	POOR	Getting worse	Good
Annual net NSW greenhouse gas emissions	POOR	Getting better	Good
Annual NSW per capita greenhouse gas emissions	POOR	Getting better	Good

Notes:
Indicator table scales:
- **Environmental status**: Good, moderate, poor, unknown
- **Environmental trend**: Getting better, stable, getting worse
- **Information reliability**: Good, reasonable, limited.

See **Indicator guide** to learn how terms and symbols are defined.
See the **Planetary boundaries alignment** page for more information about how indicators align.

Global atmospheric concentrations of greenhouse gases

Global atmospheric concentrations of carbon dioxide, methane and nitrous oxide continue to rise to record levels (**WMO 2024**).

In 2023, the globally averaged surface concentrations of major greenhouse gases reached new highs. According to the World Meteorological Organization:

- Carbon dioxide concentration reached 420 ± 0.1 parts per million (ppm), an increase of 151% relative to its pre-industrial (before 1750) concentration of 278.3ppm
- Methane concentration reached 1934 ± 2 parts per billion (ppb), an increase of 265% from its pre-industrial concentration of 729.2ppb
- Nitrous oxide was 336.9 ± 0.1ppb, an increase of 125% from its pre-industrial concentration of 270.1ppb.

The build-up of these greenhouse gases in the atmosphere is unequivocally due to emissions from human activities (**IPCC 2023**).

Find out more about **ppm and ppb as units of measurement**.

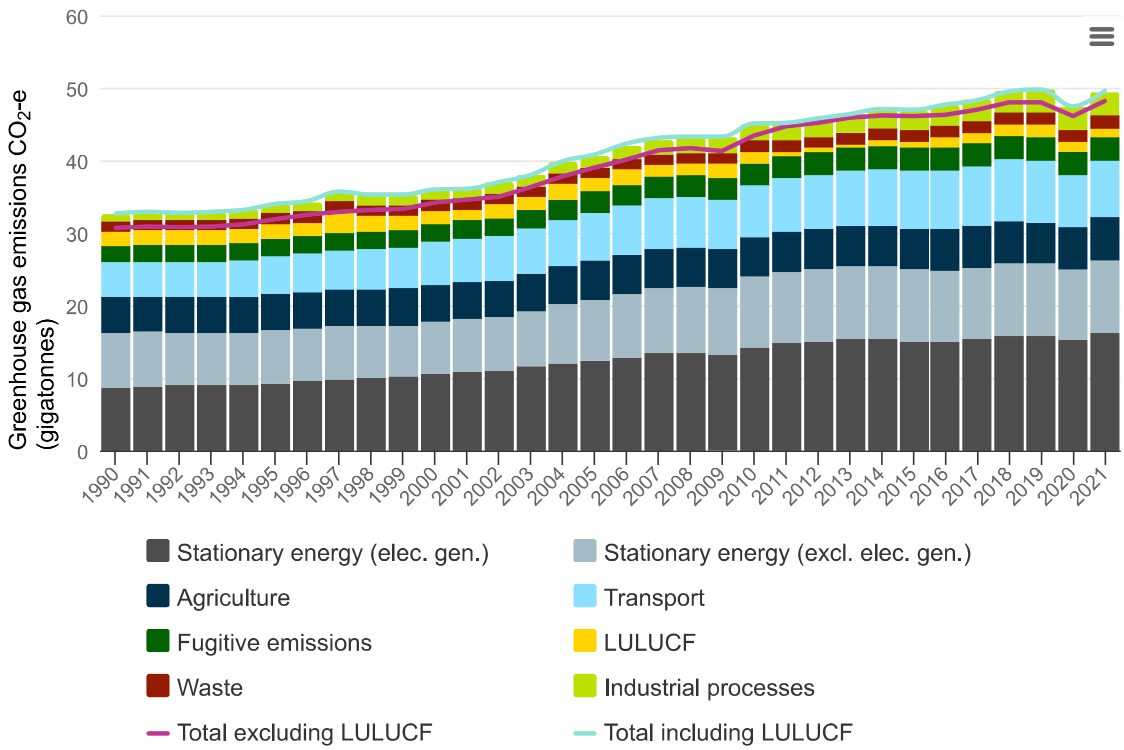
Global greenhouse gas emissions

Global emissions continue to rise, increasing by about 45% between 1990 and 2020, from 32.7 gigatonnes (Gt) of CO_2-e to 47.5Gt CO_2-e (see **Figure A2.2**).

During this period, fossil fuel combustion for electricity generation and transport contributed the most (74%).

Emissions dropped in 2020 owing to effects from the COVID-19 pandemic. Emissions are now almost back to pre-COVID levels (**Canadell et al. 2021**).

Figure A2.2: Global greenhouse gas emissions (Gt CO_2-e), 1990–2021



Notes:
All greenhouse gas emissions (including carbon dioxide, methane, nitrous oxide and others) are expressed as CO -e calculated from global warming potential values from the IPCC Sixth Assessment Report. Global emissions in this figure are reported in calendar years.
LULUCF = Land use, land use change and forestry.

Source:
Climate Watch 2022

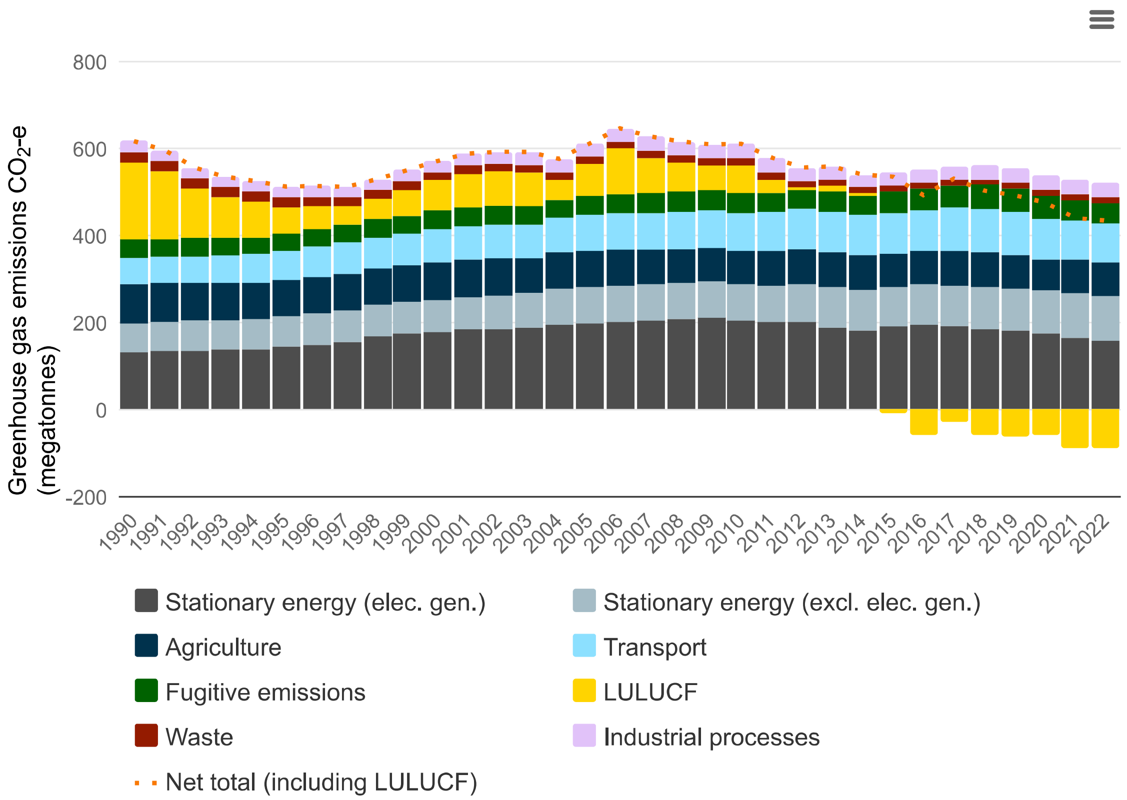
Australian greenhouse gas emissions

It is estimated that net Australian greenhouse gas emissions were 461.7 megatonnes (Mt) CO_2-e in 2021–22 (**DCCEEW-Aus 2024**).

Emissions continued to decline overall (see **Figure A2.3**).

- The land use, land use change and forestry sector has acted as a carbon sink since 2015, whereas it was previously a net emitter.
- Emissions from the stationary energy (excluding electricity generation), transport, agriculture and industrial processes sectors have increased. Therefore, more effort is needed for Australia to reach its net zero targets.

Figure A2.3: Australian net greenhouse gas emissions (Mt CO_2-e), 1990–2022



Notes:
Years shown are financial years and so cover the 12 months ending 30 June of that year. Emissions are based on the UNFCCC classification system used for reporting Australia's greenhouse gas emission inventory. Emissions are expressed as CO2-e calculated from global warming potential values from the IPCC Fifth Assessment Report.
LULUCF = Land use, land use change and forestry.

Source:
DCCEEW-Aus 2024

Australia's emissions are projected to reduce to 358 Mt CO_2-e by 2030 (**DCCEEW-Aus 2023**). This represents a 42% decline relative to 2005 levels. This decline is due primarily to the decarbonisation of the electricity sector.

See the **Net Zero Plan Stage 1: 2020–2030** topic for emissions projections and the **Energy consumption** topic for more information about renewable energy.

NSW greenhouse gas emissions

Net NSW greenhouse gas emissions were 111 Mt CO_2-e in 2021–22, 27% lower than 2005 levels of 153 Mt CO_2-e (**DCCEEW-Aus 2024**).

These emissions peaked in 1989–90 and have since generally trended downward, largely owing to decarbonisation of electricity generation and increased capacity of land use, land use change and forestry as a carbon sink (see **Figure A2.4**).

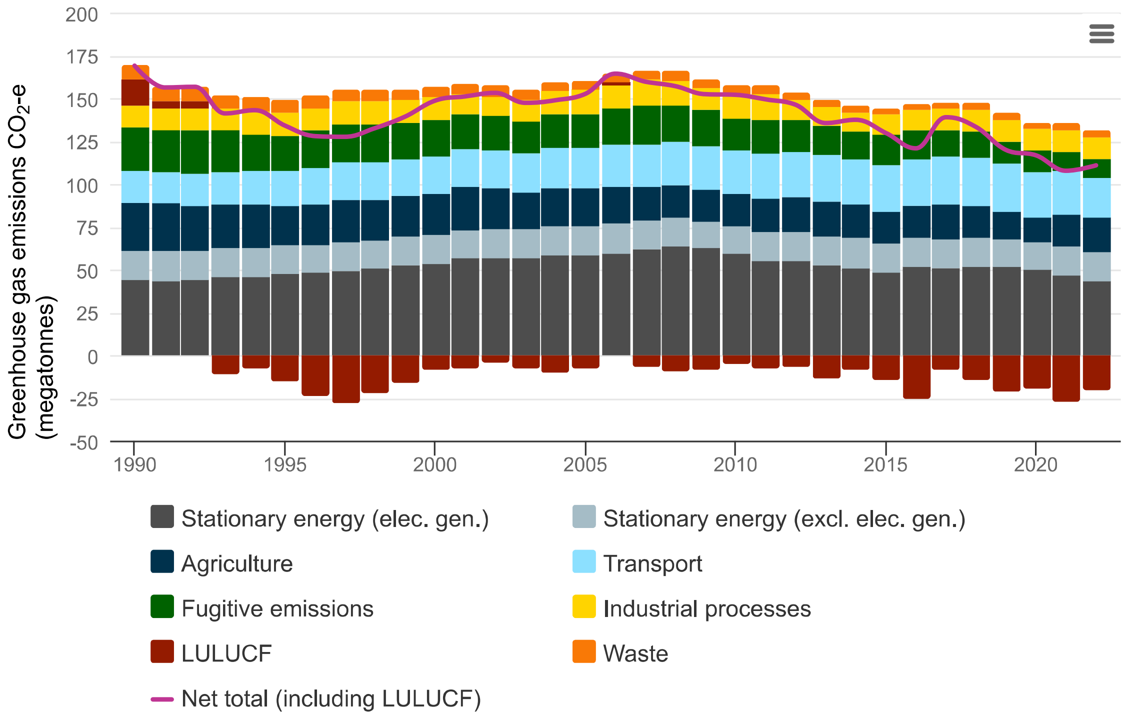
See the **Energy consumption** topic for more information about decarbonisation of the electricity sector.

The findings for different sectors are:

- Stationary energy (electricity generation) emissions remained the biggest contributor (39%) to NSW emissions in 2021–22, followed by transport (21%) then agriculture (18%).

- Stationary energy (electricity generation) emissions decreased by 26% in 2021–22 relative to 2005 levels due to uptake of renewable energy.
- Transport emissions dipped due to COVID-related restrictions in 2020. By 2021–22, they had decreased by 2% relative to 2005 levels.
- Agriculture fell by 7% in 2021–22 relative to 2005 levels. Reducing methane emissions from livestock is technically challenging.
- Waste emissions decreased by 22% in 2021–22 relative to 2005 owing to improved capture of landfill gas (methane) and less waste ending up in landfills.
- The land use, land use change and forestry sector has acted as a carbon sink since 1993, contributing significantly to the reduction in net emissions in NSW.

Figure A2.4: Net NSW greenhouse gas emissions (Mt CO_2-e), 1990–2022



Notes:
Years shown are financial years and so cover the 12 months ending 30 June of that year. Emissions are based on the UNFCCC classification system used for reporting Australia's greenhouse gas emission inventory. Emissions are expressed as CO -e calculated from global warming potential values from the IPCC Fifth Assessment Report.
LULUCF = Land use, land use change and forestry.

Source:
DCCEEW-Aus 2024

NSW emissions continue to slowly decline relative to 2005 levels. Increases in population and economic growth mean there is still more to be done to reach our emissions reduction targets, including our net zero target by 2050.

Emissions are projected to reduce by 44–50% below baseline 2005 levels by 2030 and by 65–70% by 2035 according to NSW DCCEEW's emissions projections update in 2023 (**DCCEEW 2023**).

See the **Net Zero Plan Stage 1: 2020–2030** topic for emissions projections.

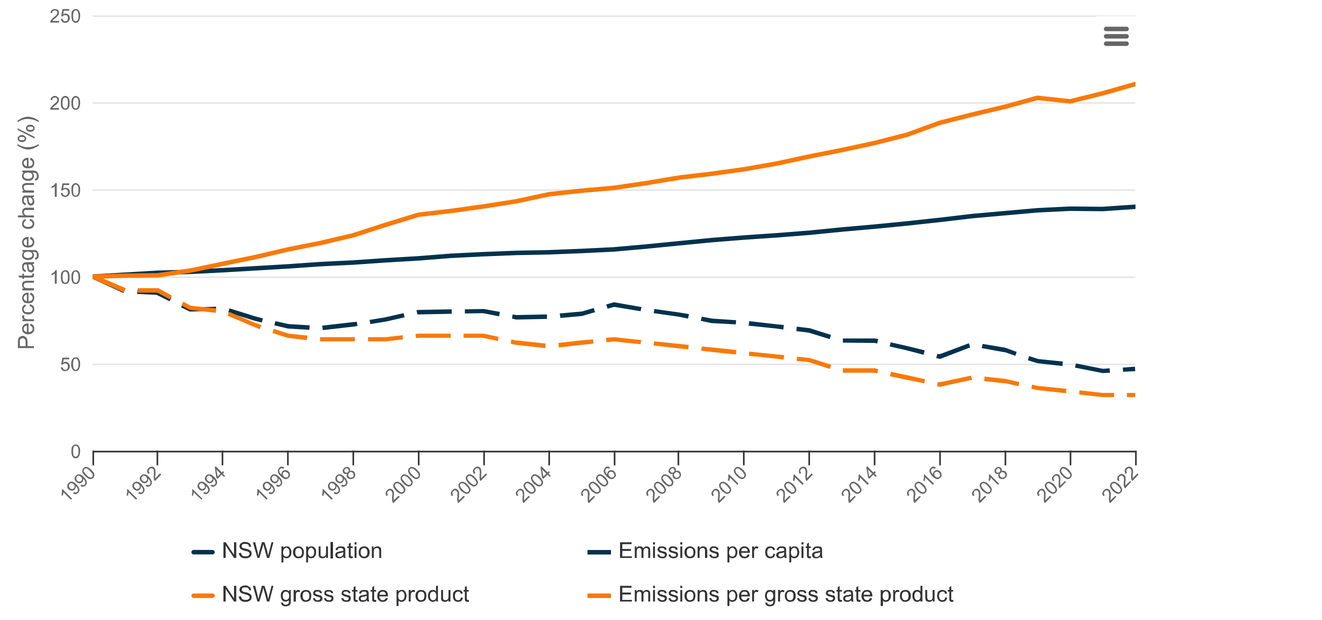
NSW emissions per capita and gross state product

NSW is decoupling emissions from both population and gross state product: even as our population and gross state product grow, advances in technology and structural shifts across the economy continue to reduce net emissions (**Figure A2.4**) and net emissions per capita (**Figure A2.5**).

Decoupling means that an increase in population (or gross state product) does not automatically equal an increase in emissions per capita (or gross state product).

Despite the downward trend, NSW emissions per capita are still far higher than the global average, meaning there is more to be done to continue to decouple these emissions.

Figure A2.5: Change in NSW energy emissions relative to population and gross state product, 1990–2022



Source:
National, state and territory population, Reference period September 2023 (ABS 2024) | National Greenhouse Accounts 2022: State and Territory Greenhouse Gas Inventory (DCCEEW-Aus 2024) | Australian National Accounts: State Accounts (ABS 2023)

The State's population is now almost 8.4 million (**ABS 2023**). A post-COVID-era migration spike saw NSW's annual population growth rate reach 2.3%, the highest since 1950 (**ABS 2023**).

The larger population comes with greater energy use, transport, waste generation and goods production and their associated emissions. Yet since 1990, greenhouse gas emissions per capita have fallen by 47% from 29.12 to 13.66 CO_2-e per capita in 2021–22.

See the **Population and the environment** topic for more information.

The NSW economy, as measured by gross state product, increased by 1.8% in 2021–22 from the previous year, reflecting greater economic activity after bushfires, drought and initial impacts of COVID (**ABS 2023**).

Since 1990, greenhouse gas emissions per dollar of gross state product in the NSW economy have fallen by 68% from 0.5 to 0.16kg CO_2-e per dollar in 2021–22.

See the **Economic activity and the environment** topic for more information.

NSW emissions by greenhouse gas type

During 2005–2022, about two-thirds of NSW net emissions were carbon dioxide (see **Figure A2.6**). Most of these emissions came from burning of fossil fuels and industrial processes.

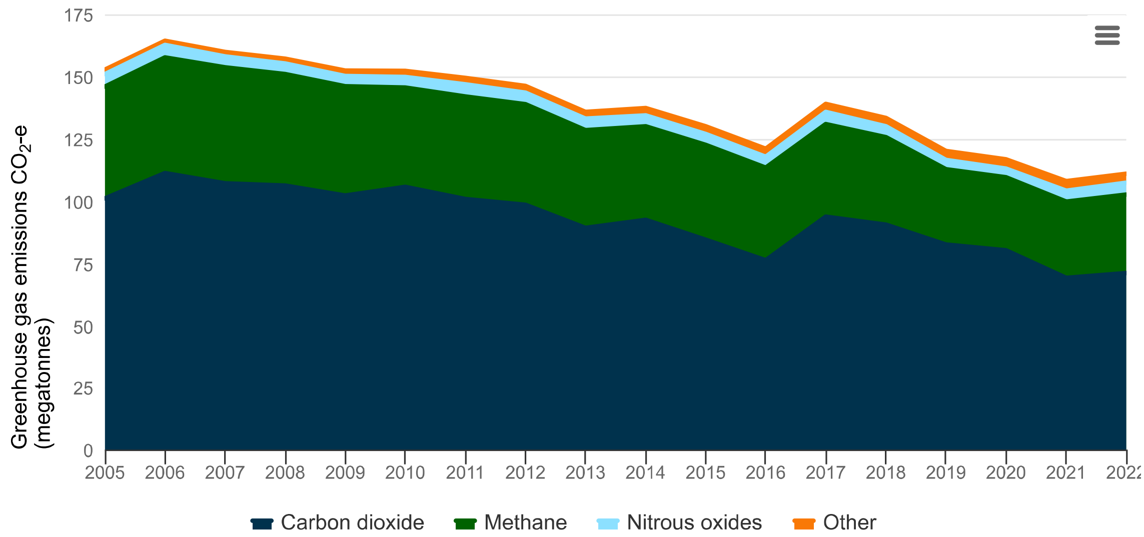
Methane accounted for about 28% of net emissions, mostly from agriculture (sheep and cattle digestive processes) and fugitive emissions from the extraction and transport of coal, oil and natural gas.

While methane is a powerful greenhouse gas, it's lifetime in the atmosphere is relatively short. This suggests that reducing methane emissions could quickly slow down the rate of global warming. Australia is signatory to the **Global Methane Pledge**, which is about taking fast global action on reducing methane emissions.

Nitrous oxide accounted for about 3% of net emissions, mostly from pastures and crops using nitrogen fertilisers.

As carbon dioxide emissions decline because of less fossil fuel burning, attention must be turned to reducing hard-to-reduce methane and nitrous oxide emissions.

Figure A2.6: NSW greenhouse gas emissions by type of gas (Mt CO_2-e), 2005–22



Notes:
Years shown are financial years and so cover the 12 months ending 30 June of that year.
'Other' gases include hydrofluorocarbons, perfluorocarbons, sulphur hexafluoride.

Source:
National Greenhouse Accounts 2022: State and Territory Greenhouse Gas Inventory (DCCEEW-Aus 2024)

Pressures and impacts

Population and economic activity

As the NSW population grows and economic activity increases, effects on emissions will continue.

While the energy sector is decoupling from these drivers, it is still, to date, based primarily on fossil fuels. This means that reductions in emissions from the decarbonisation of energy sources may be tempered by the overall increase in demand.

Emissions from agriculture, transport and waste are expected to increase with population and economic activities. Economic pressures will influence decision-making in industries, such as mineral and coal mining (see the **Decarbonising high emitting industries** section below for more details).

See the **Population and the environment**, **Economic activity and the environment**, **Energy consumption** and **Net Zero Plan Stage 1: 2020–2030** topics for more information.

Decarbonising high emitting industries

NSW's **high emitting industries** in the mining and manufacturing sectors are a crucial part of the State and national economies.

Decarbonising these industries is challenging because implementing cleaner alternatives to existing processes are sometimes too costly or not yet possible with current technology.

Achieving decarbonisation in these industries will require ongoing investment on assets, infrastructure and low-carbon fuels.

Economic pressures contributing to the complexity of decarbonising heavy industry must also be considered.

For instance, the mining industry contributes to NSW economic activity, especially in regional areas. Certain mines are essential to producing emissions-reducing technologies such as electric vehicle batteries, as they are a source of critical minerals, such as copper, lithium and cobalt.

Fossil fuel-powered transport

Transport is on track to be the highest greenhouse gas emitter in NSW in 2030, accounting for 25% of the State's total emissions by that time.

See the **Net Zero Plan Stage 1: 2020–2030** and **Transport** topics for more information.

The transport sector's decarbonisation relies on increasing the number of low- or zero-emissions vehicles. These include electric vehicles (EVs), which are powered entirely by electricity stored in batteries, plug-in hybrid EVs that can run on both traditional fuel and electricity, and hydrogen fuel-cell EVs. Vehicles powered solely by renewable energy do not emit greenhouse gases.

Although the number of EVs in NSW have doubled between 2022 and 2024, EVs are a small fraction of the total number of vehicles (**BITRE 2024**). As of January 2024, EVs made up just 0.8% (52,572) of road vehicle registrations in NSW (**BITRE 2024**).

Existing barriers, such as high upfront cost and limited charging infrastructure are preventing the uptake and widespread use of EVs. The introduction of the ***NSW Electric Vehicle Strategy*** and the Commonwealth Government's New Vehicle Efficiency Standard are aiming to overcome these barriers.

Other forms of transport, such as heavy road vehicles, shipping and aviation, currently have limited low emissions alternatives that are cost effective.

Lack of economical emission reduction technology means that aviation emissions are projected to more than double from 0.8Mt CO_2-e in 2020–21 to 2Mt CO_2-e in 2029–30. This adds to the challenge of decarbonising the transport sector.

See the **Transport** topic for more information.

Agriculture and land clearing

The production of both livestock and crops is projected to increase in NSW as our population continues to grow.

Producers already have options to optimise pasture quality and herd productivity. Options to reduce methane production by livestock, the largest contributor to agricultural emissions, are limited.

Technologies are not yet commercially available, and landholders face significant barriers to cost or implementation.

The clearing of primary forest (defined as land which has been forest since 1972) has declined since 1990. Reducing it further remains an important focus for reducing greenhouse gas emissions as it affects the future potential for carbon sequestration (capturing and storing atmospheric carbon dioxide) by the land sector, an important carbon sink.

The clearing of secondary forest or regrowth remains high.

The potential role of carbon offsets through tree planting may be at risk, as some farming groups worry that such action could drive up land prices by competing for land used for agriculture.

See the **Plants** topics for more information regarding land clearing.

Responses

Mechanisms have been put in place to ensure the delivery of renewable energy infrastructure and to better manage energy demand in NSW.

These mechanisms will advance decarbonisation in the energy sector and maximise reductions in emissions.

NSW may fall short of its emission targets owing to challenges in decarbonising key sectors, especially under pressures from population and economic growth.

Research and innovation have been funded to develop technology for hard-to-reduce emissions, in line with recently legislated emission targets and climate commitments.

Implementing legislation and policies

The ***Climate Change (Net Zero Future) Act 2023*** legislated the State's emission reduction targets (see **Table A2.2** for reduction targets) and created the independent Net Zero Commission.

The Net Zero Commission will direct the State's progress towards net zero emissions. Implementation across government is anticipated to drive action in key sectors, including electricity, manufacturing, transport and agriculture.

The NSW Net Zero Plan Stage 1: 2020–2030 was released in 2020 as the foundation of the State's action on climate change and goal to reach net zero emissions. It is monitored and updated as global and national trends in policy and technology evolve.

See the **Net Zero Plan Stage 1: 2020–2030** topic for more information.

The NSW Environment Protection Authority (EPA) has a critical role in protecting the environment from the threat of climate change and supporting NSW to achieve its net zero emissions target by 2050.

The EPA's **Climate Change Policy and Climate Change Action Plan 2023–26** supports and builds on the NSW Government's climate change policies and initiatives, helping industry to decarbonise and build greater preparedness and resilience to climate change risks.

Some of the key actions include supporting industries to prepare climate change mitigation and adaptation plans, and publishing industry-specific guidance on best practice in emissions reduction. The EPA is also establishing a greenhouse gas monitoring network, particularly for fugitive methane emissions.

Ensuring energy supply and managing demand

The **NSW Electricity Infrastructure Roadmap** is the State's 20-year plan to transform our electricity system.

This transition to net zero includes:

- supporting the private sector to deliver at least 12 gigawatts of new renewable energy generation and 2 gigawatts of long-duration storage by 2030. A new target of an additional 12 gigawatt hours by 2034 was announced in October 2024 (**DCCEEW 2024**)
- implementing five **Renewable Energy Zones,** for the generation, storage and transmission of renewable energy to homes, businesses and industry

The **NSW Energy Security Safeguard** helps ensure our energy system is more reliable, affordable and sustainable. The schemes within the safeguard create incentives to deliver cost-effective energy savings, reduce peak demand and increase the production of green hydrogen.

See the **Energy consumption** topic for more information.

Reducing transport emissions

The **NSW Electric and Hybrid Vehicle Plan** is helping to kickstart electric vehicle (EV) uptake.

This plan supports electrifying the State Government fleet, installing charging infrastructure and raising awareness through an online NSW EV guide.

The ***NSW Electric Vehicle Strategy*** commits to a 2035 target for most new cars sold to be battery or fuel cell EVs. Financial incentives were available for EV purchases from September 2021 to December 2023 (**ATO 2024**). There is ongoing work to fully electrify NSW Government passenger fleet by 2030 and develop fast charging stations across NSW, among other initiatives.

See the **Transport** topic for more information on EVs and the **Net Zero Plan Stage 1: 2020–2030** topic for updates on the State's EV strategy.

Reducing industry emissions

Funding for high emitting industries

NSW's **Net Zero Industry and Innovation Program** is the State's approach to support the manufacturing and mining sectors to decarbonise. It has funding opportunities for three focus areas:

- building infrastructure and increasing the capability of NSW supply chains for low emissions industries

- transitioning plant, equipment and other assets to low emission alternatives
- clean technology innovations to progress from the laboratory to the real world.

Developing a green hydrogen industry

The ***NSW Hydrogen Strategy*** is a plan to develop a green hydrogen industry in NSW. Green hydrogen is a clean fuel derived from splitting water in a process called electrolysis. It can drive decarbonisation in not just in the industrial sector, but also in the transport and energy sectors.

Green hydrogen technology is developing rapidly. Over $100 million has been allocated to develop **hydrogen hubs** in the Hunter, Illawarra and Moree regions. These hubs are where producers and users of green hydrogen are located together.

Generating carbon credits

The **NSW Primary Industries Productivity and Abatement** program supports farmers and land managers to reduce emissions, improve carbon management and enhance biodiversity on their land.

The program funds projects to register carbon reduction activities and generate and generate Australian Carbon Credit Units (ACCUs), which are bought and sold in the carbon offsets market. In 2023, the NSW Government awarded $6.8 million to **six project partners in the NSW primary industries and land sector**.

The creation of ACCUs could provide additional revenue for farmers and land managers.

Of note, ACCUs can be generated through other methods including energy efficiency, reducing landfill and waste emissions, and carbon capture and storage, among others.

See the Australian Government **Clean Energy Regulator website** for more information about ACCU scheme methods.

See the **Net Zero Plan Stage 1: 2020–2030** topic for more details and updates on the *Net Zero Industry and Innovation Program*, *NSW Hydrogen Strategy* and *NSW Industries Productivity and Abatement Program*.

Future opportunities

About 35% of emission reductions needed to reach global net zero emissions by 2050 come from technologies that are still in development (**IEA 2023**).

The **NSW Decarbonisation Innovation Study 2023**, developed by the Office of the NSW Chief Scientist and Engineer, provides valuable insight into the opportunities for NSW to reduce emissions and capitalise on its competitive advantages to transition and grow the economy.

Identifying the State's competitive advantages can help direct resources to key areas. The study identifies these advantages across key factors of production:

- **Policy landscape and certainty** – enables businesses to make long-term plans, fostering growth and innovation.
- **Economy structure and reduced exposure to global risks** – a diversity of industry sectors in NSW, including finance, manufacturing, tourism and services, helps mitigate risks from global economic fluctuations.
- **Natural resources and infrastructure assets –** rich wind, solar, hydro and bioenergy resources help directly decarbonise the energy sector and offer indirect electrification across the economy.
- **Innovation and research capability** – NSW hosts world-class research infrastructure, which attracts leading expertise to contribute to research projects and to collaborate with business.
- **A strong intellectual property framework** – encourages researchers and entrepreneurs to bring ideas to market and stimulates further innovation.
- **Education and workforce** – internationally recognised universities provide employees with the skills needed to adapt to evolving industries.
- **Industry and business capacity** – NSW has a strong track record of exporting goods and services to international markets supported by established ports, transportation networks and trade infrastructure.

The study outlines 47 broad foundational and sector-specific opportunities to help NSW to continue evolving its approach to the net zero transition.

It highlights several opportunities and next steps that relate more directly to emission reduction:

- **Circular economy** – accelerating decarbonisation progress through local supply of recycled/reused/repurposed clean economy technologies, materials and goods.
- **Clean sustainable fuels and energy carriers** – maximising sector-coupling opportunities enabled by 'Power-to-X' technologies (which convert renewable energy and sustainable materials into power fuels and clean chemicals) for accelerated rollout of renewable energy projects to decarbonise hard-to-reduce industries.
- **Energy efficiency and productivity** – implementing energy-efficient technologies, optimising industrial processes and adopting energy-saving practices to reduce energy waste, reduce emissions and enhance competitiveness.
- **Electric mobility and services** – developing and deploying technologies and services to support a multi-modal approach to transport.
- **Long-haul transport and non-road machinery** – developing and deploying alternative fuel technologies with supporting infrastructure for hard-to-electrify transport.
- **Embodied carbon for building and infrastructure** – developing and deploying low-emission construction materials and technologies, and using government procurement to increase uptake of low-emission construction materials and modular designs.
- **Biomanufacturing and synthetic biology** – advancing bioengineering technologies, processes and services in simple organisms (such as algae and yeast) for low-carbon materials and products.
- **Agri-tech and decarbonisation** – developing and deploying agricultural technology and enabling technologies to support agriculture and land decarbonisation.

The study notes the continued importance of strong leadership and collaborative efforts between researchers, industries, communities and governments in driving further innovation, scaling up decarbonisation efforts and achieving ambitious climate targets.

The NSW Government routinely updates policies and strategies to incorporate the State's emission reduction goals and targets. Stages 2 and 3 of the ***Net Zero Plan Stage 1: 2020–2030*** will be developed ahead of 2030 and 2040, respectively.

The ***State Infrastructure Strategy***, ***Future Transport Strategy 2056***, ***Greater Sydney Region Plan*** and other **regional plans** will be updated to ensure that they continue to deliver on good environmental outcomes.

References

ABS 2023, National, state and territory population, Australian Bureau of Statistics, accessed February 2023

ABS 2024, National, State and territory population, Australian Bureau of Statistics, accessed 28 October 2024

ATO 2024, Instant asset write-off for eligible businesses, Australian Tax Office, accessed February 2024

BITRE 2024, *Road Vehicles: Australia January 2024*, Bureau for Infrastructure and Transport Research Economics

BOM & CSIRO 2022, *State of the Climate Report 2022*, Bureau of Meteorology and Commonwealth Scientific and Industrial Research Organisation, Canberra

Canadell P, Le Quéré C, Peters G, Friedlingstein P, Andrew R & Jackson R 2021, Global emissions almost back to pre-pandemic levels after unprecedented drop in 2020, new analysis shows, *The Conversation*, accessed 18 August 2024

Climate Watch 2022, *Historical GHG Emissions: 2021*, World Resources Institute, accessed April 2022

DCCEEW-Aus 2023, Australia's emissions projections 2023, Australian Government Department of Climate Change, Energy, the Environment and Water, Canberra

DCCEEW-Aus 2024, State and Territory greenhouse gas inventories: 2022 emissions, Australian Government Department of Climate Change, Energy, the Environment and Water, accessed on 19 August 2024

DCCEEW 2023, NSW Greenhouse Gas Emission Projections, 2022–2050, accessed from The Sharing and Enabling Environmental Data Portal, NSW Department of Climate Change, Energy, the Environment and Water, Sydney

DCCEEW 2024, *Position paper: Long Duration Storage Review*, NSW Department of Climate Change, Energy the Environment and Water, Sydney

Forster PM, Smith C, Walsh T, Lamb WF, Lamboll R, Hall B, Hauser M, Ribes A, Rosen D, Gillett NP, Palmer MD, Rogelj J, von Schuckmann K, Trewin B, Allen M, Andrew R, Betts RA, Borger A, Boyer T, Broersma JA, Buontempo C, Burgess S, Cagnazzo C, Cheng L, Friedlingstein P, Gettelman A, Gütschow J, Ishii M, Jenkins S, Lan X, Morice C, Mühle J, Kadow C, Kennedy J, Killick RE, Krummel PB, Minx JC, Myhre G, Naik V, Peters GP, Pirani A, Pongratz J, Schleussner C-F, Seneviratne SI, Szopa S, Thorne P, Kovilakam MVM, Majamäki E, Jalkanen J-P, van Marle M, Hoesly RM, Rohde R, Schumacher D, van der Werf G, Vose R, Zickfeld K, Zhang X, Masson-Delmotte V & Zhai P 2024, 'Indicators of Global Climate Change 2023: annual update of key indicators of the state of the climate system and human influence', *Earth System Science Data*, vol. 16, no. 6, pp. 2,625–58

IEA 2020, CO2 Emissions from Fuel Combustion: Highlights – 2020 Edition, International Energy Agency, accessed February 2021

IEA 2023, Reaching net zero emissions demands faster innovation, but we've already come a long way, International Energy Agency, accessed 28 October 2024

IPCC 2014, *AR5 Synthesis Report: Climate Change 2014, Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* in Core Writing Team, R.K. Pachauri and L.A. Meyer (eds), Intergovernmental Panel on Climate Change, Geneva, Switzerland, pp. 151

IPCC 2021, 'SPM: Summary for Policymakers' in Masson-Delmotte V, Zhai P, Pirani A, Connors SL, Péan C, Berger S, Caud N, Chen Y, Goldfarb L, Gomis MI, Huang M, Leitzell K, Lonnoy E, Matthews JBR, Maycock TK, Waterfield T, Yelekçi O, Yu R, and Zhou B (eds), *Climate Change 2021: The Physical Science Basis, Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 3–32

IPCC 2023, 'Summary for Policymakers' in Lee H and Romero J (eds), *Climate Change 2023: Synthesis Report, Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Intergovernmental Panel on Climate Change, Geneva, Switzerland, pp. 1–34 doi:10.59327/IPCC/AR6-9789291691647.001

Ritchie H, Rosado P & Roser M 2023, CO_2 and Greenhouse Gas Emissions, Our World In Data, accessed 28 October 2024

WMO 2024, *Greenhouse Gas Bulletin No. 20: The State of Greenhouse Gases in the Atmosphere Based on Global Observations through 2023*, World Meteorological Organisation, Geneva

This page intentionally
left blank

Biodiversity

soe.epa.nsw.gov.au

This page intentionally left blank

Biodiversity

Australia has a rich native biodiversity, and is home to more than 1 million species of plants and animals, many of which are found nowhere else on earth. When biodiversity is lost, it can lead to ecosystem destabilisation, economic impacts and loss of Aboriginal cultural values.

The topics in this theme describe **plants**, **animals** and **Health of Country.**

Plants

Plants play a vital role in supporting all life on earth. The continuing decline of native vegetation threatens the health of humans, wildlife and ecosystems.

Animals

NSW is home to about 905 native animal species, many of which are found nowhere else. The number of these species listed as ‘threatened’ continues to grow.

Health of Country

Country is everything - the people, plants, animals, air, soil, rocks and the relationships between them. Many Aboriginal people are using cultural knowledge to restore Country.

The ability of NSW vegetation to support native plants, animals and ecosystems has fallen to

29%

of natural levels before industrialisation

The number of threatened animal species listings increased by

18

since 2021

As at August 2024, there were

15

community-led Indigenous Ranger groups in NSW

Introduction to biodiversity

All the elements have Lore, cultural Lore, right LORE.

We need to protect the biodiversity within the Australian landscapes otherwise we're just going to be one big flat Country like other places, void of trees and habitat for our native creatures.

Aboriginal knowledges can contribute to the development of methods to conserve and care for the biodiversity within the Country's ecosystems.

Plants

Plants form the basis of most ecosystems and play a vital role in supporting all life on earth. They provide environmental services that support the environment and our everyday lives, such as filtering water and air, as well as supporting many recreational activities.

Plants are important sources of food, medicine and cultural material for Aboriginal peoples. Ensuring the ongoing health of plants is a critical part of caring for Country.

Ecosystems function as the habitat for all species, interconnecting all living organisms. Reduction in the number of plant species will directly affect other species. For example, the disappearance of a plant species from its ecosystem can break the food chain, eventually leading to ecosystem collapse.

Forests are known as the lungs of the earth. They mainly consist of trees and shrubs. They offer myriad ecosystem services, regulate global climate and provide habitat for countless species.

Identifying and protecting threatened plant species is vital to protect local biodiversity.

Land clearing, pollution, invasive species and climate change are major threats to plant biodiversity.

Key findings from the 2024 report

- The extent of native vegetation cover declined during 2021–24. Woody native vegetation extent fell from 49.8% in 2021 to 49.6% in 2024; and non woody vegetation fell from 19% in 2021 to 17.9% in 2024. These figures relate to vegetation cover where the plant community structure has not been substantially altered.
- The Australian National University's Australia's Environment 2023 report noted that woody native regrowth in NSW has been favourable in wet years.
- The clearing rate of woody native vegetation remains significantly higher than before the regulatory reforms of 2016–17.
- The ability of remaining habitats in NSW to support native plants, animals and ecosystems has dropped to 29% of their original capacity since pre-industrialisation. The 2019–20 bushfires accelerated the loss in affected areas.
- Modelling undertaken in the assessment of the NSW Biodiversity Indicator Program predicts that, without effective management, only 50% of the 657 plant species listed as threatened are predicted to survive in 100 years' time.
- Rates of native forestry harvesting have declined by 61% since 2017.
- This topic's 'extent of native vegetation' and 'clearing of native vegetation' indicators align to the 'land system change' planetary boundary. Globally, this boundary has been crossed (see **Planetary boundaries alignment**).
- This topic's 'ecological carrying capacity' and 'number of threatened species listed' indicators align to the 'biosphere integrity' planetary boundary. Globally, this boundary has been crossed (see **Planetary boundaries alignment**).

Animals

Animals are closely linked to the overall health and functioning of ecosystems. The loss of any animal species will destabilise ecosystems and affect other species. For example, a plant may rely on an insect species to pollinate its flower. Pollination cannot occur if that insect species declines or dies out.

Many animals living in Australia are found nowhere else.

Native animals hold significant cultural values for Aboriginal peoples, serving as vital totems that embody their connection to Country. Protecting these totems is a cultural obligation, as the survival of native animals and their cultural values contributes to the balance and harmony of Country and culture.

Many of these native animal species are threatened. This means they are at high or very high risk of becoming extinct. This number increases every year as population and distribution decline.

The main threats to the survival of species are habitat destruction through the clearing of native vegetation, competition and predation by invasive species, pollution from human activities and climate change.

Key findings from the 2024 report

- The number of threatened animal species listings in NSW continues to increase, with 18 species added between December 2020 and June 2024, bringing the total to 343.
- Across NSW, the distribution of native land mammals is continuing to decrease.
- Australia has lost more mammal species than any other continent in the last 200 years, contributing to about one-third of mammal extinctions globally.
- While native birds have been more resistant to declines than native mammals, their populations are also declining.
- The number of critically endangered native fish in NSW has increased.
- After 30 years of work, invasive mammals have been successfully controlled on all NSW offshore islands, with continued monitoring and ecosystem recovery now taking place.
- Modelling in the assessment of the NSW Biodiversity Indicator Program undertaken in 2017 predicts that only 496 (or 50%) of the 991 land species listed as threatened are predicted to survive in 100 years' time
- Invasive species continue to exert pressure on native plants and animals. New threats, such as red fire ants, will continue to pose significant biodiversity risks if not eradicated. They also bring substantial economic costs of managing and controlling infestations
- Some good outcomes have been reported, including:
    - Northern populations of the Booroolong frog are recovering following captive breeding and reintroduction efforts.
    - Yellow-footed rock wallaby numbers are rebounding from 100 animals in 2003 to 299 in 2023.
    - For the first time in 20 years Glossy black cockatoos have been discovered in their previous distribution on the mid-north coast.
    - Koalas are recolonising unburnt and partially burnt sites from the 2019 bushfires.
- The density of certain bat species (amount of bats per hectare) is increasing in the Chichester State Forest.
- This topic's indicators (apart from 'invasive animals species: distribution and impact') align to the 'biosphere integrity' planetary boundary. Globally, this boundary has been crossed (see **Planetary boundaries alignment**).

Health of Country

Country is everything in the landscape, the people, plants and animals as well as the air, soil and rocks. It is also the relationships between them, the connection of ecological systems and biodiversity. Caring for Country is more than just caring for the environment, it is taking care of Country as if it is kin.

Aboriginal people value biodiversity. Culturally significant species provide food and medicine and signal the health of Country. Greater inclusion of Aboriginal knowledges will help to manage these species and safeguard the biodiversity of Country.

Aboriginal knowledges about seasons and Cultural Fire practices have shaped the management of land for tens of thousands of years. Aboriginal peoples' involvement in caring for Country continues to increase, using cultural knowledge and practices to protect biodiversity and maintain cultural sites and practices.

Key findings from the 2024 report

- Truth telling is an important part of healing. Country needs the truth to be told.
- Many Aboriginal people, organisations and community are leading the way in how biodiversity should and could be better managed.
- Cultural Fire practices are being revived by Aboriginal communities to improve the health of Country and communities. Their value in reducing risk of bushfires and improving ecosystem health is increasingly understood across government agencies and within the broader mainstream community, though there are still significant barriers.
- There is currently very limited formal recognition of the rights and interests of Aboriginal peoples in environmental protection and biodiversity conservation in NSW including protection of culturally significant species. However, some notable innovative programs that partner with Aboriginal peoples to protect cultural values on public and private lands have been developed in the past three years.
- Community based Indigenous Rangers programs have been highly successful in ecological, and socio-economic outcomes over the past 25 years. In NSW all community rangers are funded by the Commonwealth. NSW is one of only two jurisdictions in Australia that does not fund an Indigenous Ranger program.

Plants

Plants play a vital role in supporting all life on earth. The continuing decline of native vegetation threatens the health of humans, wildlife and ecosystems.

Overview

The number of threatened plant species listings increased by

18

between 2020 and 2024, bringing the total to 657

Read more

The ability of NSW vegetation to support native plants, animals and ecosystems has fallen to

29%

of natural levels before industrialisation

Read more

Plants are essential for maintaining life on earth. Plants filter water, stabilise soils and provide vital animal habitat. They give other living beings food, fuel, medicine, fibre for clothes and material for shelter (**AdaptNSW n.d.**). As living organisms, they also have their own intrinsic value (**Martín-López 2024**).

For millennia, Aboriginal peoples have maintained a deep and intricate relationship with plants, having developed scientific understandings of the often complex cultivation of plants for food, medicine and technology (**Cumpston 2020**).

Plants contribute to the comfort and wellbeing of other living beings. They provide shade in cities when there are few other features to protect against the sun. They also make human beings feel good. There are physical and mental benefits to spending time among trees and nature, and working in gardens (**Pantiru et al. 2024**).

Plants take in energy from the sun, carbon dioxide from the air and water from the soil. They convert these into oxygen, which is released back into the air, and sugars, which contain carbon. They store these sugars in their stalks, tubers and leaves to use as food.

Forests are often referred to as 'carbon sinks', because the plants and trees in them remove and store more carbon than they produce (**UNECE n.d.**). This is how plants and trees help reduce overall greenhouse gas emissions.

See the **Greenhouse gas emissions** topic for more information about carbon sinks.

This topic focuses on land-based plants.

Freshwater aquatic plants are discussed in the **Rivers and wetlands** topic, and coastal and marine plants are considered in the **Coastal and marine** topic.

Native vegetation

The plant species that occur naturally in a place are described as 'native'. Plants that are native to a specific region and not found anywhere else are called 'endemic'.

Australia has about 26,000 species of native plants (**Gallagher et al. 2021**). This includes more than 6,000 native vascular plants (ferns, cycads, pines and flowering plants) in NSW (**BGS n.d.**), of which about 1,300 are endemic (**Gallagher et al. 2021**).

Image B1.1: Waratah in Gibraltar Range National Park

Notes:
Several species of waratah, including *Telopea aspera* (pictured) are endemic to NSW.

Source:
Barbara Webster/DCCEEW

Many native plants have evolved to thrive in a unique and sometimes harsh climate through geological time (**DAFF 2012**).

There is a long history of Aboriginal cultural burning working in harmony with native vegetation.

See 'Cultural Fire management' in the **Health of Country** topic for more information on Cultural Burning.

Threats to native plants

Land management practices and policies in NSW have put native vegetation under enormous pressure, with clearing for agriculture mostly unregulated in the State before 1990 (**Heagney et al. 2021**).

The impacts of long-term land clearing and development have reduced the quantity and quality of native vegetation, while increasing the distance between remaining fragments.

More fragmented vegetation makes it hard for animals to move and plants to spread between areas to access resources and reproduce (**Lindenmayer & Dickman 2022**).

Even when native vegetation regrows after disturbance, it can take some time for it to regain its full structure and provide suitable habitat.

Other pressures, including invasive weeds, disease and animal pests are further reducing vegetation quality.

Climate change is increasing these pressures, as well as increasing the risk of heatwaves, bushfires, droughts and floods.

Species may risk dying out if they:

- cannot tolerate or adapt to climate change
- cannot move or spread between areas of suitable habitat.

The result is a loss of biodiversity and declines in ecosystem health.

Ecosystems are communities of plants, animals and invertebrates that rely on each other for food, habitat, breeding and survival.

Within NSW, the ability of remaining habitats to support native plants, animals and ecosystems has dropped to 29% of their original capacity (**DCCEEW 2024b**).

Caring for Country

Plants are of immense importance to Aboriginal peoples. Plants are not only important sources of food, medicine and cultural material but ensuring the ongoing health of plants is a critical part of caring for Country.

For millennia, Aboriginal peoples have maintained a deep and intricate relationship with plants and developed complex botanical knowledge that was essential to the survival of the world's oldest living culture (**Cumpston 2020**).

Ensuring the health of Country depends on a deep knowledge of how to look after plant species. For example, this includes understanding how introducing Cultural Fire to a landscape will impact on different plant species.

Knowledge of bush foods (bush tucker) has long been shared by Aboriginal peoples. More recently, evidence of the practice of native grain cultivation by Aboriginal peoples has been revealed and has inspired revival of these practices.

Aboriginal peoples may also look to life cycles of local plant species as indicators of seasonal changes and animal movements and migrations.

See the **Health of Country** topic and **Voice of Country** theme for more information about caring for Country.

Monitoring and classifying native vegetation

To manage and protect native vegetation in NSW, people need to understand its type, quantity (extent) and quality (condition and connectedness).

Native vegetation is monitored for a variety of reasons, including to:

- report annually on the loss of native vegetation due to clearing for agriculture, urban and industrial development, forestry, and infrastructure
- assess if land holders or developers are complying with land clearing regulatory requirements
- detect trends in the condition of native vegetation
- understand whether management actions have been effective in conserving or improving the quality and quantity of native vegetation.

To monitor the conservation status of native vegetation effectively and consistently, the NSW government has surveyed native vegetation on the ground using standardised methods.

Native vegetation is categorised into groups of plant species that grow together in the same place. The extent of these groups before clearing is extrapolated from existing vegetation remnants, geology, geomorphology, topography and other factors.

The resulting map is overlain with a map of the current extent of native vegetation to provide an estimate of the remaining extent for each type.

In NSW, native vegetation is **classified** into a three-level hierarchy, starting with the broadest classification at the top and working down to the most complex and detailed at the bottom, as follows:

- vegetation formations (broad groups with characteristics in common, such as grassy woodlands)
- vegetation classes (related plant communities)
- types of plant community (**most detailed level**).

Plant community types are the preferred ways of describing and discussing native vegetation in NSW. They form the basis for **State Vegetation Type Maps**, and are used to assess plant species' biodiversity value in the **Biodiversity Offsets Scheme**.

The NSW Government's vegetation mapping and landcover data collections and imagery help to measure, monitor and compare the type, extent and condition of vegetation and land use across NSW.

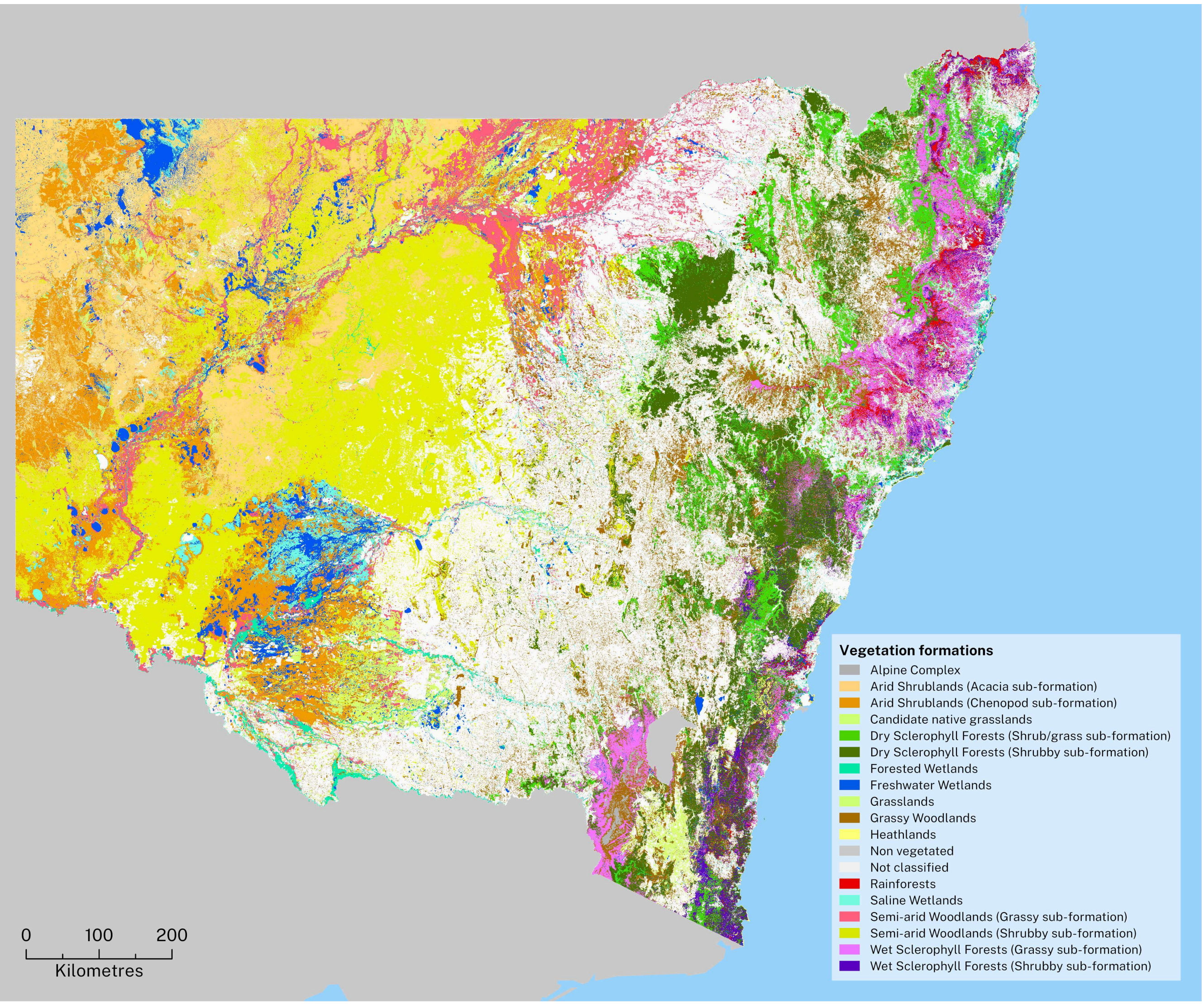
See the **landcover science** website for more information.

State Vegetation Type Mapping includes analysis of how much native vegetation remains in NSW. Vegetation mapping can also be accessed in the **Trees Near Me NSW app**.

The State Vegetation Type Map is the most complete and consistent representation of the distribution of plant community types across NSW. **Map B1.1** shows vegetation formations – broad groups of plants distinguished by major structural and physiognomic features (relating to physical appearance or form).

The areas shown in white are predominately used for infrastructure, housing and agriculture and therefore are not assigned a native vegetation formation (see '**Extent of Native Vegetation**').

Map B1.1: State Vegetation Type Map



Source:
NSW State Vegetation Type database

Protecting and repairing native vegetation

Protections for native vegetation under NSW legislation include, but are not limited to:

- public conservation areas reserving native vegetation
- identification and protection of vulnerable native vegetation on public lands
- identification and protection of threatened species and ecological communities on private and public land
- government investment in private land conservation
- regulation of land clearing
- regulation of native forestry on public and private land
- fire, water, disease, pest and weed management requirements
- offsetting impacts of clearing or development through the **Biodiversity Offsets Scheme**.

See the **Protected areas and conservation** topic for more information.

Table B1.1 outlines key legislation and policies related to protecting and managing native vegetation in NSW.

Table B1.1: Current key legislation and policies relevant to native vegetation in NSW

Legislation or policy	Purpose
Biodiversity Conservation Act 2016	Aims to protect biodiversity and fosters a productive, resilient environment while enabling ecologically sustainable development
Environmental Planning and Assessment Act 1979	Governs planning administration and laws, development assessments, building certification, infrastructure finance, appeals and enforcement. It is the primary land use planning statute in NSW.
Forestry Act 2012	Provides for the dedication, management and sustainable use of State forests and other Crown-timber land for forestry and other purposes. Establishes the framework for integrated environmental approvals for native forestry operations on Crown timber lands
Local Land Services Act 2013	Governs management of natural resources, biosecurity and agricultural production on private rural land. Part 5A of the Act sets out rules for managing native vegetation on farms. Part 5B sets out the rules for private native forestry
National Parks and Wildlife Act 1974	Aims to conserve the natural and cultural heritage of the state of New South Wales through the establishment of national parks and reserves
Native Title (NSW) Act 1994	Sets out how native title rights must be recognised and protected
National Parks and Wildlife Regulation 2019	Governs the use of national parks and other land managed under the ***National Parks and Wildlife Act 1974***
Land Management (Native Vegetation) Code 2018 (PDF 1.5MB)	Helps landholders manage land, ensuring more productive farming methods while responding to environmental risks
NSW Biodiversity Offsets Scheme	Offsets impacts on biodiversity from development through landholder stewardship agreements (agreements to conserve land)
Private Native Forestry Codes of Practice	Guides farm forestry operations in NSW and set minimum operating standards for actively managing farm forests in line with ecologically sustainable forest management
State Environmental Planning Policy (Biodiversity and Conservation) 2021	**Chapter 2** regulates clearing of native vegetation in urban areas and land zoned for environment protection. **Chapters 3 and 4** regulate development on land that has koala habitat.

Notes:
See the **Responses** section of this topic for more information about how protection of native plants is managed in NSW.
In 2023 two key pieces of legislation were reviewed: the native vegetation provisions of the ***Local Land Services Act 2013***, and the ***Biodiversity Conservation Act 2016***.

Related topics: **Animals** | **Climate change** | **Coastal and marine** | **Health of Country** | **Protected areas and conservation** | **Rivers and wetlands** |

Status and trends

Plants indicators

This report uses five indicators to assess:

- the extent, condition and clearing of native vegetation in NSW
- the capacity of the land to support biodiversity and habitat
- how many native plant species are considered threatened.

The assessments of status and environmental trend are based on long-term data. All are assessed as poor and getting worse.

These indicators are:

- **Extent of native vegetation** reports on the area of land covered by native vegetation across NSW. This is assessed as getting worse, because even though the last three years show little change, continued clearing suggests that the extent is still declining (see **Extent of native vegetation**).
  This indicator aligns to the 'land system change' planetary boundary. Globally, this boundary has been crossed (see **Planetary boundaries alignment**).
- **Clearing of native vegetation** reports on how much native vegetation has been cleared in NSW for agriculture and infrastructure. Although area cleared annually has been declining since 2018, it remains high compared to the previous decade (see **Native vegetation clearing**).
  This indicator aligns to the 'land system change' planetary boundary. Globally, this boundary has been crossed (see **Planetary boundaries alignment**).
- **Habitat condition** reports on the condition of native plant habitats. While recent data suggests short-term improvements in vegetation condition following increased rainfall, this indicator is assessed as getting worse based on long-term averages and poor ecological carrying capacity (see **Habitat condition**).
- **Ecological carrying capacity** reports on the ability of vegetation across NSW to support native plant and animal species and ecosystems. This was relatively stable in the decade before the 2019–20 bushfires but has since deteriorated along the east coast (see **Ecological carrying capacity**).
  This indicator aligns to the 'biosphere integrity' planetary boundary. Globally, this boundary has been crossed (see **Planetary boundaries alignment**).
- **Number of threatened species listed** indicates how many plant species are listed as critically endangered, endangered and vulnerable in the *Biodiversity Conservation Act 2016.* This is assessed as getting worse, because the number of listings has increased by 18 since 2020 (see **Threatened plant species**).
  This indicator aligns to the 'biosphere integrity' planetary boundary. Globally, this boundary has been crossed (see **Planetary boundaries alignment**).

Table B1.2: Plant indicators

Indicator	Environmental status	Environmental trend	Information reliability
Extent of native vegetation	POOR	Getting worse	Reasonable*
Clearing of native vegetation**	POOR	Getting worse	Reasonable*
Habitat condition	POOR	Getting worse	Reasonable
Ecological carrying capacity	POOR	Getting worse	Reasonable
Number of threatened species listed***	POOR	Getting worse	Reasonable

Notes:
* A method for measurement of regrowth is being developed – see **Responses** section
** This indicator is based on clearing of native vegetation for agriculture and infrastructure and the assessment includes consideration of long-term trends.
*** Threatened species encompasses those listed as critically endangered, endangered and vulnerable in the *Biodiversity Conservation Act 2016*.

Indicator table scales:
- **Environmental status**: Good, moderate, poor, unknown
- **Environmental trend**: Getting better, stable, getting worse
- **Information reliability**: Good, reasonable, limited.

See **Indicator guide** to learn how terms and symbols are defined.
See the **Planetary boundaries alignment** page for more information about how indicators align.

Extent of native vegetation

Vegetation extent means the amount of land covered in native vegetation, measured as a percentage of the total area (**OEH 2018**).

Native vegetation consists of woody and non woody vegetation.

- Woody vegetation refers to trees and other plants taller than two metres.
- Non woody vegetation includes natural native grasses, small shrubs, herbs and groundcover (**DPE 2022b**).
- **Derived native grasslands** – cleared areas that were previously forest or woodlands.

The vegetation classes are identified through satellite imagery and are modelled and mapped using Geographic Information System (GIS) tools.

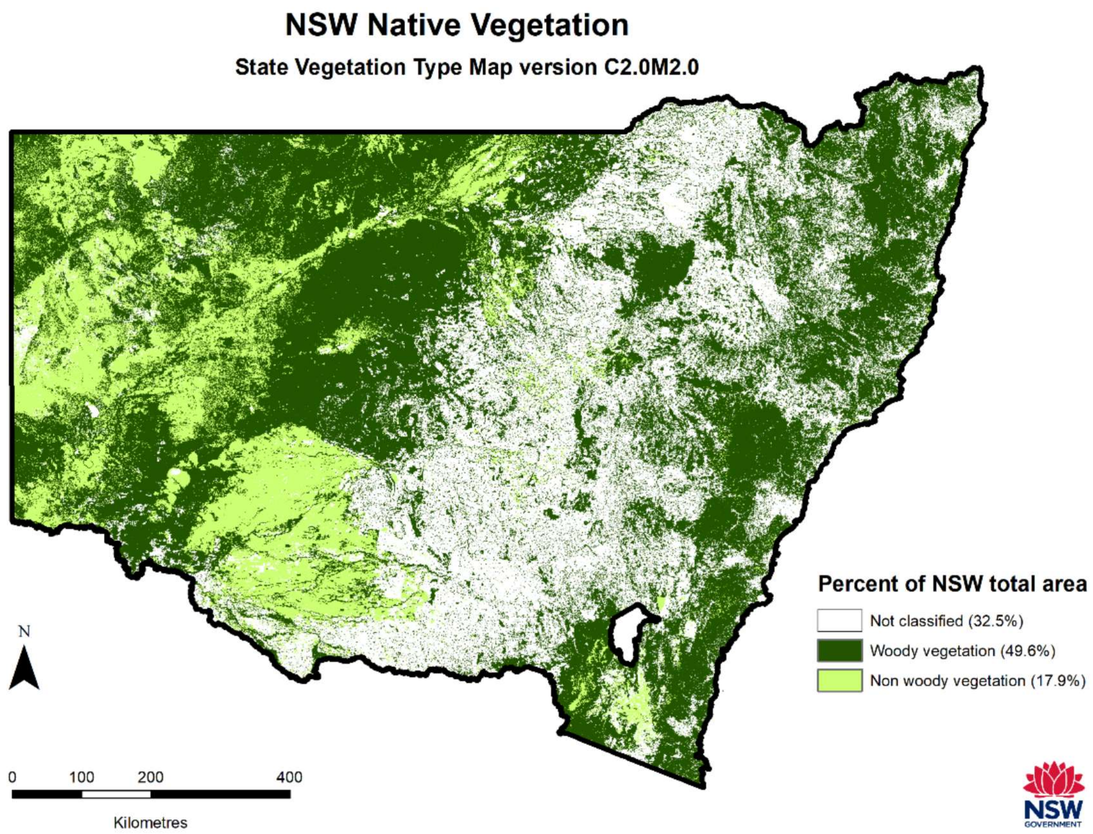
As at December 2023 (see **Map B1.2**):

- 49.6% of NSW retains woody native vegetation, compared to 49.8% in 2021
- 17.9% of NSW retains non woody native vegetation, compared to 19% in 2021, excluding derived grasslands.

The remaining 32.5% of the State's land area is categorised as 'not classified' and includes:

- areas that grow after the original native vegetation has been cleared, and may have some native vegetation and some weeds
- derived grasslands (primarily non woody vegetation)
- farmed land with crops, plantations and pasture
- areas with no plant cover at all
- developed land.

Map B1.2: Extent of native vegetation coverage in NSW as at December 2023



Notes:
This map does not include derived native grasslands.

Source:
NSW State Vegetation Type Map (version C2.0M2.0)

Clearing since European colonisation

Recent independent research finds that 46% of the forests and woodlands existing prior to European colonisation remain (**Ward et al. 2024**). This aligns with the findings of the NSW State Vegetation Type Map (SVTM) reported above (**Map B1.2**).

The SVTM calculates that 11 vegetation classes (related groups of vegetation) have lost more than 70% of their original extent since before clearing began (**DCCEEW 2024c**; **DCCEEW 2024d**) (see **Table B1.3**).

The largest proportion of clearing has occurred in:

- the inland **Riverine Plain Woodlands** along the plains of the Macquarie, Murrumbidgee, Lachlan and Murray rivers
- the **Cumberland Dry Sclerophyll Forests** of the west and south-west Sydney basin

- the **Southern Tableland Grassy Woodlands** and **Western Slopes Grassy Woodlands** to the west of the Great Dividing Range.

Table B1.3: Vegetation classes with more than 70% of vegetation cleared

Vegetation class	Percentage cleared
Riverine Plain Woodlands	88
Cumberland Dry Sclerophyll Forests	86
Southern Tableland Grassy Woodlands	84
Tableland Clay Grassy Woodlands	83
Western Slopes Grassy Woodlands	80
Temperate Montane Grasslands	77
Floodplain Transition Woodlands	75
Western Vine Thickets	75
Riverine Sandhill Woodlands	73
Coastal Valley Grassy Woodlands	71
North-west Alluvial Sand Woodlands	71

Notes:
Pre-clearing is the reference point for mapping and modelling this data (Roff et al. 2022).
Click the links in the table to learn more about each vegetation class.

Source:
NSW State Vegetation Type Map (version C2.0M2.0)

Clearing of native vegetation

'Clearing' in relation to native vegetation is defined under the *Local Land Services Act 2013* as any one or more of the following:

- cutting down, felling, uprooting, thinning or otherwise removing native vegetation
- killing, destroying, poisoning, ringbarking or burning native vegetation.

The NSW Government has mapped, monitored and reported on landcover loss since 2009 (with data available from 1988). It has used satellite imagery, with human interpretation and validation, to detect and report change in native vegetation cover every year.

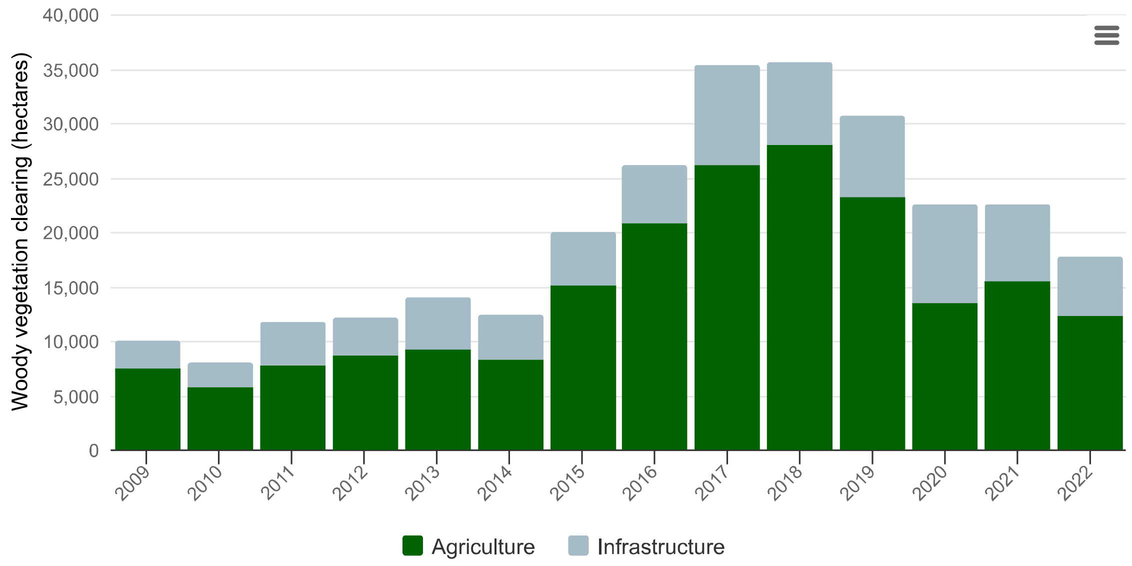
This data does not currently include information about rates of regrowth. The ***NSW plan for nature*** commits to monitoring net change in future.

Clearing for infrastructure and agriculture

In 2022, 17,791 hectares of native woody vegetation was cleared for agriculture and infrastructure across NSW (see **Figure B1.1**).

Clearing in this figure includes all detectable woody clearing, which may include the clearing of invasive native species.

Figure B1.1: Clearing of native woody vegetation for agriculture and infrastructure in NSW, from 2009 to 2022



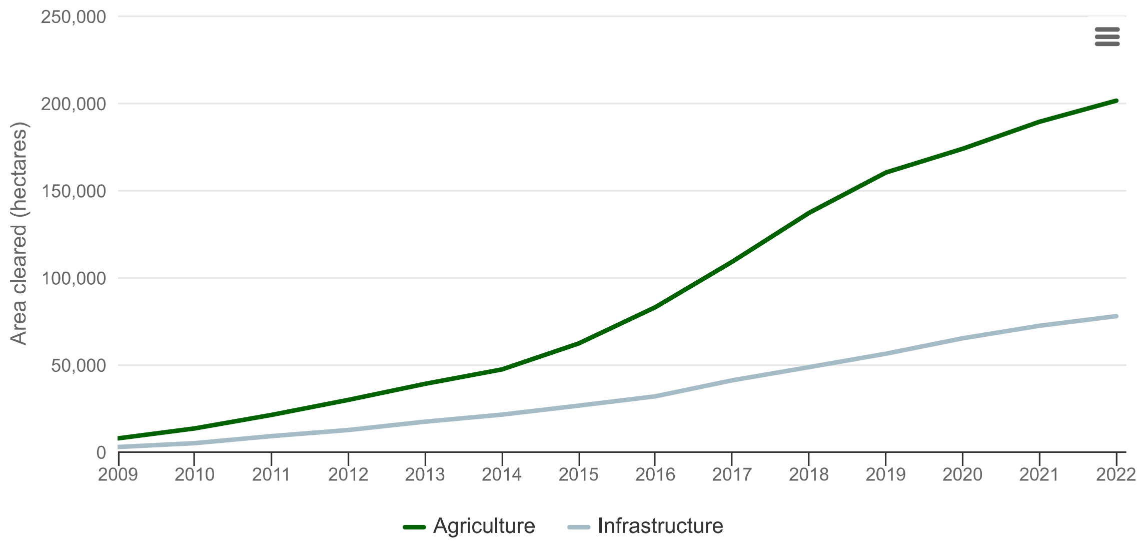
Notes:
Native vegetation was managed under the ***Native Vegetation Act 2003*** until 25 August 2017. After this date, it was managed under the **Land Management Framework**, except for clearing related to existing approvals under previous legislation.

Source:
The woody vegetation clearing dashboard

Land clearing continues to have a significant environmental impact. Since 2009, a total of 201,300 hectares of native vegetation has been cleared for agriculture (see **Figure B1.2**).

The cumulative rates of clearing for agriculture shown in **Figure B1.2** includes clearing of invasive native species and management of woody regrowth on existing agricultural land authorised under the **Land Management (Native Vegetation) Code 2018** or previous legislation.

Figure B1.2: Cumulative native woody vegetation clearing for agriculture and infrastructure in NSW, from 2009 to 2022



Notes:
Approximately 0.3% of agricultural clearing is invasive species cleared more than once.

Source:
The woody vegetation clearing dashboard

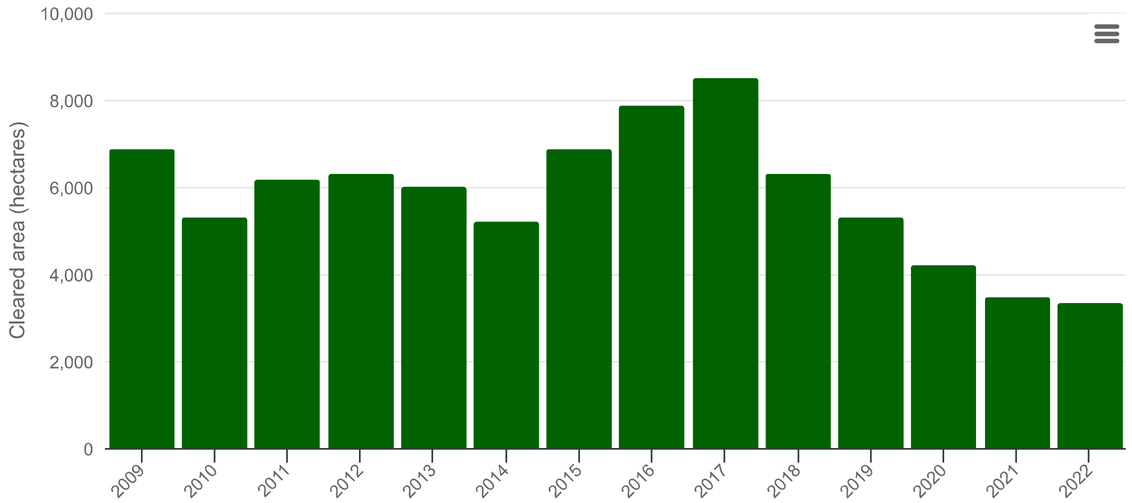
Native forest harvesting

Native forestry operations are subject to a distinct regulatory framework compared to urban, agricultural, or infrastructure-related clearing. Because these operations include a requirement to regenerate harvested areas with native vegetation, they are not classified as permanent clearing.

Harvesting operations on Crown land (public land), mainly in State forests, are regulated in accordance with **Ecologically Sustainable Forest Management** (ESFM) principles as set out in the NSW ***Forestry Act 2012*** and Regional Forest Agreements. Harvesting limits and conditions protecting key environmental features and threatened species and ecosystems are set out in **Integrated Forestry Operations Approvals** (IFOAs).

The rules for conducting native forestry on private land are set out in four Private Native Forestry Codes of Practice established under the ***Local Land Services Act 2013***. Rates of native forestry harvesting have declined by 61% since 2017 (see **Figure B1.3**).

Figure B1.3: Rates of native forest harvesting in NSW, from 2009 to 2022



Notes:
The chart shows native woody vegetation clearing for native forestry only, it excludes plantations. Woody vegetation change related to plantation forestry can be found in the dashboard.

Source:
The woody vegetation clearing dashboard

Native forestry on public land, conducted mostly in State forests, is managed by the Forestry Corporation of NSW and regulated by the NSW Environment Protection Authority (EPA). Native forestry on private rural land is regulated by Local Land Services and the EPA.

Landholders and forest managers must regenerate or revegetate harvested areas.

- **Regeneration** happens when harvesting and other actions create the conditions to support seed germination and forest growth. Actions that support regeneration to occur can include burning, ground disturbance, weeding and removing grazing animals to allow native vegetation to grow back.
- **Revegetation** happens when the conditions aren't suitable to support natural regeneration. Actions such as planting seeds or seedlings, weeding and removing grazing animals support revegetation.

See this **fact sheet on regeneration and revegetation (PDF 699KB)** for more information.

Impacts of clearing on native vegetation types

Native vegetation clearing in NSW since European colonisation has had a varying impact on the extent and condition of native vegetation in different regions across the State.

Clearing for agriculture continues in already heavily cleared areas of central NSW and extending west and north. The impact of clearing for urban purposes is most intense across northern forested wetlands, the Hunter Valley and the Sydney Basin.

Grassy woodlands are the most threatened vegetation formation in NSW. Only 22% of grassy woodlands and 34% of arid grassy woodlands remain in the State (**DPE 2023b**).

Examples of grassy woodland communities that have been listed under the *Biodiversity Conservation Act 2016* as Endangered Ecological Communities (due to extensive clearing for agriculture) include **grassy box** and **coolabah woodlands**.

Gum-Coolabah and Poplar Box woodlands across central western NSW continue to be heavily impacted by land clearing (see **Map B1.3**).

Clearing, fragmentation, and loss of understorey is widespread and substantial across most central-western NSW plant communities. Together with weeds and intensive grazing by feral animals, such as goats and rabbits, these pressures are likely to lead to further biodiversity declines without intervention.

Image B1.2: Yellow Box and Blakely's Red Gum Grassy Woodlands

Notes:
Yellow Box and Blakely's Red Gum Grassy Woodlands have been listed as a critically endangered ecological community.

Source:
Jaime Plaza/Botanic Gardens Trust

Natural native grasslands have been extensively cleared or modified, with only 35% of their original extent left across the north-west slopes, Hunter Valley, Northern Tablelands, Southern Tablelands and Riverina.

Natural native grasslands of the Gwydir, Liverpool Plains and Monaro have less than 10% of their original extent left and are highly altered and fragmented.

Rainforests in low-lying areas (coastal floodplains) have historically been extensively cleared, with 17% of plant community types in these areas considered currently of high conservation concern (**DPE 2022a**).

Rainforests in more rugged terrain are largely intact, although changes in structure and species composition have occurred in areas where trees have been harvested or burnt.

The 2019–20 bushfires significantly impacted the eastern seaboard rainforests margins where little fire had been previously recorded. Many burnt margins resulted in a loss of rainforest.

Coastal floodplain forest is under pressure from coastal development, particularly the northern paperback floodplain forests and forest in the Sydney hinterland and Upper Hunter regions.

Semi-arid tall shrublands are under pressure from dryland cropping and grazing from farming and feral animals. About 70% remain.

Heathlands are still largely intact, although most of those in the Sydney region have been impacted by housing development (**DPE 2022a**).

Clearing per bioregion

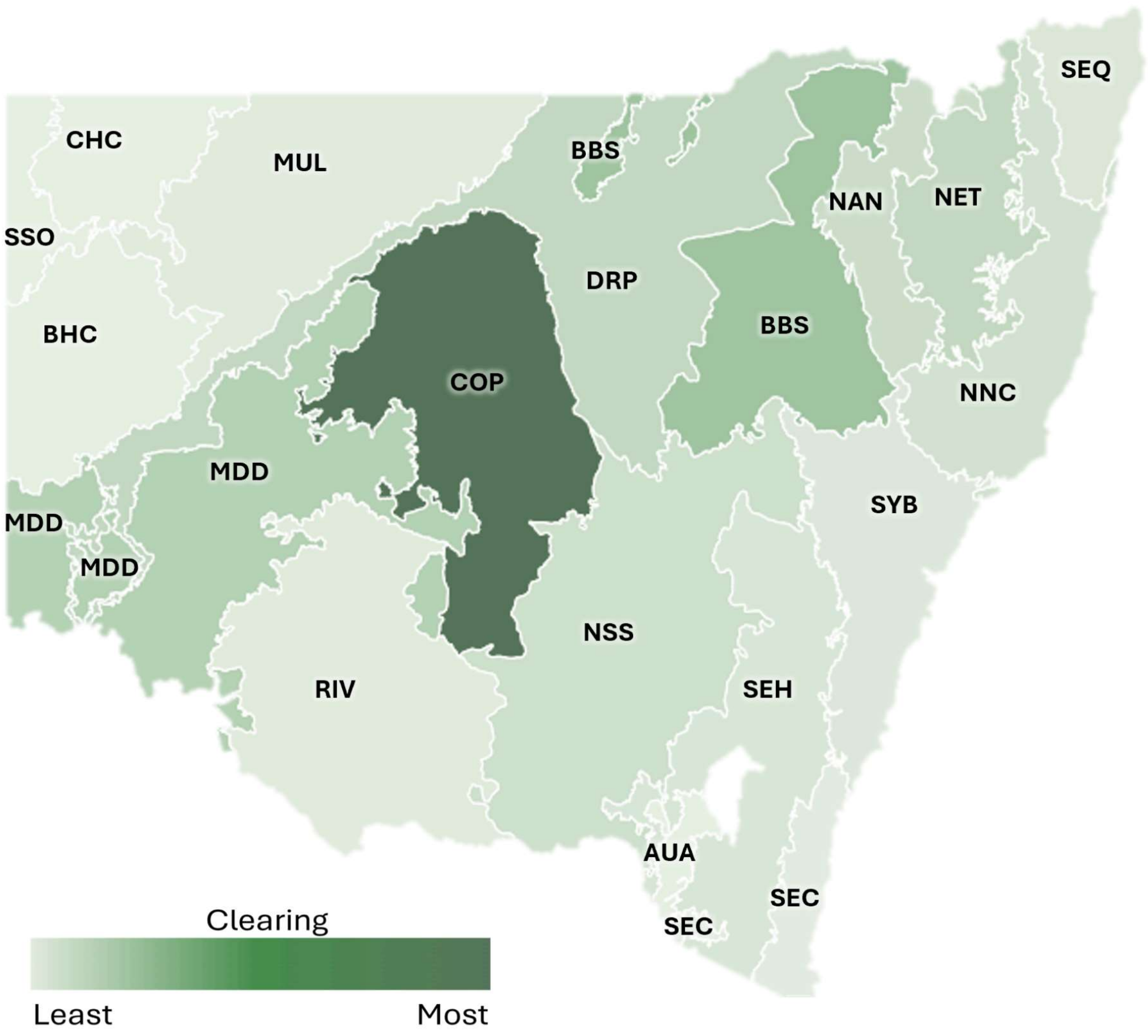
Bioregions (an abbreviation of 'biogeographic regions') are large regions of relatively similar climate, geology and landforms.

The **Interim Biogeographic Regionalisation (IBRA) framework** divides Australia into 89 bioregions. Eighteen of them are in mainland NSW. See **NSW bioregions** for more information.

Bioregions that are experiencing higher rates of land clearing have been heavily cleared since the pre-industrial period.

Map B1.3 shows that clearing of woody vegetation between 2018 and 2022 was highest in the Cobar Peneplain (COP) and Brigalow Belt South (BBS) bioregions.

Map B1.3: Cumulative area of woody clearing in NSW by Interim Biogeographic Regionalisation for Australia (IBRA), 2018–22

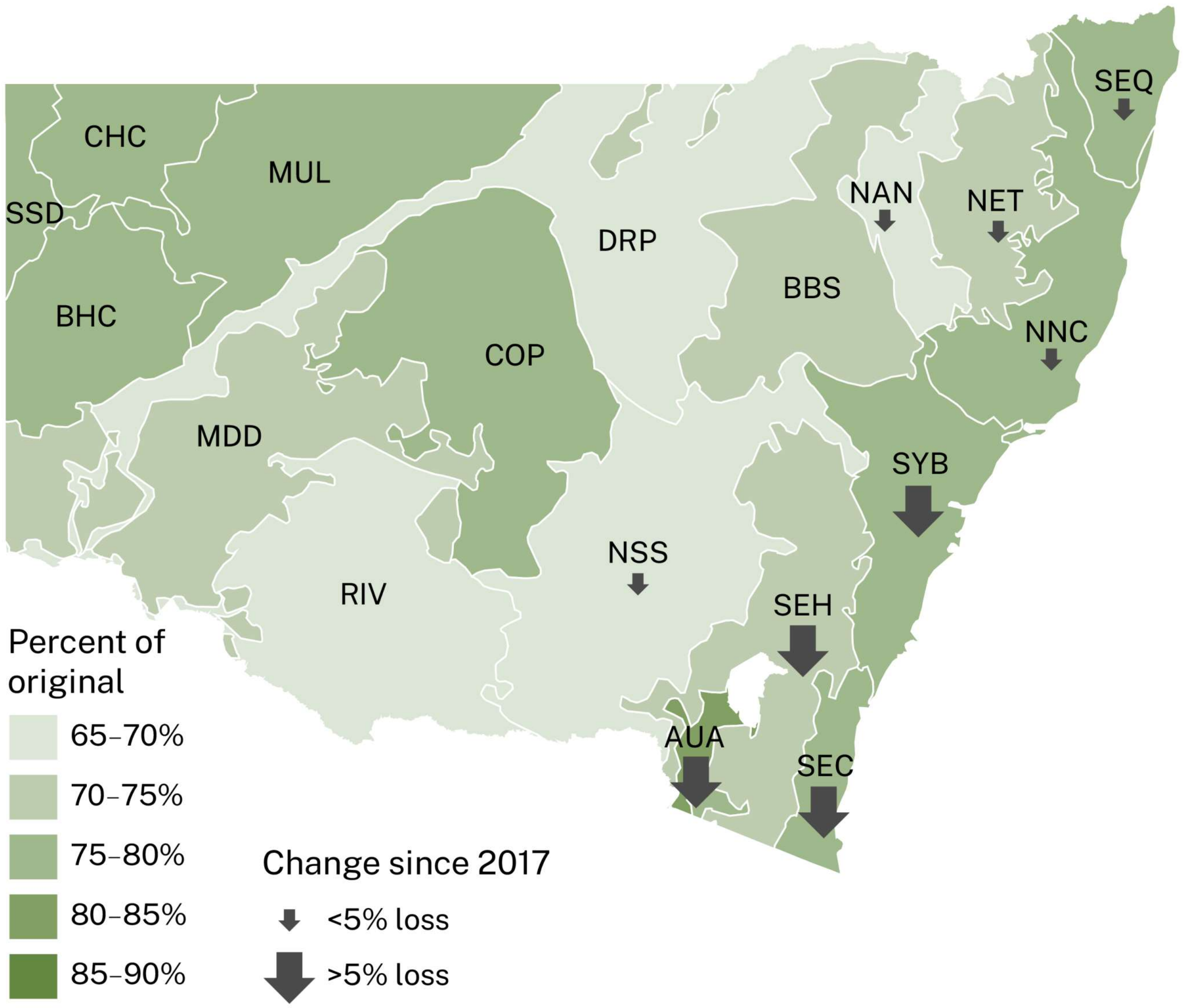


Notes:
IBRA bioregions are listed in **NSW bioregions**.

Source:
The woody vegetation clearing dashboard

Map B1.4 shows that original plant ecosystem diversity has declined the most in bioregions most affected by cumulative clearing since European colonisation, including the Darling Riverine (DRP), Riverina (RIV) and New South Wales South Western Slopes (NSS) bioregions.

Map B1.4: Percentage of original plant ecosystem diversity remaining in NSW bioregions and change since 2017 in east coast bioregions



Notes:
Values shown are for 2017, or 2020 for bioregions impacted by the 2019–20 bushfires (indicated by arrows). The degree of change is indicated by the size and direction of the arrows.
IBRA bioregions are listed in **NSW bioregions**.

Source:
DCCEEW 2024b

Bioregions in central NSW are also the least resilient to climate change (see **Map B1.5**).

Habitat loss and fragmentation have reduced the resilience of ecosystems to climate change (**DCCEEW 2024b**; **Harwood et al. 2022**).

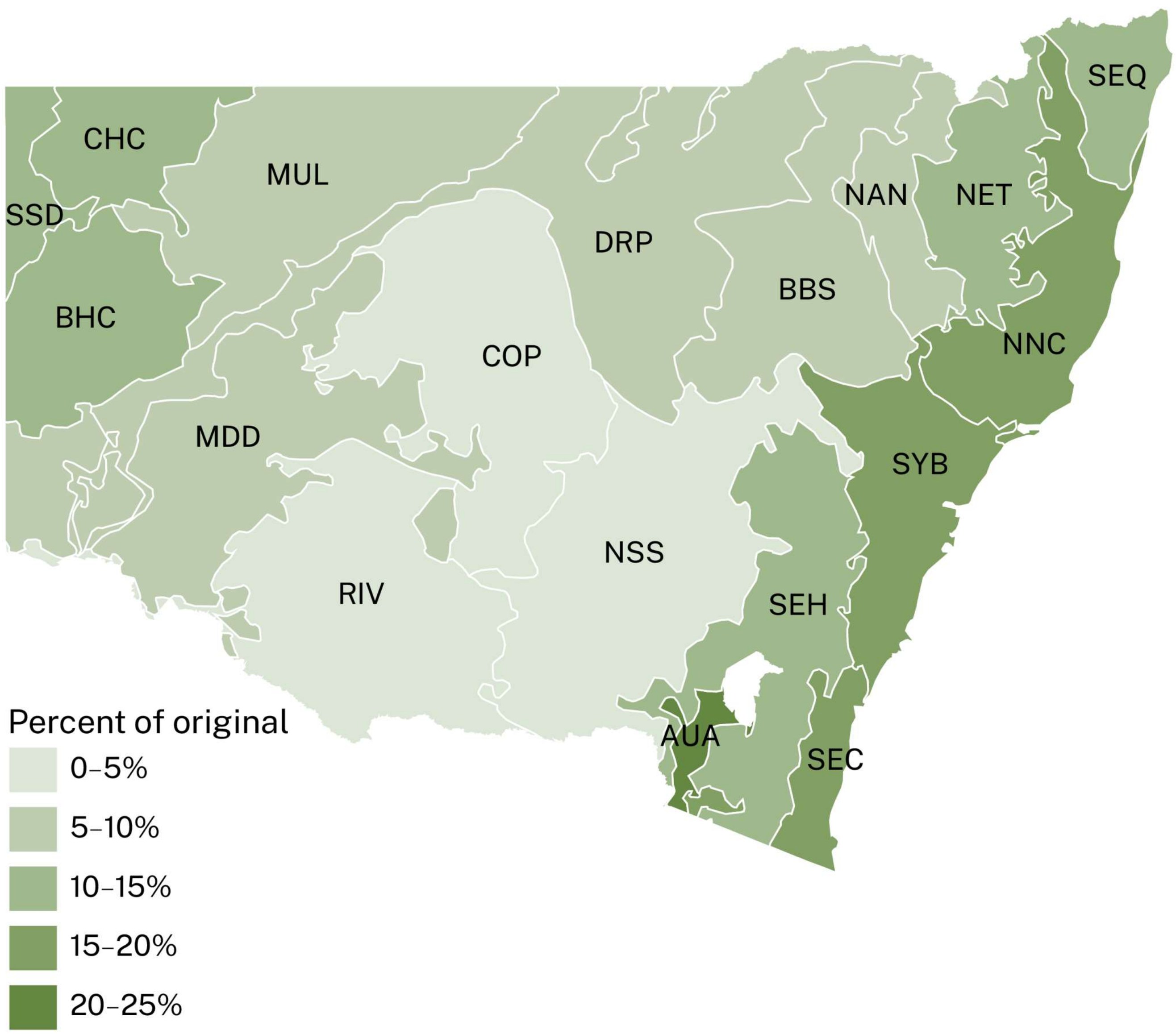
Ecosystem resilience to climate change is the capacity of the landscape to:

- resist, recover from and adapt to disturbances while maintaining its functions, structures and processes
- provide habitat for, and support the migration of, plant and animal species to suitable alternative habitat as climatic conditions change.

Measuring resilience indicates how well species in their current locations will cope with future climatic conditions. In more resilient bioregions, habitats are more intact and connected, making it easier for species to migrate in response to climate change if they need to.

Bioregions with low resilience have high rates of past habitat loss and fragmentation, and higher projected climate change impacts (see **Map B1.5**). This will make it harder for species to migrate. These areas will require the most active management to ensure their biodiversity is retained.

Map B1.5: Resilience of NSW bioregions to projected climate up to 2070



Notes:
Lower percentages indicate lower resilience.
IBRA Bioregions are listed in **NSW bioregions**.

Source:
DCCEEW 2024b

Habitat condition

Habitat and ecological condition

Vascular plants are often used as an indicator of habitat condition and overall health of biodiversity.

Ecological condition, an estimate of the quality of terrestrial habitats based on intactness and naturalness, is used to measure habitat quality and condition in NSW (**DCCEEW 2024b**).

'Intact' vegetation has all its important structural components and generally has a higher biodiversity value than more modified vegetation. Native vegetation is classified as 'intact' when its quality has not been substantially degraded.

Ecological condition is measured and reported for different bioregions in NSW through the **NSW Biodiversity Indicator Program**.

The loss and alteration of habitat that occurred from the pre-industrial period up to 2017 reduced the overall ecological condition of habitat in NSW from its original level (100%) to 43% of that level, with variation between bioregions (see **Map B1.6**).

The 2019–20 bushfires significantly reduced ecological condition in burnt areas. In NSW, including both burnt and unburnt areas, ecological condition fell from 43% in 2017 to 40% in 2020 (**DCCEEW 2024b**).

For example, Forrester's bottlebrush and betka bottlebrush were considered threatened before the fires and are now at risk of extinction (**DCCEEW-Aus 2021**).

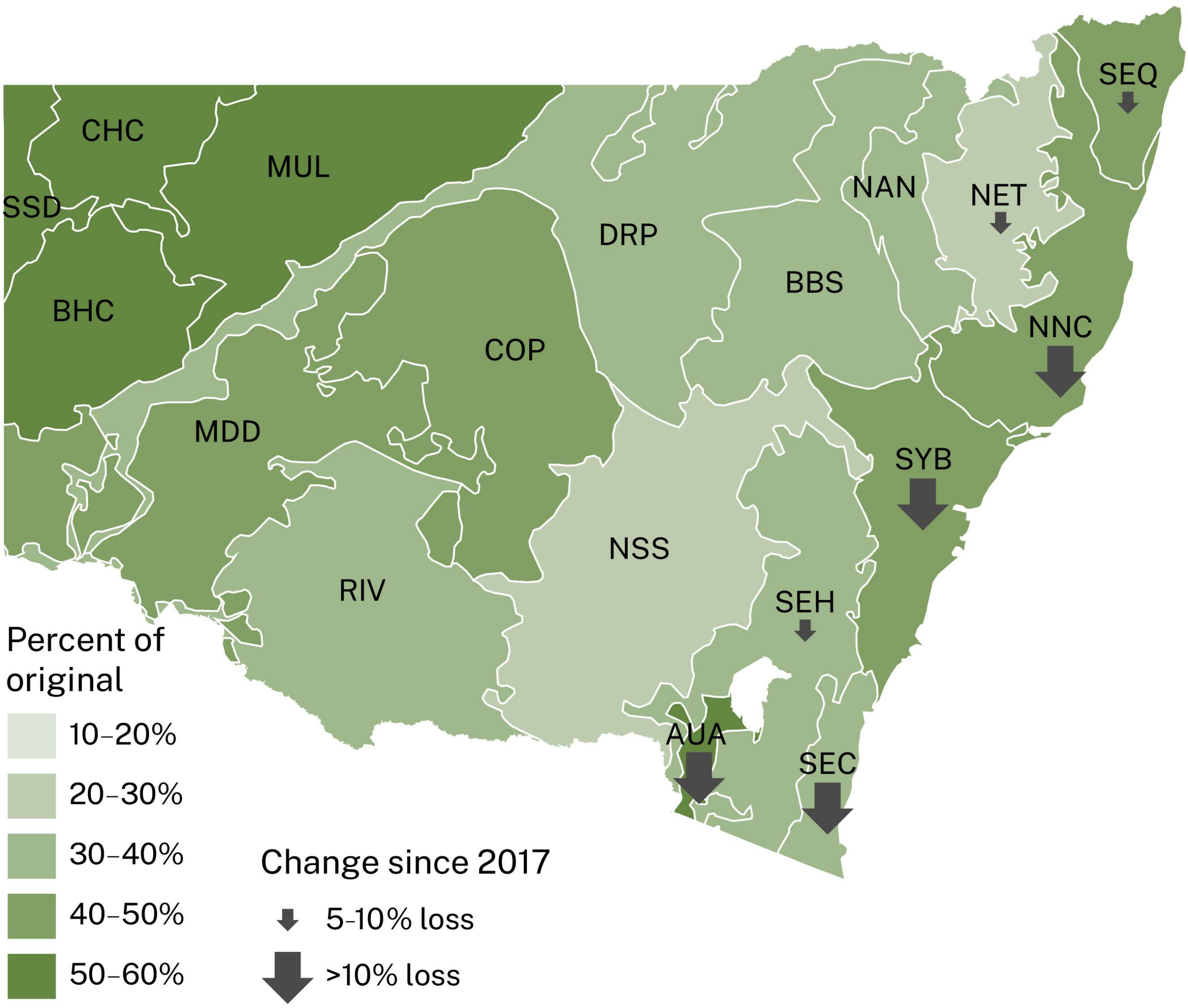
While this poor condition increases the risk of extinction of plants and animals that have most of their range in burnt areas, helping these areas to recover will reduce this risk.

For example, native species can begin recolonising burnt sites if humans:

- store seeds or tissue until areas have regenerated enough for them to be replanted
- control weeds and feral animals on burnt areas to give native plants and animals time to recolonise them.

After the 2019–2020 bushfires in NSW, 486 plant species needed action to support their long-term recovery and limit their further decline (**DCCEEW-Aus 2021**).

Map B1.6: Percentage of original ecological condition in each NSW bioregion and change since 2017 in east coast bioregions



Notes:

Values shown are for 2017, or 2020 for bioregions impacted by the 2019–20 bushfires (indicated by arrows). The degree of change is indicated by the size and direction of the arrows.

IBRA bioregions are listed in **NSW bioregions**.

Source:

DCCEEW 2024b

Ecological carrying capacity

Across NSW, ecological carrying capacity is declining.

Ecological carrying capacity is a measure of ecological condition plus the additional impacts of the loss and fragmentation of surrounding habitats on the ability of species to move through the landscape (**DCCEEW 2024b**).

Understanding changes in carrying capacity is important, as native species rely on habitat that is well-connected and in good condition.

Habitat that is in better condition and connected to other good habitat can better support healthy ecosystems and more native species because:

- native animals can forage easily for food and shelter, reproduce and migrate
- native plants and animals can spread and move around the area.

Habitat can be in good condition but have low connectivity and low ecological carrying capacity. Conversely, it might have low ecological condition but be a valued corridor or stepping stone to other habitats (**NSW EPA 2022**).

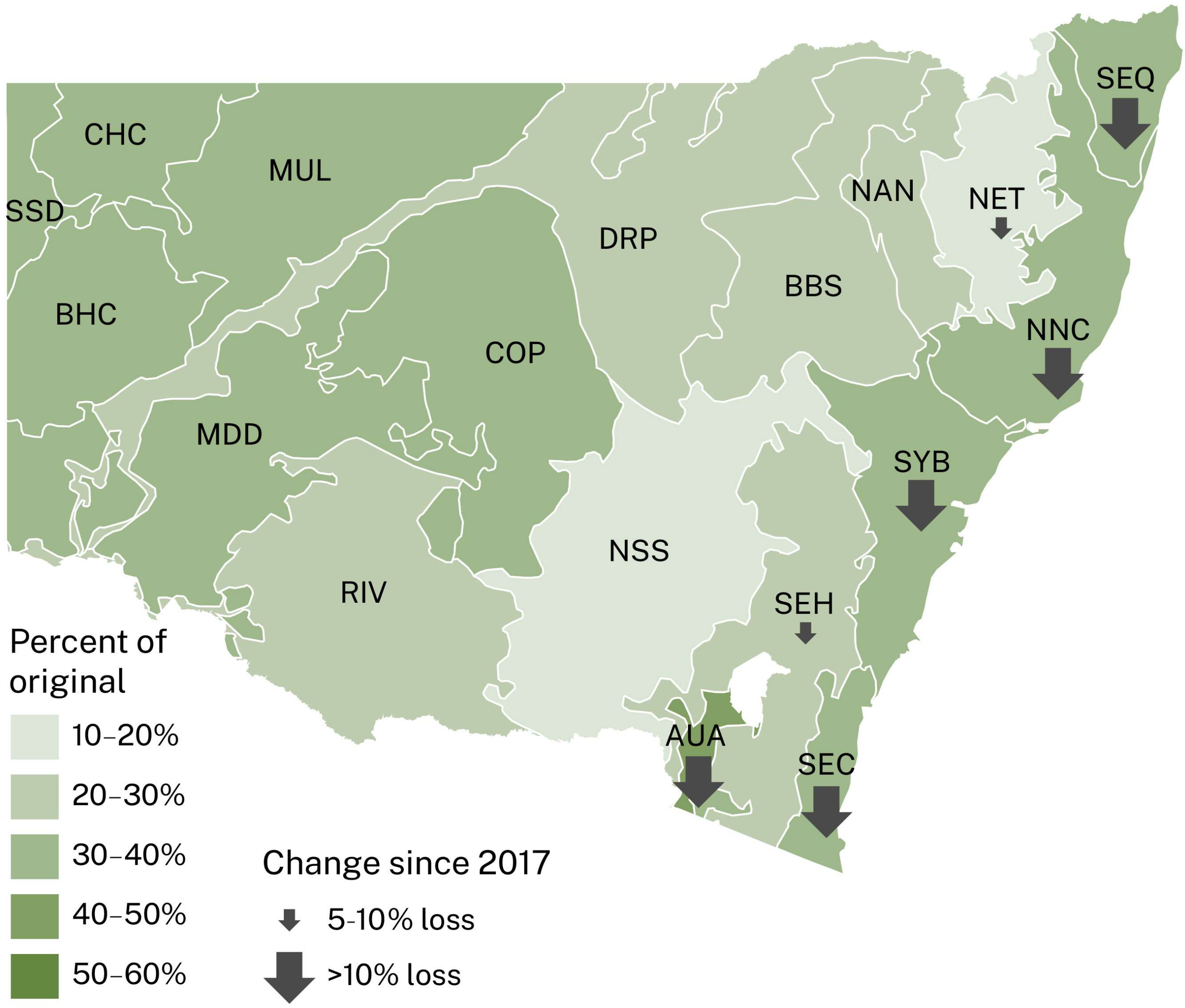
Ecological carrying capacity is measured and reported on through the **NSW Biodiversity Indicator Program**.

Key impacts on ecological carrying capacity include vegetation loss, degradation and fragmentation of native habitats.

The most recent results for ecological carrying capacity show changes between 2017 and 2020 (**DCCEEW 2024b**). In 2017, ecological carrying capacity in NSW was measured as 32% of natural levels relative to pre-industrialisation (see **Map B1.7**). This was close to the baseline assessment of 31% in 2007. After the 2019–20 bushfires, ecological carrying capacity dropped to 29%.

As at 2020, rainforests and alpine areas have the highest ecological carrying capacity of all vegetation formations in NSW.

Map B1.7: Percentage of original ecological carrying capacity in each NSW bioregion compared to pre-industrial period, since 2017 in east coast bioregions



Notes:
Values shown are for 2017, or 2020 for bioregions impacted by the 2019–20 bushfires (indicated by arrows). The degree of change is indicated by the size and direction of the arrows.
These results only include the effects of the 2019–20 bushfires. They do not take into account other changes in habitat or land use since 2017.

Source:
DCCEEW 2024b

Table B1.4 shows that the 2019–20 fires mainly affected alpine vegetation, Wet and Dry Sclerophyll Forests, Heathlands and Rainforests. These vegetation types are more common in eastern NSW.

Table B1.4: Ecological carrying capacity (%) of NSW native vegetation formations

State vegetation type	2007	2013	2017	2020
Alpine Complex	40	52	56	46
Arid Shrublands	37	37	36	36
Dry Sclerophyll Forests	41	45	44	33
Forested Wetlands	37	38	38	35
Freshwater Wetlands	32	33	33	32
Grasslands	26	27	26	26
Grassy Woodlands	26	28	28	25
Heathlands	53	58	58	34
Rainforests	62	64	64	50
Saline Wetlands	32	33	33	33
Semi-Arid Woodlands	37	38	36	36
Wet Sclerophyll Forests	57	61	61	42

Notes:
Assessments completed in 2007, 2013, 2017 and 2020. Results for 2020 are still interim as it takes several years for all input for modelling to become available.
These results only include the effects of the 2019–20 bushfires. They do not take into account other changes in habitat or land use since 2017.

Source:
DCCEEW (in press) Habitat condition: report card for the NSW Biodiversity Indicator Program 2024

Bioregions with the highest average ecological carrying capacity in 2017 were the:

- South-East Corner (61%)
- Australian Alps (59%)
- NSW North Coast (52%).

These same bioregions were also those most burnt in the 2019–20 bushfires, with ecological carrying capacity decreasing to:

- 33% in the South-East Corner
- 43% in the Australian Alps
- 40% on the NSW North Coast.

Bioregions with the lowest ecological carrying capacity in 2017, where only small areas of habitat for native species remained, were:

- the South Western Slopes (15%)
- Nandewar (22%)
- Brigalow Belt South (23%).

The 2019–20 bushfires only had a minor impact in these bioregions, with ecological carrying capacity decreasing between 0% and 1% (**DPIE 2020**).

Other measures of habitat condition

An alternative measure of habitat condition is the assessment of tree cover and vegetation condition published in the annual ***Australia's Environment*** report by the Terrestrial Ecosystem Research Network (TERN).

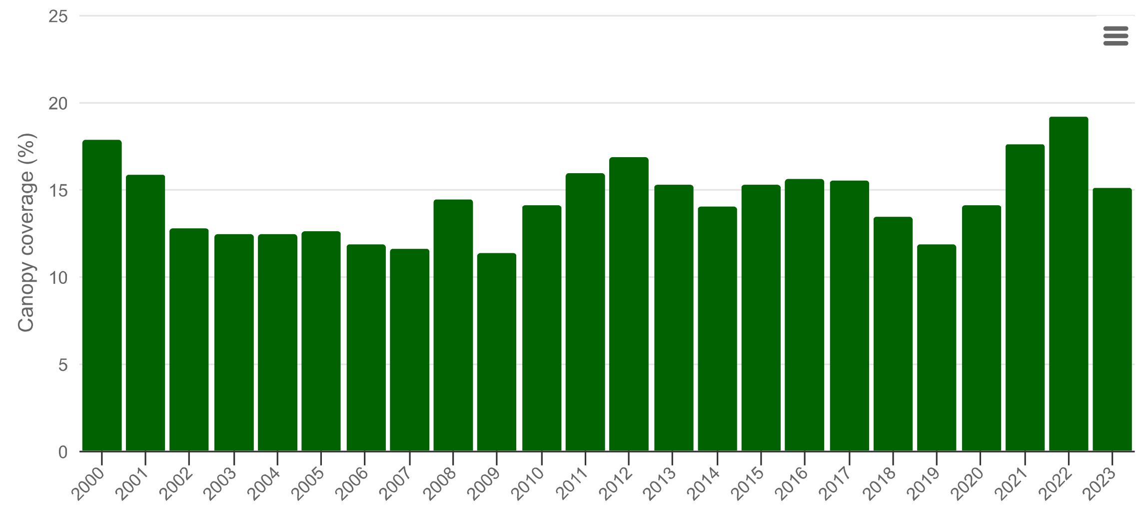
In *Australia's Environment*, 'tree cover' refers to the projected canopy cover of woody vegetation, also known as the woody cover fraction (**Liao et al. 2020**). Woody cover fraction can be used as a measure of vegetation condition, as it varies year-to-year depending on weather conditions being wet or dry.

Woody cover fraction excludes gaps within the tree canopy and between trees (**Liao et al. 2020**). So, while the estimates include non-native vegetation, they end up lower than the extent of native vegetation mapped by **State Vegetation Mapping**. See the **native vegetation clearing** section of this topic for more information.

Woody canopy cover in NSW has been variable since 2000 (see **Figure B1.4**), decreasing in dry times (for example, during the Millenium Drought 2000–09 and the Tinderbox Drought 2017–20).

From 2021 to 2023 woody canopy cover has been above average, increasing following the Tinderbox Drought and bushfires of 2019–20 (**TERN 2024**). Note that canopy cover does not directly align to forest and woodland extent because the vegetation formations do not generally have 100% canopy cover.

Figure B1.4: NSW woody canopy cover, 2000–2023

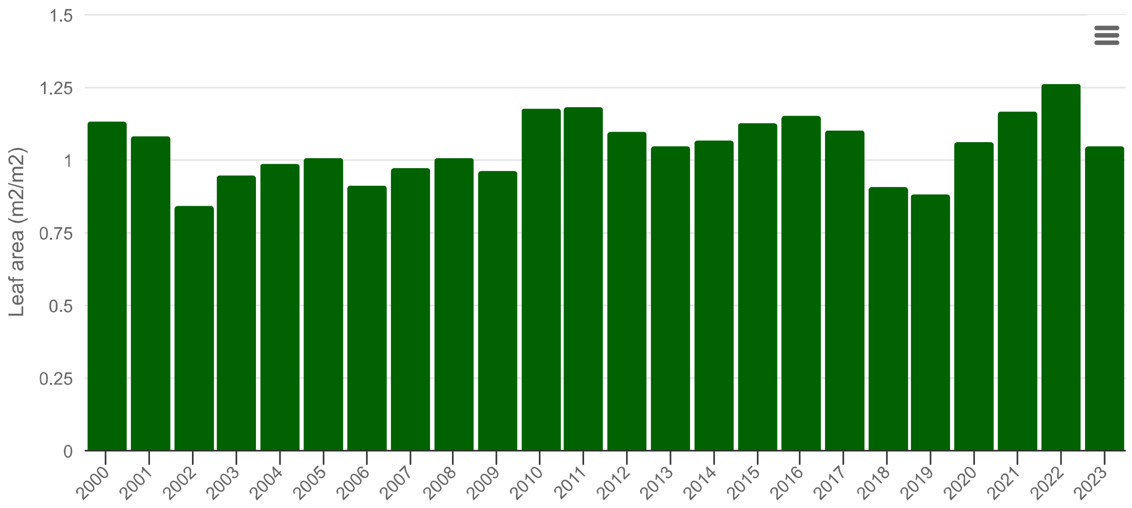


Source:
TERN 2024

Vegetation condition, in the ***Australia's Environment 2023*** report, represents the amount of all leaf area. It is partially related to woody cover fraction but is inclusive of all vegetation types including both native and non-native woody vegetation, grasslands, agricultural crops and weeds (**Van Dijk & Rahman 2019**).

Like woody cover fraction, leaf area has been variable since 2000, declining in dry periods and increasing in wet periods (see **Figure B1.5**). From 2019 to 2022, vegetation condition improved, returning to about average in 2023 (**TERN 2024**).

Figure B1.5: NSW vegetation condition (vegetation cover)



Source:
TERN 2024

Threatened plant species

Many natural and human processes threaten plant species in NSW, including:

- climate change, such as increasing frequency and duration of drought
- weeds
- feral animals
- pathogens and disease
- changing fire regimes
- alteration of habitat by human activities, such as mining and building, that result in habitat clearing, fragmentation and degradation.

A key threatening process:

- seriously harms threatened species or ecological communities
- causes a species or ecological community to become threatened (**NSW Government 2024a**).

Search the **key threatening processes** listed in the *NSW Biodiversity Conservation Act 2016*.

A species is considered threatened if it is facing high to extremely high risk of extinction. This can happen when:

- there is a reduction in its population size
- it has a restricted geographical distribution
- there are few mature individuals.

The **NSW Threatened Species Scientific Committee** decides when a non-marine plant species is threatened. The assessment is based on criteria developed by the **International Union for the Conservation of Nature**. The **Fisheries Scientific Committee** has the same responsibility for marine plants.

See the **Coastal and marine** topic for information about threatened marine plants, such as kelp, seaweed and seagrass.

See the **Rivers and wetlands** topic for more information on riparian and aquatic plants.

Between 31 December 2020 and 30 June 2024, the number of plant species **listed as threatened** under the *Biodiversity Conservation Act 2016* increased by 18, bringing the total to 657.

In addition to this, nine species of fungi and two species of algae are listed under the Act. These numbers have not changed since 2020.

Many of the 111 listings for threatened ecological communities under the *Biodiversity Conservation Act 2016* are defined by plant assemblages (groups of plants that often grow together in the same location). These include:

- **Monaro Tableland Cool Temperate Grassy Woodland in the South Eastern Highlands**
- ***Lagunaria* Swamp Forest on Lord Howe Island**
- **Freshwater Wetlands on Coastal Floodplains**.

See **the list of threatened ecological communities** for more information.

Image B1.3: Granite rose

Notes:
Granite rose (*Boronia repanda*) is one of many native plants **listed as endangered** in NSW.

Source:
Gavin Phillips/DCCEEW

The process of carrying out threat assessments continues to improve. This means some species are joining the list not because the threat level has changed, but because we now have enough data to undertake an assessment. This process also results in some species being delisted.

The listing process is scientifically rigorous and ensures decisions are made based on the latest species information.

While the numbers of threatened plants are increasing, having more accurate information means that planning and conservation actions can be developed to save them before they decline to critical levels or become extinct.

Without effective management, modelling predicts that only 49% of threatened plant species are likely to survive in 100 years' time (**DCCEEW unpub.**). Management and conservation actions will not be enough to save many species without resolving key threats, such as habitat removal and climate change.

When considering species that are of significance to Aboriginal peoples, resources for their protection are limited if the species is not currently listed as threatened. NSW is lacking a formal framework for collaborating with local Aboriginal communities to identify, document and protect culturally significant species on public lands.

Although species listing can prioritise conservation efforts, Aboriginal communities have little input in this process and the potential impact on cultural practices is often overlooked.

See the **Health of Country** topic for more information.

Community perceptions

Increasing community awareness of the importance of biodiversity will help protect it.

The annual Community Appreciation of Biodiversity Survey collects responses from a random sample of the NSW population. A set of questions are used to assess and track changes in community understanding and support of biodiversity conservation.

Community surveys have found that since 2015, the people of NSW are more aware that some NSW native plants are declining and could become extinct (see **Table B1.5**).

Table B1.5: NSW residents' awareness of risks to native plant biodiversity

Thinking about native plants, as far as you know, would you say	2015	2022	2023	2024
There are no native plant species in NSW in serious decline and at risk of becoming extinct	4%	5%	6%	6%
There are native plants in NSW in serious decline and at risk of becoming extinct	50%	75%	73%	71%
Not sure, don't know	46%	20%	21%	23%
Sample (n)	**2,000**	**1,901**	**2,063**	**2,060**

Source:
Community Appreciation of Biodiversity Survey 2015–2024 (DCCEEW 2024a; Fielding et al. 2021)

Pressures and impacts

Land clearing

Native vegetation has been extensively cleared in some parts of NSW for housing, infrastructure and agriculture.

Clearing of native vegetation is listed as a key threatening process under the *Biodiversity Conservation Act 2016*.

Environmental impacts include:

- irreversible disturbance or destruction of habitat
- fragmentation of populations of native and threatened species
- degradation of river banks
- loss or disruption of ecological function
- increased greenhouse gas emissions
- limited ability for species and ecosystems to adapt to climate change
- amplified effects of climate change
- loss of leaf litter which provides habitat and adds nutrients to soil
- loss or disruption of ecological function
- erosion, and changes to the lifeforms in soil (biota).

The clearing of native vegetation and associated land use changes has had significant impacts on Aboriginal peoples. Impacts include:

- the loss of traditional ecological knowledge
- desecrated sacred sites
- diminished access to essential resources, such as bush foods and medicinal plants.

These losses affect both the physical and cultural wellbeing of Aboriginal peoples, causing disconnection from their ancestral lands and knowledge systems.

Habitat loss and fragmentation

Native vegetation clearing results in loss of native species and destruction of their habitat.

These threats are increased by land being used for farming, housing or development and fragmentation of remnant vegetation.

These factors can prevent:

- native vegetation from regenerating and spreading
- native plants and animals from moving between suitable habitats, leading to a loss of genetic diversity (**Johnson et al. 2007**; **Taylor & Dickman 2014**).

Riparian vegetation

Degradation of native vegetation along NSW waterways is a **key threatening process**.

Riparian habitat (habitat by or on a river, stream, lake or wetlands) has declined a lot since European colonisation. Riparian habitat strengthens the quality of water and habitat in and around waterways by:

- stabilising banks to prevent erosion
- improving water quality by filtering run-off from farming or industry
- regulating water and local air temperature
- protecting food webs
- providing habitat for native plants and animals.

Loss or degradation of riparian vegetation can:

- destabilise banks, causing and increasing erosion
- change patterns in waterway flows, causing changes in habitats
- degrade aquatic ecosystems
- reduce or eliminate habitat for native plants and animals.

Climate change

Human-induced climate change is listed as a **key threatening process** under the *Biodiversity Conservation Act 2016*. Climate change is already damaging native vegetation in NSW due to:

- changing patterns in regional rainfall and snow cover
- rising sea levels
- increased risk of extreme weather, such as heatwaves, droughts, bushfires, storms and flooding.

The resilience of native vegetation to future climatic conditions has been reduced by:

- habitat fragmentation
- weeds
- invasive animals
- disease
- erosion.

Habitat fragmentation makes it hard for species to move to new suitable habitat as the climate changes.

Predicted impacts on ecosystems include:

- decreased forest growth and productivity
- unbalanced competition between perennial native grasses, leading to the growth of some at the expense of others
- increased encroachment of woody shrubs into arid and semi-arid rangelands
- continued incursion of mangroves into freshwater wetlands
- growth of woody species higher up in alpine areas
- changed timing of species' life cycles.

While there is some variation in climate projections, overall, experts agree conditions will be warmer and drier, especially in the cooler months, with rain coming in short, heavy falls.

Conditions are also likely to become more variable, with more extremely hot days (warmer than 35°C) and fewer extremely cold days.

See **Climate change**and **Extreme climate and weather** topics for more information about forecast changes to climatic conditions.

Traditional ecological knowledge is important in climate change adaptation strategies. Aboriginal peoples, as the oldest cultures on earth, have adapted and thrived through changing climates (**Netana-Glover 2023**).

Their knowledge can provide crucial insights into adapting to current and future changes driven by rapid and human-induced climate change (**Moggridge & Thompson 2024**).

See the **Climate change** topic for more information.

Invasive threats

'Invasive threats' is a general term for feral animals, weeds, pathogens, and other organisms that are introduced to places outside their native ranges, where they spread. They then damage or harm local ecosystems and species (**DAFF 2004**).

Invasive plant species (weeds)

Weeds are plants introduced to Australia from overseas and growing where they don't belong. They can spread rapidly and can seriously threaten native species, ecosystems, agricultural productivity and landscape processes (**NSW Government 2024b**).

The *Biodiversity Conservation Act 2016* lists seven **key threatening processes** related to invasive plant species.

The impacts of these processes include:

- competition with native plants for nutrients, water, sunlight and space
- formation of dense areas of vegetation that shade and smother native species
- their spread into native habitats, making them less suitable for native wildlife
- dominating regrowth in areas that have been burnt (**Graham & Taylor 2018**).

For Aboriginal peoples and communities, there are further impacts including:

- less food security due to weeds competing with culturally important species
- disruption of cultural practices and knowledge due to altered ecosystems
- disruption of the natural rhythms of ecosystems and Country
- degradation of sacred sites
- economic impacts
- impacts on culturally significant species.

As at 2024, an estimated 325 high-risk weed species were recorded in the State (**DPI n.d.**).

The weeds that are of most risk to native plants and animals in NSW are shown in **Table B1.6** (**Downey et al. 2010**).

This table also shows whether each weed is listed as:

- a priority weed in a **Regional Strategic Weed Management Plan** (RSWMP)
- a **key threatening process** in the *NSW Biodiversity Conservation Act 2016*.

Table B1.6: Top 20 widespread weeds threatening native animals and plants in NSW

Common name	Scientific name	RSWMP priority species	Key threatening process
balloon vine	*Cardiospermum grandiflorum*	No	Yes**
bitou bush	*Chrysanthemoides monilifera* subsp. *rotundata*	Yes	Yes
blackberry	*Rubus fruticosus* species aggregate	Yes	Yes*
blue morning glory	*Ipomoea indica*	No	Yes**
bridal creeper	*Asparagus asparagoides*	Yes	Yes**
broad-leaf privet	*Ligustrum lucidum*	Yes	Yes*
Cape ivy	*Delairea odorata*	No	Yes**
cat's claw creeper	*Dolichandra unguis-cati*	Yes	Yes**
ground asparagus	*Asparagus aethiopicus*	Yes	Yes**
Japanese honeysuckle	*Lonicera japonica*	No	Yes*
lantana	*Lantana camara*	Yes	Yes
lippia	*Phyla canescens*	No	Yes*
Madeira vine	*Anredera cordifolia*	Yes	Yes**
Mickey Mouse plant	*Ochna serrulata*	No	Yes*
narrow-leaf privet	*Ligustrum sinense*	Yes	Yes*
salvinia	*Salvinia molesta*	Yes	Yes*
Scotch broom	*Cytisus scoparius* subsp. *scoparius*	Yes	Yes
serrated tussock	*Nassella trichotoma*	Yes	Yes***
sweet vernal grass	*Anthoxanthum odoratum*	No	Yes***
turkey rhubarb	*Acetosa sagittata*	No	Yes*

Notes:
* invasion by escaped garden plants.
** invasion by exotic vines and scramblers.
*** invasion by exotic perennial grasses.

RSWMP=Regional Strategic Weed Management Plan

Source:
Downey et al. 2010, reviewed and updated by DPIRD

Grazing animals

Grazing by introduced animals, such as rabbits, goats, deer, horses and pigs, is listed as a **key threatening process** in the *Biodiversity Conservation Act 2016* because it poses a threat to biodiversity

Rabbits are one of Australia's most destructive invasive animals.

They breed quickly and are very adaptable. This means they can occupy a wide range of habitats across Australia, often outcompeting and displacing native species.

They can overgraze an area and eat all parts of a plant, including the seeds, bark and roots. This can lead to:

- increased erosion
- reduced plant survival
- decreased new growth.

Feral goats are a serious threat to biodiversity on Australia's rangelands (**Murphy & van Leeuwen 2021**) and islands (**Daley 2005**). They compete directly with native mammals for food and refuge (**DPI 2014**). In addition, their widespread grazing and trampling can:

- destroy the vegetation cover
- disturb the balance of species in a vegetation community
- prevent the regeneration of native plants
- lead to more rapid soil loss and erosion (**DCCEEW-Aus 2023**).

Feral goat numbers can increase rapidly under suitable conditions. Feral goat numbers in western NSW have increased from 542,145 in 1999 to 4,993,531 in 2020 (**Invasive Species Council 2023**; **DCCEEW-Aus 2023**).

See the **Animals** topic for more information about grazing animals.

Insects

Insects are the most diverse class of animals and have a profound ecological influence, whether they're native or invasive species. Insects that are predators, plant-eaters, pollinators of weeds, parasites or disease carriers can harm native plants (**Invasive Species Council 2020**).

Two insects of particular concern are psyllids and fire ants.

Psyllids are tiny, sap-sucking insects. Bell miner birds protect them from predators because they eat their excretions.

The collaboration between bell miners and psyllids leads to psyllids becoming too plentiful.

The psyllids strip eucalyptus trees of their leaves, eventually killing them. This process is called **'eucalypt dieback'** and is a key threatening process.

In 2006 it was estimated that 2.5 million hectares of NSW forest could be affected by eucalypt dieback (**Wardell-Johnson et al. 2006**). This process reduces canopy cover and habitat for the many endangered and vulnerable native animals living in eucalypt forests.

Fire ants (*Solenopsis Invicta*) are an exotic invasive pest. They are listed as a **key threatening process** in the *Biodiversity Conservation Act 2016*.

While found mainly in Queensland, there have been **two cases reported** in NSW since 2021 (**Australian Government 2024**).

The ants are highly aggressive and can spread over large distances.

They feed on seeds, other insects and small animals, including those that pollinate native plants. They also inflict a painful bite.

Fire ants can damage or destroy ecosystems by:

- killing insects and small animals that are essential elements in food chains
- reducing plant populations and destabilising ecosystems (**Wildlife Queensland 2023**).

Pathogens and disease

Pathogens are organisms, such as viruses, bacteria and fungi, that cause disease. They can seriously damage animal and plant biodiversity and harm human health.

The *Biodiversity Conservation Act 2016* identifies two pathogens that damage native vegetation and have been listed as **key threatening process**es:

- ***Phytophthora cinnamomi*** (P. *cinnamomi*) – a water mould, though commonly referred to as root-rot fungus
- **myrtle rust** – a fungal disease.

P. cinnamomi is widespread in coastal forests. It infects many native plant species, damaging or killing them (**OEH 2017**).

Myrtle rust threatens common native species, such as eucalypt, paperbark, tea tree, bottlebrush and lilly pilly trees (**Image B1.4**). First detected in Australia in 2010, it has spread rapidly along the east coast of NSW and across Australia (**NSW Government 2023**).

Heavy infection can kill leaves and stems, and even an entire plant.

Image B1.4: Myrtle rust

Notes:
Myrtle rust infection on Scrub Turpentine (*Rhodamnia rubescens*).

Source:
Gavin Phillips/DCCEEW

Responses

Policy protections

NSW plan for nature

The ***NSW plan for nature***, released in July 2024, is the NSW Government response to the statutory reviews of the ***Biodiversity Conservation Act 2016*** and native vegetation provisions of the ***Local Land Services Act 2013***.

The response acknowledges that biodiversity in NSW is in crisis and that the Government's policy objective needs to shift from mitigating decline to restoration and repair. This is essential to the wellbeing and prosperity of current and future generations.

Priority actions include:

- strengthening the *Biodiversity Conservation Act 2016*
- exploring, in partnership with Aboriginal stakeholders, new and better ways to support Aboriginal people to connect with and care for Country
- developing a NSW nature strategy
- improving whole-of-government accountability for biodiversity outcomes
- better incorporating biodiversity into strategic planning processes
- reforming the **Biodiversity Offsets Scheme**
- strengthening conservation on private land
- supporting landholders to drive improvements in land management practices and participate in natural capital markets
- improving biodiversity data, tools and reporting
- improving the regulation of native vegetation in rural areas
- commissioning independent advice on options to improve biodiversity outcomes in regional landscapes and enhance value and support for landholders.

Nature positive

Nature positive is a concept that was developed in 2019–20 to inspire action on the global biodiversity crisis, much as the net zero target galvanises climate change action.

The high-level goal of nature positive is to 'halt and reverse nature loss by 2030 on a 2020 baseline and achieve full recovery by 2050' (**NPI 2024**).

Delivering this goal requires measurable, net positive biodiversity outcomes through improvement in the abundance, diversity, integrity, and resilience of species, ecosystems and natural processes.

The concept is embedded in the **Global Biodiversity Framework's** mission to 2030 to 'take urgent action to halt and reverse biodiversity loss to put nature on a path to recovery for the benefit of people and planet' (**UNEP 2022**).

In December 2022, the Australian Government released its ***Nature Positive Plan: better for the environment, better for business***. The plan outlines the Australian Government's response to the 2020 independent **review** (PDF 6MB) of the *Environment Protection and Biodiversity Conservation Act 1999*.

The NSW Government has committed to developing and implementing a NSW nature strategy. The strategy, which will be a legal requirement under the *Biodiversity Conservation Act 2016*, will set goals and targets for conservation and restoration. These will include species recovery, landscape restoration and addressing threats, such as those outlined in this topic.

Monitoring and mapping

Nature positive spatial tools

The ***NSW plan for nature*** outlines the NSW Government's commitment to identifying areas of the State that have high biodiversity value.

Mapping these areas using a single spatial tool, as recommended by the statutory review of the ***Biodiversity Conservation Act 2016***, will help inform land use planning and nature positive outcomes.

The plan also commits to other improvements to mapping and monitoring, including:

- improving the accuracy of the **Biodiversity Values Map**
- comprehensive identification and mapping of threatened ecological communities
- ongoing native vegetation monitoring, including considering establishing a legislative requirement
- enhancing the **Statewide Landcover and Tree Study program** (SLATS) to capture both vegetation losses and gains (including revegetation and regrowth), reduce reporting time lags and enable accurate reporting of net changes in vegetation cover over time.

Measuring the health of native vegetation

NSW is transitioning to a different way of measuring the health of native vegetation. Rather than measuring 'condition', we are now measuring 'integrity' via the **Biodiversity Assessment Method (BAM)**.

An example of how this has been used in northern NSW is in the ***NSW biodiversity outlook report 2024***.

Ecological health performance scorecards

The **Ecological health performance scorecards program** is a biodiversity monitoring program by the NSW National Parks and Wildlife Service.

The pilot program measures the health of our national parks in eight sites across NSW by monitoring environmental indicators related to:

- the health of native plants and animals
- threats to ecological health, such as feral animals and weeds
- important ecological processes, such as soil chemistry and water quality
- fire patterns.

While most of the scorecards will be released in 2025, the first, for the **Royal-Heathcote-Garawarra** site, shows that despite being so close to urban areas, this area still has high conservation value. Key findings related to plants included:

- low levels of weeds away from high-use areas
- the critically endangered Scrub Turpentine (*Rhodamnia rubescens*) is significantly impacted by myrtle rust infection.

These findings will help inform management strategies for this site.

Urban greening

Shade provided by trees is important for:

- reducing heat in towns and cities
- improving air quality and reducing noise
- providing wildlife habitat
- increasing property, aesthetic and cultural values.

The NSW Government has been **mapping urban tree cover** across Greater Sydney since 2019. This helps councils plan and manage urban forests in local government areas.

The NSW Government has set a target to increase tree canopy cover across Greater Sydney to 40% by 2036.

The latest update shows an increase in canopy from 21% in 2019 to 21.7% in 2022. Most of this increase was in Central and Western Sydney local government areas (**NSW Planning n.d.**).

Land management

Aboriginal joint management

Aboriginal joint management has been in place in NSW national parks and reserves since its formal introduction in 1998. As at June 2024, about 30%, or 2,334,621 hectares of the NSW national park estate is jointly managed with Aboriginal people.

Joint management involves Aboriginal people who have a cultural association with a park being involved in park management or advising on its management.

Joint management of national parks ensures Aboriginal people have input into conservation measures, including feral animal and weed management, and Cultural Fire management.

See **Protected areas and conservation** topic for further information.

Landcare Enabling Program 2023–27

This **partnership** between Local Land Services (LLS) and Landcare NSW supports:

- Landcare groups to develop their knowledge, skills and experience
- improved efficiency of groups and networks

- the increased self-sufficiency of Landcare groups and networks.

Local Land Services Landcare Riparian Restoration Project

Between 2021 and 2023, this **collaborative project** facilitated the restoration of riparian areas that had suffered cumulative damage from recent natural disasters (floods, fires and drought).

During the life of the project:

- 25 kilometres of streambanks were rehabilitated
- 776 hectares of riparian areas were restored
- 146 hectares of riparian vegetation was enhanced or rehabilitated
- 28 hectares of land were managed for weeds
- 7 alternative watering sites for stock were installed.

Natural Heritage Trust projects 2023–28

Projects to boost a range of species and landscapes are being delivered for five years by LLS, with Australian Government funding.

The projects aim to:

- increase environment protection
- encourage sustainable agriculture
- ensure better natural resource management across NSW.

See **Natural Heritage Trust projects** for more information.

Supporting landholders

Local Land Services (LLS) supports landholders in implementing sustainable land management and agricultural practices.

This includes advice on preserving and enhancing natural habitats and managing land to improve biodiversity.

LLS also advises landholders on evaluating environmental and natural capital markets in accordance with the **NSW Natural Capital Statement of Intent**.

Under the ***NSW plan for nature*** actions, LLS is responsible for building landholder capability and boosting landholder participation in natural capital markets, and expanding access to conservation and natural capital investments.

LLS has implemented a **natural capital services and support program** to help maximise private investment in nature and expand private landholder access to natural capital markets.

Between 2021 and 2024, LLS natural resource management programs achieved the following results:

- 6,577 hectares of wetlands were enhanced, rehabilitated or protected
- 14,561 hectares of rivers and estuaries were enhanced
- 2,946 hectares of land were revegetated
- 104,149 hectares of native vegetation were enhanced, rehabilitated or protected.

Private land conservation

More than 70% of the State's biodiversity is on private land (**BCT n.d.**).

The NSW Government committed more than $350 million over five years from 2019–20 to help the **Biodiversity Conservation Trust** deliver its private land conservation program.

This program was guided by the **NSW Biodiversity Conservation Investment Strategy**.

The NSW Biodiversity Conservation Trust managed 2,476 private land conservation agreements with landholders as at 30 June 2024, covering more than two million hectares of land (**BCT n.d.**).

See the **Protected areas and conservation** topic for further information.

Fire management

The NSW government's **Applied Bushfire Science Program** addresses key recommendations from the **2020 NSW Bushfire Inquiry** relating to the environment and recognition of Aboriginal cultural knowledge, and impacts of fire on Aboriginal cultural values. The program also advances the State's capacity to lead critical bushfire research.

The program is updating the ecological research and guidelines that directly influence fire planning and policy. An important focus includes establishing a central point of information for managing fire risk for native plants, animals and Aboriginal cultural values across the state.

The following questions are central to the research program:

- what fire management regime is best for a particular species
- how can we best manage fire risk in relation to cultural values.

Aboriginal peoples' use of Cultural Fire was instrumental in maintaining a healthy landscape and managing flammable vegetation through frequent small fires. Recent studies have demonstrated that in south eastern Australia, shrub cover in woodlands increased due to the disruption to Cultural Burning after colonisation (**Mariani et al. 2022**).

One recommendation from the **independent review** of the *Biodiversity Conservation Act 2016* was to incorporate traditional knowledges and practices into native vegetation management.

Cultural Fire

A dedicated team was created to lead the implementation of recommendations 25 and 26 of the **NSW Bushfire Inquiry 2020**.

This team is developing a NSW Cultural Fire Strategy to improve the coordination of Cultural Fire, explore its implementation on a wider basis and preserve the cultural integrity of Cultural Fire.

See the **Health of Country** and the **Protected areas and conservation** topics for further information about Cultural Burning.

The NSW Government has also established research partnerships with a range of universities and the **Bushfire and Natural Hazards Research Centre**. This will further improve our understanding of how threatened plant species respond to planned and unplanned fire and support effective management.

Protecting threatened species

Threatened Species Action Plan

The Australian Government's updated **Threatened Species Action Plan 2022–2032** lays out actions to protect, manage and restore Australia's threatened species and important natural places.

The plan lists 30 priority plant species and 20 priority places across Australia, identifying key threats and actions that can be taken to protect them.

Several of these plant species and places are found in NSW, including:

- **Native guava** (*Rhodomyrtus psidoides*)
- **Wollemi pine** (*Wollemia nobilis)*
- **Greater Blue Mountains**
- **Brigalow Country**.

Threatened species and ecological communities programs

A performance **audit** assessed whether the NSW Department of Climate Change, Energy, the Environment and Water (DCCEEW) has effectively delivered outcomes to support threatened species and ecological communities across NSW, including delivery of the statutory Biodiversity Conservation Program (**Saving our Species**).

The audit found that DCCEEW had taken action to conserve fewer than one-third of all threatened species and ecological communities. This number had decreased over time, in line with reduced program funding.

Recommendations included:

- strengthening compliance, governance, planning and risk management frameworks when working with threatened species

- developing a long-term framework to coordinate and align efforts to conserve threatened species
- improving coordination among government agencies when delivering activities to increase effectiveness and decrease duplication of effort.

Threatened species framework for zero extinctions

The NSW National Parks and Wildlife Service has adopted a zero-extinction target for threatened species on land managed by the agency.

Actions to support this target and restore populations of threatened species are set out in the **threatened species framework for zero extinctions**.

The **first report** published under the framework was released in September 2024. It includes an overview of relevant programs and initiatives and highlights achievements during 2021–22 and 2022–23.

Saving our Species

The **Saving our Species** program aims to:

- maximise the number of threatened species and ecological communities that are secure in the wild in New South Wales for 100 years
- minimise the impacts of **key threatening processes**.

Saving our Species delivered actions across more than 210 projects for threatened plants and ecological communities in 2023–24. These actions were at more than 480 sites across NSW.

For example, Saving our Species program staff collaborated with Botanic Gardens of Sydney to:

- develop propagation techniques for eight threatened orchid species and establish a collection of seedlings that can be **translocated** to suitable habitat
- undertake genetic analysis of threatened plant species to inform critical management actions
- collect, store and test the seeds of high priority threatened plants.

Key threatening processes to native vegetation managed under the program include:

- infection of native plants by ***Phytophthora cinnamomi***
- the invasion, establishment and spread of ***Lantana camara***.

Invasive species

Weed management

In NSW weed management is prioritised based on risk as evaluated through the **NSW Weed Risk Management system**.

The risk for each weed is assessed based on the potential impacts if it becomes more established or more widespread.

Weeds that are considered a State biosecurity risk are managed using instruments such as Control Orders and Biosecurity Zones under the ***Biosecurity Act 2015*** and the **Biosecurity Regulation 2017 – Weeds**.

These include rubber vine (*Cryptostegia grandiflora*) and mouse-ear hawkweed (*Pilosella officinarum*), both listed as Prohibited Matter under the *Biosecurity Act 2015*. Both are on track for eradication in NSW by the Department of Primary Industries and Regional Development.

The **Regional Strategic Weed Management Plans** also use risk to prioritise weed management in the 11 LLS regions.

The plans play a critical role in the early detection and eradication of priority weed species and the containment and management of those that are more widespread.

They list 64 weed species that have been assessed as regional priority weeds for conservation and environmental land use areas in NSW.

Of these, 13 are managed with the goal of preventing their spread in at least one LLS region. These include weeds such as leaf cactus (*Pereskia aculeata*) and horsetails (*Equisetum* spp.).

A further 38 regional weed species are being managed with the goal of eradication in at least one region. These include a wide range of priority species, such as:

- bridal creeper (*Asparagus asparagoides*)
- Hudson pear (*Cylindropuntia pallida*)
- sea spurge (*Euphorbia paralias*).

Another 34 species are managed for containment and asset protection in at least one LLS region.

These include opuntioid cacti, such as the prickly pears (*Opuntioid* spp.) and Hudson pear (*Cylindropuntia pallida*), which are being managed successfully through biocontrol programs and targeted on ground management (**McConnachie et al. 2022**).

Other widespread species, including blackberry (*Rubus fruticosus* species aggregate), *Lantana camara* and serrated tussock (*Nassella trichotoma*), are managed using an asset protection approach through programs such as **Saving our Species**, which manage weeds and other threats to native species holistically. These programs aim to reduce weed impact at specific affected locations (**NRC 2024**).

LLS supports rural landholders to fulfil their responsibilities to manage weeds in accordance with Australian and NSW biosecurity legislation and Regional Strategic Weed Management Plans.

For example, from 2021 to 2024, LLS helped manage weeds on 141,100 hectares of private rural land for improved biosecurity, agricultural productivity and biodiversity.

Weed management in national parks

Weeds threaten biodiversity across NSW national parks and can also cause damage to areas that are culturally and historically important, such as Aboriginal rock art sites.

Working together with similar agencies, NSW National Parks and Wildlife Service (NPWS) manages programs that tackle these threats. NPWS has developed specific **regional pest management strategies**, which are used to guide and implement best practice control and monitoring programs in national parks and reserves. In relation to weeds, the strategies aim to:

- prevent or reduce the amount of new and emerging weeds
- help stop the destructive impact of weeds on threatened plants and animals, agriculture and cultural heritage.

NPWS plans weed control programs for where they'll have the most benefit for biodiversity and the greatest cultural and community value. For example, weeds might be removed from areas where they're impacting threatened species and their habitat.

Invasive animals

Each LLS area in NSW has regional pest animal committees. These committees coordinate activities to manage invasive animals on both public and private land. They have developed 11 **Regional Strategic Pest Animal Management Plans**.

See the 'Responses' in the **Animals** topic for more information about how invasive animals are controlled in NSW.

Fire ants

The **Biosecurity (Fire Ant) Emergency Order (No. 12) 2024** places restrictions on the movement of materials that may carry fire ants from one location to another. These include organic mulch and compost, turf, hay and chaff, potted plants, earthmoving equipment, sand and gravel.

The order sets out rules and requirements for safely transporting and using these carriers, and states the penalties for breaching the conditions.

Community involvement

Citizen science

Citizen science projects, in which community members gather data, photos and observations, are rapidly becoming more popular in Australia. They:

- allow community members to engage with environmental issues and scientists
- increase people's knowledge of, and interest in, conservation
- support traditional scientific research and monitoring.

The collaboration between community members and scientists also means data is collected more often over a longer period than is possible in a research project staffed only by scientists.

Some citizen science projects involving the protection of native vegetation include:

- **Bush Blitz**
- **iNaturalist**
- **Environment Recovery Project**
- **Wild orchid watch**
- **ClimateWatch**.

The data collected through these and other apps and projects helps build knowledge of the distribution and health of native vegetation across NSW.

Trees Near Me app

The NSW Government launched its **Trees Near Me NSW** app in August 2022.

The app provides information about plant community types and plant species, such as where they grow (or grew, before clearing), and their natural habitat.

By planting locally native trees, people can provide more habitat for native animals that may be struggling and help increase the spread of native vegetation.

Restore Trees NSW

The NSW Government has recently released a new mobile and web-based app that shows the best locations for looking after and replanting vegetation in NSW.

Restore Trees NSW provides a range of environmental information for any location in NSW including vegetation, threatened fauna, soils, climate and topography.

The app also links to helpful online resources, information, such as seed suppliers, finance, community help and **Local Aboriginal Land Councils**.

Volunteer groups

Volunteer groups contribute enormously to improving and conserving the natural environment.

Landcare Australia is one of the largest volunteer organisations, made up of thousands of groups and more than 100,000 volunteers across Australia.

Bushcare groups managed by local councils weed and revegetate native bushland to improve and create habitat for native species.

Data gaps

More native plant species than vertebrate animals are threatened in Australia, but they are only about half as likely to be the focus of monitored conservation programs (**TSR 2021**).

There is information for only a few isolated species of many plant groups. This lack of information provides little insight into the broader status and management needs of these groups.

Patterns of decline that are likely to have been present for many years are still being discovered in lesser studied groups of species.

Future opportunities

Mapping and monitoring

While several data sources are available on the impact of weeds, this information is localised and dispersed across multiple agencies. There is an opportunity to collate and centralise this data so that it can provide an up-to-date statewide overview.

NSW is preparing to integrate the NSW vegetation hierarchy with a **Global Ecosystems Typology**. This will enable a better understanding of the global context of NSW vegetation and habitat, and facilitate integrated monitoring and reporting.

Research and development is underway to enable reporting on extent of native woody vegetation regrowth in addition to native vegetation clearing in NSW. Measuring the condition of regrowth in comparison to remnant vegetation via remote sensing methods is not yet possible. These analyses, once established, would support an annual reporting process for woody vegetation loss and regrowth/revegetation on rural regulated land, which is included in the ***NSW plan for nature***.

A variety of technologies are being researched to better map and report on native grasslands across NSW. Traditionally, native grasslands have been difficult to map using remote sensing and on-ground survey has been poor. Natural native grasslands and derived grasslands, which can retain important native species, are currently being researched.

Technology

New options are becoming available for improving and expanding mapping and analysis of native vegetation.

Better satellite coverage linked to extensive on-ground data is for the first time enabling a comprehensive overview of native vegetation in NSW. This has improved our understanding and ability to report on statewide ecosystems.

Scientists can now better identify native vegetation quality by analysing data from drones using artificial intelligence (AI) and machine learning.

When AI and machine learning are integrated with the Internet of Things and networks of sensors across the State, scientists can collect and monitor in real-time data such as soil moisture, temperature, humidity and vegetation condition. Such analysis can provide early warnings of drought stress or disease outbreaks.

The use of AI also allows integration of data from satellites, ground-based sensors and historical records, for a more comprehensive understanding of vegetation health.

And passive acoustic surveillance technology can detect invasive species outbreaks.

Advances such as these will allow monitoring to occur at sites and in timeframes that would otherwise not be possible.

References

AdaptNSW n.d., Climate change impacts on our biodiversity, AdaptNSW, accessed 15 July 2024

Australian Government 2024, Red imported fire ant (Solenopsis invicta), Australian Government Outbreak, accessed 16 July 2024

BCT n.d., Private land conservation in NSW, Biodiversity Conservation Trust, accessed 16 July 2024

BGS n.d., NSW Flora Online (PlantNET), Botanic Gardens of Sydney, calculations by DCCEEW

Cumpston Z 2020, *Indigenous plant use: A booklet on the medicinal, nutritional and technological use of indigenous plants*, Clean Air and Urban Landscapes Hub, The University of Melbourne, Victoria (PDF 13.2 MB)

DAFF 2004, *Invasive species in Australia*, Department of Agriculture, Fisheries and Forestry, Canberra (PDF 0.42MB)

DAFF 2012, *Australia's Native Vegetation Framework*, Department of Agriculture, Fisheries and Forestry, Canberra (PDF 6.0MB)

Daley B 2005, *Change in the Great Barrier Reef since European settlement: implications for contemporary management*, PhD thesis, James Cook University

DCCEEW-Aus 2021, Priority list of plants requiring urgent management intervention, Australian Government Department of Climate Change, Energy, the Environment and Water, accessed 27 November 2024

DCCEEW-Aus 2023, *Draft background document for the threat abatement plan for competition and land degradation by unmanaged goats*, Australian Government Department of Climate Change, Energy, the Environment and Water, Canberra

DCCEEW 2024a, *Community Appreciation of Biodiversity Indicator - enhanced assessment (2022–ongoing)*, NSW Department of Climate Change, Energy, the Environment and Water, Sydney

DCCEEW 2024b, *NSW biodiversity outlook report 2024*, NSW Department of Climate Change, Energy, the Environment and Water, Sydney

DCCEEW 2024c, *NSW State Vegetation Map C2.0M2.0*, NSW Department of Climate Change, Energy, the Environment and Water, Sydney

DCCEEW 2024d, *NSW State Vegetation Map (Pre-Clearing)*, NSW Department of Climate Change, Energy, the Environment and Water, Sydney

DCCEEW unpub., *Threatened Plant Species* (unpublished), NSW Department of Climate Change, Energy, the Environment and Water, Sydney

Downey PO, Scanlon TJ & Hosking JR 2010, 'Prioritizing weed species based on their threat and ability to impact on biodiversity: A case study from New South Wales', *Plant Protection Quarterly*, vol. 25, no. 3, pp. 111–26, DOI: 10.3316/informit.372939901346893

DPE 2022a, *Eastern NSW plant community type percentage cleared calculation technical notes 2022*, NSW Department of Planning and Environment, Sydney

DPE 2022b, *Woody and non woody landcover change rural regulated land*, NSW Department of Planning and Environment, Sydney

DPE 2023a, Statutory Reviews into native vegetation management and biodiversity laws tabled, NSW Department of Planning and Environment, accessed 15 July 2024

DPE 2023b, *Eastern NSW plant community type percent cleared calculation: Technical Notes updated for release C2.0M2.0*, NSW Department of Planning and Environment, Sydney

DPI 2014, *Ecology and Management of Vertebrate Pests in NSW*, NSW Department of Primary Industries, Sydney

DPI n.d., NSW Weeds, NSW Department of Primary Industries, accessed 27 November 2024

DPIE 2020, *NSW Biodiversity Outlook Report - Results from the Biodiversity Indicator Program: First assessment*, NSW Department of Planning, Industry and Environment, Sydney

Fielding KS, Prober S, Williams K & Dean A 2020, *Assessment of an indicator of community appreciation of biodiversity, Biodiversity Indicator Program Implementation Report*, NSW Department of Planning, Industry and Environment, Sydney

Gallagher RV, Allen S, Berin DE, Mackenzie CJ, Yates CJ, Gosper CR, Keith DA, Merow C, White MD, Wenk E, Maitner BS, He K, Adams VM & Auld TD 2021, 'High fire frequency and the impact of the 2019–2020 megafires on Australian plant diversity', *Diversity and Distributions*, vol. 27, no. 7, pp. 1,166–79, DOI: 10.1111/ddi.13265

Graham M & Taylor K 2018, *Fire, Weeds and the Native Vegetation of New South Wales*, Report by Hotspots Fire Project, Nature Conservation Council of New South Wales and New South Wale Rural Fire Service

Harwood T, Love J, Drielsma M, Brandon C & Ferrier S 2022, 'Staying connected: assessing the capacity of landscapes to retain biodiversity in a changing climate', *Landscape Ecology*, vol. 37, pp. 3,123–39, DOI: 10.1007/s10980-022-01534-5

Heagney EC, Falster DS & Kovač M 2021, 'Land clearing in south-eastern Australia: Drivers, policy effects and implications for the future', *Land Use Policy*, vol. 102, 105243, DOI: 10.1016/j.landusepol.2020.105243

Invasive Species Council 2020, *Invasive Insects: Risks and Pathways Project*, NSW Invasive Species Council

Invasive Species Council 2023, New national feral goat plan welcomed but requires funding, Invasive Species Council, accessed 16 July 2024

Johnson C, Cogger H, Dickman CR & Ford H 2007, *Impacts of Landclearing: the impacts of the approved clearing of native vegetation on Australian wildlife in New South Wales*, World Wide Fund for Nature – Australia, Sydney

Liao Z, Van Dijk AIJM, He B, Larraondo PR & Scarth PF 2020, 'Woody vegetation cover, height and biomass at 25-m resolution across Australia derived from multiple site, airborne and satellite observations', *International Journal of Applied Earth Observations and Geoinformation*, vol. 93, 102209, DOI: 10.1016/j.jag.2020.102209

Lindenmayer D & Dickman C 2022, 'Impact of Habitat Loss and Fragmentation on Assemblages, Populations, and Individuals of Australasian Marsupials', in: Cáceres NC & Dickman CR (eds), *American and Australasian Marsupials: An Evolutionary, Biogeographical, and Ecological Approach*, Springer International Publishing, pp. 1–32, DOI: 10.1007/978-3-030-88800-8_45-1

LLS 2023, *Statutory review of the native vegetation provisions (Part 5A and Schedule 5A and Schedule 5B) of the Local Land Services Act 2013*, NSW Local Land Services

Mariani M, Connor S, Theuerkauf M, Herbert A, Kuneš P, Bowman D, Fletcher M, Head L, Kershaw P, Haberle S, Stevenson J, Adeleye M, Cadd H, Hopf F & Briles C 2022, 'Disruption of cultural burning promotes shrub encroachment and unprecedented wildfires', *Frontiers in Ecology and the Environment*, vol. 20, no. 5, pp. 292–300, DOI: 10.1002/fee.2395

Martín-López 2024, *Plural valuation of nature matters for environmental sustainability and justice*, The Royal Society, accessed 5 December 2024

McConnachie A, Jones P, Fletcher A, Savage M, Patterson A, Holtkamp R, Snow L, Taylor T, Skewes J, Dawson P, Bergin C, Harvey K, Turner P, Shilpakar R & Nawaz M 2022, *A thorny tale: Cylindropuntia pallida (Hudson pear) biocontrol in New South Wales, Australia*, 2022 Australasian Weeds Conference paper (PDF 0.16MB)

Moggridge BJ & Thompson RM 2024, 'Chapter 18 - Indigenous engagement to support resilience: A case study from Kamilaroi Country (NSW, Australia)', *Resilience and Riverine Landscapes*, pp. 363–87, DOI: 10.1016/B978-0-323-91716-2.00006-6

Murphy H & van Leeuwen S 2021, 'Australia state of the environment 2021: biodiversity', *independent report to the Australian Government Minister for the Environment*, Commonwealth of Australia, Canberra, DOI: 10.26194/ren9-3639 (PDF 24MB)

NRC 2024, *Reducing Risk, Securing the Future – NSW Invasive Species Management Review*, NSW Natural Resources Commission, Sydney

NPI 2024, What is Nature Positive, Nature Positive Initiative, accessed 17 October 2024

Netana-Glover L 2023, 'Indigenous futures and deep time connections to place', *The Routledge Handbook of Australian Indigenous Peoples and Futures*, 1st Edition, pp. 296–310, DOI: 10.4324/9781003271802-23

NSW EPA 2022, NSW State of the Environment report 2021: Native vegetation, NSW Environment Protection Authority, accessed 15 July 2024

NSW Government 2023, Introduction and establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae – profile, NSW Office of Environment and Heritage, accessed 16 July 2024

NSW Government 2024a, Key threatening processes, Environment and Heritage, accessed 15 July 2024

NSW Government 2024b, Weeds, Environment and Heritage, accessed 15 July 2024

NSW Planning n.d., Tree canopy data, NSW Planning, accessed 17 July 2024

OEH 2017, Infection of native plants by Phytophthora cinnamomic – profile, NSW Office of Environment and Heritage, accessed 16 July 2024

OEH 2018, *Biodiversity Assessment Method Operational Manual – Stage 1*, NSW Office of Environment and Heritage, Sydney (PDF 1.34MB)

Pantiru I, Ronaldson A, Sima N, Dregan A & Sima R 2024, 'The impact of gardening on well-being, mental health, and quality of life: an umbrella review and meta-analysis', *Systematic Reviews*, vol. 13, no. 45, DOI: 10.1186/s13643-024-02457-9

Roff A, Day M, Thonell J & Denholm B 2022, *NSW State Vegetation Type Map: Technical Notes*, NSW Department of Planning and Environment, Sydney

Taylor MFJ & Dickman CR 2014, *NSW Native Vegetation Act Saves Australian Wildlife*, World Wildlife Fund – Australia, Sydney

TERN 2024, *Australia's Environment 2023 Report*, Australia's Terrestrial Ecosystem Research Network and Australian Nation University, TSR 2021, Most of Australia’s threatened plants aren’t being monitored, increasing the risk of extinctions, Threatened Species Recovery Hub, accessed 16 July 2024

UNECE n.d., Carbon Sinks and Sequestration, United Nations Economic Commission for Europe, accessed 15 July 2024

UNEP 2022, *Decision adopted by the conference of the parties to the convention on biological diversity: 15/4. Kunming-Montreal Global Biodiversity Framework*, United Nations Environment Programme (PDF 0.32MB)

Van Dijk AIJM & Rahman J 2019, *Synthesising multiple observations into annual environmental condition reports: The OzWALD system and Australia's Environment Explorer*, 23rd International Congress on Modelling and Simulation, Canberra (PDF 1.78MB)

Ward M, Ashman K, Lindenmayer DB, Legge S, Kindler G, Cadman T, Fletcher R, Whiterod N, Lintermans M, Zylstra P & Stewart R 2024, ‘Shifting baselines clarify the impact of contemporary logging on forest-dependent threatened species’, *Conservation Science and Practice*, vol.6 no. 9, e13185, DOI: 10.1111/csp2.13185

Wardell-Johnson G, Stone C, Recher H & Lynch AJJ 2006, *Bell Miner associated dieback (BMAD) independent scientific literature review: a review of eucalypt dieback associated with bell miner habitat in north-eastern New South Wales, Australia*, NSW Department of Environment and Conservation

Wildlife Queensland 2023, *Fire ants threaten wildlife and ecosystems in Australia*, The Wildlife Preservation Society of Queensland, accessed 16 July 2024

Animals

Habitat loss and invasive species continue to threaten native animals. Protecting our native animals will become more important as our population grows and the climate changes.

Overview

The number of threatened animal species listings increased by

18

since 2021

Read more

Only

50%

of species listed as threatened (in 2022) are predicted to still be living in 100 years' time.

Read more

Australia is home to many animals found nowhere else on earth. About 45% of birds, 87% of mammals, 94% of amphibians, 24% of fish and 93% of reptiles are unique to Australia (**Chapman 2009**).

The animal species that occur naturally in a place are described as 'native'. Animals that are native to a specific region and not found anywhere else are called 'endemic'.

NSW has a rich biodiversity, much of which is recognised as being internationally significant.

Native animals are important as they add to the variety of life on earth. They also provide many important ecosystem services that plants, other animals and humans rely on to survive. These services include:

- pest control
- pollination
- seed dispersal
- helping vegetation grow
- providing healthy resources, like clean water
- enriching and creating soil.

Native animal species play an important role in preserving and protecting the health of the environment. For example:

- While foraging, brush turkeys can move up to 200 tonnes of soil per hectare each year (**Eldridge & James 2009**). This soil disturbance helps plants to colonise new areas.
- Old forage pits dug by bandicoots and goannas trap litter and rainwater, which eventually breaks down to enrich the soil (**Valentine et al. 2017**).

When a species declines in numbers or distribution, or dies out altogether, these services can be reduced or wiped out (**Johnson et al. n.d.**). Keeping native animals healthy and abundant is therefore an important goal for NSW.

Native animals are of cultural value to Aboriginal peoples. For example, totem animals are central to Aboriginal spirituality and cultural identity. Individuals may be connected to one or more totemic species through kinship. These are often expressed through ceremonies, art, stories and language (**Clarke 2023**). Totems serve as powerful symbols, connecting people to the land and their ancestors (**Clarke 2023**).

Aboriginal peoples recognise ways that all nature is connected, and the importance of animals in preserving the balance of nature (**Victorian Aboriginal Heritage Council 2021**).

Totem animals teach respect for nature. Aboriginal peoples' respect for animals has preserved the balance of nature for centuries and ensured the land's sustainability for future generations.

Threats to animals

Since European colonisation, there has been a steady decrease in biodiversity in NSW (**DPIE 2020**). Biodiversity means the variety of life on earth.

There has also been an increase in the number of species that are threatened and extinct.

These trends extend to both land- and water-based ecosystems, with invertebrates, amphibians, reptiles, birds, mammals and fish all included on lists of threatened species.

In 2024, there are more than 300 animal species in NSW that are threatened and at risk of extinction (See **Table B2.3**).

Key threats to animals in NSW include:

- climate change, for example, their habitat becomes too hot or cold for them
- weeds, which compete with native plants and animals and push them out of their habitat
- being preyed on by invasive species like cats and foxes, or competing for habitat with invasive animals like rabbits and goats
- changes in fire regimes, such as an increase in the frequency or intensity of wildfire, that may kill animals or cause loss or significant modification of habitat
- diseases that weaken or kill native animals
- loss of habitat where animals can find shelter, food and safety, due to people clearing native vegetation for urban, industrial or agricultural development
- pollution, including light and noise pollution, and pollution from pesticides
- traffic accidents from tractors, trucks and cars as part of agricultural and urban development
- river regulation, meaning there is less water for animals to live in or drink
- illegal hunting.

These threats may also work together and have led to significant reductions in the size of animal populations, and in their distribution and health. Many species live in smaller ranges than they previously did.

Legislation and management framework

Table B2.1 outlines current key legislation, policies and strategies related to native animals and their management in NSW. These are administered by State government agencies, including:

- NSW Department of Climate Change, Energy, the Environment and Water (NSW DCCEEW)
- Department of Primary Industries and Regional Development (DPIRD)
- Local Land Services (LLS)
- National Parks and Wildlife Service (NPWS)
- NSW Environment Protection Authority (EPA)
- Biodiversity Conservation Trust (BCT).

Recent initiatives to protect native animals in NSW include:

- the NSW Saving Our Species program (NSW DCCEEW)

- the NSW Assets of Intergenerational Significance program (NSW DCCEEW)
- the NSW Biodiversity Offsets Scheme (NSW DCCEEW)
- the NSW Private Land Conservation program (BCT)
- the Commonwealth *Threatened Species Action Plan 2022–32*
- the Commonwealth National Landcare Program (delivered by LLS in NSW)
- NPWS Threatened Species (Zero Extinctions) Framework

Table B2.1: Current key legislation, policies and strategies relevant to native animals and their management in NSW	
Legislation or policy	Summary
Biodiversity Conservation Act 2016	Aims to protect biodiversity and foster a productive, resilient environment while enabling ecologically sustainable development. Also creates the Biodiversity Offsets Scheme and Saving Our Species Program.
Biosecurity Act 2015 (Commonwealth)	Manages biosecurity threats to plans, animal and human health in Australia and Australian territories.
Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)	Protects the biodiversity of land-based plants and animals, and the environment, while enabling ecologically sustainable development.
Environmental Planning and Assessment Act 1979	Governs planning administration and laws, development assessments, environmental assessments, building certification, infrastructure finance, appeals and enforcement. It is the primary land use planning statute in NSW.
Fisheries Management Act 1994	Legislates the management of fishery resources and their habitats in NSW. It also legislates that the fishing needs and traditions of Aboriginal people are appropriately considered in the management of fisheries resources.
Forestry Act 2012	Establishes the framework for integrated environmental approvals for native forestry operations on Crown timber lands.
Local Land Services Act 2013	Governs management of natural resources, biosecurity and agricultural production on private rural land.
National Parks and Wildlife Act 1974	Aims to conserve the natural and cultural heritage of NSW through the establishment of national parks and reserves.
Protection of the Environment Operations Act 1997	Aims to achieve the protection, restoration and enhancement of the quality of the NSW environment. It enables the Government to create protection of the environment policies (PEPs), set environment protection licensing arrangements and perform other environment protection functions.
Australia's Strategy for Nature 2024–2030	Aims to halt and reverse biodiversity loss in Australia by 2030.
NSW Koala Strategy	Supports targeted investment and conservation actions that will protect koalas.
NSW plan for nature	Sets out the NSW Government response to the reviews of the *Biodiversity Conservation Act 2016* and the native vegetation provisions of the *Local Land Services Act 2013*.
Threatened Species Action Plan 2022–2032 (Commonwealth)	Sets out targets and actions to protect, manage and restore Australia's threatened species and important natural places.
Threat abatement plans (Commonwealth)	Provide for research, management and other actions required to assist the long-term survival in the wild of affected native animals.
Zero extinctions – National parks as a stronghold for threatened species recovery	Outlines a series of actions designed to secure and restore threatened species populations on the national park estate.

Notes:
See the **Responses** section for more information about how protection of native animals is managed in NSW.

Related topics: **Climate change** | **Coastal and marine** | **Health of Country** | **Plants** | **Protected areas and conservation** | **Rivers and wetlands**

Status and trends

NSW animal indicators

This report uses five indicators to assess the status and trends regarding the abundance, distribution and population of native animals in NSW (see **Table B2.2**).

- **Number of threatened species listed** reports the status and trends of the number of species listed as critically endangered, endangered and vulnerable in the *Biodiversity Conservation Act 2016* (see **Threatened species**).
- **Native mammals: population and distribution** reports on the status and trends in the populations and distribution of native mammals in NSW (see **Native mammals**).
- **Native birds: population and distribution** reports on the status and trends in the populations and distribution of native birds in NSW (see **Native birds**).
- **Native fish communities** reports on the status and trends regarding native fish in NSW (see **Native fish**).
- **Invasive animal species: distribution and impact** reports on the status and trends of invasive species (introduced animals such as rabbits, foxes and carp) on land and in water. It also reports on their distribution and impact on native animals and the environment (see **Invasive species**).

These indicators (apart from 'invasive animal species: distribution and impact') align to the 'biosphere integrity' planetary boundary. Globally, this boundary has been crossed (see **Planetary boundaries alignment** page for more information).

Table B2.2: Animals indicators

Indicator	Environmental status	Environmental trend	Information reliability
Number of threatened species* listed	**MODERATE**	Getting worse	Reasonable
Native mammals: population and distribution	**POOR**	Getting worse	Limited
Native birds: population and distribution	**MODERATE**	Getting worse	Reasonable
Native fish communities	**POOR**	Getting worse	Reasonable
Invasive animal species: distribution and impact	**POOR**	Getting worse	Reasonable

Notes:
*Threatened species encompasses those listed as critically endangered, endangered and vulnerable in the *Biodiversity Conservation Act 2016*.

Indicator table scales:
- **Environmental status**: Good, moderate, poor, unknown
- **Environmental trend**: Getting better, stable, getting worse
- **Information reliability**: Good, reasonable, limited.

See **Indicator guide** to learn how terms and symbols are defined.
See the **Planetary boundaries alignment** page for more information about how indicators align.

Threatened species

Animal species are listed under state and federal legislation as 'threatened', meaning actions are needed to stop them going extinct.

This section describes the status of native animal species listed as threatened in the ***Biodiversity Conservation Act 2016*** or the ***Fisheries Management Act 1994***.

The number of **threatened animal species listings** in NSW has increased by 18 (see **Table B2.3**) since the *State of the Environment 2021*. Changes in totals and numbers of threatened species listings do not represent the overall status of biodiversity, but are a useful indicator.

A species becomes threatened due to the threats and pressures it experiences. Some key threatening processes that pose threats to NSW native animals include:

- climate change, such as increasing temperatures and increasing frequency of drought
- invasive plants and animal species (also known as feral animals)
- changing fire patterns

- pathogens or disease
- habitat loss, degradation and fragmentation.

See the **key threatening processes** for all listed in the *Biodiversity Conservation Act 2016*.

A species is considered threatened if it is facing high to extremely high risk of extinction. This can happen when:

- there is a reduction in its population size
- it has a restricted geographical distribution
- there are few mature individuals.

A decision to list a species as threatened in the *Biodiversity Conservation Act 2016* or the *Fisheries Management Act 1994* is made in accordance with criteria developed by the **International Union for the Conservation of Nature** (IUCN).

In NSW, the **NSW Threatened Species Scientific Committee** decides if a species should be listed as threatened in the *Biodiversity Conservation Act 2016*. The **Fisheries Scientific Committee** has the same responsibility for fish and aquatic invertebrate species listed as threatened in the *Fisheries Management Act 1994*.

A **Common Assessment Method** is being also used across the Australian Government and all states and territories. This means there will be consistent assessment and listing of species in Australia, more frequent reviews of the current listing, and a more comprehensive picture of how species are doing across the continent.

As at June 2024, 343 threatened animal species were listed under the *Biodiversity Conservation Act 2016* and *Fisheries Management Act 1994*. Since 2020, there has been an increase in the number of listings for all animal taxa (categories), except for marine mammals. Listings increased after the 2019–20 bushfires, as the fires reduced the range and numbers of many species and additional funding and resources were allocated to listing assessments by governments.

Table B2.3 compares listings in 2020 to those in 2024.

Table B2.3: Numbers of threatened animals listed in the Biodiversity Conservation Act and Fisheries Management Act in 2020 and 2024

Animals	2020	2024
Mammals	57	59
Marine mammals	7	6
Birds	126	130
Amphibians	29	30
Reptiles	44	50
Fish	39	43
Invertebrates	23	25
Total	**325**	**343**

Notes:
In this table 'threatened' means all species listed as 'critically endangered', 'endangered' and 'vulnerable'.
Nine species of fungi are also listed under the *Biodiversity Conservation Act 2016*. The number has not changed since 2020.

Source:
Biodiversity Conservation Act 2016 Schedule 1 | Fisheries Management Act 1994 Schedule 4

Although more species are listed as threatened in 2024 than in 2020 in NSW, this does not necessarily mean that the species are facing more threats.

Some species have been listed as threatened because:

- there has been an increase in threats and pressures the species faces
- new or improved information about the species has become available, so there is now enough data to accurately assess them as threatened.

New data also means some species are being delisted.

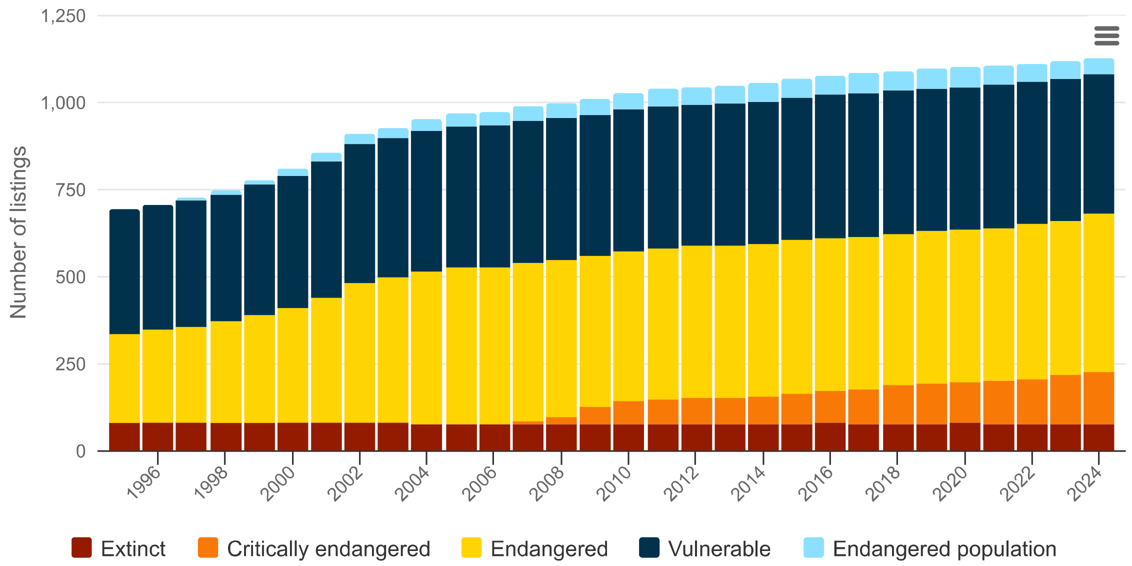
The listing process is scientifically rigorous which helps ensure decisions are made based on the latest species information.

Having more accurate information means that planning and conservation actions can be developed before animals decline to critical levels or become extinct.

In NSW, about 1,000 species and ecological communities are known to be threatened and at risk of extinction. Over time, the numbers of critically endangered and endangered animals and endangered populations listed have increased. Meanwhile, the number of extinct animals listed has fallen from 81 in 1995 to 76 in 2024.

These trends in species listings are shown in **Figure B2.1**.

Figure B2.1: Number of threatened animal species listings in NSW 1995–2024



Notes:
Years up to and including 2023 include data from 1 January to 31 December. The year 2024 only includes data for 1 January to 30 June.

Source:
Biodiversity Conservation Act 2016 Schedule 1 | **Fisheries Management Act 1994 Schedule 4**

NSW residents are also gaining more knowledge of native animal species in NSW that are in serious decline and at risk of becoming extinct (see **Table B2.4**).

When considering species that are of significance to Aboriginal peoples, resources for their protection are limited if the species is not currently listed as threatened.

See the **Health of Country** topic for more information on how Aboriginal peoples value native species and their importance locally.

Table B2.4: NSW residents' awareness of risks to native animals

Question and possible responses	Percentage of community choosing the response			
Thinking about native animal species, as far as you know, would you say	2015	2022	2023	2024
There are no native animal species in NSW in serious decline and at risk of becoming extinct	4%	6%	6%	6%
There are native animal species in NSW in serious decline and at risk of becoming extinct	68%	82%	84%	83%
Not sure, don't know	28%	11%	10%	12%
Sample (n)	2,000	1,901	2,063	2,060

Notes:
See the **Plants** topic for more information about this survey.

Source:
Community appreciation of biodiversity survey, 2015–24.

Importance of diversity

Measures of animal diversity include phylogenetic and functional diversity.

Phylogenetic diversity

Phylogenetic diversity considers how closely or distantly species are related to each other in an evolutionary tree.

For example, koalas (family *Phascolarctidae*) have a low phylogenetic diversity because they have no living relatives, while kangaroos (family *Macropodidae*) have several living relatives, including wallabies and quokkas.

We can estimate the proportion of the evolutionary tree that is expected to still exist in 100 years if certain species survive while others become extinct. Some species have no close relatives, and losing such distinctive species would result in a greater loss of phylogenetic diversity than losing a species with lots of close relatives (**DCCEEW 2024**).

Phylogenetic diversity for tetrapods (frogs, mammals, reptiles and birds) expected to survive in 100 years has declined from 92% in 2017 to 91% in 2022. This is because in 2022 more species risked extinction than in 2017 (**DCCEEW 2024**). For example, the koala, which has no close living relatives, shifted from being listed as vulnerable to endangered in 2022.

Functional diversity

Functional diversity means the range of activities a species performs in ecosystems and their interactions with their environment. For example:

- an understorey plant may provide shelter for ground-dwelling animals and rely on an insect to pollinate its flowers
- a tree may rely on a bird to eat its fruits and excrete them, releasing its seeds into the soil
- a freshwater fish may host and transport mussel larvae.

These relationships can break down if a species declines or dies out.

Only 50% of species listed as threatened (in 2022) are predicted to still be living in 100 years' time (**DCCEEW 2024**).

See the ***NSW biodiversity outlook report 2024*** for more information.

There are many examples of how well-implemented and resourced conservation actions can improve a species' status. For example:

- northern populations of the Booroolong frog are recovering due to captive breeding and reintroduction to the wild, after nearly being wiped out during the 2017–20 droughts (**NSW Government 2024e**)

- yellow-footed rock wallaby numbers have increased from 100 animals in 2003 to 299 in 2023, due to actions to improve their habitat and efforts to control foxes that prey on them (**NSW Government 2023a**)
- for the first time in 20 years, glossy black-cockatoos have been discovered in their previous range on the NSW Mid North Coast, with adults successfully nesting and raising chicks (**NSW Government 2023a**).

However, management and conservation actions will not be enough to save many species without resolving key threats, such as habitat removal and climate change.

See the **Protected areas and conservation** topic for more information about how NSW protects land.

Invertebrates

Australia is home to about 320,000 species of invertebrates (**Chapman 2009**), including bugs, beetles and snails. Of these, only 110,000 have been identified (**Invertebrates Australia n.d.**).

Invertebrates are the foundation of terrestrial and aquatic food chains across the planet. They contribute to the health of many ecosystems due to, for example, pollination, decomposition and nutrient cycling.

Invertebrates are a vital, but sometimes forgotten, part of earth's biodiversity. Their contributions are often underestimated, and the extent of their ecological interactions are poorly understood (**Sands 2018**).

When insect populations decline, so too do the populations of larger species that eat them. For example, migrating bogong moths are a primary seasonal food for the endangered mountain pygmy possum (**Gibson et al. 2017**).

The bogong moth has been in decline since the 1980s but had a huge population crash of up to 95% after the 2017 drought (**ACF 2022**).

In the following years, researchers found mountain pygmy possums had increasing pouch litter loss. This early death of young possums was linked to the significant decrease in bogong moths (**Burmeister 2019**).

In 2022, bogong moth numbers started to rebound. This is a positive development for the moths and the mountain pygmy possums (**ACF 2022**).

The bogong moth is of immense cultural significance and a central part of the Dreaming for many Aboriginal peoples of south-eastern Australia (**Wintle et al. 2021**).

For more than 2,000 years this species was a major seasonal food source in the NSW Southern Highlands, when people would travel hundreds of kilometres to gather for intertribal corroborees (**Stephenson et al. 2020**; **Australian Alps National Parks n.d.**).

Wetland fauna

Fresh water is vital to animal life. In a country as dry as Australia, fresh water is an important resource.

In NSW, natural flows and the strategic release of water from impoundments to the environment help to protect rivers and wetlands and the species that depend on them.

Monitoring of inland wetlands has shown that some wetland-dependent waterbirds, frogs and freshwater turtles have benefited from the release of environmental water.

Wetland species can be useful bioindicators, meaning their presence can show the health of the ecosystems they live in. For example, the population health of some species of waterbirds and frogs can be used to:

- identify the quality of water
- identify eutrophication, that is, when excessive growth of microorganisms takes oxygen out of the water (**Amat & Green 2010**)
- assess whether water flows are effective (**DPIE 2022**).

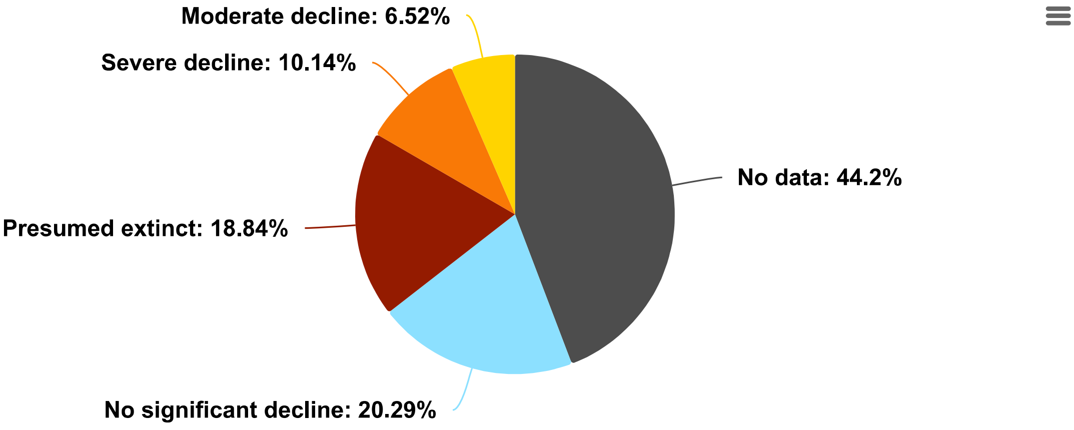
See the **Rivers and wetlands** topic for more information on water flows and population trends.

Native mammals

Australia has registered the largest loss of species in the world in recent times. In the past two centuries, Australia has lost more mammal species than any other continent, contributing to about one-third of mammal extinctions globally (**DCCEEW-Aus n.d.**).

There has been a rapid extinction of native species, and large and continuing declines in their abundance and range (**Johnson et al. n.d.**). More than 35% of Australian mammal species have declined in distribution or become extinct in the past 200 years (see **Figure B2.2**).

Figure B2.2: Number of native mammal species that have declined in distribution or become extinct in the past 200 years



Notes:
Presumed extinct – 100% contraction in distribution
Severe decline – 50–<100% change in distribution
Moderate decline – 25–<50% change in distribution
No significant decline – less than 25% change in distribution

n = total number of species recorded as inhabiting NSW at the time of European colonisation. It does not include species regarded as 'vagrants' (occasional or accidental sightings of species well outside their normal range).

Source:
Mahon et al. 2011 | DECCW 2009

Short-term contributors to this decrease are the 2017–19 drought and 2019–20 bushfires. In some cases, animals are recolonising areas formerly burnt by the bushfires, although recovery is slower for species that were threatened or in decline before the bushfires, have specialised diet or habitat needs and have slower life histories (**Ensbey et al. 2023**).

Longer-term declines have been linked to invasive species. For example, cats and European red foxes (*Vulpes vulpes*) have been the main drivers for at least two-thirds of terrestrial Australian mammals becoming extinct, and have also been the cause of declining distribution and density of many mammals (**Short & Smith 1994**; **Woinarski et al. 2015**).

Keeping track of koalas

Koalas (*Phascolarctos cinereus*) in NSW are facing a range of threats, including:

- habitat loss and fragmentation
- climate change
- bushfires
- disease
- declining genetic diversity
- vehicle strikes
- dog attacks.

These factors have resulted in significant population decline, with koalas listed as 'endangered' in NSW.

Koalas are an iconic Australian species, with deep cultural significance to Aboriginal peoples.

They are listed under the Australian Government's 110 priority species in the ***Threatened Species Action Plan 2022–2032***. Selection criteria for a species' inclusion on this list includes:

- severe or imminent threat of extinction
- whether recovery actions benefit other threatened species sharing the same habitat are feasible and cost effective

- cultural significance
- whether the animal has close relatives or is not found anywhere else
- whether the animal is representative across landscapes, seascapes and jurisdictions.

In NSW, koala surveys are being undertaken to:

- identify population trends
- understand threats and how to mitigate them
- prioritise conservation actions.

Koalas are an umbrella species

Umbrella species are those whose protection benefits many other plant and animal species sharing the habitat (**Ward et al. 2019**).

Protecting koalas and their habitat improves conservation of other native species (**DPE 2022a**). For example, koala habitat often overlaps with the habitat of barking owls, wombats and wedge-tailed eagles. Actions to protect koala habitat therefore also protect the habitat of these other species.

Conservation actions that control threats to koalas, such as bushfires, pollution and invasive predators, can also benefit many other native species.

NSW Koala Strategy

The NSW Government has prioritised koala research under the ***NSW Koala Strategy 2021–26***, which is a plan to:

- identify and prioritise key knowledge gaps – a key knowledge gap is one that, as a result of being addressed through research, will likely increase the effectiveness of koala conservation actions and/or their likelihood of implementation
- outline the process by which research grant applications will be sourced, including assessment criteria
- outline how the progress and outputs of the individual research project will be monitored and evaluated
- outline how progress and outputs of the research plan will be monitored, evaluated and revised over the life of the plan.

Under the strategy, NSW Government scientists are working on applied research (research that aims to find a solution to a known problem), to improve the knowledge of koalas and how best to manage them to support conservation actions. This includes improving knowledge on koala population locations, numbers, habitat requirements, threats and how to manage them effectively. This applied research helps inform policy development and ensures koala conservation decisions are based on the best available information, with minimum uncertainty.

The 2024 discussion paper, **Reviewing the NSW Koala Strategy**, details the research and monitoring being undertaken for koala populations.

Bushfires impact koala populations

In 2022, koala populations in Queensland, NSW and the ACT were listed as endangered for the first time (**DCCEEW-Aus 2023**). Up to 80% of koalas were lost from some areas affected by bushfires in NSW (**Beale et al. 2022**).

While these results are grim, follow-up surveys in the past three years have shown that koalas are recolonising unburnt and partially burnt sites from the 2019–20 bushfires (**Beale et al. 2022**).

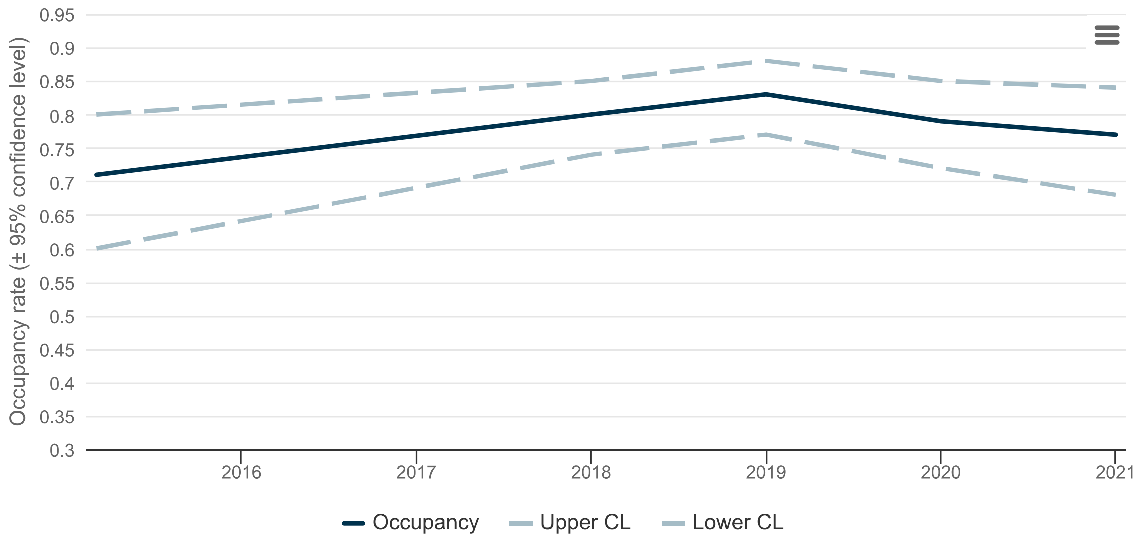
Koala monitoring in north-east NSW

Since 2015, the Department of Primary Industries and Regional Development has annually monitored koala populations in the hinterland forests of north-east NSW.

The study has recorded koala bellows (a vocal sound) and other evidence of koalas at 224 sites over 1.7 million hectares (m ha). The study has taken place on various forest sites in State forests and national parks, with better quality and poorer quality habitat.

Between 2015 and 2021, koala occupancy was stable, with most sites being occupied (see **Figure B2.3**).

Figure B2.3: Regional koala occupancy at monitoring sites, 2015–21



Notes:
This data accounts for imperfect detection and environmental factors, such as elevation, at monitoring sites.

CL=confidence level

Source:
Law et al. 2024

These results indicate a large group of separate koala populations spread across State forests and national parks.

Through the ***NSW Koala Strategy 2021–26***, the NSW Government is undertaking a baseline survey of the koala population and a sentinel monitoring program to better understand the distribution of koalas and also their genetics and health.

Other monitored species in north-east forests

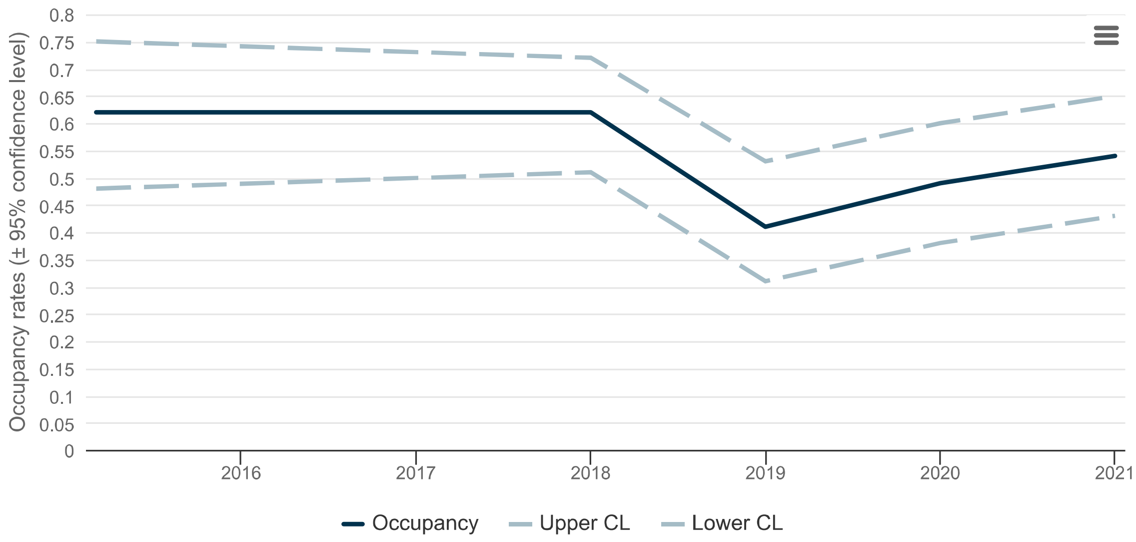
Artificial intelligence is used to identify other key forest species recorded as a part of the koala occupancy assessments. These include the yellow-bellied glider ((*Petaurus australis* (see **Image B2.1**)), squirrel glider (*Petaurus norfolcensis*), powerful owl (*Ninox strenua*) and sooty owl (*Tyto tenebricosa*).

Image B2.1: Yellow-bellied glider (Petaurus australis)

Source:
Kerri-Lee Harris/DCCEEW

Analysis of these findings is still ongoing, but results for the yellow-bellied glider (*Petaurus australis*) indicate that this species occupancy declined by 34% after the 2017 drought and the 2019–20 bushfires in north-east NSW. The glider was showing signs of recovery in 2020 and 2021 after drought-breaking rains (**Law et al. unpub.**) (see **Figure B2.4**).

Figure B2.4: Yellow-bellied glider occupancy at monitoring sites, 2015–21



Notes:
This data accounts for imperfect detection and environmental factors such as elevation at monitoring sites.

Source:
Law et al. unpub.

Changes in bat density

Bats make up 25% of Australia's mammal species. They vary greatly in size, diet, behaviour and habitat.

More than 77 species are found in Australia, 34 of which live in NSW (**DEC 2004**).

Bat species contribute to the health and regeneration of Australia's native forests by:

- transporting pollen over vast distances
- dispersing large seeds
- transferring food matter between species (**NSW Government 2023b**).

Since 1999, the Department of Primary Industries and Regional Development has done annual banding of four forest bat species in Chichester State Forest in northern NSW, which is a mountain forest climate refuge. This has allowed researchers to estimate changes in the density (number of bats per hectare) of forest bat species over time.

The species of bats monitored are the:

- large forest bat (*Vespadelus darlingtonia*)
- eastern forest bat (*Vespadelus pumilus*) (see **Image B2.2**)
- chocolate wattled bat (*Chalinolobus morio*)
- southern forest bat (*Vespadelus regulus*).

Image B2.2: Eastern forest bat (Vespadelus pumilus)

Source:
John Turbill/DCCEEW

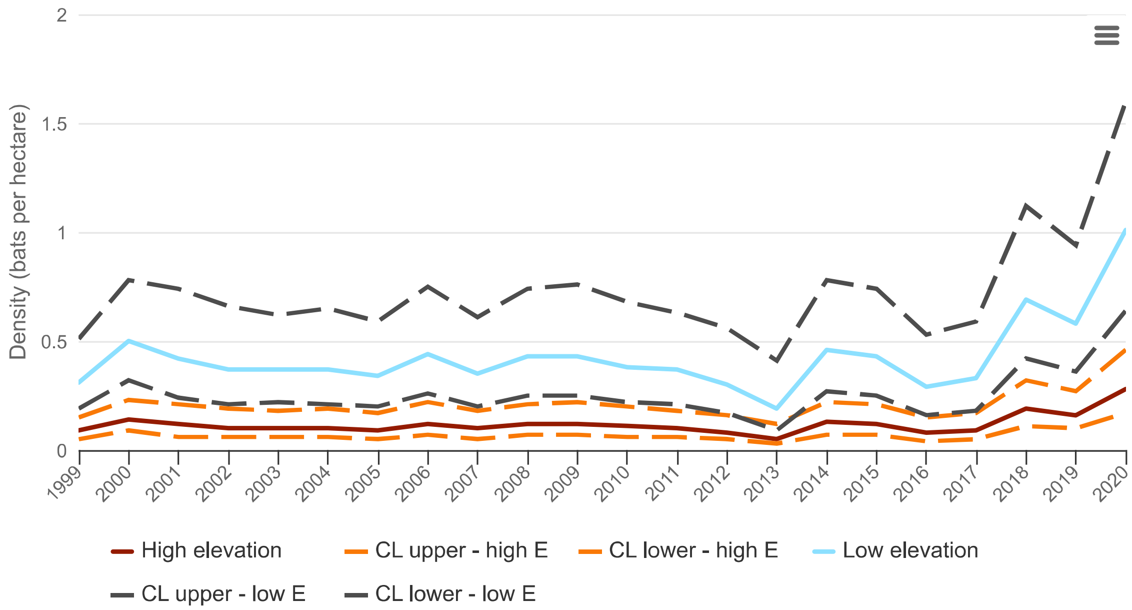
Analysis of estimated density of bats per hectare showed that:

- each species preferred either high or low altitudes
- bat density was higher in years with more annual rainfall
- bat density was lower in years with a higher maximum temperature.

Overall, the densities of all species were higher than previous estimations.

From 2013, there was an increase in density of the eastern forest bat despite a higher annual temperature on the site (see **Figure B2.5**). This is an example of a species responding to a changing climate.

Figure B2.5: Eastern forest bat (Vespadelus pumilus) density, 1999–2020



Notes:
High elevation is >600 m, and low elevation is <600 m.

Source:
Law et al. 2023

Native birds

Populations of threatened and near-threatened birds across NSW and the ACT have declined by 56.3% since 2000, reflecting a pattern witnessed globally (**BirdLife Australia 2023**).

Bird declines may be attributed to habitat loss (for example, from weeds, clearing and extreme natural events) and impacts of invasive species, such as rats mice and rabbits (**DCCEEW 2024**). The creation of invasive animal-free sanctuaries can help native bird populations to recover (**DCCEEW 2024**).

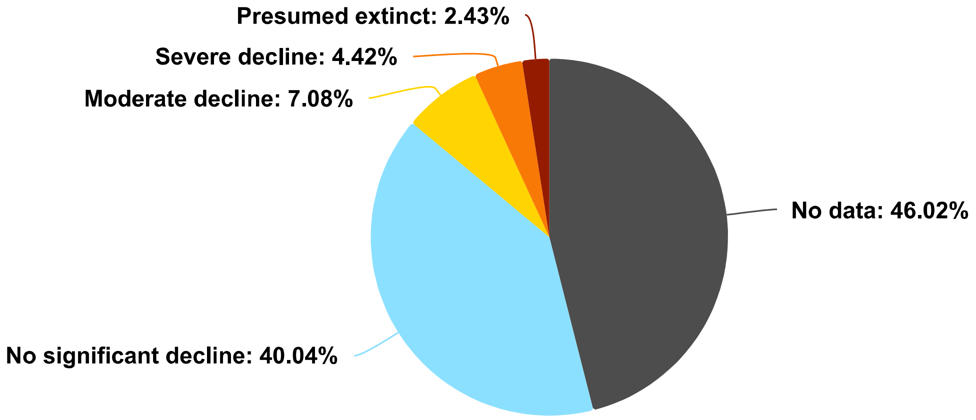
The effects of climate change also contribute to the decline, with increases in the risk of droughts, fires and heatwaves (BirdLife Australia n.d.-a). Heatwaves, combined with increasingly high temperatures, can be devastating to bird populations, even those adapted to hot dry environments.

For example, in 2017, scientists monitored the breeding season of a wild population of zebra finches in north western NSW. They found 95% of the eggs did not hatch. These deaths were due to the developing embryos being exposed to continued high temperatures during a multi-day heatwave (**McCowan & Griffith 2021**).

Some Australian bird species (14%) have declined in their distribution or become extinct in the last 200 years (see **Figure B2.6**). Generally, birds have been more resistant to declines than mammals.

While many species are declining in towns and cities, a few are flourishing, such as noisy miners (*Manorina melanocephala*) and rainbow lorikeets (*Trichoglossus moluccanus*) (**BirdLife Australia n.d.-a**). In some suburban and urban areas, there is moderate bird diversity.

Figure B2.6: Percentage of native bird species that have declined in the past 200 years



Notes:
Presumed extinct – 100% contraction in distribution
Severe decline – 50–<100% change in distribution
Moderate decline – 25–<50% change in distribution
No significant decline – less than 25% change in distribution

n=total number of species recorded as living in NSW at the time of European settlement. This does not include species regarded as 'vagrants' (occasional or accidental sightings of species well outside their normal range).

CL=confidence interval

Source:
Mahon et al. 2011 | DECCW 2009

Threatened Bird Index

The **Threatened Bird Index** measures changes in populations of Australia's threatened and near-threatened bird species. The index helps scientists better monitor progress in achieving conservation targets.

Information for the Threatened Bird Index comes from government and non-government agencies, and citizen science groups.

Bird species are put into one of four groups, depending on where they live:

- marine environments
- shoreline environments
- on land and in forests
- wetlands.

Populations of threatened bird species in NSW are decreasing. This indicates a drop in bird populations across the State over time.

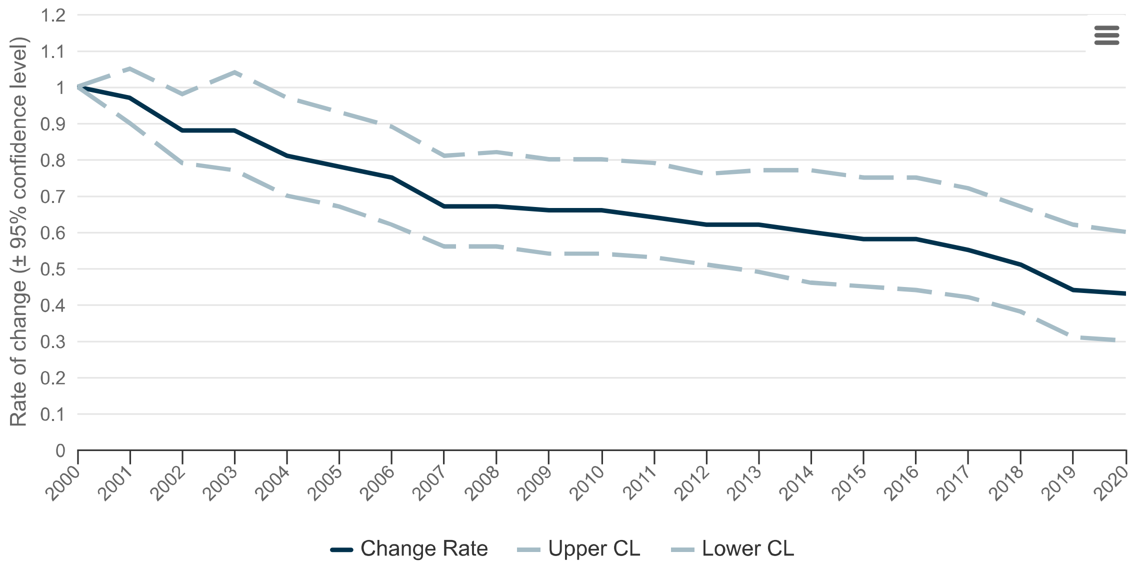
NSW and the ACT have had a decrease of 56.3% in bird populations since 2000. Birds on land and in forests have had the greatest decrease. This is due to habitat destruction, climate change and invasive species (**BirdLife Australia 2023**).

As more data for more species is added, the index will become more accurate in depicting the populations of threatened bird species.

Figure B2.7 shows the average change in bird numbers compared with the baseline in 2000. The shaded areas show the confidence interval (the amount of uncertainty in the sample data).

Steep declines in populations occurred between 2000 and 2007, with numbers stabilising from 2007 and 2016. From 2016, a continued decline can be seen through to 2019.

Figure B2.7: Threatened Bird Index 2023, showing population trends 2000–2020 across bird species in NSW



Notes:

Threatened Bird Index for NSW is based on data provided on threatened and near-threatened bird species.

The index measures average changes in bird populations each year, which is compared to the base year (2000). This year was chosen as it is the first year that consistent data are available.

For 2000, the Index gets a score of one. The score then goes up or down in subsequent years. For example, a score of 1.2 means a 20% increase on average compared to 2000. A score of 0.8 means a 20% decrease on average compared to 2000 (Threatened Species Index n.d.).

Source:

Threatened Species Index 2023

Birds after bushfires

Bushfires are a seasonal part of Australian life and play an important ecological role. As our climate changes, there will be an increased risk of bushfires becoming more frequent, intense, severe and extensive.

See the **Extreme climate and weather** topic for more information about bushfire risk.

The 2019–20 bushfire season was one of the most severe in recent history (**Nolan et al. 2020**), with more than 2.7 million hectares of NSW national park estate affected (**DPIE 2021**).

These bushfires had a catastrophic impact on wildlife, including birds (**BirdLife International 2020**). In the aftermath, eight bird species needed immediate management actions to help their long-term recovery and prevent their further decline (see **Table B2.5**). These actions included protecting unburnt areas and planting new trees to maintain food supply.

Table B2.5: NSW bird species needing immediate management actions after the 2019–20 bushfires

Common name	Scientific name	EPBC Act listing*	NSW listing
Rufous scrub-bird	*Atrichornis rufescens*	Endangered	Vulnerable
Regent honeyeater	*Anthochaera phrygia*	Critically endangered	Critically Endangered
Eastern bristlebird	*Dasyornis brachypterus*	Endangered	Endangered
Albert's lyrebird	*Menura alberti*	Unlisted	Vulnerable
Eastern ground parrot	*Pezoporus wallicus wallicus*	Unlisted	Vulnerable
Black-faced monarch	*Monarcha melanopsis*	Migratory	Unlisted
Gang-gang cockatoo	*Callocephalon fimbriatum*	Endangered	Endangered
South-eastern glossy black cockatoo	*Calyptorhynchus lathami lathami*	Vulnerable	Vulnerable

Notes:
* EPBC Act stands for *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)

Source:
DAWE 2020 | **Threatened biodiversity profile search**

Further assessment undertaken by the **Threatened Species Recovery Hub** indicated that many of these species would likely have long-term decreases in their populations because of the 2019–20 bushfires.

Birds that depend on dense vegetation may disappear from burnt areas for many years until vegetation regrows. Birds not killed outright during fires are often left vulnerable, with a lack of food and shelter (**BirdLife Australia n.d.-b**).

In contrast, some bird species that prefer open habitat thrive in post-fire areas (**Land for Wildlife Queensland 2016**).

Native fish

NSW has approximately 118 species of freshwater fish, of which 57 are native (**DPI 2016**).

There are 33 species listed as threatened and four species presumed extinct under the *Fisheries Management Act 1994*.

Since the *State of the Environment 2021*, there have been five new NSW fish species listed as critically endangered in the *Fisheries Management Act 1994*.

These are the cudgegong giant spiny crayfish (*Euastacus vesper*), short-tail galaxias *Galaxias brevissimus* and Kosciuszko galaxias (*Galaxias supremus*), Lord Howe abalone (*Haliotis rubiginosa*) and McCulloch's anemonefish (*Amphiprion mccullochi*). The full list is available **here**.

Another six species in NSW have been listed as critically endangered and 14 as endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth).

There have been declines in freshwater fish communities due to:

- river regulation that restricts their habitat or makes it no longer suitable
- loss and degradation of habitat
- limited places to move to
- population fragmentation
- modification of waterways
- excessive water taken by irrigators or farmers

- over-exploitation
- invasive species competing for habitat
- climate change.

Healthy native fish populations provide many environmental, social and economic benefits. Native fish cycle nutrients, support food webs, and provide food and recreation for people through fishing.

Native fish are also important for the social and cultural wellbeing of Aboriginal peoples (**DPI n.d.-b**). For many Aboriginal people, native fish species are their totem and considered as kin.

Fish are great indicators of wetland and river health. An abundance and diversity of species in an area is connected to good water quality and connected food webs. The presence of native fish and crustaceans is an early indicator of wetland recovery (**Rummell et al. 2023**).

Improving river ecosystems to stabilise banks, improve water quality, drive food webs and provide habitat can support healthy populations of native fish and help recover threatened species (**Feio et al. 2022**).

Habitat essential to the survival of endangered or critically endangered species, populations of a species or ecological communities can be declared as **critical habitat**.

See the **Coastal and marine** topic for more information about marine fish diversity and abundance.

Freshwater fish surveys

The Murray–Darling Basin is Australia's largest and most complex river system. It starts in southern Queensland, then flows through NSW and Victoria to reach the sea south-east of Adelaide (**MDBA 2023a**).

The Murray–Darling Basin is home to more than 50 native freshwater fish species and up to 20 that use the estuary, of which 36% are threatened (**MDBA 2023b**).

Inland rivers and their fish communities can vary over short periods of time due to the influence of events such as floods. To reliably assess fish health, it is best to consider long-term trends (**Crook et al. 2023**).

For example, the **Basin Plan Environmental Outcomes Monitoring for Fish** (BPEOM-Fish) surveys fish populations at 240 sites across the NSW portion of the Murray-Darling Basin at the same locations every year to create a strong long-term dataset. It provides **detailed reports** on current fish condition in the NSW Murray–Darling Basin.

See the **Rivers and wetlands** topic for detailed reports on the numbers, distribution and biomass of key freshwater fish species.

Coastal fisheries surveys

The **Status of Australian Fish Stocks (SAFS) reports** provide an indication of population health for many recreational and commercial fish.

Combining historical fish surveys with recent surveys can help assess the changing distribution of fish populations. However, due to the limited nature of the historical surveys and inconsistent sampling over time, it is difficult to assess changes in distribution, so scientists can't assess most species.

See the **Coastal and marine** topic for more information.

Invasive species

'Invasive species' describes animals, plants and other organisms, such as pathogens, that are introduced to places outside their native ranges, where they spread and potentially harm local ecosystems and species (**DEH 2004**). They are also called introduced or feral species.

Invasive species can prey on native species or compete with them for food. They can alter the habitat of native species, by, for example, eating plants that native animals rely on, or spreading pathogens and disease.

Invasive species can also disrupt and degrade the cultures and practices of Aboriginal peoples. They may:

- disrupt traditional food sources
- degrade sacred sites
- alter natural ecosystems

- disrupt cultural practices and knowledge
- threaten culturally significant species and totem animals.

Across NSW, the spread and impact of many invasive species is increasing, with new threats emerging every year.

The ***NSW Invasive Species Plan 2023–2028*** helps to:

- prevent new invasive species entering NSW
- eliminate or contain existing populations
- manage already widespread invasive species.

In NSW, many invasive species are **key threatening processes**. A key threatening process can harm or damage threatened species or ecological communities, or make a native species threatened (**NSW legislation 2024**).

Key threatening processes are identified and listed under the *NSW Biodiversity Conservation Act 2016* (**NSW Government 2024c**). They include climate change, fire and diseases.

See the **Plants** topic for more information on the ways invasive species affect native plants and ecological communities.

Invasive species on land

Invasive dogs, pigs, rabbits, foxes, goats, cats, pigs and deer are the most significant and widespread invasive animals on land in NSW (**DPI 2023**).

Predation by the European red fox (*Vulpes vulpes*), cats (*Felis catus*), pigs (*Sus scrofa)*, deer (several species) and ship rats (*Rattus rattus*) are listed as key threatening processes under the *Biodiversity Conservation Act 2016*. Foxes and cats are widespread throughout NSW and have contributed to the regional decline and extinction of many small to medium-sized native animals (**CSIRO 2019**).

The ability of cats to breed rapidly, travel great distances in search of prey and thrive in a wide range of habitats has made them a major threat to native animals, including threatened species (**Menon et al. 2024**).

Foxes can limit the habitat choices and population sizes of native species, particularly medium-sized ground-dwelling and semi-arboreal mammals, ground-nesting birds and freshwater turtles.

Grazing, browsing, trampling and digging by introduced herbivores, including deer, rabbits, goats and horses can:

- lead to habitat degradation by increasing soil erosion
- destroy native plants
- prevent seedlings from growing
- spread weeds
- foul waterholes
- lead to a decline in native vegetation health, diversity and productivity.

Introduced herbivores can also outcompete native herbivores for resources. For example, feral goats can eat and trample on the habitat of endangered brush-tailed rock-wallabies and push them out of an area (**Menkhorst & Hynes 2011**).

While the distribution and abundance of many invasive animals can change with rainfall, especially in the rangelands, most invasive herbivores, such as rabbits, remain widespread and abundant across NSW.

Kosciuszko National Park has the largest wild horse population in NSW national parks. The October 2023 **horse population survey** estimated there were between 12,797 to 21,760 wild horses in the park.

The population had steadily increased over the past 20 years (**DPE 2022b**), however major control operations in 2023–24 have significantly reduced numbers.

Under the **Kosciuszko National Park Wild Horse Management Plan 2021**, NPWS is required to maintain a population target of 3,000 wild horses in 32% of the park by mid-2027.

The distribution and numbers of all invasive deer species is increasing across NSW. Their distribution has increased from 17% in 2016 to 22% of NSW in 2020 (**NSW Government 2023c**). In the Royal National Park, they have had a major impact on the variety and abundance of plant species (**NSW Government 2023c**).

Invasive species also kill native animals because they are poisonous or toxic. For example, cane toads (*Rhinella marina)* are a threat to native animals because they are poisonous and eating them can kill most native animals.

To slow the spread of, and prevent more, cane toads in NSW, a **Cane Toad Biosecurity Zone** is in place. This incorporates all areas of NSW, except a small corner in the north-east where the species is locally established (**DPI n.d.-e**).

Smaller invasive mammals, such as rats and mice, can also have an environmental impact. Invasive mice damage plants by feeding on seeds and seedlings. Invasive rats can eat seabird eggs and chicks, which is particularly devastating around seabird colonies and islands.

Introduced rats on Lord Howe Island are responsible for the extinction of five endemic bird species, at least 13 species of endemic invertebrates and two plant species.

The Lord Howe Island rodent eradication program was undertaken in 2019. The eradication has so far been successful. Strict biosecurity measures and monitoring were reactivated on the island and at shipping ports and the airport in April 2021 after a rat was seen (**LHIB n.d.-a**.).

Aquatic species

Introduced fish can threaten native fish, frogs and invertebrates by preying on them or competing with them for food and space.

Introduced trout, gambusia and carp are of particular concern. For example, predation and competition from trout has almost eradicated the critically endangered native fish, stocky galaxias (*Galaxias tantangara)* from Kosciuszko National Park. Predation by plague minnows seriously threatens the vulnerable green and golden bell frog (*Litoria aurea*) (**NSW Government 2017**).

Introduced carp are adaptable, can reproduce quickly and can modify environments, sometimes leading to significant declines in water quality and habitat availability for native fish. They have become a major invasive species throughout most of the Murray–Darling Basin.

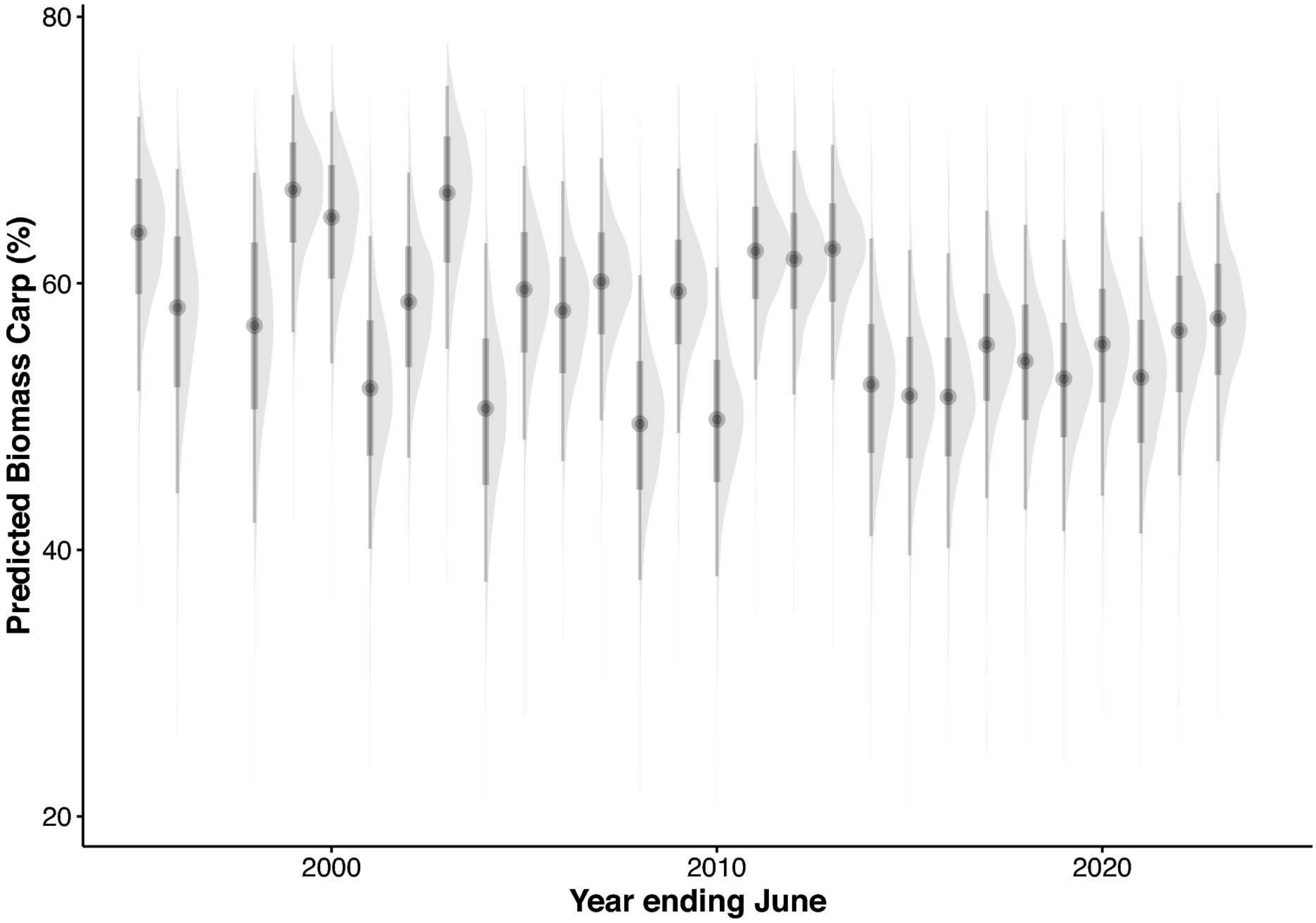
These fish have large fluctuations in numbers, possibly having **larger numbers during floods** (**DPI n.d.-f**).

The relative proportion of carp numbers in the NSW Murray–Darling Basin has been stable at about 57% of total fish biomass since the mid-1990s. This suggests the capacity of carp to reproduce has been reached (see **Figure B2.9**).

Surveys of freshwater fish species in the Murray–Darling Basin between 2014–15 and 2022–23 have found that only 6% of sites were free of introduced fish. A few sites (7%) contained only introduced fish.

Most sites sampled were in the Murray–Darling Basin, which generally has fewer native fish species than coastal and other inland waterways. On all sites, introduced species accounted for 38% of fish species. For detailed reports on each NSW Murray–Darling Basin catchment, see the **NSW DPIRD Murray–Darling Basin Fish monitoring reports**.

Figure B2.9: Percentage of total fish biomass contributed by carp across the NSW Murray–Darling Basin



Notes:
Annual estimates of the percentage of biomass contributed by carp using data from sites across the NSW Murray–Darling Basin (elevation <700m).
The shading shows the distribution of estimates. The dots show the median estimates. Thick grey bars show the 80% credible intervals, and the thin grey bars show the 95% credible intervals.
See
Stuart et al. 2021
and
Schilling et al. 2024
for more information on carp.

Source:
Reproduced from Schilling et al. 2024, licensed under a Creative Commons Attribution 4.0 International License. No changes have been made to the image.

Pressures and impacts

Habitat loss and fragmentation

When land is cleared of native vegetation, there is a loss of native animal species, due to their habitat being disrupted. Further disturbance follows from subsequent development and the fragmentation of remaining native vegetation.

These factors stop native plants from regenerating and native animals from moving across the landscape, leading to a loss of genetic diversity (**Johnson et al. 2007**; **Taylor & Dickman 2014**).

Many insect species rely on specific habitat conditions, including old-growth mature trees, logs and fallen timber for some, or all, of their life stages. Once lost, these habitats can take decades to be replaced (**Sands 2018**).

The decline in habitat due to clearing and fragmentation is described by two **Biodiversity Indicator Program** indicators for habitat quality – ecological condition and ecological carrying capacity.

The level of ecological carrying capacity in 2013 was assessed at 32% of the natural levels before European settlement, and 29% in 2020 following the 2019–20 bushfires. The 2020 assessment only includes the effects of the 2019–20 bushfires. It doesn't consider other changes in habitat or land use since 2017.

See the **Plants**topic for more information about these indicators.

Urbanisation

Fragmented habitat and loss of habitat for native species are exacerbated by urban development. Impacts on native species include:

- light pollution
- noise pollution
- traffic related injuries
- invasive species.

Scientists are conducting research in NSW to understand the impacts of urban light and noise pollution on wildlife, with studies showing both can seriously harm some species.

Streetlights, headlights and security lights in towns and cities can subject nocturnal native animals to more than 1,000 times the amount of light they would naturally get from moonlight (**Jones 2018**). This increased light can:

- expose nocturnal animals to predation by invasive species such as foxes and cats
- drive native bats from roosting sites
- disrupt breeding cycles
- reduce animals' ability to communicate, find food and travel (**DCCEEW-Aus 2024**)
- result in shorter foraging periods so animals don't get enough food.

Noise pollution can disrupt:

- migration paths for, and communications between, both birds and whales
- the hunting success of bats
- breeding opportunities for frogs and birds, with some species unable to find partners (**AAS n.d.**).

Development often means more vehicles. There are more animals going into rescue and rehabilitation due to motor vehicle collisions every year (**DPE 2023**).

The **wildlife rehabilitation data dashboard** uses information from wildlife rehabilitation providers about native species that are killed or injured as a result of car strikes and domestic animal attacks in NSW.

Towns and cities also help invasive species to become established and spread (**LLS 2024**). While towns and cities have challenges for native animals, they also provide habitat for them (**TERN 2019**). It's estimated about 30% of Australia's **threatened species** listed in the *Environment Protection Biodiversity and Conservation Act 1999* (Commonwealth) live in towns and cities.

Research conducted on the distribution of threatened species finds that urban areas have more threatened species than rural areas (**CAUL n.d.**; **Ives et al. 2015**).

Urban development also damages aquatic ecosystems in a number of ways:

- land clearing, dredging and land reclamation along the NSW coast degrades estuarine ecosystems
- vegetation clearing, snag removal and bank erosion causes loss of habitat
- there's increasing sediment, nutrient and pollution runoff
- construction of dams, weirs, floodgates and road crossings obstruct migration routes, reduce breeding opportunities and restrict native species' ability to avoid predation (**DPI n.d.-c**)

Urban, industrial and agricultural development have disrupted the natural environment and the freshwater environments of NSW. Native fish have seriously decreased in distribution and numbers, with nearly two-thirds of native freshwater fish listed as threatened under State or Commonwealth legislation.

See the **Rivers and wetlands** and **Coastal and marine** topics for more information.

New and emerging invasive species

Invasive species have greatly contributed to the decline and extinction of many native species and continue to impact Australia's unique biodiversity.

Invasive insects

Red imported fire ants (*Solenopsis invicta*) and yellow crazy ants (*Anoplolepis gracilipes*) are among the top 100 invasive species worldwide. They are a potential ongoing threat in NSW (**Lowe et al. 2000**).

These are an omnivorous, opportunistic species that can form aggressive 'super colonies' (**Parks Australia n.d.**). They can change ecosystems by:

- outcompeting native insect species
- preying on ground-dwelling native species such as reptiles, amphibians and small mammals (**DCCEEW-Aus 2021a**)
- spraying formic acid, which is toxic to some animals (**Parks Australia n.d.**)
- eating the seeds and seedlings of native plants.

Red fire ants are known to have infested areas of south-east Queensland, close to the NSW border (**DPI 2024**). Two invasions of red fire ants were recently detected and managed in northern NSW, having spread from a larger invasion in south-east Queensland. These red fire ant infestations in NSW have not yet extended beyond Murwillumbah and Wardell (**DPI 2024**).

Two invasions of **yellow crazy ants** in 2018 around Lismore, in northern NSW, have been managed and surveillance is ongoing. Following an extensive surveillance and treatment program both sites remained free of yellow crazy ants until a small colony was identified in early 2021 in the Lismore CBD (**DPI n.d.-d**).

These ants will pose a significant risk if they are not eradicated, because:

- they threaten agriculture, infrastructure, outdoor recreation and human health
- their painful stings can cause severe allergic reactions in some people
- they can prey on native plants and animals, leading to biodiversity loss.

The economic costs of managing and controlling fire ant infestations can be substantial for both the public and private sectors (**DPI 2024**).

See the **Status and trends** section of this topic for other invasive animals and invertebrates.

Invasive plants or weeds

Invasive plants or weeds can:

- smother or outcompete native plants, reducing the habitat for native animals
- help bushfires spread and be more intense
- have spines or thorns that can hurt native animals, or are poisonous
- form impenetrable thickets so native animals cannot reach suitable habitat
- affect soil nutrient levels, salinity and stability, leading to habitat modification and loss of food for native animals (**NSW EPA 2022**).

For example, toxins in introduced pasture grass *Phalaris aquatica* can give eastern grey kangaroos the deadly disease, chronic phalaris toxicity (**Chen et al. 2024**).

Some aquatic weeds can decrease water quality and reduce available habitat (**Perna et al. 2012**). For example, floating weed mats formed by alligator weed (*Alternanthera philoxeroides*) can deprive water of oxygen and kill native fish (**DPI 2009**).

Pathogens and disease

Exotic parasites and pathogens can be introduced by invasive species. Several of these can harm native wildlife, livestock and humans.

Threatened species with reduced or restricted populations are particularly vulnerable. Even a small decrease in the numbers of these species can result in their eventual extinction (**DCCEEW-Aus 2021b**).

For example, toxoplasmosis is carried by invasive cats and *Angiostrongylus cantonensis*, a lung worm, is carried by introduced rats. Both these can infect native wildlife, humans and domestic animals.

Marsupials are particularly at risk from toxoplasmosis. Infection can cause paralysis, blindness, and respiratory and reproductive disorders (**BMCC 2020**).

Some diseases are already harming native species.

Koalas can contract chlamydia, a common disease that can result in blindness, urinary tract infection and reduced reproductive success. The NSW Government is funding research and vaccine trials to increase koalas' resistance to chlamydia (**NSW Government 2022**).

Chytridiomycosis is caused by the chytrid amphibian fungus. It is a global threat to frog populations, including in Australia where it can spread quickly and cause mass deaths.

It attacks the keratin in a frog's skin, although the exact cause of death is still unknown (**DCCEEW-Aus 2013**). While there is no treatment yet, the NSW Government is funding projects to find one.

Pathogens and diseases affecting plants, such as **myrtle rust** and **phytophthora dieback**, can also harm native animals, because they cause loss of habitat for native animals that rely on these plants for food and shelter.

Bird flu (**Avian influenza**) is an infectious disease that affects birds worldwide. Some mild strains are present in Australia but have little impact on wildlife (**NSW Health 2024**).

One highly infectious strain (H5N1 Clade 2.3.4.4b) is different to other strains of avian influenza because it spreads rapidly in both birds and other wildlife (**NSW Health 2024**). Overseas, it has led to mass deaths of wild birds and mammals, particularly marine mammals (such as seals, sealions and dolphins) and mammals that prey or scavenge on birds (**NSW Health 2024**). This strain cannot be eradicated.

H5N1 has not been detected locally in Australia (**NSW Health 2024**). However, there is no way to prevent H5N1 entering Australia and the risk of it entering Australia in the future is high (**Wildlife Health Australia 2023**).

See the **Wildlife Harm Australia** website for more information.

Long-term data gaps

Although knowledge of the conservation status of many species has improved markedly over the past 20 years, especially the distribution and abundance of land-based vertebrates, there is still much to learn about other groups. Many species remain poorly known or have not yet been scientifically described and named.

Recording the status of all animal species across NSW is a huge, complex task, especially when many species remain unknown. Systematic monitoring of the NSW-wide array of biodiversity is also difficult due to spatial, financial and technological limitations.

For most invertebrates, information exists for only a few isolated species, and this provides little insight into their broader status and management needs. This can lead to biases in our overall understanding of diversity, and whether species and groups are threatened.

Long-term data for insect and fungi species status and trends is almost non-existent, even though they are vital to ecosystem health.

Patterns of decline that are likely to have been present for many years are still being discovered in lesser-studied groups of animal species.

Climate change

Climate change is increasing the threats native animals face, and introducing additional pressures (**Steffen et al. 2009**; **DECCW 2010**; **Hughes 2011**).

The ability of native species to adapt and persist under climate change is limited (**AdaptNSW n.d.-a**). The following factors are likely to decrease the resilience of species to climate change:

- less opportunity to move or extend their range due to fragmentation of habitat and isolation of populations (**Doherty et al. 2024**)

- increased risk of more frequent or intense extreme weather events, such as heatwaves, droughts, storms, floods and bushfires, pushing species outside their regular habitats.

Climate change will probably overtake habitat destruction as the greatest global threat to biodiversity over coming decades (**Leadley et al. 2010**).

In NSW, habitat loss and climate change combine to reduce the resilience of ecosystems. For example, bioregions in central NSW have historically high rates of habitat loss. They will need more active habitat management, such as restoration projects, to prevent further biodiversity loss due to climate change (**DCCEEW 2024**).

See the **Climate change** topic for more information.

Extreme weather

Recent extreme weather such as the 2019–20 drought and bushfires and 2021–22 storms and floods have increased the threat to biodiversity.

Higher than average temperatures, low rainfall and dry vegetation following an extended drought from 2017 to 2020 were large contributors to the 2019–20 bushfire season (**AIDR n.d.**).

The length and intensity of bushfire seasons and increased number of high-risk fire weather days are also consistent with the impacts of climate change (**CSIRO 2020**).

The 2019–20 bushfires had a profound impact on NSW wildlife:

- 2.7 million hectares of national parks were burnt
- almost 3 billion native animals were killed or displaced
- 22% of all good to very good koala habitat in eastern NSW was burnt
- 46 threatened species had at least 90% of their habitat in burnt areas (**Legge et al. 2021**).

Recovery will be slow for most fire-affected species. For some animals the fires have accelerated pre-existing population declines.

During the record-setting 2022 floods across north-east NSW, thousands of injured animals were taken in by wildlife hospitals and carers across the impacted region (**LLS n.d.**).

See the **Extreme climate and weather** topic for more information.

Climate change in rivers and wetlands

Climate change is predicted to have severe impacts on communities of fish and individual species, leading to local extinction and declines in species distribution in rivers and wetlands (**AdaptNSW n.d.-b**).

Climate change is already leading to habitat and range changes such as:

- increased water temperatures that disrupt breeding and alter competition
- less native vegetation available to control erosion and filter water, disrupting and altering collaborative relationships between species
- the spread of disease
- poor fish health.

The reduced flow of rivers and streams will:

- reduce habitat quality and quantity
- limit the ability of fish to move from place to place
- restrict the movement of fish to seek suitable habitat and spawn.

See the **Rivers and wetlands** topic for more information.

Change of range

Most rangeland habitats are becoming harder for native animals to live in, particularly when there is little water.

As the climate changes, Australia's native animals are showing an 'adapt, move or die' response (**CSIRO 2016**). Some species have already moved, with species that depend on cooler habitats moving to higher altitudes and others extending their ranges due to warmer average temperatures.

The coastal waters of eastern Australia have seen at least 70 marine species moving south. This is due to warming temperatures and cooler ocean waters in the south.

See the **Coastal and marine** topic for more information.

Birds and bats are moving more to follow food, escape competition from introduced species or move to more suitable habitats (**Diengdoh et al. 2022**).

The loss of canopy cover also reduces availability of shade.

See the **Plants** topic for more information on canopy cover.

Responses

Strategy and policy protections

Biodiversity Conservation Act

The purpose of the ***Biodiversity Conservation Act 2016*** is to maintain a healthy, productive and resilient environment for the greatest wellbeing of the community, now and into the future, consistent with the principles of ecologically sustainable development.

The Act establishes several regulatory programs and governance arrangements, including:

- the biodiversity conservation program (known as **Saving our Species**) for threatened species and threatened ecological communities
- the private land conservation framework, and requirements to develop a ***Biodiversity Conservation Investment Strategy*** and a **biodiversity values map**
- the **Biodiversity Offsets Scheme** and **Biodiversity Conservation Fund**
- the Biodiversity Conservation Trust
- compliance frameworks – including for licensing, conservation, listing of threatened plants and animals, assessment requirements for planning activities and land certification
- scientific and other advisory committees.

An independent review of the Act found that it did not meet its purpose of maintaining a healthy, productive and resilient environment. It recommended a number of reforms.

NSW plan for nature

NSW plan for nature, released in July 2024, is the State Government's response to the recommendations made in reviews of the ***Biodiversity Conservation Act 2016*** and the native vegetation provisions of the ***Local Land Services Act 2013***.

The response acknowledges that biodiversity in NSW is in crisis and that the Government's policy objective needs to shift from mitigating decline to restoration and repair. This is essential to the wellbeing and prosperity of current and future generations.

Priority actions include:

- strengthening the *Biodiversity Conservation Act 2016*
- exploring, in partnership with Aboriginal stakeholders, new and better ways to support Aboriginal people to connect with and care for Country
- developing a NSW nature strategy
- improving whole-of-government accountability for biodiversity outcomes
- better incorporating biodiversity into strategic planning processes
- reforming the **Biodiversity Offsets Scheme**

- improving biodiversity data, tools and reporting
- improving the regulation of native vegetation in rural areas
- commissioning independent advice on options to improve biodiversity outcomes in regional landscapes, and enhance value and support for landholders.

Threatened Species (Zero Extinctions) Framework

The NSW National Parks and Wildlife Service (NPWS) has adopted a zero-extinction target for threatened species on land managed by the agency. Actions to support this target and restore populations of threatened species are set out in the **Threatened Species Framework**.

The **first report** published under the framework was released in September 2024. It includes an overview of relevant programs and initiatives, and highlights achievements during 2021–22 and 2022–23.

Australia's Strategy for Nature 2024–2030

A **National Biodiversity Strategy and Action Plan**, titled *Australia's Strategy for Nature 2024–2030*, is a collaboration between state and federal governments. The strategy aims to halt and reverse biodiversity loss in Australia by 2030.

Threatened Species Action Plan 2022–32

The Australian Government's updated ***Threatened Species Action Plan 2022–32*** lays out actions to protect, manage and restore Australia's threatened species and important natural places.

Basin Plan and water sharing plans

The **Basin Plan** sets the amount of water that can be taken from the Murray–Darling Basin each year, while leaving enough for our rivers, lakes and wetlands and the plants and animals that depend on them.

Water sharing plans protect environmental health of water and ensure it is sustainable, by showing when and how water will be available for extraction.

Improved water management under the Basin Plan and water sharing plans will help recover threatened fish populations, by increasing water flows on floodplains and habitats.

Assets of intergenerational significance

Assets of intergenerational significance are areas of land within NSW declared under the *National Parks and Wildlife Act 1974* as having exceptional environmental or cultural value. Once land has been declared as an asset of intergenerational significance, it cannot be interfered with, damaged, harmed or disturbed.

As at November 2024, there were 279 areas declared as an asset of intergenerational significance. These include habitats for the Wollemi pine, koalas and the greater bilby.

Conservation programs

NSW Koala Strategy

The ***NSW Koala Strategy 2021–26*** supports investment in koala protection and conservation actions.

In 2022–23, as part of this strategy, 5,885 hectares of koala habitat had been restored or were in the process of being restored.

The NSW Government is **reviewing the strategy** to identify future conservation priorities and ensure the long-term survival of koalas in the wild.

In March 2024, 140 stakeholders from across NSW met at Taronga Zoo for the NSW Koala Summit to discuss the effectiveness of koala conservation efforts and make recommendations to shape the future of the strategy. This was a key point in the strategy review (**NSW Government 2024d**).

Feedback from the discussion paper and the NSW Koala Summit will also inform the review.

Find out more about **actions to protect koalas**.

Saving our Species

Legislated under the *Biodiversity Conservation Act 2016*, the **Saving our Species** program aims to secure threatened species in the wild and control key threats. It delivers conservation strategies and supports actions that can help save threatened plants and animals from extinction.

Since the program began in 2013, it has worked in partnership with more than 300 community and government organisations, universities, researchers and the business sector to maximise investment and strengthen conservation actions.

More than 170 species that Saving our Species invested in during 2023–24 are on track to be secure in the wild in NSW for 100 years.

During 2023–24, Saving our Species delivered actions across more than 300 projects for threatened plants, animals and ecological communities and key threatening processes at more than 690 sites across NSW.

Some actions taken through Saving our Species in 2023–24 were:

- using aerial surveys to find eight new colonies of the threatened brush-tailed rock-wallaby in Kangaroo Valley
- using DNA analysis to identify prey species in predator scats
- using traditional knowledge from Aboriginal people – this information helped identify which introduced and threatened native animals lived in an area and create actions to control the predators.

Bushfire science

While some native animals cannot survive intense fires, others need it to thrive. As bushfires are increasing in intensity and frequency, the NSW Government has implemented the **Applied Bushfire Science Program** to:

- improve understanding of how bushfires affect native plants and animals
- improve clarity of information provided to fire managers so they can make better decisions
- integrate cultural and environmental knowledge into bushfire risk management and planning.

Aquatic habitat mapping

The Aquatic Habitat Mapping Program:

- develops riverine mapping projects to identify instream and riparian habitats
- provides information to assess environmental impacts
- introduces restoration and rehabilitation actions to improve aquatic environments and manage river flows.

See **fish and flows** for more information.

The Fisheries Threatened Species Captive Breeding & Conservation Stocking program increases numbers of threatened fish species through genetic rescue and breeding.

Between 2020 and 2023, 13 threatened fish species were bred in captivity. More than 375,000 fish were released into suitable habitats in rivers and streams.

See **fish stocking** for more information.

WildCount

WildCount was the NPWS long-term animal monitoring program.

From 2012 to 2022, motion-sensitive digital cameras were used at 200 sites, in 146 NSW parks and reserves, to track changes in wildlife sightings. The data was used to:

- identify changes in occupancy to understand if animals are in decline, increasing or stable
- guide conservation actions
- work out whether changes in animal populations could be related to factors such as climate change, seasonal weather and bushfires.

For example, WildCount has extensive data for 200 sites before the 2019–20 bushfires. Seventy sites were burnt during the bushfires. Information from these sites can help scientists understand the impacts of bushfires on native wildlife and how they recover after fire (**NSW Government 2024f**).

Broadscale monitoring also enables:

- new records of threatened species to be detected
- species to be found outside their known ranges

- the ability to detect changes in distribution of invasive species, such as foxes and rabbits.

The final WildCount report, including the monitoring results from the second half of the program from 2017 to 2022, is being finalised. It should be available in early 2025.

Ecological health scorecards

The ecological health performance scorecards program is a biodiversity monitoring program led by the NPWS.

The pilot program measures the health of our national parks in eight sites across NSW by monitoring environmental indicators related to:

- the health of native plants and animals
- threats to ecological health, such as invasive animals and weeds
- important ecological processes, such as soil chemistry and water quality
- fire patterns.

Each site represents a major ecosystem within the national park estate. Most of the scorecards should become available in 2025.

Invasive animal control

Lord Howe Island

The **Lord Howe Island Rodent Eradication Project** has succeeded in removing the ship rat (*Rattus rattus*) and house mouse (*Mus musculus*) from Lord Howe Island, nearby islands and rocky islets.

Wiping out these rodents has benefited biodiversity and many native plants and animals, including the endangered Lord Howe Island woodhen. It has also meant critically endangered species can be reintroduced, such as the Lord Howe Island stick insect (**LHIB n.d.-a**). No rats were found on the island between 2021 and 2023 (**LHIB n.d.-b**).

National parks

Invasive animals threaten biodiversity across NSW national parks and can also cause damage to areas that are culturally and historically important, such as Aboriginal rock art sites.

Working together with similar agencies, the NPWS manages programs that tackle these threats. The NPWS has developed specific **regional pest management strategies**, which are used to guide and implement best practice control and monitoring programs in national parks and reserves.

The NPWS has been delivering record levels of invasive animal control since 2019–20, including the largest aerial shooting program in its history.

The NPWS aerial shooting and baiting programs have been increasing since January 2020 to address invasive animals including foxes, feral cats, wild dogs, goats, pigs, wild horses and deer. These efforts:

- mean there is more habitat and food for native animals
- prevent the spread of diseases brought in by introduced animals that native animals have no resistance to
- protect threatened species, native plants, animals, landscapes and catchment values
- limit the impact on neighbouring properties.

In addition, NPWS has commenced an $8.5 million targeted feral cat control initiative focused on strategic feral cat control and monitoring over three years. The initiative includes a dedicated feral cat ground shooting team that will also work to establish an effective toxic bait for feral cats in NSW (**NSW Government 2024b**).

Private land

Local Land Services coordinates nil tenure, collaborative invasive animal control programs, with a focus on private land.

A nil tenure approach means that responsibility, control activity and cost for invasive animal management is shared across private and public land managers to fix a common problem.

Local Land Services also gives land managers tools, programs, support, training and advice to help them control invasive species on their land.

Carp

Released in 2022, the **National Carp Control Plan** uses a virus to kill introduced carp. Scientists are determining if the virus is safe, effective and feasible so it can be released in waterways where carp live.

Feral predator-free areas

The NPWS is establishing a network of **predator-free areas** within NSW national parks. At the time of writing, the network contains 10 sites where locally extinct and threatened native mammals are being reintroduced and ecosystem functions are being restored.

This will eventually create 65,000 hectares of land where threatened animals can survive.

More than 50 threatened and locally extinct animals will benefit from the exclusion of these predators. Some threatened species, including bilbies, numbats and golden bandicoots, have already been released on three of the sites.

Restoration and rehabilitation

Biodiversity Offsets Scheme

Legislated under the *Biodiversity Conservation Act 2016*, the **Biodiversity Offsets Scheme** provides a mechanism to avoid, minimise and offset the impacts of development and some types of clearing on biodiversity in NSW.

As at 30 September 2023, the scheme had:

- protected 64,889 hectares through land management under Biodiversity Stewardship Agreements
- invested $288 million in the Biodiversity Stewardship Payment Fund for managing Biodiversity Stewardship Agreement sites
- paid nearly $15 million from the Biodiversity Stewardship Payment Fund to generate biodiversity gains through weed and invasive species management, fire management and land restoration works
- established a $106 million Biodiversity Credits Supply Fund to supply biodiversity credits.

Habitat restoration

Local Land Services is delivering 17 projects across NSW as part of the **National Landcare Program**. This program helps threatened birds, such as the mallee fowl, plains-wanderer, swift parrot and regent honeyeater.

In 2022–23, Local Land Services:

- restored 10,500 hectares of mallee fowl habitat
- restored 4,914 hectares of plains-wanderer habitat
- protected 1,129 hectares of native habitat to support swift parrot recovery.

Wildlife rescue

Volunteers in wildlife rehabilitation rescue more than 100,000 sick, injured and orphaned native animals every year. They represent about 500 different species.

The NSW Government is working on implementing the ***NSW Volunteer Wildlife Rehabilitation Sector Strategy 2020–23*** to help support volunteers and improve wildlife rehabilitation in NSW.

For information on native species in care, see the **wildlife rehabilitation data dashboard.**

Knowledge sharing

The Gumbaynggirr community on the NSW Mid North Coast shared knowledge of traditional weaving techniques with volunteers to create new homes for threatened golden-tipped bats (*Phoniscus papuensis*).

This vulnerable bat roosts in native birds' abandoned nests but had much of its habitat burnt during the 2019–20 bushfires.

Using traditional weaving techniques and local vegetation, Gumbaynggirr people and volunteers made and installed 60 roosts, to replace those lost in the fires. Two years later, two pairs of golden-tipped bats have used these roosts, as well as many native birds (**NSW Government 2024a**).

Natural Heritage Trust Projects 2023–28

Natural Heritage Trust projects led by Local Land Services, with Australian Government funding, will boost a range of species and landscapes.

The projects aim to:

- increase environment protection
- encourage sustainable agriculture
- ensure better natural resource management across NSW.

Capacity building

Managing injured wildlife

As a result of the **2020 NSW Bushfire Inquiry**, the NPWS has been working with other incident response agencies (such as Fire and Rescue NSW), wildlife rehabilitators and the veterinary sector to provide improved response to injured wildlife in emergencies.

A **Bushfire Emergency Response for Wildlife** program has been established to:

- develop the Wildlife in Emergencies Sub Plan for the Environmental Services Functional Area
- develop guidelines for wildlife response during emergencies
- provide training and personal protective equipment to qualified wildlife responders
- improve NSW firefighters' ability to assist wildlife in an emergency
- develop training videos and other interactive learning opportunities.

Regional services

Local Land Services supports landholders in implementing land management practices that benefit biodiversity and threatened plants and animals. This support includes:

- helping landholders to preserve and enhance habitats for native animals
- technical advice on how to manage lands to improve biodiversity.

Citizen science

Citizen science is scientific work done by the community, often in collaboration with, or supervised by, professional scientists and scientific organisations.

Citizen scientists often help with collecting data. For example, recording observations of animals, identifying animals in photographs, or taking measurements in their local environment.

Citizen science programs that focus on expanding our understanding of Australia's animals include:

- **Australian Pollinator Count**
- Birdlife Australia's **Aussie bird count**
- **Bush Blitz**
- **iNaturalist**
- **BioCollect**
- **TurtleSAT**.

There are many other ways people can get involved in animal conservation or habitat restoration. They can get involved in a **bushcare group**, take part in a wildlife conservation project, volunteer in national parks or download apps like the ones above.

The NSW DCCEEW has several **citizen science opportunities** available.

The Australian Citizen Science Association also hosts a state-based **citizen science project finder** where people can discover and get involved with citizen science projects in NSW.

The data collected by these programs helps build knowledge of species' distribution and population health across NSW.

For example, the **1 Million Turtles program** uses the TurtleSAT app, which enables people to record sightings of turtles and turtle nesting sites. This program trains people in skills to:

- increase public awareness of turtles
- conduct turtle nest predation surveys

- protect turtle nests from predators.

See the **Rivers and wetlands** topic for more information about turtles and their conservation.

Much of the data from citizen science projects is collated through publicly available databases such as:

- **Birdata**, which is one of the largest collections of publicly accessible bird data in Australia, combining information from individuals, groups and organisations.
- **The Atlas of Living Australia,** which collects Australian biodiversity data from many sources for scientists, policy makers, environmental planners and land managers, industry and the general public.

Future opportunities

Traditional knowledge and Cultural Fire

Aboriginal communities have a strong role to play in ensuring the long-term health of native animals and their habitats. Partnerships with Aboriginal communities are important for delivering coordinated conservation actions informed by cultural expertise.

Aboriginal joint management has been in place in NSW national parks and reserves since its formal introduction in 1998. As at November 2024, about 31% or 2,334,621 hectares of the NSW national park estate is jointly managed with Aboriginal peoples.

Joint management involves Aboriginal peoples who have a cultural association with a park being involved in park management or advising on its management.

Joint management of national parks ensures Aboriginal peoples have input on conservation measures, including invasive animal and weed management, and Cultural Fire management.

The Invasive Species Council's **Voice of Country campaign** is putting Aboriginal knowledge and culture at the forefront of invasive species policy-making by:

- talking and engaging with Aboriginal communities about the impacts of invasive species on Country
- building awareness, ecological knowledge, advocacy skills and community capacity to manage Country (**ISC 2024**).

In partnership with organisations such as Bush Heritage Australia, the Ngiyampaa Wangaaypuwan Traditional Custodians have undertaken a variety of conservation actions to protect the old-growth mallee woodlands and the small caves, rock shelters and art sites contained within.

One of these actions has included harvesting invasive goats. Reducing goat numbers has in turn protected habitat for the malleefowl, grey-crowned babbler and hooded robin (**Bush Heritage Australia n.d.**).

There is further opportunity to listen to Aboriginal peoples in decision-making roles in inclusive and respectful settings.

Cultural Fire management

Cultural Fire management has many benefits, one of which is to help reduce the impact of bushfires.

Aboriginal peoples use of Cultural Fire is important to:

- enhance and protect natural and cultural values
- express and maintain culture, kinship and identity
- continue to share knowledge and practice

The **NSW Bushfire Inquiry** into the bushfires of 2019–20 received many responses about reviving Cultural Fire management to prevent future bushfires and heal Country.

NPWS partners with Aboriginal peoples to undertake culturally informed burning and community (low-risk) cultural burning on NPWS reserves. Read more about the **NPWS Cultural Fire management policy.**

See the **Health of Country** topic for an overview of Cultural Fire management in NSW.

Aquatic ecosystems

Further actions that can be taken to improve threatened and native fish numbers include:

- habitat rehabilitation
- improved water management
- captive breeding, reintroduction and translocation of threatened and native species
- long-term monitoring programs to preserve and improve fish communities and increase numbers of native fish in coastal rivers
- installing fishways, removing weirs, managing floodgates and designing culverts (the tunnels under roads) to be fish-friendly, so they can swim from one side to the other.

Read more about **improving fish habitats**.

Climate change

Understanding the threats native animals and their habitats face from climate change will inform scientists in the development of appropriate adaptation and management actions to help native species adapt.

See the **Climate change** topic for more information.

Insects

The small size and secretive nature of many insects make it hard to identify threatened insect species.

Despite making up 95% of animal diversity in Australia, insects make up only 15% of species assessed under the *Environment Protection and Biodiversity Conservation Act 1999* (**Invertebrates Australia n.d.**).

The reality is that many more insects than we know about are under threat. Increased monitoring of insects would help scientists:

- assess which insects in NSW are threatened
- better map the relationships between insects and other native species.

Monitoring opportunities

Recording the status of all plant and animal species across NSW is a very large, complex task, especially when many species remain unknown. To simplify the task, Government scientists have developed a suite of indicators to measure different aspects of biodiversity and ecological integrity (the capacity of ecosystems to retain biodiversity and adapt to change). The results of indicators on the status of NSW biodiversity and ecological integrity are available in the ***NSW biodiversity outlook report 2024***.

Increasing the monitoring of threatened animal species and the effectiveness of actions to conserve them, such as through Saving Our Species and other programs, will continue to support effective conservation of threatened species.

Conserving threatened animals on privately owned land can help:

- build vegetation corridors so native animals can move between privately owned land and national parks and reserves, and increase their habitat area
- enhance the ability of native animals and their ecosystems to adapt to, and cope with, climate change and habitat disturbance.

Monitoring these animals on private as well as publicly owned land will help to maintain sustainable populations of native plants and animals.

Traditional knowledge of local ecosystems can also help identify threats to native animals and the effectiveness of conservation actions. For example, Aboriginal peoples' **seasonal calendars** reveal a deep understanding of how plant and animal phenology (timing of events in nature) is interconnected (**CSIRO n.d.**).

See the **Health of Country** topic for more information.

Biodiversity Indicator Program

In 2014, the independent **Biodiversity Legislation Review** Panel recommended the development of a comprehensive system for monitoring and reporting on the extent and quality of biodiversity in NSW.

In response, the **Biodiversity Indicator Program** was established under the *Biodiversity Conservation Act 2016* to collect, monitor and assess information on the status and trends in biodiversity in NSW.

Indicators are used to assess the status and trends of biodiversity in New South Wales and help us understand the impact of current biodiversity management and conservation measures.

The first NSW biodiversity outlook report was published in 2020.

The ***NSW biodiversity outlook report 2024*** shows that biodiversity is on the decline in NSW. New indicators for community appreciation, invasive species, conservation areas and climate resilience have been included in 2024 as part of the evolution of the report.

Technology

Technological advances are improving and expanding options for undertaking more efficient and cost-effective monitoring and data analysis of native animals.

This can help researchers track the presence of native animals without direct observation or disturbance. For example:

- eco-acoustics, the study of sounds produced in the environment, can use artificial intelligence tools to scan audio recordings and identify the calls of different species at study sites (DPI n.d.-a)
- eDNA (environmental DNA) collected from soil, water or air samples can identify native animals living in an area (CSIRO 2023).

Wildlife drone hub

The NSW Government has established a **Wildlife Drone Hub** to monitor and survey biodiversity using drones.

The hub provides specialised training to land managers that enables them to use drones to detect both wildlife and vegetation. The hub manages the data collected by drones and provides digital tools and advanced artificial intelligence (AI) analytics. This data is accessible through a **digital dashboard** that allows managers to analyse and interact with the data in real time.

Drones fitted with thermal cameras can improve biodiversity monitoring because they can survey complex, dangerous or sensitive terrain to detect wildlife. Some advantages of drones over traditional on-ground operations include less disturbance, improved detection and survey efficiencies. For example, a single drone can survey between 100 to 200 hectares a night, as they travel at 30km an hour.

Drones are often deployed at the same time as ground surveys as complementary approaches.

References

AAS n.d., Noise pollution and the environment, Australian Academy of Science, accessed 24 July 2024

ACF 2022, *A Flicker of Hope: 2022 Bogong moth migration snapshot*, Australian Conservation Foundation

AdaptNSW n.d.-a, Climate change impacts on our biodiversity, AdaptNSW, accessed 24 October 2024

AdaptNSW n.d.-b, Climate change impacts on our rivers and wetlands, AdaptNSW, accessed 11 December 2024

Amat JA & Green AJ 2010, 'Waterbirds as Bioindicators of Environmental Conditions', *Conservation Monitoring in Freshwater Habitats*, Springer, Dordrecht, pp. 45–52, DOI: 10.1007/978-1-4020-9278-7_5

Australian Alps National Parks n.d., Aboriginal Heritage, Australian Alps National Parks Co-Operative Management Program, accessed 24 October 2024

AIDR n.d., *Bushfires - Black Summer New South Wales, July 2019 - March 2020*, Australian Government National Emergency Management Agency, Australian Institute for Disaster Resilience, accessed 3 December 2024

Beale P, Youngentob KN & Marsh KJ 2022, *Effects of fire on koalas and their habitat*, report prepared for the Department of Climate Change, Energy, the Environment and Water, Canberra

BirdLife Australia 2023, New data reveals 60% decline in threatened bird populations, BirdLife Australia, accessed 29 August 2024

BirdLife Australia n.d.-a, Urban Birds, BirdLife Australia, accessed 24 July 2024

BirdLife Australia n.d.-b, Bushfire recovery, BirdLife Australia, accessed 24 July 2024

BirdLife International 2020, Australia's birds suffered from intense bushfires during 2019-2020, BirdLife International, accessed 24 July 2024

BMCC 2020, *Feral Animals Fact Sheet No 2: Feral Cats*, Blue Mountains City Council, Sydney

Burmeister S 2019, *Mountain Pygmy-possum Operational Contingency Plan*, Victoria Department of Environment, Land, Water and Planning, Melbourne (PDF 2.1MB)

Bush Heritage Australia n.d., Mawonga, Bush Heritage Australia, accessed 24 October 2024

CAUL n.d., Threatened Species in Urban Areas, The Clean Air and Urban Landscapes Hub, accessed 24 July 2024

Chapman AD 2009, *Numbers of Living Species in Australia and the World*, Australian Biodiversity Information Services, Toowoomba, Australia

Chen T, Whiteley P, Skerratt LF, El-Hage C, Ploeg R, Davis N & Hufschmid J 2024, 'Poor Survival Rate of Eastern Gray Kangaroos (Macropus giganteus) Affected by Chronic Phalaris Toxicity', *Journal of Wildlife Diseases*, vol. 60, no. 4, pp. 903–11, DOI: 10.7589/JWD-D-23-00168

Clarke PA 2023, 'Birds as Totemic Beings and Creators in the Lower Murray, South Australia', *Journal of Ethnobiology*, vol. 36, no. 2, DOI: 10.2993/0278-0771-36.2.277

Crook DA, Schilling HT, Gilligan DM, Asmus M, Boys CA, Butler GL, Cameron LM, et al. 2023, 'Multi-decadal trends in large-bodied fish populations in the New South Wales Murray–Darling Basin, Australia', *Marine and Freshwater Research*, vol. 74, no. 11, pp. 899–916, DOI: 10.1071/MF23046

CSIRO 2016, Species everywhere are on the move, Commonwealth Scientific and Industrial Research Organisation, accessed 25 July 2024

CSIRO 2019, Invasive species are Australia's number-one extinction threat, Commonwealth Scientific and Industrial Research Organisation, accessed 29 August 2024

CSIRO 2020, The 2019-20 bushfires: a CSIRO explainer, Commonwealth Scientific and Industrial Research Organisation, accessed 3 December 2024

CSIRO 2023, eDNA explained: unlocking nature's hidden biodiversity, Commonwealth Scientific and Industrial Research Organisation, accessed 24 July 2024

CSIRO n.d., Indigenous seasonal calendars, Commonwealth Scientific and Industrial Research Organisation, accessed 24 October 2024

DAWE 2020, *Provisional list of animals requiring urgent management intervention*, Australian Government Department of Agriculture, Water and the Environment, Sydney

DCCEEW 2024, *NSW biodiversity outlook report 2024*, NSW Department of Climate Change, Energy, the Environment and Water, Sydney

DCCEEW-Aus 2013, *Chytridiomycosis (Amphibian Chytrid Fungus Disease)*, Australian Government Department of Climate Change, Energy, the Environment and Water, Sydney

DCCEEW-Aus 2021a, Red imported fire ant - Solenopsis Invicta, Australian Government Department of Climate Change, Energy, the Environment and Water, accessed 24 July 2024

DCCEEW-Aus 2021b, Diseases, fungi and parasites in Australia, Australian Government Department of Climate Change, Energy, the Environment and Water, accessed 24 July 2024

DCCEEW-Aus 2023, Koala listing under national environmental law, Australian Government Department of Climate Change, Energy, the Environment and Water, accessed 28 August 2024

DCCEEW-Aus 2024, Let's switch off light pollution together!, Australian Government Department of Climate Change, Energy, the Environment and Water, accessed 24 July 2024

DCCEEW-Aus n.d., *State of the Environment Report 2021: Biodiversity*, Australian Government Department of Climate Change, Energy, the Environment and Water, Sydney

DECCW 2009, *New South Wales State of the Environment 2009*, NSW Department of Environment, Climate Change and Water, Sydney (PDF 1.0MB)

DECCW 2010, *NSW Natural Resources Monitoring, Evaluation and Reporting Strategy 2010–2015*, NSW Department of Environment, Climate Change and Water, Sydney

DEC 2004, *Bat roosts - natural resource management information note*, NSW Department of Environment and Conservation, Canberra (PDF 0.18MB)

DEH 2004, *Invasive species in Australia*, Australian Government Department of Agriculture, Fisheries and Forestry, Canberra (PDF 0.42MB)

Diengdoh VL, Ondei S, Hunt M & Brook BW 2022, 'Predicted impacts of climate change and extreme temperature events on the future distribution of fruit bat species in Australia', *Global Ecology and Conservation*, vol. 37, e02182, DOI: 10.1016/j.gecco.2022.e02181

Doherty TS, Macdonald KJ, Nimmo DG, Santos JL & Geary WL 2024, 'Shifting fire regimes cause continent-wide transformation of threatened species habitat', *Proceedings of the National Academy of Sciences*, vol. 121, no. 18, e2316417121, DOI: 10.1073/pnas.2316417121

DPE 2022a, *NSW koala strategy 2022*, NSW Department of Planning and Environment, Sydney (PDF 4.8MB)

DPE 2022b, *A survey of the wild horse population in Kosciuszko National Park, November 2022*, NSW Department of Planning and Environment, Sydney (PDF 0.55MB)

DPE 2023, *NSW Wildlife Rehabilitation 2021–22 Annual Report*, NSW Department of Planning and Environment, Sydney

DPI 2009, *Recognising water weeds: Plant identification guide*, NSW Department of Primary Industries, Sydney

DPI 2016, *Fish communities and threatened species distributions of NSW*, NSW Department of Primary Industries, Sydney

DPI 2023, *NSW Invasive Species Plan 2023–2028*, NSW Department of Planning and Environment, Sydney

DPI 2024, Red imported fire ants (*Solenopsis invicta*), NSW Department of Planning and Environment, accessed 29 August 2024

DPI n.d.-a, Fauna identification service, NSW Department of Primary Industries, accessed 24 July 2024

DPI n.d.-b, Fish and flows, NSW Department of Primary Industries, accessed 24 July 2024

DPI n.d.-c, Threats to fish habitats, NSW Department of Primary Industries, accessed 24 July 2024

DPI n.d.-d, Yellow crazy ants, NSW Department of Primary Industries, accessed 24 October 2024

DPI n.d.-e, Cane Toad, NSW Department of Primary Industries, accessed 24 October 2024

DPI n.d.-f, Carp, NSW Department of Primary Industries, accessed 24 October 2024

DPIE 2020, *NSW Biodiversity Outlook Report - Results from the Biodiversity Indicator Program: First assessment*, NSW Department of Planning, Industry and Environment, Sydney

DPIE 2021, *NSW Wildlife and Conservation Bushfire Recovery: Supplement A - Assessing the impact of the bushfires on wildlife and conservation*, NSW Department of Planning, Industry and Environment, Sydney (PDF 2.6MB)

DPIE 2022, *Review of freshwater turtle ecology and flow*, NSW Department of Planning, Industry and Environment, Sydney

Eldridge DJ & James AI 2009, 'Soil-disturbance by native animals plays a critical role in maintaining healthy Australian landscapes', *Ecological Management & Restoration*, vol. 10, no. s1, pp. S27–34, DOI: 10.1111/j.1442-8903.2009.00452.x

Ensbey M, Legge S, Jolly CJ, Garnett ST, Gallagher RV, Lintermans M, Nimmo DG, Rumpff L, et al. 2023, 'Animal population decline and recovery after severe fire: Relating ecological and life history traits with expert estimates of population impacts from the Australian 2019–20 megafires', *Biological Conservation*, vol. 283, 110021, DOI: 10.1016/j.biocon.2023.110021

Feio MJ, Hughes RM, Serra SRQ, Nichols SJ, et al. 2022, 'Fish and macroinvertebrate assemblages reveal extensive degradation of the world's rivers', *Global Change Biology*, vol. 29, no. 2, pp. 355–74, DOI: 10.1111/gcb.16439

Gibson RK, Broome L & Hutchinson MF 2017, 'Susceptibility to climate change via effects on food resources: the feeding ecology of the endangered mountain pygmy-possum (*Burramys parvus*)', *Wildlife Research*, vol. 45, no. 6, pp. 539–50, DOI: 10.1071/WR17186

Hughes L 2011, 'Climate change and Australia: key vulnerable regions', *Regional Environmental Change*, vol. 11, no. 1, pp. 189–95, DOI: 10.1007/s10113-010-0158-9

Invertebrates Australia n.d., Conservation Assessments, Invertebrates Australia Ltd, accessed 28 August 2024

ISC 2024, Voice of Country, The Invasive Species Council, accessed 29 August 2024

Ives CD, Lentini PE, Threlfall CG, Ikin K, Shanahan DF, Garrard GE, Bekessy SA, Fuller RA, Mumaw L, Rayner L, Rowe R, Valentine LE & Kendal D 2015, 'Cities are hotspots for threatened species', *Global Ecology and Biogeography*, vol. 25, no. 1, pp. 117–26, DOI: 10.1111/geb.12404

Johnson C, Cogger H, Dickman CR & Ford H 2007, *Impacts of Landclearing: the impacts of the approved clearing of native vegetation on Australian wildlife in New South Wales*, World Wide Fund for Nature – Australia, Sydney

Johnson C, Woinarski J, Lindenmayer D, Legge S, Cadenhead N & Morgain R n.d., *Submission to the Senate Inquiry on Australia's faunal extinction crisis: Ecological impacts of faunal extinction and decline*, Australia's faunal extinction crisis, submission 159, Threatened Species Recovery Hub (PDF 0.49MB)

Jones T 2018, What happens to wildlife in a city that never sleeps?, The University of Melbourne, accessed 24 July 2024

Land for Wildlife Queensland 2016, *Note F3: Fire and Fauna*, Land for Wildlife Queensland, South East Queensland (PDF 1.0MB)

Law B, Brassil T, Proud R & Potts J 2023, 'Estimating density of forest bats and their long-term trends in a climate refuge', *Ecology and Evolution*, vol. 13, no. 6, e10215, DOI: 10.1002/ece3.10215

Law B, Gonsalves L, Brassil T & Kerr I 2024, 'Broad-scale acoustic monitoring of koala populations suggests metapopulation stability, but varying bellow rate, in the face of major disturbances and climate extremes', *Ecology and Evolution*, vol. 14, no. 5, e11351, DOI: 10.1002/ece3.11351

Law B, Gonsalves L, Brassil T, Kerr I & Sawyers E unpub., *Acoustic surveys of Yellow-bellied Gliders in north-east New South Wales: occupancy monitoring in public forests and baseline surveys in private forests* (unpublish), DPI Report to DCCEEW

Leadley P, Pereira HM, Alkemade R, Fernandez-Manjarrés JF, Proença V & Scharlemann JPW 2010, *Biodiversity Scenarios: Projections of 21st century change in biodiversity and associated ecosystem services*, Technical Series no. 50, Secretariat of the Convention on Biological Diversity, Montreal, Canada

Legge S, Woinarski JCZ, Garnett ST, et al. 2021, *Estimates of the impacts of the 2019–20 fires on populations of native animal species*, NESP Threatened Species Recovery Hub, Project 8.3.2 report, Brisbane

LLS 2024, *Greater Sydney Regional Strategic Pest Animal Plan 2024–2028*, Local Land Service, Sydney

LLS n.d., Flood affected wildlife, Local Land Services, accessed 24 October 2024

LHIB n.d.-a Rodent Eradication Project, Lord Howe Island Board, accessed 29 August 2024

LHIB n.d.-b, Checkpoint program 2023, Lord Howe Island Board, accessed 17 December 2024

Lowe S, Browne M, Boudjelas S & De Poorter M 2000, *100 of the World's Worst Invasive Alien Species: A selection from the Global Invasive Species Database*, The Invasive Species Specialist Group (ISSG), a specialist group of the Species Survival Commission (SSC) of the World Conservation Union (IUCN) (PDF 1.34MB)

Mahon P, King S, O'Brien C, Barclay C, Gleeson P, McIlwee A, Penman S & Schulz M 2011, *Assessing the Sustainability of Native Fauna in NSW*, Monitoring, Evaluation and Reporting Program, Technical report series, NSW Office of Environment & Heritage, Sydney (PDF 2.8MB)

McCowan LSC & Griffith SC 2021, 'Baked eggs: catastrophic heatwave-induced reproductive failure in the desert-adapted Zebra Finch (*Taeniopygia guttata*)', *International Journal of Avian Science*, vol. 163, no. 4, pp. 1207–16, DOI: 10.1111/ibi.12958

Menkhorst P & Hynes E 2011, *National Recovery Plan for the Brush-tailed Rock-wallaby Petrogale penicillate*, Victorian Government Department of Sustainability and Environment (DSE) East Melbourne (PDF 0.64MB)

Menon V, McGregor H, Giljohann K, et al. 2024, 'Ecological factors influencing invasive predator survival and movement: insights from a continental-scale study of feral cats in Australia', *Biological Invasions*, vol. 26, pp. 1505–20, DOI: 10.1007/s10530-024-03254-0

MDBA 2023a, The Basin, The Murray–Darling Basin Authority, accessed 29 August 2024

MDBA 2023b, Fish, The Murray–Darling Basin Authority, accessed 29 August 2024

Nolan RH, Boer MM, Collins L, de Dios VR, Clarke H, Jenkins M, Kenny B & Bradstock RA 2020, 'Causes and consequences of eastern Australia's 2019–20 season of mega-fires', *Global Change Biology*, vol. 26, no. 3, pp. 1039–41, DOI: 10.1111/gcb.14987

NSW EPA 2022, NSW State of the Environment Report 2021: Native Fauna, NSW Environment Protection Authority, accessed 27 August 2024

NSW Health 2024, Bird flu (avian influenza) fact sheet, NSW Health, accessed 11 December 2024

NSW legislation 2024, Biodiversity Conservation Act 2016 No 63, NSW legislation, accessed 24 July 2024

NSW Government 2017, Predation by Gambusia holbrooki Girard, 1859 (Plague Minnow or Mosquito Fish) – profile, NSW Office of Environment & Heritage, accessed 29 August 2024

NSW Government 2022, Securing a future for koalas - chlamydia vaccine trial begins in south-west Sydney, Environment and Heritage, accessed 24 July 2024

NSW Government 2023a, 12 wins for conservation in 2023, Environment and Heritage, accessed 28 August 2024

NSW Government 2023b, Flying-foxes, Environment and Heritage, accessed 24 July 2024

NSW Government 2023c, Feral deer, Environment and Heritage, accessed 24 October 2024

NSW Government 2024a, Golden tipped bats make Indigenous woven roosts their home on NSW mid north coast, Environment and Heritage, accessed 29 August 2024

NSW Government 2024b, Inquiry into management of cat populations in New South Wales, submission No. 94, New South Wales Government submission (December 2024) (PDF 380KB)

NSW Government 2024c, Key threatening processes, Environment and Heritage, accessed 24 July 2024

NSW Government 2024d, Reviewing the NSW Koala Strategy, Environment and Heritage, accessed 24 October 2024

NSW Government 2024e, Saving the Booroolong frog - no croaking matter, Environment and Heritage, accessed 28 August 2024

NSW Government 2024f, WildCount, Environment and Heritage, accessed 28 August 2024

Parks Australia n.d., Yellow crazy ant biocontrol, Parks Australia, accessed 24 October 2024

Perna CN, Cappo M, Pusey BJ, Burrows DW & Pearson RG 2012, 'Removal of aquatic weeds greatly enhances fish community richness and diversity: an example from the Burdekin River floodplain, tropical Australia', *River Research and Applications*, vol. 28, no. 8, pp. 1093–104, DOI: 10.1002/rra.1505

Rummell AJ, Borland HP, Leon JX, Henderson CJ, Gilby BL, Ortodossi NL, Mosman JD, Gorissen B & Olds AD 2023, 'Fish and crustaceans provide early indicators of success in wetland restoration', *Restoration Ecology*, vol. 31, no. 8, e13952, DOI: 10.1111/rec.13952

Sands DPA 2018, 'Important issues facing insect conservation in Australia: now and into the future', *Austral Entomology*, vol. 57, no. 2, pp.150–72, DOI: 10.1111/aen.12342

Schilling H & Crook D 2023, *Basin Plan Environmental Outcomes Monitoring for Fish (2014/15 – 2019/20): Water Resource Planning Area Reports*, NSW Department of Primary Industries, Fisheries NSW, Port Stephens Fisheries Institute (PDF 45MB)

Short J & Smith A 1994, 'Mammal decline and recovery in Australia', *Journal of Mammalogy*, vol 75, no. 2, pp. 288–97, DOI: 10.2307/1382547

Steffen W, Burbidge AA, Hughes L, Kitching R, Lindenmayer D, Musgrave W, Stafford Smith M & Werner P 2009, *Australia's Biodiversity and Climate Change: A strategic assessment of the vulnerability of Australia's biodiversity to climate change*, Report to the Natural Resource Management Ministerial Council, Department of Climate Change, CSIRO Publishing, Canberra (PDF 3.1MB)

Stephenson B, David B, Fresløv J, et al, 2020, '2000 Year-old Bogong moth (*Agrotis infusa*) Aboriginal food remains, Australia', *Scientific Reports*, vol. 10, 22151, DOI: 10.1038/s41598-020-79307-w

Stuart IG, Fanson BG, Lyon JP, Stocks J, Brooks S, Norris A, Thwaites L, Beitzel M, Hutchison M, Ye Q, Koehn JD & Bennett AF 2021, 'Continental threat: How many common carp (*Cyprinus carpio*) are there in Australia?', *Biological Conservation*, vol. 254, 108942, DOI: 10.1016/j.biocon.2020.108942

Taylor MFJ & Dickman CR 2014, *NSW Native Vegetation Act Saves Australian Wildlife*, World Wildlife Fund – Australia, Sydney

TERN 2019, Observing Environmental Change in Australia: Conversations for Sustainability, Australia's Terrestrial Ecosystem Research Network, assessed 24 July 2024

Threatened Species Index 2023, *Australia's Threatened Bird Index: Summary of trends up to 2020, Released November 2023*, Ecosystem Research Infrastructure, National Research Infrastructure for Australia, Birdlife Australia, Department of Climate Change, Energy, the Environment and Water, Sydney

Threatened Species Index n.d., How does the index work?, Threatened Species Index, accessed 28 August 2024

Valentine LE, Bretz M, Ruthrof KX, Fisher R, St J Hardy GE & Fleming PA 2017, 'Scratching beneath the surface: Bandicoot bioturbation contributes to ecosystem processes', *Austral Ecology*, vol. 42, no. 3, pp. 265–76, DOI: 10.1111/aec.12428

Victorian Aboriginal Heritage Council 2021, *Taking Control of Our Heritage - Recommendations for reform of the Aboriginal Heritage Act 2006*, Victorian Aboriginal Heritage Council, Melbourne

Ward M, Rhodes JR, Waston JEM, Lefevre J, Atkinson S & Possingham HP 2019, 'Use of surrogate species to cost-effectively prioritize conservation actions', *Conservation Biology*, vol. 34, no. 3, pp. 600–10, DOI: 10.1111/cobi.13430

Wildlife Health Australia 2023, *High Pathogenicity Avian Influenza (HPAI) clade 2.3.4.4b incursion risk assessment for Australia, Based on information as of 20 July 2023 ABRIDGED VERSION*1, Wildlife Health Australia, Canberra (PDF 1.8MB)

Wintle B, Tunney O, Cadenhead N, Visintin C, Mackay E, Crossing I, Hutton C, Monk N, Naccarella A, Southwell D, Broome L, Caley P, Heinz D, Kriesner P, Weeks A, White M, McDonald G & Warrant E 2021, *The Bogong moth, Agrotis infusa: cultural context, knowledge gaps, conservation and monitoring options*, National Environmental Science Program Threatened Species Recovery Hub, Brisbane

Woinarski JCZ, Burbidge A & Harrison PL 2015, 'A review of the conservation status of Australian mammals', *Therya*, vol. 6, no. 1, pp. 155–66, DOI: 10.12933/therya-15-237

Health of Country

Healthy Country, healthy people, healthy culture.

Introduction

As at August 2024, there were

15

community-led Indigenous Ranger groups in NSW

Read more

As at August 2024, there were

11

Indigenous Protected Areas in NSW

Read more

Aboriginal and ‘Eurocentric’ world views of the natural world have some commonalities but also important differences.

The term ‘Country’ is used by Aboriginal peoples to refer to everything in the landscape. It encompasses living (such as humans, plants and animals) and non-living entities (such as air, soil and rocks) and the relationships among them.

Aboriginal peoples understand that everything is connected. This includes ecological systems and biodiversity.

Aboriginal peoples have a moral, cultural and spiritual inheritance and obligation to protect Country (land, sea, sky) because Country is integral to the cultures of Aboriginal peoples. This includes caring for cultural sites, such as rock art, shell middens and scar trees (tangible cultural heritage). It also includes caring for ‘living culture’ by caring for places and landscapes and important plants and animals and maintaining cultural practices, such as Cultural Fire and sharing knowledge (intangible cultural heritage).

Caring for Country is more than just caring for the environment: it is taking care of Country as if it is kin.

The loss of biodiversity in Australia coincided with the removal and oppression of Aboriginal peoples, and the disruption of the holistic and symbiotic relationship between people and Country. Truth telling is part of healing. Country needs the truth to be told.

This topic covers how Aboriginal peoples value biodiversity, base their seasonal calendars on local environmental and weather patterns, apply Cultural Fire to improve the health of Country and strengthen connection to culture. It highlights Indigenous-led initiatives to care for Country.

Cultural value of biodiversity

Caring for culturally significant biodiversity

While all species and ecosystems are valuable to Aboriginal people, culturally significant species are species and ecological communities that hold vital importance in Aboriginal cultures (termed Culturally Significant Entities in **Goolmeer et al. 2022**). These species are totems and may provide food and medicine, indicate the health of Country and be considered as kin. Ensuring these species are healthy and cared for by Aboriginal people is critical to maintaining Aboriginal cultures and knowledges.

The current model for funding conservation of species and ecosystems in NSW uses 'western' values of prioritisation based on the conservation status of the species. They are formally classified as threatened under the NSW *Biodiversity Conservation Act 2016* or the Commonwealth *Environment Protection and Biodiversity Act 1999*.

Some threatened species have been identified as culturally significant. It is likely that most culturally significant species are not on the threatened species list and therefore not eligible for most existing sources of funding.

Culturally significant species that are also classified as threatened may be eligible for funding under the **Saving Our Species program**. Under this program, a conservation strategy is developed for a threatened species. The strategy outlines the actions needed to secure the species in the wild based on western scientific assessments.

Some on-ground conservation projects include engagement with Aboriginal peoples. There is an identified need to expand and formalise this and ensure these species are managed appropriately with the leadership and input of Aboriginal peoples and in a place-based way.

Importance of place in biodiversity conservation

The cultural importance of plants, animals and ecosystems varies according to place. For this reason, the protection, restoration or management of culturally significant species and use of traditional knowledges to manage these species must be place based and led by local Aboriginal communities.

The use and application of traditional knowledge must always follow international agreements and principles, including **Free Prior and Informed Consent** and respect for **Indigenous Cultural and Intellectual Property** (**DPE 2023a**).

In many places across NSW, culturally significant species are at risk or are no longer found on Country. This has led to significant cultural disruption within Aboriginal communities (see the excerpt from Barkandji Elder, William (Badger) Bates below). It has also impacted the condition of ecosystems (**Goolmeer et al. 2022**).

Image B3.1 shows a brolga in the Macquarie Marshes.

Image B3.1: Brolga, Macquarie Marshes (Wailwan Country)

Source:
Nicola Brookhouse/DCCEEW (2021)

> 'We thought of the Brolgas exactly if they were our Elders, we had respect and love for them, and they showed us their dances. But now there are seldom any Brolgas in Barkandji country because they need water on the floodplains and swamps for food and shelter for their nests, and these days the floodplains don't get the water. To Murray Darling Basin Authority they think it is all OK if there is somewhere where the brolgas can live, but they don't understand how it breaks our heart if they can't come and live on Barkandji country like they used to. They just don't get that at all.'
>
> **Excerpt from statement of Barkandji Elder, William (Badger) Bates for the Murray Darling Basin Royal Commission 2018 (MDBRC 2018).**
>
> Permission obtained from William (Badger) Bates, 24 June 2024.

Importance of involving Aboriginal people in biodiversity conservation decisions

There is a recognised need to create culturally appropriate opportunities for Aboriginal peoples to be involved in decision-making about biodiversity (**Goolmeer & van Leeuwen 2023**; **DPE 2023b**).

Examples of current representation on NSW biodiversity-focused committees:

- The ***NSW Koala Strategy*** established an Aboriginal Advisory Panel in 2022, and as of July 2024 is has over 70 members.
- The Biodiversity Conservation Trust Board includes an Aboriginal member and has since the Biodiversity Conservation Trust commenced in 2017–18.
- The **Saving Our Species program** Board has one identified position, which as of July 2024 is vacant.
- The Biodiversity Conservation Advisory Panel as of October 2024 includes two Aboriginal panel members.
- The NSW Threatened Species Scientific Committee as of July 2024 does not have any identified positions or members who represent Aboriginal perspectives.

In 2022, the **Threatened Species Scientific Committee** and the Department of Climate Change, Energy, Environment and Water (then Department of Planning and Environment) jointly identified the need for threatened species conservation assessments and final determinations to include Aboriginal Traditional Ecological Knowledge. This was in recognition of the importance of Aboriginal language, kinship and cultural practice in understanding the place of species in Country (distribution, ecology and threats) and culture (uses, stories and kinship).

A guideline for project officers has been developed. It outlines culturally appropriate ways of incorporating Traditional Ecological Knowledge and Aboriginal cultural values into conservation assessments (**DCCEEW 2024a**). Key elements of the guideline include:

- protecting Indigenous cultural and intellectual property
- procedures for appropriately making contact and building relationships with Aboriginal peoples
- a new method for referencing Aboriginal knowledges
- useful references and resources
- standard text for incorporation in conservation assessments.

The guideline was piloted on the conservation assessment for magenta lilly pilly (*Syzygium paniculatum*) (see **Image B3.2**). This is a species with a distribution strongly linked to the use and transport by Aboriginal people. It has also been applied to the assessment of coastal emu (see **Case study B3.1** below).

Image B3.2: Magenta lilly pilly (Syzygium paniculatum)

Source:
Kevin Mills/DCCEEW

These recent efforts aim to provide formal mechanisms for Aboriginal peoples to be involved in decision making or to be engaged on existing projects at a local scale.

It is recognised that additional structural and governance issues must be addressed in order to fully support Aboriginal peoples to undertake their cultural obligations with respect to caring for Country.

Case study B3.1: Coastal Emu, 2023

The geographically isolated 'coastal emu' exists on the north coast of NSW.

It is listed as an Endangered Population under the NSW *Biodiversity Conservation Act 2016*. Fewer than 50 individuals are thought to remain in the wild.

The emus roam over a large area. They traverse a range of habitats, including highly modified agricultural land.

Recent decades have seen a dramatic decline in the population. This is largely due to predation of eggs and chicks by feral pigs and wild dogs. Other contributors are impacts from being struck by passing vehicles, fencing and other human disturbance.

A captive breeding program is thought to be the best available option for saving the coastal emu from extinction.

The population is of high cultural importance to Aboriginal people from the Gumbaynggirr, Yaegl and Bundjalung nations:

- Emus and their eggs have been a traditional source of food.
- They remain part of local song lines.
- Their movement pathways provide important knowledge.
- Stories woven around the population have guided generations of Aboriginal people to understand seasons and resources in the landscape.

The coastal emu is fundamental to traditional practice for many Aboriginal people in northern NSW. Loss of the population would forever remove this important cultural totem.

Many listed and non-listed plants, animals and ecological communities in NSW have immense cultural value for Aboriginal people. Through the Saving our Species program, Traditional Owners from northern NSW are working alongside the NSW Government to:

- address threats to the coastal emu population
- develop recovery strategies
- realise cultural values.

The work is the result of strong relationships built at a regional level. It is bringing opportunities for Aboriginal people to participate in contemporary conservation actions and fulfil cultural obligations.

Source:
DCCEEW 2023

Independent review of the *NSW Biodiversity Conservation Act*

An independent review of the NSW *Biodiversity Conservation Act 2016* was conducted in 2023. The review identified '*the need to better recognise the intrinsic relationship between biodiversity and Aboriginal culture, and embed Aboriginal participation at all levels – advisory, decision-making, implementation and delivery*' (**DPE 2023b**).

In addition, the review found that '*The Act does not adequately recognise the rights, culture and economic aspirations of Aboriginal people and communities*' (**DPE 2023b**).

The review panel heard that the **Biodiversity Offsets Scheme** is creating a financial barrier for Aboriginal peoples who want to realise social and economic aspirations from managing their lands.

In response, the NSW Government committed to 'exploring, in partnership with Aboriginal stakeholders, new and better ways to support Aboriginal people to connect with and care for Country' (**DCCEEW 2024b**).

The NSW Government also committed to undertake tailored engagement with Aboriginal organisations, communities and people. The aim is to ensure their views, knowledge, values and interests underpin the development and implementation of actions and initiatives under this response. This includes:

- legislative reform to prioritise Aboriginal cultural values
- inclusion of Traditional Ecological Knowledge in the application of Environmentally Sustainable Development and strategic land use planning

- engaging Aboriginal organisations and communities to design natural and cultural capital support products that value traditional knowledge and reflect their needs and aspirations.

The response does not address how to include more Aboriginal people in decision-making. For example, it did not establish an Aboriginal advisory group or commit to ensuring identified positions for Aboriginal representation on relevant boards and committees, such as the NSW Threatened Species Scientific Committee.

New opportunities to conserve culturally significant species and places on private lands

There is an emerging opportunity for Aboriginal landowners (organisations and individuals) to seek funding from the Biodiversity Conservation Trust for conservation works on their lands through the **Cultural Biodiversity Conservation Offer**.

This offer is designed to support biocultural conservation with expanded criteria for funding. This included protection or restoration of culturally significant species.

The application process has been redesigned in response to advice from Aboriginal landowners and managers so it better suits Aboriginal applicants.

The Biodiversity Conservation Trust has also developed a Respect and Recognition Guide for its programs. This provides support to all landowners in the programs to learn from local Aboriginal communities and knowledge holders about the cultural values of their properties and how to protect them. It also guides Biodiversity Conservation Trust staff in undertaking due diligence. This is resulting in better relationships between local Aboriginal communities and landowners and improving access to Country.

Seasonality

Aboriginal peoples have lived in harmony with nature for millennia, maintaining a spiritual connection with and deep respect for ancestral lands (**Netana-Glover 2023**).

Aboriginal peoples determine seasons by observing animal behaviours, floristics (plant identification and classification), weather cycles and patterns and celestial patterns. These observations can result in recognising up to six seasons each year.

Aboriginal peoples gain insight into climate changes by monitoring seasonality over long time scales. It is through this understanding that Aboriginal peoples adapt to changes, manage the land and ensure food sustainability (**Woodward & McTaggart 2019**).

As Australia's first scientists, Aboriginal peoples have embedded environmental management practises in cultures. By closely observing and relating to the environment, knowledge is created about when food is ready to harvest, when animals are breeding and how to prepare communities for seasonal changes. This traditional knowledge underpins the sustainability of food supplies and supports cultural activities.

Unlike the western four-season calendar (summer, autumn, winter, spring), Aboriginal people's relationship with weather and climate is based on knowledge acquired through thousands of years of observation passed down through intergenerational transfer. This knowledge is specific to each time and place.

The plants, animals, landscapes and weather systems of each Country are unique. This requires localised and specific knowledge of how to care for each Country.

Seasonal cycles are based on observations of weather patterns, animal migrations and plant flowering or timing of reproduction.

This detailed understanding of Country along with knowledge systems and an understanding of sustainable resource management allows Aboriginal people to live sustainably and in harmony with their environment.

The **Banbai Fire and Seasonal Calendar** (**McKemey & Banbai Rangers 2020**) is an example of this intricate understanding. It describes three distinct fire seasons:

- wildfire time – wet and hot and becoming warm (November to March)
- grass cures – dry becoming cool (April to mid-May)
- burning time – dry and cold to frosty (mid-May to June).

Using seasonal calendars in environmental management

Seasonal, or Cultural, calendars embed traditional practices within communities and support environmental management decisions in Aboriginal communities. They are also a modern framework for intergenerational knowledge transfer and can support work planning for environmental management programs.

The Australian Bureau of Meteorology has incorporated Aboriginal weather knowledges for various locations across Australia on their website. This includes **Dharawal seasonal descriptions** for the Sydney area.

There is an opportunity for collaboration with other Aboriginal Nations throughout NSW to explore the management potential of Aboriginal seasonal calendars. These calendars can be utilised (with respect for **Indigenous Cultural Intellectual Property principles**) to guide specific activities on Country. These include hazard-reduction activities, biodiversity surveys and citizen science activities. They act as a unifying foundation for monitoring in each bioregion.

Aboriginal peoples' knowledge of seasons, based on observations of Country, have been found to be more appropriate than the traditional four seasons for interpreting pollution data. For example, the Centre for Atmospheric Chemistry group at the University of Wollongong is drawing on Aboriginal knowledge of weather cycles to better understand seasonal variability in Sydney's air quality (**Beaupark et al. 2023**).

Seasonal cues depend on healthy Country

Two pressures impact culture and knowledge systems and the ability to integrate these into management of natural systems:

- Pressures of development (urban and agricultural), land clearing, invasive species, climate change and loss of biodiversity have meant that some seasonal cues are no longer seen. This is especially true for cues related to insect abundance, such as lack of Christmas beetles, bogong moths and fireflies.
- Lack of access to Country means that seasonal cues cannot be observed.

Education is needed to improve our understanding of the multiple threats that result in changes to seasonal indicators and how to respond to restore habitats and ecosystem functions.

It is important that all land and water managers listen to and incorporate Aboriginal knowledges. They must also identify, respect and protect tangible and intangible cultural heritage and recognise local seasonal cues. This should follow Indigenous Intellectual and Cultural Property principles and ensure that place-based approaches are taken.

Image B3.3 shows how the story of scrub turkeys, a totem species for Gamilaraay People, is told through sculpture in Deriah Aboriginal Area near Narrabri supporting knowledge sharing and education for the public and land managers.

Image B3.3: Scrub turkey nest sculptures, Wagun Picnic Area Deriah Aboriginal Area

Source:
DCCEEW

Cultural Fire management

All the elements have Lore, cultural Lore, right LORE

We have many different fires, cultural fires, Land Management fires, ceremonial fires, fires to keep us warm, cooking fires. There is a different law today. A lot of our people have gone, there is only handfuls of people in our communities that still know that language.

Learning Aboriginal stuff can teach you a lot, a better way of managing Country, like our old people did many, many years ago with just a bit of fire. Nice, cool burn used to manage and care for Country.

The fire is only part of the story when it comes to talking about fire, what a lot of people don't understand is that the smoke and wood is also important. The wood that you use to make the fire or put on the fire; you do with good intention. It's all about the intention you put in the pieces of wood that you make the fire with. When the fire burns, you know the messages gets up to the universe through the smoke. That's how we get the stories or the messages up to the old people is through the white smoke.

Source: EPA Aboriginal Peoples Knowledge Group

Cultural Fire management is a cultural practice that Aboriginal peoples use to care for Country. It reflects a deep connection and understanding of Country, as well as an inherent responsibility to care for Country that is passed down through generations.

Cultural Fire outcomes are diverse and include reducing the risk of bushfires, promoting and strengthening connection to culture and promoting broad environmental benefits. Notably, many native plant species rely on fire to thrive and there is known water quality benefits.

Aboriginal peoples' use of fire, including the exclusion of fire from some places, has shaped the Australian landscape and its ecology.

As an ongoing result of colonisation, the practice of Cultural Fire management is impacted through the dispossession of Aboriginal lands, decline of language speakers, disruption to knowledge sharing and systemic barriers to accessing Country. Despite these challenges, Aboriginal peoples are leading the revival of Cultural Fire management throughout Australia, including in NSW over recent years.

Understanding and support for Cultural Fire management is increasing across government agencies and within the broader mainstream community. There remains significant challenges for Aboriginal peoples in implementing Cultural Fire, including regulatory barriers, broad lack of acceptance and recognition of the benefits, application processes and related insurance constraints.

Revival of Cultural Fire management in NSW

One of the drivers accelerating the revival of Cultural Fire management in NSW is a renewed interest in Aboriginal land management practices following the Black Summer bushfires of 2019–2020.

The final report of the **NSW Bushfire Inquiry** made two recommendations relating to Cultural Fire management (**Owens & O'Kane 2020**), both of which are being implemented. First, the NSW Government created a **Cultural Fire Management Unit** in 2021 with Aboriginal Cultural Fire expertise and advised by an Aboriginal Working Group. Second, the NSW Bush Fire Coordinating Committee as of 2020 includes representation from three Aboriginal organisations: the NSW Aboriginal Land Council, the Native Title Services Corporation Limited and a representative to promote the integrity of Cultural Burning.

Cultural Fire management is also undertaken on Aboriginal controlled lands, such as Indigenous Protected Areas, and on public and private lands with Cultural Burning activities led by Aboriginal communities.

Firesticks is an Indigenous-led organisation that promotes and supports the revitalisation of Cultural Burning (**Firesticks 2024**).

> "Firesticks empowers Aboriginal communities to revive cultural knowledge practices including Cultural Fire and has supported 35 communities over the past 10 years."

Firesticks Alliance

Firesticks Alliance has been supporting communities across NSW in the revival of fire knowledges and Cultural Fire management since 2018 by providing learning tools for communities to lead and determine the best way forward to manage and heal their own Country.

Southern Yuin

The Southern Yuin Firesticks team has been mentoring First Nations peoples across Djiringanj/Walbunga, and the broader Yuin nation in cultural land management.

Throughout 2023, a total of 20 Cultural Fire workshops attended by over 90 community members were delivered within the region across various land tenures, including national parks.

Current community priorities involve continued collaboration with the Biamanga and Gulaga Boards of Management to restore a traditional fire regime across the Gulaga and Biamanga cultural landscape. This has the potential to change legislative guidelines that currently restrict cultural land management practices. In particular, monitoring and data collection on Country will formulate the evidence required to recognise Gulaga and Biamanga landscapes as significant cultural assets to be managed by community and Indigenous ranger teams.

The Southern Yuin Firesticks team continues to work alongside the ***NSW Koala Strategy*** to support cultural monitoring of one of the last-known coastal koala populations between the NSW and Victorian border. The information gained from this work will be crucial to understanding koala movement, seasonality and population variability across Country types.

See the **Firesticks webpage about the Southern Yuin community** for more information.

Greater Sydney

Various partnerships have been developed for the purpose of introducing Cultural Fire and other Indigenous land management practices into the Greater Sydney region, through a 2-year mentorship program.

Firesticks has built strong partnerships across Dharawal, Dharug and Gundungurra nations and is currently mentoring 18 community members as part of the Indigenous Fire and Land Management Mentoring program.

Lead Fire Practitioners are also assisting with the delivery of burn workshops outside the mentoring program, across a range of Country types.

See the **Firesticks webpage about the Greater Sydney community** for more information.

Hunter NSW

Firesticks has been working with communities in the Hunter region since 2016 when the Biraban Local Aboriginal Land Council collaborated with local groups to return Cultural Fire to land in Morisset for the first time since colonisation. This sparked a pilot program led by four Local Aboriginal Land Councils to engage Firesticks in a series of Cultural Burns over four years.

In 2020, the first mentoring program began in the Hunter region which culminated in the recognition of 22 new Cultural Fire Practitioners in 2023.

Throughout their mentorship, practitioners engaged in a series of interactive projects on Country, including the development of an interpretative signage guided tour that showcases their efforts to revive Cultural Fire practice.

See the **Firesticks webpage about the Hunter community** for more information.

Central West NSW

Firesticks has been supporting communities across Central West NSW to develop their leadership and skills in Indigenous fire practices.

Fifteen aspiring Cultural Fire Practitioners are currently being mentored through the mentoring program on Wiradjuri Country. The program has enabled knowledge exchange between Indigenous communities and supported Elders and local community members.
Firesticks has also established partnerships with local schools and youth services to support Aboriginal students through on-Country learning opportunities, ensuring the passing down of knowledge to the next generation.

Recently, other public land managers have been supporting the implementation of Cultural Burns on public lands, national parks and reserves. These managers include Forestry Corporation of NSW, Crown Lands and the NPWS.

Cultural Fire management has economic, social, health and wellbeing benefits. Further benefits include self-determination, strengthened culture and improved environmental outcomes and bushfire management (**McKemey et al. 2020**).

Image B3.4 shows a Cultural Burn on Djirringanj Yuin Country.

Image B3.4: Cultural Burn in the Murrah Flora Reserve, Djirringanj Yuin Country

Source:
Amber Webb

Barriers to Cultural Fire management

There is growing interest in, and support for, revitalisation of Cultural Fire management in some sectors. There are still significant barriers to undertaking Cultural Burns in a culturally appropriate way (**McKemey & Banbai Rangers 2020**; **Williamson 2021**).

These barriers span legislative, policy and procedural settings. There is also a lack of understanding of and respect for Aboriginal cultural knowledges.

Outlined below are some of the most significant barriers and opportunities to resolve them.

Legislative and regulatory challenges

Significant barriers exist within the approval and regulatory processes, which often do not align with Cultural Fire practices. These include restrictive legislation, inappropriate regulations and thresholds and a lack of understanding of Cultural Fire (**McCormack et al. 2024**).

These barriers lead to counterproductive conditions that do not align with cultural practices. Examples are fire taking place at the wrong time and under the wrong conditions, and requirements for excessive qualifications for Aboriginal community members undertaking the burn.

A lack of understanding and appropriate policies also results in prohibitive insurance costs for communities (**McCormack et al. 2024**).

Cultural Burns undertaken by Aboriginal community members or organisations are documented as hazard reduction burns and require the same environment assessment and permits. This is despite them being very different from hazard reduction burns.

Video B3.1 provides an example of using Cultural Fire to manage Country.

Video B3.1: Cultural Fire Practitioner explains how Cultural Fire is used to manage Country

Notes:
Photo used in above video preview was captured during filming.

Source:
Extract of commissioned video recorded for the NSW State of the Environment 2021

Aboriginal Community Controlled Organisations are generally required to obtain permits from the Rural Fire Service. The exceptions are when the burn is done outside the fire danger season, is not deemed to be a risk to property and occurs within a Rural Fire District. Sometimes permits are also required from the NSW Environment Protection Authority within this same framework.

Aboriginal community representatives have asked for an approval pathway for Cultural Fire that is flexible, is fit for purpose and recognises what a Cultural Burn is. This would include recognition of the leadership of Aboriginal people and the cultural knowledge and expertise applied.

There is a need for increased awareness about what Cultural Burning entails. This is especially the case in the context of incorporating Indigenous Cultural and Intellectual Property principles.

Opportunities also exist for partnerships between Aboriginal organisations and fire practitioners, regulators and researchers to improve understanding and practice.

Recognising cultural values and knowledges

Current policy and legislation around fire management is not framed to recognise or achieve tangible and intangible cultural outcomes.

Ideally, fire management systems would recognise cultural landscapes as cultural assets. This would allow communities to use Cultural Fire to protect them in the way that hazard reduction fires are used to protect properties.

Aboriginal communities are calling for cultural knowledges to be included in fire management regimes. They are also calling for recognition of the beneficial application of Cultural Fire to maintain biodiversity and healthy ecosystems.

Fire frequency intervals for ecosystems and species are currently based on ecological impacts of hazard reduction or bushfires and require exclusion of fire for set intervals. Aboriginal knowledge holders know that Cultural Fire could be applied more frequently in some cases to enhance biodiversity outcomes. For example, this would suppress weeds, improve system function and health, improve soil health and structure and maintain habitat and food resources (**Steffensen 2020**).

It is important to recognise that cultural protocols embedded in Cultural Burning ensure the application of right fire in the landscape to reduce risk and support multiple benefits.

Need for economic opportunities

Opportunities exist for Indigenous communities to receive economic benefits from fire management by engaging in carbon markets, especially in northern Australia.

Aboriginal communities have asked for pathways in NSW to gain benefits from carbon or nature repair markets through Cultural Fire activities.

There are real prospects in NSW to identify economic opportunities with Aboriginal people by recognising the value of the expertise of Cultural Fire practitioners in all processes around Cultural Fire. This could include a fee for service for Aboriginal Peoples working on public and private lands and appropriate and affordable insurance provisions.

Looking to the future

Efforts are being made to address barriers and further support the obligations of Aboriginal communities to practice Cultural Fire.

- The **Bushfire Hazards Cooperative Research Centre** has published a report (**Weir et al. 2021**) and six posters that present six diverse personal Cultural Burning experiences from Aboriginal custodians and traditional owners across southern Australia. These aim to help dispel misunderstandings about fire management practices used by Aboriginal peoples.
- The Healthy Country Team in the NSW Department of Climate Change, Energy, the Environment and Water (formerly the Cultural Fire Management Unit in the Department of Planning, Housing and Infrastructure) is developing a Cultural Fire Strategy. It has funded 10 community-led Cultural Fire projects in NSW.
- The NSW Rural Fire Service (NSWRFS) is developing a Cultural Burning Guide to support Aboriginal communities navigate requirements, such as permits and approval pathways.
- As of 2024, the NSWRFS has four Targeted Aboriginal and Torres Strait Islander Mitigation Crews (16 positions) that work particularly in partnership with Crown Lands. An additional 30 Targeted Aboriginal and Torres Strait Island Mitigation positions exist outside the partnership with Crown Lands. All Aboriginal and Torres Strait Islander Mitigation members assist with bushfire mitigation works. They also work with communities regarding culturally informed burning and Cultural Burning.

The NSWRFS and the NSW EPA are also looking for opportunities to reduce legislative and regulatory barriers.

Firesticks are partnering on research initiatives led by Indigenous communities across Australia to:

- increase understanding of the benefits of Cultural Burning
- identify and address the current legislative and insurance barriers limiting the scaling of Cultural Burning
- support the development of culturally sound methods for equitable engagement in carbon and nature repair markets.

There are increasing efforts to develop meaningful indicators of Cultural Fire. Firesticks supports communities to document and record their cultural-bio indicators and monitor the results of Cultural Fires.

Further work is needed to determine if and how Aboriginal communities want to tell the story of Cultural Fire. Before any reporting of this information, issues of data governance and sovereignty would need to be addressed.

The NSW Bushfire Inquiry (**Owens & O'Kane 2020**) noted how important it is that Aboriginal land management practices are led by Aboriginal people with the support of government agencies.

Aboriginal rangers in NSW

Aboriginal peoples have successfully cared for Country for over 60,000 years. The responsibility to care for Country through kinship relationships with Country, cultural practices, language and Lore continues to this day.

Aboriginal peoples are often frustrated by lack of access to Country and ongoing environmental damage from unsustainable development. Community-led Aboriginal land and water management programs provide opportunities for Aboriginal peoples to have access to Country and care for Country in the way they see fit.

Indigenous communities across Australia have driven the resurgence of Indigenous involvement and leadership in land and sea management over many decades. This includes the establishment of Indigenous Protected Areas and Indigenous Ranger Programs led by communities.

These programs are highly successful and have been shown to deliver environmental, social and economic benefits improving the lives of Indigenous peoples and improving environmental outcomes that benefit all Australians (**SVA 2016**).

Indigenous Protected Areas

Indigenous Protected Areas (IPAs) were designed in 1997 at a national meeting of Aboriginal Australians and Torres Strait Islander peoples. IPAs were defined by the meeting as follows:

> An Indigenous Protected Area is governed by the continuing responsibilities of Aboriginal and Torres Strait Islander peoples to care for and protect lands and waters for present and future generations.
>
> Indigenous Protected Areas may include areas of land and waters over which Aboriginal and Torres Strait Islanders are custodians, and which shall be managed for cultural biodiversity and conservation, permitting customary sustainable resource use and sharing of benefit. (**DEWHA 2008**)

At the meeting, it was agreed that IPAs would contribute towards Australia's National Reserve System.

The National Reserve System (NRS) in Australia is a network of protected areas that conserves the country's ecosystems, biodiversity, and landscapes, including national parks, nature reserves and Indigenous Protected Areas. It aims to protect a comprehensive range of ecosystems, ensure their sustainability, and involve collaborative management between governments, Indigenous communities and landowners (**DCCEEW-Aus 2023**).

Across Australia IPAs now make up more than 50% of the National Reserve System (**DCCEEW-Aus 2024a**).

In NSW, as at August 2024, there were 11 declared IPAs in NSW and four IPA consultation projects or areas under consideration for funding (**DCCEEW-Aus 2024b**).

Indigenous Ranger programs

Many Aboriginal people work as rangers and field officers and in other roles in a number of NSW government land and sea management agencies working on Country or towards the health of Country.

The focus of this section is describing and documenting Aboriginal community-led Indigenous Ranger groups in NSW.

The Commonwealth Indigenous Ranger Program started in 2007. It offers grants to support Aboriginal and Torres Strait Islander communities establish Indigenous Ranger groups.

This program funds more than 120 individual Indigenous Ranger groups across Australia. Fifteen of these are in NSW. These consist of 10 Indigenous Ranger groups and five Murray Darling Basin River Ranger groups (**NIAA 2024**)

In 2023, the Commonwealth Government committed to expanding this program to double the number of Indigenous Rangers to 3,800 by 2030.

Indigenous Rangers use cultural and local knowledge and their connection to Country to protect and manage land and sea Country. Their work includes:

- protecting biodiversity
- controlling feral animals and invasive weeds
- reducing bushfire risk
- maintaining cultural sites and practices.

Most Australian states and territory governments also fund and support community-led Indigenous Ranger Programs. The exceptions are NSW and Victoria.

As at June 2024, funding from the National Indigenous Australian Agency for Indigenous Rangers in NSW supports the employment of 97.55 fulltime equivalent staff. An expansion of the program was announced in late 2024, with a commitment to create 1,000 new Indigenous Ranger jobs across Australia.

Challenges

Indigenous Protected Areas and Indigenous Ranger programs are funded through a competitive grant process. The short-term and insecure nature of this funding model poses significant challenges for Aboriginal Community Controlled Organisations. Secure long-term funding would ensure the ongoing success of these programs.

Aboriginal people also face challenges in gaining access to Country in NSW. Existing regulations on lands and waters of different tenure can create barriers. For example, access to Crown land to care for cultural sites or places requires a formal permit application.

Additional long-term support for an Aboriginal Ranger program in NSW would allow Aboriginal Community Controlled Organisations to increase their capacity to care for Country and result in flow-on social and cultural benefits for local communities.

References

Beaupark S, Guérette É-A, Paton-Walsh C, Bursill L, Chambers SD, Dadd L, Miller M, Tobin C, Hughes M & Woodward E 2023, 'Indigenous Knowledge of seasons delivers a new way of considering annual cycles in atmospheric dispersion of pollutants', *Journal of Southern Hemisphere Earth Systems Science*, vol. 73, no. 1, pp. 44–59, DOI: 10.1071/ES22027

DCCEEW-Aus 2023, National Reserve System, Australian Government Department of Climate Change, Energy, the Environment and Water, accessed 13 November 2024

DCCEEW-Aus 2024a, Indigenous Protected Areas, Australian Government Department of Climate Change, Energy, the Environment and Water, accessed 15 October 2024

DCCEEW-Aus 2024b, *Indigenous Protected Areas national map*, Australian Government Department of Climate Change, Energy, the Environment and Water, Canberra

DCCEEW 2024a, *Weaving traditional ecological knowledge into conservation assessments: A guide for project officers*, NSW Department of Climate Change, Energy, the Environment and Water, Sydney

DCCEEW 2024b, *NSW plan for nature*, NSW Department of Climate Change, Energy, the Environment and Water, Sydney

DEWHA 2008, Indigenous Protected Area – Background, Department of the Environment, Water, Heritage and the Arts, accessed 13 November 2024

DPE 2023a, *Indigenous Cultural and Intellectual Property Protocol*, NSW Department of Planning and Environment, Sydney (PDF 3.1MB)

DPE 2023b, *Independent review of the Biodiversity Conservation Act 2016 – Final Report*, NSW Department of Planning and Environment, Sydney, Goolmeer T, Skroblin A, Grant C, van Leeuwen S, Archer R, Gore-Birch C & Wintle B 2022, 'Recognizing culturally significant species and Indigenous-led management is key to meeting international biodiversity obligations', *Conservation Letters*, vol. 15, no. 6, e12899, DOI: 10.1111/conl.12899

Goolmeer T & van Leeuwen S 2023, 'Indigenous knowledge is saving our iconic species', *Trends in Ecology & Evolution*, vol. 38, no. 7, pp. 591–4, DOI: 10.1016/j.tree.2023.03.010

Firesticks 2024, Custodians of our communities and Countries: An Indigenous organisation empowering communities to lead the way in healing the planet, Firestick, accessed 13 November 2024

McCormack P, McKerney M & Costello O 2024, *Identifying and overcoming legal barriers to Cultural Burning*, North East NSW Forestry Hub, Camperdown

McKemey M, Costello O, Ridges M, Ens EJ, Hunter JT & Reid NCH 2020, 'A review of contemporary Indigenous cultural fire management literature in southeast Australia', *EcoEvoRxiv*, DOI: 10.32942/osf.io/fvswy

McKemey M & Banbai Rangers 2020, 'Winba = Fire: Banbai Fire and Seasons Calendar', *Firesticks Alliance NSW, Released under Creative Commons: CC BY-NC-SA 4.0*, DOI: 10.25952/5ee18a43bfd53

MDBRC 2018, *Statement for Murray Darling Basin Royal Commission*, Murray Darling Basin Royal Commission (PDF 1.2MB)

Netana-Glover L 2023, 'Indigenous futures and deep time connections to place', *The Routledge Handbook of Australian Indigenous Peoples and Futures*, 1st Edition, pp. 296–310, DOI: 10.4324/9781003271802-23

NIAA 2024, *Indigenous Protected Areas – Commonwealth Funded Indigenous Ranger Programs – March 2024 (Map)*, Australian Government National Indigenous Australians Agency, Canberra

Owens D & O'Kane M 2020, *Final Report of the NSW Bushfire Inquiry 31 July 2020*, NSW Department of Premier and Cabinet, Sydney

Steffensen V 2020, *Fire Country: How Indigenous Fire Management Could Help Save Australia*, Hardie Grant Explore, Melbourne, DOI: 10.1071/WFv29n11_BR

SVA 2016, *Social Return on Investment: Consolidated report on Indigenous Protected Areas*, Social Ventures Australia, Sydney

Weir JK, Freeman D & Williamson B 2021, *Cultural Burning in Southern Australia*, Bushfire and Natural Hazards CRC, Melbourne

Williamson B 2021, *Cultural Burning in New South Wales: Challenges and Opportunities for Policy Makers and Aboriginal Peoples*, Centre for Aboriginal Economic Policy Research, Australian National University, Canberra

Woodward E & McTaggart MP 2019, 'Co-developing Indigenous seasonal calendars to support 'healthy Country, healthy people' outcomes', *Global Health Promotion*, vol. 26, no. 3, pp. 26–34, DOI: 10.1177/1757975919832241

Climate

soe.epa.nsw.gov.au

This page intentionally left blank

Climate

Human-made greenhouse gas emissions are warming the planet, leading to climate change and increased extreme weather events. NSW is committed to reaching net zero emissions by 2050.

The topics in this theme describe how **climate change** is affecting the State's people and environment, the resulting impacts of increased **extreme climate and weather** and how the NSW Government is delivering on meeting **net zero** targets**.**

Climate change

Climate change is an urgent global issue. The impacts on ecosystems and economies are already felt and could get worse as climate continues to change.

The average surface air temperature over land in NSW has risen by

1.4°C

since 1910

Extreme climate and weather

Climate change is increasing the frequency, intensity, or duration of certain types of extreme weather that increases the risk of flooding, heatwaves and bushfires.

'Hot days' are projected to increase, on average, by about

45.5

per year by 2080–99 under a high-emissions scenario

Net Zero Plan Stage 1: 2020–30

In line with Australian aspirations, NSW has set emissions reduction targets. Based on latest projections, NSW is not on track to achieve its emissions reduction target by 2030 and 2035.

NSW is projected to reduce emissions to

44–50%

below baseline 2005 levels by 2030

Climate change

Climate change is an urgent global issue.

Certain human activities, such as burning fossil fuels, emit greenhouse gases. The accumulation of greenhouse gases in the atmosphere leads to increasing surface temperatures overland, rising sea levels and warmer sea surface temperatures.

Impacts are projected to get worse as a result of higher continuing greenhouse gas emissions.

Aboriginal peoples gain insight into climate shifts and changes by monitoring seasonality over long time scales, which supports adaptation and food sustainability.

See the **Greenhouse gas emissions** topic for more information about sources of emissions.

Key findings from the 2024 report

- NSW average surface temperatures over land have risen 1.4°C since national records began in 1910.
- Several climate drivers, El Niño and La Niña, contribute to the State's seasonal rainfall, which makes it difficult to establish clear trends.
- In NSW, sea level rose by 12 centimetres between 1991 and 2023 and is projected to rise by up to one metre by the end of the 21st century.
- Sea surface temperatures in the Sydney area have increased by about 0.14–0.2°C per decade since the 1950s.

Extreme climate and weather

Extreme climate and weather, such as extreme rainfall (such as 'hot days' or severe fire weather) can damage our environments, infrastructure, health and economy.

Extreme weather events cause damage to cultural sites and landscapes.

Some climate and weather events may increase in frequency, intensity or duration due to human-induced climate change.

Key findings from the 2024 report

- The number of 'hot days' (where the maximum temperature is equal to or higher than 35°C) is projected to increase by 2080–99, particularly in northern regions of NSW.
- The number of severe fire weather days (where there is a combination of wind, high temperatures, low humidity and no recent rainfall, resulting in Forest Fire Danger Index > 50) is also projected to increase by 2080–99.
- Extreme rainfall (99th percentile of precipitation in millimetres per day) is projected to increase or decrease depending on the season and geographical area. Further research is needed to understand the uncertainties in the projections.
- Significant uncertainty remains around rainfall projections, meaning it is difficult to project when drought conditions will occur.

Net Zero Plan Stage 1: 2020–30

Under the Paris Climate Agreement, Australia is committed to reducing greenhouse gas emissions by 43% (compared to 2005 levels) by 2030 and achieve net zero emissions by 2050.

Based on modelling performed in 2023, Australia is projected to reduce emissions by 42% on 2005 levels by 2030, which is slightly less than the legislated target of 43%.

The NSW Net Zero Plan, released in 2020, is the foundation of NSW Government's action for climate change and its goal to reach net zero emissions.

The *NSW Climate Change (Net Zero Futures) Act 2023* sets guiding principles for the State's climate action, sets emissions reduction targets and an adaptation objective for NSW to be more resilient to a changing climate and establishes the Net Zero Commission to monitor, review, report and advise on progress towards emissions reduction targets.

The State's legislated targets are 50% emissions reductions on 2005 levels by 2030, 70% reduction on 2005 levels by 2035, and net zero by 2050.

NSW is not guaranteed to reach the interim reduction by 2030 relative to 2005 levels.

Further action beyond current policies will be needed to address ongoing greenhouse gas emissions, particularly by transport, agriculture and heavy industry.

See the **Greenhouse gas emissions** topic for more information about emissions sources.

Key findings from the 2024 report

- The State's emissions reduction targets may not be achieved without significant additional effort. Based on modelling performed in 2023, existing policy program settings are projected to reduce emissions by 44–50% by 2030. This suggests that more is required to achieve the 50% reduction target.
- Transport is set to become the biggest greenhouse gas contributor by 2030, overtaking stationary energy (electricity generation) as NSW continues to decarbonise the electricity sector.
- Of the 16 net zero initiatives, three are 'complete' (Riverina battery project, Low Emissions Building Materials Program, and Decarbonising Infrastructure Delivery Policy) and 13 are 'being delivered' (NSW Electricity Infrastructure Roadmap, NSW Electric Vehicle Strategy, Net Zero Industry and Innovation Program and various others).

This page intentionally
left blank

Climate change

NSW will be warmer, the sea surface warmer and sea levels higher owing to climate change.

Overview

The average surface temperature over land in NSW has risen by

↑1.4°C

since 1910

Read more

In NSW, sea level rose

12cm

just between 1991 and 2023

Read more

Human-induced climate change is a global issue.

Climate change is caused by emissions of carbon dioxide (CO_2) and other greenhouse gases from the burning of fossil fuels (coal, oil and gas), and other human activity, including changes in land use.

These gases trap heat in the earth's atmosphere, leading to increases in global average temperatures. Globally, 2023 was the hottest year on record since 1900 (**NASA 2023**).

The effects of climate change are already being experienced in NSW, and some extremes are expected to increase in frequency, intensity or duration in the future.

Urgent action is required to reduce greenhouse gas emissions and to adapt to a changing climate, thereby reducing detrimental impacts on ecosystems, human health, infrastructure and livelihoods.

> **Watch this video to find out more about the latest climate status**.

Aboriginal peoples, as the oldest living cultures on earth, have adapted and thrived through changing climates. They hold intergenerational knowledge of climate resilience, including stories and knowledges from deep time (**Netana-Glover 2023**).

Temperature is increasing

Average global temperatures in 2014–23 have already risen by a range of 1.06–1.30°C above pre-industrial levels (1850–1900) (**Forster et al. 2024**). The increase is projected to exceed 2.2–3.5°C by the end of this century if further action is not taken to limit greenhouse gas emissions (**IPCC 2023**).

Global temperatures have historically fluctuated, but even small shifts can significantly affect our climate. A change of 2°C is likely to cause major disruptions and mass extinctions (**Hoegh-Guldberg et al. 2018**).

The average surface temperature over land in NSW has risen by about 1.4°C since 1910 (**AdaptNSW 2024**). This value is not directly comparable to average global warming, which includes surface air temperatures over both land and ocean. Surface warming occurs faster over land than the ocean.

This increase in NSW temperatures has implications for ecosystems, infrastructures, livelihoods and the economy.

Climate change is also contributing to increasing frequency, intensity and duration of 'hot days' and the risk of heatwaves. Heatwaves occur when three or more consecutive days reach temperatures considered 'hot' for that location, based on observed temperatures over a preceding period (**AdaptNSW n.d.-a**).

See the **Extreme climate and weather** topic for more information.

Average winter rainfall may decrease in some parts of NSW

Significant uncertainty remains in relation to rainfall projections. Several climate drivers contribute to the State's seasonal rainfall. Seasonal variations driven by these climate drivers, including El Niño and La Niña, mean that clear trends can be more difficult to establish by using historical rainfall data.

El Niño and La Niña are naturally occurring climate phenomena originating from the Pacific Ocean that have a substantial influence on Australian and global weather patterns. These phases affect ocean temperatures, winds, surface air pressures and rainfall.

Sometimes we experience a warmer weather with less rain (El Niño), and sometimes we experience a cooler weather with more rain (La Niña). More than half of the time, we experience normal weather (neutral climate phase).

Together these weather phases are called the El Niño Southern Oscillation (ENSO).

> **Watch this video to learn more about ENSO**.

Projections suggest that coastal regions of NSW may experience significant reductions in rainfall in winter (**AdaptNSW 2024**).

Sea level is rising

Climate change is causing sea levels to rise.

As global temperatures rise, ice sheets and glaciers in Greenland and Antarctica are melting. Combined with the thermal expansion of water (water expands as it warms), this is causing sea levels to rise (**IPCC 2021a**).

The rate of global sea level rise has significantly increased since 1901 (**IPCC 2021a**). They are now rising at three times the rate in the early to mid-1900s. Increases in the past 100 years have been:

- 13 centimetres (cm) per year between 1901 and 1971 (71 years)
- 19cm per year between 1971 and 2006 (35 years)
- 37cm per year between 2006 and 2018 (13 years) (**IPCC 2021a**).

In NSW, sea level rose 12cm just between 1991 and 2023 (**BOM n.d.-b**).

Projections suggest that sea levels are likely to rise by more than 100cm (1 metre) by the end of the 21st century (**IPCC 2021a**), resulting in coastal erosion, coastal flooding, saltwater intrusion and infrastructure damage.

There is uncertainty over the response of marine-based ice sheets to future warming, meaning sea level rise could be considerably higher (**IPCC 2021a**).

Sea surface temperature is increasing

The waters near NSW underwent the highest warming in the Australian region since the 1970s (**BOM & CSIRO 2024**).

Globally, oceans absorb more than 90% of the extra heat trapped by the high concentrations of greenhouse gases in the atmosphere (**BOM & CSIRO 2024**). Near-surface sea temperature near Sydney increased by 0.14–0.2°C per decade since the 1950s.

Changing sea surface temperatures will lead to changing weather patterns over NSW.

Impacts on oceans

Ocean warming is leading to more frequent and intense marine heatwaves (**BOM & CSIRO 2024**), such as the unprecedented marine heatwave during the summer of 2015–16 (**Oliver et al. 2017**; **Brown et al. 2024**).

It exposes ocean ecosystems, plants and animals to temperatures they are not adapted to, which means they may not survive in NSW waters.

Ocean ecosystems are also affected by ocean acidification that occurs when seawater absorbs more carbon dioxide from the atmosphere. The levels of carbon dioxide in the atmosphere are rising owing to increasing emissions from human activities (**Shi & Li 2024**).

This particularly affects marine shell-building organisms, such as sea urchins, corals and phytoplankton (**Shi & Li 2024**).

See the **Coastal and marine** topic for more information about ocean temperatures and acidification.

Assessing and modelling

Assessing climate change is essential for driving action to reduce the impacts of climate change.

Intergovernmental Panel on Climate Change

At the global level, climate change is assessed by the **Intergovernmental Panel on Climate Change (IPCC)**. Its Sixth Assessment Report (**IPCC 2021a**) highlights key findings, including:

- the clear human influence on global warming
- projections indicating likely warming 2.2–3.5°C by 2100
- a greater intensity of multiple hazards with each increment of global warming.

NSW and Australian Regional Climate Modelling project (NARCliM)

The NSW Department of Climate Change, Energy, the Environment and Water (NSW DCCEEW) has developed the **NSW and Australian Regional Climate Modelling project** (NARCliM) to project future climate changes in NSW, south-east Australia and parts of Australasia (**AdaptNSW 2024**; **Di Virgilio et al. 2024**).

Using different scenarios of global greenhouse gas emissions, NARCLiM helps inform evidence-based actions for adaptation to climate change.

See **Scenarios used in modelling climate projects** for more information on these scenarios.

This report relies on the newest NARCliM data (NARCliM2.0) for insights on future temperature and rainfall in NSW. Further information and resources are available via the **AdaptNSW website**. NARCliM projections can be explored using an **interactive climate change map** or downloaded from **NSW Climate Data Portal**.

Climdex

Climdex is a joint project between the University of NSW and the Australian Research Council's Centre of Excellence for Climate Extremes. Climdex indices are used to understand how temperature and rainfall extremes change among times and places.

Suitable for advanced users, datasets from different locations can be downloaded at **Climdex**.

Impacts

Climate change is already affecting NSW communities.

Impacts to human health, the environment, water resources, the economy, properties and infrastructure will continue to increase.

- Human health impacts include respiratory and cardiovascular problems, as well as mental health concerns (**DHAC 2023**) due to warmer temperatures and poorer air quality from dust particles, bushfire smoke and storm activity.
- Environmental impacts include increasing temperatures and changes to rainfall patterns in some locations occurring too fast for plants and animals to adapt (**Malhi et al. 2020**), warming ocean temperatures forcing organisms to move further south (**Gervais et al. 2021**) and ocean acidification reducing the ability of some organisms to form shells (**Shi & Li 2024**).
- Water resource impacts include water scarcity in some places due to changes in rainfall patterns in some locations and seasons (**Caretta et al. 2022**).
- Economic impacts include declining crop yields (**Moore et al. 2021**) and damage to critical infrastructure.
- Coastal erosion and property losses will increase with rises in sea levels and sea surface temperatures (**Hanslow et al. 2023**).

The current impacts of climate change on Country and Aboriginal cultural values, health and livelihoods are significant because they have occurred so rapidly, and in conjunction with colonisation, compromising the ability of communities to adapt.

Responding to the changing climate

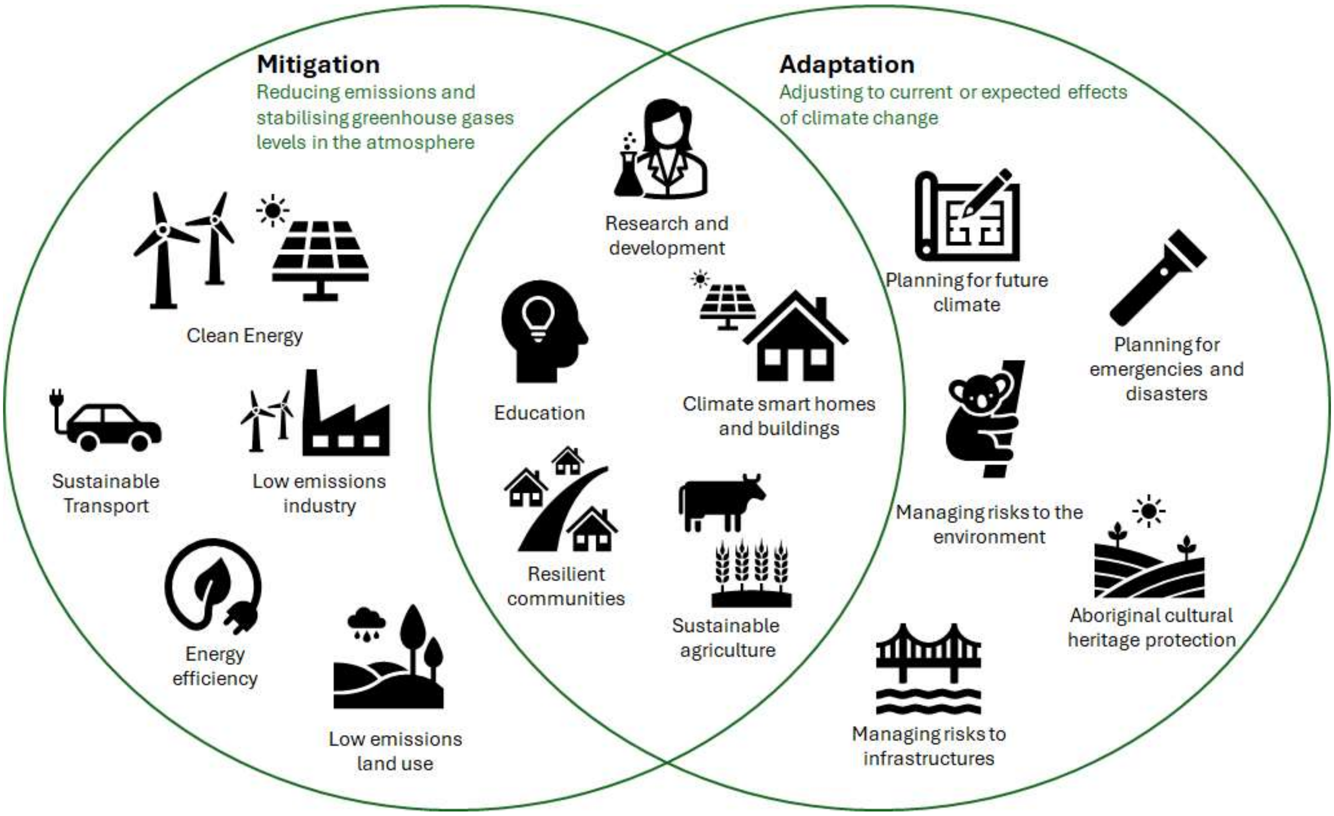
Managing climate risks will help to reduce the impacts of climate change.

Effective management strategies must include actions for both **mitigation** and **adaptation** (see **Image C1.1**).

Mitigation means actions to reduce greenhouse gas emissions or removing greenhouse gases from the atmosphere to reduce the rate of climate change.

Adaptation means adjusting to the actual or expected effects of changing climate.

Image C1.1: Examples of climate change mitigation and adaptation actions and complementary approaches



Source:
Adapted from AdaptNSW

Aboriginal knowledges can provide crucial insights into adapting to current and future changes driven by rapid and human-induced climate change (**Moggridge et al. 2024**).

While there is an increasing recognition of the need to listen to and incorporate Aboriginal perspectives, a gap remains between intent and implementation (**Moggridge & Thompson 2024**).

The *NSW Climate Change (Net Zero Future) Act 2023* sets emission reduction targets and an objective for the state to become more resilient to a changing climate. The Act also establishes an independent body, the Net Zero Commission, to monitor progress towards these objectives and targets.

One of the guiding principles of the Act states that action to address climate change should take into account the knowledge and perspectives of Aboriginal communities and the need to support Aboriginal communities who may be affected by the action.

See the **Net Zero Plan Stage 1: 2020–2030** and **Greenhouse gas emissions** topics for more information about climate change mitigation.

Climate change creates risks and opportunities for almost all areas of society, the environment and the economy. This means climate change adaptation is an issue that cuts across every portfolio in the NSW Government.

Table C1.1 lists current key legislation, policies and guidelines related to climate change and adaptation in NSW. It is not an exhaustive list because adaptation is a far reaching and complex issue. These are intended to help NSW to anticipate the harmful effects of climate change and develop ways to lessen exposure and vulnerability.

Table C1.1: Current key legislation, policies and guidelines to adapt to climate change in NSW

Legislation, policy or guideline	Summary
Climate Change (Net Zero Future) Act 2023	The main features of the Act are: • providing guiding principles for actions to address climate change that consider impacts, opportunities and the need for action in NSW • setting emissions reduction targets • setting an objective for NSW to be more resilient to a changing climate • establishing an independent **Net Zero Commission** to monitor, review, report on and advise on progress towards these targets.
Coastal Management Act 2016	Establishes the coastal zone and objectives to manage the use and development of the coastal environment in an ecologically sustainable way. Includes reforms to consider climate change impacts and responses in coastal planning. The reforms resulted in a new coastal management manual and **State Environmental Planning Policy (Coastal Management) 2018**.
NSW Reconstruction Authority Act 2022	Promotes community resilience to the impact of disasters in NSW through disaster prevention, preparedness and adaptation, and recovery and reconstruction following disasters. This Act also establishes the NSW Reconstruction Authority.
Climate Risk Ready NSW Guide	Includes a suite of tools that can help government agencies to identify and manage climate risks.
Disaster Adaptation Plans	Outline projects, strategies or actions to mitigate or minimise the impact of disasters caused by natural hazards at a local level. These plans are aligned to the State Disaster Mitigation Plan.
EPA's Climate Change Policy and Climate Change Action Plan 2023–26	Outline a comprehensive regulatory approach and set of actions to address the causes and consequences of climate change in NSW. They include actions to support licenced industries to decarbonise and build resilience to climate change.
NSW Climate Change Adaptation Strategy	Strengthens and expands the framework to adapt to climate change now and over the long term.
NSW Climate Change Adaptation Action Plan 2025–2029	This whole-of-government plan includes 46 actions led by eight agencies that target known climate change impacts and risks and help work towards achieving the *Climate Change (Net Zero Future) Act 2023* adaptation objective. The actions help create the knowledge, skills, resources and processes needed to enable further adaptation on a larger scale. The plan states that decisions on adaption in NSW should be planned and based on comprehensive analysis of the best available information, including Aboriginal knowledge systems. The strategy includes 'Enable Aboriginal adaptation' as a key criterion in establishing Adaptation Action Plans which will include actions co-designed with Aboriginal communities to promote social, economic and cultural wellbeing.
NSW Climate Change Fund	Provided funding between 2017 and 2022 for activities that reduce the impacts of climate change, including energy efficiency, clean energy, adaptation and resilience.
NSW Climate Change Policy Framework	Maximises the economic, social and environmental wellbeing of NSW in the context of a changing climate and of current and emerging international and national policy settings and actions to address climate change. It also defines the NSW Government's role in reducing carbon emissions and adapting to the impacts of climate change.

Legislation, policy or guideline	Summary
State Disaster Mitigation Plan	Designed to improve community resilience and better prepare NSW to face the challenges of disasters caused by natural hazards such as floods, bushfires, storms and cyclones, coastal erosion and inundation.

Notes:
See the **Responses** section for more information about how **Climate change** is being addressed in NSW.

Related topics: Animals | Coastal and marine | Energy consumption | Extreme climate and weather | Greenhouse gas emissions | Groundwater | Net Zero Plan Stage 1: 2020–2030 | Plants | Rivers and wetlands | Water use

Status and trends

Climate change indicators

The NSW Government monitors the annual mean near-surface temperature (2 metres above land), sea level rise and sea surface temperature in NSW (see **Table C1.2**).

This monitoring reflects the global nature of climate change and enables comparison of indicators between countries.

- **Annual mean land temperature** is increasing (getting worse). Projections show increasing temperatures under all emissions scenarios, with extreme consequences under a high-emissions scenario (see **Temperature**).
- **Sea level rise** is increasing (getting worse). Projections show that the rate of sea level rise should stabilise under a low-emissions scenario but could double under a high-emissions scenario if greenhouse gas emissions aren't reduced (see **Sea level rise**).
- **Sea surface temperature** is increasing (getting worse). This indicator has been downgraded from 'moderate' to 'poor' as temperature has risen at the rate of 0.14–2°C per decade from 1953 to 2020 (see **Sea surface temperature**).

Owing to seasonal and geographic variability and uncertainty, rainfall in NSW is not used as an indicator. The current state and projections are discussed in the **Rainfall** section.

Table C1.2: Climate change indicators

Indicator	Environmental status	Environmental trend	Information reliability
Annual mean land temperature	MODERATE	Getting worse	Good
Sea level rise	MODERATE	Getting worse	Good
Sea surface temperature	POOR	Getting worse	Good

Notes:
*See the **Extreme climate and weather** topic for status and trends relating to extreme rainfall, 'hot days' and severe fire weather.

Indicator table scales:
- **Environmental status**: Good, moderate, poor, unknown
- **Environmental trend**: Getting better, stable, getting worse
- **Information reliability**: Good, reasonable, limited.

See **Indicator guide** to learn how terms and symbols are defined.

Looking forward with the NSW and Australian Regional Climate Modelling project (NARCliM)

There is conclusive evidence that the climate is changing. The extent of climate change depends on future levels of global greenhouse gas emissions (**IPCC 2021a**).

To better understand the extent of climate change we may face, the NSW Government uses the NARCliM regional climate model.

NARCliM1.0 was released in 2014, focusing on NSW, the ACT and parts of Australasia. NARCliM2.0 was released in 2024, incorporating new data on global emissions and climate change, providing higher resolution of results and delivering technical improvements.

NARCliM2.0 downscales global climate models to the Australian region to project regional impacts of climate change under future greenhouse gas emissions scenarios.

These scenarios are known as the Shared Socioeconomic Pathways – Representative Concentration Pathways (SSP-RCPs) (**IPCC 2023**). They describe how the world may develop under different types of energy generation, rates of population growth, economic development and land uses. These lead to different levels of greenhouse gas emissions over time.

See **Scenarios used in modelling climate projects**.

This chapter refers to two scenarios:

- **SSP1–2.6** – a low-emissions scenario where global CO_2 emissions are cut to net zero by about 2075 and estimated global warming is 1.3–2.4°C by 2081–2100
- **SSP3–7.0** – a high-emissions scenario where global CO_2 emissions are projected to double by 2100 and estimated global warming is 2.8–4.6°C by 2081–2100.

Some indicators, including temperature and rainfall, are affected by variability of drivers such as ENSO and the Indian Ocean Dipole (**BOM & CSIRO 2024**).

- NARCLiM2.0 is one of several datasets that project future climate. It is unique in currently being the first regional climate modelling in Australia to simulate a very high resolution of 4 kilometres, which helps simulate events associated with convection like storms.
- Uncertainty remains in climate change estimations under all climate model projections, including NARCliM2.0.
- NSW is a large state with diverse topography; these factors significantly influence its climate and weather.

Projections for future sea level rise and sea surface temperature are not within the current scope of NARCliM2.0.

See **Scenarios used in modelling climate projects** for more information on shared socioeconomic pathways.

Scenarios used in modelling climate projections

The Intergovernmental Panel on Climate Change (IPCC) was created by the United Nations to assess the science of climate change, the science of impacts and adaptation, and the state of knowledge of mitigation. In 2021, IPCC released its Sixth Assessment Report, which adopts a set of future global climate scenarios called the Shared Socioeconomic Pathways (SSPs) combined with Representative Concentration Pathways (RCPs), or the SSP-RCPs (**IPCC 2021a**).

The SSPs are five baseline narrative scenarios (SSP1 to SSP5) based on socioeconomic, geopolitical and technological trends.

SSP1 (Sustainability – Taking the Green Road): The most optimistic scenario, which entails great global strides in sustainable development.

SSP2 (Middle of the Road): The next best scenario, where countries work more slowly towards sustainability.

SSP3 (Regional Rivalry – A Rocky Road): Socioeconomic trends follow historical trends, with slow progress towards sustainability.

SSP4 (Inequality – A Road Divided): Conflicts cause countries to prioritise national or regional concerns.

SSP5 (Fossil-Fuelled Development): There is rapid global economic growth but at the cost of massive use of fossil fuels.

The RCPs are greenhouse gas emissions scenarios that were initially adopted in IPCC's Fifth Assessment Report in 2014. Scenarios differ according to the potential level of 'radiative forcing' in watts per square metre (W/m^2) in 2100. Higher radiative forcing means greater amounts of heat energy available to warm our climate.

The Sixth Amendment Report uses the following SSP-RCP scenarios (labelled as SSP*x*-*y*, where *x* is the SSP baseline number and *y* is the RCP level). The very likely range of warming in **2081–2100** relative to the average global temperature in 1850–1900 is presented here. The bold scenarios are those used in this report.

- SSP1–1.9 (very low-emissions with very likely warming of 1.0–1.8°C)
- **SSP1–2.6 (low-emissions with very likely warming of 1.3–2.4°C)**
- SSP2–4.5 (intermediate emissions with very likely warming of 1–3.5°C)
- **SSP3–7.0 (high-emissions with very likely warming of 2.8–4.6°)**
- SSP5–8.5 (very high-emissions with very likely warming of 3.3–5.7°C)

This topic uses NARCliM2.0 modelling under the low- (SSP1–2.6) and high- (SSP3–7.0) emissions scenarios, as these capture a broad range of plausible future climates we may experience.

NARCliM2.0 modelling under the 'middle of the road' SSP2–4.5 scenario will be released in 2025.

The projections of the IPCC's Sea Level Projections Tool (**NASA n.d.**) under all scenarios (SSP1–1.9 to SSP5–8) were used to model potential sea level rise on the east coast of NSW.

Source: **IPCC 2023**

Temperature

NSW temperature has been increasing

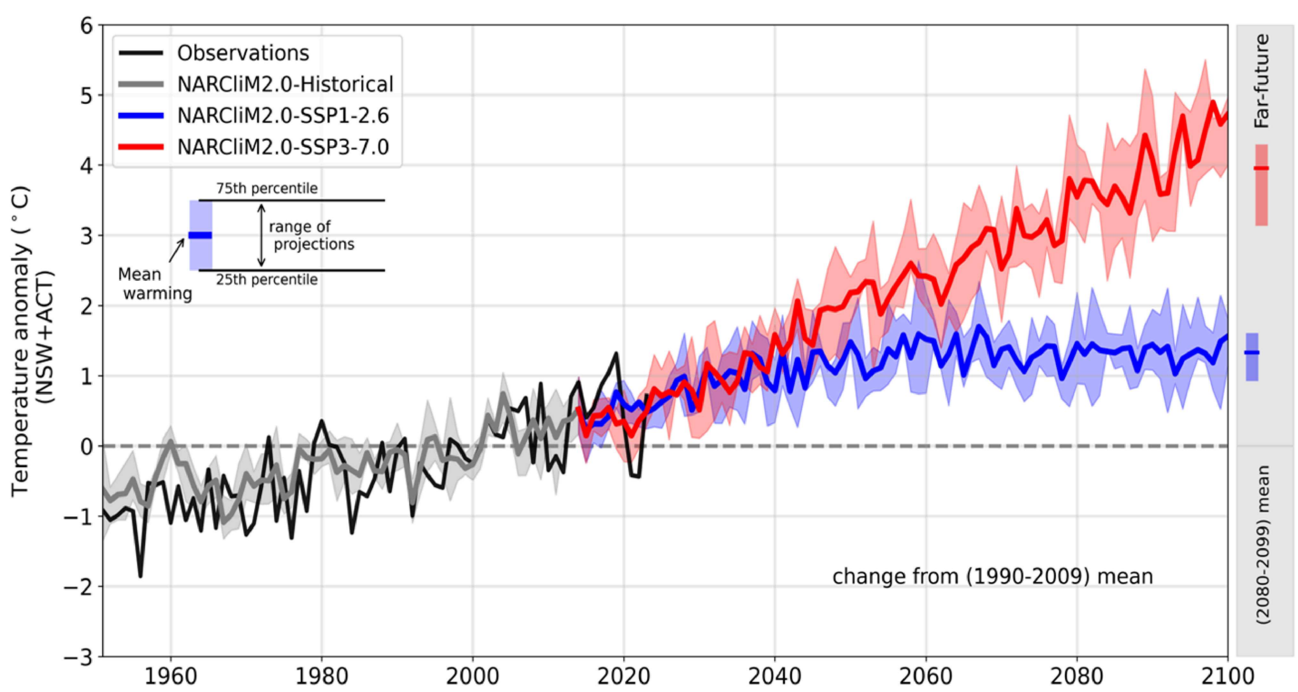
Temperatures have been increasing in NSW since 1910, when national records began, and are projected to continue to increase under both low- and high-emissions scenarios (**AdaptNSW 2024**).

The annual mean surface temperature over land in NSW has increased by 1.4°C compared to 1910 levels (**AdaptNSW 2024**). Meanwhile, Australian warming averaged 1.51 ± 0.23°C in the same period (**BOM & CSIRO 2024**).

Considerable year-to-year variability in temperatures associated with the ENSO and other climate drivers is evident across NSW. This means that while the past two decades have been Australia's warmest so far, cooler years do occur. La Niña years are commonly associated with cooler-than-average temperatures in NSW.

Within the year-to-year fluctuations, there is clearly an upward trend in temperature changes in NSW (see **Figure C1.1**). Changes or 'anomalies' in land surface temperature are expressed as deviations from a baseline average temperature. A positive value means that the observed temperature is warmer than the baseline and a negative value means that it is cooler.

Figure C1.1: Historical and projected average temperature changes in NSW



Notes:
Temperature anomalies or change in temperature compared to the historical baseline (1990–2009) temperature.

The **solid black line** represents observed historical temperature change (recorded differences in temperature).
The **grey line** represents the modelled historical temperature anomalies.
The **black line** represents the observed temperature anomalies.
The **red line** represents the average of NARCliM2.0 high-emissions climate projections.
The **blue line** represents the average of NARCliM2.0 low-emissions climate projections.
The **shading** around each of the solid lines represents the model ranges (from 25 to 27 percentile).

Source:
AdaptNSW 2024

Temperatures will continue to increase

Temperatures in NSW are projected to keep increasing. The increase will be exacerbated if global greenhouse gas emissions are not reduced to net zero. NARCliM2.0 projections have high model agreement under both low- and high-emissions scenarios that show an increase in NSW temperatures (see **Figure C1.1**).

Under a high-emissions scenario (red line in **Figure C1.1**), the estimated average warming by 2080–90 will be 4°C relative to 1990–2009, nearly three times the 1.3°C warming under lower emissions scenario (blue line).

Where will temperatures increase?

Temperatures in NSW will increase under both low- and high-emissions scenarios (see **Figure C1.2**).

The maps in **Figure C1.2** show higher warming in the semi-arid inland and northern NSW regions than along the coast.

Under the high-emissions scenario (SSP3–7.0) by 2080–99:

- Significantly higher temperature increases under this scenario relative to under SSP1-2.6.

- Annual (**Figure C1.2**, map a): Increase of about 4°C and up to 4.7°C in the north of the State (dark red area).
- Summer (map b): Increase of about 4.3°C and up to 4.9°C in the north and inland of the State (dark red area).
- Winter (map c): Increase of about 3.4°C and up to 4.1°C in the north of the State.

Under the low-emissions scenario (SSP1–2.6) by 2080–99:

- Annual (map d): Increase of about 1.3°C and up to 1.6°C in the north of the State.
- Summer (map e): Increase of about 1.6°C and up to 2°C in the north of the State.
- Winter (map f): Increase of about 1°C and up to 1.3°C in the north of the State.

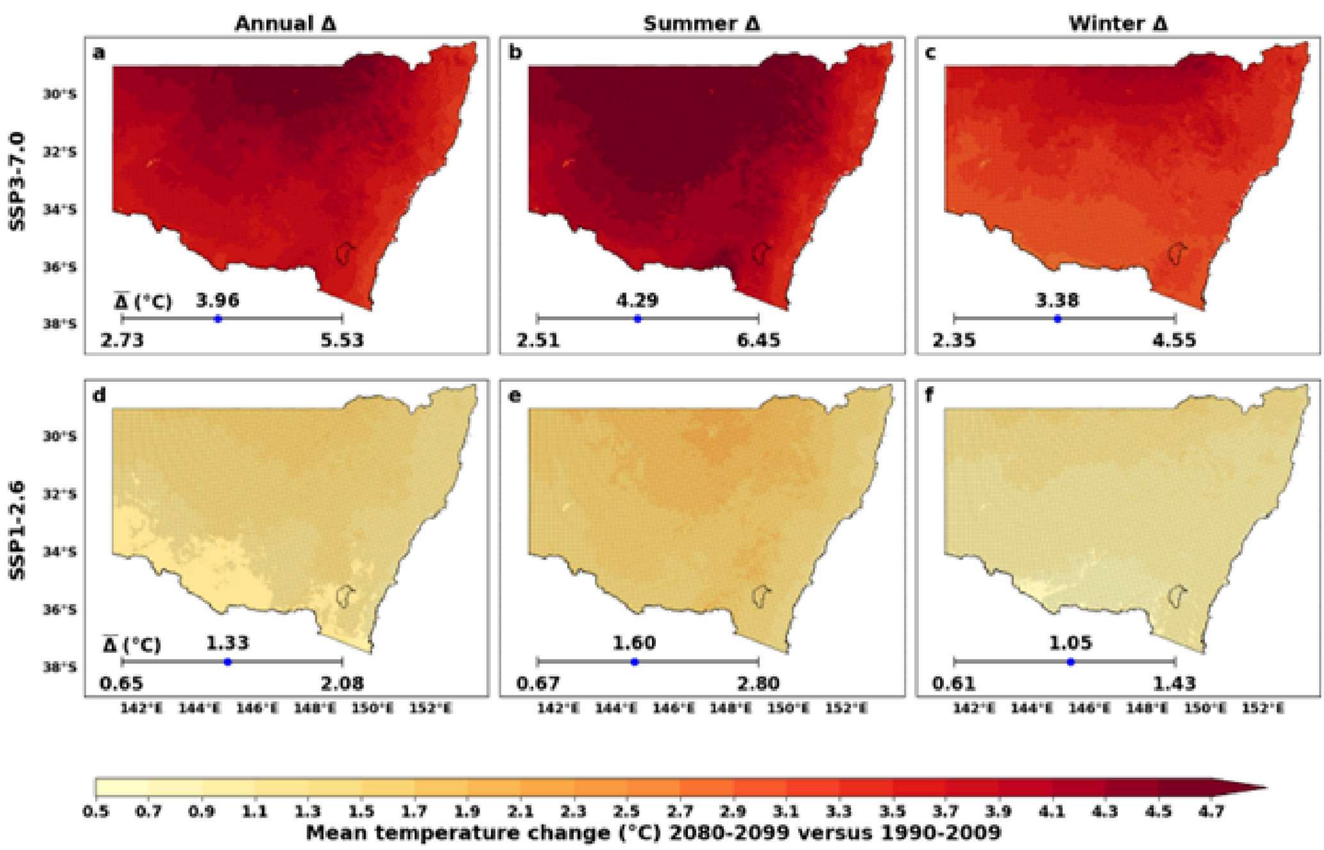
The projected warming across the State is more pronounced in summer than in winter and is greatest in summer under the high-emissions scenario (map b).

Temperature changes are presented as a range of values (**Figure C1.2**, bottom left corner of each map). This reflects the uncertainty in the exact degree of change.

All temperature changes are consistently positive values, which indicates confidence that temperatures will increase under all emissions scenarios.

See the **Interactive climate change projections map** for in-depth exploration of NARCliM2.0 data data including projections for various regions and time periods (eg, 2030–2049, 2040–59 and others).

Figure C1.2: Projected changes (Δ, difference between 2080–99 and 1990–2009) in mean near-surface air temperature



Notes:
NARCliM2.0 modelled mean near-surface temperature increases in 2080–99 under SSP3–7.0 (maps a, b, c) and SSP1–2.6 (maps d, e, f).
Annual (maps a & d), summer (maps b & e) and winter (maps c & f) projections are presented.
The average change (Δ) from all the models comprising NARCliM2.0 are shown at the bottom left of each plot, along with the range of changes from the individual models.
The stippling (small dots) shows locations where projected changes are statistically significant.
The Mann–Whitney U test (α = 0.05) is used to test the statistical significance.
Temperature changes are calculated from historical baseline (1990–2009).

Source:
Di Virgilio et al. 2024

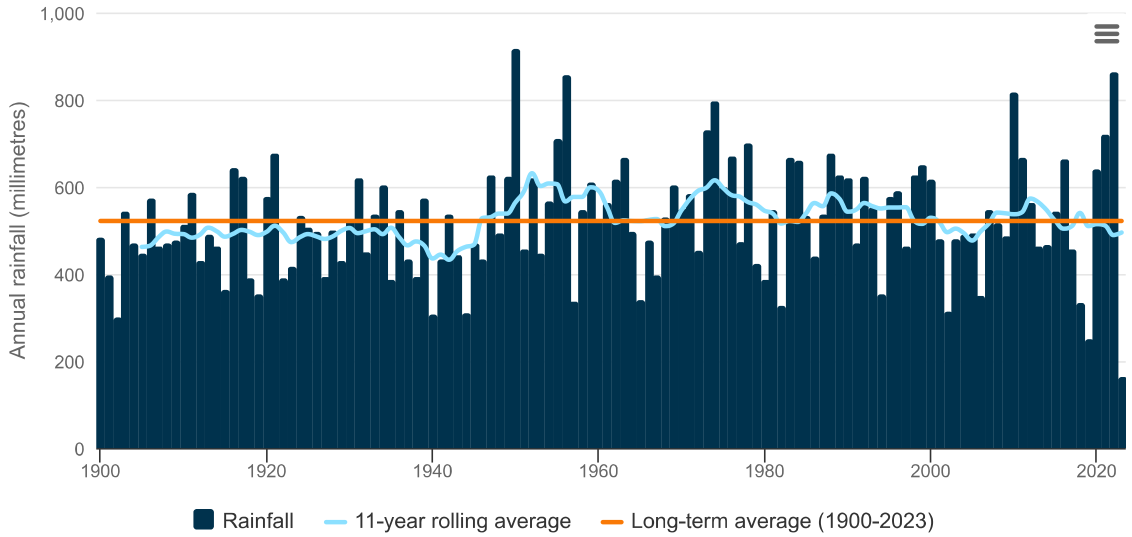
Rainfall

Complexities in the weather systems that generate rain mean there is some uncertainty around rainfall projections (**AdaptNSW 2024**).

Figure C1.3 shows the interannual variability in average historical rainfall in NSW. Rainfall patterns in NSW have historically been variable (see **Figure C1.3**), because they are strongly influenced by a combination of local conditions, seasonal variability and large-scale climate drivers, including ENSO, the Indian Ocean Dipole and the Southern Annular Mode (**Udy et al. 2023**; **Pui et al. 2012**).

The bars in **Figure C1.3** show the interannual variability in average historical rainfall in NSW, which is due to factors such as large-scale climate drivers and variability across seasons and regions.

Figure C1.3: Average annual rainfall in NSW, 1990–2023



Notes:
The bars represent the average annual rainfall across NSW for the years shown. The red line represents the 11-year rolling average.
The green horizontal line represents the long-term average from 1900–2023.

Source:
BOM n.d.-a

There is uncertainty around rainfall projections generated by all global and regional climate models.

Modelling rainfall can be more challenging than modelling temperature due to the complexities of the weather systems that generate rain and substantial interannual variability in rainfall patterns across NSW.

NARCliM projections capture a range of plausible climate futures under the different emissions scenarios, including wet and dry outcomes. This means that rainfall is inherently more variable and uncertain in the NARCliM projections than temperature, and the full range of rainfall projections should be taken into account.

NARCliM2.0 projections indicate that NSW is likely to experience varied changes in mean precipitation patterns across the different emissions scenarios and each season and location (see **Figure C1.4**).

These changes highlight the importance of considering both spatial and seasonal variations when planning climate adaptation strategies in NSW.

The NARCliM2.0 mean precipitation projections suggest that NSW may experience changes in precipitation patterns by 2080–99, with overall reductions in annual, summer and winter precipitation under both low- and high-emissions scenarios.

The magnitude of annual and winter changes is greater under a high-emissions scenario versus the low-emissions scenario, reflecting the implications of higher greenhouse gas concentrations for average precipitation patterns.

Summer reductions are generally larger in magnitude under the low-emissions scenario.

Under the high-emissions scenario (SSP3–7.0) by 2080–99:

- Significant decrease in winter precipitation in southern and coastal areas.
- Annual (**Figure C1.4**, map a): An overall decrease of about 4.5 millimetres (mm) per month, this is geographically variable and greatest in eastern NSW (brown areas).
- Summer (map b): An overall decrease of about 2mm per month, this is geographically variable and increases in north-eastern NSW (teal-blue areas).
- Winter (map c): An overall decrease of about 6mm per month, notably in coastal NSW (dark brown areas).

Under the low-emissions scenario (SSP1–2.6) by 2080–99:

- Annual (map d): An overall decrease of about 3.9mm per month, greatest in eastern NSW (brown areas).
- Summer (map e): An overall decrease of about 6.6mm per month, with larger decreases over the eastern areas of the State (dark brown areas).
- Winter (map f): An overall decrease of about 1.7mm per month, notably in coastal NSW (dark brown areas), but increases in other parts of NSW (blue areas).

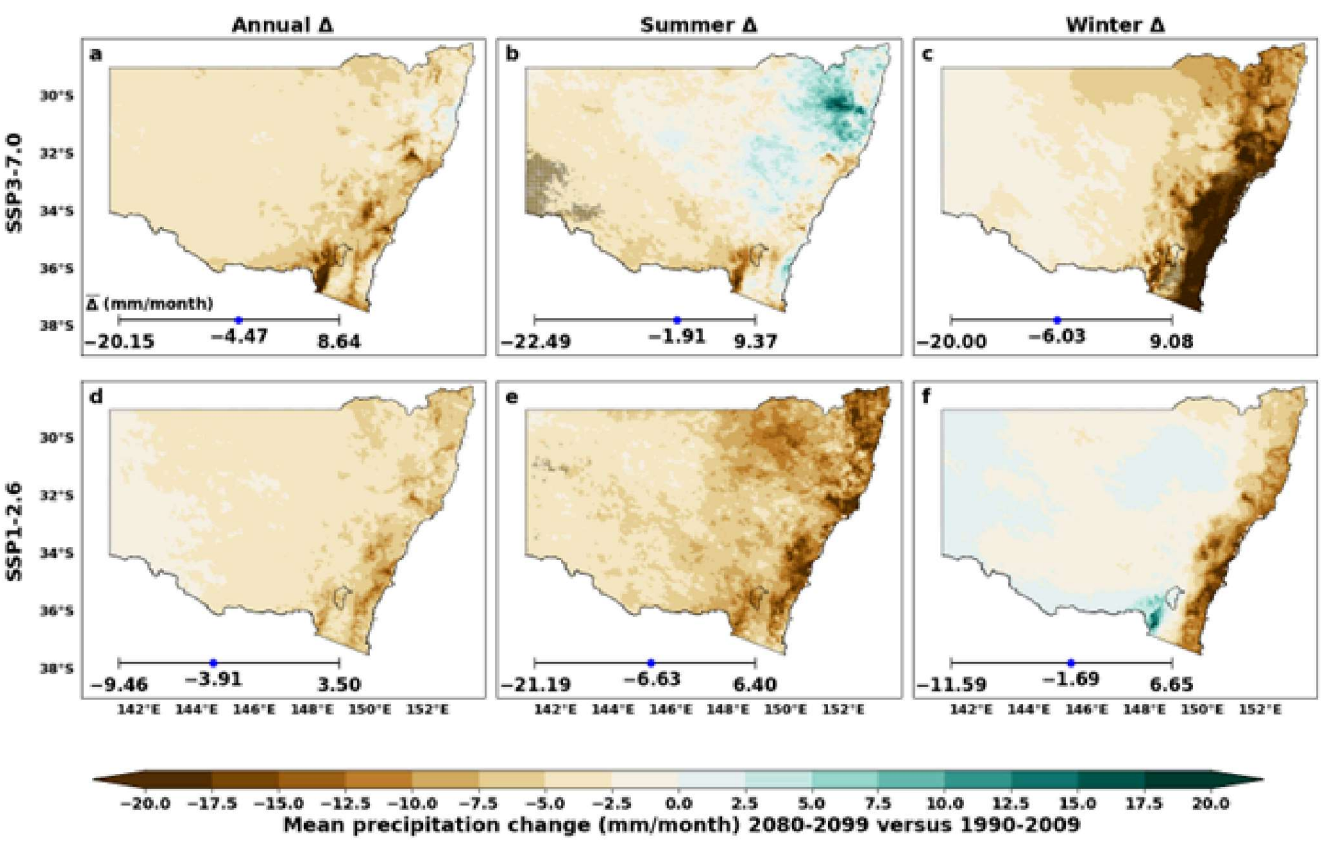
These projections suggest that some regions such as north-eastern NSW may see an increase in summer rainfall, whereas southern coastal NSW may see a reduction in winter rainfall.

Nonetheless, the wide range of values ranging from negative to positive (see **Figure C1.4**, bottom left corner of each map) indicate that there is a high level of uncertainty in these projections. Further research is required to understand uncertainties in modelling results.

Most of NSW will not see a significant change in precipitation on the basis of these projections.

See the **Interactive climate change projections map** for in-depth exploration of NARCliM2.0 data.

Figure C1.4: Projected changes (Δ, difference between 2080–99 and 1990–2009) in mean precipitation



Notes:

NARCliM2.0 modelled changes in mean precipitation in 2080–99 under SSP3–7.0 (maps a, b, c) and SSP1–2.6 (maps d, e, f). Annual (maps a & d), summer (maps b & e) and winter (maps c & f) projections are presented.

The average change (Δ) from all the models comprising NARCliM2.0 are shown at the bottom left of each plot, along with the range of changes from the individual models.

The stippling (small dots) shows locations where projected changes are statistically significant.

The Mann–Whitney U test (α = 0.05) is used to test the statistical significance.

Source:
Di Virgilio et al. 2024

Sea level rise

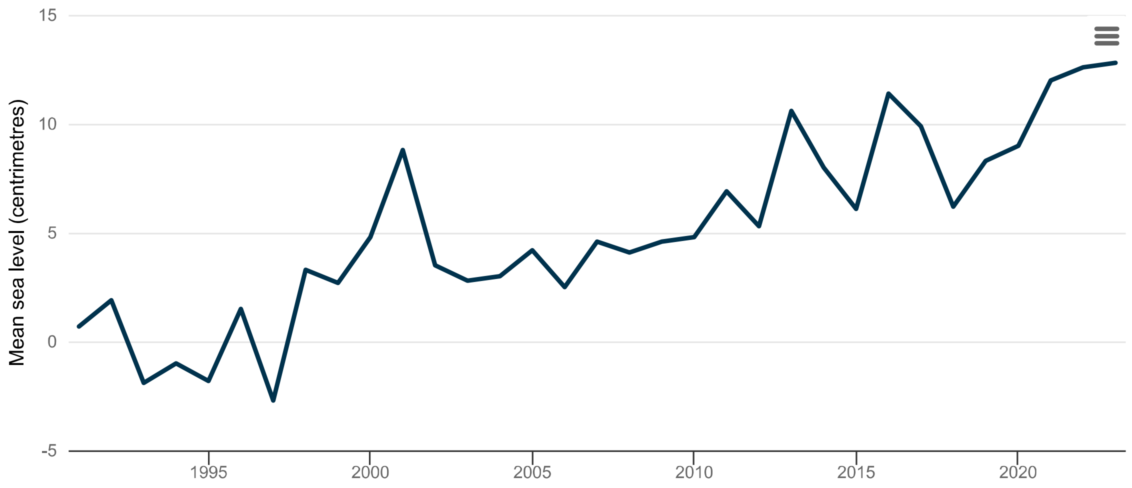
Already rising sea levels are projected to continue to rise (**AdaptNSW 2024**).

The sea level rise along the NSW coastline is monitored at the Baseline Sea Level Monitoring Station in Port Kembla (Wollongong).

From July 1991 to December 2023, the sea level at Port Kembla increased by about 3.7mm per year (**BOM 2024**), with a total increase of about 12cm since 1991 (see **Figure C1.5**).

The increase is large enough that we are beginning to see the impacts of continual sea level rise on many coastal communities, particularly during storm surges and high tides.

Figure C1.5: Measured historical annual mean sea level at the Port Kembla Baseline Sea Level Monitoring Station, 1991–2023



Notes:

The 1991 data include only part of the year following the site upgrade as part of the Australian Baseline Sea Level Monitoring Project.

Lowest Astronomic Tide (LAT) units are adjusted to Australian Height Datum (AHD) units.

Source:

BOM n.d.-b | BOM 2007

The rate of this rise could accelerate if global greenhouse gas levels in the atmosphere remain high.

Sea level along the NSW coast is projected to continue rising under all emissions scenarios. At Port Kembla, sea level is projected to rise by 11–24cm under the SSP1-2.6 emissions scenario and by 16–28cm under the SSP3-7.0 by 2050 relative to a baseline period of 1995–2014.

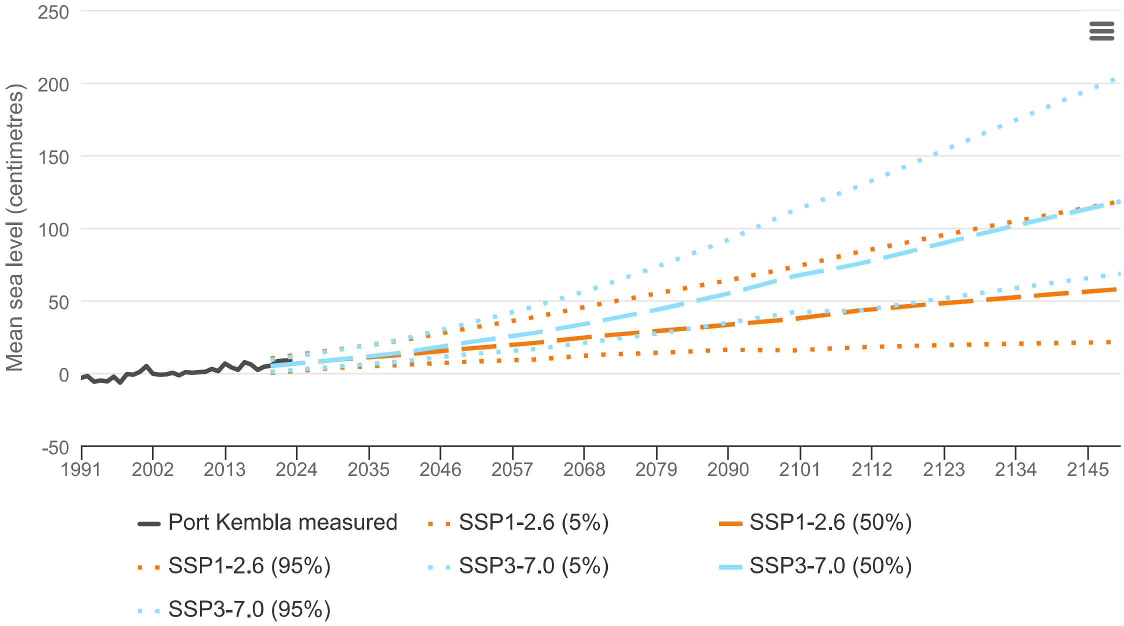
Later in the century, sea level rise is projected to accelerate under both emissions scenarios, with significantly faster acceleration under the SSP3-7.0 scenario. Sea-level rise by 2100 is projected to be 24–56cm under the SSP1-2.6 emissions scenario and 50–91cm under the SSP3-7 scenario. Even greater sea-level rise will occur by 2150, with a projected rise of 33–93cm under a low-emissions scenario and 84–165cm under a SSP3-7.0 emissions scenario.

Projected sea levels at Port Kembla under different emissions scenarios are shown in **Figure C1.6**. The scenarios used here are based on the SSP-RCP storylines from the IPCC's Sixth Assessment Report (explained in **Scenarios used in modelling climate projects**).

Modelling projects that the sea level at Port Kembla could rise by about 58cm by 2150 if global net zero emissions were achieved in 2075 (SSP1–2.6, low-emissions scenario) and about 120cm if emissions were to double by 2100 (SSP3–7.0, high-emissions scenario).

See the interactive **IPCC 6th Assessment Report Sea Level Projections** for more information.

Figure C1.6: Projected mean sea level rise at Port Kembla using IPCC AR6 modelling (SSP-RCP) for different greenhouse gas emission levels



Notes:
The plot shows measured and projected sea level rise at Port Kembla.
The solid black line represents historically measured values from 1990 to 2023, including annual observations from the Port Kembla Seaframe tide gauge.
The other solid lines represent the median (or 50th percentile) projections for the low- (SSP1–2.6) and high- (SSP3–7.0) emissions scenarios.
The dotted lines show the 5th to 95th percentile ranges for SSP1–2.6 and SSP3–7.0.
Projections are relative to a 1995–2014 baseline.

Source:
Historical data from BOM website (BOM n.d.-c) | Projected data from the IPCC's Sea Level Projections tool (NASA n.d.)

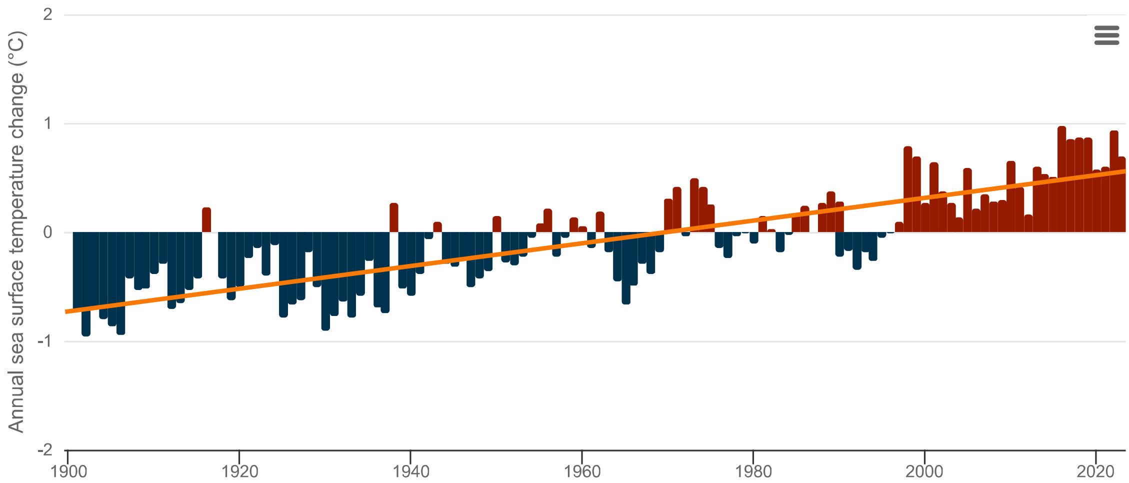
Sea surface temperature

Sea surface temperature along and near the NSW coastline is increasing.

It is important to track sea surface temperature, as it affects marine ecosystems as well as NSW industries, such as fisheries and aquacultures.

The annual sea surface temperature in the Tasman Sea has increased since 1997 relative to the baseline average annual temperature in 1961–90 (see **Figure C1.7**).

Figure C1.7: Annual sea surface temperature change in the Tasman Sea, 1900–2023



Notes:
The change in annual sea surface temperature was calculated from a 30-year baseline (1961–90).
Data comes from the Bureau of Meteorology (BOM), which used the National Oceanic and Atmospheric Administration's Extended Reconstructed Sea Surface Temperature version 5 (NOAA ERSST V5).

Source:
BOM n.d.-c

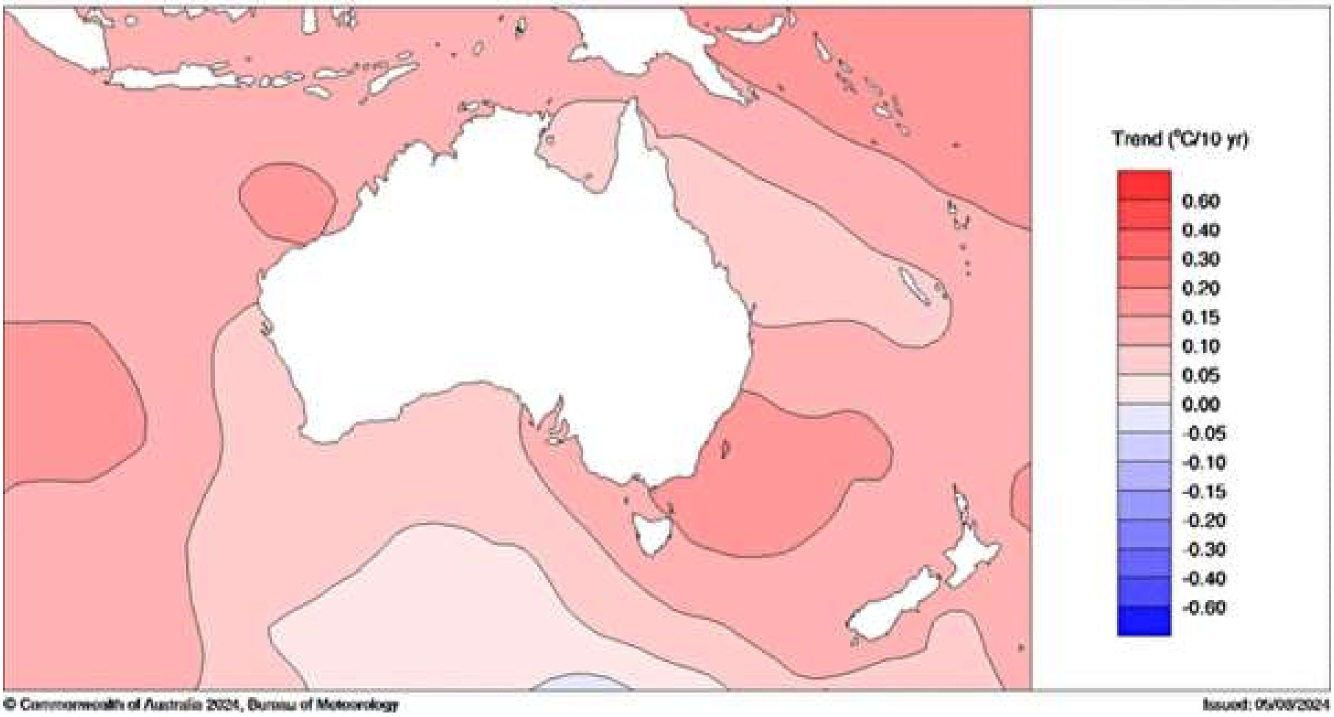
Near-surface ocean temperature at Port Hacking (Sydney) increased at an average rate of about 0.14–0.2°C per decade from 1953 to 2022 (**Hemming et al. 2023**).

Waters off south-east Australia experienced the greatest warming in the Australian region since the 1970s (**BOM & CSIRO 2024**) (see **Map C1.1**).

The East Australian Current now extends further south, causing the Tasman Sea to warm at twice the global average rate (**BOM & CSIRO 2024**). As a result, off the coast of NSW the southern half of the state has warmed at a rate twice that of the north, about 0.5°C per decade from 1992 to 2017 (**Malan et al. 2021**).

> Watch **this video to find out more about the East Australian Current**.

Map C1.1: Trend in Australian region sea surface temperatures, 1970–2023



Source:
BOM n.d.-c

Pressures and impacts

Greenhouse gas emissions

Global greenhouse gas emissions from human sources continue to increase, although emissions are reducing in some countries (**BOM & CSIRO 2024**). Human activities include demand for housing, land, energy, water, food, consumer products and transport services.

As a result of these activities and of our growing population, we now generate more emissions than at any earlier time.

This growth has increased the level of greenhouse gases in our atmosphere to a point where the global temperature is increasing at an unprecedented rate. This is resulting in feedback loops, such as:

- climate change is leading to more warm days
- warmer days will lead to more use of air conditioners, which are powered by coal-fired power plants
- this generates more greenhouse gas emissions
- which will lead to increased temperatures
- resulting in increased use of air conditioning.

This means that the more energy we use derived from fossil fuel combustion, the more emissions we create and the more energy we therefore need to use.

Average global temperatures in 2014–23 have already risen by 1.06–1.30°C above pre-industrial levels (1850–1900) (**Forster et al. 2024**). The increase is projected to exceed 2.2–3.5°C during this century without significant policy intervention (**IPCC 2023**).

See the **Greenhouse gas emissions**, **Energy consumption**, **Transport** and **Population and the environment** topics for more information.

Changes in land use

Land use refers to the use and management of land resources, including the production of goods (food, timber, energy and raw materials) and services (housing, utilities and nature conservation) (**DAFF n.d.**).

Land and oceans act as carbon sinks by absorbing carbon from the atmosphere.

Land absorbs carbon through plants. Plants convert carbon dioxide (CO_2) into carbohydrates through photosynthesis. The carbohydrates eventually accumulate in soil as the plants decay. About 31% of CO_2 emissions have been absorbed into land from 2010 to 2019, helping to manage the level of CO_2 in the atmosphere (**IPCC 2021b**).

See the **Plants** topic for more information.

Land use can be a significant driver of climate change.

Globally, agriculture, forestry and other land uses accounted for 21% (11.9 gigatonnes) of annual carbon dioxide equivalent (CO_2-e) emissions from 2010 to 2019 (**Nabuurs et al. 2022**). This means that, while land can be a carbon sink, globally, it emits more greenhouse gases than it absorbs.

In NSW, the agricultural sector accounted for 18% of the total greenhouse gas emissions in 2022 (**DCCEEW-Aus 2024**).

The land use, land use change and forestry sector has acted as a carbon sink in NSW since 2007, reducing the State's total emissions by 19% in 2022 (**DCCEEW-Aus 2024**).

See the **Greenhouse gas emissions** topic for more information.

Increased human activity due to population growth could result in increased demand for urbanisation, deforestation and intensive farming.

See the **Population and the environment** and **Economic activity and the environment** topics for more information.

Human health impacts

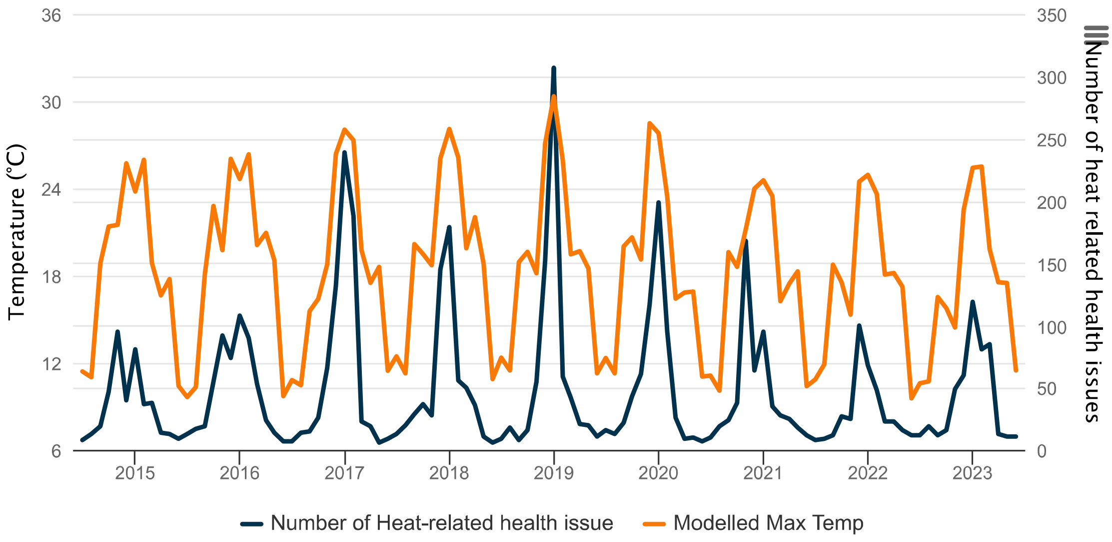
Climate change is already affecting the health and wellbeing of communities (**DHAC 2023**; **AdaptNSW n.d.-b**).

Impacts from climate change, such as warmer temperatures, poorer air quality and increased pollen production, can lead to health problems, such as respiratory and cardiovascular issues. Decreased rainfall can lead to poorer water quality or increases in blooms of blue-green algae (**AdaptNSW n.d.-c**).

Heat-related deaths are predicted to double on average across major Australian cities from 2020 to 2050 (**DCCEEW-Aus 2021**; **NSW EPA 2023**). It is estimated that declining air quality due to climate change will result in about 60 extra premature deaths per year in Sydney by 2050 (**Physick et al. 2014**; **NSW EPA 2023**).

The correlation between heat and heat-related illness is evident through the direct relationship between maximum temperatures and heat-related presentations in hospital emergency departments in NSW (see **Figure C1.8**).

Figure C1.8: Heat-related presentations in hospital emergency departments in NSW from July 2014 to June 2023

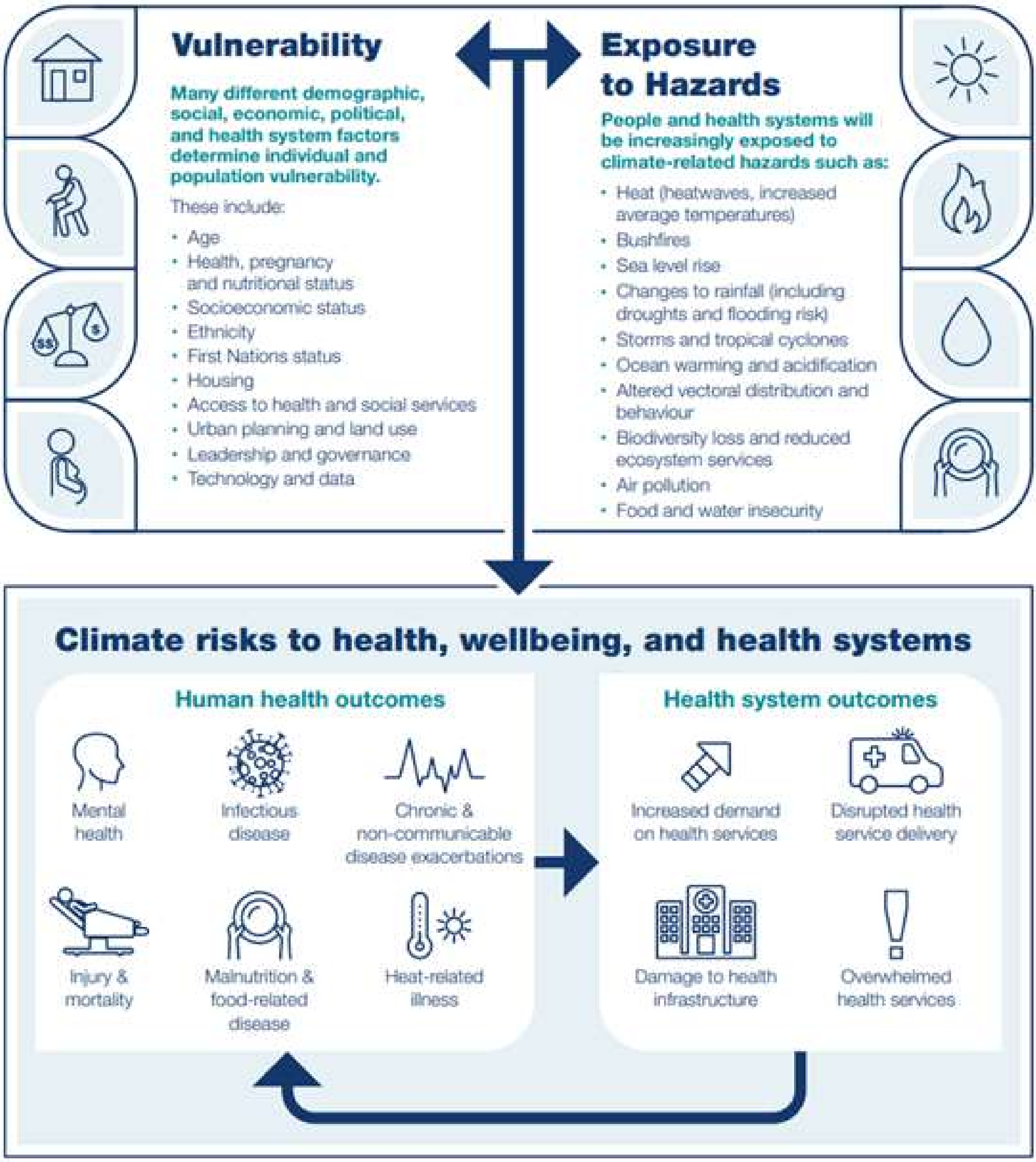


Notes:
The **blue line** is the number of heat-related health presentations in emergency departments in NSW.
The **orange line** is the mean maximum temperature in NSW.

Source:
Data has been provided directly by NSW Health in 2024

The most vulnerable groups (children, the elderly, people with pre-existing health conditions and people with low income) are unlikely to have the means to quickly adapt to the changing weather patterns associated with climate change. This could lead to adverse health impacts and place further strain on the health system (see **Image C1.2**).

Image C1.2: Climate-related risks to health and wellbeing



Source:
DHAC 2023

Heat also affects mental health, with increased instances of aggression and domestic violence, self-harm and suicide (**DftEA 2021**).

'Eco-distress' or 'eco-anxiety' – the fear of environmental doom – can result in stress, worry, sleeplessness and despair (**DftEA 2021**).

These concerns particularly affect young people and those with strong ties to a place.

Communities who have been affected by climate change have higher levels of concern about climate change (**DftEA 2021**). This includes communities affected by the Black Summer bushfires or the severe flooding in 2022.

Impacts to Aboriginal cultural values

Climate change affects the ability of Aboriginal peoples to care for Country and practice culture (**AdaptNSW n.d.-d**).

Increased frequency and intensity of extreme weather events causes damage to cultural sites and active landscapes. For example, coastal sites, such as shell middens and burial grounds, are being damaged by erosion, whilst catastrophic bushfires, like those in 2019–20, have caused extensive damage to cultural landscapes including cultural sites and important plants and animals.

Impacts to Country also impact the health and wellbeing of Aboriginal peoples

Severe flooding in NSW in 2022 displaced some Aboriginal communities and damaged Aboriginal-owned social and cultural assets.

Health impacts from climate change include increased vulnerability to impacted by vector-borne and water-borne diseases, heat stress and isolation during flooding (**AdaptNSW n.d.-d**).

Rivers and wetlands, critical to Aboriginal cultures, are threatened by rainfall decreases and unsustainable water extraction, reducing access to food resources and the ability to practice and teach culture (**Adapt NSW n.d.-d**; **DPHI 2023**).

Environmental impacts

Impacts on freshwater and terrestrial ecosystems

Climate change is expected to exacerbate the effects of existing threats and introduce additional pressures to many ecosystems within NSW (**Steffen et al. 2009**; **Hughes 2011**).

Ecosystems are affected by changing climate conditions. Some species could adapt, for example, some plants may bloom earlier, or some animals disperse to a wider geographic area. However, some Australian species, including those native to NSW, are unable to tolerate changes in temperature or drier conditions (**Hughes et al. 2019**; **Vijayan et al. 2021**). The decline of one species is likely to have flow-on effects on others (**Hughes et al. 2019**).

By 2085, some freshwater animals in NSW, such as crayfish and frogs, are projected to decline owing to loss of habitat or inability to disperse (**Bush 2015**). The list includes species that are threatened and critically endangered (**Love et al. 2020**).

See the **Rivers and wetlands** topic for more information.

Impact on marine ecosystems

Ocean acidification

The amount of carbon dioxide absorbed by oceans increases as greenhouse gas emissions from human activities increase.

About 23% of global emissions from 2010 to 2019 have been absorbed by the ocean ‘carbon sink’ (**IPCC 2021b**). This absorption alters the chemical composition of seawater, causing the pH of the ocean to become more acidic (**IPCC 2021b**). The greater acidity harms marine life.

While marine species can cope with short-term variations in acidity, long-term and permanent changes may reduce the ability of some to adapt. Ocean acidification reduces the availability of minerals used by marine organisms, such as sea urchins, corals and some plankton, to form their shells and exoskeletons (**Shi & Li 2024**).

Impact on marine life

Increases in ocean temperatures will also affect marine life.

In NSW, certain plant and animal species from tropical and subtropical areas of northern marine environments are likely to move south, if they can, and species in the southern marine environments will migrate into Victoria, Tasmania and even further south. Some marine organisms may run out of available habitat (**Gervais et al. 2021**).

Other impacts of higher ocean temperatures that have been observed in NSW waters are:

- spread of pathogens that affect seaweeds (**Campbell et al. 2011**; **Qiu et al. 2019**)
- decline of temperate kelp forests, which alters the composition and structure of marine ecosystems (**Wernberg et al. 2016**)
- spread of invasive species like sea urchins (**Davis et al. 2023**)
- migration of tropical species, such as certain coral, into temperate areas (**O’Connell et al. 2023**)

See the **Coastal and marine** topic for more information.

Climate hazards causing pollution discharge to the environment

If climate risks are not appropriately managed, pollution events that are detrimental to the environment may occur. For example, in March 2022 after a sustained rainfall event, local sewerage treatment plants in the Northern Rivers region were damaged. This event resulted in the discharge of untreated sewage into waterways, posing environmental and health risks.

Water resources impacts

Climate change can strongly affect the water cycle and the availability and quality of water resources (**Caretta et al. 2022**).

Lean more about the **natural water cycle**.

In Australia, most rainfall evaporates, leaving only 10% as surface water (streams, rivers and lakes) and groundwater. These waters are vital for the survival of ecosystems, people and industries, such as agriculture and tourism.

NSW's households and industries are highly dependent are highly dependent on surface water and ground water (**AdaptNSW n.d.-e**).

Small changes in rainfall can significantly affect the flow of water into streams and rivers (**Cohen et al. 2022**), affecting the availability of surface water.

Surface water quality could be degraded:

- sea level rise could push saltwater upstream, contaminating freshwater
- extreme rainfall could erode (wash away) soil into rivers, making it harder to treat the water for drinking
- warmer temperatures could increase harmful microorganisms in lakes and dams (**AdaptNSW n.d.-e**).

Adaptation approaches include water conservation measures and using alternative, weather-independent water supplies (**WSAA 2020**).

See the **Rivers and wetlands**, **Groundwater**, and **Water use** topics for more information on the State's water resources.

Economic impacts

Climate change is already affecting the NSW economy and will continue to do so.

Modelling by NSW Treasury estimates $15.8–17.2 billion (in 2021 dollars) in total economic costs from disasters triggered by extreme weather events on average every year by 2060–61, that is more than threefold increase from $5.1 billion in 2020–21 (**NSW Treasury 2021**). These losses reflect, in part, increases in some events resulting from extreme weather.

Climate change can have complex implications for agriculture. On the one hand, increasing temperature and changed rainfall patterns could limit the growth of certain plants and reduce crop yield (**Moore et al. 2021**). On the other hand, other plants could adapt or thrive under new climatic conditions (**Anderson & Song 2020**).

See the **Responses** section for more information about a recent study into these potential impacts.

Increasing ocean temperatures and marine heatwaves could impact the productivity of primary industries, including fisheries and aquacultures (**Fulton et al. 2018**).

Climate change could increase the risk of extreme weather events, such as bushfires and floods (see the **Extreme climate and weather** topic). This has flow-on effects on the economy, such as:

- increases in insurance premiums, especially in bushfire- or flood-prone areas (**AdaptNSW n.d.-f**)
- damage to critical infrastructure, disrupting travel, electricity and water, telephone and internet services, which can disrupt businesses and delivery of services
- damage to the environment, damage to ecosystems and increased public health risks, resulting in major clean-up and liability costs.

Erosion and property loss impacts

Many sites in NSW are subject to tidal inundation.

Sometimes referred to as 'sunny day' or 'nuisance' flooding, events include flooding of streets and paths during higher tides. The frequency of these events is variable but has increased over the past few decades (**Hague et al. 2022**; **Hanslow et al. 2019**; **Hanslow et al. 2023**) as sea levels rise.

Considerable development along the NSW coast is exposed to inundation and erosion hazards. This risk of damage to infrastructure and houses on the coast will increase with climate change. Pollution discharge to coastal areas causing ecological damage could occur if risks are not appropriately managed.

Modelling by NSW Treasury estimates that up to 46,000 properties could be exposed to coastal erosion or inundation by 2060–61 (see the **Sea level rise** section of this topic for more detail).

Exposure to tidal inundation during king tides currently affects about 600 properties (more than half the site) near estuaries in NSW. This is predicted to increase to:

- 4,300 with 0.5m of sea level rise
- 22,100 with 1m of sea level rise
- 43,300 with 1.5m of sea level rise (**Hanslow et al. 2018**; **OEH 2018**).

Adaptation to these changes requires further investment in infrastructure, such as raising houses and roads, installing tidal gates to restrict ingress of tidal water into stormwater systems, building levees and sea walls and undertaking beach nourishment.

Some coastal assets will be lost with continued sea level rise.

Responses

Climate change impacts are already felt across NSW.

Climate modelling suggests that even under a global low-emissions scenario, the NSW climate will change. NSW could remain vulnerable to climate-related risks for many decades to come without action now.

This section focuses on climate adaptation. The following is not an exhaustive list because adaptation is a far reaching and complex issue. Other actions to build resilience against extreme climate and weather-related disasters are discussed in the **Responses** section of the **Extreme climate and weather** topic.

Actions related to climate mitigation, which are about reducing greenhouse gas emissions, are discussed in the **Responses** section of the **Greenhouse gas emissions** and **Energy consumption** topics.

The **Net Zero Plan Stage 1: 2020–2030** topic provides an update on progress towards the **NSW Net Zero Plan**.

Climate change adaptation policies, strategies and plans

Climate change legislation

The NSW Government has legislated action on climate change in 2023. The ***Climate Change (Net Zero Future) Act 2023*** sets an adaptation objective to help make NSW more resilient to a changing climate. It also sets greenhouse gas emission reduction targets to help reduce further climate change and establishes an independent body, the Net Zero Commission, to monitor progress towards the act's goals.

NSW Climate Change Adaptation Strategy

The ***NSW Climate Change Adaptation Strategy***, released in 2022, lays out the NSW Government's approach to making the state more resilient and adapted to climate change (**AdaptNSW 2022**).

It builds on principles of previous policies and plans, such as the **NSW Climate Change Policy Framework** of 2016 and **Net Zero Plan Stage 1: 2020–2030** of 2020.

The strategy has four high-level priorities:

1. Develop robust and trusted metrics and information on climate change risk
2. Complete climate change risk and opportunity assessments
3. Develop and deliver adaptation action plans
4. Embed climate change adaptation in NSW Government decision-making.

The strategy also includes 16 detailed actions to help deliver these priorities.

NSW Climate Change Adaptation Action Plan 2025–29

In accordance with the *Climate Change Adaptation Strategy*, the NSW Government is committed to publish an NSW adaptation action plan at least every five years.

The ***NSW Climate Change Adaptation Action Plan 2025–29***, released in 2024, is the first plan released under the strategy.

This plan includes 46 actions to target known climate change impacts and risks, help prevent loss and damage, lay the foundation for further adaptation action and help achieve the adaptation objective under the *Climate Change (Net Zero Future) Act 2023*. The actions help create the knowledge, skills, resources and processes needed to enable further adaptation on a larger scale.

The plan states that decisions on adaption in NSW should be planned and based on comprehensive analysis of the best available information, including Aboriginal knowledge systems. The strategy includes 'Enable Aboriginal adaptation' as a key criterion in establishing adaptation action plans which will include actions co-designed with Aboriginal communities to promote social, economic and cultural wellbeing.

Reconstruction Authority

The NSW Reconstruction Authority released Australia's first ***State Disaster Mitigation Plan*** in February 2024. This plan helps communities to become safer, more resilient and better prepared for natural disasters including those that are exacerbated by climate change.

Disaster mitigation is discussed in greater detail in the **Responses** section of the **Extreme climate and weather** topic.

NSW EPA Climate Change Policy and Action Plan

The NSW Environment Protection Authority (EPA) has a statutory duty to protect the environment of NSW from harm, and this includes harm from the impacts of a changing climate. To fulfil this duty, in January 2023 the EPA released its **Climate Change Policy and Action Plan**, which outlines key actions it will do over the next three years. These include:

- supporting its regulatory partners, such as the Department of Planning, Housing and Infrastructure and Local Government Areas to understand and consider climate change risks and adaptation when making land use planning decisions
- supporting NSW industry to understand the impacts of climate change on their activities and to reduce their exposure to climate risks in a way that contributes to the State's goal of making NSW more resilient and adapted to a changing climate
- responding to the environmental impacts of climate change-related incidents, emergencies and disasters, under the State's emergency management arrangements.

Aboriginal cultural values protection

Combating climate change requires a coordinated, multi-level response from governments, industry and community that addresses both mitigation (reducing greenhouse gas emissions) and adaptation (increasing resilience to climate change impacts). It is essential to include Aboriginal communities in decision-making processes and support Aboriginal communities to access and care for Country.

Increasing numbers of cultural sites and landscapes will be impacted by climate change. This means it is crucial to support Aboriginal communities to lead initiatives that protect cultural values and practices from climate impacts and to develop cultural adaptation pathways.

The NSW Government is delivering adaptation assessment and support for Aboriginal lands and Aboriginal cultural heritage protection.

The **Climate Change Adaptation for Aboriginal Cultural Values project** aims to embed Aboriginal cultural knowledges in program delivery.

This project supports Aboriginal communities to develop strategies for reducing impacts on cultural practices and values. Each community determines its cultural values in specific locations and identifying key actions and stakeholders.

Climate projections

NSW and Australian Regional Climate Modelling project (NARCliM)

NARCliM2.0 projects future climate outcomes for NSW based on global emissions scenarios.

Available at a fine (4km) scale for south-east Australia and a coarser (20km) scale over Australasia, the updated climate projections are among the most detailed available in the country.

The interactive climate change projections map allows users to search, explore and download specific subsets of the data.

NARCliM projections are regularly updated as new information becomes available and as global climate models are improved.

Modelling impacts of climate change on the NSW economy

The **2021–22 NSW Intergenerational Report** is a snapshot of the future to inform future policies (**NSW Treasury 2022**).

The report projects 40 years ahead to 2061 to understand how the State's population, economy and finances may change on the basis of global and local trends and current policies.

It examines key long-term challenges associated with an ageing population, growing expenditure and rapid transformation in the economy and climate change.

It includes projections for economic outlook to a range of climate scenarios, developed and assessed as plausible by the United Nation's Intergovernmental Panel on Climate Change.

These projections are consistent with an assumption of moderate warming, with an average global surface temperature increase of 2.0°C by 2060–61 compared with the pre-industrial average.

There is considerable uncertainty in this assumption, because the actual extent of climate change will depend on both the future trajectory of global greenhouse gas emissions and how they affect global and local climate.

The projections considered the economic impact of four key climate risks:

1. natural disasters, including bushfires, floods and storms
2. sea level rise
3. heatwaves
4. effects of climate change on agricultural production.

Climate change will affect a wider range of risks, so this discussion should not be considered a comprehensive assessment of the total cost of climate change for NSW.

Protecting critical infrastructure

Climate risk assessment

Climate risk assessments are performed to assess current and future climate-related hazards. This helps to protect public infrastructure and ensure continued delivery of essential services in a changing climate.

The **Climate Risk Ready NSW Guide**, developed in 2021, supports government agencies in identifying and managing climate-related risks (**DPIE 2021**). It includes a four-step process for managing climate-related risks:

1. establish the context
2. identify, analyse and evaluate the risks
3. treat the risks
4. monitor and review.

This guide recommends data sources, such as NARCliM, and provides practical tools and templates to support each step. It assists in incorporating climate change considerations into an agency's existing risk management frameworks and procedures.

XDI (Cross Dependency Initiative) NSW pilot project

The XDI tool is an online software used for climate risk analysis (**XDI n.d.**). The Department of Planning, Industry and Environment (DPIE) led the XDI NSW project, which ran from 2017–20.

The project aimed to determine climate-related risks to critical infrastructure, including how those risks are interconnected and could affect different sectors. Understanding the interdependencies of critical infrastructure could encourage their owners to work together on adaptation planning (**AdaptNSW n.d.-g**; **Audit Office 2021**).

While the project was able to provide hazard information for water, power, transport and other sectors, more work is needed for this approach to be fully functioning (**Audit Office 2021**).

Climate modelling and risk analysis tools must be used with caution, as they involve a degree of uncertainty due to the complex nature of climate change (**Kurian et al. 2024**; **Nick et al. 2021**).

Risk assessments cannot predict how various factors, including political, regulatory, technological and behavioural, will influence future outcomes (**XDI n.d.**; **Nick et al. 2021**).

Moreover, these tools depend on the accuracy of the data fed into the models, such as satellite imagery, historical insurance records and regional climate models. While these sources are valuable, they cannot capture the full scope of factors influencing risk (**Nick et al. 2021**).

Managing impacts on primary industries

Climate change poses challenges as well as opportunities for sectors reliant on natural resources, such as agriculture, forestry and fisheries (**DAFF 2023**).

The NSW Department of Primary Industries and Regional Development's (DPIRD) ***Climate Change Research Strategy***, first published in 2018, provides insights to government, producers and industry of opportunities for timely and appropriate responses to the changing climate, carbon markets and energy opportunities (**DPI 2018**).

Industry climate change initiatives can focus on both mitigation, such using clean energy alternatives, or sequestering carbon through on-farm projects such as tree planting or soil carbon which can reduce greenhouse gas emissions. They can also address adaptation, such as changing crop varieties, modifying farm management practices or installing infrastructure, such as shade covers to reduce heat impacts. A findings and recommendations report released in 2023 provides project updates and identifies next steps to address challenges (**DPI 2023**).

The **Climate Vulnerability Assessment Project**, released in 2024, provides detailed information on how future climate will impact the climate suitability of valuable commodities, including certain fruits, crops and livestock.

Understanding these changes has helped identify vulnerable industries that will need adaptation strategies to remain productive into the future as well as opportunities for growth into regions that have become more suitable (**DPI 2024**).

Adapting to sea level rise

The NSW **Coastal Management Framework** helps communities manage coastal hazards, including sea level rise.

The Australian Government and the NSW Government provide policies and guides to consider sea level rise in future developments.

- The Australian Government provides guidance through the **CoastAdapt website** that provides resources for Australian jurisdictions, **adaptation options** and **Coastal Climate Adaptation Decision Support**.
- The NSW **State Environmental Planning Policy (Coastal Management) 2018** uses Local Environment Plans to ensure that coastal hazards be considered for vulnerable areas projected to be affected by sea level rise before zoning and development.
- The NSW **Coastal management toolkit** supports councils to prepare and implement Coastal Management Plans. It provides guidance for engaging with stakeholders and Aboriginal people, as well as information for taking a risk-based approach.

Other adaptations will also be necessary, including raising houses and roads, installing tidal gates to restrict ingress of tidal water into stormwater systems, building levees and sea walls, and undertaking beach nourishment.

Maintaining healthy coastal ecosystems can reduce the impact that sea level rise has on surrounding areas. Actions to support coastal ecosystems include:

- maintaining or expanding coastal buffer zones
- replanting and protecting coastal dunes
- fencing creeks and rivers to keep livestock out
- controlling invasive species

- protecting and restoring mangroves and saltmarsh areas.

See the **Coastal and marine** topic for more information about coastal management.

Sea level rise will also exacerbate the impacts of extreme weather, such as storms, potentially increasing the risk of coastal flooding.

See the **Extreme climate and weather** topic for more information about risk of flooding.

Future opportunities

Working with Aboriginal peoples

Aboriginal peoples are, and continue to grow as, major landowners and caretakers across NSW.

There is opportunity for Aboriginal communities to play a leading role in climate change mitigation and within new and sustainable economies as part of the transition to renewable energy.

Aboriginal youth are leading climate action through initiatives such as **Seed Mob**, Australia's first Indigenous youth-led climate network. They are building a movement for climate justice, with a vision for a just and sustainable future with strong cultures and communities, powered by renewable energy.

There are numerous opportunities to enhance Aboriginal voices in climate decisions, including supporting Aboriginal-led climate change research and respectfully integrating Aboriginal knowledge and scientific data alongside western scientific data (**Moggridge et al. 2024**).

Further opportunity lies in continuing to support Aboriginal communities to develop whole-of-Country plans such as the **Banbai Whole of Country Plan**. This takes a landscape approach to caring for the environment and community.

Research priorities

NARCliM2.0 clearly shows that temperatures will increase, helping inform climate-related risk assessments and adaptation strategies. However, it is less certain on future changes in rainfall.

Further research to understand uncertainties in climate models could provide greater clarity on the magnitude and direction of rainfall changes. The outcomes of this research will be crucial to developing plans and strategies for the State's water supply, agriculture and environmental protection.

Better understanding the effects of climate change on the State's water cycle and its implications for the frequency, duration and intensity of droughts and floods could help reduce impacts on water sources and ecosystems.

Other areas of research could include:

- understanding how climate change exacerbates the risk of natural disasters, such as droughts, floods and bushfires
- finding weather-independent water resources that will reduce the risk of water shortages and build the resilience of communities
- understanding the impacts of climate change on air quality and NSW public health to strengthen the science and drive progress in reducing people's exposure and vulnerability
- improving our understanding of sea level rise and inundation to support NSW's coastal hazard management
- piloting and testing the adaptations to ensure that agriculture remains productive under the changing climate providing food security and economic prosperity to regional NSW.

Strategic direction

- Retrofitting old buildings and designing new ones to adapt to increasing temperatures can help save energy, reduce strain on power systems and limit the risks of heat in households.
- Intensifying efforts towards mitigating greenhouse gas emissions and adapting to climate change. Although progress has been made, greater action is required to achieve emission reduction targets and realise good community outcomes.
- Developing a clear strategy to determine NSW's greatest climate-related risks. A risk-based approach would help focus resources and investment on achieving the best possible outcomes for communities.
- Accelerating adaptation efforts to mitigate known risks, for example, building resilience of bushfire-prone areas to develop communities' ability to anticipate exacerbation of risks brought by climate change.

References

AdaptNSW 2022, *NSW Climate Change Adaptation Strategy*, AdaptNSW, Sydney

AdaptNSW 2024, NSW Climate Change Snapshot, AdaptNSW, accessed 28 August 2024

AdaptNSW n.d.-a, Climate change impacts on heatwaves, AdaptNSW, accessed 11 November 2024

AdaptNSW n.d.-b, Climate change impacts on our health and wellbeing, AdaptNSW, accessed 12 August 2024

AdaptNSW n.d.-c, Climate change in NSW, AdaptNSW, accessed 26 July 2024

AdaptNSW n.d.-d, Climate change impacts on our cultural values, accessed 3 September 2024

AdaptNSW n.d.-e, Climate change impacts on our water resource, AdaptNSW, accessed 26 July 2024

AdaptNSW, n.d.-f, Rising climate risks: Why accessible, affordable home insurance is under threat, AdaptNSW, accessed 10 September 2024

AdaptNSW n.d.-g, Greater climate planning for Greater Cities, AdaptNSW, accessed 13 August 2024

Anderson JT & Song BH 2020, 'Plant adaptation to climate change—Where are we?', *Journal of Systematics and Evolution*, vol. 58, no. 5, pp. 533–45, DOI: 10.1111/jse.12649

Audit Office 2021, *Managing climate risks to assets and services, New South Wales Auditor-General's Report*, Audit Office of New South Wales, Sydney

BOM 2007, *Metadata for Tidal Data Exchange Port Kembla*, Bureau of Meteorology, Canberra (PDF 0.038MB)

BOM 2024, *Monthly Data Reports – December 2023: Australian Baseline Sea Level Monitoring Project*, Bureau of Meteorology, Canberra

BOM n.d.-a, Australian climate variability & change – Time series graphs: Annual rainfall New South Wales/ACT (1900 to 2023), Bureau of Meteorology, accessed 15 August 2024

BOM n.d.-b, Monthly sea levels for Port Kembla, Bureau of Meteorology, accessed 13 August 2024

BOM n.d.-c, Australian climate variability & change – Time series graphs: Annual sea surface temperature anomaly Tasman Sea (1900 to 2023), Bureau of Meteorology, accessed 13 August 2024

BOM & CSIRO 2024, *State of the Climate Report 2024*, Bureau of Meteorology and Commonwealth Scientific and Industrial Research Organisation

Brown MV, Ostrowski M, Messer LF, Bramucci A, van de Kamp J, Smith MC, Bissett A, Seymour J, Hobday AJ & Bodrossy L 2024, 'A marine heatwave drives significant shifts in pelagic microbiology', *Communications biology*, vol. 7, 125, DOI: 10.1038/s42003-023-05702-4

Bush 2015, *Priorities and Uncertainties of Predicted Impacts of Climate Change on Freshwater Biodiversity in New South Wales*, Department of Biological Sciences, Macquarie University, Sydney

Campbell AH, Harder T, Nielsen S, Kjelleberg S & Steinberg PD 2011, 'Climate change and disease: Bleaching of a chemically defended seaweed', *Global Change Biology*, vol.17, no.9, pp. 2,958–70. doi:10.1111/j.1365-2486.2011.02456.x

Caretta, MA, Mukherji A, Arfanuzzaman M, Betts RA, Gelfan A, Hirabayashi Y, Lissner TK, Liu J, Lopez Gunn E, Morgan R, Mwanga S & Supratid S 2022, 'Chapter 4: Water' in Pörtner H-O, Roberts DC, Tignor M, Poloczanska ES, Mintenbeck K, Alegría A, Craig M, Langsdorf S, Löschke S, Möller V, Okem A & Rama B (eds), *Climate Change 2022 - Impacts, Adaptation and Vulnerability, Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 551–712, DOI: 10.1017/9781009325844.006

Cohen TJ, Suesse T, Reinfelds I, Zhang N, Fryirs K & Chisholm L 2022, 'The re-greening of east coast Australian rivers: An unprecedented riparian transformation', *Science of the Total Environment*, vol. 810, 151309, DOI: 10.1016/j.scitotenv.2021.151309

DAFF 2023, Climate change and the agricultural sector, Department of Agriculture, Fisheries and Forestry, accessed 10 September 2024

DAFF n.d., *Land use information for Australia*, Department of Agriculture, Fisheries and Forestry, Canberra (PDF 3.5MB)

Davis TR, Knott NA, Champion C & Przeslawski R 2023, 'Impacts of Climate Change on Densities of the Urchin Centrostephanus rodgersii Vary among Marine Regions in Eastern Australia', *Diversity*, vol. 15, no. 3, 419, DOI: 10.3390/d15030419,

DCCEEW-Aus 2021, *Australia State of the Environment 2021*, Australian Government Department of Climate Change, Energy, the Environment and Water, Canberra

DCCEEW-Aus 2024, State and Territory greenhouse gas inventories: 2022 emissions, Australian Government Department of Climate Change, Energy, the Environment and Water, accessed on 19 August 2024

DftEA 2021, *How Climate Change Affects Mental Health in Australia*, Doctors for the Environment Australia

DHAC 2023, *National Health and Climate Strategy*, Australian Government Department of Health and Aged Care

Di Virgilio G, Evans J, Ji F, Tam E, Kala J, Andrys J, Thomas C, Choudhury D, Rocha C, White S, Li Y, El Rafei M, Goyal R, Riley M & Lingala J 2024, 'Design, evaluation and future projections of the NARCliM2.0 CORDEX-CMIP6 Australasia regional climate ensemble', *Geoscientific Model Development* (in press), DOI: 10.5194/gmd-2024-87

DPHI 2023, Climate Change Adaptation project, NSW Department of Planning, Housing and Infrastructure, accessed 3 September 2024

DPI 2018, Climate Change Research Strategy, NSW Department of Primary Industries, accessed 13 August 2024

DPI 2023, *Primary Industries Climate Change Research Strategy: Findings and recommendations*, NSW Department of Primary Industries, Orange

DPI 2024, *Climate Vulnerability Assessment Summary Report*, NSW Department of Primary Industries, Orange

DPIE 2021, *Climate Risk Ready NSW Guide*, NSW Department of Planning, Industry and Environment, Sydney

Forster PM, Smith C, Walsh T, Lamb WF, Lamboll R, Hall B, Hauser M, Ribes A, Rosen D, Gillett NP, Palmer MD, Rogelj J, von Schuckmann K, Trewin B, Allen M, Andrew R, Betts RA, Borger A, Boyer T, Broersma JA, Buontempo C, Burgess S, Cagnazzo C, Cheng L, Friedlingstein P, Gettelman A, Gütschow J, Ishii M, Jenkins S, Lan X, Morice C, Mühle J, Kadow C, Kennedy J, Killick RE, Krummel PB, Minx JC, Myhre G, Naik V, Peters GP, Pirani A, Pongratz J, Schleussner C-F, Seneviratne SI, Szopa S, Thorne P, Kovilakam MVM, Majamäki E, Jalkanen J-P, van Marle M, Hoesly RM, Rohde R, Schumacher D, van der Werf G, Vose R, Zickfeld K, Zhang X, Masson-Delmotte V & Zhai P 2024, 'Indicators of Global Climate Change 2023: annual update of key indicators of the state of the climate system and human influence', *Earth System Science Data*, vol. 16, no. 6, pp. 2,625–58

Fulton EA, Hobday AJ, Pethybridge H, Blanchard J, Bulman C, Butler I, Cheung W, Gorton B, Hutton T, Lozano-Montes H, Matear R, Pecl G, Villanueva C & Zhang X 2018, *Decadal scale projection of changes in Australian fisheries stocks under climate change*, Fisheries Research and Development Corporation and Commonwealth Scientific and Industrial Research Organisation

Gervais CR, Champion C & Pecl GT 2021, 'Species on the move around the Australian coastline: A continental-scale review of climate-driven species redistribution in marine systems', *Global Change Biology*, vol. 27, no. 14, pp. 3,200–17, DOI: 10.1111/gcb.15634

Hague BS, Jones DA, Jakob D, McGregor S & Reef R 2022, 'Australian coastal flooding trends and forcing factors', *Earth's Future*, vol. 10, no. 2, e2021EF002483, DOI: 10.1029/2021EF002483

Hanslow DJ, Morris BD, Foulsham E & Kinsela MA 2018, 'A regional scale approach to assessing current and potential future exposure to tidal inundation in different types of estuaries', *Scientific Reports*, vol. 8, 7065, DOI: 10.1038/s41598-018-25410-y

Hanslow DJ, Fitzhenry MG, Power HE, Kinsela MA & Hughes MG 2019, 'Rising tides: tidal inundation in south east Australian estuaries', *Australasian Coasts and Ports 2019 Conference*, pp. 520–6

Hanslow DJ, Fitzhenry MG, Hughes MG, Kinsela MA & Power HE 2023, 'Sea level rise and the increasing frequency of inundation in Australia's most exposed estuary', *Regional Environmental Change*, vol. 23, no. 4, 146, DOI: 10.1007/s10113-023-

02138-8

Hemming MP, Roughan M, Malan N & Schaeffer A 2023, 'Observed multi-decadal trends in subsurface temperature adjacent to the East Australian Current', *Ocean Science*, vol. 19, no. 4, pp. 1,145–62, DOI: 10.5194/os-19-1145-2023

Hoegh-Guldberg O, Jacob D, Taylor M, Bindi M, Brown S, Camilloni I, Diedhiou A, Djalante R, Ebi KL, Engelbrecht F, Guiot J, Hijioka Y, Mehrotra S, Payne A, Seneviratne SI, Thomas A, Warren A & Zhou G 2018, 'Chapter 3 - Impacts of 1.5°C Global Warming on Natural and Human Systems' in Masson-Delmotte V, Zhai P, Pörtner H-O, Roberts D, Skea J, Shukla PR, Pirani A, Moufouma-Okia W, Péan C, Pidcock R, Connors S, Matthews JBR, Chen Y, Zhou X, Gomis MI, Lonnoy E, Maycock T, Tignor M & Waterfield T (eds), *Global Warming of 1.5°C: An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*, Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 175–312, DOI: 10.1017/9781009157940.005

Hughes L 2011, 'Climate change and Australia: key vulnerable regions', *Regional Environmental Change*, vol. 11, no. 1, pp. 189–95, DOI: 10.1007/s10113-010-0158-9

Hughes L, Dean A, Steffen W & Rice M 2019, *This is what climate change looks like*, Climate Council of Australia

IPCC 2021a, 'SPM: Summary for Policymakers' in Masson-Delmotte V, Zhai P, Pirani A, Connors SL, Péan C, Berger S, Caud N, Chen Y, Goldfarb L, Gomis MI, Huang M, Leitzell K, Lonnoy E, Matthews JBR, Maycock TK, Waterfield T, Yelekçi O, Yu R, and Zhou B (eds), *Climate Change 2021: The Physical Science Basis, Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 3–32, DOI: 10.1017/9781009157896.001

IPCC 2021b, 'Chapter 5: Global Carbon and Other Biogeochemical Cycles and Feedbacks' in Masson-Delmotte V, Zhai P, Pirani A, Connors SL, Péan C, Berger S, Caud N, Chen Y, Goldfarb L, Gomis MI, Huang M, Leitzell K, Lonnoy E, Matthews JBR, Maycock TK, Waterfield T, Yelekçi O, Yu R, and Zhou B (eds), *Climate Change 2021: The Physical Science Basis, Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 673–816, DOI: 10.1017/9781009157896.007

IPCC 2023, 'Summary for Policymakers' in Lee H and Romero J (eds), *Climate Change 2023: Synthesis Report, Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Intergovernmental Panel on Climate Change, Geneva, Switzerland, pp. 1–34 doi:10.59327/IPCC/AR6-9789291691647.001

Kinsela MA, Morris BD, Linklater M & Hanslow DJ 2017, 'Second-Pass Assessment of Potential Exposure to Shoreline Change in New South Wales, Australia, Using a Sediment Compartments Framework', *Journal of Marine Science and Engineering*, vol. 5, no. 4, 61, DOI: 10.3390/jmse5040061

Kurian S, Reid G & Sutton M 2024, *Climate Change and Financial Risk*, Reserve Bank of Australia

Love J, Thapa R, Robb J & Drielsma MJ 2020, 'Climate change impacts in the NSW and ACT Alpine region', *Research Gate*, DOI:10.13140/RG.2.2.31496.85767

Malan N, Roughan M & Kerry C 2021, 'The Rate of Coastal Temperature Rise Adjacent to a Warming Western Boundary Current is Nonuniform with Latitude', Geophysical Research Letters, vol. 48, no. 3, DOI: 10.1029/2020GL090751

Malhi Y, Franklin J, Seddon N, Solan M, Turner MG, Field CB & Knowlton N 2020, 'Climate change and ecosystems: threats, opportunities and solutions', *Philosophical Transactions of the Royal Society B*, vol. 375, no. 1,794, 20190104, DOI: 10.1098/rstb.2019.0104

Moggridge BJ & Thompson RM 2024, 'Chapter 18 - Indigenous engagement to support resilience: A case study from Kamilaroi Country (NSW, Australia)', *Resilience and Riverine Landscapes*, pp. 363–87, DOI: 10.1016/B978-0-323-91716-2.00006-6

Moggridge BJ, Evans G, Ireland L, Lansbury N & Munro-Harrison T 2024, 'Knowledge keeps the fires burning': how ancient Indigenous wisdom can transform our battle against climate change, *The Conversation*, accessed 30 October 2024

Moore CE, Meacham-Hensold K, Lemonnier P, Slattery RA, Benjamin C, Bernacchi CJ, Lawson T & Cavanagh AP 2021, 'The effect of increasing temperature on crop photosynthesis: from enzymes to ecosystems', *Journal of Experimental Botany*, vol. 72, no. 8, pp. 2,822–44, DOI: 10.1093/jxb/erab090

Nabuurs G-J, Mrabet R, Hatab AA, Bustamante M, Clark H, Havlík P, House J, Mbow C, Ninan KN, Popp A, Roe S, Sohngen B & Towprayoon S, 2022, 'Chapter 7: Agriculture, Forestry and Other Land Uses (AFOLU)' in Shukla PR, Skea J, Slade R, Al Khourdajie A, van Diemen R, McCollum D, Pathak M, Some S, Vyas P, Fradera R, Belkacemi M, Hasija A, Lisboa G, Luz S & Malley J (eds), *Climate Change 2022: Mitigation of Climate Change, Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, UK and New York, NY, USA, DOI: 10.1017/9781009157926.009

NASA 2023, NASA Analysis Confirms 2023 as Warmest Year on Record, National Aeronautics and Space Administration, accessed 26 July 2024

NASA n.d., *IPCC* 6th assessment report sea level projections, Intergovernmental Panel on Climate Change

Netana-Glover L 2023, 'Indigenous futures and deep time connections to place', *The Routledge Handbook of Australian Indigenous Peoples and Futures*, 1st Edition, pp. 296–310, DOI: 10.4324/9781003271802-23

Nick W, Maddy B & Philip A 2021, *An indicative assessment of four key areas of climate risk for the 2021 NSW Intergenerational Report*, NSW Treasury, Sydney

NSW EPA 2023, Rising concern on human health implications of climate change, NSW Environment Protection Authority, accessed 26 July 2024

NSW Treasury 2022, *2021–22 NSW Intergenerational Report*, NSW Treasury, Sydney

O'Connell MJ, Fowler AM, Allan SJ, Beretta GA & Booth DJ 2023, 'Subtropical coral expansion into SE Australia: a haven for both temperate and expatriating tropical reef fishes', *Coral Reefs*, vol. 42, pp. 1,257–62, DOI: 10.1007/s00338-023-02429-w

OEH 2018, *NSW Estuary Tidal Inundation Exposure Assessment*, NSW Office of Environment and Heritage, Sydney

Oliver EJ, Benthuysen JA, Bindoff NK, Hobday AJ, Holbrook NJ, Mundy CN & Perkins-Kirkpatrick SE 2017, 'The unprecedented 2015/16 Tasman Sea marine heatwave', *Nature Communications*, vol. 8, 16101, DOI: 10.1038/ncomms16101

Physick W, Cope M & Lee S 2014, 'The Impact of Climate Change on Ozone-Related Mortality in Sydney', *International Journal of Environmental Research and Public Health*, vol. 11, no. 1, pp. 1,034–48, DOI: 10.3390/ijerph110101034

Pui A, Sharma A, Santoso A & Westra S 2012, 'Impact of the El Niño–Southern Oscillation, Indian Ocean Dipole, and Southern Annular Mode on Daily to Subdaily Rainfall Characteristics in East Australia', *Monthly Weather Review*, vol. 140, no. 5, pp. 1,665–82, DOI: 10.1175/MWR-D-11-00238.1

Qiu Z, Coleman MA, Provost E, Campbell AH, Kelaher BP, Dalton SJ, Thomas T, Steinberg PD & Marzinelli EM 2019, 'Future climate change is predicted to affect the microbiome and condition of habitat-forming kelp', *Proceedings Biological sciences*, vol. 286, no. 1,896, 20181887, DOI: 10.1098/rspb.2018.1887

Shi Y & Li Y 2024, 'Impacts of ocean acidification on physiology and ecology of marine invertebrates: a comprehensive review', *Aquatic Ecology*, vol. 58, pp. 207–26, DOI: 10.1007/s10452-023-10058-2

Steffen W, Burbidge AA, Hughes L, Kitching R, Lindenmayer D, Musgrave W, Stafford Smith M & Werner P 2009, *Australia's Biodiversity and Climate Change: A strategic assessment of the vulnerability of Australia's biodiversity to climate change*, Report to the Natural Resource Management Ministerial Council, Department of Climate Change, CSIRO Publishing, Canberra (PDF 3.1MB)

Udy D, Kiem A & Vance T 2023, *Review of NSW rainfall drivers*, the University of Tasmania and the University of Newcastle for the Department of Planning and Environment, Sydney (PDF 4.6MB)

Vijayan A, Maina JM, Lawson R, Chang HC, Beaumont L & Davies PJ 2021, 'Land use planning to support climate change adaptation in threatened plant communities', *Journal of Environmental Management*, Vol. 298, 113533, DOI:10.1016/j.jenvman.2021.113533

Wernberg T, Bennett S, Babcock RC, de Bettignies T, Cure K, Depczynski M, Dufois F, Fromont J, Fulton CJ, Hovey RK, Harvey ES, Holmes TH, Kendrick GA, Radford B, Santana-Garcon J, Saunders BJ, Smale DA, Thomsen MS, Tuckett CA, Tuya F, Vanderklift MA & Wilson S 2016, 'Climate-driven regime shift of a temperate marine ecosystem', *Science*, vol. 353, no. 6,295, pp. 169–72, DOI: 10.1126/science.aad8745

Woodward E & McTaggart MP 2019, ‘Co-developing Indigenous seasonal calendars to support 'healthy Country, healthy people' outcomes’, *Global Health Promotion*, vol. 26, no. 3, pp. 26–34, DOI: 10.1177/1757975919832241

WSAA 2020, *All options on the Table – Urban water supply options for Australia*, Water Services Association of Australia, Sydney

XDI 2020, *Climate Risk Analysis Report*, Cross Dependency Initiative, Carrington (PDF 1.67MB)

XDI n.d., XDI Greater Sydney Case Study, XDI Cross Dependency Initiative, accessed 13 August 2024

This page intentionally left blank

Extreme climate and weather

Rising temperatures are driving more intense rainfall events, 'hot days' and severe fire weather days in NSW.

Overview

By 2080–99, NSW may experience an average increase of

45.5

hot days per year under a high-emissions scenario

Read more

Severe fire weather days are projected to increase, on average, by

9.4

per year by 2080–99 under a high-emissions scenario

Read more

Weather is a short-term state of the atmosphere, whereas climate is the long-term condition.

Extreme climate, such as warmer land and ocean temperatures, influences our weather patterns. Projections indicate that our climate will become more extreme, with historical trends and current status demonstrating that these are occurring faster and more intensely than predicted.

See the **Greenhouse gas emissions** and **Climate change** topics for more information about human-induced climate change.

Extreme weather is weather that occurs with extreme severity, such as heavy rainfall over a short period, or when least expected, such as a very hot day in winter. Extreme weather events could cause damage to the environment, communities and infrastructure.

Increased frequency and intensity of extreme weather events also cause damage to Aboriginal cultural sites and landscapes.

Although extreme weather occurs naturally, human-induced climate change is changing the frequency, intensity or duration (happens more, or less often, becomes more intense or lasts longer) of different types of extreme weather events.

There is strong evidence that the future climate will be hotter, which has implications on heat-related extreme weather events. While there is strong evidence of increasing risk of more extreme heat events and fire danger, projected changes to the frequency, intensity and duration of hazards that are influenced by rainfall such as, droughts, storms and floods are less certain.

Why is extreme climate and weather a problem?

Being more variable than expected, extremes in climate and weather can cause damage in ways we are not prepared for. This includes severe changes to our environment, damage to infrastructure, harm to the environment, short- and long-term health problems, and effects on livelihoods and economic growth.

Should extremes in our climate and weather become more common, our environment, communities and infrastructure may lack the resilience needed to avoid damage or recover.

Significant research is being undertaken into modelling and projecting changes to the climate to better understand what may happen in the future.

Globally, communities and governments are committed to reducing greenhouse gas emissions to mitigate climate change. They are developing policies and programs to prepare for, respond to and increase resilience to extreme weather.

See the **Greenhouse gas emissions** topic for more information.

Extreme weather events in NSW

In NSW, extreme weather events of greatest concern are extreme rainfall, hot days and severe fire days. These extremes in weather can increase the risk of flooding, heatwaves and bushfires, respectively. Other impactful extreme weather events are strong winds, hail, storms and cyclones.

The risk of drought is also a concern in NSW. Drought may develop over a long period of low rainfall, or it may result from a sudden drying of the land. Drought conditions may be brief, or they may last for many years.

Recent examples of events resulting from extreme weather include the **Black Summer bushfires of 2019–20**, the **Northern Rivers floods of 2022**, as well as localised and unexpected storm events such as the **Port Macquarie cyclone** and the **Christmas day hailstorm in Grenfell**.

What are we doing?

The **NSW and Australian Regional Climate Modelling project**, or NARCliM, uses high-resolution regional climate models to project future climate changes in NSW, south-east Australia and parts of Australasia (**AdaptNSW 2024**; **Di Virgilio et al. 2024**).

This report relies on the newest NARCliM data (NARCliM2.0) to understand future extreme climate in NSW.

Visit the **AdaptNSW website** to learn more about how climate change may different regions in NSW.

NARCliM projections can be explored using an **interactive climate change map** or downloaded from **NSW Climate Data Portal**.

It can be inferred from climate projections that the frequency, intensity or duration of certain types of extreme weather could increase. It is more important than ever to prepare for and respond to extreme weather events.

The NSW Government is:

- reducing greenhouse gas emissions to lessen the impacts of ongoing temperature increases due to climate change
- supporting environmental restoration to provide natural buffers and refuge from extreme weather
- adapting our infrastructure and planning to be resilient to weather extremes
- supporting communities to be aware of, prepared for and responsive to extreme weather.

Table C2.1 lists the current key legislation and policies related to climate change mitigation and adaptation in NSW.

Table C2.1: Current key legislation and policies related to extreme climate and weather in NSW	
Legislation or policy	Purpose
Climate Change (Net Zero Future) Act 2023	The main features of the act are: • providing guiding principles for actions to address climate change that consider impacts, opportunities and the need for action in NSW • setting emissions reduction targets • setting an objective for NSW to be more resilient to a changing climate • establishing an independent **Net Zero Commission** to monitor, review, report on and advise on progress towards these targets.
NSW Reconstruction Authority Act 2022	Promotes community resilience to the impact of disasters in NSW through disaster prevention, preparedness and adaptation, and recovery and reconstruction following disasters. This act also establishes the NSW Reconstruction.
State Emergency and Rescue Management Act 1989	Outlines responsibilities, powers and coordination mechanisms for responding to emergencies, including extreme weather events and hazards. Also requires the preparation of state, regional and local **Emergency Management Plans** and **Recovery Plans**.
Disaster Adapation Plans	Outline projects, strategies or actions to mitigate or minimise the impact of disasters caused by natural hazards at a local level. These plans are aligned to the State Disaster Mitigation Plan.
EPA's Climate Change Policy and Climate Change Action Plan 2023–26	Outline a comprehensive regulatory approach and set of actions to address the causes and consequences of climate change in NSW. They include actions to support licenced industries to decarbonise and build resilience to climate change.
NSW Climate Change Adaptation Action Plan 2025–2029	This whole-of-government plan includes 46 actions led by eight agencies that target known climate change impacts and risks and help work towards achieving the *Climate Change (Net Zero Future) Act 2023*'s adaptation objective. The actions help create the knowledge, skills, resources and processes needed to enable further adaptation on a larger scale. The plan states that decisions on adaption in NSW should be planned and based on comprehensive analysis of the best available information, including Aboriginal knowledge systems. The strategy includes 'Enable Aboriginal adaptation' as a key criterion in establishing Adaptation Action Plans which will include actions co-designed with Aboriginal communities to promote social, economic and cultural wellbeing.
State Disaster Mitigation Plan	Designed to improve community resilience and better prepare NSW to face the challenges of disasters caused by natural hazards, such as floods, bushfires, storms and cyclones, coastal erosion and inundation.

Notes:
See the **Responses** section for more information about how **Extreme climate and weather** are being addressed in NSW.

Related topics: **Air quality** | **Climate change** | **Energy consumption** | **Greenhouse gas emissions** | **Net Zero Plan Stage 1: 2020–2030**

Status and trends

Extreme climate projections

This section uses climate modelling projections rather than indicators based on observed trends.

A summary of extreme climate projections under low- and high-emissions scenarios is provided to indicate future trends (see **Table C2.2**).

See **Scenarios used in modelling climate projects** in the **Climate change** topic for more information about the scenarios used in modelling climate projections.

Table C2.2: Summary of extreme climate projections for NSW relative to a baseline period between 1990 and 2009

Extreme weather type	Definition	Low-emissions SSP1–2.6 (by 2080–99)	High-emissions SSP3–7.0 (by 2080–99)
Extreme rainfall	Infrequent, intense rainfall (daily 99th percentile of precipitation). May increase the risk of flooding.	Decrease in summer. Decrease in winter over eastern and coastal regions but increase in winter over inland regions.	Increase in summer, particularly over eastern and central regions. Decrease in winter over eastern and coastal areas but increase over inland regions.
'Hot days'	Maximum temperature is higher than or equal to 35°C. May increase the risk of heatwaves.	More days above 35°C on average each year by 2080–99 (about 15.9 additional days per year), especially in northern NSW.	Far more days above 35°C each year (about 45.5 additional days per year), especially in northern NSW.
Severe fire weather	Forest Fire Danger Index >50. Combination of high temperatures, low humidity, no recent rainfall and wind. When combined with other factors, such as dry conditions, may increase the risk of bushfires.	More days of severe fire weather (about 3.5 additional days per year on average), especially in northern and western NSW.	Twice as many severe fire weather days as now (about 9.4 additional days per year), especially in northern and western NSW.

Notes:
Projections are discussed in more detail in the **Extreme rainfall**, **'Hot days'** and **Severe fire weather** sections.

Due to the many definitions of drought and the complex interactions involved between the atmosphere and land surface, making projections for drought conditions difficult. Some studies suggest that drought intensity and frequency may increase over most areas of NSW (**Ukkola et al. 2016**), while the Upper Tablelands and Great Dividing Range areas may remain stable or improve (**DPI 2024**).

Flash droughts that develop quickly over shorter periods are also challenging to project (**ESCC 2021**).

Events resulting from extreme weather 2021–24

Between June 2021 and June 2024 there were 62 extreme weather events declared as **'natural disasters'** in NSW.

In part, owing to consecutive La Niña seasons across the past four years, the more damaging of these events have arisen from extreme and prolonged rainfall, rather than the dry weather, heat and bushfires cited in the *State of the Environment 2021*.

Major rainfall, storm and flooding events in this reporting period include some of the most devastating and widespread in NSW history:

- **NSW-wide flooding (February to July 2022)** – 61 local government areas affected; 9 flood-related deaths in NSW; estimated $3.35 billion of damage in NSW and Queensland combined.
- **Northern Rivers, Mid North Coast and Sydney flooding (March to June 2021)** – about 62,000 people evacuated; 2 flood-related deaths; estimated $629.6 million in damage.
- **Sydney and Hunter flooding (June to July 2022)** – 37 local government areas affected; 14,500 homes damaged; 5,000 left uninhabitable.
- **Eugowra flooding (November 2022)** – 159 people evacuated; 2 deaths; 80% of homes in the town affected; estimated $150 million in damage.
- **NSW-wide floods (September 2022 to March 2023)** – 157 homes destroyed; 2,816 left uninhabitable.

Many individuals, families and communities remain physically, mentally and emotionally affected by these events. Recovery efforts for the more recent events are still underway.

A full report of the **2022 NSW Flood Inquiry** was commissioned in response.

It is difficult to attribute these floods to climate change. Moreover, it is not possible to predict the type and severity of future flooding.

Nonetheless, research indicates that extreme events are likely to become more frequent, intense or longer in duration (**Ayat et al. 2022**; **Dowdy et al. 2019**; **Hague et al. 2020**). Investing in infrastructure, planning and recovery funding for all types of extreme weather events will help to develop and sustain resilient communities.

Climate modelling

To better understand the range of extreme weather we may face, the NSW Government has developed a high-resolution regional climate modelling project called **NSW and Australian Regional Climate Modelling**, or NARCliM.

NARCliM1.0 was released in 2014, focusing on NSW, the ACT and parts of Australasia. NARCliM2.0 was released in 2024, incorporating new data on global emissions and climate change, increasing the resolution of projections and delivering technical improvements (**Di Virgilio et al. 2024**).

NARCliM2.0 downscaled global climate models to project potential changes in climate under future global climate scenarios (**Di Virgilio et al. 2024**).

These scenarios are known as the Shared Socioeconomic Pathway-Representative Concentration Pathways (SSP-RCPs). They describe how the world may develop under different levels of greenhouse gas emissions (**IPCC 2023**).

This chapter refers to two scenarios:

- **SSP1–2.6** – a low-emissions scenario where global CO_2 emissions are cut to net zero by about 2075 and estimated global warming is 1.3–2.4°C by 2100
- **SSP3–7.0** – a high-emissions scenario where global CO_2 emissions are projected to double by 2100 and estimated global warming is 2.8–4.6°C by 2100.

See **Scenarios used in modelling climate projects** in the **Climate change** topic for more information on Shared Socioeconomic Pathways.

Uncertainty remains in the estimation of future extreme weather under NARCliM2.0 projections:

- The extent of climate change depends on future global rates of emission of greenhouse gases (**IPCC 2021**).
- Extreme weather is affected by variability of natural drivers, such as **El Niño Southern Oscillation (ENSO)**, the **Indian Ocean Dipole** and **Southern Annular Mode** (**BOM & CSIRO 2024**).
- NARCLiM2.0 uses one of several approaches for estimating future climate and is best practice. While it is unique for being the first regional climate modelling in Australia to simulate at very high resolution, there is no single ‘right way’ to project future climate.
- NSW is a large state with diverse topography, these factors significantly influence its climate and weather.

NARCliM2.0 is now being used to prepare projections for aadditional extreme weather events like heatwaves, droughts and storms. See the **AdaptNSW website** to learn more.

Extreme rainfall

Historical trends over the past 20 years strongly suggest an increase in the intensity of short-duration rainfall (less than an hour) near Sydney. Short-duration intense rainfall is one of the factors that can increase the risk of flooding (**Ayat et al. 2022**).

Extreme rainfall is projected to change depending on the season and geographic area of NSW (see **Figure C2.1**). In this topic, the intensity of extreme rainfall is represented by the daily 99th percentile of precipitation. This means that extreme rainfall is infrequent, with high precipitation levels ranking in the top 1%.

The modelling results are highly variable, with some models projecting reductions and others projecting increases. These uncertainties suggest that further research is needed.

Annual projections show mixed signals in extreme precipitation events. Winter projections have greater consistency among the NARCLiM2.0 models than summer projections. Extreme rainfall in winter is projected to decrease along the coast and increase inland, especially under the high-emissions scenario.

Under a high-emissions scenario (SSP3–7.0) by 2080–99

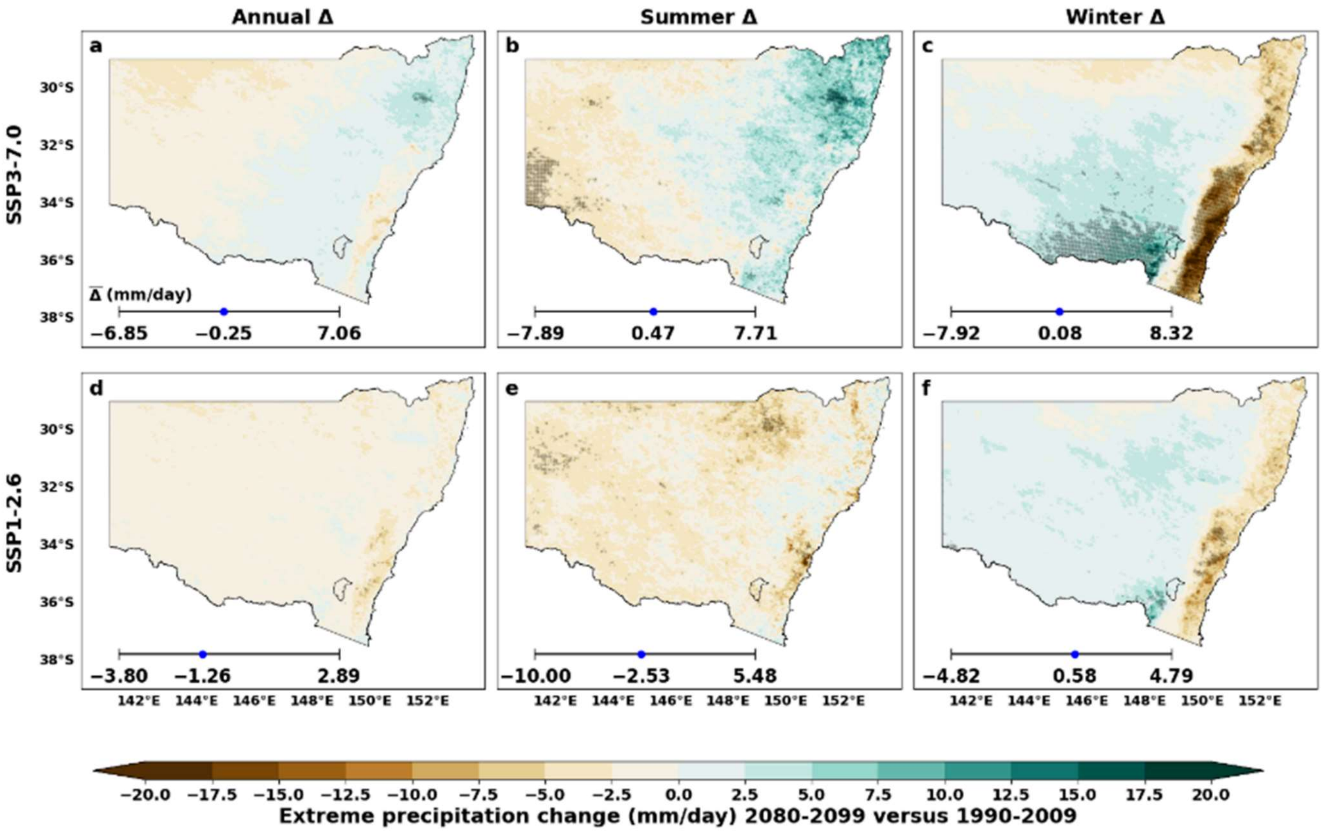
- Annual (**Figure C2.1**, map a): Overall small change in the annual mean of −0.25 millimetres (mm) per day (with a range of −6.85 to +7.06mm per day). This highlights more drying in north-western regions and precipitation increases along and to the west of the Great Dividing Range, with general reductions along coastal regions except in the north-east.
- Summer (map b): Increases in extreme rainfall intensity are projected for North Coast NSW during summer.
- Winter (map c): Variation in trend extreme rainfall across NSW (-7.9 to 8.3mm). Inland regions, particularly those in the Riverina, show a slight increase in extreme rainfall during winter. In contrast, there is a reduction in extreme precipitation in coastal NSW east of the Great Dividing Range. This indicates potential increases in extreme precipitation over inland regions that could have impacts like contributing to an increased risk of flash flooding. In contrast, there is a projected reduction in extreme precipitation along the eastern and coastal regions.

Under a low-emissions scenario (SSP1–2.6) by 2080–99

- Annual (map d): General reduction in extreme daily precipitation across NSW of 1.26mm per day (with a range of −3.80 to +2.89mm per day), dependent on the model in NARCLiM 2.0, indicating that some models project more drying, while others suggest strong precipitation increases across the State.
- Summer (map e): More pronounced decrease in extreme precipitation of 2.53mm per day (with a range of –10.0 to +5.48mm per day).
- Winter (map f): Increase in extreme precipitation over inland regions of 0.58mm per day (with a range of −4.82 to +4.79mm per day). This indicates potential increases in extreme precipitation under a low-emissions scenario over some regions, particularly inland, whereas a drying signal is predicted for eastern and coastal regions, although the magnitude of this reduction in extreme precipitation is less under the low emissions scenario.

See the **Interactive climate change projections map** for an in-depth exploration of NARCliM 2.0 data.

Figure C2.1: Projected changes (difference Δ between 2080–99 and 1990–2009) in daily 99th percentile of precipitation (%)



Notes:

NARCliM2.0 modelled changes in extreme precipitation in 2080–99 under SSP3–7.0 (maps a, b, c) and SSP1–2.6 (maps d, e, f). Annual (maps a & d), summer (maps b & e) and winter (maps c & f) projections are presented.

The average change (∆) from all the models comprising NARCliM2.0 are shown at the bottom left of each plot, along with the range of changes from the individual models.

The stippling (small dots) shows areas where projected changes are statistically significant.

The Mann–Whitney U test (α = 0.05) is used to test the statistical significance.

See **Table C1.4** in the **Climate change** topic for more information on scenarios used in modelling climate projections.

Source:

Di Virgilio et al. 2024

Risk of storms

Projections for storms vary from highly confident to highly uncertain (**Allen et al. 2014**; **IPCC 2021**; **Brown et al. 2024**).

Studies using previous NARCliM projections suggest decreases in the frequency of East Coast Lows (ECL) over eastern Australia especially in winter. The amount of rain and the wind speed of these lows are projected to increase, meaning less frequent storms that are potentially more severe (**Ji et al. 2015**; **Pepler et al. 2016**; **Walsh et al. 2016**; **Dowdy et al. 2019**). Studies using NARCliM2.0 will provide updated insights on frequency and severity of storms.

Hail is one of the leading causes of insured losses in Australia.

Data from 1979 to 2021 show that the number of hail-prone days per year decreased across much of Australia but increased in some heavily populated areas. The annual number of hail-prone days in and around Sydney increased by about 40% (**Raupach et al. 2023**).

While projections suggest that climate change could decrease the frequency of hailstorms and increase their severity, there is large variation in observed and modelled changes, so hailstorm responses to climate change remain highly uncertain in Australia and across the world (**ARC 2023**; **Raupach et al. 2023**).

Risk of flooding

The increase in extreme rainfall does not necessarily result in increased risk of flooding, however, projections of rainfall and flood frequency are regionally consistent (**Wasko et al. 2023**).

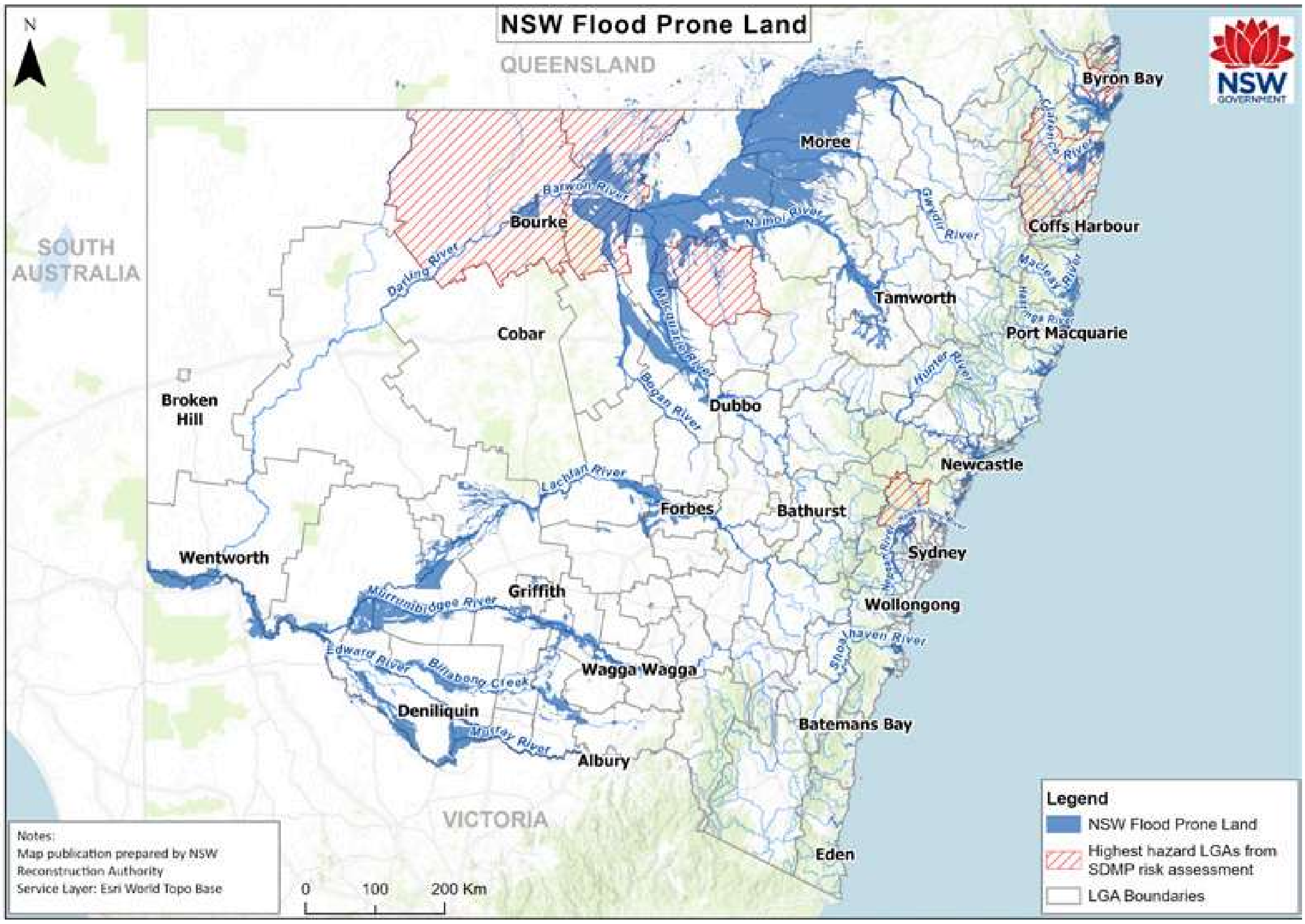
Projecting future risk of flooding in NSW is difficult and requires consideration of many factors, including atmospheric conditions, catchment development and land use changes, such as urbanisation (**Ishak & Rahman 2019**).

Rising sea levels are likely to increase the risk of flooding in coastal and estuarine areas, placing these areas at further risk (**Herold et al. 2018**; **Hague et al. 2020**).

See the **Climate change** topic for more information about sea level rise.

Most NSW communities along major river systems and in coastal areas are already vulnerable to floods (see **Map C2.1**). The Hawkesbury, Clarence Valley, Ballina, Coonamble and Bourke Local Government Areas are the most prone to damage from extreme rainfall and the increased risk of flooding (blue and striped areas in map).

Map C2.1: Flood-prone areas across NSW



Source:
NSW RA 2024

'Hot days'

To measure one type of heat extreme in weather, NARCliM2.0 models 'hot days'.

'Hot days' are defined as days where the maximum temperature is greater than or equal to 35°C (**AdaptNSW 2024**). This is a useful measure of the effects of extreme heat on people, as human susceptibility to heat stress, stroke and exhaustion increases at these temperatures (**Peng et al. 2011**; **Coates et al. 2014**).

The number of hot days in NSW tend to increase with distance inland. Currently areas near the coast have an average of less than 10 hot days per year near the coast and while inland north-western areas have an average of about 80 hot days per year (**AdaptNSW 2024**).

The number of hot days is projected to increase under all emission scenarios and across all seasons. Almost all increases are statistically significant (see **Figure C2.2**).

Under a high-emissions scenario (SSP3–7.0) by 2080–99:

- Significantly higher number of hot days.

- Annual (**Figure C2.2** map a): Average increase of 45.5 hot days per year and up to 60 in the north of the State (dark red area).
- Summer (map b): Average increase of 23.4 hot days and up to 30 in areas west of the Great Dividing Range (dark orange area).

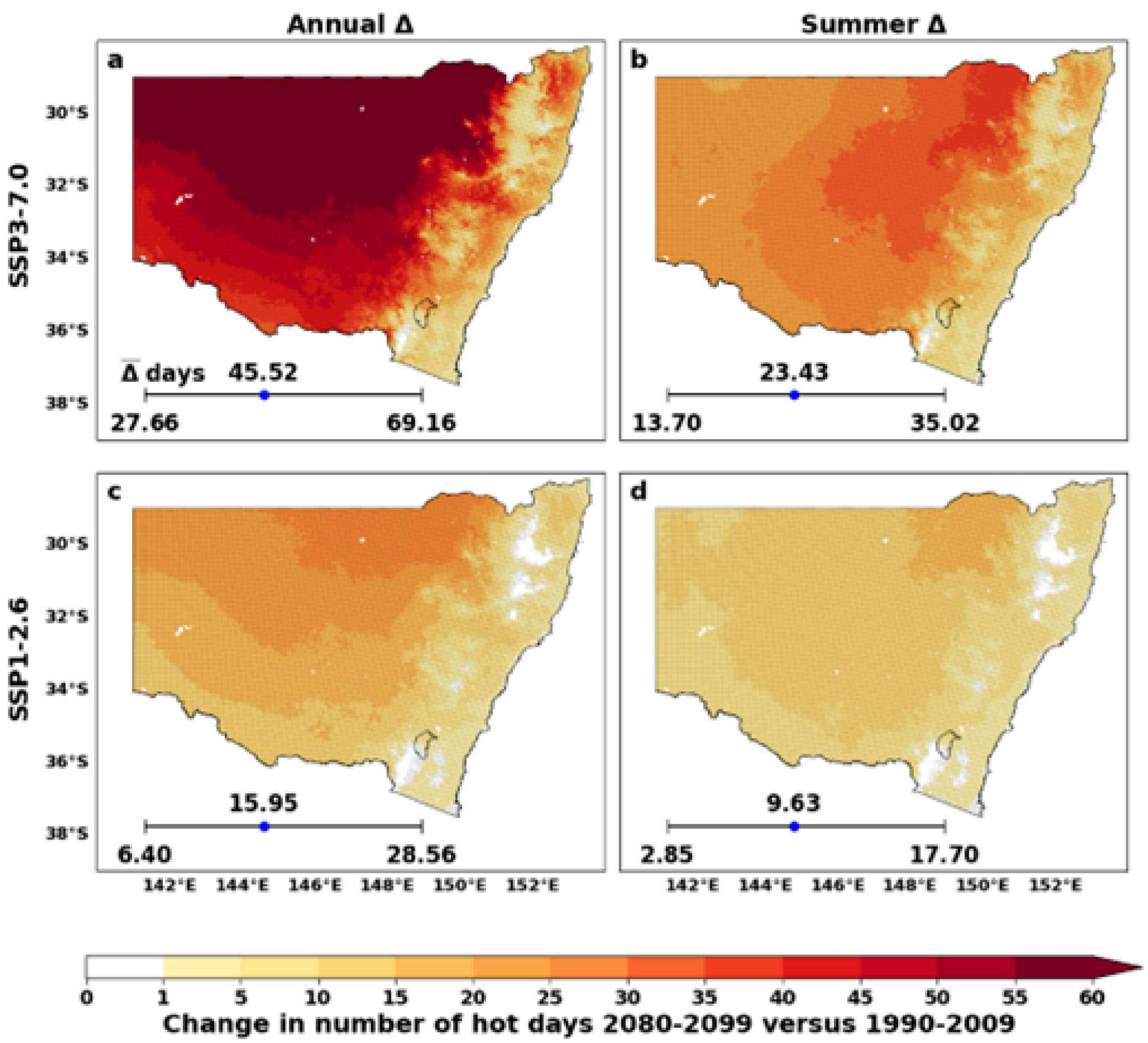
Under a low-emissions scenario (SSP1–2.6) by 2080–99:

- Annual (map c): Average increase of 15.9 hot days per year and up to 20 in northern NSW (orange area).
- Summer (map d): Average increase of 9.6 hot days and up to 15 in northern NSW.

The largest increases in the number of hot days will occur in the north and west of the State.

The impacts of hot days on coastal areas may be greater, as these areas hold most of our population and some infrastructure is not designed to handle extreme heat conditions. Conditions are also likely to be made worse by urban development.

Figure C2.2: Projected changes (difference Δ between 2080–99 and 1990–2009) in 'hot days'



Notes:

NARCliM2.0 modelled changes in number of hot days in 2080–99 under SSP3–7.0 (maps a, b, c) and SSP1–2.6 (maps d, e, f). Annual (maps a & c) and summer (maps b & d) projections are presented.

The average change (Δ) from all the models comprising NARCliM2.0 are shown at the bottom left of each plot, along with the range of changes from the individual models.

The stippling (small dots) shows locations where projected changes are statistically significant.

The Mann–Whitney U test (α = 0.05) is used to test the statistical significance.

See **Table C1.4** in the **Climate change** topic for more information on scenarios used in modelling climate projections.

Source:
Di Virgilio et al. 2024

See the **Climate change** topic for more information about average surface temperature overland increase projections.

Risk of heatwaves

Heatwaves (prolonged periods of above average heat for the expected season) have increased in intensity, duration and frequency in parts of NSW since 1911 (**OEH 2015**).

The most significant increases in heatwave intensity have occurred just inland of the east coast, along the Great Dividing Range, in parts of the Far West and along the eastern seaboard (**Argüeso et al. 2015a**).

Significant increases in urban heat intensity could be worse under a high-emissions scenario (**AdaptNSW 2024**).

Find out more about **heatwaves in Australia**.

Impacts in urban areas

'Hot days' and heatwaves can be significantly worse in urban areas owing to a combination of heat-absorbing concrete and building materials, as well as limited vegetation and tree canopy coverage, known as the urban heat island effect (**AdaptNSW n.d.-a**).

Temperature increases caused by the urban heat island effect are usually greater at night than during the day and during winter than during summer.

The urban heat island effect is of particular concern for communities in NSW expecting population growth and urban development, which make them particularly susceptible to an increase.

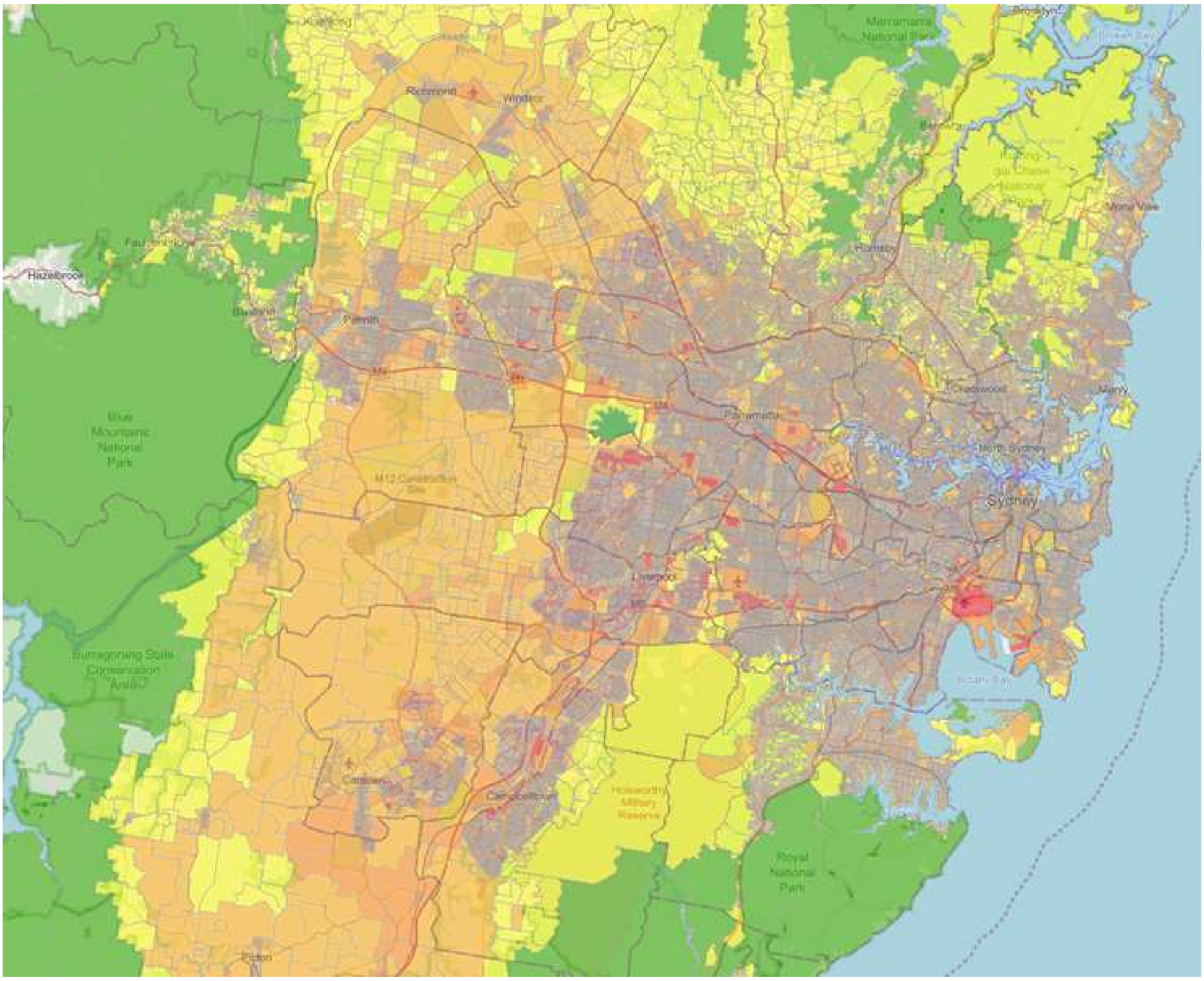
The largest temperature increases due to the urban heat island effect are projected to occur in areas converted from forest and grasslands to new urban development (**Argüeso et al. 2015b**) or in areas of intense urbanisation.

Large parts of south-western Sydney are expected to be 3–6°C warmer than non-urban areas (see **Map C2.2**, orange areas). Intensely urbanised areas such as Sydney Airport are expected to be more than 9°C warmer (see **Map C2.2**, red areas).

These urban heat effects will further increase the impacts of projected increases in hot days and heatwaves, particularly in areas such as Western Sydney (**Ogge et al. 2018**).

Find out more about the **urban heat island effect in Sydney**.

Map C2.2 Urban heat island effects in Sydney



Notes:
Green = cooler than baseline
Yellow = 0–3°C warmer
Light orange = 3–6°C warmer
Dark orange = 6–9°C warmer
Red = 9–12°C warmer

Baseline temperatures for this analysis were taken from well vegetated urban areas.

Source:
Devereux & Caccetta 2017

Severe fire weather

Severe fire weather conditions feature a combination of high temperatures, low humidity, no recent rainfall and wind, increasing the risk of bushfire occurrence and spread.

Severe fire weather risk is represented in NSW by the Forest Fire Danger Index (FFDI). This combines vegetation dryness, air temperature, wind speed and humidity to create a risk level (**BOM & CSIRO 2024**).

The number of severe fire weather days (days when FFDI is greater than 50) is projected to increase under both high- and low-emissions scenarios (see **Figure C2.3**).

More frequent severe fire weather days are expected inland, particularly in the north-west of NSW.

Under a high-emissions scenario (SSP3–7.0) by 2080–99:

- Much higher number of severe fire weather days.
- Annual (**Figure C2.3** map a): Average increase of 9.4 days per year and up to 14 in north-western NSW (black area).

- Spring (map b): Average increase of about 3 days in spring over some eastern regions and up to 8 in north-western NSW (red area).
- Summer (map c): Average increase of about 5 days in summer and up to 13 in north-western NSW (dark red area).

Under a low-emissions scenario (SSP1–2.6) by 2080–99:

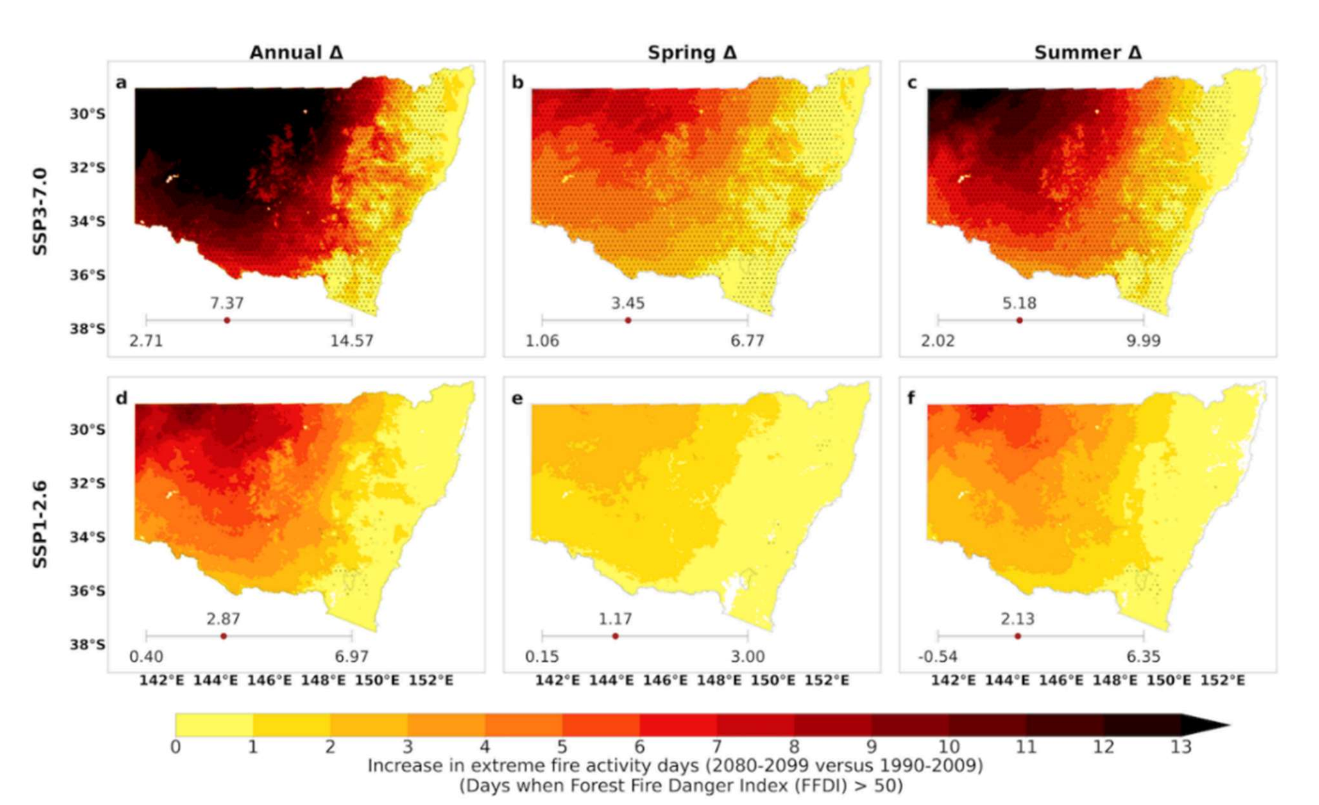
- Annual (map d): Overall increase of 3.5 days per year on average and up to 10 in north-western NSW (red area).
- Spring (map e): Average increase of about 1 day and up to 3 in north-western NSW (orange area).
- Summer (map f): Average increase of about 2 days and up to 6 in north-western NSW (red area).

The east coast is projected to experience fewer additional severe fire weather days than the north and west of the State.

Projections show notable increases in severe fire weather days annually (map a) and in summer (map c) under a high-emissions scenario.

See the **Interactive climate change projections map** for in-depth exploration of NARCLiM2.0 data.

Figure C2.3: Projected changes (difference between 2080–99 and 1990–2009) in the number of extreme fire activity days



Notes:
Extreme fire activity days are defined as days when the forest fire danger index – FFDI – is greater than 50.
NARCliM2.0 modelled changes in extreme fire activity days in 2080–99 under SSP3–7.0 (maps a, b, c) and SSP1–2.6 (maps d, e, f). Annual (maps a & c) and summer (maps b & d) projections are presented.
The average change (Δ) from all the models comprising NARCliM2.0 are shown at the bottom left of each plot, along with the range of changes from the individual models.
The stippling (small dots) shows locations where projected changes are statistically significant.
The Mann–Whitney U test (α = 0.05) is used to test the statistical significance.

See **Table C1.4** in the **Climate change** topic for more information on scenarios used in modelling climate projections.

Source:
Di Virgilio et al. 2024

Risk of bushfire

The combination of severe fire weather and periods of low rainfall can increase the risk of bushfire.

Bushfires in NSW can be extremely destructive, resulting in substantial costs, including the loss of human lives, buildings, infrastructure and livestock.

Although bushfires are a natural part of the Australian environment, climate change is increasing the frequency, duration, extent and intensity of 'fire weather' in southeast Australia (**van Oldenborgh et al. 2021**; **Dowdy et al. 2019**).

Recent trends suggest an increase in pyrocumulonimbus (pyroCb) storms, or smoke-infused thunderstorms, since their discovery in 2000 (**Peterson et al. 2021**).

These storms occur when multiple large bushfires close together produce intense updrafts. They can produce lightning, hail, downdraft wind and tornadoes, but not rain (**Fromm et al. 2022**). They are unpredictable and can spread rapidly in many directions.

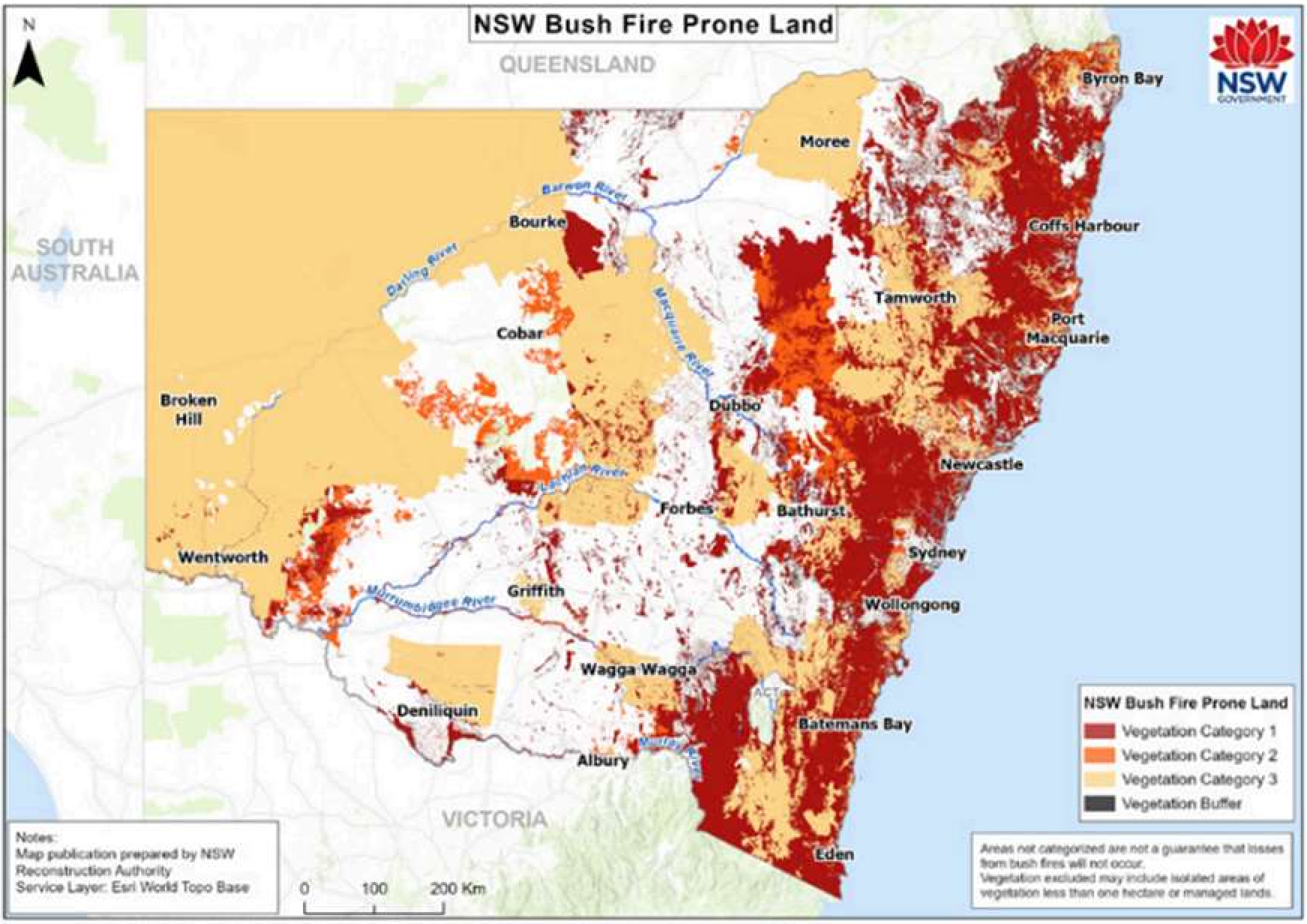
Their intensity pulls smoke plumes up into the lower stratosphere that can then travel around the globe for months.

Two record-setting pyroCb storms have taken place in Australia in the last four years (including the Black Summer bushfires in 2019–20). These events may increase in magnitude and intensity because of climate change (**Peterson et al. 2021**).

NSW has experienced an increase in the number of severe fire weather days in the recent decades (**AdaptNSW 2024**). Already, the fire season arrives more than three months earlier than it did in the mid-1950s (**RC 2020**).

Many communities and large areas of the State are at risk of bushfires (see **Map C2.3**).

Map C2.3: Bushfire-prone areas across NSW



Notes:
Service Layer: Esri World Topo Base
Vegetation Category 1: Highest hazard. Areas of forest, woodlands, heaths (tall and short), forested wetlands and timber plantations.
Vegetation Category 2: Rainforests. Lower-risk vegetation parcels, including remnant vegetation and land with ongoing land management practices that reduce bushfire risk.
Vegetation Category 3: Grasslands, freshwater wetlands, semi-arid woodlands, alpine complex and arid shrublands.

Source:
NSW RA 2024

Drought conditions

Drought conditions are characterised by reduced rainfall or flow of water in streams, creeks and rivers (**AdaptNSW n.d.-b**).

Droughts can be prolonged events, beginning slowly and developing gradually, or flash events, developing in just a few weeks (**ESCC 2021**).

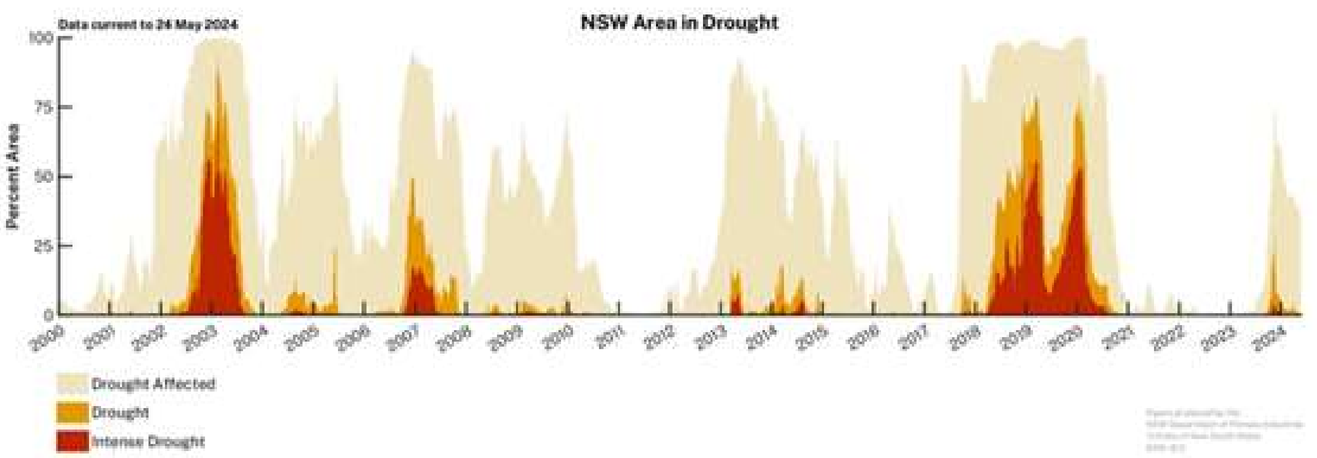
The 'Millennium Drought' from 1997 to 2010 was characterised by a sequence of lower-intensity drought events separated by short recovery periods (**van Dijk et al. 2013**).

The most recent drought in 2017–20 (sometimes called the 'Tinder Box' drought) was shorter but of considerably higher intensity and covered a much larger area (**Devanand et al. 2024**).

Evidence from long term analysis (500–2,000 years) indicates that NSW has experienced more prolonged and severe droughts in the past than observed in modern records (100–150 year) (**Vance et al. 2022**).

The **Combined Drought Indicator** uses a combination of factors, including rainfall, soil water (soil moisture content) and plant growth (**Clark et al. 2016**) to assess and monitor drought conditions in NSW (see **Figure C2.4**).

Figure C2.4: Area of NSW in drought from 2000 to early 2024



Notes:
The data represent the proportion of NSW in each of the three drought categories of the Combined Drought Indicator.

Source:
Updated from DPI 2024

Find out more about the **types and impacts of drought** in Australia.

Risk of drought

As rising temperatures change rainfall patterns and increase evaporation, water will become scarcer (**AdaptNSW n.d.-b**; **Herold et al. 2021**).

There is strong likelihood that NSW will become warmer in the future. Uncertainty remains in relation to NSW rainfall projections.

See the **Status and trends** section of the **Climate change** topic for more information on rainfall and temperature projections in NSW.

Drought projections in NSW can only be made with low to moderate confidence due to limitations in climate models (**Lane et al. 2023**).

Global and regional climate models tend to agree that droughts could change with warmer temperatures influencing the rate of drying of the landscape. In NSW, the expectation is that droughts (specifically related to long-term decreases in rainfall) could intensify, last longer and become more frequent in southern NSW (**Feng et al. 2018**; **Herold et al. 2018**; **Kirono et al. 2020**; **Ukkola et al. 2016**; **DPI 2024**).

This does not hold true for all regions of NSW. Under the NSW Department of Primary Industries-assessed high-emissions scenario, drought characteristics are likely to remain unchanged or may improve slightly in the Upper Tablelands and Great Dividing Range regions (**DPI 2024**).

Further research is needed to enhance projections for drought conditions in NSW.

Pressures and impacts

Greenhouse gas emissions

Greenhouse gas emissions have been rapidly accumulating since the industrial era (1910) owing to human activities, driving global temperature increase and climate change (**IPCC 2021**).

This increase in overall temperature is resulting in variations in Australia's rainfall patterns, as well as heightened frequency, intensity or duration of extreme weather (**BOM & CSIRO 2024**).

There is an urgent need to radically reduce emissions to slow down global warming and mitigate the worst impacts of climate change (**IPCC 2023**).

The **NSW Net Zero Plan Stage 1: 2020–2030** commits to net zero emissions by 2050.

Projections for climate change impacts are based on future greenhouse gas emissions scenarios (see **Table C1.4** in the **Climate change** topic for more information on scenarios used in modelling climate projections).

See the **Greenhouse gas emissions** and **Net Zero Plan Stage 1: 2020–2030** topics for more information.

Climate change

The surface air temperature over land in NSW has warmed by 1.4°C since national records began in 1910. This warming is not directly comparable to average estimates of global warming that include surface air temperature over both land and ocean. Surface warming occurs faster over land than the ocean.

The effects of climate change are already apparent:

- The past two decades have been the warmest in Australia thus far, having seen the warmest year (2019) as well as eight of the nine warmest years on record since 2013 (**BOM & CSIRO 2024**).
- The Tasman Sea is warming at twice the global average (**BOM & CSIRO 2024**), an increase of 0.35°C per decade since 1945 near Sydney.
- Sea level monitoring shows a total increase of 22 centimetres since 1900, half of this in the last 50 years, owing to climate change (**BOM & CSIRO 2024**).

The effects of climate change will continue to get worse with each increment of global warming (**IPCC 2021**). This will mean that extreme weather events may occur more frequently, be more intense or affect larger areas.

Human health impacts

Extreme weather harms the health and wellbeing of Australians (**DHAC 2023**).

In Australia, heatwaves are one of the deadliest natural hazards, causing 55% of natural-disaster-related deaths (**Coates et al. 2014**).

They can cause dehydration, heat exhaustion, heat stroke or death when the body's ability to cool itself is exceeded (**NSW RA 2024**). Babies, children, the elderly, pregnant women and people with pre-existing health conditions are at higher risk of heat-related health impacts. Communities in urban areas are also exposed to the urban heat island effect.

Heat-related deaths are predicted to double on average across major Australian cities from 2020 to 2050 (**Hill et al. 2021**).

See the **Climate change** topic for more information about heat-related health impacts.

Poor air quality from extreme weather, such as smoke from bushfires or dust during droughts, exacerbates respiratory and cardiovascular symptoms. This means that people with existing conditions, including asthma and diabetes, are more at risk from the fine particulate matter released (**Vardoulakis et al. 2020**).

As with heat, smoke from bushfires particularly affects the most vulnerable groups across the community (**Hime et al. 2018**). This will have a flow-on affect for health services, with potential increases in visits to emergency departments, hospitalisations and death (**Borchers-Arriagada et al. 2020**; **Vardoulakis et al. 2020**).

See the **Air quality** topic for more information on health impacts.

Exposure to extreme weather can cause communities to experience psychological distress (**DftEA 2021**). Mental health impacts can range from increased domestic abuse and alcohol and substance abuse to anxiety, depression and post-traumatic stress disorder (**DftEA 2021**).

Communities experiencing decreased productivity and incomes owing to extreme weather are also at increased risk of depression and suicide (**Yazd et al. 2019**).

These issues affect more than the direct health of our population; the flow-on effects also disrupt productivity (**DHAC 2023**). For example, the need for sick leave may increase, working conditions might worsen, particularly for those who work outdoors, or communities could be displaced owing to extreme weather events.

See **Image C1.1** in the **Climate change** topic for more information on climate-related risks to health and wellbeing.

Environmental impacts

Changes in natural patterns of extreme weather could significantly affect the environment (**DCCEEW-Aus 2021**).

Australian plant and animal populations can tolerate extreme weather and usually recover in time. But as extreme weather events occur with greater frequency, severity or duration, plant and animal populations will experience more damage to recover from and less time to do so (**Nolan et al. 2021**).

Repeated extreme weather events will lead to a degraded natural environment with less resilience to future events. This may result in permanent changes in ecosystem processes and potentially the collapse of some ecosystems.

Cumulative impacts may come from repetition of the same types of extreme events, such as repeated drought conditions, or a combination of extreme weather types, such as bushfires followed by flooding (**DCCEEW-Aus 2021**).

More research into ‘repetition’ events is required for greater understanding of their impacts. It is possible that if too much damage is done to an ecosystem, such as an unprecedented amount of forest is burnt, it may not be able to recover sufficiently before the next event.

Extreme weather also causes damage to cultural sites and landscapes. Coastal archaeological sites, such as shell middens and burial grounds, are being damaged by erosion. Catastrophic bushfires, such as the Black Summer bushfires in 2019–20, have caused extensive damage to cultural landscapes, including cultural sites and important plants and animals.

Impacts on the economy

Impacts on livelihoods, food security, water supply, and economic growth due to extreme events are projected to increase as climate change continues (**IPCC 2023**).

Modelling by NSW Treasury’s estimates $15.8–17.2 billion (in 2021 dollars) in total economic costs from disasters triggered by extreme weather events on average every year by 2060–61, that is more than threefold increase from $5.1 billion in 2020–21 (**NSW Treasury 2022**). This includes direct economic costs, fiscal costs (as measured through **Government Disaster Recovery Arrangements**) and total costs from storms, floods, bushfires and heatwaves (**Wood et al. 2021**.

The report also estimates that between 700,000 and 2.7 million days of work could be lost to heatwaves alone.

The Black Summer bushfires in 2019–20 caused economic damage of about $6.5 billion (**Rose 2021**) and loss of about 7,300 jobs (**Reiner et al. 2024**) from tourism shutdown. The degree to which climate change influenced these fires remains to be established.

Agriculture and food production

Extreme weather is projected to compromise agriculture and food production (**AdaptNSW n.d.-c**). By 2050, the agricultural output of the irrigated areas of the Murray–Darling Basin could halve compared to levels reported in 2018 (**Climate Council 2019**). The Basin covers much of NSW and currently accounts for 50% of Australia’s irrigated agricultural output by value (about $7.2 million per year) (**Climate Council 2019**).

Drought conditions, including ‘hot days’ and heatwaves, particularly affect the incomes of people in regional and rural NSW communities.

The NSW economy experienced an estimated $20 billion loss in Gross Domestic Product (GDP) during the 2017-20 drought (**Wittwer & Waschik 2021**). It is estimated that by 2061, this could lead to annual average production losses of up to $1.5 billion across Australia (**Wood et al. 2021**).

Loss of income and livelihood flows on to affect the income of local businesses and communities through higher food prices and scarcity and poor mental health.

Property costs, infrastructure damage and insurance

Extreme weather can pose challenges for property and infrastructure that were not designed and built with extreme weather in mind.

People working and living in such buildings will require additional heating or cooling during periods of extreme heat or extreme cold snaps. Increased heating and cooling also increases the strain on the energy grid and greenhouse gas emissions from electricity generation.

Additionally, extreme weather could lead to pollution that can cause harm to the environment and public health and will entail clean-up and liability costs.

See the **Energy consumption** and **Greenhouse gas emissions** topics for more information.

Hailstorms have historically been the costliest extreme weather in NSW, costing $23.2 billion in normalised losses from 1967 to 2022 (**NSW RA 2024**).

Floods are also among the costliest events resulting from extreme weather as they can cause extensive damage to infrastructure (**Wood et al. 2021**).

Heatwaves can lead to infrastructure damage through overheating electricity substations and through increased maintenance costs for improved resilience.

Increased frequency, intensity or duration of events resulting from extreme weather can also affect cost-of-living through increased insurance premiums (**ICA 2023**). This could affect crop insurance, property insurance, and health and life insurance (**AdaptNSW n.d.-c**).

The economic impact and cost of insurance was noted in the 2022 NSW Flood Inquiry (**DPC 2022**). The Insurance Council of Australia reported 59,000 claims lodged and $618 million damages incurred because of the 2022 flood event.

Properties at increased risk may not be insurable at all.

Extreme weather can also cause detrimental damage to the environment and ecological systems. The cost of addressing damages can be significant.

Natural disaster relief

The NSW Government allocates funding to respond to natural disasters each year (**Audit Office 2023**). It is used to help communities recover from the impacts of natural disasters, including:

- coordinating emergency responses
- recovery programs for regional councils, businesses and community organisations
- disaster relief and recovery grants
- building community resilience
- research programs.

The NSW Government budget for natural disaster recovery continues to increase each year (**Audit Office 2023**):

- $725 million in 2020–21.
- $1.9 billion in 2021–22.
- was $2.5 billion in 2022–23.

The NSW Government and the Australian Government jointly committed to an additional $2.6 billion for the 2025–26 budget in response to three major storm and flood events in NSW in 2022.

Responses

Climate change will increase the frequency and intensity of extreme rainfall, 'hot days' and severe fire weather that can contribute to disaster. The NSW Government is committed to building the State's resilience to a changing climate.

A coordinated, multi-level response from government, industry and community must include Aboriginal communities and organisations in decision-making roles and support Aboriginal communities to access and care for Country.

This section focuses on actions to enhance the State's resilience against extreme climate and disasters that can be exacerbated by climate change.

See the **Responses** section of the **Climate change** topic for other climate adaptation actions.

See the **Responses** section of the **Greenhouse gas emissions** and **Energy consumption** topics for greenhouse gas emissions-related climate mitigation actions.

See the **Net Zero Plan Stage 1: 2020–2030** topic for an update on progress towards the **NSW Net Zero Plan**.

Policies and strategies on resilience

This section focuses on policies and programs that are helping to enhance NSW's resilience to climate-related risks and its ability to anticipate, reduce, accommodate or recover from the effects of a hazardous event (**Denton et al. 2014**).

Overarching policies and strategies

The ***Climate Change (Net Zero Future) Act 2023*** legislates an adaptation objective for NSW to be more resilient to a changing climate.

The **NSW Climate Change Adaptation Strategy 2022** sets out the NSW Government's approach to make NSW more resilient and adapted to climate change. Under the strategy, statewide climate change risk and opportunity assessments and adaptation action plans will be completed at least every five years.

The **NSW Climate Change Adaptation Action Plan 2025–29** is a whole-of-government plan that includes 46 actions addressing known climate change impacts and risks and help to achieve the 'adaptation objective' under the ***Climate Change (Net Zero Future) Act 2023***. The actions help create the knowledge, skills, resources and processes needed to enable further adaptation on a larger scale.

See the **Responses** section of the **Climate change** topic for more information about these policies and plans.

State Disaster Mitigation Plan

The NSW Reconstruction Authority was established under the **NSW Reconstruction Authority Act 2022** to proactively reduce the impact of future disasters across NSW and to help communities recover from them faster.

The authority will complete critical planning and preparation with communities, businesses and all levels of government to reduce the impact natural disasters have on NSW.

The **State Disaster Mitigation Plan**, developed by the NSW Reconstruction Authority, identifies areas at risk of natural disasters, including hazards that can be heightened by climate change, such as coastal flooding, heatwaves or bushfires. It sets actions to strengthen policies and programs for disaster management (**NSW RA 2024**).

Critical Infrastructure Resilience Strategy

The ***NSW Critical Infrastructure Resilience Strategy*** (PDF 3.1MB) aims to ensure that critical infrastructure in NSW can withstand and quickly recover from disruptions such as natural disasters. It promotes systems that continue to operate during disasters or that can be restored quickly after disruption.

Enhancing community resilience

The NSW Government is helping local councils and communities build resilience to drought.

The **Natural Hazards Package** helps communities and councils prepare for, manage and recover from extreme weather. This includes a strategic guide, resource kit and handbook that helps in strategic planning for natural hazard risk management (**DPE 2021**).

The **Increasing Resilience to Climate Change** grants program granted about $600,000 to 23 projects that were completed in March 2022. The projects ranged from water-resilient community gardens, information campaigns for household cooling, bushland revegetation, and bushfire and drought education.

Managing risks for flooding and storms

The **Flood-Prone Land Policy** aims to make the community more flood resilient. It recognises that flood-prone land is a valuable resource and focuses on reducing the impacts for owners and occupiers of flood-prone property and reducing public and private losses.

The **Flood Risk Management Manual** guides councils on how to manage flood risk in their communities through. This includes helping councils develop and implement flood risk management plans. The manual also outlines technical assistance provided to councils by the NSW Government.

The **Floodplain Management Program** provides financial support to local councils and eligible public land managers to help them manage flood risk in their communities.

The program funded 35 projects totalling $6,818,477 in 2023–24 to assess risks and reduce impacts of flooding in NSW.

Managing risks for heatwaves

Managing extreme heat in homes and communities

The NSW Government has provided advice on **passive cooling**, which involves designing homes and using materials that can lower temperature in hot weather. This can make homes more resilient to heatwaves.

NSW Health's **Beat the Heat** initiative provides guidance for communities to protect themselves on very hot days. It includes information on keeping cool and the signs of heat-related illness.

Reducing the heat island effect

Designing cities to absorb less heat can reduce the heat island effect.

NSW Government policies and strategies, including the **Sydney Green Grid**, **5 Million Trees Program** and **Greener Places Framework**, are supporting the establishment of a network of green cover and open spaces. The **Greater Sydney Region Plan** has a target of 40% canopy cover in Greater Sydney by 2056.

While supporting the cooling of cities by providing shade, trees also increase the risk of bushfires. Adaptation strategies can be diversified to avoid increasing risk to communities.

Planning and building standards can significantly reduce risks of heat events. These include infrastructure considerations such as green roofs or façades and light-coloured building materials.

Some areas of Sydney have already incorporated these, such as Wilton to the south of Sydney: the **Wilton Growth Area Development Control Plan 2021** encourages these considerations, as well as prioritising materials with low heat absorption and incorporating shading elements.

Managing risks for bushfire

The NSW Rural Fire Service's **Planning for Bush Fire Protection (2019)** document provides standards and requirements for designing and building on bushfire-prone land in NSW.

It supports planners, developers and fire authorities in integrating bushfire risk management into land use planning. It also mandates appropriate bushfire protection measures for new developments.

The draft **Bush Fire Prone Land Package** further develops the consideration of bushfire risk in land use planning. It also aims to address climate change, lower recovery and rebuilding costs and support communities to be more resilient to bushfires.

Managing risks for drought

The NSW Department of Primary Industries and Regional Development uses the **Combined Drought Indicator** and the **Enhanced Drought Information System** to track drought in NSW.

Real-time data are available through the **Interactive drought map**.

The NSW **DroughtHub** contains information and resources for primary producers to prepare for and manage drought. The **Drought Ready and Resilient Fund** provides access to low-interest loans for primary producers to build resilience.

Future opportunities

Advancements in modelling have enhanced our understanding of future climate. There are opportunities to better understand and apply climate projections.

Opportunities include:

- improving the modelling and observation frameworks to represent and detect changes in rainfall dynamics, leading to improved confidence in forward estimates of extreme climate and weather events
- understanding the likelihood of rare, extreme temperature and rainfall that have the potential to break the resilience of environments, communities and infrastructure
- explaining the compounding effects of changing temperature and rainfall and their impacts on the risks of flooding, heatwaves and drought
- understanding the flow-on effects of extreme weather on ecosystems, communities and industries.

Councils and local communities will be better equipped for extreme climate and weather through:

- designing energy efficient buildings that can reduce the impact of high temperatures
- increasing capacity for councils and local communities to assess, control and monitor their own climate-related risks
- investing in appropriate adaptation measures now to reduce community vulnerability and build resilience for future extremes.

References

AdaptNSW 2024, NSW Climate Change Snapshot, AdaptNSW, accessed 28 August 2024

AdaptNSW n.d.-a, Climate change impacts on urban heat, AdaptNSW, accessed 6 August 2024

AdaptNSW n.d.-b, Climate change impacts on drought, AdaptNSW, accessed 6 August 2024

AdaptNSW n.d.-c, Climate change impacts on our economy, AdaptNSW, accessed 7 August 2024

Allen JT, Karoly DJ & Walsh KJ 2014, 'Future Australian Severe Thunderstorm Environments. Part II: The Influence of a Strongly Warming Climate on Convective Environments', *Journal of Climate*, vol. 27, no. 10, pp. 3,848–68, DOI: 10.1175/JCLI-D-13-00426.1

ARC 2023, Hailstorms in Queensland, Victoria and New South Wales – 2022, The ARC Centre of Excellence for Climate Extremes

Argüeso D, Evans JP, Pitman AJ & Di Luca A 2015a, 'Effects of City Expansion on Heat Stress under Climate Change Conditions', *PLoS ONE*, vol. 10, no. 2, e0117066, DOI:10.1371/journal.pone.0117066

Argüeso D, Di Luca A, Evans JP, Parry M, Gross M, Alexander L, Green D & Perkins S 2015b, *Heatwaves affecting NSW and the ACT: Recent trends, future projections and associated impacts on human health, NARCliM Technical Note 5*, Report to the NSW Office of Environment & Heritage, Sydney, Australia (PDF 5.0MB)

Audit Office 2023, *Natural Disasters*, Audit Office of NSW

Ayat H, Evans J, Sherwood SC & Soderholm J 2022, 'Intensification of subhourly heavy rainfall', *Science*, vol. 378, no. 6620, pp.655–9, DOI:10.1126/science.abn8657

BOM & CSIRO 2024, *State of the Climate Report 2024*, Bureau of Meteorology and Commonwealth Scientific and Industrial Research Organisation

Borchers-Arriagada N, Palmer A, Bowman D, Morgan G, Jalaludin B & Johnston F 2020, 'Unprecedented smoke-related health burden associated with the 2019–20 bushfires in eastern Australia', *The Medical Journal of Australia*, vol. 213, no. 6, pp. 282–3, DOI: 10.5694/mja2.50545

Brown A, Dowdy A & Lane TP 2024, 'Convection-permitting climate model representation of severe convective wind gusts and future changes in southeastern Australia', *Natural Hazards and Earth System Sciences*, vol. 24, no. 9, pp. 3,325–43, DOI: 10.5194/nhess-24-3225-2024

Clark AJ, McGowen IM, Crean JJ, Lines-Kelly R & Wang B 2016, *Stage 1: Enhanced Drought Information System, NSW DPI Combined Drought Indicator, Technical Report*, NSW Department of Primary Industries, Orange, DOI:10.13140/RG.2.2.33183.64161

Climate Council 2019, *Compound Costs: how climate change is damaging Australia's economy*, Climate Council of Australia Limited (PDF 1.7MB)

Coates L, Haynes K, O'Brien J, McAneney J & De Oliveira FD 2014, 'Exploring 167 years of vulnerability: An examination of extreme heat events in Australia 1844–201', *Environmental Science & Policy*, vol. 42, pp. 33–44, DOI:10.1016/j.envsci.2014.05.003

DCCEEW-Aus 2021, *Australia State of the Environment 2021*, Australian Government Department of Climate Change, Energy, the Environment and Water, Canberra

Denton F, Wilbanks TJ, Abeysinghe AC, Burton I, Gao Q, Lemos MC, Masui T, O'Brien KL & Warner K 2014, 'Chapter 20: Climate-resilient pathways: adaptation, mitigation, and sustainable development', in Field CB, Barros VR, Dokken DJ, Mach KJ, Mastrandrea MD, Bilir TE, Chatterjee M, Ebi KL, Estrada YO, Genova RC, Girma B, Kissel ES, Levy AN, MacCracken S, Mastrandrea PR, & White LL (eds), *Climate Change 2014: Impacts, Adaptation, and Vulnerability, Part A: Global and Sectoral Aspects, Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1,101–31, DOI: 10.1017/CBO9781107415379.025

Devanand A, Falster GM, Gillett ZE, Hobeichi S, Holgate CM, Jin C, Mu M, Parker T, Rifai SW, Rome KS, Stojanovic M, Vogel E, Abram NJ, Abramowitz G, Coats S, Evans JP, Gallant E, Pitman AJ, Power SB & Rauniyar SP 2024, 'Australia's Tinderbox Drought: An extreme natural event likely worsened by human-caused climate change', *Science Advances*, vol. 10, no. 10, DOI: 10.1126/sciadv.adj3460

Devereux D & Caccetta PA 2017, 'Estimation of Land Surface Temperature and Urban Heat Island effect for Australian urban centres', Report CSIRO Data61, Australia, DOI: 10.4225/08/5a0497a855f6f

Di Virgilio G, Evans J, Ji F, Tam E, Kala J, Andrys J, Thomas C, Choudhury D, Rocha C, White S, Li Y, El Rafei M, Goyal R, Riley M & Lingala J 2024, 'Design, evaluation and future projections of the NARCliM2.0 CORDEX-CMIP6 Australasia regional climate ensemble', *Geoscientific Model Development* (in press), DOI: 10.5194/gmd-2024-87

DftEA 2021, *How Climate Change Affects Mental Health in Australia*, Doctors for the Environment Australia

DHAC 2023, *National Health and Climate Strategy*, Australian Government Department of Health and Aged Care

Dowdy AJ, Ye H, Pepler A, Thatcher M, Osbrough SL, Evans JP, Di Virgilio G & McCarthy N 2019, 'Future changes in extreme weather and pyroconvection risk factors for Australian wildfires', *Scientific Reports*, vol. 9, 10073, DOI: 10.1038/s41598-019-46362-x

DPC 2022, *2022 NSW Flood Inquiry*, Department of Premier and Cabinet, Sydney

DPE 2021, *Planning for a more resilient NSW A strategic guide to planning for natural hazard*, NSW Department of Planning and Environment, Sydney (PDF 3.2MB)

DPI 2024, *NSW Drought in a Changing Climate Technical Report*, Climate Change Research Strategy, NSW Department of Primary Industries, Orange

ESCC 2021, *Flash drought in Australia*, Earth Systems and Climate Change (PDF 5.0MB)

Feng PY, Liu DL, Wang B, Waters C, Zhang MX & Yu Q 2018, 'Projected changes in drought across the wheat belt of south-eastern Australia using a downscaled climate ensemble', *International Journal of Climatology*, vol. 39, no. 2, pp. 1,041–53, DOI: 10.1002/joc.5861

Fromm M, Servranckx R, Stocks BJ & Peterson DA 2022, 'Understanding the critical elements of the pyrocumulonimbus storm sparked by high-intensity wildland fire', *Communication Earth & Environment*, vol. 3, 243, DOI: 10.1038/s43247-022-00566-8

Herold N, Ekstrom M, Kala J, Goldie J & Evans JP 2018, 'Australian climate extremes in the 21st century according to a regional climate model ensemble: Implications for health and agriculture', *Weather and Climate Extremes*, vol. 20, pp. 54–68, DOI: 10.1016/j.wace.2018.01.001, DOI/10.1016/j.wace.2018.01.001

Herold N, Downes SM, Gross MH, Ji F, Nishant N, Macadam I, Ridder NN & Beyer K 2021, 'Projected changes in the frequency of climate extremes over southeast Australia', *Environmental Research Communications*, vol. 3, no.1, 011001, DOI:10.1088/2515-7620/abe6b1

Hague BS, McGregor S, Murphy BF, Reef R & Jones DA 2020, 'Sea level rise driving increasingly predictable coastal inundation in Sydney, Australia', *Earth's Future*, vol. 8, no. 9, e2020EF001607, DOI:10.1029/2020EF001607

Hill S, Cumpston Z & Quintana VG 2021, *Australia State of the Environment 2021:* Urban, Australian Government Department of Climate Change, Energy, the Environment and Water, Canberra

Hime N, Vyasa A, Lachireddya K, Wyetta S, Scalley B & Corvalan C 2018, 'Climate change, health and wellbeing: challenges and opportunities in NSW, Australia', *Public Health Research and Practise*, vol. 28, no. 4, e2841824, DOI: 10.17061/phrp2841824

ICA 2023, Insurance Catastrophe Resilience Report 2022–23, Insurance Council of Australia, Sydney (PDF 3.6MB)

IPCC 2021, 'Chapter 11: Weather and Climate Extreme Events in a Changing Climate', in Seneviratne SI, Zhang X, Adnan M, Badi W, Dereczynski C, Luca AD, Ghosh S, Iskandar I, Kossin J, Lewis S, Otto F, Pinto I, Satoh M, Vicente-Serrano SM, Wehner M & Zhou B (eds), *Climate Change 2021: The Physical Science Basis, Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 1513–766, DOI:10.1017/9781009157896.013

IPCC 2023, *AR6 Synthesis Report: Climate Change 2023*, The Intergovernmental Panel on Climate Change

Ishak E & Rahman A 2019, 'Examination of Changes in Flood Data in Australia', *Water*, vol. 11, no. 8, 1734, DOI:10.3390/w11081734

Ji F, Evans JP, Argueso D, Fita L & Di Luca A 2015, 'Using large-scale diagnostic quantities to investigate change in East Coast Lows', *Climate Dynamics*, vol. 45, pp. 2,443–53, DOI:10.1007/s00382-015-2481-9

Kirono DGC, Round V, Heady C, Chiew FHS & Osbrough S 2020, 'Drought projections for Australia: Updated results and analysis of model simulations', *Weather and Climate Extremes*, vol. 30, 100280, DOI:10.1016/j.wace.2020.100280

Lane TP, King AD, Perkins-Kirkpatrick SE, Pitman AJ, Alexander LV, Arblaster JM, Bindoff NL, Bishop CH, Black MT, Bradstock RA, Clarke HG, Gallant AJE, Grose MR, Holbrook NJ, Holland GJ, Hope PK, Karoly DJ, Raupach TH & Ukkola AM 2023, 'Attribution of extreme events to climate change in the Australian region – A review', *Weather and Climate Extremes*, vol. 42, 100622, DOI: 10.1016/j.wace.2023.100622

Nolan RH, Collins L, Leigh A, Ooi MKJ, Curran TJ, Fairman TA, Resco de Dios V & Bradstock R 2021, 'Limits to post-fire vegetation recovery under climate change', *Plant, Cell & Environment*, vol. 44, no. 11, pp. 3,471–89, DOI:10.1111/pce.14176

NSW RA 2024, *State Disaster Mitigation Plan 2024–2026*, NSW Reconstruction Authority, Sydney

NSW Treasury 2022, *2021–22 NSW Intergenerational Report*, NSW Treasury, Sydney

OEH 2015, *Urban Heat Climate Change Impact Snapshot*, NSW Office of Environment & Heritage, Sydney

Ogge M, Browne B & Hughes T 2018, *HeatWatch Extreme heat in Western Sydney*, The Australian Institute (PDF 1.43MB)

Peng Bi, Williams S, Loughnan M, Lloyd G, Hansen A, Kjellstrom T, Dear K & Saniotis A 2011, 'The Effects of Extreme Heat on Human Mortality and Morbidity in Australia: Implications for Public Health', *Asia Pacific Journal of Public Health*, vol. 23, no. 2, pp. 27S–36S, DOI: 10.1177/1010539510391644

Pepler ASA, Di Luca F, Ji L, Alexander V, Evans JP & Sherwood SC 2016, 'Projected changes in east Australian midlatitude cyclones during the 21st century', *Geophysical Research Letters*, vol. 43, no. 1, pp. 334–40, DOI:10.1002/2015GL067267

Peterson DA, Fromm MD, McRae RHD, Campbell JR, Hyer EJ, Taha G, Camacho CP, Kablick III GP, Schmidt CC & DeLand MT 2021, 'Australia's Black Summer pyrocumulonimbus super outbreak reveals potential for increasingly extreme stratospheric smoke events', *npj Climate and Atmospheric Sciences*, vol, 4, 38, DOI:10.1038/s41612-021-00192-9

Raupach TH, Soderholm JS, Warren RA & Sherwood SC 2023, 'Changes in hail hazard across Australia: 1979–2021', *npj Climate and Atmospheric Science*, vol. 6, 143, DOI:10.1038/s41612-023-00454-8

RC 2020, *Royal Commission into National Natural Disaster Arrangements Report*, Royal Commissions, Canberra

Reiner V, Pathirana NL, Sun YY, Lenzen M & Malik A 2024, 'Wish You Were Here? The Economic Impact of the Tourism Shutdown from Australia's 2019–20 'Black Summer' Bushfires', *Economics of Disasters and Climate Change*, vol. 8, pp. 107–27, DOI:10.1007/s41885-024-00142-8

Rose T 2021, *Climate Risk and the Cost of Capital in NSW*, Institute for Energy Economics and Financial Analysis, Australia

Ukkola AM, Prentice IC, Keenan TF, Van Dijk AI, Viney NR, Myneni RB & Bi J 2016, 'Reduced streamflow in water-stressed climates consistent with CO2 effects on vegetation', *Nature Climate Change*, vol. 6, no. 1, pp. 75–8, DOI:10.1038/nclimate2831

van Dijk AIJM, Beck HE, Crosbie RS, de Jeu RAM, Liu YY, Podger GM, Timbal B & Viney NR 2013, 'The Millennium Drought in southeast Australia (2001–2009): Natural and human causes and implications for water resources, ecosystems, economy, and society', *Water Resources Research*, vol. 49, no. 2, pp. 1,040–57, DOI: 10.1002/wrcr.20123

van Oldenborgh GJ, Krikken F, Lewis S, Leach NJ, Lehner F, Saunders KR, van Weele M, Haustein K, Li S, Wallom D, Sparrow S, Arrighi J, Singh RK, van Aalst MK, Philip SY, Vautard R & Otto FEL 2021, 'Attribution of the Australian bushfire risk to anthropogenic climate change', *Natural Hazards and Earth System Sciences*, vol. 21, no. 3 pp. 941–60, DOI:10.5194/nhess-21-941-2021

Vance TR, Kiem AS, Jong LM, Roberts JL, Plummer CT, Moy AD, Curran MAJ & van Ommen TD 2022, 'Pacific decadal variability over the last 2000 years and implications for climatic risk', *Communications Earth & Environment*, vol. 3, 33, DOI: 10.1038/s43247-022-00359-z

Walsh K, White C, McInnes K, Holmes J, Schuster S, Richter H, Evans J, Di Luca A & Warren R 2016, 'Natural hazards in Australia: storms, wind and hail', *Climatic Change*, vol. 139, pp. 55–67, DOI:10.1007/s10584-016-1737-7

Wasko C, Guo D, Ho M, Nathan R & Vogel E 2023, 'Diverging projections for flood and rainfall frequency curves', *Journal of Hydrology*, vol. 620, Part A, 129503, DOI: 10.1016/j.jhydrol.2023.129403

Wittwer G & Waschik R 2021, 'Estimating the economic impacts of the 2017–2019 drought and 2019–2020 bushfires on regional NSW and the rest of Australia', *The Australian Journal of Agricultural and Resource Economics*, vol. 65, no. 4, pp. 918–36, DOI: 10.1111/1467-8489.12441

Wood N, Beauman M & Adams P 2021, *An indicative assessment of four key areas of climate risk for the 2021 NSW Intergenerational Report*, NSW Treasury, Sydney

Net Zero Plan Stage 1: 2020–2030

The Net Zero Plan is the foundation for NSW to reduce emissions. NSW could miss its targets without further action from the Government and private sector.

Overview

NSW is projected to reduce emissions to

44–50%

below baseline 2005 levels by 2030

Read more

Out of 16 initiatives,

3

have been completed and 13 are being delivered

Read more

Global and Australian commitments to net zero

Climate change is a global issue.

The **Paris Agreement**, reached under the United Nations Framework Convention on Climate Change (UNFCCC), commits countries to reducing greenhouse gas emissions.

In 2016, Australia agreed to a nationally determined contribution to reduce greenhouse gas emissions by 26–28% (compared with 2005 levels) by 2030. This commitment was increased in 2022 to a reduction of 43% (compared with 2005 levels) by 2030 and net zero emissions by 2050.

NSW Net Zero Plan

The ***Net Zero Plan Stage 1: 2020–2030***, released in 2020, is the foundation for the NSW Government's action on climate change and its goal to reach net zero emissions by 2050 (**DPIE 2020a**).

The Net Zero Plan outlines the NSW Government's commitment to reducing emissions, while balancing economic needs and the quality of life of the people of NSW. It has four key priorities which guide its emissions reduction initiatives across all sectors of the economy:

- **Priority 1**: Drive the uptake of proven emissions reduction technologies.
- **Priority 2**: Empower consumers and businesses to make sustainable choices.
- **Priority 3**: Invest in the next wave of emissions reduction innovation.
- **Priority 4**: Ensure that the NSW Government leads by example.

The NSW Government has passed the ***Climate Change (Net Zero Future) Act 2023***. The main features of this Act are:

- providing guiding principles to address climate change that consider impacts, opportunities and the need for action in NSW
- legislating 50% emissions reductions on 2005 by levels 2030, 70% reduction on 2005 levels by 2035 and net zero by 2050
- setting an adaptation objective for NSW to be more resilient to a changing climate

- establishing an independent Net Zero Commission to monitor, review, report on and advise on progress towards these targets and objectives.

The Net Zero Commission commenced operations in July 2024. The Commission builds on the NSW Net Zero Emissions and Clean Economy Board, the advisory body established under Section 34 of the *Energy and Utilities Administration Act 1987*. The Commission released its first **annual report** in November 2024.

The Net Zero Plan is designed to be adaptable for continual improvement. This includes incorporating new technologies, responding to global trends and policies related to achieving net zero, and using improved data, assumptions and modelling as they become available.

Policies being delivered under the plan include the ***NSW Electricity Infrastructure Roadmap***, ***NSW Hydrogen Strategy***, ***NSW Electric Vehicle Strategy*** and ***NSW Waste and Sustainable Materials Strategy 2041***.

See the **Greenhouse gas emissions**, **Energy consumption**, **Transport** and **Waste and recycling** topics for more information about plans and strategies.

Progress towards Net Zero Plan targets

NSW net emissions in 2022

NSW net greenhouse gas emissions were 111 megatonnes of carbon dioxide-equivalent (Mt CO_2-e) in 2021–22 as per the **State and Territory Greenhouse Gas Inventories 2022** (STGGI) produced by the Australian Government (**DCCEEW-Aus 2024**). This value is 27% lower than 2005 levels (**DCCEEW-Aus 2024**).

The data are used in the **Greenhouse gas emissions**, **Energy consumption** and **Transport** topics.

Modelling future NSW emissions

To track NSW's progress towards net zero, the NSW Department of Climate Change, Energy, the Environment and Water (NSW DCCEEW) produces annual state and economy wide emissions projections. The 2023 projections update is based on the **STGGI 2021** (**DCCEEW-Aus 2023a**). The 2024 update to the STGGI reflects improvements to the land use, land use change and forestry (LULUCF) sector modelling methods, which has led to recalculations across all historical data and an increase in the carbon sink for this sector.

For analytical purposes, this topic presents the 2023 projections update and the associated data used in modelling.

Projections are updated annually, accounting for new inventory data as well as changes to market trends and abatement outcomes for programs.

The 2023 projections indicate that under a 'business-as-usual' scenario (defined in **Table C3.2**), NSW net emissions in 2030 are projected to be 36% lower than the 2005 levels. When emission reductions from Net Zero Plan programs and related policies are considered, NSW net emissions in 2030 are projected to be 44–50% lower than 2005 levels (**NSW Government 2024**).

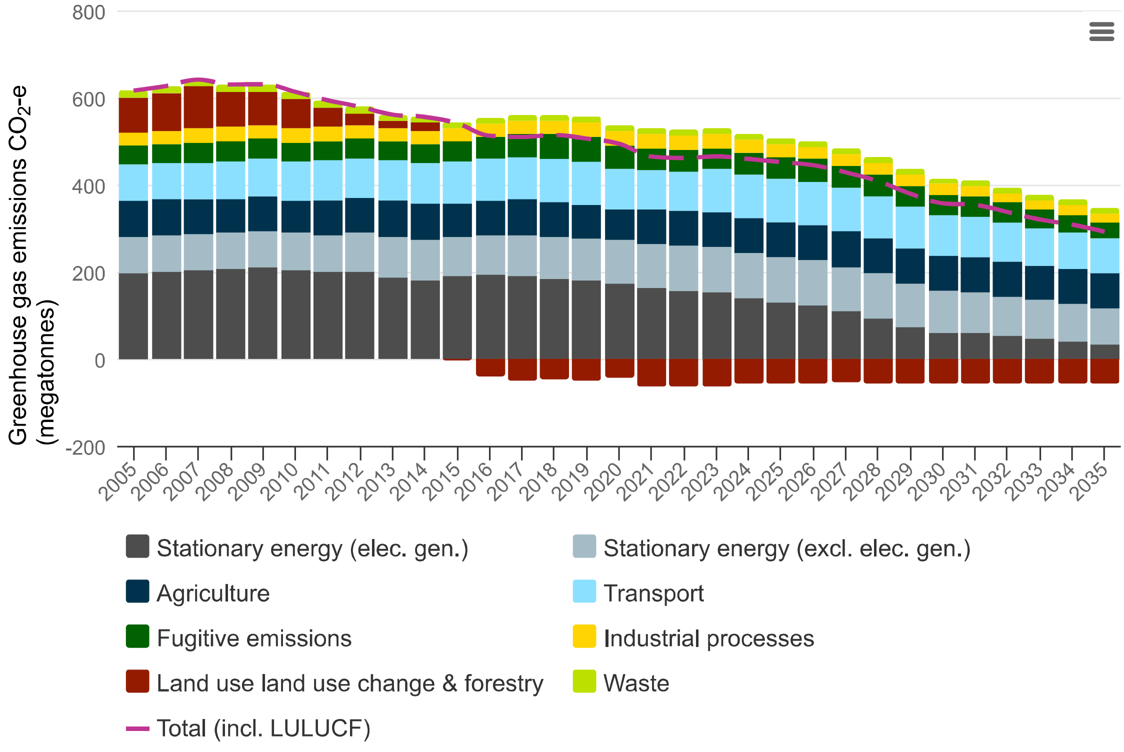
These projections suggest that while progress is being made, further effort is required to realise the interim target of 50% reduction relative to 2005 levels is realised by 2030.

> **Related topics**: **Climate change** | **Energy consumption** | **Greenhouse gas emissions** | **Transport** | **Waste and recycling**

Australian emission projections

Australian projections under the 'with additional measures' scenario (which includes policies still under consultation) estimate that national emissions will reduce to 358Mt CO_2-e by 2030 (see **Figure C3.1**). This represents 42% emissions reduction on 2005 levels by 2030, which is slightly less than the legislated national target of 43% (**DCCEEW-Aus 2023b**).

Figure C3.1: Net Australian greenhouse gas emissions (Mt CO_2-e), historical (2005–21) and projected (2022–35) under the 'with additional measures' scenario



Notes:
Years shown are financial years and so cover the 12 months ending 30 June of that year.
LULUCF = Land use, land use change and forestry.

Source:
DCCEEW-Aus 2023a

Most projected emissions reductions in Australia are due to the decarbonisation of the electricity sector as we transition to renewable energy. This transition involves the uptake in renewable energy sources and the retirement of coal-fired power stations (**DCCEEW-Aus 2023b**).

Accelerating the rollout of renewable energy in Australia is necessary to meet the 82% renewable electricity target by 2030. Progress is being made, including through the establishment of the **Capacity Investment Scheme**. However, delays could affect the decarbonisation of the electricity sector and the wider economy.

Safeguard Mechanism reforms are also expected to reduce emissions from stationary energy (excluding electricity), fugitive (escaped) emissions and industrial processes.

Transport emissions in Australia are projected to decrease under the 'with additional measures' scenario by 2030, owing to the **National Electric Vehicle Strategy** measures including a **fuel efficiency standard** for light vehicles (**DCCEEW-Aus 2023b**).

NSW emission projections

Net NSW greenhouse gas emissions

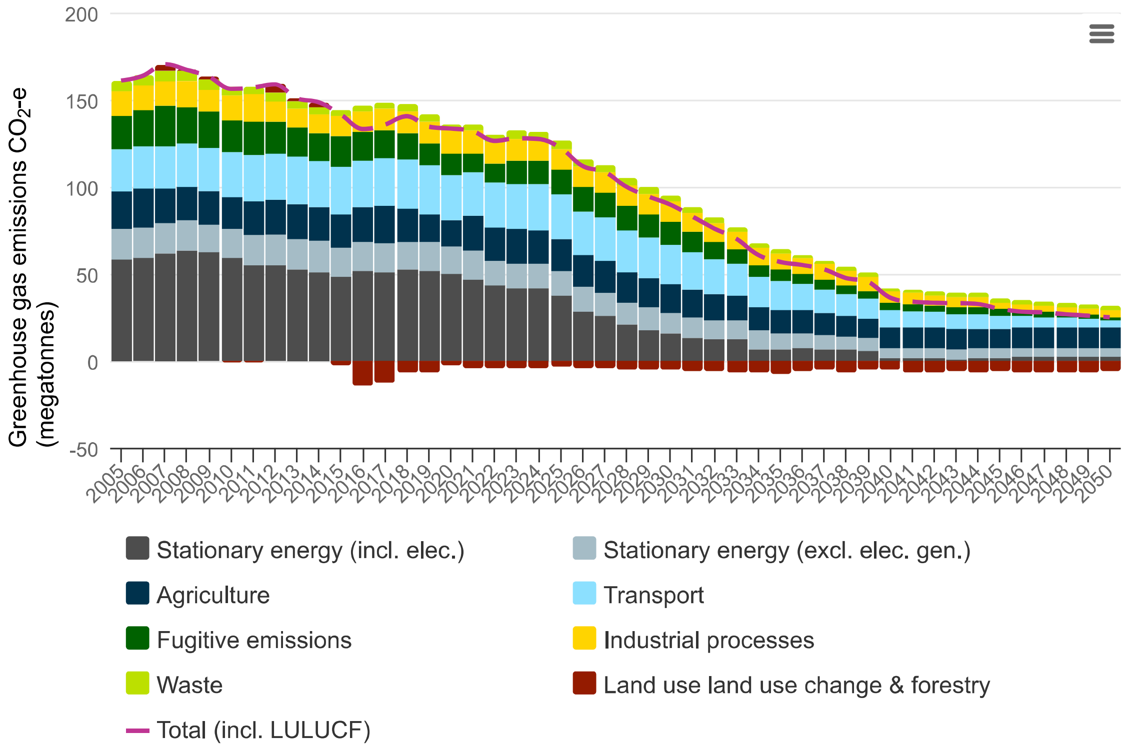
NSW is at risk of not achieving its interim target of 50% emissions reduction on 2005 levels by 2030 without further action by NSW Government and the private sector.

The 2023 projections indicate that with existing policies and near-term initiatives, emissions could reduce by 44–50% below baseline 2005 levels by 2030 and by 65–70% by 2035 (**NSW Government 2024**).

The ‘abatement as currently tracking’ scenario projections, presented in **Figure C3.2**, reflect the uncertainties in the outcomes of certain emission reduction policies and initiatives. These projections suggest that more effort is required to ensure targets set by the ***Climate Change (Net Zero Future) Act 2023*** will be met.

Although there has been significant increase in renewable energy in NSW, the rollout of renewable energy projects and infrastructure remains slower than required, which could affect the State’s ability to meet its emissions reduction targets (**Climate Council 2024**).

Figure C3.2: Net NSW greenhouse gas emissions (Mt CO_2-e), historical (2005–21) and projected (2022–50) under the ‘abatement as currently tracking’ scenario



Notes:
Years shown are financial years and so cover the 12 months ending 30 June of that year.
Emissions are expressed as CO -e calculated from global warming potential values from the IPCC Fifth Assessment Report.
The historical net emissions presented here are drawn from the State and Territory Greenhouse Gas Inventories 2021 (**DCCEEW-Aus 2023a**), which has data until financial year 2020–21. This data is the basis for NSW emissions modelling from 2022–50.
LULUCF = Land use, land use change and forestry.
The projected net emissions are modelled by DCCEEW. Projections indicate what future emissions in NSW could be under the assumptions underpinning the projection. They are dissimilar to forecasts, which predicts actual future events and changes.

The projected net emissions are based on the Net Zero Plan ‘abatement as currently tracking’ scenario (defined in **Table C3.2**). Projections are updated annually.

Source:
DCCEEW-Aus 2023a | DCCEEW 2023

Cumulative emissions

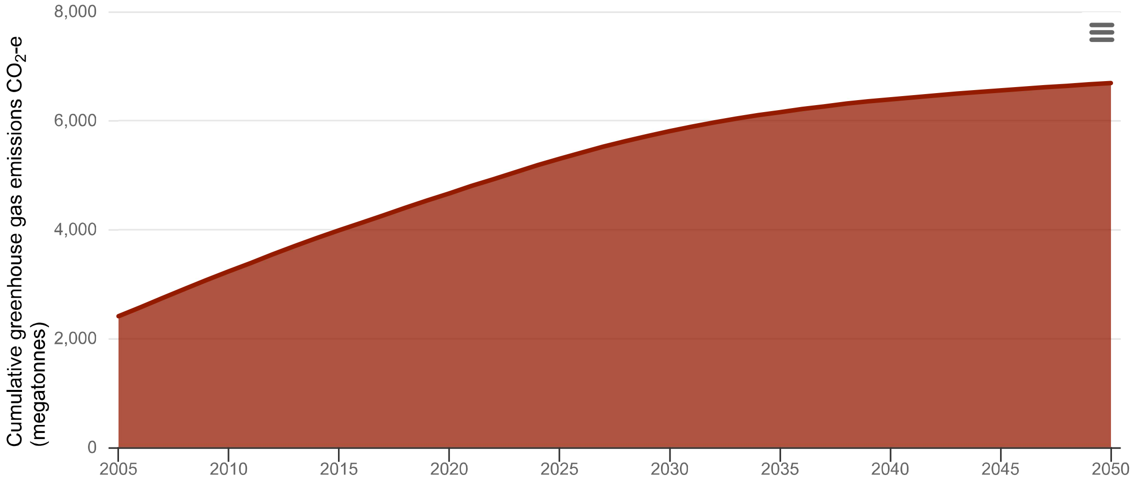
From 2005 to 2022, annual NSW net emissions have slowly decreased (see **Figure C3.2**). However, the cumulative emissions (running total of emissions over time) have rapidly increased (see **Figure C3.3**). They will continue to increase until net zero emissions are achieved.

Taking note of cumulative emissions is important because certain greenhouse gases like carbon dioxide and nitrous oxide drives climate change for a long time (**IPCC 2021a**). This means that even if future emissions were reduced, past emissions still affect global warming.

Cumulative emissions are also crucial to determining the ‘remaining carbon budget’, which is amount of carbon dioxide that can still be emitted while keeping global warming to 2°C (**IPCC 2021b**).

Current mitigation efforts tend to focus on arbitrary point-in-time targets compared to a baseline year. Impacts of climate change, such as warming temperatures and extreme weather, are projected to worsen over coming decades, highlighting the importance of early mitigation of greenhouse gas emissions where possible to stay within the remaining carbon budget and limit global warming.

Figure C3.3: Cumulative NSW greenhouse gas emissions, 2005–50



Notes:

Years shown are financial years and so cover the 12 months ending 30 June of that year.

Emissions are expressed as CO_2-e calculated from global warming potential values from the IPCC Fifth Assessment Report.

The cumulative emissions from 1990–2021 were calculated from the State and Territory Greenhouse Gas Inventories 2021 (**DCCEEW 2023**), which has data until financial year 2020–21. This dataset is the basis for NSW emissions modelling from 2022–50.

The cumulative emissions from 2022–50 were calculated from projected net emissions on the basis of the Net Zero Plan 'abatement as currently tracking' scenario, (defined in **Table C3.2**). Projections are updated annually.

Source:

DCCEEW-Aus 2023a | DCCEEW 2023

NSW greenhouse gas emissions projections by sector

On the basis of existing policies and initiatives, emissions from all sectors are projected by NSW DCCEEW to decline by 2030 relative to their 2005 levels, but to varying degrees. The projections under the 'abatement as currently tracking' scenario are summarised by sector in **Table C3.1**.

For the latest information on NSW emissions by sector, refer to the **NSW Net Zero Emissions Dashboard**.

Table C3.1: NSW greenhouse gas emissions projections under the 'abatement as currently tracking' scenario summarised by sector	
Sector	**2030 projections relative to baseline 2005 levels**
Stationary energy (electricity generation)	Projected to fall by about 73% owing to transition to renewable energy. Implementation of the **NSW Electricity Infrastructure Roadmap** will further increase renewable energy generation, delivery and storage. See the **Energy consumption** topic for more details.
Stationary energy (excluding electricity generation)	Projected to reduce by 32% as technologies that use fossil fuels are replaced with those that use electricity
Transport	Projected to reduce by only 5% and will become the highest source of emissions in NSW, overtaking the stationary energy (electricity generation) sector (see **Figure C3.4**). See the **Transport** topic for more details.
Fugitive emissions	Projected to reduce by 31%, but their proportion of NSW total emissions will increase (see **Figure C3.4**)
Agriculture	Projected to descrease in the short term (2025–30), with 25% reduction by 2030. Substantial reductions are not anticipated owing to a lack of technology-ready options to significantly reduce enteric fermentation methane emissions from livestock.
Industry processes	Projected to decrease in the short term (2025–30), with 21% reduction by 2030
Waste	Projected to reduce by 33% assuming targets in the **Waste and Sustainable Materials Strategy** are achieved
Land use, land use change and forestry (LULUCF)	Projected to marginally increase (as a carbon sink) by 2030 as emissions from grassland and cropland remain relatively stable while forest land sink slightly increases. Current policies are aimed at enhancing carbon sequestration of this sector to help offset emissions from other sectors.

Notes:
The projected net emissions are modelled by NSW DCCEEW. Projections indicate what future emissions in NSW could be under the assumptions underpinning the projection. They are dissimilar to forecasts, which predicts actual future events and changes.

The projected net emissions are based on the Net Zero Plan 'abatement as currently tracking' scenario (defined in **Table C3.2**). Projections are updated annually.

Source:
DCCEEW-Aus 2023a | DCCEEW 2023

Comparison of current and future contributions by sector

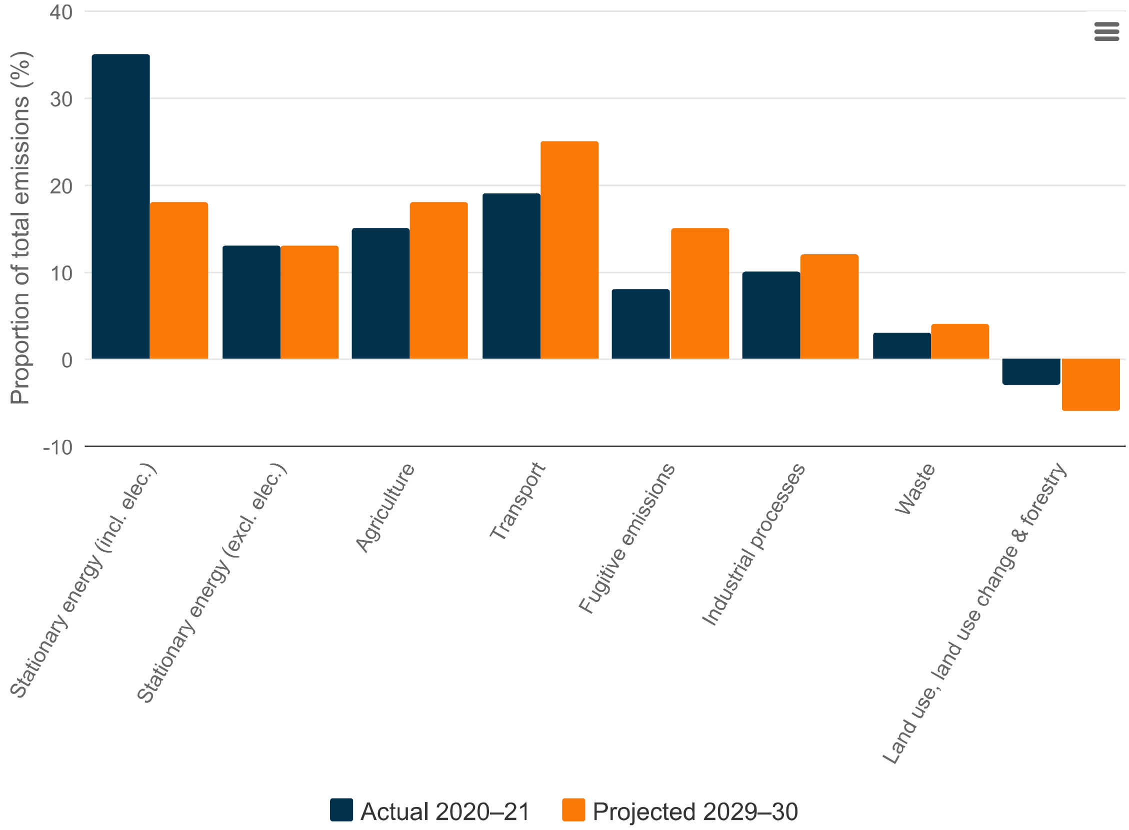
Viewing the projected emissions by sector shows a clearer picture of how much, proportionally, each sector could change and contribute to overall NSW.

Emissions from stationary energy (electricity generation) are projected to decline significantly as the electricity sector transitions to renewable energy (see **Figure C3.4**).

The transport sector is set to become the biggest contributor to NSW emissions by 2030, overtaking stationary energy (electricity generation).

Sectors with emissions that are hard to abate, such as fugitive emissions, agriculture, industrial processes and waste, are also expected to contribute a greater proportion of emissions by 2030.

Figure C3.4: NSW greenhouse gas emissions (Mt CO_2-e), historical (2020–21) and projected (2029–30) proportions by sector under the 'abatement as currently tracking' scenario



Notes:

Years shown are financial years and so cover the 12 months ending 30 June of that year.

Emissions are expressed as CO -e calculated from global warming potential values from the IPCC Fifth Assessment Report.

The sum of percentages shown above may not add to 100% owing to rounding.

The 2020–21 data presented here are drawn from State and Territory Greenhouse Gas Inventories 2021 (
DCCEEW 2023
). This dataset is the basis for NSW emissions modelling from 2022–50.

The projected net emissions are modelled by the NSW DCCEEW. Projections indicate what NSW future emissions could be under the assumptions underpinning the projection. They are dissimilar to forecasts, which predicts actual future events and changes.

The projected net emissions in 2029–30 are based on the Net Zero Plan 'abatement as currently tracking' scenario, (defined in **Table C3.2**). Work is underway to update the projections based on the basis of latest inventory data.

Source:
DCCEEW-Aus 2023a | DCCEEW 2023

Impact of the Net Zero Plan

Comparison of emissions projections scenarios

Emissions projections used to track progress under the Net Zero Plan are based on 'business-as-usual', 'abatement as originally designed' and 'abatement as currently tracking' policy scenarios.

Table C3.2: Definitions of ‘business-as-usual’, ‘abatement as originally designed’ and ‘abatement as currently tracking’ scenarios

Scenario	Definition
‘business-as-usual’	Accounts for factors affecting NSW emissions but excludes impacts of the Net Zero Plan
‘abatement as originally designed’	Uses the ‘business-as-usual’ scenario and adjusts the trajectory on the basis of designed reductions in current NSW and Australian Government policies. These include reductions through Stage 1 of the Net Zero Plan, **NSW Climate Change Fund** under Stages 2 and 3 of the Net Zero Plan, and related policies such as the NSW EPA’s **Climate Change Policy and Action Plan** and the **Commonwealth Safeguard Mechanism**. Projected emissions reductions under the Net Zero Plan also include reductions from a range of strategies and initiatives including the: • **NSW Electricity Infrastructure Roadmap** • **Net Zero Industry and Innovation Program** • ***NSW Electric Vehicle Strategy*** • ***NSW Waste and Sustainable Materials Strategy 2041*** *policies* • ***NSW Hydrogen Strategy***.
‘abatement as currently tracking’	Further adjusts the ‘as designed’ trajectory, reflecting uncertainties in expected emissions reductions of certain policies and programs

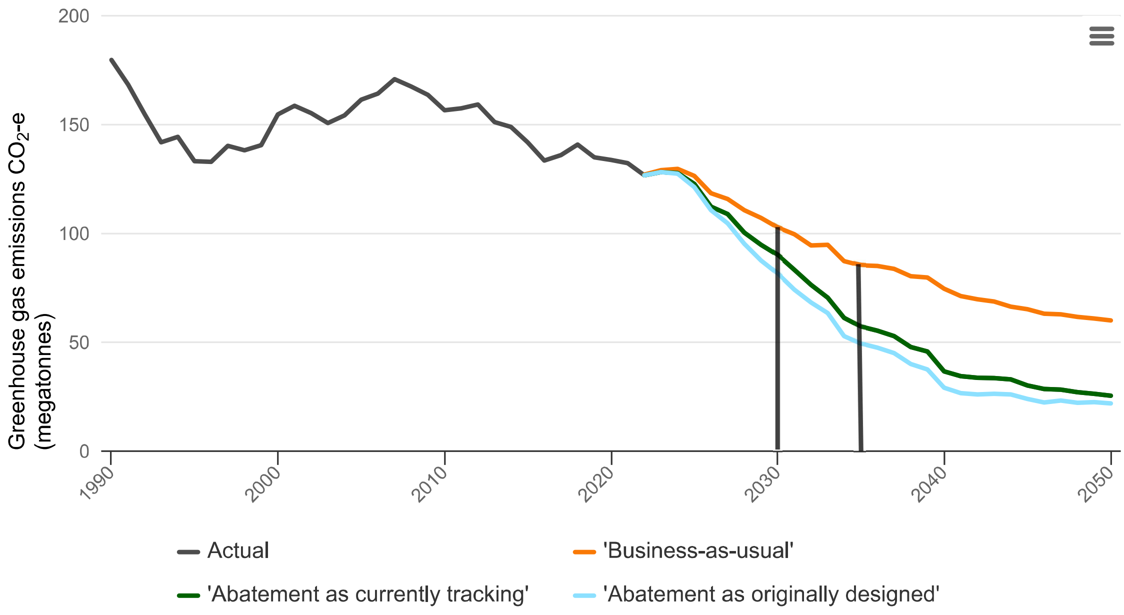
Source:
DCCEEW 2023

By 2030, the ‘business-as-usual’ scenario is projected to reduce net emissions by 58.7Mt CO_2-e or 36% relative to 2005 levels (see **Figure C3.5**). Reductions will be due mostly to the ongoing decarbonisation of the electricity generation sector. This move away from fossil fuels will not be enough to meet NSW targets.

The Net Zero Plan will further reduce emissions. Emissions reductions from existing programs and policies have been split into two scenarios:

- The ‘abatement as originally designed’ scenario is projected to result in a further reduction of 79.8Mt CO_2-e or 50% in annual emissions by 2030. The interim 2030 target will be met under this scenario.
- The ‘abatement as currently tracking’ scenario is projected to reduce emissions by 71.3Mt CO_2-e or 44% in annual emissions by 2030. The interim 2030 target may not be met under this scenario, given the Net Zero Plan’s current trajectory.

Figure C3.5: Comparison of 'business-as-usual', 'abatement as originally designed' and 'abatement as currently tracking' emissions projections



Notes:

Years shown are financial years and so cover the 12 months ending 30 June of that year.

Emissions are expressed as CO -e calculated from global warming potential values from the IPCC Fifth Assessment Report.

The historical net emissions presented here are drawn from State and Territory Greenhouse Gas Inventories 2021 (**DCCEEW 2023**), which has data until financial year 2020–21. This dataset is the basis for NSW emissions modelling from 2022–50.

The projected net emissions are modelled by NSW DCCEEW. Projections indicate what NSW future emissions could be under assumptions underpinning the projection. They are dissimilar to forecasts, which predicts actual future events and changes.

See **Table C3.2** for definitions of 'business-as-usual', 'abatement as originally designed' and 'abatement as currently tracking' projections.

The vertical lines indicate the years, 2030 and 2035, when NSW has set interim reduction targets of 50% and 70% reduction, respectively, on 2005 levels. Net zero emissions is targeted by 2050.

Source:

DCCEEW-Aus 2023a | DCCEEW 2023

For more information on projections under different scenarios, refer to the **NSW Net Zero Emissions Dashboard**.

Reaching net zero by 2050

Further investment is required to meet the State's net zero objective.

While technologies on the market today can offer immediate emission reductions, around 35% of the CO_2 emission reductions needed in 2050 must come from technologies that are still in development (**IEA 2023**).

This means that major innovation efforts will be required this decade to develop new technologies and bring them to market.

The next stages of the Net Zero Plan will be developed ahead of 2030 (stage 2) and 2040 (stage 3) to address this challenge.

The **NSW Decarbonisation Innovation Study**, developed by the Office of the NSW Chief Scientist and Engineer (**OCSE 2020**), will help guide the direction of NSW action beyond 2030. The study provides valuable insights into the opportunities for NSW to reduce emissions and capitalise on its competitive advantages to transition and grow the economy.

The latest edition of the study, published in November 2023, outlines 47 foundational and sector-specific opportunities to help NSW to continue evolving its approach to the net zero transition. Cross-sector opportunities enhance the effectiveness of decarbonisation initiatives, like infrastructure planning for growth in low-carbon technology and services.

Economic impacts

Net zero initiatives are expected to bring significant economic benefits to the State.

The implementation of the Net Zero Plan, together with the Electricity Infrastructure Roadmap, could result in more than 13,000 jobs by 2035. Up to $39 billion in private investment may also result from this work, the majority expected to be across regional NSW (**OECC 2022**).

The ***Climate Change (Net Zero Future) Act 2023*** ensures that economic outcomes are a priority of NSW action on climate change through the Net Zero Plan. The act notes among its guiding principles that action to address climate change should be taken in a way that:

- is fiscally responsible
- promotes sustainable economic growth
- considers the economic risks of delaying action to address climate change
- considers the impact on rural, regional and remote communities.

Other environmental benefits

Initiatives under the Net Zero Plan are expected to have additional environmental and human health benefits associated with renewable energy and carbon sequestration.

These include improvements in air quality, biodiversity and soil health. The NSW Government plans will develop metrics to measure and evaluate the environmental benefits of these initiatives.

Air quality

Air quality is determined by the types and amounts of pollutants emitted into the atmosphere.

Poor air quality can significantly affect human health, increasing the risk of chronic respiratory and cardiovascular disease and mortality (**WHO 2013**).

Major sources of human-generated air pollutants come from burning fossil fuels for energy generation, motor vehicles and industry. In 2013, motor vehicles accounted for 55% of Sydney's human-generated nitrogen oxide (NOx) emissions, 13% of volatile organic compound (VOC) emissions and 13% of particulate matter ($PM_{2.5}$) emissions (**NSW EPA 2019**).

See the **Air quality** topic for more about air pollutants and their health impacts.

Biodiversity and soil health

Protecting biodiversity and soil health now will safeguard our soils for future generations.

Climate change impacts will exacerbate the loss of organic carbon from soils and reduce agricultural productivity (**AdaptNSW n.d.**). The Net Zero Plan supports initiatives within the agricultural and land sectors to manage biodiversity and soil health while also reducing greenhouse gas emissions.

Carbon farming reduces atmospheric greenhouse gas levels by sequestering, or locking away, atmospheric carbon through vegetation and soils. It may also mitigate land degradation by retaining or enhancing native vegetation and improving groundcover.

Indicators have been developed to measure the condition of biodiversity and ecological integrity at state and regional scales through the **Biodiversity Indicator Program**.

Private entities in the agricultural sector are implementing frameworks for agricultural producers to assess and monitor the environmental condition of their farms (for example, **Meat and Livestock Australia's Environmental Credentials program**).

See the **Soil condition** topic for more information.

Status of initiatives

This section outlines how the following sectors are being transformed and tracks their performance across Net Zero Plan priority areas.

- Energy (see **Table C3.3**)
- Transport (see **Table C3.4**)

- Industry (see **Table C3.5**)
- Waste (see **Table C3.6**)
- Land use (see **Table C3.7**)
- Agriculture (see **Table C3.8**)
- Built environment (see **Table C3.9**)
- Government (see **Table C3.10**)

The updates presented in **Tables C3.3–9** pertain at the time of publication. The NSW Department of Climate Change, Energy, the Environment and Water (NSW DCCEEW) provides periodic **Implementation Updates**.

Table C3.3: Energy-related initiatives and implementation status

Status	Initiative
Being delivered *The first Renewable Energy Zone in Central-West Orana received planning approval in June 2024.* *Four more Renewable Energy Zones are in various stages of planning.*	The Net Zero Plan includes a range of lower emissions energy initiatives being delivered as part of the ***NSW Electricity Infrastructure Roadmap*** (**DPIE 2020b**). The roadmap supports the development of new electricity infrastructure in NSW. It will support the private sector to bring 12 gigawatts (GW) of renewable energy and 2GW of storage, such as batteries and pumped hydro, online by 2030. The roadmap will support the development of five **Renewable Energy Zones** in the Central-West Orana, New England, South West, Hunter-Central Coast and Illawarra regions of NSW. The first Renewable Energy Zone in Central-West Orana will initially unlock at least 4.5GW of new network capacity by the late 2020s and is expected to bring up to $20 billion in private investment to the region by 2030. At its peak, it is expected to support up to 5,000 construction jobs.
Being delivered *The Energy Savings Scheme has been operational since 2009, resulting in 48,000GWh of energy savings.* *The Peak Demand Reduction Scheme commenced in 2022.* *The Renewable Fuel Scheme will commence in 2026.*	The **Energy Security Safeguard** aims to improve the affordability, reliability and sustainability of energy in NSW. It includes the Energy Savings Scheme, the Peak Demand Reduction Scheme, and the Renewable Fuel Scheme. The **Energy Savings Scheme** is NSW's largest energy efficiency program. It is legislated to run until 2050. The scheme avoided emissions of about 23Mt CO_2-e from 2009–22. The **Peak Demand Reduction Scheme** commenced in late 2022 and creates incentives for activities that reduce electricity demand at peak times. Reducing peak demand improves the reliability and resilience of the electricity system. The **Renewable Fuel Scheme**, commencing in 2026, will provide financial incentives to produce renewable fuel such as green hydrogen.
Being delivered	Most energy initiatives so far are delivering outcomes that support Priority 1 of the Net Zero Plan which is to drive the uptake of proven emission reduction technologies. Other initiatives are designed to empower customers to make informed decisions about their energy use, which addresses Priority 2 of the Net Zero Plan. **Energy Saver** provides information about how households and businesses can switch to lower emission retailers and energy solutions that best fit their needs.

Notes:
Updates have been provided by NSW DCCEEW.

Source:
DPIE 2020b | DPIE n.d.

Table C3.4: Transport-related initiatives and implementation status

Status	Initiative
Being delivered *Rebates and stamp duty exemptions for EVs ran from 1 September 2021 to 31 December 2023.* *Development of a fast-charging network for EVs across NSW is in progress.*	The ***NSW Electric Vehicle Strategy*** (**DPIE 2021a**) was launched in June 2021, giving effect to the commitment to increase the uptake of electric vehicles (EVs). Targets include growing sales of new passenger and light commercial EVs to 52% of the market by 2031 and the vast majority by 2035. The strategy has several facets: • 100% of new NSW government passenger fleet vehicles to be electric by 2030, 50% by 2026. • A $105 million **EV fleets incentive program** uses a reverse auction process to provide incentives to increase EVs in council and private fleets. Three rounds of the program have been held so far, with Round 4 currently underway. • Investment of $149 million to ensure a widespread and world-class fast charging network across the state. **Fast charging grants** support private industry to build, own and operate fast charging stations across NSW. • **EV destination charging grants** provides funding of up to 75% of costs for installation of eligible alternating current and low power direct current chargers. The program is expected to co-fund the installation of approximately 1,500 charge ports at 600 sites across NSW at places such as motels, cafes, wineries and visitor information centres. As of October 2024, 660 charge ports at over 500 sites are already operational across regional NSW. • **EV kerbside charging grants** are supporting the installation of on-street chargers in local government areas with low access to off-street parking. Round 1 provides funding for over 650 charging ports at almost 400 sites. Round 2 is currently underway. • **EV ready buildings** scheme will co-fund upgrades to electrical infrastructure in about 100 medium and large apartment buildings. It is designed to support drivers who live in apartment buildings to be able to charge their vehicle at home. The first stage of the program was launched in mid-October 2023 and closed to new applicants in December 2023 owing to high demand high demand. The second stage of the program opened in August 2024 with applications undergoing assessment as of October 2024. EV rebate and stamp duty exemptions were available from 1 September 2021 until 31 December 2023. They entailed: • Rebates of $3,000 on sales of the first 25,000 EVs valued at under $68,750. About 15,000 rebates were provided as of October • Stamp duty exemption for EVs under $78,000. Almost 37,900 exemptions were provided as of October 2024 These initiatives are supporting Priorities 1, 2 and 4 of the Net Zero Plan by driving the uptake of proven emission reduction technologies, supporting consumers to make sustainable choices, as well as reducing government transport emissions.

Notes:
Updates have been provided by NSW DCCEEW.

Source:
DPIE 2021a

Table C3.5: Industry-related initiatives and implementation status	
Status	**Initiative**
Being delivered *Funds provided for various initiatives, including green hydrogen and clean technologies.* *Grant applications under the Net Zero Manufacturing Initiative are currently under assessment, with results expected in early 2025.*	The **Net Zero Industry and Innovation Program** was announced by the NSW Government in March 2021. This $750 million program focuses on supporting NSW industry and business to capitalise on the opportunities in the global transition to net zero (**DPIE 2021b**). The program has three focus areas: • **new low carbon industry foundations** lays the foundations for low emissions industries by building infrastructure and increasing the capability of NSW supply chains • **high emitting industries** supports existing, high-emitting industrial facilities in NSW to transition plant, equipment and other assets to low-emission alternatives • **clean technology innovation** supports the development and continued innovation of emerging clean technologies The Office of the NSW Chief Scientist and Engineer and the NSW Environmental Trust funded the **NSW Decarbonisation Innovation Hub** in June 2022 to support collaborations between researchers, industry and government. Since 2021, the program has: • reduced about 0.5Mt CO_2-e per year through the **Orica Tertiary Abatement Project**, which addressed nitrous oxide emissions from chemical manufacturing plants • funded 3 scoping studies to support high emitting manufacturing facilities in the aluminium, chemicals and agribusinesses develop options to decarbonise their operations • developed best-practice regional decarbonisation pathways for Hunter and Illawarra regions • made green hydrogen incentives available • awarded funding to establish hydrogen hubs across the state • introduced **GreenPower**, Australia's first green gas certification • awarded $15.9 million funding in Round 1 of the **Clean Technology Innovation** program for businesses and researchers to develop low-emissions technologies. In February 2024, the NSW Government launched the **Net Zero Manufacturing Initiative**. This includes funding for: • round 2 of **Clean Technology Innovation** (up to $25 million) that will support the commercialisation of emerging clean technologies • **Low Carbon Product Manufacturing** (up to $100 million), which will establish local industrial facilities and manufacturing capabilities for low carbon industries • **Renewable Manufacturing** (up to $150 million) that will increase local capacity to manufacture components for renewable energy projects, alleviating supply chain constraints and increasing the State's capability to support the Renewable Energy Zones and hydrogen hubs.

Status	Initiative
Being delivered *Hydrogen hubs will help decarbonise hard-to-abate sectors.*	The ***NSW Hydrogen Strategy*** is a plan to support industries and innovators to rapidly increase the scale and competitiveness of green hydrogen in NSW (**DPIE 2021c**). It provides up to $3 billion in support for the hydrogen industry through: • exemptions for green hydrogen production from government charges • a 90% exemption from electricity network charges for green hydrogen producers who connect to parts of the network with spare capacity • incentives for green hydrogen production. The strategy is expected to attract up to $80 billion of investment in NSW and to drive decarbonisation in hard-to-abate sectors like industry and transport. The **Net Zero Industry and Innovation Program** will help scale up hydrogen as an energy source and feedstock. As part of the **New Low Carbon Industry Foundations** stream, over $109 million has been allocated to develop **hydrogen hubs** in the Hunter, Illawarra and Moree regions. These hubs will combine demand from existing and emerging hydrogen users to deliver the fuel in a coordinated fashion that will drive scale, reduce costs, focus innovation and grow workforce skills. Their aim is to accelerate the growth of the State's clean hydrogen industry and unlock the heavy transport sector as a key new market for clean hydrogen demand. They aim to produce green hydrogen from 2026 onwards.

Notes:
Updates have been provided by NSW DCCEEW.

Source:
DPIE 2021b | DPIE 2021c

Table C3.6: Waste-related initiatives and implementation status

Status	Initiative
Being delivered *Delivery of various programs are underway.* *The target is net zero emissions from organic waste to landfill by 2030.*	The ***NSW Waste and Sustainable Materials Strategy 2041: Stage 1 2021–2027***, launched in June 2021, outlines actions to deliver on the NSW Government's long-term objectives to transition to a circular economy (**DPIE 2021d**). This $356 million strategy will help deliver priority programs and policy reforms that minimise waste and value resources while decarbonising the economy. Some features of the strategy include: • mandating the collection of food and garden organics for select businesses by 2025 and all NSW households by 2030, with $65 million to help with the transition • introducing regulatory measures to require gas capture and net zero emissions from landfills with $7.5 million invested in the installation of gas capture infrastructure • the $37 million **Carbon Abatement and Recycling Fund** to support innovative circular economy approaches to manage waste and materials more efficiently and reduce emissions. This includes the use of low-carbon recycled materials, trialling new approaches to reduce waste and improve recycling, help businesses co-locate in areas like the **Clean Manufacturing Precincts** and **Special Activation Precincts**, and support the recovery of biogas from organic waste materials. This strategy contributes to the Net Zero Plan Priorities 1 and 2 to drive the uptake of emission reduction technologies and empower consumers and businesses to make sustainable choices.

Notes:
Updates have been provided by NSW DCCEEW.

Source:
DPIE 2021d

Table C3.7: Land use-related initiatives and implementation status

Status	Initiative
Being delivered The NSW Government has awarded $6.8 million to six project partners in the primary industries and land sector to reduce emissions. Further grants will be offered in late 2024.	Through the **Primary Industries Productivity and Abatement Program**, the NSW Government is investing $105 million this decade to support farmers and land managers across the state to reduce their emissions improve their carbon management, and enhance biodiversity on their land alongside production (**DPIE 2024a**). The program will also support the sector to increase revenue by giving access to environmental markets, accelerating finance for natural capital and low carbon farming, and demonstrating environmental performance to consumers and the supply chain. Grant funding of $6.8 million has been awarded to six 'high impact partnerships' (**DPIE 2024b**).

Notes:
Updates have been provided by NSW DCCEEW.

Source:
DPI 2018 | DPIE 2024a | DPIE 2024b

Table C3.8: Agriculture-related initiatives and implementation status

Status	Initiative
Being delivered *A report on key findings of various primary industries research projects was published in 2023.* *Strategies to reduce methane from livestock was published in 2021.*	The NSW Primary Industries and Regional Development ***Climate Change Research Strategy***, supported by a $29.2 million investment from the **NSW Climate Change Fund**, provides insights to government, producers and industry of opportunities for timely and appropriate responses to the changing climate, carbon markets and energy opportunities (**DPI 2018**). A **report** published 2023 provides key findings of research projects under the strategy and recommendations for practical implementation (**DPI 2023**). **Strategies to reduce methane from livestock** and its effects on productivity and animal health was published in 2021 (**Almeida et al. 2021**).

Notes:
Updates have been provided by NSW DCCEEW.

Source:
Almeida, Hegarty & Cowie 2021 | DPI 2023

Table C3.9: Built environment-related initiatives and implementation status

Status	Initiative
Complete *Over 50 industry bodies have joined MECLA.*	Launched in early 2021, the **Low Emissions Building Materials Program** entailed partnership between NSW Government and industries to grow the demand for low emissions building materials such as 'green' steel and concrete. This will help to reduce embodied carbon, which refers to the greenhouse gas emissions generated in manufacturing and transporting materials and products used in construction (**DPIE 2021e**). In partnership with **World Wide Fund for Nature-Australia**, the **Materials Embodied Carbon Leaders' Alliance** (MECLA) was formed in April 2021. This alliance includes professionals from the building industry and government. Major suppliers and users of steel and concrete are participating to develop standards for low-emission alternatives. The program concluded in 2022. The alliance, funded and led by industry, remains in operation. The **Low Emissions Specifications** program is leading the development, trial and implementation of low carbon concrete specifications for select NSW government agencies and local councils.
Being delivered *NABERS continues to expand to accelerate the transition to net zero buildings.*	The **National Australian Built Environment Rating System** (NABERS) measures the energy, water, waste and indoor environmental impacts of buildings in Australia on a one to six-star rating scale (**NABERS 2024**). NABERS ratings are available in various sectors, including offices, apartments, shopping centres, hotels and data centres, public schools and retail stores. The NSW Government is investigating plans to increase the uptake of NABERS ratings for public schools and hospitals in NSW, as part of Priority 4 of the Net Zero Plan. Moreover, to help reduce emissions in the construction of new Australia's commercial buildings, NABERS has released **tools**, including an emissions factors database, to measure and analyse embodied carbon. These initiatives address Priority 2 of the Net Zero Plan by empowering consumers and businesses to make sustainable choices in designing and using the built environment.

Notes:
Updates have been provided by NSW DCCEEW.

Source:
DPIE 2021e | NABERS 2024

Table C3.10: Government-related initiatives and implementation status

Status	Initiative
Complete *60MW / 120MWh battery energy storage system in Riverina to support the NSW Government electricity contract.*	As part of a 10-year contract with Shell Energy, a 60 megawatts (MW) / 120 megawatt hours (MWh) battery energy storage system near Darlington Point in the Riverina commenced operations in October 2023 to help power schools, hospitals and government buildings across NSW (**Edify Energy 2023**).
Complete *The policy applies to projects that initiate a strategic business case after April 2025.*	The NSW Government's **Decarbonising Infrastructure Delivery Policy** (**Infrastructure NSW 2024a**) and accompanying **Embodied Carbon Measurement for Infrastructure Technical Guidance** (**Infrastructure NSW 2024b**) were released in April 2024 to help NSW Government agencies manage embodied carbon in public infrastructure projects. Infrastructure NSW worked with the Australian Department of Infrastructure, Transport, Regional Development, Communications and the Arts and other state jurisdictions to adapt the Measurement Guidance for national use.
Being delivered *Solar PV installations on government property are underway.*	Under the **NSW Government Resource Efficiency Policy**, all NSW Government agencies are required to achieve measures, targets and minimum standards to reduce energy and water use and improve waste management and air quality (**DCCEEW 2019**). The Net Zero Plan set a new target for government buildings to generate a total 126,000MWh of annual solar energy by 2024. As of 30 June 2023, over 100,000MWh of annual solar generation had been installed.
Being delivered *Circular design guidelines for the built environment were released in February 2023.* *The Choose Circular program has kicked off projects with 10 government agencies to date.*	The ***NSW Waste and Sustainable Materials Strategy 2041*** (**DPIE 2021d**) recognises the NSW Government's role in leading circular economy. It includes the following actions: • requiring NSW Government departments to preference the use of recycled material on an 'if not, why not' basis. This is action is supported by the $13 million **Circular Innovation Fund**, identifying opportunities to embed circular design principles in new NSW Government buildings, infrastructure and precincts. • requiring that all NSW Government-owned and leased buildings over 1,000 square metres obtain and publish a **NABERS Waste Rating** by 2026, to drive waste avoidance and recycling in government operations. The **Choose Circular program**, funded by the **Circular Innovation Fund**, aims to stimulate circular economy innovation and increase the uptake of recycled materials through NSW Government procurement.

Status	Initiative
Being delivered *More electric buses in Sydney.* *$33 million to transition government fleet to EVs.*	The Net Zero Plan identified commitments to transition the NSW public transport system to low emissions. Transport for NSW released its **Net Zero and Climate Change Policy** in October 2023, with a range of emissions targets including: • 100% renewable energy for the rail, light rail and metro train networks by 2025 • net zero operational and fleet emissions by 2035 • net zero embodied emissions by 2045 • net zero transport sector emissions by 2050 (**TfNSW 2023**). The **Zero Emission Buses Transition Plan** aims to replace NSW's 8,000-vehicle bus fleet with electric buses. This plan aims to complete the transition in Greater Sydney by 2035, in Outer Metropolitan regions by 2040 and in Regional NSW by 2047. The ***NSW Electric Vehicle Strategy*** (**DPIE 2021a**) commits $33 million to electrifying the NSW Government passenger fleet by 2030. It sets an interim target of 50% EV procurement by 2026. These initiatives are in line with Priority 4 of the Net Zero Plan for the NSW Government to lead by example on the road to net zero emissions.

Notes:
Updates have been provided by NSW DCCEEW.

Source:
OEH 2019 | Edify Energy 2023 | Infrastructure NSW 2024a | Infrastructure NSW 2024b | DPIE 2021a | TfNSW 2023 | DPIE 2021b

How we are keeping track

The status of initiatives in the Net Zero Plan have been reported in NSW State of the Environment since 2021. To track NSW's progress towards net zero, NSW DCCEEW produces annual state- and economy-wide emissions projections. Projections are updated annually, accounting for new inventory data as well as changes to market trends and abatement outcomes for programs and reported on the **Net Zero Emissions Dashboard**.

The reporting requirements will be reviewed after the current 2024 report with the Net Zero Commission. The Commission released its first **annual report** in late 2024, providing insights on the State's progress to net zero.

Various NSW Government agencies provided advice on NSW emissions projections, status of programs and initiatives, ongoing research and other relevant matters.

NSW DCCEEW will continue to provide annual emissions projections updates, reflecting changes in data and assumptions. This, along with program evaluations, may lead to improved understanding and adjustment of programs.

The Office of the NSW Chief Scientist and Engineer will continue to report on emerging technologies that reduce emissions and are commercially competitive through its **NSW Decarbonisation Innovation Study**. The **latest of these reports** was published in November 2023.

References

AdaptNSW n.d., Climate change impacts on our soils, AdaptNSW, accessed 23 August 2024

Almeida AK, Hegarty RS & Cowie A 2021, 'Meta-analysis quantifying the potential of dietary additives and rumen modifiers for methane mitigation in ruminant production systems', *Animal Nutrition*, vol. 7, no. 4, pp. 1,129–30, DOI: 10.1016/j.aninu.2021.09.005

Climate Council 2024, *Race to The Top: Australia's Clean Energy Momentum*, Climate Council of Australia

DCCEEW-Aus 2023a, National Greenhouse Accounts 2021: State and Territory Greenhouse Gas Inventory, Australian Government Department of Climate Change, Energy, the Environment and Water, accessed 15 October 2024

DCCEEW-Aus 2023b, *Australia's emissions projections 2023*, Australian Government Department of Climate Change, Energy, the Environment and Water, Canberra

DCCEEW-Aus 2024, State and Territory greenhouse gas inventories: 2022 emissions, Australian Government Department of Climate Change, Energy, the Environment and Water, accessed on 19 August 2024

DCCEEW 2019, *NSW Government Resource Efficiency Policy*, NSW Department of Climate Change, Energy, the Environment and Water, Sydney

DCCEEW 2023, NSW Greenhouse Gas Emission Projections, 2022−2050, accessed from The Sharing and Enabling Environmental Data Portal, NSW Department of Climate Change, Energy, the Environment and Water, Sydney

DPI 2018, Climate Change Research Strategy, NSW Department of Primary Industries, accessed 13 August 2024

DPI 2023, *Primary Industries Climate Change Research Strategy: Findings and recommendations*, NSW Department of Primary Industries, Orange

DPIE 2020a, *Net Zero Plan Stage 1: 2020–2030*, Department of Planning, Industry and Environment, Sydney

DPIE 2020b, *Electricity Infrastructure Roadmap*, Department of Planning, Industry and Environment, Sydney

DPIE 2021a, *NSW Electric Vehicle Strategy*, Department of Planning, Industry and Environment, Sydney

DPIE 2021b, *Net Zero Industry and Innovation Program*, Department of Planning, Industry and Environment, Sydney

DPIE 2021c, *NSW Hydrogen Strategy, Making NSW a global hydrogen superpower*, Department of Planning, Industry and Environment, Sydney

DPIE 2021d, *NSW Waste and Sustainable Materials Strategy 2041 – Stage 1: 2021–2027*, Department of Planning, Industry and Environment, Sydney

DPIE 2021e, Low emission building materials, Department of Planning, Industry and Environment, accessed 6 November 2024

DPIE 2024a, Primary industries productivity and abatement, Department of Planning, Industry and Environment, accessed 6 November 2024

DPIE 2024b, High impact partnerships, Department of Planning, Industry and Environment, accessed 6 November 2024

DPIE n.d., Energy Security Safeguard, Department of Planning, Industry and Environment, accessed 8 November 2024

Edify Energy 2023, *Darlington Point Energy Storage System: Lessons Learnt Report no.1*, Edify Energy Pty Ltd

IEA 2023, Reaching net zero emissions demands faster innovation, but we've already come a long way, International Energy Agency, accessed 28 October 2024

Infrastructure NSW 2024a, *Decarbonising Infrastructure Delivery Policy: Reducing Upfront Carbon in Infrastructure*, Infrastructure NSW

Infrastructure NSW 2024b, *Embodied Carbon Measurement for Infrastructure: Technical Guidance*, Infrastructure NSW

IPCC 2021a, 'Chapter 6: Short-lived Climate Forcers' in Masson-Delmotte V, Zhai P, Pirani A, Connors SL, Péan C, Berger S, Caud N, Chen Y, Goldfarb L, Gomis MI, Huang M, Leitzell K, Lonnoy E, Matthews JBR, Maycock TK, Waterfield T, Yelekçi O, Yu R, and Zhou B (eds), *Climate Change 2021: The Physical Science Basis, Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 817–922

IPCC 2021b, 'Chapter 3: Human Influence on the Climate System' in Masson-Delmotte V, Zhai P, Pirani A, Connors SL, Péan C, Berger S, Caud N, Chen Y, Goldfarb L, Gomis MI, Huang M, Leitzell K, Lonnoy E, Matthews JBR, Maycock TK, Waterfield T, Yelekçi O, Yu R, and Zhou B (eds), *Climate Change 2021: The Physical Science Basis, Contribution of Working Group I to the*

Sixth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 423–552

NSW EPA 2019, *Air Emissions Inventory for the Greater Metropolitan Region in New South Wales: 2013 Calendar Year*, NSW Environment Protection Authority, Sydney

NSW Government 2024, Emissions projections show NSW needs to redouble climate efforts to meet targets, Environment and Heritage, accessed 25 July 2024

NABERS 2024, *NABERS Policy Toolkit: Using NABERS to plan, procure, target and achieve better environmental outcomes in Australia's buildings*, National Australian Built Environment Rating System

OCSE 2020, *NSW Decarbonisation Innovation Study: Opportunities for prosperity in a decarbonised and resilient NSW*, Office of NSW Chief Scientist and Engineer, Sydney

OECC 2022, *Net Zero Plan Implementation Update 2022*, Office of Energy and Climate Change, NSW Treasury

TfNSW 2023, Sustainability – Respond to climate change, Transport of NSW, accessed 6 November 2024

WHO 2013, *Review of evidence on health aspects of air pollution – REVIHAAP project: Final technical report*, World Health Organization, WHO Regional Office for Europe, Copenhagen

People and industry

soe.epa.nsw.gov.au

This page intentionally
left blank

People and industry

Human settlement is our most heavily modified and intensively used environment. It presents specific challenges in the use of resources and services and the management of pollution and waste.

The topics in this theme describe how **energy consumption, transport, water use, waste and recycling** and **contaminated sites** impact the environment and human health.

Energy

Energy is critical to modern life. As our population grows it will be increasingly important to continue reduce our greenhouse gas emissions by transitioning to renewable energy sources.

Transport

Transport increasingly contributes to greenhouse gas emissions. As our population and economy grow, we must limit the impacts of motor vehicles and infrastructure.

Water use

Water is a vital resource for people and the environment. We must balance human demands with maintaining the health of the environment that provides the water we use.

Renewable energy sources provided about

34%

of the State's electricity generation in 2022–23

In 2022, the transport sector accounted for

21%

of all greenhouse gas emissions in NSW

Households use about

11%

of all the water used

Waste and recycling

Transitioning to a circular economy is more important than ever as our waste generation outpaces our capacity to manage its impacts on the environment, human health and the economy.

Contaminated sites

Some human activities lead to contamination of the soil or groundwater with harmful substances. We remediate sites where the contamination isn't safe for people or the environment.

Total waste generation increased by

19.7%

between 2015–16 and 2022–23 to 22.4 million tonnes

The EPA was notified of

25

significantly contaminated sites during 2021–23

Introduction to people and industry

All the elements have Lore, cultural Lore, right LORE.

The natural environment is changing there is less trees and shrubs more erosion and less place to go to find the bush. It's just really, really disappointing to see and know.

For us, as Aboriginal people, places we used to go and get traditional foods, just doesn't exist anymore. The environment can't sustain our gathering of food, medicines and hunting.

The human settlement expansion has impacted on our access to Country and continuation of our cultural practices

Energy consumption

Energy consumption is a critical aspect of modern life. It drives industrial processes, transportation and daily household activities.

Energy continues to be the largest source of greenhouse gas emissions in NSW. About 80% of our total energy comes from non-renewable sources, such as fossil fuels, coal and gas.

As our population continues to grow, industry electrifies and more people purchase electric vehicles, it will become increasingly important to keep growing the renewable energy sector. This will require transitioning to renewable energy sources (such as wind and solar) for electricity generation, transport and industry to achieve net zero emissions.

See the **Greenhouse gas emissions** and **Net Zero Plan Stage 1: 2020–2030** topics for more information.

Key findings from the 2024 report

- Declining overall energy consumption between 2020–21 and 2021–22 was dominated by a decline in transport energy consumption. It remains to be seen whether this was a result of COVID-19 lockdowns. Transport's share of energy increased in 2022–23.
- In 2022–23, there was a major increase in electricity share delivered by renewable energy generation. It comprised about 34% of the State's electricity generation.
- Residential energy use per capita in NSW increased by 2% between 2020–21 and 2022–23.
- Annual demand for electricity from the NSW grid declined by more than 14,000 gigawatt hours, or about 18% of total electricity demand, between 2008 and 2023. This was primarily driven by energy efficiency measures and the strong uptake of behind-the-meter rooftop photovoltaics.

Transport

Transport is one of the biggest sources of greenhouse gas emissions in NSW. This contributes to climate change and affects the health of our environment and communities.

International trends show a move away from fossil fuels. Many countries are seeing a significant uptake of electric vehicles. In Australia, there are more of these vehicles, but as a proportion of total vehicles sold, their number is well below where it needs to be.

Transport networks play a vital role in movement of people and goods. The infrastructure required to create networks, and the vehicles that use them, can have significant negative impacts.

As our population and economy grow, we must limit these impacts by moving away from non-renewable resources. We need to limit ecosystem destruction as we build infrastructure and plan for the increased temperatures as our climate changes.

Key findings from the 2024 report

- In 2022, road transport represented 89% (20.9 megatonnes) of the NSW transport sector's greenhouse gas emissions and 21% of all NSW emissions. This is related to continued reliance on private vehicles, a preference for SUVs and lack of electric freight vehicles.
- Uptake of electric vehicles is increasing but overall numbers remain low, at 0.8% (52,572) of all road vehicle registrations in January 2024. This is an increase of 753% since 2021 when only 6,160 electric vehicles were registered.
- There has been a 16% increase in motor vehicle registrations since 2016, which is twice the population growth rate over that period (7.7%).
- In 2023, vehicles on NSW roads travelled 74.8 billion kilometres. This was a 12% increase since 2004. There was a significant drop during the period of COVID-19 restrictions.
- In the five years to June 2023, wildlife volunteers conducted 62,116 native animal rescues were due to motor vehicle collisions. Of these, 73% (45,803) died.

Water use

Water is vital in our everyday lives and in the environment around us. We use it in our households, industries, food production, cultural practices and for restoring the environment.

Access to clean, safe and reliable water is fundamental to the health and wellbeing of all people, communities, cultures, animals and plants.

There is less water available for human use than most people think. Only 1% of all water on earth is freshwater. Of this 1%, an even smaller percentage of that is accessible for human consumption, as most of it is contained in glaciers and polar ice sheets.

Globally, 92% of all water used produces agricultural products, with about 4.4% used for industrial products and 3.6% for domestic use.

Effective management and monitoring of water resources is essential to balancing human demands and maintaining a healthy environment.

Key findings from the 2024 report

- Total water use in the State increased from about 3,332 gigalitres in 2019–20 to just over 5,820 gigalitres in 2021–22. This has been attributed to increased water availability and eased restrictions following good rainfall.
- Just over 4,000 gigalitres of environmental water were delivered to rivers and wetland habitats across NSW between 2021–22 and 2023–24. This is the most water in any three-year period in the last decade. In 2023–24 alone 1,781 gigalitres were delivered.
- Annual per property residential water consumption has decreased since 2005–06. This indicates households have adopted measures to reduce their water use. The reduction per household was partially offset by our increasing population.
- All but one utility provided 100% of their population with water that met the guidelines for chemicals and contamination with *E.coli* (Inverell achieved 99.9%).
- The NSW government is beginning to address systemic issues to improve recognition of Aboriginal rights and access to water by strengthening the role of Aboriginal people in planning, governance and decision-making.

Waste and recycling

Worldwide, as economies have grown over the past half century, so has the generation of solid waste.

Most waste is dumped or disposed of in landfill.

Globally, the percentage of recovered materials being recycled, reused or repurposed is declining.

Waste can negatively affect the environment and human health. It can leak pollutants into the air, water and land, which then impacts plants and animals, and can lead to health concerns for people.

There are also challenges with legacy waste and contamination on discrete Aboriginal communities and ongoing illegal dumping due to their remote settings and a lack of adequate waste and recycling services.

Managing waste and transitioning to a circular economy is more important than ever.

The circular economy means that rather than disposing of things after their use, materials are circulated again through reuse, repair, recycling and re-manufacture. This reduces landfill and the potential for harmful health effects. It can also improve the economy by creating jobs and reducing the demand for extraction of resources to create new materials.

Our waste generation will increase with growth in population, renewable energy projects and waste from extreme climate and weather events.

Key findings from the 2024 report

- Total waste generation in NSW rose from 18.7 million tonnes in 2015–16 to 22.4 million tonnes in 2022–23. This exceeded the pre-pandemic peak of 2018–19 by 72,000 tonnes. This was 1.4 million tonnes (7%) more than in 2021–22.
- On average, we generated 2.7 tonnes of waste per person in 2022–23. This was up from 2.4 tonnes in 2015–16.
- The amount of littered items in NSW is decreasing. This shows a continued decline since a peak in 2018–19 and a decline of 51% from 2021–22. This suggests we are on track to meet the NSW Government's target of a 60% reduction by 2030.
- Plastic litter also continues to decrease, with a 55% decrease between 2021–22 and 2022–23, exceeding the NSW Government target of a 30% decline for this type of litter by 2025.
- NSW recycles only 13% of its annual plastic waste from a total of 850,000 tonnes.
- The NSW Container Deposit Scheme *Return and Earn* has collected 15.2 billion containers since the scheme started in 2017. This resulted in the recycling of more than 1.08 million tonnes of material.
- Household waste is the most common form of waste illegally dumped in 2022–23 (61.6%).

Contaminated sites

Before European colonisation, the lands, waters and skies of what is now NSW were free of modern contaminants.

A contaminated site is a place where the soil or groundwater has been polluted by harmful substances. The level of contaminants usually exceeds what is considered safe for people and the environment.

Some substances are harmful at any level of contamination. This means that any exposure to them creates an unacceptable risk. Such substances include petrol, lead, PFAS and asbestos.

Aboriginal peoples are disproportionately impacted by contamination due to legacy contamination on discrete Aboriginal communities, poor Government housing practices in some communities and ongoing exposure to contaminants.

Many contaminated sites are only identified for remediation when the use of the land changes, such as an apartment development on a former industrial site. The contaminants could have been undetected for a long time. Identifying and managing these legacy contaminated sites will reduce the potential exposure for people and the environment.

Key findings from the 2024 report

- In NSW during 2021–23 the number of regulated contaminated sites remained stable. The NSW Environment Protection Authority (EPA) regulated about 202 sites per year in that period.
- In the same period, an average of six sites per year were assessed to be no longer significantly contaminated enough to require regulation. That meant the EPA ended regulation of those sites.
- The cumulative number of sites requiring regulation by the EPA continued to increase, reaching 406 by 2023.
- The cumulative number of sites where regulation by the EPA was ended continued to increase, reaching a total of 203 remediated sites by 2023.
- In 2023, lead blood levels exceeded the national limit in 74% of Aboriginal children and 37% of non-Aboriginal children aged one to four years in Broken Hill.

This page intentionally
left blank

Energy consumption

Energy powers our world, and NSW is driving the shift to clean energy and towards a net zero emissions goal.

Overview

Total NSW and ACT electricity generation increased by

4%

between 2018–19 and 2022–23 as the population continued to grow

Read more

Renewable energy sources provided about

34%

of the State's electricity generation in 2022–23

Read more

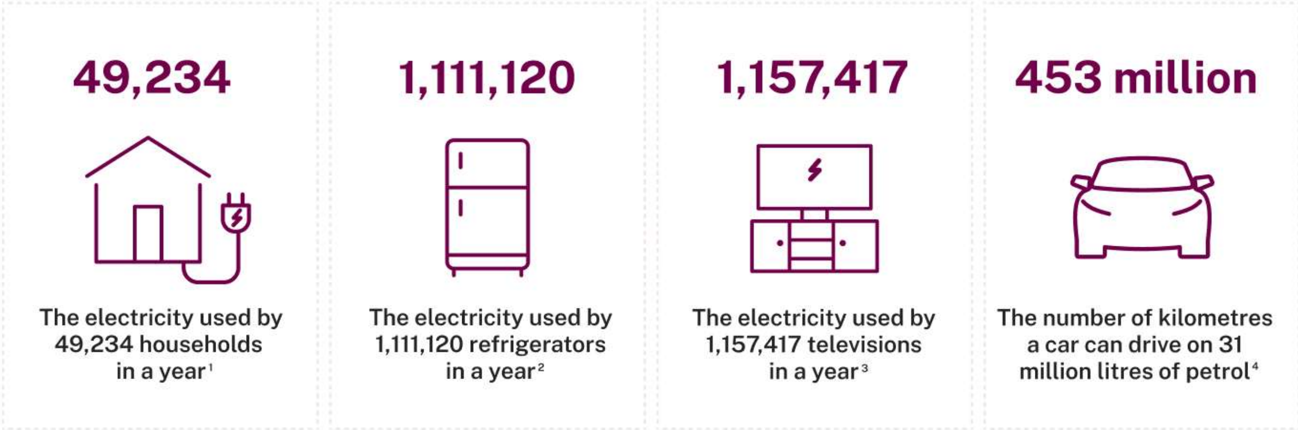
Energy underpins every aspect of our daily lives.

It's what we use when we turn on a light, when we cook a meal, when we drive our car. It's also what manufacturers need to run the equipment that makes products.

Because we're always using energy, we need to keep track of how much we use, what sources it's coming from and how these change over time.

Energy consumption for NSW is measured in petajoules (see **Image P1.1**). One petajoule (PJ) is 1 million gigajoules (GJ) or 277.8 gigawatt hours (GWh).

Image P1.1: Examples of energy use equating to 1 petajoule (PJ)



Notes:

Based on the average home using about 5.6MWh of electricity per year in 2022–23.
Based on a typical 3-star 400L fridge using 250kWh of electricity per year.
Based on a 55-inch, 6-star label television using 240kWh of electricity per year.
Based on a car consuming 7 litres of unleaded petrol per 100 kilometres.

Source:
AER n.d., calculated by DCCEEW | Energy Rating calculator n.d.

Energy in NSW

NSW has the largest economy, population and energy infrastructure estate in Australia.

This means we generate and use more energy than almost any other state in Australia. Queensland uses just a little more. Energy use in NSW accounts for about 25% of Australia's energy consumption.

Electricity versus energy

- Electricity is a type of energy, but there are also other sources of energy.
- Often the terms ‘energy’ and ‘electricity’ are used interchangeably. This is understandable given that we, as domestic consumers, mainly use electricity as the energy source in our homes.
- Currently, fossil fuels such as coal and gas (and other combustible materials) are burned to produce some of our electricity.
- The share of renewable generation (such as solar and wind) in the electricity mix is increasing. As this trend continues, electricity will increasingly form part of more energy use.
- Many industrial processes need a huge amount of heat. These processes currently use fossil fuels to produce that heat.

NSW consumed 1,439 petajoules (PJ) of primary energy in 2022–23 across all the different sectors of the economy.

In 2022–23, the overall mix of primary energy sources used in NSW was oil (44.3%), coal (36.9%), gas (9.7%) and renewable energy (10.0%).

Primary energy refers to the raw source of energy, such as coal, wood, and petroleum products, like oil and gas. Final energy, such as electricity, is the energy that is delivered to and used by end consumers after it has been converted from its primary form.

In 2022–23, petroleum products were mostly consumed by the transport (475PJ) and industrial (121PJ) sectors. Combined, this represented 56.2% of final energy consumption. The total final energy consumption for NSW in 2022–23 was 1,089PJ (**Figure P1.2**).

Other final energy consumed across the economy includes electricity from coal and gas (19.4%), natural gas (10.2%), coal (7.1%) and renewables (7.1%) (**DCCEEW-Aus 2024a**).

In 2022–23, about 34% of NSW electricity generation came from renewable sources. This included 18.6% from large-scale solar and rooftop solar photovoltaics 8.5% from wind power stations and 5.1% from hydro power stations.

Energy framework in NSW

The energy framework is a system of laws, policies, and regulatory bodies that govern the production, distribution and regulation of energy in NSW, including electricity, gas and renewable energy initiatives. Energy is managed by both state and national bodies in NSW.

NSW is part of the **National Electricity Market** (NEM). This is a system that allows electricity to flow, and be traded, across regions in Australia.

The NEM is underpinned by the National Electricity Law (***National Electricity (NSW) Law No 20a 1997***) and National Electricity Rules.

It is supported by energy market bodies, including the:

- Australian Energy Market Commission (AEMC)
- Australian Energy Market Operator (AEMO)
- Australian Energy Regulator (AER).

The NSW Independent Pricing and Regulatory Tribunal oversees the safety and reliability of the electricity transmission and distribution network in NSW.

Gas remains an important part of the energy mix in NSW. The operation of gas pipelines, supply and distribution to gas consumers in NSW is regulated by state legislation.

NSW is part of the East Coast Gas Market in which the wholesale gas market is governed by uniform legislation established under the **National Gas Law** and National Gas Rules.

This legislative framework is supported by the work of the AEMC, AEMO, AER and Australian Competition and Consumer Commission (ACCC). All these bodies play a role in promoting the efficient operation of gas markets in NSW.

The NSW Department of Climate Change, Energy, the Environment and Water (NSW DCCEEW) is driving the transition to renewable energy.

NSW DCCEEW is also responsible for the legislation and policies discussed in **Table P1.1**.

Table P1.1: Current key legislation and policies relevant to energy

Legislation or policy	Role
Electricity Infrastructure Investment Act 2020	Sets out the NSW Government's plan to decarbonise its electricity system. That is, eliminating or reducing carbon emissions as much as possible.
Electricity Supply Act 1995	Regulates the supply of electricity in the retail market, the functions of those engaged in the conveyance and supply of electricity and the management of electricity supply emergencies.
Energy and Utilities Administration Act 1987	Establishes the **Energy Corporation of NSW** (EnergyCo), which is responsible for delivering the **Electricity Infrastructure Roadmap** and **Renewable Energy Zones**.
Energy Security Corporation Act 2024	Establishes the Energy Security Corporation, seeded with $1 billion of capital, to co-invest with the private sector in clean energy technologies to accelerate the State's energy transition.
Gas Supply Act 1996	Regulates the supply and distribution of gas in NSW, ensuring safety, reliability and fair pricing for consumers.
Pipelines Act 1967	Regulates the construction, operation and maintenance of pipelines in NSW, ensuring safety, environmental protection and proper land use management.
Electricity Infrastructure Roadmap	Outlines a 20-year plan to integrate renewable energy into the energy-generation mix in NSW. The main goals are to replace coal-fired generators, enhance energy reliability and lower prices by establishing **Renewable Energy Zones**.
Energy Security Safeguard	Helps ensure the NSW energy system is more reliable, affordable and sustainable. It contains three schemes: **Energy Savings Scheme**, **Peak Demand Reduction Scheme** and **Renewable Fuel Scheme**.
Net Zero Plan Stage 1: 2020–2030	Outlines policies and actions for NSW to achieve net-zero emissions by 2030.
NSW Electric Vehicle Strategy	Sets out the NSW Government's plan to accelerate the State's uptake of electric vehicles.
NSW Hydrogen Strategy	Sets out the vision and path for developing a green hydrogen industry in NSW.

Notes:
See the **Responses** section for more information about how **Energy consumption** is being addressed in NSW.

The NSW energy institutional framework is also supported by the bodies listed in **Table P1.2**.

Table P1.2: Additional energy framework supports in NSW	
Body	Role
Australian Energy Regulator	Enforces the laws for the National Electricity Market, selected gas markets, and the retail energy market. It also sets prices for the use of energy networks and the maximum price that retailers can charge electricity on standing offer contracts (the Default Market Officer). It also undertakes a number of regulatory functions under the *Electricity Infrastructure Investment Act 2020* in relation to Renewable Energy Zones.
Consumer Trustee (AEMO Services Limited)	Independently issues a 10-year Tender Plan and 20-year Development Pathway and runs competitive processes for the timely construction of energy generation, long duration storage and firming infrastructure to meet legislated objectives in the long-term financial interests of electricity.
EnergyCo	The Energy Corporation (EnergyCo) of NSW is a statutory authority established under the *Energy Utilities and Administration Act 1987* and is responsible for leading the delivery of Renewable Energy Zones.
Energy Security Target Monitor	Calculates and sets a 10-year energy security target for NSW to ensure there will be a reliable supply of electricity available to meet electricity demands over the medium term.
Independent Pricing and Regulatory Tribunal	Helps NSW residents get energy services at a fair price. Regulates the Energy Security Safeguard schemes. It also provides certain regulator functions under the *Electricity Infrastructure Investment Act 2020.*
NSW Electricity Infrastructure Jobs Advocate	Advises the Minister for Energy on strategies and incentives to encourage investment, workforce development, employment, education and training in the energy sector. It also advises on road, rail and port infrastructure required to promote export opportunities for generation, storage and network technology.
Renewable Energy Sector Board	Helps make sure local workers, communities and industries share in the economic benefits of the transition to renewable energy.

Notes:
See the **Responses** section for more information about how **Energy consumption** is being addressed in NSW.

Related topics: Climate change | **Greenhouse gas emissions** | **Net Zero Plan Stage 1: 2020–2030** | **Population and the environment** | **Transport**

Status and trends

Energy indicators

Four indicators are used to assess the state of energy in NSW (see **Table P1.3**). They are:

- **Total NSW non-renewable energy consumption**: declined by 14.6% to a total of 66.4% between 2019–20 to 2022–23 (see **Energy use by fuel type and sector**).
- **Transport sector use of non-renewable energy**: increased to 483PJ in 2022–23 (see **Final energy use by sector**).
- **Renewable electricity generation in NSW**: increased by 4% to a total of 33.6%, between 2021–22 to 2022–23 (see **Renewable energy generation**).

- **Per capita residential energy consumption**: declined by 1.4GJ between 2011–12 and 2022–23 (see **Per capita energy consumption**).

Table P1.3: Energy consumption indicators

Indicator	Environmental status	Environmental trend	Information reliability
Total NSW non-renewable energy consumption	POOR	Stable	Good
Transport sector use of non-renewable energy	POOR	Stable	Good
Renewable electricity generation in NSW	MODERATE	Getting better	Good
Per capita residential energy consumption	MODERATE	Stable	Good

Notes:
NSW includes ACT as source data cannot be disaggregated.

Indicator table scales:
- **Environmental status**: Good, moderate, poor, unknown
- **Environmental trend**: Getting better, stable, getting worse
- **Information reliability**: Good, reasonable, limited.

See **Indicator guide** to learn how terms and symbols are defined.

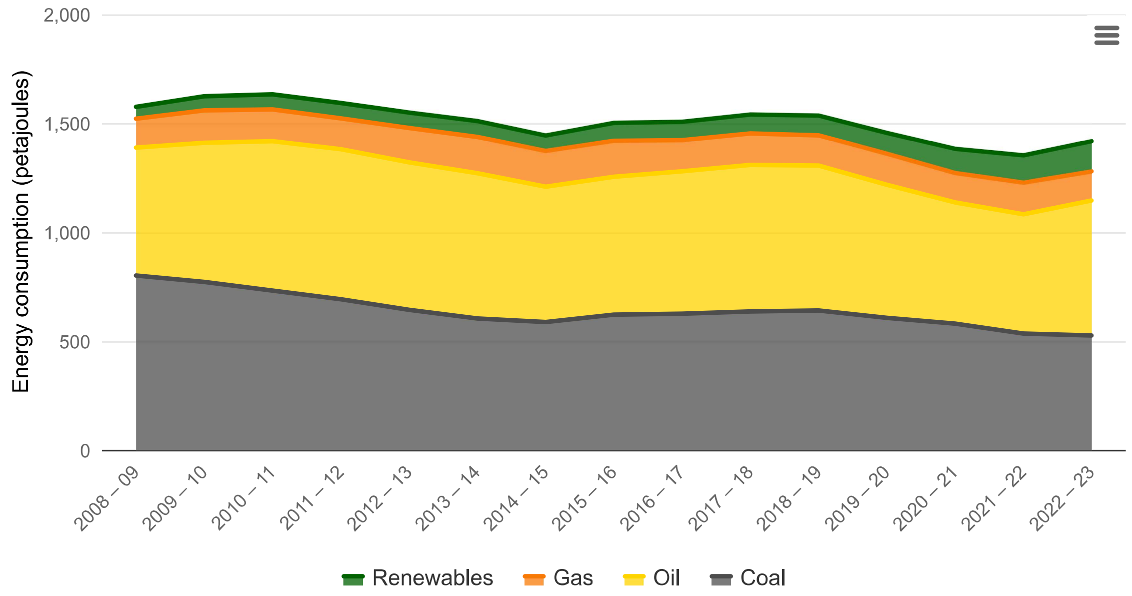
Energy use by fuel type and sector

Primary energy refers to energy in its natural, unprocessed form before it is converted or transformed for use.

Figure P1.1 shows that primary energy consumption has decreased since 2008–09 across all fuel types (coal, oil, gas and renewables). In 2008–09, total primary energy consumption was 1,594PJ and 1,439PJ in 2022–23.

Improvements in energy efficiency across industries and households have contributed to a reduction in overall energy demand.

Figure P1.1: Primary energy consumption by fuel type in NSW, 2008–09 to 2022–23



Notes:
Total net energy consumption is the total quantity (in energy units) of primary and derived fuels consumed less the quantity of derived fuels produced.
Petroleum products (final energy) are derived from oil (primary energy).

Source:
DCCEEW-Aus 2024a, Derived from Australian Energy Statistics, Table C

Final energy is the energy that is delivered to and used by end consumers after it has been converted from its primary form.

Figure P1.2 shows final energy consumption by sector and fuel type (petroleum, electricity, gas, coal and renewable sources) in NSW and the ACT in 2022–23.

In 2022–23, petroleum accounted for about 56.2% of final energy used. Transport sector was the major user of petroleum (475PJ), followed by the industrial sector (121PJ).

Electricity use increased to 19.4% of energy used. Total electricity use has increased slightly (213PJ in 2022–23 versus 204PJ in 2018–19). This may largely be due to population growth.

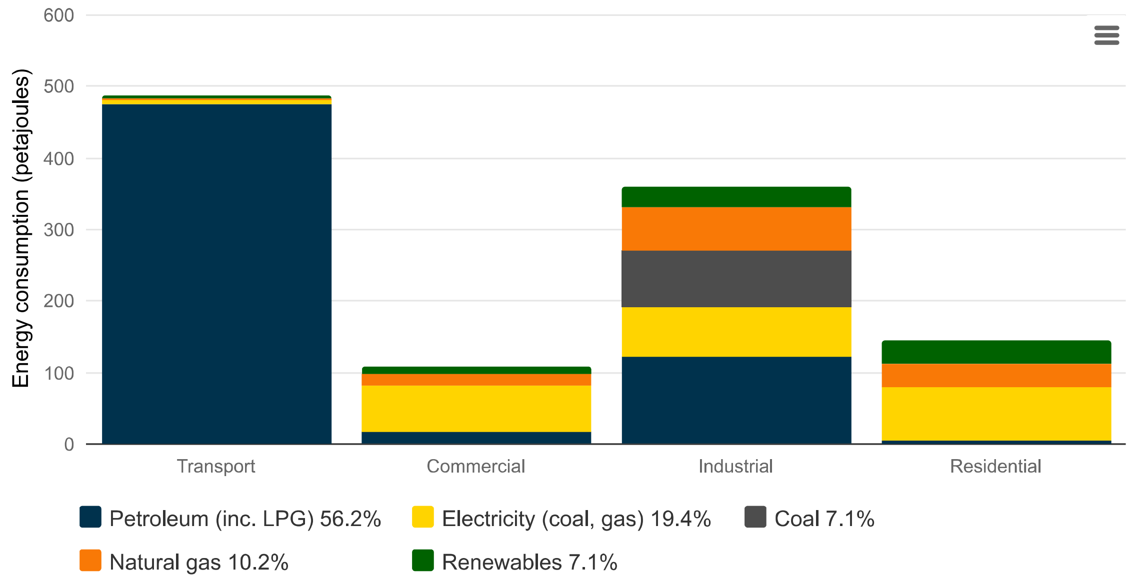
Renewable energy use in final consumption remained the same, at 78PJ, between 2018–19 and 2022–23. This largely represents the use of biomass (organic matter), wind, solar and hydroelectric power.

In 2022–23, coal use accounted for about 7.1% of consumption. Natural gas use was 10.2% (excluding coal and gas used for electricity generation).

The industrial sector is one of the main users of coal (along with coal to generate electricity). Coal is used to generate heat as part of manufacturing processes. Total coal use by the industrial sector declined from 126PJ in 2015–16 to 78PJ in 2022–23.

The industrial sector is also the largest user of gas, mostly as a raw material input. Total use of gas stayed flat at 112PJ between 2018–19 to 2022–23.

Figure P1.2: Final energy consumption for each sector by fuel type in NSW and the ACT, 2022–23



Notes:
Data re-analysed by NSW Department of Climate Change, Environment, Energy and Water to avoid double-counting and better allocate energy use to sectors.
Final consumption figures exclude waste heat losses in power plant facilities, conversion losses in refineries and network losses from the transmission of electricity over long distances.
Consumption by the electricity generation sector is not shown.
Coal consumption figures exclude coal inputs to electricity generation.
Natural gas consumption figures exclude gas inputs to electricity generation.
Renewable energy figures quoted include biomass (including biofuels), solar and hydroelectricity.
Industrial energy consumption excludes coal by-products.
Reported sub-category changes between versions of Australian Energy Statistics Table F means that calculated chart data is lower than in *State of the Environment 2018*.

Source:
DCCEEW-Aus 2024a, Derived from Australian Energy Statistics, Table F

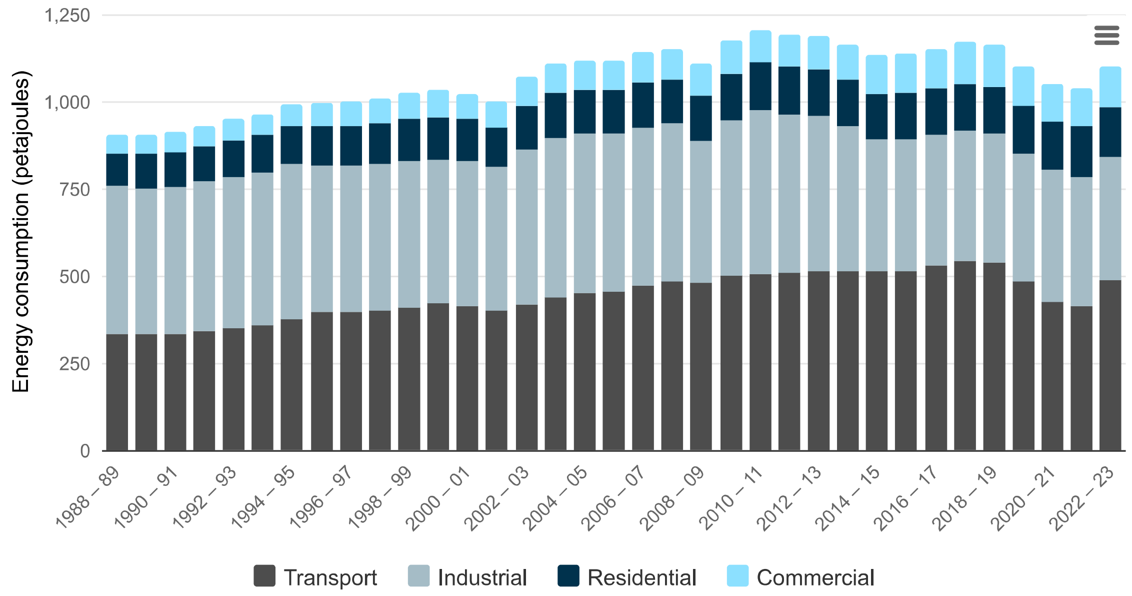
Final energy use by sector

Energy consumption in NSW and the ACT rose from the early 1990s until 2010. This was followed by a subsequent decline over the next decade, with minor fluctuations.

Final energy consumption decreased by about 5.6% in the last decade, from 1,163PJ in 2013–14 to 1,038PJ in 2022–23, with a small increase in the past 3 years.

Figure P1.3 shows the trends in final energy consumed per sector for the NSW and ACT economies.

Figure P1.3: Final energy consumption by sector in NSW and the ACT, 1993–94 to 2022–23



Notes:
Data is shown for NSW plus the ACT, as source data cannot be disaggregated.
Industrial sector includes agriculture, mining and manufacturing.
Commercial sector includes general commercial, construction and water, sewerage and drainage industries.

Source:
DCCEEW-Aus 2024a, Derived from Australian Energy Statistics, Table F

In the period 1993–94 to 2022–23, energy consumption by the:

- transport sector increased steadily, from 357 to 487PJ
- industrial sector fell from 440 to 354PJ
- residential sector increased from 106 to 144PJ
- commercial sector almost doubled from 60 to 112PJ.

In 2022–23, the transport sector continued to be the highest energy user (44.3% of the total), compared to the industrial sector (32.3%), residential sector (13.1%) and commercial sector (10.3%).

In comparison, in 2013–14 the energy share of transport was 43.9%.

Transport's share of energy use has increased from last financial year. This may be due to post COVID-19 increased travel. However, this is uncertain and further data and analysis are needed to make that determination.

Per capita energy consumption

Between 2011–12 and 2022–23, increases in energy efficiency and changes in usage patterns have offset the increase of the NSW population. This has allowed our total consumption per capita of energy to decrease slightly (see **Table P1.4**).

Table P1.4: Energy consumption in NSW and the ACT, 2011–12 to 2022–23

Financial year	Population	Consumption (PJ)	Per capita consumption (GJ)	Residential consumption (PJ)	Per capita residential consumption (GJ)
2011–12	7.6	1,189.8	155.9	135.5	17.8
2012–13	7.7	1,188.1	153.7	135.3	17.5
2013–14	7.8	1,163.2	148.4	134.9	17.2
2014–15	8.0	1,135.4	142.8	130.2	16.4
2015–16	8.1	1,137.0	140.9	129.9	16.1
2016–17	8.2	1,150.0	140.1	133.1	16.2
2017–18	8.3	1,169.8	140.3	132.8	15.9
2018–19	8.5	1,160.0	137.1	134.0	15.8
2019–20	8.6	1,102.5	128.8	135.8	15.9
2020–21	8.6	1,051.0	122.9	138.6	16.2
2021–22	8.6	1,037.9	120.4	146.3	17.0
2022–23	8.8	1,098.0	124.8	144.2	16.4

Source:
DCCEEW-Aus 2024a, Derived from Australian Energy Statistics, Table B | ABS 2024 population data

Residential consumption per capita also includes residential solar generation. Residential electricity generated may be exported to the wider grid as well as consumed by households.

Between 2011–12 and 2022–23, the population of NSW increased by more than 12% or about a million people.

Over the same period, per capita energy consumption fell about 16%, with total and residential energy consumption decreasing by about 5%. The sudden increase in residential consumption between 2020–21 to 2021–22, is most likely due to COVID-19 related lifestyle changes. With more people working from home, it means greater likelihood of household appliances, heating and cooling systems being in regular use.

Between 2020–21 to 2022–23, per capita energy consumption has increased by 2%, but remains below previous highs.

Electricity demand and electrification

In the past 15 years (2008–23), annual demand for electricity from the NSW grid has declined by more than 14,000 gigawatt hours. This is the equivalent of about 18% of total electricity demand in the period.

The reduced demand was primarily driven by energy efficiency measures and the strong uptake of behind-the-meter rooftop solar.

Electricity consumption is forecast to increase significantly in coming years. This will be the result of population growth, commercial and industrial electrification, and the uptake of electric vehicles.

There are two drivers for this predicted increase:

- It is often now cheaper and more efficient to use electricity rather than other forms of energy. More consumers will switch to electricity as technologies, such as electric vehicles, heat pumps for air and water heating, and induction cookers become more common and affordable.

- The electricity system is transforming into one that is cheap, clean and reliable. This means that electrification will support the achievement of the State's emissions reduction targets.

Clean electricity, generated from renewable sources, such as solar and wind means we can phase out burning fossil fuels to generate electricity. Electricity can be used as a replacement for other fuels in places like:

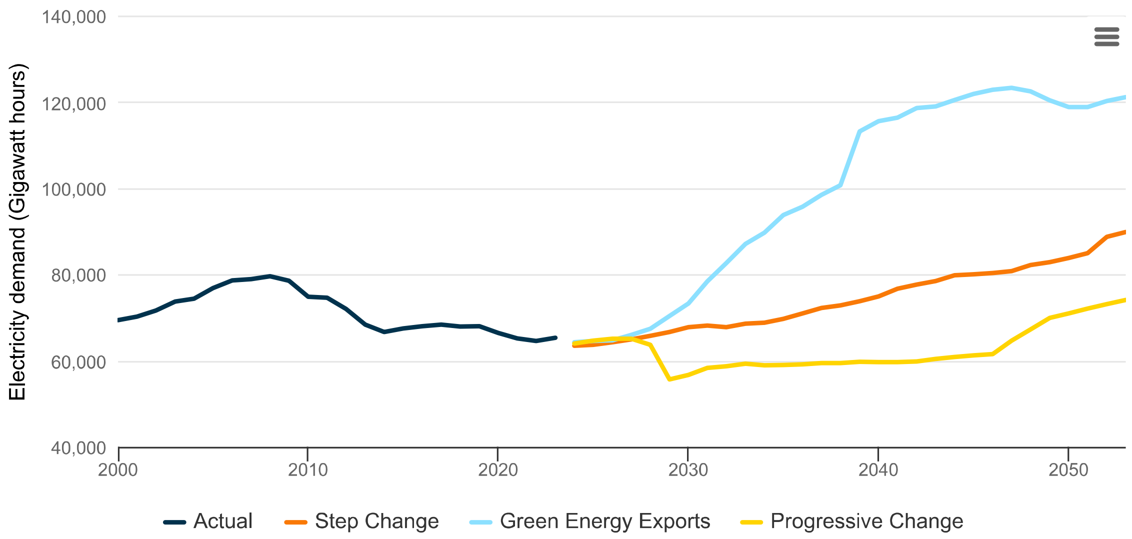
- transport via electric vehicles
- heating and cooling via efficient electric heat pumps
- industrial heating via electric furnaces.

Electrification is already starting to take place in households and industries and is expected to accelerate.

The size of the increase will depend on how fast these changes occur (see **Figure P1.4**).

The only forecast scenario where electricity demand might not increase in the short term is the 'progressive change' scenario where the Tomago aluminium smelter is assumed to close in 2029. This smelter is the largest electricity user in NSW.

Figure P1.4: Historical and forecast grid electricity consumption in NSW and the ACT, 2000–2053



Notes:
Data is shown for NSW plus the ACT, as source data cannot be disaggregated.
For information on forecasting scenarios, refer to the Australian Energy Market Operator (AEMO) 2023–24 Inputs, Assumptions and Scenarios Report (AEMO 2023).

Actual change: This is the real electricity demand in the period.
Step change: This is the most likely scenario. Key drivers are growth in electrification of business, residential and transport sectors; continued uptake of Consumer Energy Resources including distributed photovoltaics; and emerging hydrogen production for primarily domestic use.
Green energy exports: This scenario reflects very strong decarbonisation activities. These include strong use of electrification and development of green hydrogen exports and biomethane. They would cause a large increase in electricity demand.
Progressive change: This is the slowest scenario to meet Australia's current Paris Agreement commitment. It closely follows the 'step change' scenario until 2030. Factors that slow it down include slower electrification and electric vehicle uptake and lower hydrogen production. This scenario also includes large industrial load closures, including Tomago in 2029–30.

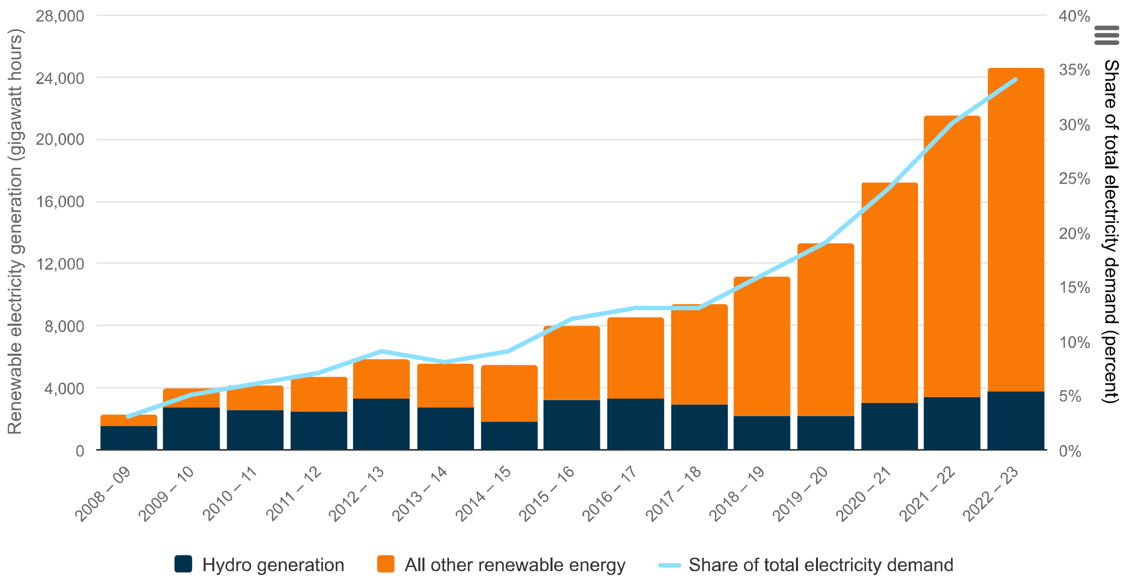
Source:
AEMO 2024b

Renewable energy generation

In 2022–23, renewable fuel sources provided about 34% of the State's total electricity generation. That is more than three times what they provided in 2013–14 (see **Figure P1.5**).

Figure P1.5 does not include energy supplied by household solar hot water heating. In 2021–22, that energy provided an estimated supply of about 4.9PJ. That is equivalent to 1,361GWh.

Figure P1.5: Renewable fuel sources for NSW electricity, 2008–09 to 2022–23



Source:
DCCEEW-Aus 2024b, Derived from Australian Energy Statistics, Table O

Between 2013–14 and 2022–23, wind generation grew from 899GWh to 6,211GWh. Over the same period, solar photovoltaic generation increased from 975GWh to 7,498GWh.

In 2022–23, combined wind and solar photovoltaic generation exceeded 17,300GWh. It supplied almost 27% of the State's total electricity demand.

Bioenergy generation (burning of plants, biogas and other organic material) has declined slightly since the *State of the Environment 2021*.

Bioenergy electricity sources include bagasse (sugar cane waste) and landfill gas. In 2022–23, bioenergy sources generated 992GWh of electricity. In 2020–21, they generated 1,097GWh.

Cost of renewable energy

Renewable energy comes from natural sources, such as sunlight and wind, which are naturally occurring unlimited resources.

Renewable energy is crucial for reducing pollution and combating climate change, as it helps lower greenhouse gas emissions and lessens reliance on expensive fossil fuels.

Embracing renewable energy also supports a cleaner, more sustainable environment for the future.

Renewable generation costs have decreased over time due to improvements in:

- technology
- efficiency
- supply chains
- workforce skills.

When combined with very low operating costs, renewable generation has become more cost-effective than fossil fuel-generated sources.

The levelised cost of electricity is a measure of the average cost of electricity produced by a generator over its lifetime.

According to the most recent **CSIRO GenCost 2023–24 report**, the levelised cost of electricity cost range for variable renewable energy (solar photovoltaics and wind) with integration costs is the lowest of all new-build technologies in 2023 and 2030. The cost range overlaps with the lower end of the cost range for existing (sunk cost) coal and gas generation.

Looking ahead, the prices for renewable energy are forecast to continue falling (**CSIRO 2024**). In contrast, the cost of coal is expected to remain stable or gradually increase due to ongoing power station maintenance expenses. This trend underscores the continuing economic viability of renewable energy sources over traditional fossil fuel generation.

Pressures and impacts

Climate change

Globally, it is expected that climate change will result in higher energy consumption by 7–17% by 2050, driven in part by increased demand for cooling (**IEA 2022**).

In NSW, it is less clear what impact climate change will have on energy consumption.

Warmer temperatures in winter months will lead to lower heating requirements for households and businesses.

In summer months, higher temperatures are expected to lead to greater cooling demand.

In NSW, the days when people need to run cooling technologies (such as air conditioners) are the peak demand days and when the most electricity is used.

Climate change may mean that the maximum amount of electricity we use on any given summer day will increase over time.

Climate change concerns are also leading to a fundamental reshaping of energy demand in non-electricity sectors, such as transport and heavy industry.

The move to electrified transportation and industrial processes will shift energy demand in these sectors from largely fossil fuel and petroleum-based to electricity.

There will be increases in electricity demand due to climate change, population growth and sectoral transitions. This underscores the importance of an increased focus on energy demand-side measures to accompany new renewable electricity generation.

For example, measures can include energy efficiency improvements, smart metering and time of use pricing. This minimises peak-demand pressures on the electricity system.

Transport and fuel demand

Transport is the second largest source of emissions, especially from motor vehicles, which are a major source of air pollution, particularly in urban areas.

Public transport, including trains and buses, offers a more efficient and lower-emission alternative to private vehicles. Public transport plays a crucial role in reducing overall transport emissions.

Rail infrastructure is also key in transporting bulk goods over long distances. This supports more sustainable practices and reduces dependence on road transport. Despite this, trucking remains dominant due to its versatility and ability to access locations without a rail line.

Most vehicles in NSW are fuelled by petrol or diesel. Under the *Biofuels Act 2007*, the State has set targets for 6% of petrol and 2% of diesel sold to come from ethanol and biodiesel, respectively.

Fuel efficiency standards are set by the Australian Government. These standards will be further strengthened with the **New Vehicle Efficiency Standard**, which is proposed to begin on 1 January 2025.

The growing availability and affordability of electric vehicles present an opportunity to increase the use of renewable energy in the transport sector.

Electric vehicle adoption continues to rise. Battery electric vehicles comprised 7.2% of new Australian passenger vehicle sales in 2023 (**FCAI 2024**).

See the **Transport** topic for more information on electric vehicles in NSW.

Infrastructure transition

As NSW moves away from reliance on fossil fuels, supporting measures must be implemented to respond to exiting coal-fired generation. These measures are needed to ensure the integrity and reliability of the grid while renewable sources and transmission capacity come online (**EnergyCo 2023a**).

Coal-fired power stations were a reliable source of power for many generations but are now ageing and scheduled to close. They are expensive to operate and maintain, and have become less reliable. This increases the price we pay for electricity.

As coal-fired power stations close for good, we need to be ready to meet our future energy needs.

Three out of the four coal-fired power stations, supplying about two-thirds of the State's electricity, are scheduled to close by 2033. The first closure will be **Eraring power station**. It is NSW's largest coal-fired power station, supplying 18% of the State's current electricity needs. It is set to close in mid-2027.

The stations set to close are being replaced by renewable energy sources. These include sources developed under the **NSW Electricity Infrastructure Roadmap**.

The transition to renewable energy sources is well underway.

NSW has abundant solar and wind resources. These natural advantages are being harnessed.

Firmed renewables have replaced coal as the most affordable source of new build electricity.

A firmed renewable is a renewable electricity source (such as solar or wind) that is backed by storage (such as a battery) to ensure consistent and reliable electricity supply.

More people are installing systems to return energy to the grid. Electric vehicle uptake is forecast to increase. The profile for electricity use is changing.

So too is the way battery storage is used. Increasing support or adaptation is needed for the changes in these systems as the electricity grid was originally designed to operate as a **one-way power-delivery system** with large energy generators, such as coal-fired power stations, delivered electricity via poles and wires to homes and businesses.

As population expands, so does the demand for housing, transportation and services, driving-up electricity usage.

To meet the growing demand, investment in renewable electricity, energy efficiency measures and grid modernisation must continue to develop.

Some concern remains about whether the existing electricity infrastructure can cope with the added energy sources. For example, it could be a challenge to integrate large amounts of residential solar and battery systems into a network that was not built to support it. A variety of solutions, such as community batteries, demand management and time-of-day charging, are being explored to manage this potential risk.

See the **Moving away from fossil fuels** section of this topic for more information.

Responses

Responding to a changing climate

The **NSW Climate Change Policy Framework** guides the NSW Government's policy and programs to achieve the State's objectives to:

- achieve net-zero emissions by 2050
- make NSW more resilient to a changing climate.

The ***NSW Net Zero Plan*** builds on the framework by supporting a range of initiatives to reduce emissions from energy consumption. These initiatives include the:

- **NSW Electricity Infrastructure Roadmap**

- ***NSW Electric Vehicle Strategy***
- **NSW Hydrogen Strategy**
- **NSW Net Zero Industry and Innovation Program**.

See the **Net Zero Plan Stage 1: 2020–2030** topic for more information on these initiatives.

The ***NSW Climate Change (Net Zero Futures) Act 2023*** was passed in November 2023. It puts the framework objectives into legislation

The Act sets a clear path to net zero by enshrining three emission reduction targets:

- a 50% emissions reduction on 2005 levels by 2030
- a 70% emissions reduction on 2005 levels by 2035
- net zero emissions by 2050.

The decarbonisation of energy across all sectors – particularly electricity, transport and heavy industry – will be the biggest driver to meeting the State's emissions-reduction commitments.

The framework's adaptation objective supports efforts to reduce energy consumption. It does this by working to ensure actions to adapt to climate change support the State's emissions-reduction targets, rather than conflict with them.

An example of this could be managing the impacts of extreme heat through passive design measures. This could have the co-benefit of minimising peak-demand pressures and electricity consumption.

The Electricity Infrastructure Roadmap

The **NSW Government's Electricity Infrastructure Roadmap** is delivering the power network the State needs now and in the future. The upgrades will deliver more clean, affordable and reliable electricity.

As it steadily moves away from coal, NSW will be powered by a mix of renewable technologies. These include:

- rooftop solar
- household batteries
- solar and wind projects
- large-scale electricity storage, such as pumped hydro and big batteries.

Released in 2020, the roadmap is a 20-year plan supporting the delivery of at least 12GW of new renewable electricity generation and two gigawatts and 16GWh of long-duration storage by 2030.

Planning and coordination of energy infrastructure roll out

One of the cornerstones of the roadmap is the delivery of at least five **Renewable Energy Zones** (REZs) across NSW.

REZs have been selected for their abundant renewable energy resources.

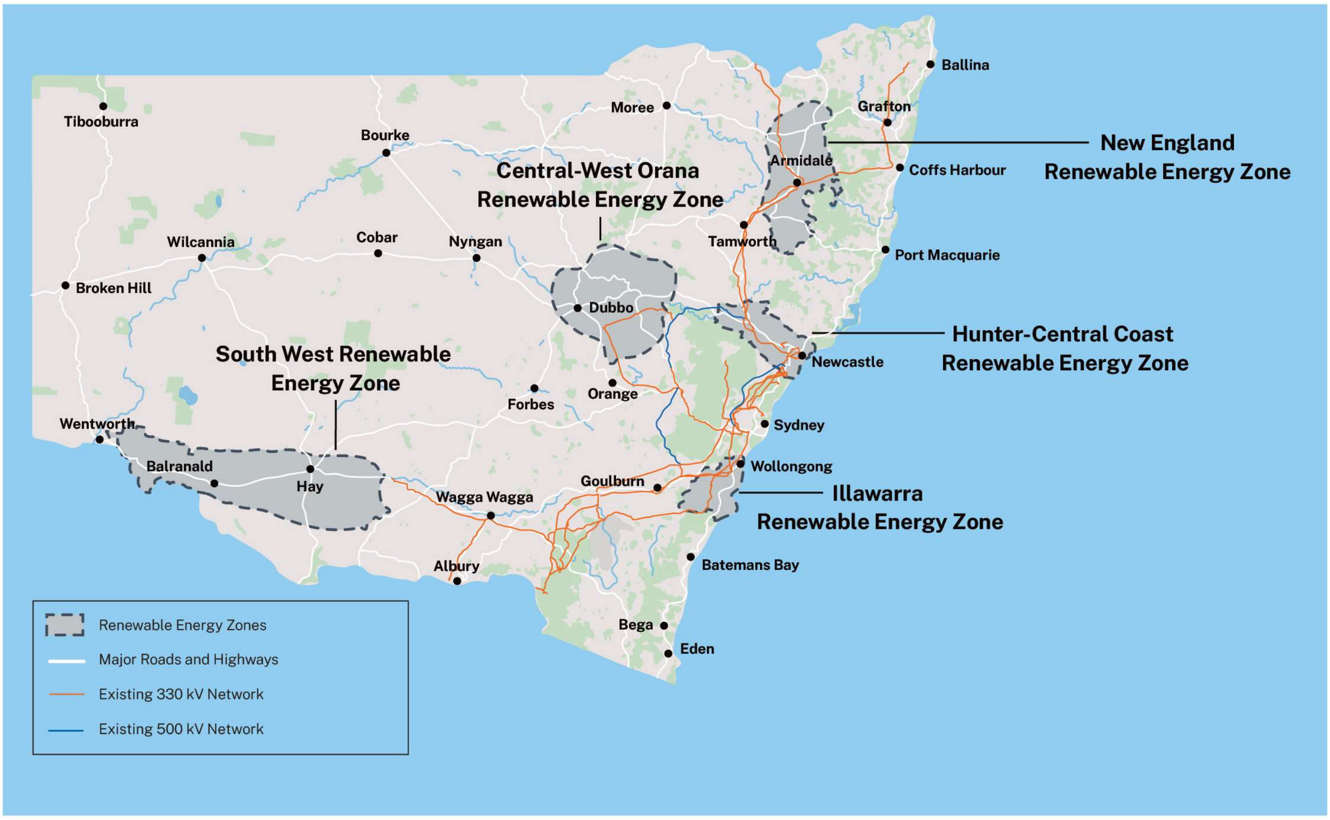
REZs combine:

- renewable energy generation, such as wind and solar
- storage, such as batteries
- network infrastructure, such as high-voltage poles and wires.

Five REZs have been declared: Central-West Orana, New England, Hunter–Central Coast, South West and Illawarra.

The Energy Corporation of NSW (EnergyCo) has been appointed as Infrastructure Planner to coordinate the delivery of the REZs (see **Map P1.1**).

Map P1.1: NSW Renewable Energy Zone locations



Source:
EnergyCo 2023b

Transmission is a critical enabler for:

- modernising the energy grid
- transporting clean, renewable energy from generating and storage assets, from load centres and across jurisdictions.

Projects such as Hunter Transmission Project, HumeLink and Project EnergyConnect will play a key role in improving the State's transmission capacity.

The ***NSW Network Infrastructure Strategy*** and the Infrastructure Investment Objectives Report seek to coordinate the development of the State's electricity infrastructure. This includes transmission options.

The NSW Government is building supporting infrastructure to modernise the electricity grid with batteries around the State. These include the **Waratah Super Battery**. This is a backup electricity storage system. It is designed to act as a 'shock absorber' in the event of sudden power surges. These power surges may be caused by bushfires or lightning strikes, for example.

Moving away from fossil fuels

In response to the transition away from fossil fuels, the NSW Government is leading the development of the **Orderly Exit Management Framework**. It is doing this on behalf of the Energy and Climate Change Ministerial Council.

The objective of the framework is to ensure an orderly energy market transition. This will be achieved by ensuring that scheduled thermal generators are not retired before replacement infrastructure is in place.

Gas

Nearly all Australian gas is exported, which occasionally leaves insufficient supply for Australia.

During the energy transition, gas may play a role in firming the electricity grid and providing an energy source in sectors that are hard to abate (**IGCC 2022**).

Gas faces strong competition from batteries, pumped hydro, demand management and time-of-use tariffs.

The State's demand for gas is projected to decline. The decline in gas demand will not match the decline in gas supply for the entire East Coast Gas Market. Shortfalls are projected from 2025 (**AEMO 2024a**).

Energy Ministers across jurisdictions have agreed to national reforms, including providing additional powers to energy market bodies to manage gas supply adequacy and reliability risks.

The reforms are supported by a Gas Code of Conduct and Heads of Agreement between the Australian Government and liquefied natural gas exporters. These create measures to supply the domestic Australian gas market before exporting.

Alternative fuels

The NSW Government is considering options for supporting the development and use of other renewable fuels in NSW.

The **Sustainable Aviation Fuel Prospectus** outlines the opportunities that a sustainable fuel aviation fuel industry could bring to NSW.

Hydrogen

The ***NSW Hydrogen Strategy*** was released in 2021. It sets out the pathway to becoming a global leader in green hydrogen.

Implementation of the strategy is underway. It provides up to $3 billion of incentives through 60 industry development actions. These actions recognise the critical role of hydrogen in decarbonising sectors that are hard to abate and serves as the building blocks for many renewable fuels.

Key actions of the strategy include the **NSW hydrogen hubs initiative** and production incentives.

NSW hydrogen hubs initiative

The NSW Government has awarded $109 million of grant funding to three hydrogen hub projects. With an anticipated production capacity of 700 megawatts by 2030, these hubs are critical to decarbonising emissions-intensive industries. These industries are mostly in the chemicals sector, such as ammonia and metals.

Production incentives

Producers can sell green hydrogen at a lower cost by taking advantage of **a range of electricity concessions** and the **Renewable Fuel Scheme**. These incentives are intended to significantly reduce the cost of green hydrogen production.

The NSW Decarb Hub

Established in June 2022, **the NSW Decarb Hub** supports the Net Zero Plan. Funding from the NSW Government through the Office of the Chief Scientist and Engineer and the NSW Environmental Trust, the hub is co-hosted by the University of NSW and the University of Newcastle. It is supported by other leading universities across NSW.

The hub supports and accelerates the Net Zero Plan by facilitating and supporting projects within its three networks:

- Land and Primary Industries
- Electrification and Energy Systems
- Powerfuels, including Hydrogen.

Acting on local community needs

Renewable Energy Sector Board

The Renewable Energy Sector Board was established in February 2021 under the *Electricity Infrastructure Investment Act 2020*.

The board helps make sure local workers, communities and industries share in the economic benefits of the transition to a more affordable, clean and reliable electricity system.

The board has developed a plan for the NSW renewable energy sector to achieve objectives for the construction of generation, storage and network infrastructure in a cost-effective way. These objectives include:

- the use of locally produced and supplied goods and services
- employment of suitably qualified local workers
- opportunities for apprentices and trainees.

The board also advises the Minister for Energy and Electricity Infrastructure Roadmap-delivery entities on how to support:

- the growth and competitiveness of the NSW renewable energy sector
- jobs for NSW workers.

Workforce for the energy transition

Australia's energy transition is gaining pace. This means it is crucial to have a sufficiently large and skilled workforce.

The Australian Electricity Workforce for the 2022 Integrated System Plan: Projections to 2050 is reported by the **Institute for Sustainable Futures** and Australian Energy Market Operator and funded by **Reliable, Affordable, Clean Energy (RACE) for 2030**.

The report estimates the workforce needed for this transformation.

It offers projections across various scenarios, including Australia's potential as a renewable energy exporter and the impact of offshore-wind targets.

The report also provides guidance on workforce development to maximise regional and national benefits, stabilise the industry and support effective policy making.

Engaging with Aboriginal communities

The NSW Government is committed to genuine and meaningful engagement with local Aboriginal communities in the implementation of the Electricity Infrastructure Roadmap.

The **First Nations Guidelines** set out the expectations for consultation and negotiation with local Aboriginal communities and their aspirations for increasing employment and income opportunities in the construction and operation of new electricity infrastructure projects under the roadmap.

There are two parts to the guidelines: general guidelines and region-specific guidelines:

- General guidelines provide information about best practice engagement with local Aboriginal communities.
- Region-specific guidelines support the general guidelines for each of the five Renewable Energy Zones.

Each region-specific guideline is co-developed with representatives from the local Aboriginal communities, with assistance from Aboriginal consultants, to ensure that:

- engagement and consultation are culturally appropriate
- content is community driven and relevant to the needs and opportunities of the region's Aboriginal people and businesses.

Monitoring the needs of the energy system

The NSW Government has appointed the Australian Energy Market Operator (AEMO) as the **Energy Security Target Monitor** under the *Electricity Infrastructure Investment Act 2020*.

Under the appointment, the AEMO's role is to calculate and set a 10-year energy security target for NSW. This ensures there will be a reliable supply of electricity that meets demand.

The AEMO is also responsible for assessing and monitoring whether the firm capacity (generation, firming and storage and transmission capacity) is sufficient to meet the energy security target under different scenarios.

The Energy Security Target Monitor lets the energy market know how much new infrastructure the NSW Government expects will be required to meet the State's energy needs.

The Energy Security Target Monitor Report is regularly updated. It shows the amount of reliable electricity needed in NSW to service maximum consumer demand. For example, the report would accommodate a summer heatwave plus a buffer.

Partnerships

Partnering with the private sector

The independent Consumer Trustee is running competitive tenders according to a 10-Year Tender Plan to recommend **Long-Term Energy Service Agreements** to project developers.

These agreements incentivise construction of enough renewable energy generation, long duration storage and firming infrastructure to meet a 20-Year Development Pathway. The agreements are designed to provide revenue certainty for private investors once operating, which helps secure finance for project construction.

Committed projects and roadmap tenders mean that half of the minimum required 12GW of renewable electricity generation and around a quarter of the 2GW of long-duration storage required by 2030 are locked in.

This investment will bring more renewable electricity into the grid, which will put downward pressure on electricity prices.

Partnership with the private sector is also being facilitated through the establishment of the Energy Security Corporation (ESC). The *Energy Security Corporation Act 2024* established the ESC as a state-owned body to co-invest with the private sector to accelerate investment in clean energy projects that improve the reliability, security and sustainability of electricity supply and help NSW meet its emissions reduction targets.

The ESC is intended to make its first investments in 2025–26.

Partnering with the Commonwealth

The NSW Government is partnering with the Commonwealth to deliver the energy transition.

In December 2022, the NSW and Commonwealth Governments announced their Rewiring the Nation deal. The deal is valued at $7.8 billion.

The deal will fast-track eight critical transmission and Renewable Energy Zone projects in NSW. These projects are:

- Sydney Ring – Hunter Transmission Project
- Central-West Orana Renewable Energy Zone
- New England Renewable Energy Zone
- HumeLink
- Victoria to NSW Interconnector West
- Hunter–Central Coast Renewable Energy Zone
- Sydney Ring – Southern Sydney Ring
- South-West Renewable Energy Zone.

Through the **Capacity Investment Scheme** (CIS), the Australian Government is underwriting up to 23GW of variable renewable energy generation capacity and 9GW of clean dispatchable capacity nationally.

The CIS pilot was delivered in 2023 in partnership with the NSW Electricity Infrastructure Roadmap. The CIS supported an expansion of NSW Roadmap's Tender 2 for Firming Infrastructure. Originally seeking projects delivering at least 380MW, with CIS support eventually six successful projects were announced capable of dispatching 1,075MW of capacity into the network at short notice. Two projects delivering 480MW of this capacity were supported by the CIS.

On 6 November 2024, the Commonwealth confirmed it would underwrite a further 7.1GW of renewable electricity generation capacity and at least 1.3GW (5.2GWh) of clean dispatchable capacity in NSW through subsequent CIS tenders. Through the tenders the Commonwealth is targeting projects capable of reaching commissioning by 2030 to support the achievement of its target of reaching 82% renewable electricity by 2030.

Delivering this additional capacity in NSW will put downward pressure on wholesale electricity prices, support reliability, and support the achievement of NSW's legislated targets for delivering renewable energy generation and emissions reductions.

The NSW and Commonwealth Governments are also partnering on measures to address energy affordability.

In January 2024, the Commonwealth and NSW Governments jointly announced a $206 million package to deliver long-term cost-of-living savings to 30,000 NSW households. The package will fund energy-saving upgrades in social housing properties and access to solar for renters and apartment dweller.

This will allow residents to reduce their energy bills.

Partnering with energy consumers

The **Energy Savings Scheme** provides businesses and households with financial incentives to implement energy-saving activities. The scheme is legislated to run until 2050.

Activities implemented under the scheme between 2009 and 2022 will deliver about 48,000GWh of energy savings and $11.9 billion in energy bill savings by 2033.

Higher energy-saving targets were legislated for the Energy Savings Scheme in 2021.

The **Peak Demand Reduction Scheme** commenced in 2022 and is legislated to run to 2050. It provides incentives for households and businesses to undertake activities that reduce electricity demand during peak times.

Reducing peak demand improves the reliability and resilience of the energy system as well as affordability.

It is estimated to deliver $1.2 billion in energy bill savings for households and businesses across NSW by 2040.

Future opportunities

Consumer Energy Strategy

The NSW Government released a new ***Consumer Energy Strategy*** in 2024.

The goal is to help households and businesses access benefits of energy saving technology, such as household batteries and energy efficient appliances. The strategy will:

- keep energy bills low
- help achieve net zero emissions
- make the energy system more reliable
- ensure everyone can benefit from, and participate in, the energy transition.

Strategic Benefit Payments Scheme

As coal-fired power power stations retire it becomes increasingly critical to build the new electricity infrastructure needed in time to ensure energy security, reliability of supply and affordability.

Under the **Strategic Benefit Payments Scheme**, private landowners in NSW may receive annual payments for hosting transmission infrastructure associated with certain new major high-voltage transmission projects.

This includes Renewable Energy Zone network infrastructure projects. It also includes priority transmission projects and other transmission projects identified in the **Australian Energy Market Operator's Integrated System Plan**.

The payments are a set rate of $200,000 (in real 2022 dollars) per kilometre of transmission hosted. It is paid out in annual instalments over 20 years.

Supporting innovation and employment opportunities

In February 2024, the NSW Government announced $275 million in grants under the **Net Zero Manufacturing Initiative**. This aims to secure NSW as the place to develop and manufacture clean technology and create new jobs in the process.

As part of the Net Zero Manufacturing Initiative, up to $150 million was made available for renewable manufacturing to increase NSW's capacity to make the components needed for renewable energy projects. The goal was to alleviate supply chain constraints and increase local content capability.

The initiative will focus on technologies that are already lab proven and the manufacturing of market-ready products that are ready to be scaled up and rolled out across NSW. This will support the State's five Renewable Energy Zones and hydrogen hubs, giving them access to more materials produced in NSW.

To ensure the energy regulatory framework is fit for purpose for the energy transition, the NSW Government continues to modernise the legislative and regulatory framework for the safety and technical regulation of the gas network and pipelines.

This includes adjusting for future changes in pipeline use, such as transporting hydrogen and other renewable fuels.

Long duration storage

Long-duration storage serves an important role as it allows renewable electricity, such as solar and wind, to be stored and then dispatched when needed for extended periods. When constructed the NSW based Snowy 2.0 (2,200 megawatts and 350,000 megawatt hours) will be one of the largest pumped hydro facilities in the world.

Long Duration Storage technologies are varied and can also **include** batteries, compressed and liquid air storage and other emerging technologies. For some years now, the **Emerging Energy** and **Pumped Hydro Recoverable Grants Programs** have been supporting the commercialisation of Long Duration Storage projects in NSW.

The *Electricity Infrastructure Investment Act 2020* takes a technology neutral approach to meeting NSW's long duration storage needs. Regular competitive tenders for Long-Term Energy Service Agreements are incentivising construction of projects that store electricity that can be dispatched for at least eight hours.

The Consumer Trustee has held two tenders for long duration storage, collectively the projects that have been awarded long term energy service agreements will deliver 4,592 megawatt hours of storage to NSW. Results of a third tender are expected early 2025, and a fourth tender round is expected to open May 2025.

References

ABS 2024, National, State and territory population, Australian Bureau of Statistics, accessed 28 October 2024

AEMO 2023, *2023 Inputs, Assumptions and Scenarios Report*, Australian Energy Market Operator

AEMO 2024a, *2024 Gas Statement of Opportunities*, Australian Energy Market Operator

AEMO 2024b, *2024 Electricity Statement of Opportunities (ESOO)*, Australian Energy Market Operator

AER n.d., Networks performance reporting, Australian Energy Regulator, accessed 28 November 2024

CSIRO 2024, *GenCost 2023–24 report*, Commonwealth Scientific and Industrial Research Organisation

DCCEEW-Aus 2024a, *Australian Energy Statistics 2024 Energy Update Report*, Australian Government Department of Climate Change, Energy, the Environment and Water, Canberra

DCCEEW-Aus 2024b, *Australian Energy Statistics, Table O Electricity generation by fuel type 2022–23 and 2023*, Australian Government Department of Climate Change, Energy, the Environment and Water, Canberra

EnergyCo 2023a, *NSW Network Infrastructure Strategy*, Energy Corporation of NSW, Dubbo

EnergyCo 2023b, *Renewable Energy Zone Locations*, Energy Corporation of NSW, Dubbo

Energy Rating calculator n.d., Find and compare energy – efficiency appliances, Australian Government Energy Rating, accessed 20 November 2024

FCAI 2024, *Australia breaks all-time new vehicle sales in 2023*, Federal Chamber of Automotive Industries, Kingston

IEA 2022, *Climate Resilience for Energy Security*, International Energy Agency, accessed 8 July 2024

IGCC 2022, *Changing pathways for Australian gas: A 1.5°C scenario analysis of new Australian gas projects*, Investor Group on Climate Change, Sydney

This page intentionally left blank

Transport

While greenhouse gas emissions from transport remain high due to the dominance of road transport, efforts to transition towards electric and active transport are gathering pace.

Overview

In 2022, the transport sector accounted for

21%

of all greenhouse gas emissions in NSW

Read more

Electric vehicles made up

0.8%

of light vehicles on NSW roads as at January 2024

Read more

Transport networks play a key role in allowing people and goods to get from one place to another. These networks connect us to our work, to services, such as healthcare, and to our families and friends. They fulfil an essential social and economic function by connecting communities and enabling trade.

However, the infrastructure required to create the networks and the vehicles that use them can have negative impacts on the environment and human health. These include:

- extraction and use of non-renewable resources for fuel and vehicle manufacture
- greenhouse gas emissions
- air, water and noise pollution
- land clearing for transport infrastructure and the possible fragmentation of habitat
- increased heat in urban areas.

As populations and economies grow, so too does the need for more housing and transport infrastructure. Without a coordinated approach, this growth can inadvertently worsen these environmental impacts.

Private motor vehicles generally have greater impacts on the environment than public transport. This is because they are less efficient at moving large numbers of people and mostly rely on polluting energy sources across the lifecycle of the vehicle (**IEA 2023a**).

Vehicles with internal combustion engines rely on fossil fuels. Large vehicles such as SUVs have greater impacts than smaller cars due to their higher fuel consumption and the additional resources needed to manufacture them.

Globally, especially in developed countries such as Australia, private vehicles dominate as a mode of transport (**Prieto-Curiel & Ospina 2024**). Vehicle ownership and use are influenced by a variety of factors, including reason for journey, travel time, income, access to public transport, fuel prices, ease of parking, health, population density and environmental awareness.

Transport in NSW

NSW has over 40,000 kilometres (km) of **state and regional roads** along with more than 180,000km of local and other roads, and over 10,000km of railway lines (**TfNSW 2024d**). As a geographically large state, we rely heavily on road infrastructure to convey people, services, freight and utilities across the long distances between cities and rural areas.

People living and working in rural and regional NSW are more reliant on private vehicles due to the long distances they may need to travel and more limited transport options (**TfNSW 2022d**; **Hansson et al. 2019**). Despite an increase in public transport options and road infrastructure, even some people living in parts of Sydney, such as the **South West Growth Area**, are also more reliant on private transport (**Fuller & Huntsdale 2024**).

In line with global trends, most vehicles in NSW are fuelled by petrol or diesel and there is a strong preference for SUVs, with correspondingly high carbon dioxide emissions as a result.

In 2022 (the most recent available data), transport emissions in NSW accounted for 21% of all greenhouse gas emissions (**DCCEEW-Aus 2024d**).

Reducing the impacts

Urban planning and transport strategies and policies that take a long-term view can prevent or mitigate environmental impacts.

Good land use planning reduces the need for private vehicles and can lessen congestion by reducing the distance people need to travel for their daily needs – for example, locating workplaces and essential services near stations and improving public transport services and connections between outer suburbs or country towns and city centres.

Improving the quality and delivery of public transport leads to increased patronage, which in turn reduces fuel consumption and congestion and leads to lower environmental impacts.

Making it easier for people to walk or cycle to their destination (active transport) also helps as these are the most energy-efficient transport modes. Active transport relieves pressure on our roads and public transport networks and is part of a healthy lifestyle for our communities.

Transitioning the transport sector away from fossil fuels is essential. This includes ramping up renewable energy generation for the electrification of public transport, increased uptake of electric vehicles (EVs) and rolling out charging infrastructure.

Recent research suggests that shifting to electric rail for freight and passengers will have the greatest impact on transport emissions, providing reductions of 80% to 90% from 2030 onwards (**Smit 2024**).

Despite an increasing switch to EVs, the **International Energy Agency** predicts that in 2030 almost 80% of cars and vans globally will still be powered by internal combustion engines (**IEA 2023b**). Improving fuel and vehicle efficiency is therefore critical to reducing emissions from these vehicles.

Improved design for both car components and road surfaces can reduce air and water pollution by minimising the wear and tear that creates pollutants, such as fine particles.

Strategies to manage the environmental impacts of road and related infrastructure are essential to project planning, design, construction, operation and maintenance. These include:

- minimising the use of non-renewable resources
- diverting waste from landfill during construction
- managing erosion and sediment during construction works
- protecting biodiversity via planning approvals and conditions
- implementing additional wildlife protection features, such as fauna fencing and fauna crossings
- reducing energy use and greenhouse gas emissions through LED traffic and street lights.

Road design can incorporate vegetation and water treatment to respond to and improve surrounding ecosystems. Through planting, roads can help mitigate urban heat-island effects and contribute to an area's tree canopy targets (**TfNSW 2023a**).

Lighter road surface colour and reduced paving areas also mitigate urban heat. Incorporating **raingardens** into roadside stormwater drainage infrastructure filters pollution before it enters waterways.

Locating freight infrastructure on the outskirts of cities has been common practice globally. This results in negative environmental impacts, such as pollution and congestion, because it increases the distance that freight vehicles need to travel.

Freight-efficient land use planning (**Holguin-Veras et al. 2021**) can improve the efficiency of freight activity and mitigate these impacts by reducing the distance goods are moved by road. It can also have a positive impact on cost-of living expenses.

Moving freight over long distances (long haul) by rail has significantly lower environmental impacts than transporting it by road. This is mainly due to rail's greater efficiency in hauling larger volumes of goods. Rail freight produces 16 times less greenhouse gas emissions and is four times more fuel-efficient than road freight (**TfNSW 2023c**).

A consequence of increased movement of freight by rail is greater noise impacts on communities around rail lines. Noise along freight lines can be addressed by maintaining and improving track conditions, better noise compliance by rolling stock and effective noise monitoring and regulation.

Approaches to mitigate and reduce the impacts of shipping (**DCCEEW 2024b**) and air transport (**DCCEEW 2024a**) include the development of less polluting fuel sources, improved efficiency and regulation of ports and air traffic (**Alquezar & Macedo 2019**).

Transport for NSW is responsible for setting the strategic direction for transport across NSW including consolidating transport policy, planning, infrastructure, service delivery and non-service delivery functions.

Transport for NSW works with other government agencies according to the key legislation and policies listed in **Table P2.1**. Some issues, such as fuel efficiency standards and international shipping regulation, are the responsibility of the federal government.

Table P2.1: Current key legislation and policies related to transport in NSW	
Legislation or policy	Purpose
Protection of the Environment Administration Act 1991	Requires public transport agencies to comply with the principles of ecologically sustainable development as defined in section 6 (2).
Transport Administration Act 1988	Includes an objective to promote the delivery of services in an environmentally sustainable manner.
Biodiversity Policy	Outlines how Transport for NSW aims to achieve its goal of no net loss of biodiversity resulting from infrastructure development activities.
Future Energy Strategy* and *Future Energy Action Plan	Outlines the commitment of Transport for NSW to securing our transport energy needs from sustainable sources and supports the transport sector's transition to net zero emissions by 2050. The action plan sets out the steps to achieve the strategy's goals for electric vehicle uptake.
Future Transport Strategy	Outlines the Transport for NSW vision to deliver safe, healthy, sustainable, accessible and integrated passenger and freight journeys. Supporting documents include infrastructure and services plans for **regional NSW** and **Greater Sydney**, the ***Transport Technology Strategy*** and the ***Active Transport Strategy***.
Net Zero and Climate Change Policy	Sets ambitious and prescriptive targets and principles to support the transport sector's transition to net zero and continue creating a transport network that is resilient, responsive and adapted to our changing climate.
NSW Electric Vehicle Strategy	Outlines the NSW Government's commitments to increase the uptake of electric vehicles.
NSW State Infrastructure Strategy 2022–2042	Sets out the NSW Government's priorities for the next 20 years, including road and transport infrastructure projects.
NSW Zero Emissions Bus Transition Strategy	Aims to transition the state's 8,000+ diesel and natural gas public transport buses to zero emissions technology.
Towards Net Zero Emissions Freight Policy	Outlines the actions that Transport for NSW can take to support the heavy road and rail freight industry to reduce emissions and transition to low and zero emissions technologies in NSW.
Transport for NSW Sustainability Plan	Sets out the focus areas and goals for Transport for NSW to ensure sustainability is integrated into all its work.

Notes:
See the **Responses** section for more information about how **Transport** is managed in NSW.

Related topics: **Animals** | **Air quality** | **Climate change** | **Greenhouse gas emissions** | **Net Zero Plan Stage 1: 2020–2030** | **Plants**

Status and trends

Transport indicators

This report uses five indicators to assess the status and trends related to transport in NSW:

- **Greenhouse gas emissions from transport** – This indicator is assessed as poor because the long-term trend since 1990 shows a continued increase, apart from during COVID restrictions which contributed to a slight downturn (see **Transport emissions**).
- **Access to the 30-minute city** – measures the percentage of urban homes within 30 minutes of their nearest metropolitan centre via active or public transport. At around 61%, this is assessed as moderate (see **Metropolitan** travel).
- **Access to regional day return** – This indicator measures the extent to which people can easily travel between regional centres using public and on-demand modes of transport within a day. With 90% of people in regional areas having access to these services in 2023, this indicator is assessed as good (see **Regional** travel).
- **Vehicle kilometres travelled** – In 2023, vehicles on NSW roads travelled 74.8 billion kilometres (see **Distance travelled by road**).
- **Electric vehicle registrations in NSW** – Reported on for the first time in 2021, this indicator is assessed as poor due to the very small number of electric vehicles in use, but getting better thanks to a rapid increase in sales over the past two years (see **How vehicles are powered**).

Table P2.2: Transport indicators for NSW

Indicator	Environmental status	Environmental trend	Information reliability
Greenhouse gas emissions from transport*	**POOR**	Unknown**	Good
Access to the 30-minute city	**MODERATE**	Stable	Good
Access to regional day return	**GOOD**	Stable	Good
Vehicle kilometres travelled***	**POOR**	Unknown**	Good
Electric vehicle registrations in NSW	**POOR**	Getting better	Good

Notes:
* While state and national greenhouse gas accounts include data to 2022, NSW Government modelling is based on 2021 data.
** The impacts of COVID restrictions make it difficult to assess these trends.
*** This measure refers to total distance travelled by all vehicle types, including both passenger and freight vehicles, which may show different trends if considered individually.

Indicator table scales:
- **Environmental status**: Good, moderate, poor, unknown
- **Environmental trend**: Getting better, stable, getting worse, unknown
- **Information reliability**: Good, reasonable, limited.

See **Indicator guide** to learn how terms and symbols are defined.

The proportion of people using public transport has also been an indicator in previous years. This is not reported for 2024 due to changes in people's working, shopping and social habits during and since COVID restrictions, which makes trend assessment more complicated than previously.

Transport continues to impact wildlife, but not enough data is available to develop an indicator for these impacts.

Transport emissions

Emissions in the transport sector largely result from the combustion of fuels. This includes road transport, domestic aviation, rail, domestic shipping, off-road recreational vehicle activity and gas pipeline transport.

In NSW, the transport sector is the fastest growing producer of greenhouse gas emissions.

See the **Greenhouse gas emissions** topic for comparison with other sectors.

Transport emissions have increased from 19 megatonnes (Mt) carbon dioxide-equivalent in 1990 to 23.5Mt in 2022 (most recent data), a rise of 26% since 1990 (**NSW Government 2024**).

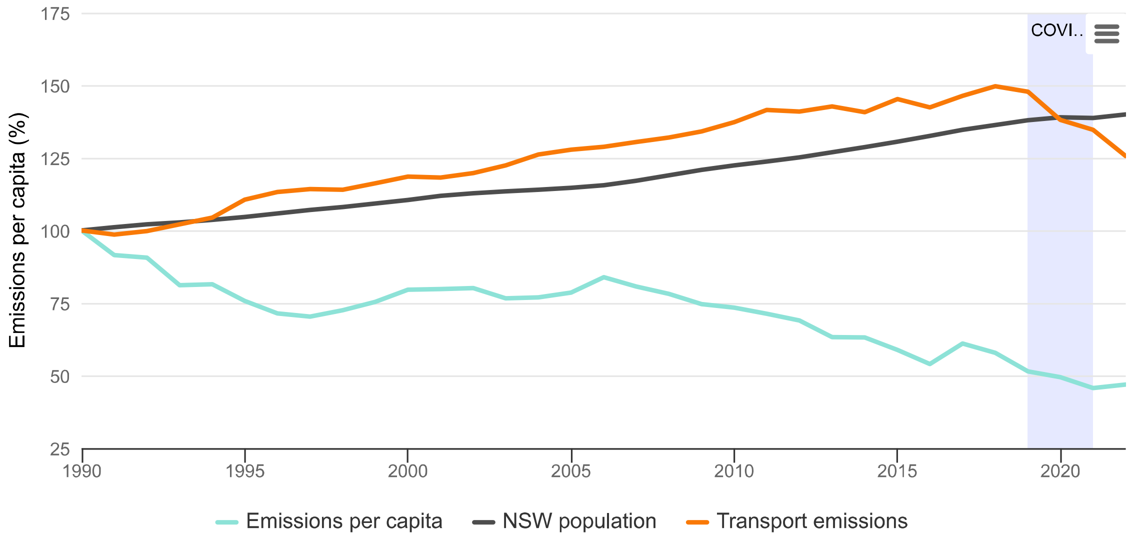
In 2022 transport emissions in NSW accounted for 21% of all greenhouse gas emissions (**DCCEEW-Aus 2024d**). While this is a decrease from 23% in 2019, the quantity of transport emissions has not decreased as much as emissions from other sectors over the past 20 years. In 2004–05, transport was responsible for 23.9Mt of emissions compared to 23.5Mt in 2021–22.

Decoupling (separating) negative environmental trends from population growth is essential for improving sustainable outcomes. **Figure P2.1** shows that, while total greenhouse gas emissions per capita have not increased at the same rate as the population, emissions from transport have been outpacing population growth.

The chart shows a dip in per capita emissions from 2019 to 2022 which reflects the impact of COVID restrictions on transport. When available, more recent emissions data will provide a more accurate picture of the trend.

See the **Greenhouse gas emissions** and **Net Zero Plan Stage 1: 2020–2030** for more information.

Figure P2.1: Historic trends in NSW transport emissions compared with key NSW statistics, 1990–2022



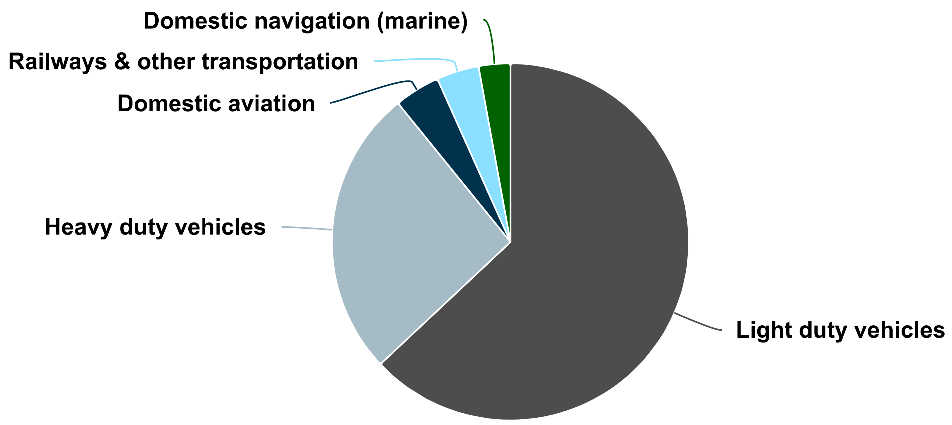
Notes:
Years shown cover the 12 months to 30 June for each year.

Source:
ABS 2024 | **Australia's National Greenhouse Accounts** | **NSW Net Zero Emissions Dashboard**

Figure P2.2 shows the contribution of different sectors to total transport emissions in 2022, with road transport representing 89% of the NSW transport sector's greenhouse gas emissions (20.9Mt carbon dioxide-equivalent).

In comparison, other forms of transport, such as railways, domestic aviation, domestic navigation and other transport, emitted only a total of 2.5Mt during this period.

Figure P2.2: Emissions by transport sector in 2021–22



Notes:
Light duty vehicles are motor vehicles with a Gross Vehicle Mass (GVM) of 4.5 tonnes or less or trailers with an Aggregate Trailer Mass (ATM) of 4.5 tonnes or less.
Heavy duty vehicles are motor vehicles with a GVM exceeding 4.5 tonnes or trailers with an ATM exceeding 4.5 tonnes.
GVM – the maximum your vehicle can weigh when fully loaded, according to the manufacturer.
ATM – the maximum fully loaded weight of the trailer or caravan being towed by your vehicle, shown on the identification plate.
'Other transportation' includes pipelines.

Source:
DCCEEW-Aus 2024c

Emissions from all transport sectors are expected to decline in future due to the increased electrification of vehicles.

However, while the ***NSW Electric Vehicle Strategy*** (**DPIE 2021**) and the introduction of the Commonwealth Government's **New Vehicle Efficiency Standard** will incentivise the purchase of zero or low-emitting vehicles, transport emissions are projected to fall by only 5% by 2030, compared to the 2004–05 baseline (**NSW Government 2024**).

See the **Net Zero Plan Stage 1: 2020–2030** topic for more information about emissions projections.

Emission reductions from the uptake of battery electric and plug-in hybrid vehicles are also offset by record sales of new vehicles, a large proportion of which are classified as SUVs or light commercial vehicles, such as utes (**FCAI 2024**). This trend has been encouraged by tax incentives for businesses in recent years, such as the exemption from fringe benefits tax (**ATO 2023**) for vehicles able to carry more than one tonne.

Adding to the transport sector's emission reduction challenges, fewer accessible zero or low-emission options are available for other forms of transport, such as heavy road vehicles, shipping and aviation transport. Based on 2021 modelling, aviation emissions are projected to more than double to over 2Mt by 2030 (from 0.8Mt in 2021), reflecting a lack of viable options for reducing emissions in the sector (**DCCEEW-Aus 2022**).

In addition to greenhouse gases, petrol and diesel-fuelled vehicles are also the main sources of oxides of nitrogen (NOx) emissions in Greater Sydney and the second-largest source of population exposure to fine particles (**Broome et al. 2020**).

See the **Air quality** topic for information about these and other harmful vehicle emissions.

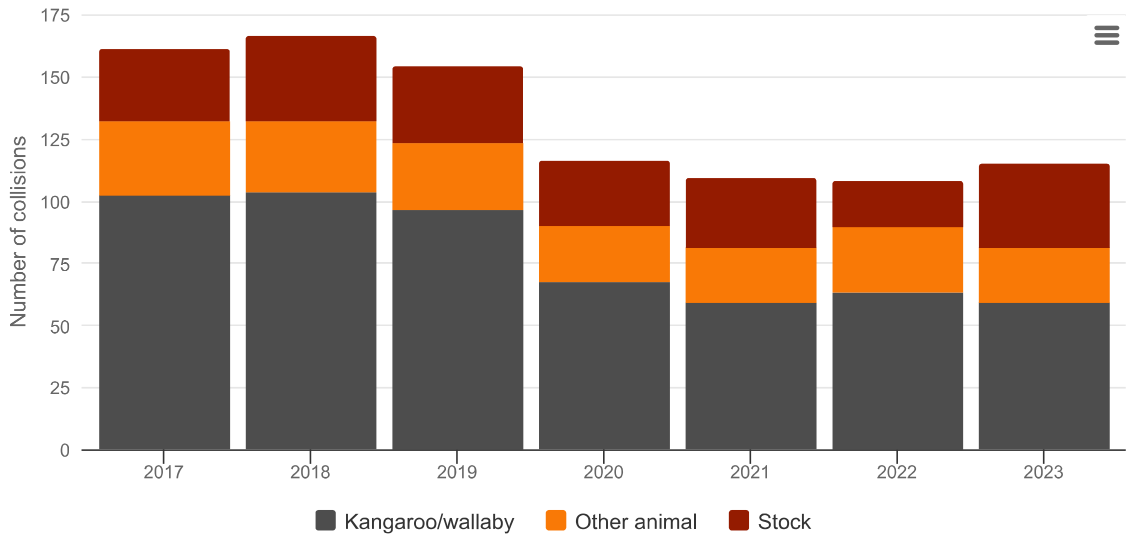
Wildlife impacts

The transport sector also impacts the environment through collisions with wildlife (roadkill), clearing of vegetation, fragmentation of habitats, and light and noise pollution that interrupts normal patterns of animal behaviour (**Dean et al. 2019**; **Taylor & Goldingay 2010**).

One in every 41 crashes on country roads are estimated to result in human injury or death when a vehicle hits an animal (**TfNSW 2024f**). Between 2017 and 2023, animals were involved in over 900 crashes on NSW roads that resulted in human injury or death (**TfNSW 2022b**).

While some collisions involved domestic livestock, more than half of all collisions were with kangaroos and wallabies (see **Figure P2.3**).

Figure P2.3: Animals involved in road collisions that caused human injury or death, 2017–23



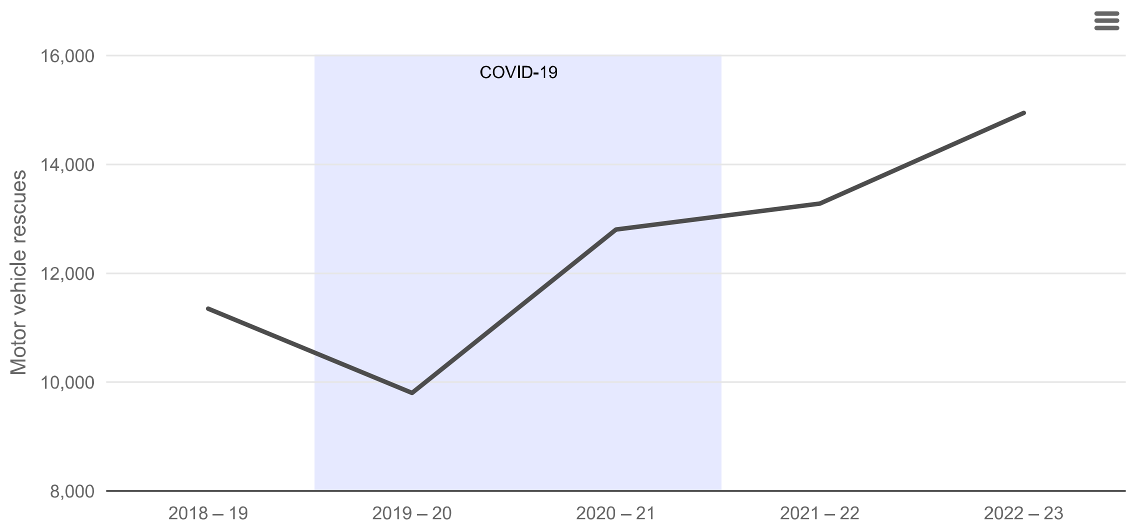
Source:
TfNSW 2022b | TfNSW unpublished data

Wildlife rehabilitation data also shows the impacts of collisions. Wildlife rescue volunteers across NSW record data about the animals they rescue and care for, which is uploaded to the **Wildlife rehabilitation data dashboard**.

The dashboard shows that between 2018 and 2023, motor vehicle collisions were the reason for 62,116 wildlife rescues (12%), by far the highest number of rescues where the reason for rescue was identified. With the reason unknown for 53% of all rescues, the proportion due to collisions with motor vehicles may be higher.

Of the animals rescued over this period, 74% (45,803) died, 16% were released and the remaining 11% remained in care or were transferred to another organisation. There was a 32% increase in the number of vehicle collision rescues over this period from 11,335 to 14,934 (**Figure P2.4**).

Figure P2.4: Number of rescues due to motor vehicle collisions, 2018–19 to 2022–23



Source:
Wildlife rehabilitation data dashboard

Animals are also orphaned due to collisions, but data for this is not collected. Only 4% (20,057) of all rescues were recorded as orphaned or abandoned and 2% (12,046) had parents taken into care.

Most rescues occurred along the coast, which corresponds with the larger human populations in those regions. See the geographic spread on the dashboard's **interactive map**.

Table P2.3 shows the 10 most commonly rescued animals due to motor vehicle collisions between 2018 and 2023 in the following proportions:

- 51.8% kangaroos and wallabies
- 35.9% birds
- 12.2% other marsupials.

Table P2.3: Ten animals most commonly rescued following a motor vehicle collision, 2018–19 to 2022–23

Species	Total
Eastern grey kangaroo	14,043
Laughing kookaburra	3,594
Rainbow lorikeet	3,110
Red-necked wallaby	3,021
Tawny frogmouth	2,578
Bare-nosed wombat	2,426
Swamp wallaby	2,418
Australian magpie	2,230
Common brushtail possum	2,165
Galah	1,989

Source:
Wildlife rehabilitation data dashboard

During this period, 2% (1,364) of all rescues due to motor collisions were threatened species. Of these, 67% (848) were koalas; 16% (197) were grey-headed flying fox; and 4% (51) were powerful owls. Other threatened species rescued, each at numbers less than 50, included the bush stone-curlew, gang-gang cockatoo and superb parrot.

Personal travel

In-depth personal transport data is collected for the Sydney **Greater Capital City Statistical Area** (GCCSA) (as defined by the Australian Bureau of Statistics) and the Hunter and Illawarra regions through the annual **Household Travel Survey**.

In this section, 'Sydney' is used to refer to the GCCSA.

The survey is the most comprehensive source of personal travel data in these regions with its statistics used in long-term planning to reduce impacts on the environment, improve amenity and meet the state's transport needs.

The COVID-19 pandemic lockdowns disrupted the collection of data for the survey and sample sizes for 2020 through to 2022 are smaller than previous years.

Metropolitan areas

Between 2012–13 and 2022–23, the total number of trips on an average weekday in the Sydney, Hunter and Illawarra regions by all modes of transport increased by 2.2% from 24.7 million trips to about 25.3 million trips (**TfNSW 2023b**).

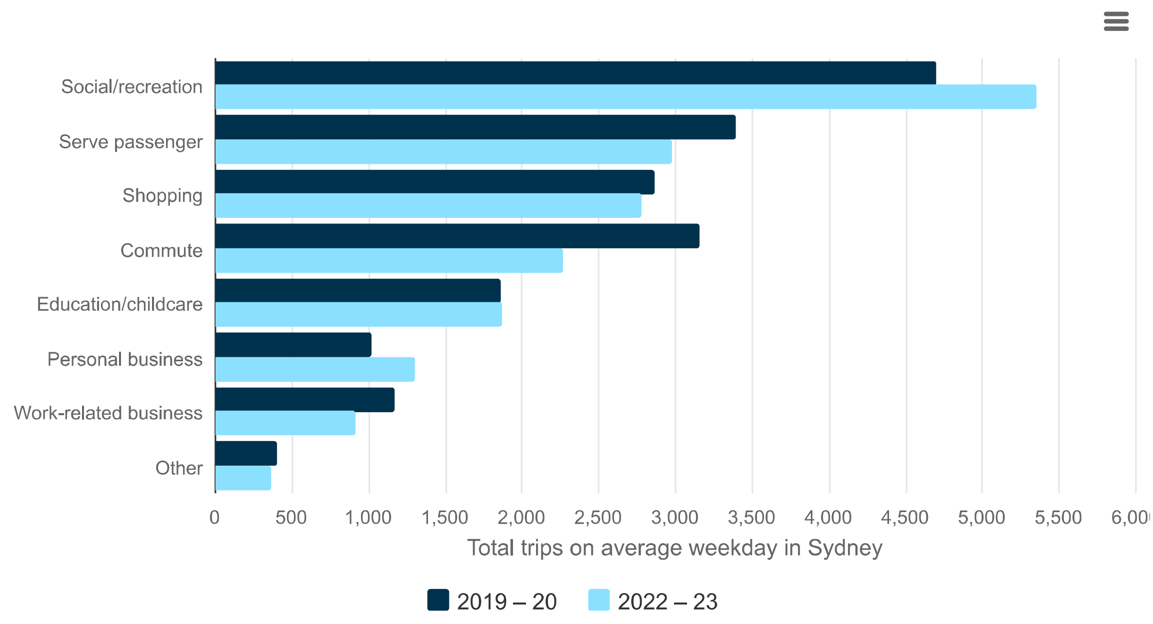
This was lower than the rate of population growth of 12.7% over the same period (**ABS 2024**).

Most trips taken in 2022–23 (21.3 million or 84.3%) occurred in Sydney. Trips increased in both Sydney and the Hunter, while Illawarra recorded a reduction in annual trips.

Details for the differences between regions are available on an interactive dashboard for the **Household Travel Survey**.

Figure P2.5 shows that trips taken in Sydney for various purposes on an average weekday in 2022–23 differed from those three years previously.

Figure P2.5: Total trips for various purposes on an average weekday in Sydney, 2019–20 and 2022–23



Notes:
'Sydney' is used to refer to the Sydney Greater Capital City Statistical Area (GCCSA).

Source:
TfNSW 2023b

Social changes, such as online shopping and working from home were likely factors in the reduction of shopping, work-related and commute trips. Online shopping peaked during the COVID-19 pandemic but has remained high, at 16.8% of retail spending across Australia in 2023 (**Australia Post 2024**).

It is possible that the increase in social/recreation trips is also related to these changes as people working from home need to go out for weekday social activities rather than add them onto their commute.

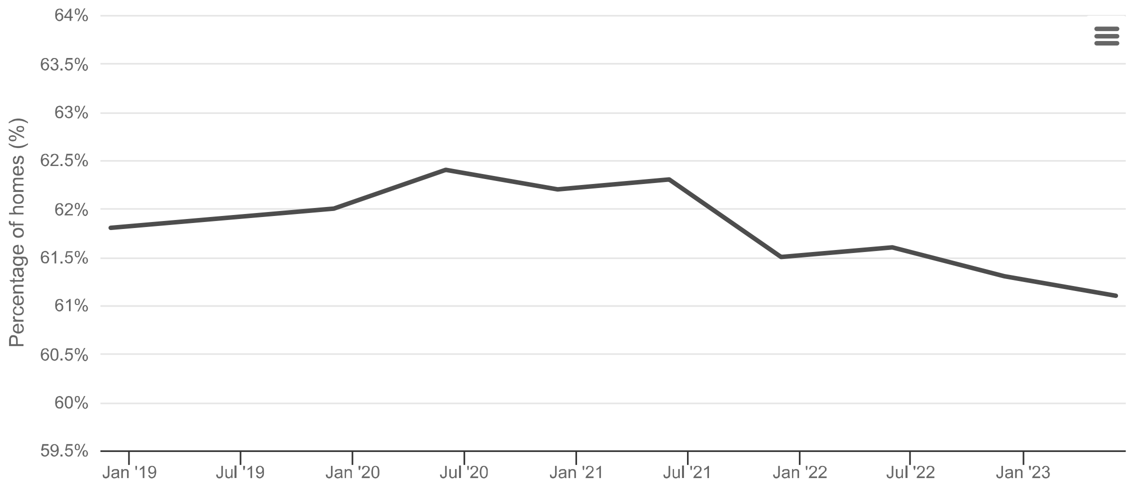
The shift to hybrid working that has continued following COVID-19 lockdowns has affected travel trends. Since 2019–20, the number of trips for commuting purposes on an average weekday dropped by 28.2%. The number of trips for work-related business also fell by 21.6%.

The 30-minute city

Making it easier for people in cities to choose public transport can reduce the use of private cars and the environmental impacts associated with them. These choices can be supported by delivering more transport options, such as the new Metro lines, Parramatta light rail and interchanges.

The **Greater Sydney Regional Plan** sets an objective for locating most city residents within 30 minutes of their nearest metropolitan centre using public and active transport (the **'30-minute city'**). About 61% of homes across Greater Sydney met this objective in December 2023 (**Figure P2.6**).

Figure P2.6: Percentage of urban homes within 30 minutes of their nearest metropolitan centre using active or public transport



Notes:
Methodology for calculations is available on the TfNSW **Open Data Hub**. It does not attempt to reflect the performance of the network and services or customer choice.

Source:
NSW Treasury 2022

Regional NSW

While the **Household Travel Survey** provides a snapshot of travel in more heavily populated areas of coastal NSW, there is no equivalent study for regional centres.

Public transport options to service those in rural and remote communities include bus services (in 2022–23 approximately 90% of routes were school services), as well as on-demand, point-to-point travel options in some regional centres.

On-demand is a flexible public transport service designed to improve connections to transport hubs and popular destinations like shopping centres and hospitals. There were 168,000 trips on these services in 2022–23, an increase of 34% over 2020–21 and a 367% increase since 2018–19, when most contracts for providing the service began.

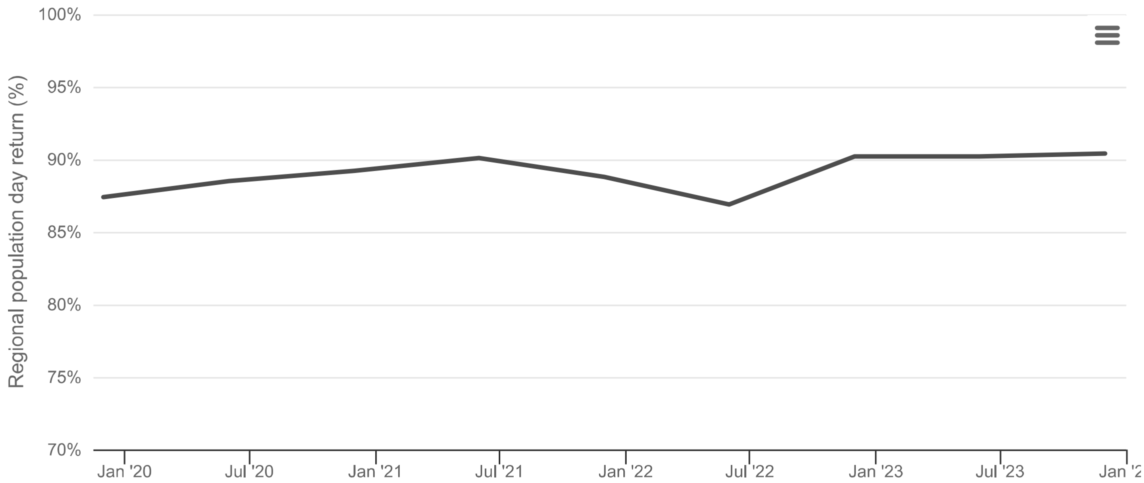
Bushfires in late 2019 and COVID-19 from early 2020 impacted regional transport significantly in some areas, leading to a reduction in trips taken from 41.6 million in 2020–21 to 33.8 million in 2021–22. While not quite at pre-COVID levels, patronage in 2022–23 shows a recovery, at 38.8 million trips.

Regional day-return

Providing more transport choices for regional communities will help reduce reliance on private transport. This can be achieved by improving connectivity between regional centres through initiatives such as improved bus and on-demand services and timetables that enable people to travel to and from a local centre on the same day, without needing to stay overnight.

Figure P2.7 shows that the proportion of regional residents with access to regional day-return has trended upwards over the past five years, apart from a dip during the period of COVID-19 restrictions.

Figure P2.7: Percentage of regional residents with access to day-return to regional centres



Notes:
The methodology for calculating the indicator is available on the Transport for NSW **Open Data Hub**.

Source:
NSW Treasury 2022

Modes of transport

How people travel

The **Household Travel Survey** indicates that private vehicles, such as cars and motorbikes, remain the dominant mode of transport for residents in the surveyed areas.

In this section, ‘Sydney’ is used to refer to the Sydney **Greater Capital City Statistical Area**.

On an average weekday across all surveyed regions in 2022–23 (**TfNSW 2023a**):

- 71.9% of trips were by private vehicles
- 8.5% were by public transport
- 2.1% were by other transport modes (mainly taxis and bicycles)
- 17.5% were by walking linked to other transport modes such as train or bus.

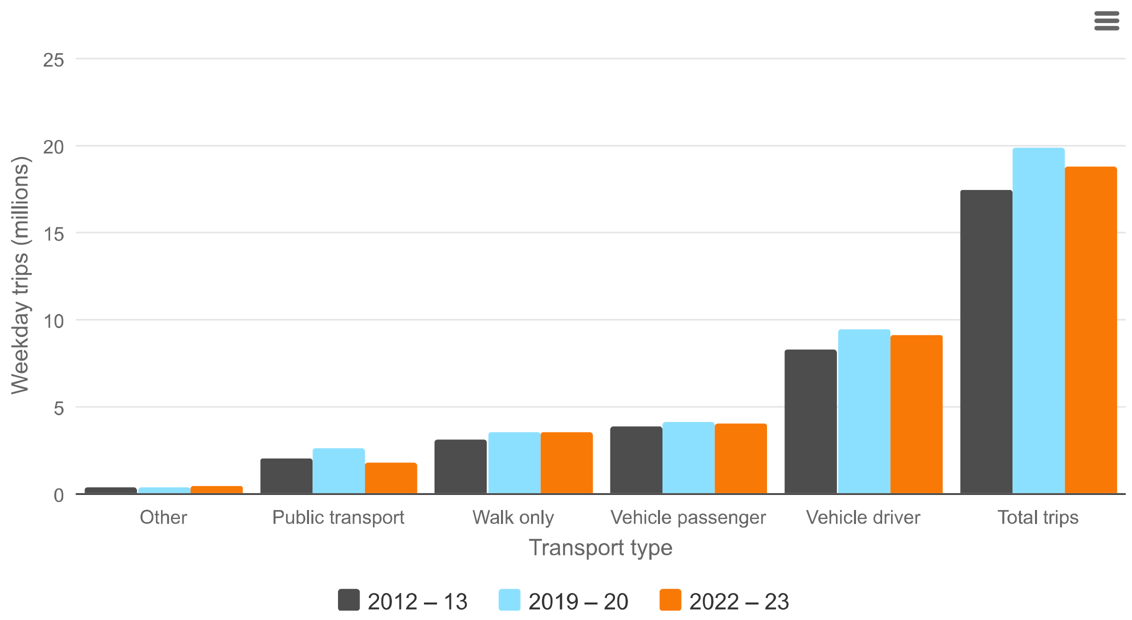
Figure P2.8 shows that in Sydney, the proportion of trips on an average weekday for each mode of transport largely remained constant, with private vehicles continuing to be the main form of transport. However, over the 10-year period:

- there was an 8% increase in total trips
- the number of public transport trips fell by 10%
- private vehicle trips for drivers and passengers rose 15%.

These changes are likely related to many people continuing to work from home after the COVID-19 pandemic restrictions lifted.

While Sydney dominates overall trends, trends in the Hunter and Illawarra regions are similar. Explore the differences on the **Household Travel Survey** website.

Figure P2.8: Trips by mode across Sydney on an average weekday, 2012–13 to 2022–23



Notes:

'Sydney' is used to refer to the Sydney **Greater Capital City Statistical Area (GCCSA)**.

'Vehicle' includes cars and motorbikes for trips by drivers and passengers.

'Public transport' includes bus, train, ferry and light rail.

'Other' includes bicycles, taxi/rideshare/car share, aircraft and other public transport other modes.

The total trips excludes 'walk-linked' trips.

Source:

Household Travel Survey

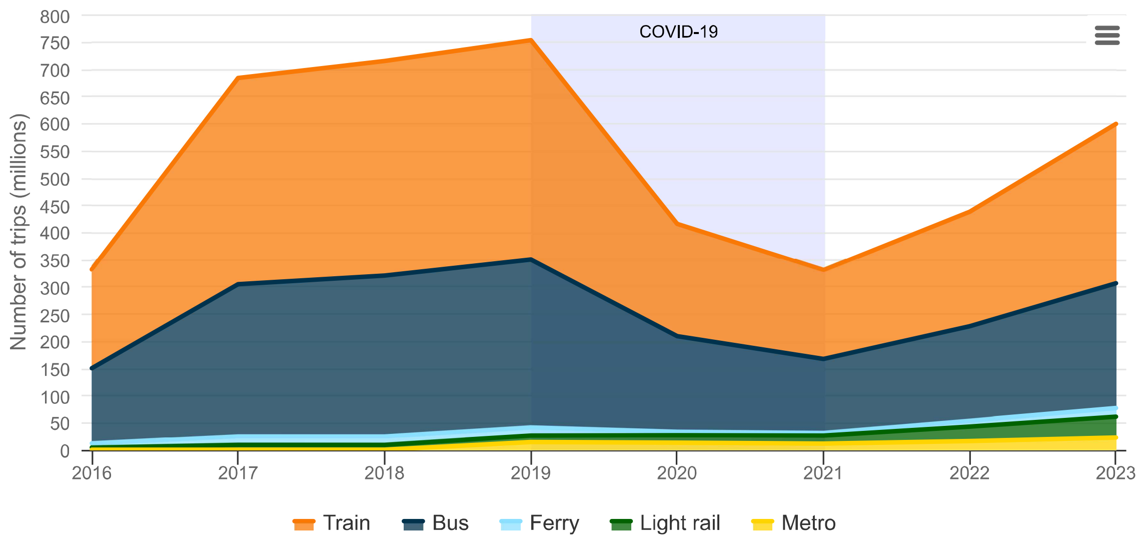
Public transport

The Opal smartcard ticketing system, which was rolled out in 2012, is used to pay for travel on public transport in Sydney, the Blue Mountains, Central Coast, the Hunter and the Illawarra. Opal ticketing data is the main source of information on use of public transport in these regions.

Figure P2.9 shows the number of trips by mode, based on Opal data, on the network from 2016 to 2023.

The impacts of COVID-19 are apparent with patronage declining during the lockdown period and still not fully recovered in 2023. This is likely due to many people continuing to work from home for at least part of their working week.

Figure P2.9: Public transport patronage by mode across the Opal network, 2016–2023

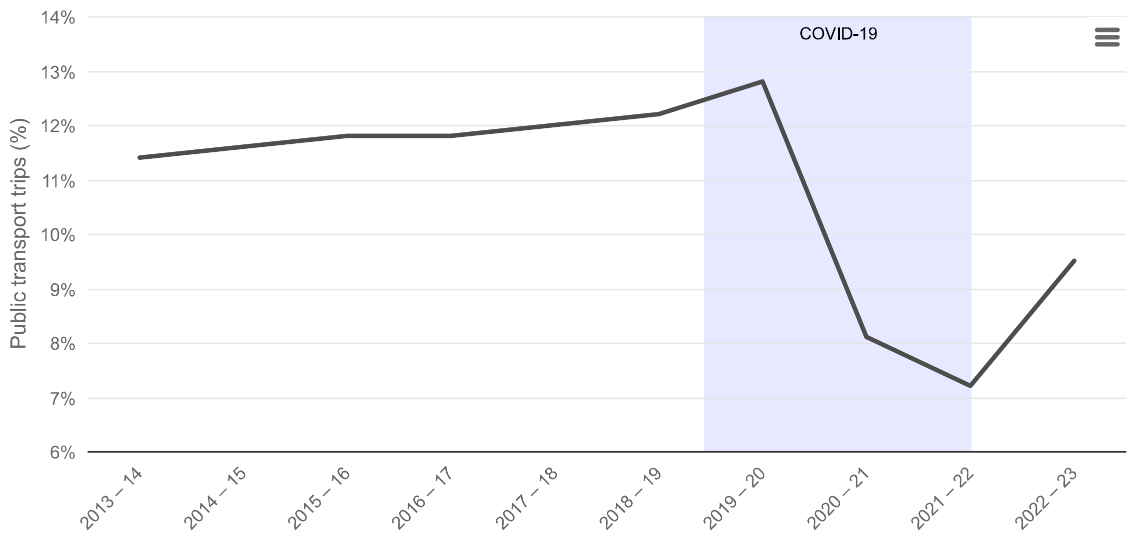


Notes:
The steep rise in 2016 is related to the rollout of Opal cards, which captured trips more accurately than previous estimates of public transport use.

Source:
TfNSW 2024b

This trend is reflected in the **Household Travel Survey** data, which suggests that the proportion of trips taken by public transport decreased during COVID-19 lock-downs and is now slowly recovering (**Figure P2.10**).

Figure P2.10: Public transport as a percentage of all trips* in Sydney, 2013–14 to 2022–23



Notes:
The 2020–21 and 2021–22 releases are based on a reduced data collection period and smaller samples. This may affect results.
* Total trips excludes all walk-linked trips

'Sydney' is used to refer to the Sydney **Greater Capital City Statistical Area (GCCSA)**.

Source:
Household Travel Survey

Regional centres

Outside the metropolitan areas, towns are serviced by regional trains and coaches stopping at 369 transit station locations. Together, these carried more than 1.8 million passengers in 2022–23 (**NSW Trains 2023**).

Data for train trips in regional NSW also reflect the impacts of COVID-19 restrictions (**TfNSW 2024b**). In 2022–23, there were on average 64,962 Opal-ticketed passenger trips each day on NSW TrainLink Intercity trains. This was an increase of 83% compared to 2021–22 when the COVID-19 outbreak triggered a lockdown, but a decrease of 43% compared with pre-COVID, 2018–19.

Walking and cycling

It is estimated that more than 1.5 billion trips are made on foot or by bicycle every year in NSW. This includes 600 million walking trips that are linked to a public transport journey (**TfNSW 2022a**).

A biennial **National Walking and Cycling Participation Survey** by Cycling and Walking Australia and New Zealand is the main source of information about active transport in NSW, although only a small number of people are surveyed (in 2023, 631 households containing 1,635 individuals). Respondents may submit multiple reasons for walking or cycling.

The most recent survey for NSW (**CWANZ 2023**) indicates that in a typical week in 2023:

- over 70% of walking trips were for recreation or exercise
- over 60% were for shopping
- 48% were for personal business.

The survey has more detailed information on NSW bike riding habits and participation rates. The survey found that 15% of NSW residents rode a bicycle in a typical week in 2023, the same as the national average of 15% (**CWANZ 2023**) and the 2021 findings for NSW (**CWANZ 2021**).

COVID-19 appears not to have had a significant impact on cycling rates in NSW, with the similar levels of participation in 2021 (36%) and 2023 (38%).

There has been an ongoing increase in the percentage of residents who report riding a bike in NSW, with 38% of people saying they had ridden a bike in the past year (2023) compared to 29% in 2017.

Weekly cycling participation is slightly higher in regional NSW (18%) compared to Greater Sydney (14%). It is also higher for males (17%) than for females (13%) in NSW as a whole (**CWANZ 2023**).

The survey asked people to state their reasons for cycling over the past month. Respondents submitted multiple reasons, with 87% of those in NSW indicating that they had cycled for recreation, compared to 28% who had used their bike as a form of transport, for instance to visit friends/relatives, commute, access education or for shopping.

Distance travelled by road

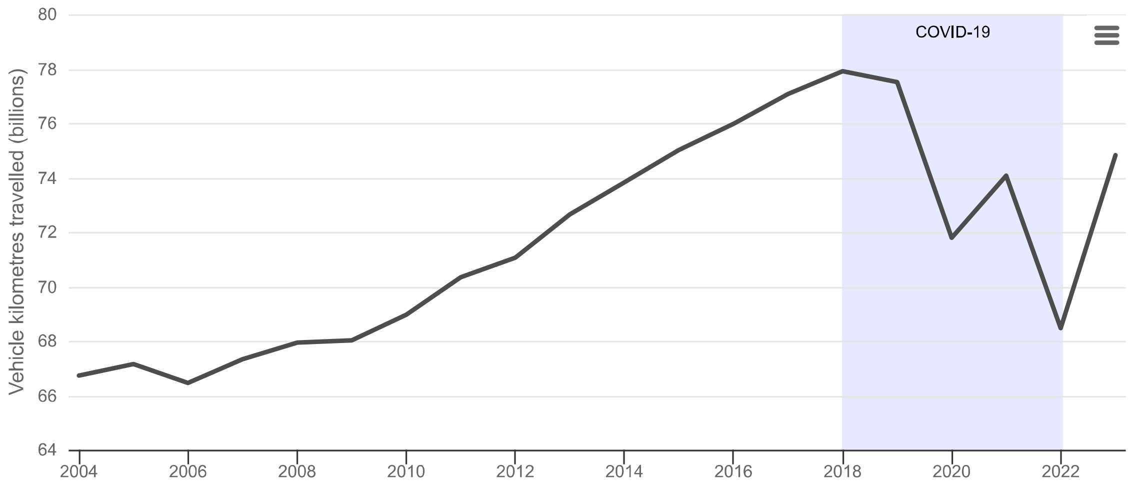
In 2023, vehicles on NSW roads travelled an estimated 74.8 billion kilometres, a 12% increase since 2004.

Figure P2.11 shows that between 2004 and 2018, the distance travelled by NSW vehicles increased on average by 1.2% each year, a similar rate to population growth.

See the **Population and the environment** topic for more information.

COVID-19 restrictions caused a rapid reduction in distance travelled, but as restrictions eased, this increased sharply. With a 9% increase in vehicle kilometres travelled between 2022 and 2023, it’s not yet clear whether distance travelled will continue to grow or will stabilise at a lower rate.

Figure P2.11: Vehicle kilometres travelled in NSW from 2004 to 2023



Notes:
Total includes all vehicles, including buses and trucks. Passenger and freight vehicles may show different trends if considered individually.

Source:
BITRE 2024a

Motor vehicle ownership

On 31 March 2024, NSW had 7,309,712 registered vehicles of all types (**TfNSW 2024c**), 17% more than at the same date in 2016 (**TfNSW 2016**). This increase is higher than the rate of population growth over the same period (7.7%) (**ABS 2024**).

Most (76%) if all new vehicles sold in NSW in 2022 were SUVs (54%) or light commercial vehicles (22%) (**FCAI 2023**). This is similar to national trends, these vehicles combined representing 78.4% of sales in 2023 (**FCAI 2024**).

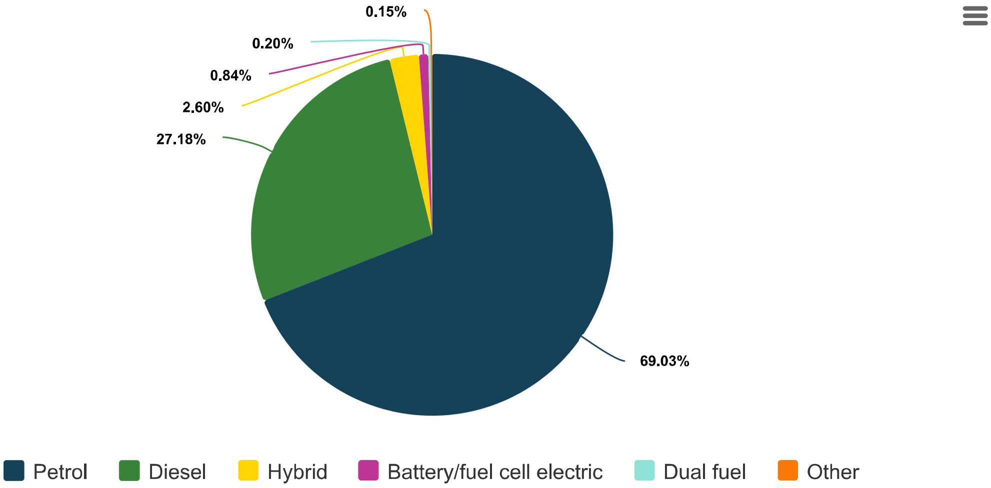
How vehicles are powered

As at 31 January 2024 (**BITRE 2024b**):

- more than 4.3 million vehicles registered in NSW were powered by petrol
- over 1.7 million were diesel-powered
- 163,801 were hybrid electric
- 52,572 were battery electric.

Figure P2.12 shows that most vehicles registered in NSW are powered by petrol or diesel.

Figure P2.12: How vehicles are powered in NSW, January 2024



Notes:
The data presented in this chart is for road vehicles that are registered for unrestricted use on private roads.
Dual fuel vehicles have more than one power source.

Source:
BITRE 2023 | BITRE 2024a

Battery electric vehicles (EVs) are considered a better option for reducing emissions because, unlike hybrids, they do not need petrol to operate. However, their impact depends on the source of electricity used to charge the vehicle, as emissions will still be generated if the charger is not powered by renewable energy. In future, the storage capacity of electric vehicle batteries will be a significant contributor to firming the power grid (**ARENA 2023**), further increasing their environmental benefits.

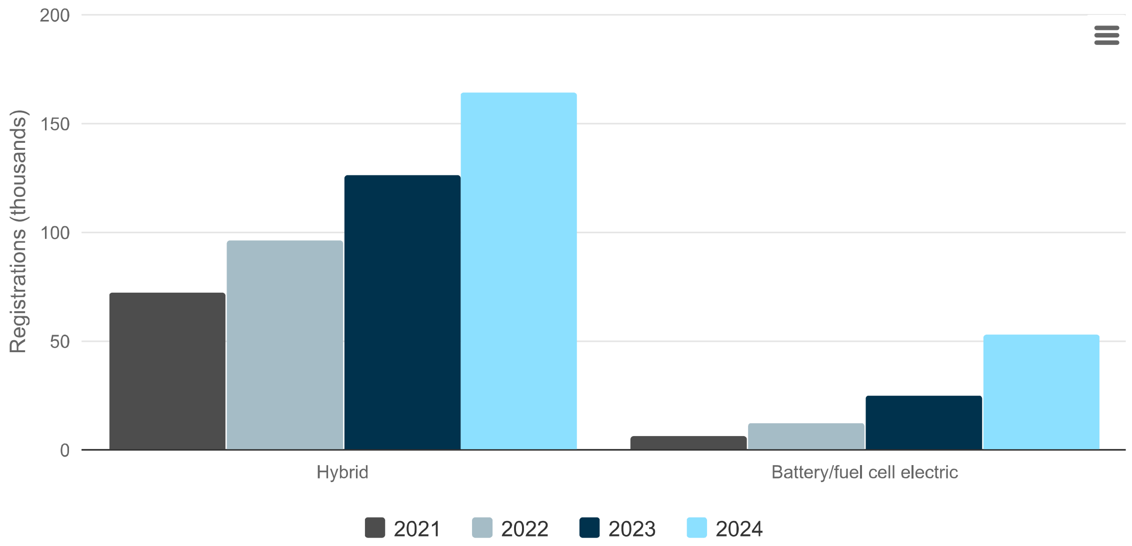
The Electric Vehicles Council estimates that for Australia to achieve its climate targets, EVs will need to make up more than 50% of new car sales in 2030 (**EVC 2023**). The ***NSW Electric Vehicle Strategy*** (**DPIE 2021**) aims to increase EV sales to 52% by 2030–31.

Sales of electric vehicles are increasing, with a rapid uptake in recent years. In 2023, about 9% of all new vehicles sold in NSW were EVs, up from about 4% in 2022 (**EVC 2024**). While promising, this still falls short of the global average of 15.8% annually (**Irle R 2023**).

Sales in Australia for hybrids and EVs were about the same in 2023, with over 98,000 sold in each category. Nationally, new sales for battery EVs are increasing at a much higher rate than for hybrids. In 2023, new EV sales increased at a rate of 161% compared to 2022, while hybrid sales increased only 20% (**FCAI 2024**).

As at January 2024, EVs made up just 0.8% (52,572) of road vehicle registrations in NSW (**BITRE 2024b**). While very low, this is an increase of 753% since 2021, when only 6,160 EVs were registered (**BITRE 2023**). Hybrids still far outnumber EVs in terms of total vehicle registrations (**Figure P2.13**).

Figure P2.13: Trends in electric vehicle registrations in NSW, 2021–2024



Source:
BITRE 2023 | BITRE 2024a

EV charging infrastructure

By the end of 2023, there were 229 public EV charging locations in NSW, of which 164 were fast and 65 were ultrafast. The number is rapidly increasing, with 80 new stations added in 2023 (**EVC 2024**). See the **NSW electric vehicle charging map** for charging locations.

Freight

By volume, most freight in NSW is transported by road (**TfNSW 2018**). However, significant amounts of coal and grain are moved by rail and some fuel is moved by pipeline.

Coal exports are by far the largest single commodity by volume transported in NSW, accounting for about one-third of total NSW freight. Grain is the largest agricultural commodity moved around the State.

Some sectors rely more heavily on road transport than others. For example, construction is heavily dependent on roads for the delivery of crude materials (such as sand, gravel and cement). Retail products and waste are also mostly moved by road.

The volume of freight in NSW is forecast to increase from 455 million tonnes in 2021 to 609 million tonnes in 2061, a 34% increase. The volume is expected to increase by 56% between 2021 and 2061 in Greater Sydney and by 14% in regional NSW (**TfNSW 2022d**).

The mix of freight is likely to change in future, as coal exports decline and other commodities, such as grain, beef and steel increase. Emerging industries, such as renewable energy and waste management, will also contribute to changes in the flow of freight from regional areas to ports and cities (**TfNSW 2022d**).

Population growth, rising per capita income, changing consumer trends (including online consumerism), global demand for commodities and the State's high output will continue to drive an increasing demand for goods and services that will require freight services.

Zero emissions freight transition

There are significant challenges in transitioning heavy vehicles and rollingstock to low and zero emissions vehicles. These include regulatory barriers, technology limitations, range and high upfront costs.

Zero emission freight vehicles tend to be heavier and have greater impacts on impacts pavements and sensitive infrastructure, such as bridges. This can make it harder to access some roads and properties and increases the cost of maintaining the road network.

Infrastructure for charging and refuelling, especially for long-haul routes, is also limited and work to understand grid capacity needs to be undertaken.

Population growth, rising per capita income, global demand for commodities and the State's high output will continue to drive an increasing demand for freight.

The number of heavy vehicles transitioning to electric or hybrid power sources is increasing slowly, with most change occurring over the year to June 2024 (**Table P2.4**). Greater use of low and zero emission heavy vehicles will have positive impacts on air quality and noise (**TfNSW 2023c**).

Table P2.4: Electric and hybrid heavy vehicles registered in NSW, December 2023

Snapshot date	Heavy vehicle registrations (less buses, trailers and plant)	Registrations of battery electric vehicles (BEV)	PERCENTAGE (%) of registrations of electric vehicles (BEV)
30-Sep-22	132,136	0	0.00
31-Dec-22	134,819	0	0.00
31-Mar-23	134,490	7	0.01
30-Jun-23	135,168	15	0.01
30-Sep-23	135,147	28	0.02
31-Dec-23	137,174	63	0.05
31-Mar-24	136,926	83	0.06
30-Jun-24	137,224	105	0.08

Notes:
Heavy vehicle registrations do not include vehicles under 4.5 tonnes. Heavy vehicles comprise 12% of all commercial vehicle registrations.
While most vehicles that are not used for freight – such as buses and trailers, and machinery such as tractors and mobile cranes – have been excluded, this data may include other heavy vehicles that are not freight vehicles.
Regular hybrids are not included, although the numbers are also very low, with 125 registrations at 30 June 2024. No registrations were recorded for plug-in hybrid electric vehicles.

Source:
TfNSW 2024c

Pressures and impacts

Population

The NSW population is expected to grow to 9.8 million people by 2041 (**NSW Planning 2024**). An expanding population is associated with economic growth as more people consume more goods and need more housing and services.

The 2023 Sydney housing supply forecast estimates that 172,000 new homes will be built in Greater Sydney between 2022–23 and 2028–29 (**NSW Government 2023**). Of these about 24% will be located on previously undeveloped 'greenfield' sites, such as bush or farmland.

Historically in NSW, population growth has resulted in urban sprawl, as new housing is often built on greenfield areas on the outskirts of cities. Sometimes bush needs to be cleared to make way for these developments, which can result in loss or fragmentation of native vegetation and habitat. See the **Plants** topic for more information.

Greenfield areas often have little in the way of existing transport infrastructure. If public transport services and options for active transport are not built into these new suburbs from the start, people living there may need to rely on private vehicles for transport.

Growth also brings an increased demand for transport, with more goods moving around the State and through our ports and airports. More roads and transport infrastructure, such as ports, will be built or expanded to meet this demand. This may require further extraction of non-renewable resources and the generation of greenhouse gases during construction.

If current trends continue, population and economic growth will lead to an increasing number of private and freight vehicles on NSW roads, many of them powered by non-renewable fossil fuels. These additional vehicles contribute to road congestion, slowing travel times, reducing vehicle fuel efficiency and increasing traffic heat and emissions. Congestion will affect the quality of the urban environment and therefore its liveability.

Growth and development must be carefully planned, managed and regulated to prevent and mitigate harmful impacts on our land, air, climate, water, native animals and plants, and to human health and wellbeing.

Climate change

The global climate trend is for increasing temperatures, with the last 10 years being the warmest on record (**NOAA 2024**). Hot days are projected to become more frequent and hotter. See the **Climate change** topic for more information.

The NSW flood events of 2022 were preceded by intense storms and flooding in February and March 2021, the 2019–20 NSW bushfires, and the extreme 2017–19 drought. The severity of these weather events has had devastating effects on NSW communities and the economy.

See the **Extreme climate and weather** topic for more information.

The transport sector is particularly vulnerable to climate change, as extreme weather and climate shifts will compromise the network and services.

Floods and fire can cause damage to roads, bridges and railways. Extreme heat buckles rail lines. These events slow and disrupt transport services and the need to rebuild results in further resources being committed to transport infrastructure.

Extreme weather conditions brought about by climate change will put greater pressure on the freight transport network's capacity to recover from a disruption. Recent weather events of this kind have already caused significant disruption to both the State and national rail networks.

Such disruptions can lead to a lack of confidence in the reliability of the rail network and affect the choice of rail as a mode of transportation, despite it being a more sustainable transport option to move freight, particularly over long distances.

Climate change will exacerbate the urban heat island effect created where new developments cause an increase in hard and dark-coloured surfaces and the loss of mature trees and canopy (**DPHI 2024**; **TfNSW 2022c**).

Climate change will make active transport a less attractive option if cycleways and footpaths are not protected from the effects of higher temperatures.

See the **Climate change** topic for more information.

Damaged habitat

Construction of new roads and transport infrastructure, if not planned and managed carefully, can have damaging effects on wildlife and vegetation (**Polak et al. 2014**; **Taylor & Goldingay 2010**).

Roads and railway lines are obstacles that prevent animals from moving through the landscape to find food, water and mates. This is known as 'habitat fragmentation' and can lead to local extinctions and a decline in genetic diversity.

The significant and cumulative impacts of road and railway lines on wildlife and ecosystems are well documented globally (**Johnson et al. 2022**). Plants are destroyed and animal habitat is lost or further fragmented when land is cleared for construction or road-widening.

Collisions with large animals can cause damage to vehicles and sometimes result in human fatalities. Many animals also lose their lives on roads and railway lines.

New roads in regional and fringe urban areas can take a particularly heavy toll on vegetation and wildlife unless properly planned. Roads aid the dispersal and movement of weeds and invasive species which can displace native species, degrade habitat and change genetic populations through interbreeding.

New roads or road improvements increase human access which can increase impacts to ecosystems from activities such as firewood and bush-rock removal, littering, trailbikes and horse-riding and the spread of pathogens.

Seeds and spores can travel on vehicles in mud deposits and colonise new areas, while feral animals (such as cats, dogs and foxes) use the roads as a corridor to move into new areas (**Mackey et al. 1998**).

Off-road vehicles, which expand access to remote areas, can disturb wildlife and increase erosion and damage to native plants.

Air pollution

Petrol and diesel-fuelled vehicles emit air pollutants, such as oxides of nitrogen (NOx) and fine particles, which can have serious health impacts. In the Greater Sydney Region, transport emissions continue to be the main source of NOx.

Air pollutants from traffic also include particulate matter, carcinogens, volatile organic carbons (VOCs), carbon monoxide and polycyclic aromatic hydrocarbons (PAHs). VOCs and NOx react on warm, sunny days to form ground-level ozone.

On-road motor vehicles are the second highest human-made source of population exposure to fine particle pollution.

A systematic review of research into traffic-related air pollution (**HEI 2010**) found there was sufficient evidence to conclude that exposure to this kind of pollution can make asthma worse.

The evidence linking exposure from traffic-related air pollution to other health outcomes was weaker, but suggestive of a causal relationship. These outcomes were the onset of childhood asthma, non-asthma respiratory symptoms, impaired lung function, total and cardiovascular mortality and cardiovascular morbidity.

A more recent systematic review that specifically examined studies of traffic-related air pollution and asthma from birth until 18 years of age supports traffic-related air pollution exposure being associated with the development of asthma in children (**Khreis et al. 2017**).

Reducing exposure to traffic-related air pollution will provide public health benefits, including improved cardiovascular and respiratory health and reduced rates of some cancers (**NSW Health 2018**).

See the **Air quality** topic for more information.

Water pollution

Urban sprawl in cities increases the area of hard surfaces, such as concrete, that cannot absorb water when it rains. This leads to increased runoff into local waterways, as less water soaks into the ground. Increased runoff has been linked to rising pollution levels in local waterways (**Awonaike et al. 2022**).

Vehicles contribute to this pollution through the build-up of deposits from emissions and from mechanical parts wearing out. Tyres and brake linings, petrol and oil deposits are a source of metals, such as copper and zinc, and heavy metals, such as cadmium, lead and nickel (**Peikertova & Filip 2016**). These are all potentially harmful to humans, animals and many plants.

Vehicles deposit small amounts of these contaminants as they travel and, the more vehicles on the roads, the more the deposits build up. When it rains, the deposits can be washed into stormwater systems, eventually polluting waterways, estuaries and beaches, where the stormwater is released.

Road and track construction can also impact the local natural environment, by changing an area’s water flows and increasing erosion and sedimentation in local waterways. This in turn affects the composition of species, often favouring weeds. See the **Rivers and wetlands** and **Coastal and marine** topics for more information.

Transport infrastructure construction projects may introduce increased sediment loads to local waterways if not well managed. Developers are required to prepare and implement erosion and sediment control plans to mitigate these potential impacts.

Australia’s coastal environment is threatened by our heavy dependence on international and coastal shipping. Ballast water, bilge water, sewage, wastes from vessel maintenance and anti-fouling paints can have environmental impacts if not well managed.

Ballast water, used to stabilise empty ships when travelling to pick up cargoes, may contain invasive non-native organisms, diseases, toxins and parasites that can affect humans and impact local environments.

The Australian Government estimates that up to 30% of invasive marine species have been introduced through ballast water discharge (**DAFF 2021**). Find out more about invasive species on the NSW coast on the **marine pests map**.

Anti-fouling paints are used on vessels to stop organisms growing on hulls. These paints contain toxic chemicals that are regulated so they do not leach into the surrounding water when vessels are cleaned, polluting harbours and waterways.

Noise pollution

Noise pollution is unwanted, disturbing or excessive noise. It can be caused by road traffic, heavy rail and aircraft, especially in urban areas, as well as industrial, construction and agricultural works.

Noise pollution can impact human health and wellbeing in various ways, including sleep disturbance, annoyance, cardiovascular and metabolic disease, anxiety and depression, as well as hearing loss (particularly in the workplace) (**Australian Department of Health 2018**; **Chen et al. 2023**).

There is a lack of systematic data on the extent of the NSW population's exposure to unhealthy noise levels. Noise monitoring and mapping conducted overseas has shown that many people live in areas where noise levels are harmful to health, for example, at least 20% of the population of Europe (**EEA 2020**).

Like light pollution, noise pollution can affect the ability of wildlife to navigate and find food, as well as hindering communication, generating physiological stress and jeopardising breeding (**Kok et al. 2023**; **Parris & McCauley 2016**).

Responses

The NSW Government is committed to delivering a transport system that is environmentally, economically and socially sustainable. This approach aligns with Australia's commitment to the United Nations **Sustainable Development Goals**, which cover areas such as:

- developing quality, reliable, sustainable and resilient infrastructure
- providing access to safe, affordable, accessible and sustainable transport
- taking action to reduce emissions, support climate change science research, build resilience and reduce additional pressures on systems affected by climate change.

Details on the government's delivery of sustainability outcomes related to the pressures and impacts of transport are available on the **Transport for NSW website**.

Climate change

Reducing emissions

As the second-largest generator of greenhouse gas emissions, it is essential the transport sector helps to meet the State's goal to reach net zero emissions by 2050. Sustainable transport networks will reduce our carbon footprint by adopting technologies, such as electrification, that reduce reliance on fossil fuels.

Transport for NSW's **Net Zero and Climate Change Policy** sets out a plan for transitioning the NSW transport sector to net zero emissions. This includes:

- continued transitioning of the public transport bus fleet to zero emission buses
- electrifying ferries
- supporting rollout of electric vehicle charging
- investing in green energy technologies based at Transport for NSW sites
- collaborating with the freight sector to support the uptake of zero emission technologies
- supporting the creation of a sustainable aviation industry in NSW.

Tackling the embodied emissions in new infrastructure (for example, in concrete, vehicles and buildings) is an important step in properly accounting for emission reductions. Transport for NSW has set a target for net zero in the agency's annual embodied emissions by 2045.

Zero Emission buses and ferries

The Transport for NSW **Zero Emission Buses program** will transition the state's 8,000+ diesel and natural gas public transport buses to zero emissions technology. The program will be delivered in stages to allow local industry time to prepare, and technology advancements to be assessed and adopted along the way.

The first stage of the program is expected to be complete by 2028, with around 1,700 zero emission buses expected to be operating on Sydney roads by the end of 2028.

The full transition is expected to be complete in Greater Sydney by 2035, in Outer Metropolitan regions by 2040 and in Regional NSW by 2047.

With buses accounting for 69% of emissions from Transport for NSW's operations in 2023–23, (**TfNSW 2024d**), this transition has potential to make a significant dent in public transport emissions.

The NSW Government has set a requirement that **new ferries are zero emissions**. Ferries are responsible for 6% of Transport for NSW emissions (**TfNSW 2024d**).

Transport for NSW operations and fleet

Building on the NSW Government's net zero targets, Transport for NSW has committed to achieving **net zero emissions** from its operations and fleet by 2035.

Significant progress has been made in achieving this target with all of **Sydney Metro trains stations and operational facilities** being powered entirely by renewable electricity since mid-2019.

The Sydney Trains and NSW TrainLink electrified network have been powered by 100% renewable electricity since mid-2021.

Regional Rail fleet

The NSW Government's **Regional Rail project** is replacing the ageing NSW regional rail fleet with 29 new trains that will operate with an Australian first – bi-mode technology.

Bi-mode technology enables the train to run using either diesel engines or electric power from the overhead wire when operating on the electrified train network. This technology will significantly reduce carbon emissions and diesel particulates, compared to the current regional fleet.

Find out more about bi-mode technology in this **fact sheet (PDF 234KB)**.

Freight

Towards Net Zero Emissions – Freight Policy (**TfNSW 2023c**) sets out the strategic direction and actions to support emission reductions across the road and rail freight transport sector. It is framed around short-term actions (0–2 years), medium-term actions (3–5 years) and long-term actions (5+ years).

The **Freight Policy Reform program** is addressed decarbonisation as part of its review and consultation. **Proposed actions** include identifying:

- how emissions data can be made more widely available
- actions and incentives that will encourage the transition to zero- and low-emissions vehicles
- incentives for switching from road to rail.

Electric vehicles

The ***NSW Electric Vehicle Strategy*** (**DPIE 2021**) aims to increase EV sales to 52% by 2030–31 and help NSW achieve net-zero emissions by 2050.

Through the strategy, the NSW Government has prioritised investment in charging infrastructure across metropolitan and regional areas to make EV ownership easier regardless of where someone lives.

The NSW Government has invested $209 million in critical charging infrastructure including ultra-fast charging, destination charging, and kerbside charging.

An additional $263 million will underpin the rollout of a new EV strategy with a focus on boosting investment in critical infrastructure and ensuring charging is deployed equitably across NSW.

See the **Net Zero Plan Stage 1: 2020–2030** topic for more information.

Technology

The NSW ***Transport Technology Strategy*** (**TfNSW 2024e**) sets out a vision for optimising the use of technologies to provide a safe, reliable, equitable, sustainable and electric transport network for NSW.

Planning for resilience

When damaging events occur, we need to reduce the risk and impact on communities and build back to a more resilient standard.

As part of the NSW Government's response to recent severe weather events, several priority resilience programs have been implemented to provide assistance for extreme weather and natural disasters and prepare for future events, including:

- **Regional Roads and Transport Recovery Package** (jointly funded with the Australian Government)
- **Regional and Outer Metropolitan – Network Resilience Program** (including Bushfire Corridor Resilience, Customer Journey Resilience Plans and the Aboriginal Cultural Landscapes Management Project)
- the **Hawkesbury-Nepean Valley Flood Evacuation Road Resilience Program**
- the **Regional Transport Resilience Fund** as part of the Central West Recovery and Resilience Package (jointly funded with the Australian Government).

Transport for NSW provides **assessment and reporting tools** to help projects identify and mitigate their climate risk and reduce carbon impacts.

Reducing the impacts of transport infrastructure on wildlife

Transport agencies around the world are building fences to prevent wildlife from accessing roads and railways, and installing underpasses and overpasses to allow safe crossings, connect habitats, support gene flow and allow animals to repopulate after floods and fire.

Fencing, however, cannot be practically installed on many roads. Emerging technologies, such as Artificial Intelligence (AI) assisted cameras linked to road signs or cars, have the potential to radically improve driver awareness of animals on roads and road verges. Other technologies offer innovative ways to deter animals from entering the road corridor at all.

Wildlife vehicle collisions are a significant risk to human safety, a threat to wildlife conservation and an animal welfare concern.

In May 2024, Transport for NSW hosted a symposium to investigate the potential role of emerging technologies in reducing wildlife vehicle strike. The symposium brought together a global network of ecologists, technologists, road safety experts, wildlife carers and government to hear about the current state of the science of wildlife vehicle strike reduction.

A report on the outcomes of the symposium will be available in late 2024. The report will set the direction for trials of the most promising new technologies in hope of making a substantial contribution to reducing wildlife vehicle strike on our roads and railways. See **highlights from the symposium**.

In addition to its ***Biodiversity Policy*** (**TfNSW 2022c**), Transport for NSW has developed the ***Biodiversity Management Guideline*** (**TfNSW 2024a**), which provides guidance for protecting and managing biodiversity on the agency's projects. This includes information about matters such as:

- pre-clearing processes
- re-establishing native vegetation
- weed and pathogen management
- artificial hollows.

Urban planning

Cities with high population densities generally have higher rates of public and active transport use. Clustering new development (including housing, employment and services) around public transport nodes, such as stations, wharves and rapid bus hubs, facilitates walking and encourages public transport use, achieving substantial shifts in favour of more sustainable modes.

Better integrated transport and land use planning can support more sustainable travel and reduce urban sprawl. The **Transport Oriented Development (TOD) Program** (**NSW Planning 2023**) aims to support car-free, active, sustainable transport options, including providing customer-centric design for public transport hubs and more efficient end-to-end journeys.

Planning for the movement and delivery of freight is also an important part of successful urban planning for our cities. Land use planning and zoning of land needs to consider freight as it is a critical service for communities.

With careful design, the renewal of existing sites could also support other uses, such as education or childcare, giving people easier access to jobs, education and recreation. By planning for multiple uses, infrastructure can adapt to the changing and maturing of neighbourhoods.

Supporting growth around public transport can reduce peak congestion on our roads and offer more diversity and affordability in housing and other uses. It can even spur renewal in locations with the potential for high-quality housing, local jobs and community infrastructure and result in improvements that make precincts greener and more liveable.

Under Transport's **Road User Space Allocation Policy**, roads are used to support the creation of better places and ensure road space is optimised to encourage walking, cycling and efficient public transport. The **Providing for Walking and Cycling in Transport Projects Policy** requires all transport projects funded by Transport for NSW to include provision for walking and cycling.

Other programs and policies that support walking and cycling include:

- the ***Active Transport Strategy***
- the **Get NSW Active program**
- the **Strategic cycleway corridors for Greater Sydney** program
- the **Movement and Place** framework and Design of Roads and Streets.

The best-practice approach for provision of landscape and green infrastructure on roads and streets as part of Transport for NSW projects, including the need for shade along footpaths and cycleways in urban settings, is addressed in Transport's **Landscape Design Guideline**.

The NSW Government has committed to address urban heat through a range of initiatives, such as **mapping tree canopy** and **grants for new tree planting projects** in Greater Sydney.

Contamination management

Transport for NSW has developed a range of **guidelines for preventing and managing land and water contamination** related to the construction, maintenance and use of transport infrastructure. The guidelines are for use by both Transport for NSW staff and contractors and address issues, such as erosion and sediment control, runoff from construction site and acid sulfate materials that may be exposed during construction.

The NSW Government has also developed a **risk-based framework** that can be used to manage the impacts of urban development on NSW waterways.

Managing marine impacts

The Australian ***Biosecurity Act 2015*** and related legislation collectively prescribe how ballast water should be managed in Australian waters. The discharge of unmanaged ballast water or ballast tank sediments is an offence.

The ***Australian Ballast Water Management Requirements*** explain how to comply with the legislation while operating a vessel in Australian waters.

Since September 2019, all vessels that use ballast water have been required to meet the regulation D-2 discharge standard of the **International Convention** for the Control and Management of Ships' Ballast Water and Sediments at their next renewal survey.

Visit the Australian government's **ballast water** webpage for more information.

In NSW, the ***Pesticides Act 1999*** and **Pesticides Regulation 2017** set out requirements for the approval and **safe use and disposal of anti-fouling products** to prevent water pollution.

Federal initiatives

Review of the national freight and supply chain strategy

The 2023 review of the ***National Freight and Supply Chain Strategy*** recommends that decarbonising the freight and supply chain sector should be a new strategic goal and key priority in the refreshed strategy.

The review states that this will support coordination of a more consistent approach across all states and territories and businesses. Decarbonisation can be encouraged through a range of measures, such as:

- regulatory consistency across jurisdictions
- policies to encourage adoption of low-emission vehicles
- shifting more freight to rail
- smart technology for route-planning.

Efficiency standards

The Australian Government is introducing a **new vehicle efficiency standard** in 2025. This aims to increase the supply of energy-efficient vehicles, including EVs, and boost NSW efforts to increase EV uptake.

The Commonwealth is also introducing **improvements to fuel quality** in December 2025 that will reduce noxious emissions from vehicles that rely on fossil fuels.

See the **Air quality** topic for more information about these initiatives.

Future opportunities

Data gaps and opportunities

Although wildlife rescue data provides some information about the impacts of motor vehicles on our wildlife, no data is available on animals hit by vehicles but not rescued. This means that available data is likely to be significantly lower than the actual death toll.

Information about the potential fragmentation of habitat due to construction is not available but is also not easy to measure.

There is a lack of systematic data on the extent of the NSW population's exposure to unhealthy noise levels, including road noise. Data on the impacts of transport-related noise and light on NSW wildlife is also lacking.

Smart technologies

There are opportunities to increase the efficiency of our roads, rail and ports through data sharing, and new technologies and travel modes.

The ***Transport Technology Strategy*** (**TfNSW 2024e**) outlines ways in which smart technologies can improve environmental outcomes. These include:

- encouraging walking, cycling and other active transport, for example apps that identify the nearest ride-share bicycle, improvements to trip planning apps and making it possible to pay for bike lockers with Opal cards
- encouraging the adoption of EVs by increasing the rollout of new infrastructure technologies, such as smart charging stations (perhaps fuelled by green hydrogen)
- monitoring factors such as energy consumption and the carbon footprint of the transport sector's supply chain.

Feeding the energy grid

Electric vehicles that are fitted with **bidirectional chargers** can feed power back into the electricity grid, homes or other electric devices, depending on the type of charger that is fitted. This means that vehicles can be used as storage devices, with their owners able to reduce electricity bills (especially if charging with rooftop solar), charge appliances while travelling and sell energy back to the grid. There is also scope to use such vehicles to supply power during power outages, for example, during emergencies.

Only a limited number of vehicles in Australia are fitted with bidirectional chargers and none are currently able to feed back to the grid, but this technology offers opportunities for increased energy storage, efficiency and security. The Australian Renewable Energy Agency has published a report on the opportunities, challenges and policy changes needed to adopt the technology in Australia (**ARENA 2023**).

This technology can also be used for scooters and bicycles. An enterprise in Vietnam, for example, is exploring the **use of e-bikes** to supply power to small businesses during power blackouts.

References

ABS 2024, Table 4: Population – states and territories (time series spreadsheet), National, state and territory population, December 2023 release, Australian Bureau of Statistics, Canberra, accessed 15 July 2024

Alquezar RD & Macedo RH 2019, 'Airport noise and wildlife conservation: What are we missing?' *Perspectives in ecology and conservation*, vol. 17, no. 4, pp. 163–717

ARENA 2023, *V2X.au Summary Report–Opportunities and Challenges for Bidirectional Charging in Australia 30*, Australian Renewable Energy Agency, Canberra

ATO 2023, Exempt use of eligible vehicles, Australian Tax Office, accessed February 2024

DHAC 2018, *enHealth Guidance: The health effects of environmental noise* Australian Government Department of Health and Aged Care

Awonaike B, Parajulee A, Lei YD & Wania F 2022, 'Traffic-related sources may dominate urban water contamination for many organic contaminants', *Environmental Research Letters vol. 17*, no. 4, DOI 10.1088/1748-9326/ac5c0e

BITRE 2023, *Road Vehicles: Australia January 2023*, Bureau for Infrastructure and Transport Research Economics

BITRE 2024a, *Australian Infrastructure and Transport Statistics - Yearbook 2023*, Bureau for Infrastructure and Transport Research Economics

BITRE 2024b, *Road Vehicles: Australia January 2024*, Bureau for Infrastructure and Transport Research Economics

Broome RA, Powel J, Cope ME & Morgan GG 2020, 'The mortality effect of $PM_{2.5}$ sources in the Greater metropolitan Region of Sydney, Australia', *Environment International* vol. 137, 105429

Chen X, Liu M, Zuo L, Wu X, Chen M, Li X, An T, Chen L, Xu W, Peng S, Chen H, Liang X & Hao G 2023, 'Environmental noise exposure and health outcomes: an umbrella review of systematic reviews and meta-analysis', *European Journal of Public Health*, vol. 33, no. 4, pp. 725–31

CWANZ 2021, National Walking and Cycling Participation Survey 2021, Cycling and Walking Australia and New Zealand, accessed 18 October 2024

CWANZ 2023, *National Walking and Cycling Participation Survey 2023*, Cycling and Walking Australia and New Zealand, accessed 18 October 2024

DAFF 2021, *Marine Pests*, Department of Agriculture, Fisheries and Forestry, Canberra

DCCEEW-Aus 2022, *Australia's Emissions Projections 2022*, Australian Government Department of Climate Change, Energy, the Environment and Water, Canberra

DCCEEW-Aus 2024a, Air transport, Australian Government Department of Climate Change, Energy, the Environment and Water, Canberra, accessed 31 July 2024

DCCEEW-Aus 2024b, Maritime transport, Australian Government Department of Climate Change, Energy, the Environment and Water, Canberra, accessed 31 July 2024

DCCEEW-Aus 2024c, *National Inventory Report 2022*, Australian Government Department of Climate Change, Energy, the Environment and Water Canberra

DCCEEW-Aus 2024d, State and Territory greenhouse gas inventories: 2022 emissions, Australian Government Department of Climate Change, Energy, the Environment and Water, accessed on 19 August 2024

Dean WRJ, Seymour CL, Joseph GS & Foord SH 2019, 'A review of the impacts of roads on wildlife in semi-arid regions', *Diversity*, vol. 11, no. 5, 81

DPHI 2024, Urban heat, Department of Planning, Housing and Infrastructure, accessed 6 August 2024

DPIE 2021, *NSW Electric Vehicle Strategy*, NSW Department of Planning, Industry and Environment, Sydney

EEA 2020, *Environmental Noise in Europe: 2020*, European Environment Agency, Copenhagen, Denmark

FCAI 2023, *FCAI 2022 Zero and Low Emission Vehicles Report*, Federal Chamber of Automotive Industries, Kingston (PDF 1.6MB)

FCAI 2024, *Australia breaks all-time new vehicle sales in 2023*, Federal Chamber of Automotive Industries, Kingston

Fuller K & Huntsdale J 2024, Transport inequity challenges south-west Sydney residents as young people worry about car dependence, ABC News, accessed 17 September 2024

Hansson J, Pettersson-Löfstedt F, Svensson H & Wretstrand, A 2019, 'Preferences in regional public transport: a literature review', *European Transport Research Review*, vol. 11, no. 38

Holguin-Veras J, Ramirez-Rios D, Ng J, Wojtowicz J, Haake D, Lawson CT & Wang C 2021, 'Freight-Efficient Land Uses: Methodology, Strategies, and Tools', *Sustainability*, vol.13 No. 6, 3059, DOI: 10.3390/su13063059

IEA 2023a, *Tracking Transport*, International Energy Agency, accessed 17 September 2024

IEA 2023b, *Well-to-wheel GHG intensity of motorised passenger transport modes, 2022*, International Energy Agency, accessed 17 September 2024

Irle R 2023, Global EV Sales for 2023, EV Volumes

Johnson CD, Matthews T, Burke M & Jones D 2022, 'Planning for fauna-sensitive road design: A review', *Frontiers in Environmental Science*, vol. 10, 959918, DOI:10.3389/fenvs.2022.959918

Khreis H, Kelly C, Tate J, Parslow R, Lucas K & Nieuwenhuijsen M 2017, 'Exposure to traffic-related air pollution and risk of development of childhood asthma: A systematic review and meta-analysis', *Environment International*, vol. 100, pp. 1–31

Kok ACM, Berkhout BW, Carlson NV, Evans NP, Khan N, Potvin DA, Radford AN, Sebire M, Sabet SS, Shannon G & Wascher CAF 2023, 'How chronic anthropogenic noise can affect wildlife communities', *Frontiers in Ecology and Evolution*, vol. 11, 1130075, DOI: 10.3389/fevo.2023.1130075

NOAA 2024, Monthly global climate report for June 2024, National Centers for Environmental Information, accessed 6 August 2024

NSW Government 2023, Sydney housing supply forecast 2023 data

NSW Government 2024, NSW Net Zero Emissions Dashboard

NSW Health 2018, *TP03: Health Effects of Traffic-related Air Pollution*, NSW Health, Sydney, (PDF 2.7MB)

NSW Planning 2023, *Transport Oriented Development Program*, Parramatta

NSW Planning 2024, *Population Projections*, Parramatta

NSW Trains 2023, *NSW TrainLink Annual Report: Volume 1*, NSW Trains, Wollongong

NSW Treasury 2022, *NSW Budget 2022–23: No.02 Outcomes Statement Budget Paper*, NSW Treasury, Sydney (PDF 2 MB)

Parris K & McCauley R 2016, Noise pollution and the environment, Australian Academy of Science, accessed 29 July 2024

Peikertova P & Filip P 2016, 'Influence of the automotive brake wear debris on the environment: A review of recent research', *SAE International Journal of Materials and Manufacturing*, vol. 9, no. 1, pp. 133–46

Polak T, Rhodes R, Jones D & Possingham HP 2014, 'Optimal planning for mitigating the impacts of roads on wildlife', *Journal of Applied Ecology*, vol. 51, no. 3, pp. 726–34

Prieto-Curiel R & Ospina JP 2024, 'The ABC of mobility', *Environment International*, vol. 185, 108541

Smit R 2024, We compared land transport options for getting to net zero. Hands down, electric rail is the best, *The Conversation*, accessed 14 November 2024, Taylor DB & Goldingay RL 2010, 'Roads and wildlife: impacts, mitigation and implications for wildlife management in Australia', *Wildlife Research*, vol. 37, no. 4, pp. 320–31

TfNSW 2022a, *Active Transport Strategy*, Transport for NSW, Sydney

TfNSW 2022b, *Annual Statistical Statement for road traffic crashes: Table 13*, Transport for NSW, Sydney

TfNSW 2022c, *Biodiversity Policy*, Transport for NSW, Sydney (PDF 489KB)

TfNSW 2022d, *Future Transport Strategy: Our vision for transport in NSW*, Transport for NSW, Sydney

TfNSW 2022e, Registration and licensing statistics: Table1.1.2 – Vehicle usage by vehicle type – registered vehicles as at 31 March 2014, Transport for NSW, Sydney

TfNSW 2023a, *Design of Roads and Streets*, Transport for NSW, Sydney

TfNSW 2023b, *Household Travel Survey*, Transport for NSW, Sydney

TfNSW 2023c, *Towards Net Zero Emissions – Freight Policy*, Transport for NSW, Sydney

TfNSW 2024a, *Biodiversity Management Guideline: Protecting and managing biodiversity on Transport for NSW projects*, Transport for NSW, Sydney (PDF 15MB)

TfNSW 2024b, Public transport (Opal) data, Transport for NSW, Sydney

TfNSW 2024c, Registration snapshot report, Transport for NSW, Sydney

TfNSW 2024d, *Transport Sustainability Report 2022–23*, Transport for NSW, Sydney,

TfNSW 2024e, *Transport Technology Strategy*, Transport for NSW, Sydney

TfNSW 2024f, Watch for animals, Transport for NSW, Sydney, accessed 18 October 2024

Water use

In a State with highly variable rainfall, equitable access to water depends on capturing it, storing it and using it efficiently. Climate change and population growth are making this more difficult.

Overview

NSW uses an average of about

5,650 gigalitres

of water per year

Read more

Households use about

11%

of all the water used

Read more

Water is a vital resource in our everyday lives and in the environment around us. We use it in our households, industries and food production, in cultural practices and for maintaining and restoring the environment.

Nearly all the water we use comes from rainfall. Rainfall in NSW is highly variable, so we need to capture and store it for later use. We also need to use it efficiently and wisely to make sure it is available for all users.

Climate change makes this harder in two ways – higher temperatures increase water use and the severity of drought, and rainfall becomes more variable and likely to decrease.

Water management is also challenged by our increasing population.

Removing too much water from our rivers, streams and groundwater systems can reduce their environmental health. Putting water back at the wrong time, at the wrong temperature or with different amounts of nutrients can harm plants and animals.

We need to manage our water use to ensure aquatic environments have the water they need at the right times This will protect the environmental and cultural values of rivers and groundwater systems.

How we use water

In NSW, we used on average about 5,650 gigalitres (GL) of water per year from 2014–15 to 2023–24 (**DPIRD n.d.-a**). This varies annually depending on water availability in rivers, as less is available during drought.

The Australian Bureau of Statistics uses surveys to find the main uses for water in Australia. Their data for the years 2014–15 to 2021–22 showed the main uses for water in NSW were:

- agriculture, forestry and fishing industry, about 64%
- electricity generation, gas production, water supply losses and waste services, about 16%
- households, about 11%
- other industry, about 7%
- mining about 2% (**ABS 2023**).

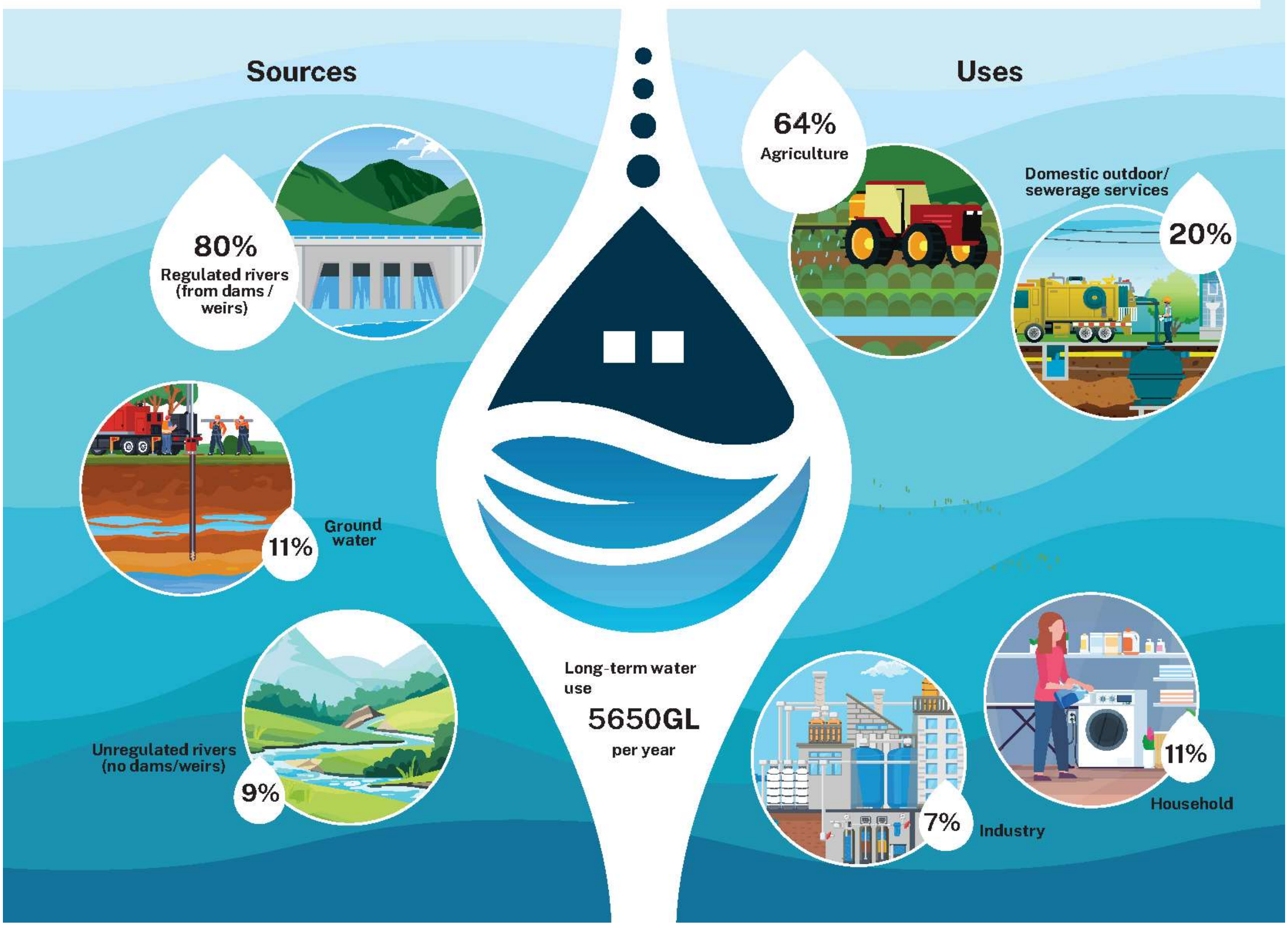
Water is lost from storages and the distribution system due to evaporation and leakage.

Most of the water supplied in NSW is extracted from rivers, surface water runoff and groundwater systems (see **Figure P3.1**). A small fraction comes from desalinated seawater. Some water is recycled from homes and industries to be used on parks and gardens, and by industry. Sydney Water is developing purified recycled water by treating recycled water further to meet drinking water standards.

Excluding supply to Sydney, in 2022–23 about 74% of this water came from regulated rivers. Flows in these rivers are controlled by large dams and weirs. Of the remainder, just under 17% was sourced from unregulated rivers (rivers without large dams or weirs) and about 9% from groundwater (**WaterNSW 2024**).

See the **Rivers and wetlands** and **Groundwater** topics for more information.

Figure P3.1: Conceptual model of water use paths



Source:
NSW EPA 2024

Environmental impacts

Water use patterns and practices in NSW have contributed to the degradation of aquatic ecosystems. Changes to the timing, amount and temperature of water in our streams have caused significant biodiversity loss and declining ecosystem health, particularly in the Murray–Darling Basin.

A striking example of this is the occurrence of mass fish deaths when oxygen levels in the water fall too low. Two significant such events occurred in the Darling–Baaka River in the last three years (**ONCSE 2023**).

Various human activities alter the natural properties and composition of water. The addition of harmful chemicals can cause both short- and long-term impacts on plants and animals.

In addition, water use and infrastructure in urban areas affects aquatic ecosystems through:

- increased stormwater runoff, which adds pollutants
- higher water flows, which erode banks and deepen channels

- the building of artificial waterways that don't allow plants and animals to grow
- discharges from sewage treatment plants, which change flow rates, temperatures and amounts of nutrients.

See the **Rivers and wetlands** and **Coastal and marine** topics for more information.

How we manage water

Water is regulated in NSW through a system of water licences and allocations for every water source.

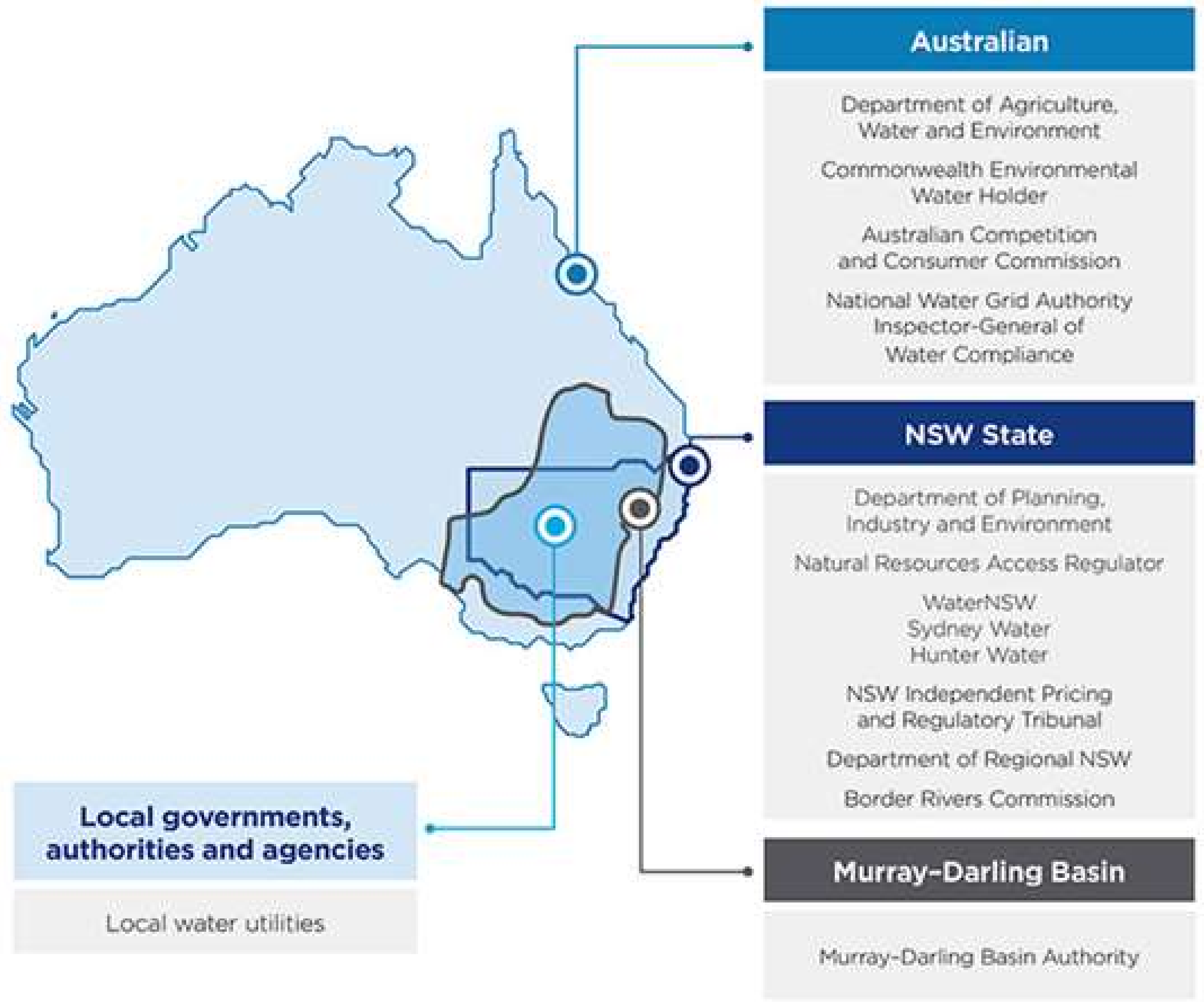
Many agencies manage water in NSW (see **Figure P3.2**). These include:

- the Australian Department of Climate Change, Energy, the Environment and Water
- the NSW Department of Climate Change, Energy, the Environment and Water
- WaterNSW
- the Murray–Darling Basin Authority
- local water utilities in regional towns
- metro water utilities (Sydney Water and Hunter Water).

NSW Health endorse the **Australian Drinking Water Guidelines**.

Water management is becoming harder as NSW's climate changes. Rainfall is more variable. Higher temperatures have made droughts more severe and more rapid. Less water is available and our storages are used up sooner.

Figure P3.2: Major agencies and organisations involved in water regulation in NSW



Notes:
Created prior to 2023. Since 2023, some entities listed above have changed names.

Source:
DCCEEW n.d.-a

The ***Water Management Act 2000*** and various regional Water Sharing Plans provide the legal framework for water licencing, allocations, water sharing, environmental flows and water trading.

Water is allocated for licence holders annually. Allocation depends on various factors, including availability and prioritisation.

See the **WaterNSW website** for more information on how water is allocated.

Water for the environment is specifically set aside to sustain and restore natural waterways. It is essential to improving environmental, economic, social and cultural outcomes.

See the **water for the environment website** for more information.

Aboriginal people, communities and organisations in NSW can apply for an Aboriginal cultural water licence for up to 10 megalitres (ML) to provide water to care for cultural values or maintain cultural practices.

The ***NSW Water Strategy*** underpins the State's approach to improving the security, reliability and quality of water resources while balancing the need to supply water in order to:

- provide a healthy environment
- secure water resources for human use
- support Aboriginal cultural outcomes

- enable economic function.

A combination of public health and water quality legislation and policies ensure high-quality drinking water in NSW.

NSW manages water resources by using a range of legislative instruments, strategies, policies and plans (see **Table P3.1**). Their purpose is to provide safe water to people, businesses and industries in ways that minimise impacts on the environment.

Table P3.1: Current key legislation and policies for the management of water and its use

Legislation or policy	Summary
Commonwealth Water Act 2007	Makes provision for the management of the water resources of the Murray–Darling Basin, and to make provision for other matters of national interest in relation to water and water information, and for related purposes.
NSW Water Management Act 2000	Recognises the need for allocation and provision of water for environmental health of rivers and groundwater. It provides water licence holders with secure access and trade opportunities.
Public Health Regulation 2012	Regulates drinking water standards.
Australian Drinking Water Guidelines 2011	Endorsed by the NSW Government and used to assess safety of water for drinking.
Commonwealth Basin Plan 2012	Sets out objectives and outcomes to manage the water resources in the Murray–Darling basin. Legislative instrument made under subparagraph 44(3)(b)(i) of the Commonwealth *Water Act 2007*.
National Water Quality Management Strategy	Assists water resource managers to understand and protect water quality so that it is 'fit for purpose.'
NSW Long-term Water Plans	As part of NSW's commitments under the Basin Plan, NSW has developed long-term water plans for nine NSW river catchments which guide and inform water management (including water for the environment) for environmental outcomes over the long term by setting objectives, targets and watering requirement for plants, waterbirds, fish, other species such as frogs over 5-, 10- and 20-year timeframes.
NSW Water Strategy 2021	A 20-year, statewide strategy to improve the security, reliability and quality of the State's water resources over the coming decades. Sets the overarching vision for twelve regional and two metropolitan water strategies, tailored to the individual needs of each region in NSW. Implementation plan 2022–24 sets out current work, 42 actions across 7 priorities.
Water Sharing Plans	Provides rules for the allocation and sharing of water between water users and environmental needs. Plans are provided for different regions and water sources within NSW.

Notes:
See the **Responses** section for more information about how **Water use** is being addressed in NSW.

Related topics: **Climate change** | **Groundwater** | **Population and the environment** | **Rivers and wetlands**

Status and trends

Water use indicators

Indicators are chosen to represent how successful we are in delivering safe water to support the environment, industry and households. We need to store water so it can be delivered when needed, while also making sure there are effective systems in place for sharing it. Minimising use is an important part of making sure we have enough.

Table P3.2 shows water use indicators relating to environmental use.

- **Proportion of water extraction covered by water sharing plans** remains stable owing to high surface water availability from relatively high rainfall in 2021–24 (see **Extraction from NSW rivers**).
- **Allocation of water for the environment** significantly improved from previous years from 'moderate' to 'good' (see **Water for the environment**).

Table P3.2: Water use indicators – environmental use

Indicator	Environmental status	Environmental trend	Information reliability
Proportion of water extraction covered by water sharing plans	GOOD	Stable	Good
Allocation of water for the environment	GOOD	Getting better	Reasonable

Notes:
Indicator table scales:
- **Environmental status**: Good, moderate, poor, unknown
- **Environmental trend**: Getting better, stable, getting worse
- **Information reliability**: Good, reasonable, limited.

See **Indicator guide** to learn how terms and symbols are defined.

Table P3.3 shows indicators relating to water supply.

- **Proportion of the metropolitan and regional water supply meeting national guidelines** is stable, continuing to meet national guidelines and provide communities with high-quality water that is safe to use (see **Urban water**).
- **Minimising total and per person water use in metropolitan and regional centres** is moderate and use is decreasing in urban areas meaning the trend is getting better (see **Urban water**).
- **Water recycling** (both **major utilities** and **local water utilities**) is increasing, however, recycled water still provides only a small fraction of the water supply (see **Other water sources**).

Table P3.3: Water use indicators – supply

Indicator	Environmental status	Environmental trend	Information reliability
Proportion of the metropolitan and regional water supply meeting national guidelines	GOOD	Stable	Good
Minimising total and per person water use in metropolitan and regional centres	MODERATE	Getting better	Good
Water recycling – major utilities	MODERATE	Stable	Good
Water recycling – local water utilities	MODERATE	Getting better	Good

Notes:
Indicator table scales:
- **Environmental status**: Good, moderate, poor, unknown
- **Environmental trend**: Getting better, stable, getting worse
- **Information reliability**: Good, reasonable, limited.

See **Indicator guide** to learn how terms and symbols are defined.

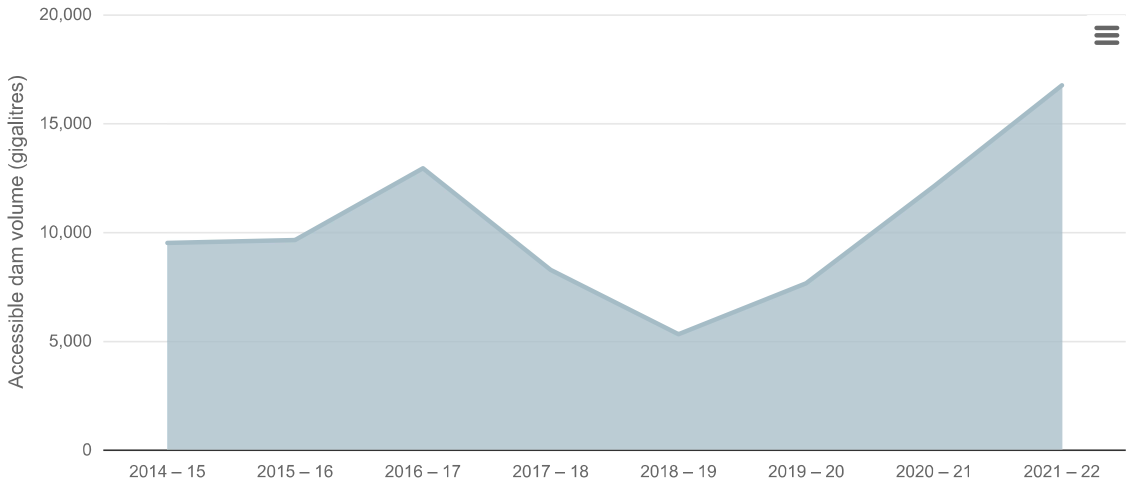
Storage volumes

Water storage in NSW is highly dependent on rainfall.

The amount of water stored in dams across NSW decreased from 2017 into 2020 because of below-average rainfall (see **Figure P3.3**). By February 2020, combined total regional dam levels reached their lowest point since 2007, with some storages facing supply issues.

Significant rainfall in February and March 2020 increased dam levels in the Greater Sydney region to about 82% by the end of March. Yet these weather events increased dam levels in the regions only marginally, to about a quarter of capacity.

Figure P3.3: Accessible volumes of water (GL) in major NSW dam storages, as at 30 June 2024, from 2015 to 2022

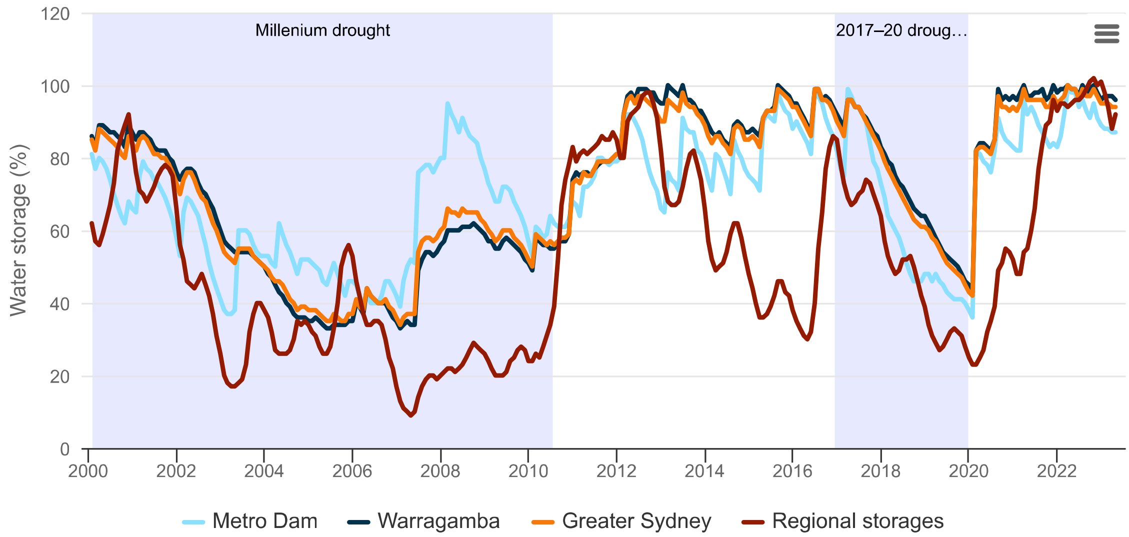


Source:
ABS 2023

Storage throughout NSW remained above 80% until February 2023 (see **Figure P3.4**). Spilling occurred in some areas at the end of 2022.

Rainfall can vary significantly within NSW resulting in marked differences in dam storage levels.

Figure P3.4: NSW storage level profiles between 2000 and 2024



Notes:
Metro Dam includes Cataract, Cordeaux, Avon, Woronora and Nepean dams. Regional storage information excludes Glen Lyon and Oberon dams owing to incomplete data.

Source:
WaterNSW data 2024

Extraction from NSW rivers

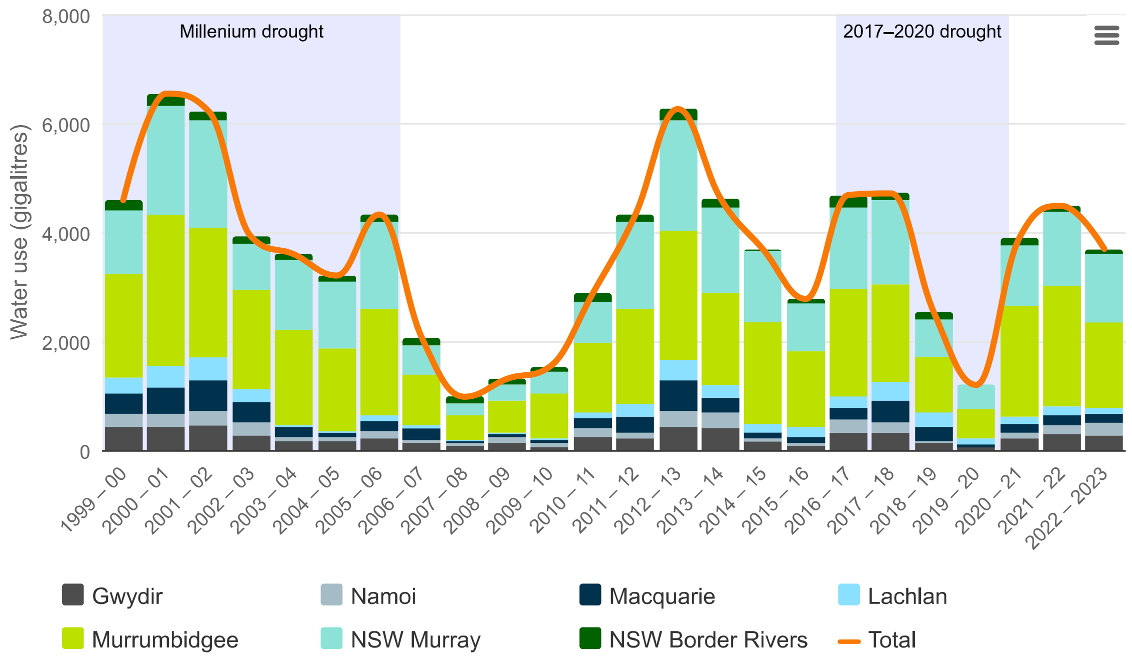
Climate variability affects water extraction

Figure P3.5 shows water use by licensed users from 1999–2000 to 2022–23 taken from the major NSW inland regulated river valleys (Gwydir, Namoi, Macquarie, Lachlan, Murrumbidgee and NSW Murray).

Much less water was used at the end of the Millennium Drought (2001–09) and during the 2017–20 drought. Dry conditions eased in 2020 and wetter weather occurred in 2021–23. This replenished storages and enabled full allocations for licence holders.

Water use has decreased from 1999–2000 to 2022–23.

Figure P3.5: Water use (GL) by licensed users in major NSW regulated valleys from 1999–2000 to 2022–23



Notes:
Some 'water remaining' is lost to evaporation, seepage and other transmission losses. While in the system, this water may have some benefit to the environment, depending on the duration, volume and timing of its flow.
Water use figures refer to licensed account usage. Water licences are held for town water supply, agriculture and the environment.
Floodplain harvesting is not included in the charts.
Total flow and observed diversions in the Murrumbidgee Valley are influenced by water released from the Snowy Mountains Scheme. These releases have greatest relative contribution in dry years. Development in the valley reflects this inter-valley transfer.
NSW Border Rivers data before 2009 were estimated from Independent Pricing and Regulatory Tribunal submissions.

Source:
DCCEEW – NSW Water Accounting System (WAS)

Figure P3.6 (a–e) shows water usage for each of the five major NSW inland regulated river valleys (excluding the Murray) as the amount of water extracted and the amount remaining in the river after extraction. Percentages for each are listed. The graphs show the large variation in water supply from rainfall and that it can change quickly.

Water demand increases when rainfall is lower but this also reduces water flowing into our rivers. Water sharing plans set out how much water will be distributed. NSW limits the impact of dry conditions on river systems by releasing water from storage, by limiting the amount of water extracted and by specifically allocating water to the environment.

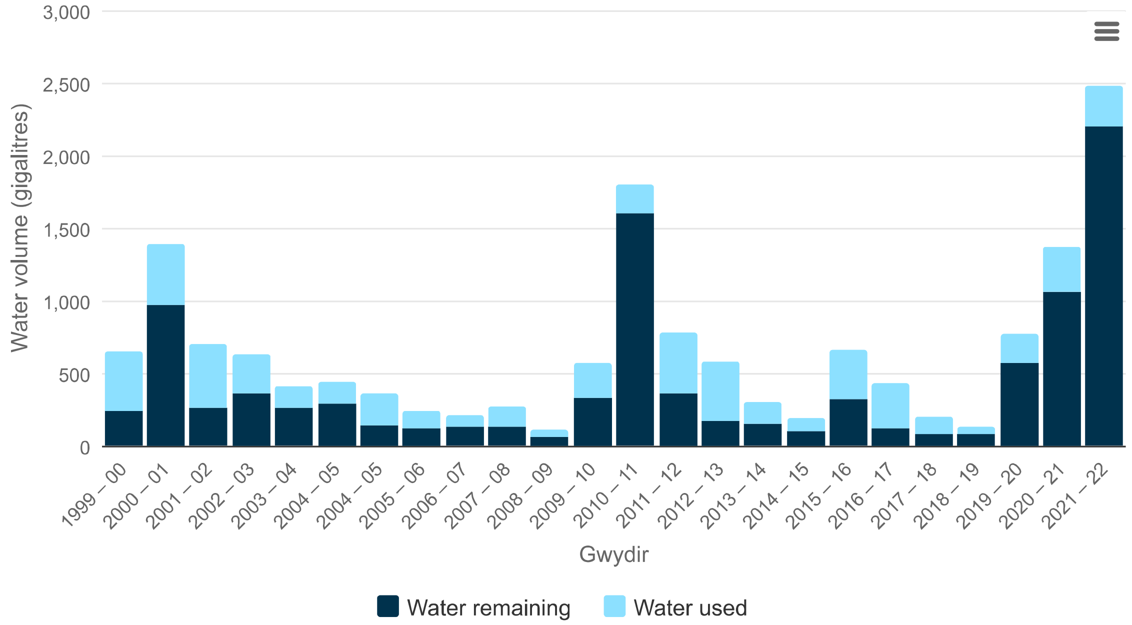
The graphs show the differences that can occur in water availability among these five river valleys over the same period due to variable rainfall across the State.

In 2016–17, more water was available in the Macquarie (6c), Lachlan (6d) and Murrumbidgee (6e) from higher-than-usual rainfall. In contrast, the Gwydir (6a) and Namoi (6b) experienced median rainfall.

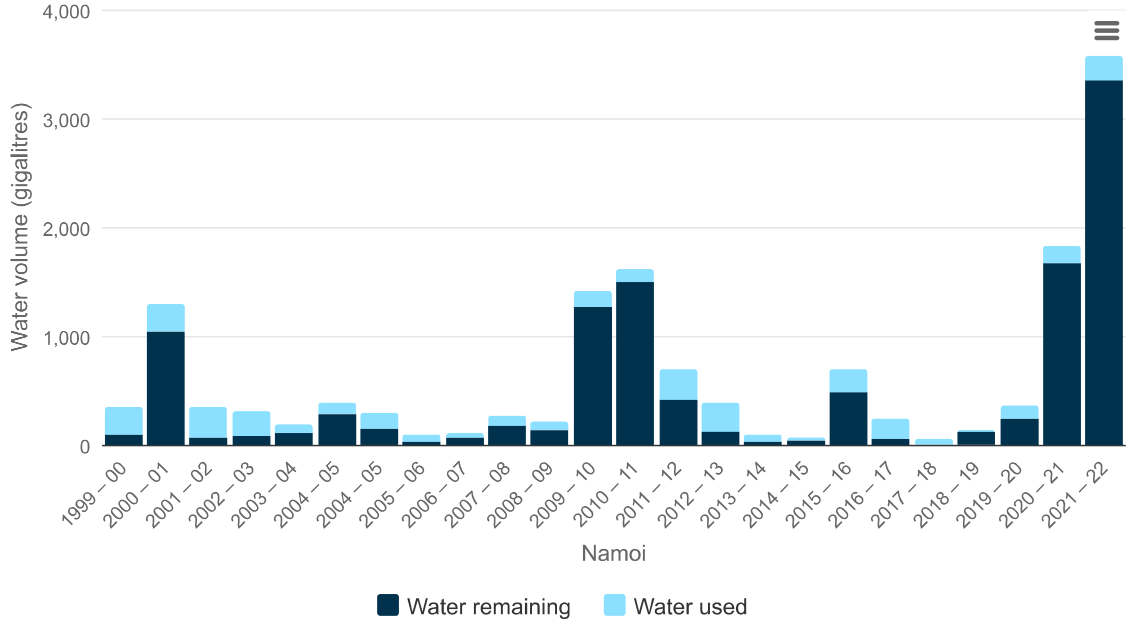
See the **Climate change** topic for more information about rainfall patterns.

Figure P3.6 (a–e): Amount of water (GL) in rivers from major inflows and water remaining after extraction in the major NSW regulated valleys, 1999–2000 to 2022–23 (from north to south of NSW)

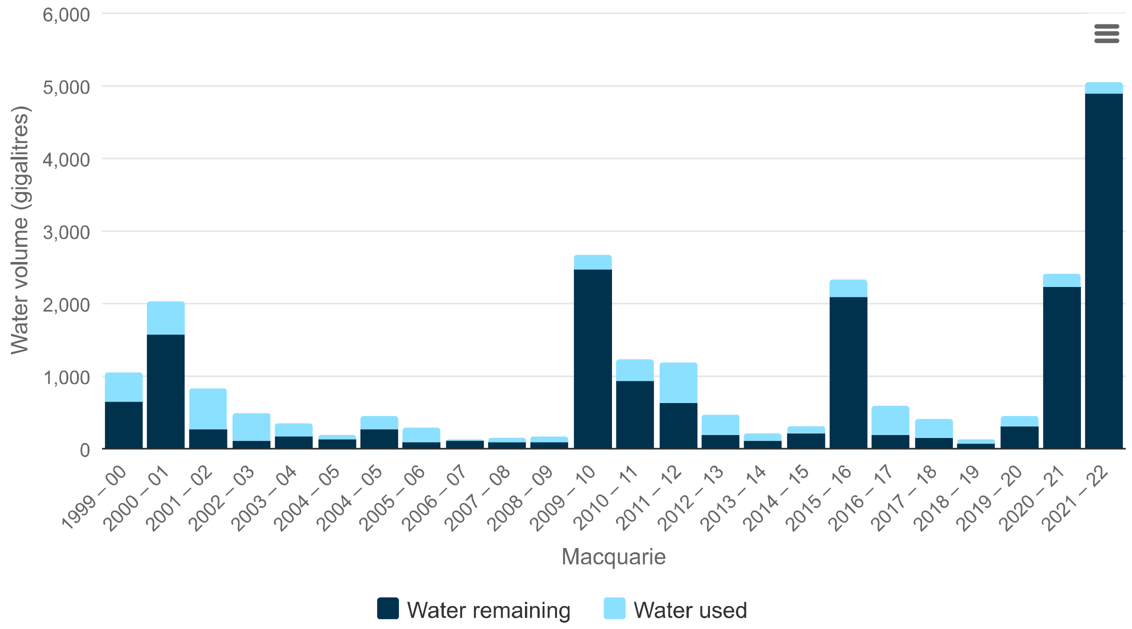
a) Gwydir



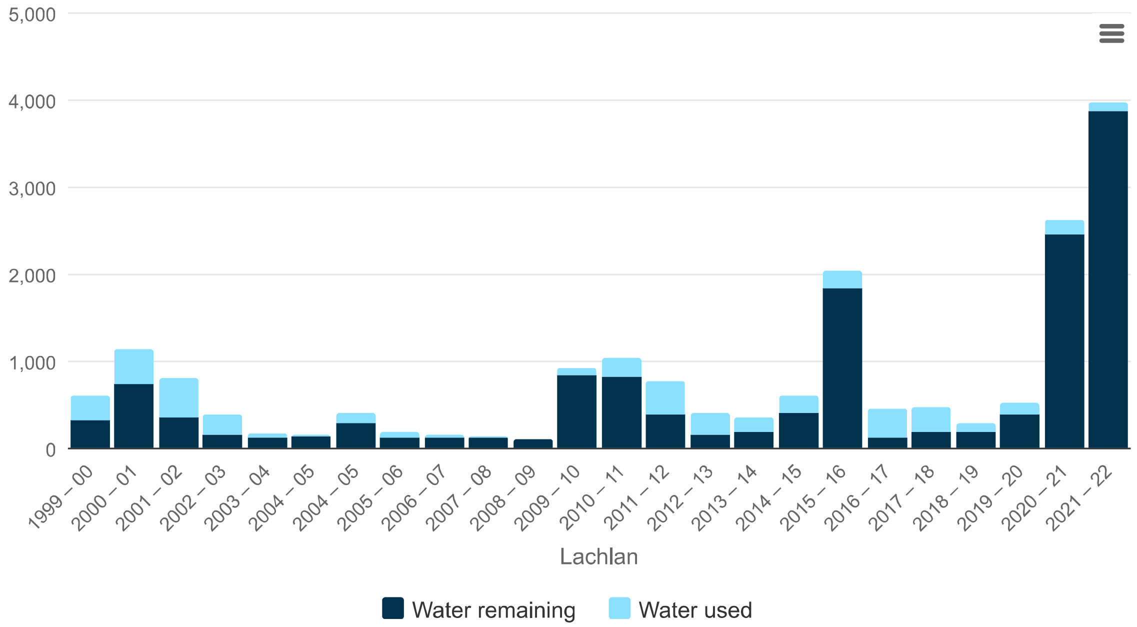
b) Namoi



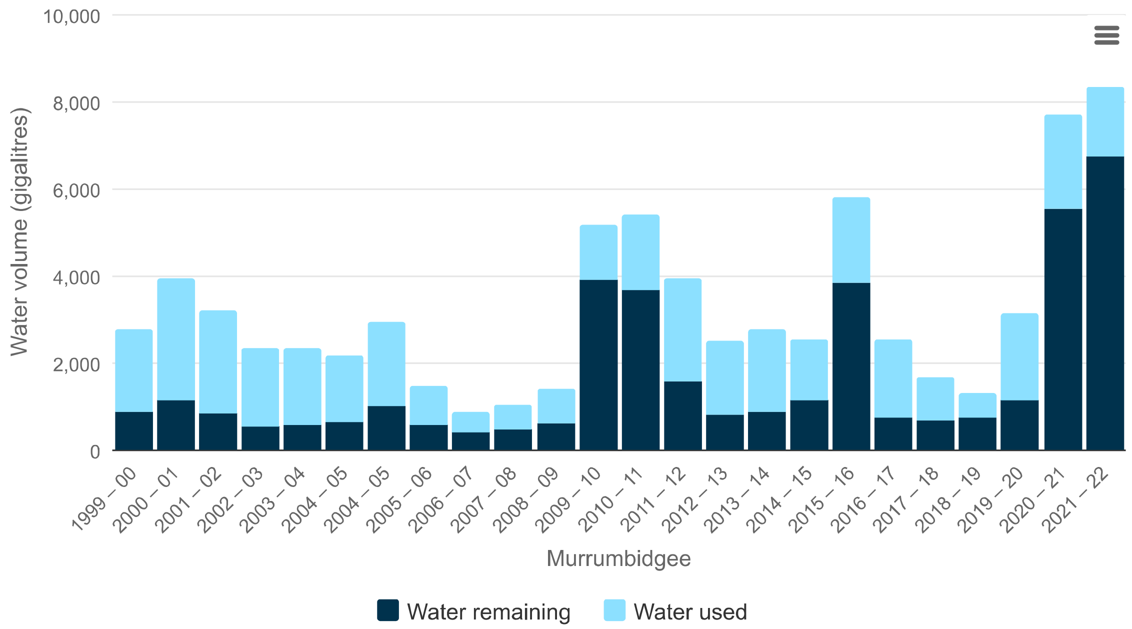
c) Macquarie



d) Lachlan



e) Murrumbidgee



Notes:
The NSW Border rivers and NSW Murray River valleys are not included in this set of charts.
Some 'water remaining' is lost to evaporation, seepage and other transmission losses. This water may have some benefit to the environment depending on the duration, volume and timing of its flow.
Water use figures refer to licensed account usage, including general security, high security, conveyance, water utilities, domestic and stock and supplementary access. Water licences are held for town water supply, agriculture and the environment.
Floodplain harvesting is not included in the charts. Diversions include licensed environmental water use.
The data for each valley represent total water available and are taken from a representative gauging station downstream of major tributary inflows and upstream of major extractions.
Total flow and observed diversions in the Murrumbidgee Valley are influenced by water released from the Snowy Mountains Scheme. These releases have greatest relative contribution in dry years. Development in the valley reflects this inter-valley transfer.

Source:
DCCEEW – Analysis input data from NSW HYDSTRA and water accounting systems

Water for the environment

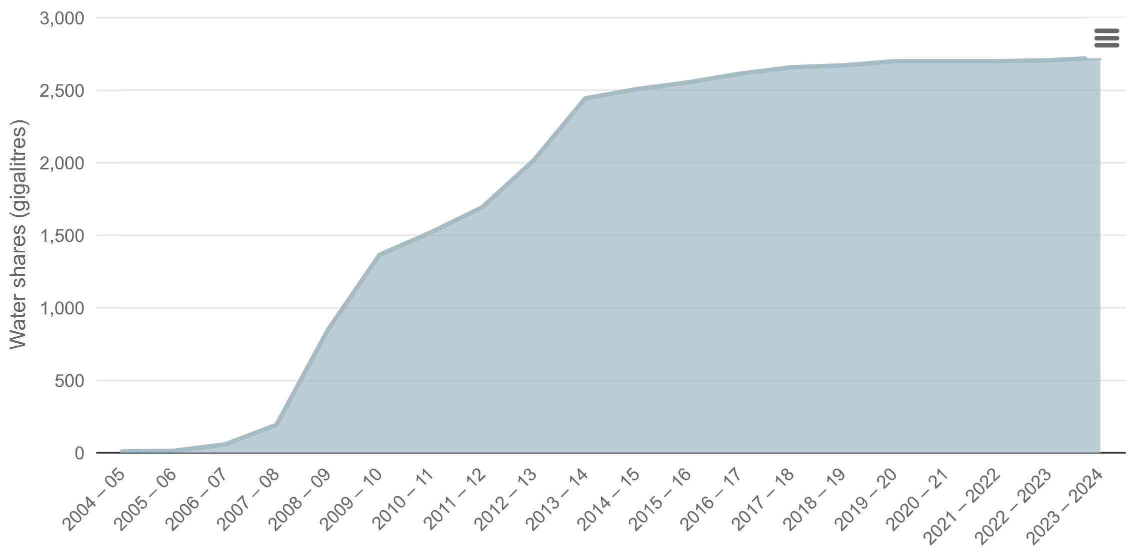
Water for the environment is allocated through water sharing rules and water licences held by both the NSW Government and the Australian Government. Water for the environment is allocated to sustain and improve the health of rivers, wetlands and floodplains.

NSW water for the environment shares have grown from 2005–06 to 2023–24 from water licence purchases and the creation of new entitlements through water savings infrastructure projects (see **Figure P3.7**).

NSW has a total of 2,553GL of licensed water for the environment (see **Figure P3.7**). This is made up of:

- 331GL NSW Government holdings within regulated rivers
- 15GL NSW Government holdings within unregulated rivers
- 571GL Living Murray holdings within regulated rivers
- 13GL Living Murray holdings within unregulated rivers
- 1,576GL Australian Government holdings within regulated rivers
- 47GL Australian Government holdings within unregulated rivers.

Figure P3.7: Growth in water for the environment shares in NSW (GL)



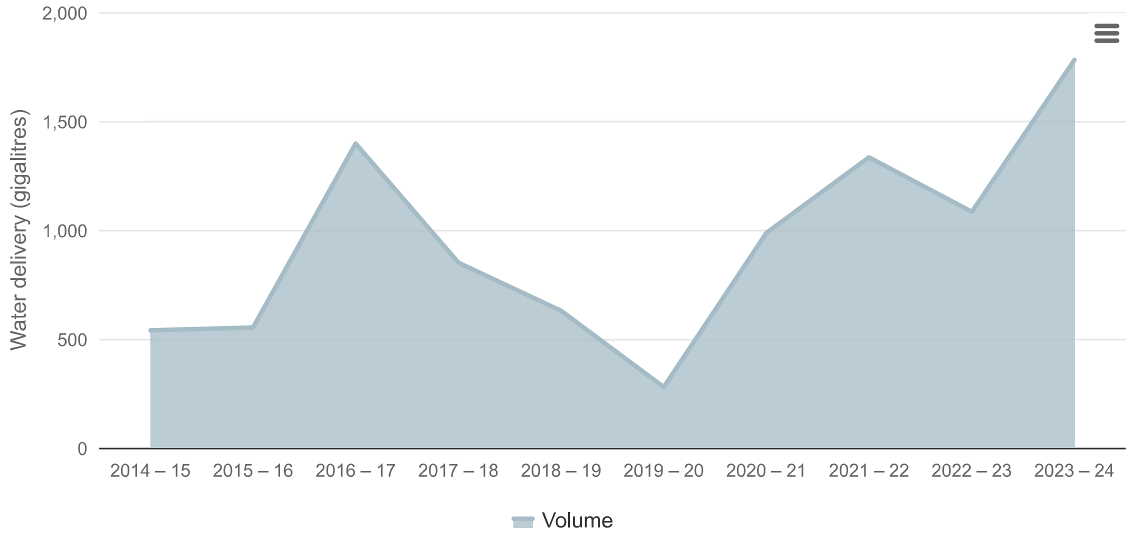
Source:
DCCEEW data 2024

The volume of water for the environment delivered to locations across inland NSW was significantly higher during 2020–21 to 2022–23 than in the previous three years (see **Figure P3.8**).

Volumes ranged from about 279GL in 2019–20 to more than 1,300GL in 2021–22, the largest amount delivered since 2016–17. These large changes highlight how quickly water availability can change, owing to large, rapid reductions from drought and record-breaking high temperatures, and rapid recovery from high rainfall, which can cause flooding.

The delivery of this water promoted native fish breeding and movement, increased river and wetland connectivity, recharged groundwater reserves, supported native vegetation and provided important habitat for bird breeding events.

Figure P3.8: Water delivered to support the environment (GL)



Source:
DCCEEW data 2024

Urban water

Urban water sources

Surface water provides more than 90% of the water for Sydney Water and Hunter Water and more than 80% for local water utilities. Other than during drought years, this has been the case since 2005–06.

Surface water comes directly from rain, so storage is critical to ensure water supply in the State's variable climate. The predicted reduction in rainfall due to climate change means we need to plan our approach to supplying water to where it is needed. This includes considering sources for water, how much to store, and ways to minimise use including re-using water and reducing water losses.

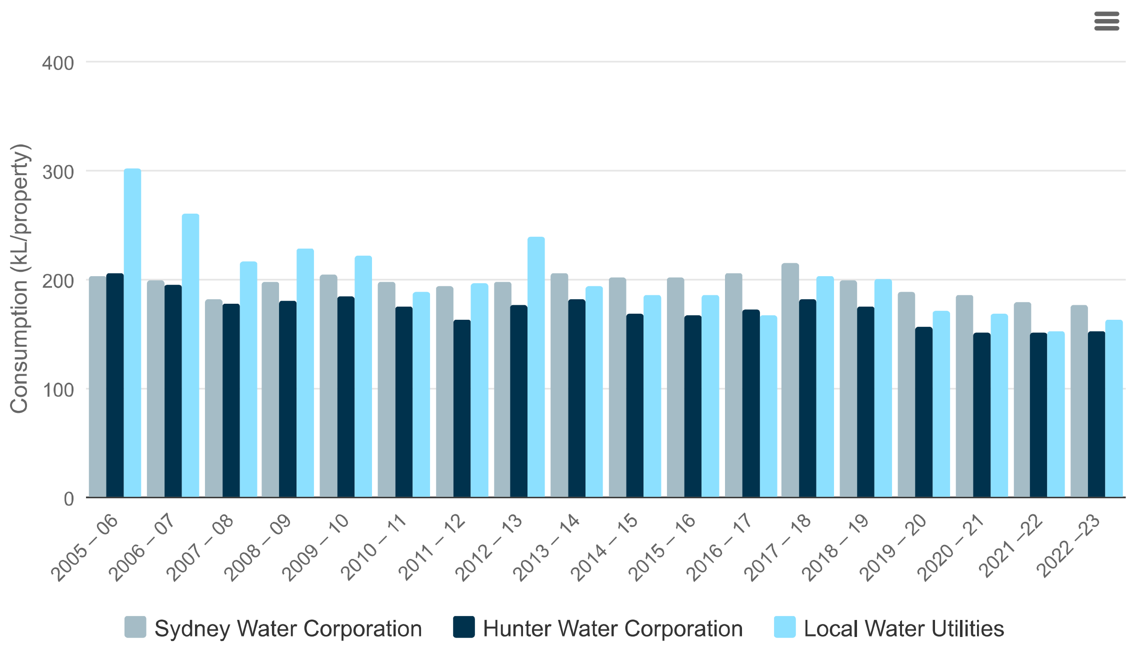
Urban water use has been decreasing

Figure P3.9 shows declining water consumption per connected property.

Water consumption has been following a downward trend since 2005–06. The decrease in consumption was initially brought on by water conservation measures and user restrictions during drought. While wetter weather reduced demand, the continued reduction in water use suggests that people have continued some of the water conservation measures they adopted during the most recent drought.

Sydney's residential water use was 18% lower in 2022–23 than in 2017–18, despite the end of enforced drought response measures from early 2020 (**Sydney Water 2023a**; **BOM 2024**).

Figure P3.9: Annual per property residential water consumption for local water utilities, Sydney Water and Hunter Water from 2004–05 to 2022–23 (kL)



Notes:
This figure shows annual consumption per residential connection by each utility operational area.
For local water utilities, the figure is based on the median value of annual average residential consumption. Because the Hunter Water supply network interconnects with adjacent local water utilities, it can supply and receive bulk treated water from Central Coast Council and MidCoast Water.

Source:
EPA 2024 from data supplied by Sydney Water, Hunter Water, DCCEEW-Water

Regional NSW had the greatest decrease (43%) because of water efficiency measures introduced during recent droughts.

See the **Responses** section of this topic for more information.

Drinking water quality is maintained

Drinking water in the State's metropolitan areas and its regional cities and towns is routinely tested against the ***Australian Drinking Water Guidelines***. The guidelines set limits on concentrations of particular contaminants, namely microbes (measured by concentrations of *Escherichia [E.] coli*), particular chemicals and aesthetics (colour, smell and taste).

In 2022–23, all utilities provided 100% of their population with water that met the guidelines for chemicals (**DCCEEW n.d.-f**), and all but one provided 100% of their population with water meeting guidelines for contamination with *E. coli* (Inverell achieved 99.9%).

In 2023–24, Hunter Water distribution system samples complied with the *Australian Drinking Water Guidelines* (**Hunter Water 2024**).

Water provided by each of Sydney Water's 13 delivery systems met the water guidelines (**Sydney Water 2023b**).

Impact of extreme climate and weather on water quality

Droughts, bushfires and floods affect not only water flow in catchments, but also water quality.

Drought in 2017–20 and bushfires in 2019–20 damaged vegetation in many drinking water catchments. Hot and dry weather was followed by heavy rains from 2020 to 2022, which caused flooding and significant runoff. This runoff carried greater amounts of sediments, pathogens and nutrients into rivers.

The runoff from burnt areas created significant challenges for water treatment and prompted an increased number of 'boil water' alerts (**NSW Health 2024**). 'Boil water' alerts decreased in 2023–24, but heavy rainfall was a contributing factor from December 2023 to April 2024.

Testing of water supply systems in remote Aboriginal communities in NSW showed continued problems with high levels of hardness, fluoride, turbidity and total dissolved solids (**Balasooriya et al. 2023**).

Other water sources

Recycled and desalinated water are not dependent on rainfall and help secure the State's water supply by providing an alternative source. They currently contribute a small portion to the supply but can increase to help NSW become more resilient to variable climate.

Recycled water

Recycled water in NSW is supplied for non-potable (not drinkable) uses such as irrigation of playing fields, parks and golf courses, and for industrial uses. It is not used for drinking.

The Millenium Drought (2001–09) prompted investment in recycled, but it remains a small contributor to water supply, less than 10% across NSW. Recycled water production has not changed significantly since 2017–18 (**DCCEEW 2024b**).

Sydney Water's recycled water schemes produced 40GL of recycled water in 2022–23 (**Sydney Water 2023a**). This provided additional water for irrigation and was used in place of drinking water. Demand for drinking water decreased by 12GL.

In the same period, Hunter Water supplied 3.2GL of recycled water to its customers and an additional 3.4GL to coNEXA, a third-party service provider. Supply of 6.8GL from recycled water saved about 5.8GL of drinking water (**Hunter Water 2023**).

Desalinated water

Desalinated water is available in Greater Sydney. It plays a critical role as the region's main rainfall-independent potable water supply increasing resilience to extreme weather events including droughts and floods.

Desalination uses advanced reverse osmosis technology to filter particles, salts and other pollutants from seawater. The treated water is integrated into the city's water supply system.

See the **Sydney Water website** for more information on desalination.

Pressures and impacts

Impact on the environment

Changing water flows

Plants and animals are adapted to the natural variation in flows in rivers and streams (**DPIRD n.d.-b**). Human-made changes to water flow can interfere with their lifecycles thereby harming these ecosystems.

Adverse weather and artificial barriers combined to cause mass fish deaths in the Darling–Baaka River in December 2018–19. Weather greatly reduced water inflow trapping fish between weirs, reduced oxygen in the water, and suffocating the fish (**MDBA 2019**). Water infrastructure, such as the dams and weirs used for storage, irrigation, flood mitigation, and hydropower generation can both increase and decrease river flows (**WaterNSW n.d.-b**), alter the timing and seasonality of flows and modify water levels (**WSAA 2013**).

These changes can destroy aquatic habitats, disrupt animal reproduction and lifecycles, and create physical barriers that prevent movement of species (**DCCEEW n.d.-d**; **DPIRD n.d.-b**).

Impact on water quality

The quality of environmental flows is important to the health of ecosystems. Healthy water has a natural range of temperature, acidity, oxygen content and other properties. It also has safe (typically low) levels of nutrients, metals and other elements.

See the **Murray–Darling Basin Authority website** for more information about healthy water quality.

Water quality can be degraded by runoff, industrial discharges and urban wastewater.

Stormwater runoff flows over urban infrastructure, such as roofs, driveways, streets, construction sites and industrial areas. It can carry leaves, dirt and other debris into receiving bodies, affecting their odour and colour. Stormwater runoff can also carry nutrients that can cause algal blooms (**WaterNSW n.d.-c**).

Agricultural runoff from fields and farmlands can introduce fertilisers, sediments and pesticides into receiving waters (**DECC 2009**; **Hollinger et al. 2001**).

Industrial discharges can contain heavy metals and synthetic chemicals (**DECC 2009**).

Urban wastewater, including untreated sewage, can significantly degrade water quality by increasing nutrient levels and introducing pathogens.

Water in rivers and storages are routinely tested by water utilities, local councils, and NSW government agencies to monitor water quality and aquatic ecology. See the **NSW Government website** for more information.

Many pollutants, such as nutrients and metals, are strictly monitored, and their potential impacts on the environment are well documented. However, previously un-monitored contaminants are always newly emerging (**Rasmussen et al. 2024**).

Water market

In NSW, Water Sharing Plans allow licensees to trade their water allocations under certain rules and regulations (**WaterNSW n.d.-a**). This trading system creates a water market that influences water use.

Through the water market, water can be reallocated to where it is most needed. Water rights can be temporarily or permanently traded from areas with surplus water to those facing shortages. This system helps increase supply during times of need and facilitates the return of water to the environment (**Aither 2016**).

Water trading has helped farmers to adapt to fluctuating water availability due to climate variability and droughts (**Aither 2016**).

While this system supports more efficient water distribution, it also adds complexity to water management (**Aither 2016**). Careful oversight is needed to make sure water trading is equitable and sustainable (**DCCEEW 2020**).

Impact of water shortage on people and industries

Water security is an important concern in NSW.

In urban areas, the risk of water shortage can trigger tighter water restrictions. While these restrictions are necessary for water security, they affect the daily lives of people and the operation of businesses.

In regional NSW, water security strongly affects industrial productivity. Water shortage reduces crop yield and livestock production (**MDBA 2024**). It also disrupts mining activities. Impacts on industry have flow-on effects, such as economic stress.

Achieving water security in regional areas is challenging, because a water source may be used by several water utilities (**AECOM 2010**).

Population

Population growth is associated with urban expansion and increase in demand for food and other goods. This increases total water demand by households and industries.

See the **Population and the environment** topic for more information.

In urban NSW, water demand per capita has been stable over the past two decades because of increased water conservation and efficiency. (See the **Urban water** section of this topic for more information). Nonetheless, populations in places such as Greater Sydney are expected to grow and increase water demand to levels that surpass the available supply. Current water strategies and planning are focused on solutions to the supply–demand gap (**DPE 2022**).

In regional NSW, water demand is influenced by water-dependent industries, notably agriculture, food processing and mining. These industries contribute greatly to the NSW economy. They are anticipated to grow and increase water demand (**DCCEEW n.d.-c**).

Climate variability

Australia is a hot and dry country, and drought is a fundamental part of its climate and landscape.

Rainfall in NSW is highly variable owing to several climate drivers, notably the El Niño Southern Oscillation and the Indian Ocean Dipole (**AdaptNSW n.d.**).

Major droughts that last up to several years, over wide areas, occur naturally. Seven have affected NSW since 1895 (**DCCEEW n.d.-b**; **BOM n.d.**).

Short-term and more localised droughts can also occur (**ESCC 2021**). They too can have significant impacts, particularly if they occur while crops are growing.

Rainfall variability and droughts put significant pressure on water availability. When rainfall is lower, less surface water is available and water demand increases as agriculture and households increase irrigation. This poses a high risk of water shortage if storage is not large enough to cover dry periods.

See the **Climate change** and **Extreme climate and weather** topics for more information.

Climate change

Changes in global and regional climate patterns are already affecting water availability and quality for communities and the environment of NSW.

Climate model projections show that our climate will be hotter with greater rainfall variability. We need to plan for more severe droughts and more flooding, particularly flash flooding from intense rainfall events. Moreover, the frequency and intensity of droughts is predicted to increase in some parts of NSW.

These climate changes will exert significant pressure on water management in NSW. We need to plan our approach to managing water to make sure water continues to be available to communities, industry and the environment. Both floods and droughts harm water quality and availability. Water management will need to consider water sources, including reducing reliance on rainfall, how much we need to store, and ways to minimise use including re-using water and reducing water losses in the water supply system.

Hotter, drier weather will also increase water usage as water is used to keep us cool. Good water management is crucial to making sure our communities remain resilient to climate change.

This is particularly evident in regional communities, which at times lacked suitable water during the 2017–20 drought.

In contrast, NSW faced several major flood events between 2020 and 2024. In 2022, it experienced the wettest spring on record, and many dams filled beyond capacity. Sequential rain events during this prolonged period created unprecedented flows into rivers and dams operated by WaterNSW. This can have significant, ongoing impact on the surrounding communities.

See the **Climate change** and **Extreme climate and weather** topics for more information.

Responses

The way that industries and households use water, from extracting water from regulated rivers to discharging wastewater into waterways, affects aquatic environments and ecosystems. Plans and projects have been developed to reduce impact on the environment. These include better managing catchments and river flows, enhancing water quality monitoring programs and rehabilitating natural environments.

Water use in NSW is influenced by rainfall and drought. To increase resilience of water sources, various projects and initiatives were designed to enhance water efficiency and conservation. Additionally, water strategies were developed to address current and future water demand.

Reducing environmental impacts

Hunter catchment

Hunter Water has developed a **Environmental Management Plan 2021–2024** that includes an objective to reduce impact on waterways. The plan aims to reduce wastewater overflows to the environment, develop catchment management strategies, and set up monitoring programs for emerging contaminants for wastewater and water resources.

Seaham Weir Refurbishment and Modification Project

Hunter Water upgraded the five-decade-old **Seaham Weir** on the Williams River to improve safety, enable effective management of water flow, maintain the weir pool's water levels and improve fish passage. It installed four new low-flow gates on the eastern side of the weir to allow smaller releases of water when needed and provide a new fishway for improved fish passage both upstream and downstream. Works were completed in 2023.

Sydney catchment

One of the priorities of the ***Greater Sydney Water Strategy***, released in August 2022, is to ensure waterways are healthy, including in the declared catchment area. An independent audit of the catchment is conducted every three years.

The **latest audit** (**ELA 2023**) stated that recent climate-driven events – severe drought, bushfires and subsequent heavy rainfall events – have harmed catchment health. It also reported that actions taken by water management agencies in partnership with industry and the community have reduced many hazards to catchment health. These actions include restoration and rehabilitation of the natural environment and policy and decision-making backed by sound evidence.

The audit also noted the positive impact of the joint work of WaterNSW and NSW National Parks and Wildlife Service to control weeds and erosion. Disturbance in Special Areas has been minimised by restricting physical access.

Water security and resilience

Addressing water security risks across the state is critical to making sure suitable water is available. The NSW Government is working with local water utilities in the **Town Water Risk Reduction Program**. The program is developing long-term solutions to manage risks to water and sewerage services. It identifies barriers to strategic management and supports local water utilities to use their local expertise overcome them.

The first phase of the program, which concluded in July 2022, included various activities to help local water utilities to better manage risks and priorities. The second phase of the program, which will run until June 2025, aims to address critical skills shortages, develop collaboration with NSW Healths, and help local water utilities improve dam safety and reduce water quality risks.

The **Safe and Secure Water program** is a regional infrastructure co-funding program for eligible water and sewerage projects in regional NSW. More than $1 billion has been allocated to it.

Greater Sydney Water Strategy

Priority 2 of the ***Greater Sydney Water Strategy*** focuses on the security and resilience of Greater Sydney's water supply. Key actions include a concentrated focus on water conservation and efficiency, optimising the use of Sydney Desalination Plant, planning for new rainfall independent water supplies and preparing for drought.

Greater Sydney Drought Response Plan

The **Greater Sydney Drought Response Plan** sets out how Sydney Water, WaterNSW and the NSW Government will work together to respond to droughts in the future. It is an adaptive plan that allows decisions and actions to adjust to observed conditions, growth and supply.

Lower Hunter Water Security Plan

The 2022 **Lower Hunter Water Security Plan** was prepared by Hunter Water and published by the NSW Government. It is a whole-of-government approach to ensuring the region has a resilient and sustainable water future.

The plan prioritises actions to improve water security including reducing drinking water use, strategies to increase water supply and implementation of rainfall-independent drinking water supply (a seawater desalination plant at Belmont). The plan also identifies how and when each action should be implemented to ensure Hunter Water and the NSW Government are accountable for each action.

Funding for local water utilities

About 90 local water utilities provide water and sewerage services to nearly 2 million people in regional and remote NSW communities. About 20% of these utilities have been assessed as at risk of water quality issues due to inadequate existing infrastructure. These utilities provide water to almost 600,000 people. The poor infrastructure increases their risk of water-borne diseases (**NSW Productivity Commission 2024**).

Because some of these utilities serve small populations, local funding through council rates may not be enough to pay for maintenance. The NSW Productivity Commission reviewed alternative funding options to reduce risk for local water utilities in regional NSW. It noted the significant challenges and recommended ongoing well-targeted funding to support efficient water and sewerage operations that meet community expectations and statutory requirements (**NSW Productivity Commission 2024**).

Water conservation

Water conservation reduces water demand and builds community resilience in preparation for and during times of water shortage.

Water utilities and councils lead conservation efforts (**DCCEEW n.d.-e**). Saving water outside of drought conditions encourages people to develop water efficient behaviours, preparing them for droughts and helps bolster reservoirs (**DPE 2022**).

Water restrictions can vary from place to place (**DCS 2024**). They limit or ban the use of water for certain purposes, such as watering, irrigation, cleaning and filling pools. They may also require leaks to be promptly fixed.

Strategies in NSW focus on further water conservation efforts to improve water efficiency and reduce water loss.

See the **NSW Government website** for more information about local water restrictions.

Water efficiency

Water efficiency measures can reduce water demand and increase water security.

Support for water efficiency projects

The **NSW Water Efficiency Framework**, first published in August 2022, has been designed for government, water utilities, councils and large businesses to use in planning, implementing and reviewing water efficiency programs. It provides detailed steps on how to meet water efficiency objectives and continue to make improvements.

Identifying options is a key step in developing a water efficiency plan. The **Water Efficiency Opportunities Scan**, released in 2020, helps to identify a broad range of water efficiency options and provides best practice examples. Examples include using water-efficient devices in showers, toilets and washing machines, automating control of irrigation, and providing rebates and grants for water-efficient appliances.

Fixing leaks

Leaks in water networks or in homes wastewater. Fixing leaks improves water efficiency and reduces water bills.

The **Regional Leakage Reduction program**, which began in March 2023, aims to help water local utilities to better identify and fix leaks. Grants have been awarded for investments in leak detection devices and building capacity in leakage control and metering. Since 2022, 9,950 million litres per year of network leaks have been found.

Planning for the future

NSW water strategies focus on ensuring the sustainable management and use of water resources to meet current and future demands. They include measures to improve water security, enhance water quality, and protect ecosystems while promoting efficient water use and resilience against climate change.

NSW Water Strategy

The ***NSW Water Strategy***, first published in 2021, is a 20-year plan aimed at improving the security, reliability, quality and resilience of water resources across the State. It sets out strategic priorities and actions to address challenges such as climate variability and population growth. It includes 12 regional and two metropolitan water strategies specific to each area. By focusing on sustainable water management, it aims to ensure thriving communities and ecosystems for future generations.

NSW Aboriginal Water Strategy

The NSW Government is currently consulting Aboriginal communities on the development of an ***Aboriginal Water Strategy*** that will recognise cultural values of water and Aboriginal people's water rights, and increase access to and ownership of water for cultural and economic purposes. A draft of the strategy became available for public consultation in August 2024.

Connectivity Expert Panel

A panel of independent experts was convened in 2023 by the NSW Minister for Water to provide advice on how to improve connectivity in the Northern Basin (Barwon–Darling) through improvements to rules in Water Sharing Plans. The **panel's recommendations**, published in July 2024, propose multiple changes, including adopting a holistic approach to connectivity, recognising the importance of riparian targets and changes to rules in water sharing plans. The NSW Government is considering its response.

Future opportunities

The *NSW Water Strategy* and the two metropolitan and twelve regional water strategies identify strategic priorities to improve the management and resilience of NSW water sources.

The following opportunities could be explored to better protect water resources and manage water use:

- **Water-sensitive urban design**: This design principle integrates the water cycle with urban planning. An example is the use of nature-based solutions, such as raingardens or wetlands, to manage stormwater. These natural treatment processes slow down flows and remove pollutants from stormwater runoff, protecting water bodies (**Sydney Water n.d.-a**). Additional benefits include helping cities become greener, cooler and more liveable (**CRCWSC n.d.**). So far only small water-sensitive design projects have been implemented in Australia. Stronger policy and direction are needed (**Fogarty et al. 2021**).
- **Water efficiency**: Further work is needed to enhance water efficiency. A potential focus could be the use of new sensor and digital technologies to detect leaks, maximise water savings and collect data to be used to develop water efficient strategies for households and businesses. Further research is needed to integrate them into practicable solutions (**UTS n.d.**).
- **Water quality monitoring and data management**: A wealth of water quality data is collected by several agencies and industries across NSW. However, it is not clear what types of data are available and how reliable they are. There are also challenges in data collection, storage and sharing. The NSW Government's **NSW Water Quality Governance Roadmap**, released in June 2024, identifies opportunities to improve the management of water quality information. It recommends aligning monitoring programs to fill data gaps and improve how data are stored, acquired, shared and interpreted. These actions will help inform policy decisions, operational responses and investment decisions (**DCCEEW 2024-a**).
- **Renewing or upgrading ageing water infrastructure**: In Greater Sydney, ageing assets are close to capacity and are at risk of not meeting the needs of the growing population. Significant investment is needed to replace or upgrade them to meet water quality and environmental standards and to manage climate-related risks (**DPE 2022**).

Resilience can be enhanced by diversifying water sources, thus reducing reliance on rainfall. This approach will increase flexibility in addressing supply challenges due to droughts, floods and climate change.

Several opportunities are available:

- **Increasing community awareness of purified recycled water for drinking**: Stormwater or wastewater that has been treated to meet drinking water standards. Many cities around the world use purified recycled water, including Perth, where it is used to augment groundwater (**Radcliffe & Page 2020**; **Water Corporation n.d.**).
  Although purified recycled water is safe for drinking, gaining community support is a challenge (**WSAA 2020**). Sydney Water opened a demonstration plant in Quakers Hill, Sydney in 2023 to increase awareness of the importance of rainfall-independent water sources to support population growth (**Sydney Water n.d.-b**).
  Further work is needed to engage openly with communities, deepen their knowledge and build trust in water utilities and providers.
- **Recycled water for agriculture:** Although the non-potable use of recycled wastewater in NSW is increasing, there is potential for further expansion. In its 2024 report on wastewater reuse opportunities, the National Water Grid identified areas in NSW that can supply treated wastewater for agriculture (**GHD 2023**).
- **Reducing cost of seawater desalination**: Seawater desalination is a proven rainfall-independent water source. However, its reliance on large amounts of energy makes the cost of the produce expensive. Further innovation to increase the efficiency of the process, and therefore increase the production of drinking water from seawater, may reduce the costs and energy use (**Bundschuh et al. 2023**).
- **Research on brackish and saline groundwater desalination**: There is also opportunity to use desalinated brackish and saline groundwater in agriculture. Further research is required to understand the needs of farmers and to reduce the cost through integration with renewable energy sources. Inland, there is a need to understand how to manage the brine (the concentrated liquid by-product of desalination) (**NWGA n.d.**).

References

AAS 2019, *Investigation of the causes of mass fish kills in the Menindee Region NSW over the summer of 2018–2019*, Australian Academy of Science, Canberra

ABS 2023, Water Account, Australia, Australian Bureau of Statistics, accessed 4 July 2024

AdaptNSW n.d., The NSW Climate, AdaptNSW, accessed 05 December 2024

AECOM 2010, *Regional Towns Water Quality and Security Review Report — Volume 1*, AECOM Australia Pty Ltd, Sydney

Aither 2016, *Water markets in New South Wales: market outcomes, trends and drivers*, Aither Pty Ltd, Melbourne

Balasooriya BMJ, Rajapakse J & Gallage C 2023, 'A review of drinking water quality issues in remote and indigenous communities in rich nations with special emphasis on Australia', *Science of the Total Environment*, vol. 903, 166559, DOI: 10.1016/j.scitotenv.2023.166559

BOM 2024, *National performance report 2022–23: urban water utilities, part A*, Bureau of Meteorology, Melbourne

Bundschuh J, Kaczmarczyk M, Ghaffour N & Tomaszewska B 2021, 'State-of-the-art of renewable energy sources used in water desalination: Present and future prospects', *Desalination*, vol. 508, 115035, DOI: 10.1016/j.desal.2021.115035

CRCWSC n.d., Green infrastructure, Cooperative Research Centre for Water Sensitive Cities Ltd, accessed 14 October 2024

DCCEEW 2020, *Transparency in the NSW water market, Discussion paper*, NSW Department of Planning, Industry and Environment, Sydney

DCCEEW 2024, *NSW Water Quality Governance Roadmap*, NSW Department of Climate Change, Energy, the Environment and Water, Sydney (PDF 4.5MB)

DCCEEW 2024, *Recycled water roadmap*, NSW Department of Climate Change, Energy, the Environment and Water, Sydney

DCCEEW n.d., How is water shared in NSW?, NSW Department of Climate Change, Energy, the Environment and Water, accessed 6 November 2024

DCCEEW n.d., Drought, floods and extreme events, NSW Department of Climate Change, Energy, the Environment and Water, accessed 11 October 2024

DCCEEW n.d., Priority 5, NSW Department of Climate Change, Energy, the Environment and Water, accessed 11 October 2024

DCCEEW n.d., Surface water environments, NSW Department of Climate Change, Energy, the Environment and Water, accessed 14 October 2024

DCCEEW n.d., Water saving tips, NSW Department of Climate Change, Energy, the Environment and Water, accessed 14 October 2024

DCCEEW n.d., *LWU Performance Reporting Data Dashboard*, NSW Department of Planning, Industry and Environment, Sydney

DCS 2024, Water restrictions, NSW Department of Customer Service, accessed 14 October 2024

DECC 2009, *NSW Diffuse Source Water Pollution Strategy*, NSW Department of Environment and Climate Change, Sydney

DPE 2022, *Greater Sydney Water Strategy*, NSW Department of Planning and Environment, Sydney

DPIRD n.d.-a, NSW Department of Primary Industries and Regional Development, accessed 15 November 2024

DPIRD n.d.-b, Water flow, NSW Department of Primary Industries and Regional Development, accessed 14 October 2024

ELA 2023, *Sydney Drinking Water Catchment Audit 2019–2022*, Eco Logical Australia, Newcastle

ESCC 2021, *Flash drought in Australia*, Earth Systems and Climate Change (PDF 5.0MB)

Fogarty J, van Bueren M & Iftekhar MS 2021, 'Making waves: Creating water sensitive cities in Australia', *Water Research*, vol. 202, 117456, DOI: 10.1016/j.watres.2021.117456

GHD 2023, National Water Grid Authority – National Review of Wastewater Reuse Opportunities for Agriculture Project Findings Report, Gutteridge Haskins & Davey Pty Ltd, Canberra

Hollinger E, Cornish PS, Baginska B, Mann R & Kuczera G 2001, 'Farm-scale stormwater losses of sediment and nutrients from a market garden near Sydney, Australia', *Agricultural Water Management*, vol. 47, no. 3, pp. 227–41, DOI: 10.1016/S0378-3774(00)00107-4

Hunter Water 2023, *Water Conservation Annual Report 2022–23*, Hunter Water Corporation, Newcastle

Hunter Water 2024, *Compliance and Performance Report 2023–24*, Hunter Water Corporation, Newcastle

MDBA 2024, Drought, Murray–Darling Basin Authority, accessed 14 October 2024

NSW Health 2024, Drinking water quality and incidents, NSW Health, accessed 19 July 2024

NSW Productivity Commission 2024, *Alternative Funding Models for Local Water Utilities Issues Paper*, NSW Treasury, Sydney (PDF 3.8MB)

WaterNSW 2024, Usage dashboard, WaterNSW, accessed 12 December

NWGA n.d., Review of low-cost desalination opportunities for Australian agriculture, Australian Government National Water Grid Authority, accessed 14 October 2024

ONCSE 2023, *Independent review into the 2023 fish deaths in the Darling-Baaka River at Menindee*, Office of the NSW Chief Scientist & Engineer, Sydney

Radcliffe JC & Page D 2020, 'Water reuse and recycling in Australia — history, current situation and future perspectives', *Water Cycle*, vol. 1, pp. 19–40, DOI: 10.1016/j.watcyc.2020.05.005

Rasmussen JA, Ingleton T, Bennett WW, Pearson RM, McAneney CA, Foulsham E, Hanslow D, Scanes PR & Connolly RM 2024, 'The effects of estuarine outflows on coastal marine ecosystems in New South Wales, Australia', *Marine Pollution Bulletin*, vol. 208, 116915, DOI: 10.1016/j.marpolbul.2024.116915

Sydney Water 2023a, *Annual Water Conservation Report 2022–23*, Sydney Water Corporation, Sydney

Sydney Water 2023b, *Annual Report 2022-2023*, Sydney Water Corporation, Sydney

Sydney Water n.d.-a, *Water Sensitive Urban Design*, Sydney Water, Sydney

Sydney Water n.d.-b, Purified recycled water, Sydney Water, accessed 14 October 2024

UTS n.d., Smart buildings and digital water, University of Technology Sydney, accessed 14 October 2024

Water Corporation n.d., Groundwater replenishment, Water Corporation, accessed 14 October 2024

WaterNSW n.d.-a, Trading water, WaterNSW, accessed 11 October 2024

WaterNSW n.d.-b, Dams and weirs, WaterNSW, accessed 14 October 2024

WaterNSW n.d.-c, Management – Monitoring water quality across the state, WaterNSW, accessed 14 October 2024

WSAA 2013, *Dams Information Pack*, Water Services Association of Australia, Sydney

WSAA 2019, *Water Efficient Australia*, Water Services Association of Australia, Sydney

WSAA 2020, *All options on the Table – Urban water supply options for Australia*, Water Services Association of Australia, Sydney

MDBA 2019, *Independent assessment of the 2018–19 fish deaths in the lower Darling*, Murray Darling Basin Authority, Canberra

Waste and recycling

Transitioning to a circular economy is more important than ever, as our waste generation outpaces our capacity to manage its impacts on the environment, human health and the economy.

Overview

Total waste generation increased by

19.7%

between 2015–16 and 2022–23 to 22.4 million tonnes

Read more

On average, we generated

2.7 tonnes

of waste per person in 2022–23

Read more

Managing waste and transitioning to a circular economy are crucial for minimising the environmental impact of human activities.

'Waste' is material that:

- has been discarded after its primary use
- is an unintended and unused byproduct of a natural or industrial process.

For the purposes of managing waste in NSW, a more **precise definition** is used.

Waste has a number of impacts on the environment and economy.

Accumulation of waste can lead to leaching of pollutants into air, water and land. This has an impact on natural processes and amenity.

Waste products may be ingested by animals, for example, seabirds swallow plastics in the ocean. This impacts the survival and reproduction of the affected animals.

Economically, waste can be costly to remove, process or manage. Waste results in a loss of resources from our economy.

The impacts of waste can be addressed through the transition to a circular economy.

A circular economy values resources by keeping products and materials in use for as long as possible.

Examples of this process include:

- designing products that last longer and can be easily repaired and reused
- ensuring the materials used in a product are still valuable for other purposes when consumers have finished using it.

Maximising the use and value of resources brings major economic, social and environmental benefits. It contributes to innovation, growth and job creation, while reducing our impact on the environment.

Increasingly, governments are using the circular economy concept to steer industry into more sustainable practices.

Complete circularity would exist if all waste was reused, recycled or reprocessed. We are far from achieving this.

Waste in NSW

NSW creates about one-third of Australia's total waste (**DPIE 2021a**).

Waste generated in NSW is forecast to grow from 21 million tonnes in 2021 to nearly 37 million tonnes by 2041 (**DPIE 2021a**). This is related to the State's continued increase in population, economic growth and product consumption and disposal.

In 2022–23 NSW generated 891,000 tonnes of plastic waste. Only 14% of this material was recycled (**NSW EPA 2024b**).

In the five years to 2022–23, on average only around 13% of the State's plastic waste was recycled each year (**Blue Environment unpub.**), out of an annual average of 850,000 tonnes generated. This is despite plastic being a common waste product for over 50 years.

New waste products and trends are emerging, such as a rise in waste from renewable energy. It is forecast that by 2025 NSW will generate 3,000 to 10,000 tonnes of photovoltaic solar panel and battery storage system waste per year (**Florin et al. 2020**). This will rise to between 40,000 and 71,000 tonnes per year by 2035.

Floods, bushfires and other disasters create a lot of 'disaster waste'. This impacts future landfill capacity. It may also damage facilities and disrupt local services.

It is likely that disaster waste volumes will increase with climate change and increased weather variability.

Current waste management challenges

NSW is on the brink of a waste crisis and is facing urgent challenges to enabling a safe circular economy (**DPIE 2021a**; **DPIE 2021b**; **DPIE 2021c**) :

- Landfills servicing households, businesses and major infrastructure projects in Greater Sydney are expected to run out of space by 2030, or possibly earlier. Without intervention, waste will need to be sent into regional NSW or interstate for disposal, which is likely to worsen cost-of-living pressures for households due to the additional transport costs and delay the delivery of critical infrastructure across the state.
- The NSW waste levy's effectiveness as an incentive for resource recovery has diminished, meaning that recycling rates in NSW have stagnated at 65% of the waste we generate. Consequently, high volumes of valuable material are being landfilled that could otherwise be recovered and recycled, placing additional pressure on already constrained landfills.
- Hazardous and problematic materials like asbestos, batteries and harmful chemicals are making resource recovery difficult, costly, and high-risk as they continue to enter the waste stream. These materials pose a threat to human life and property, and are undermining industry's willingness and confidence to invest in urgently needed waste and recycling infrastructure.

In addition, discrete Aboriginal communities in NSW (previously Aboriginal reserves or missions) continue to experience the harmful effects of legacy waste, contamination and illegal dumping. This is due to a lack of adequate waste management and recycling services.

See the **Contaminated sites** topic for more information on waste in discrete Aboriginal communities.

Managing waste and recycling

Waste and recycling in NSW are subject to a combination of state and federal policies.

The Australian Government is responsible for export controls on waste materials. Nationally agreed plans and goals guide state and territory legislation.

The NSW Government is committed to the State becoming a circular economy.

It is committed to fulfilling the targets and actions set by the **National Waste Policy** (**DCCEEW-Aus 2018**). It also supports other national goals for waste and recycling.

See the **Responses** section for more details.

NSW Waste and Sustainable Materials Strategy 2041

The ***NSW Waste and Sustainable Materials Strategy 2041: Stage 1 2021–2027*** (**DPIE 2021a**) sets out the first stage of a 20-year vision for the State's transition to a circular economy.

The strategy sets a vision to:

- meet future infrastructure and service needs as waste volume and population continues to grow
- reduce carbon emissions through better waste and materials management
- protect the environment and human health from waste pollution caused by littering, illegal dumping and the mishandling of hazardous wastes.

The strategy sets targets to:

- reduce total waste generated by 10% per person by 2030
- have an 80% average recovery rate from all waste streams by 2030
- significantly increase the use of recycled content by governments and industry
- phase out problematic and unnecessary plastics by 2025
- halve the amount of organic waste sent to landfill by 2030
- reduce litter by 60% by 2030 and plastics litter by 30% by 2025
- triple the plastics recycling rate by 2030.

Approaches within this strategy to improve outcomes regarding waste include:

- reviewing the NSW waste levy to make recycling more cost effective
- phasing out problematic single-use plastic items and incentivising manufacturers and producers to design out problematic plastics
- having government agencies preference recycled content
- introducing tighter environmental controls for energy from waste in NSW, with further consideration of planning and waste infrastructure needs
- mandates on collection of organic waste from households and select businesses
- programs to incentivise investment in waste and circular economy activities.

The strategy is underpinned by legislation and supported by several plans and policies (see **Table P4.1**).

Table P4.1: Current key legislation and policies relevant to waste and recycling in NSW

Legislation or policy	Purpose
Plastic Reduction and Circular Economy Act 2021	Phases out many single-use plastic items.
Protection of the Environment Operations Act 1997	Provides a definition of waste in NSW and aims to eliminate harmful wastes, reduce the use of materials, and reuse, recover and recycle materials.
Recycling and Waste Reduction Act 2020	Provides a national framework to regulate the export of waste materials, including to ban the export of waste plastic, paper, glass and tyres, and to manage impacts from the disposal of products and waste from products through product stewardship schemes.
Waste Avoidance and Resource Recovery Act 2001	Encourages efficient use of resources, waste reduction and waste management and reduction in environmental harm.
Protection of the Environment Operations (General) Amendment (Thermal Energy from Waste) Regulation 2022	Puts into law the NSW Government's Energy from Waste Infrastructure Plan.
Protection of the Environment Operations (Waste) Regulation 2014	Clarifies obligations of generators, processors and consumers of waste materials, addresses administrative issues and increases EPA oversight.
Energy from Waste Infrastructure Plan (2021)	Guides strategic planning for thermal energy-from-waste facilities.
NSW Waste and Sustainable Materials Strategy 2041 (Stage 1 Plan: 2021–27)	Outlines the actions that will be taken over 2021–27 to move NSW towards a circular economy. Includes the **NSW Plastics Action Plan**, which aims to reduce plastic waste and prevent it entering the environment.
Waste Delivery Plan 2021	Outlines how we will work with our partners to deliver on our strategic waste priorities and the NSW Government's *Waste and Sustainable Materials Strategy 2041: Stage 1 2021–2027* and NSW Plastics Action Plan.

Notes:
See the **Responses** section of this topic for more information about how **Waste and recycling** are managed in NSW.

Common terms in waste

Waste is categorised into broad 'streams' based on the origin of the material. These waste categories are used throughout this topic. They include:

- municipal solid waste – generated by households and local government operations, and mostly consists of paper/cardboard, plastics, glass, food and garden waste
- commercial and industrial waste – generated by businesses, industries and institutions, and mainly contains metals, plastics, food, paper, cardboard and wood
- construction and demolition waste – generated by building and demolition activities, and includes bricks, concrete and soil, as well as problem waste (such as material containing asbestos).

Other common waste types (based on origin, properties or processing) discussed in this topic include:

- e-waste (electrical and electronic items)
- problem waste (such as tyres and batteries)

- controlled waste, which includes hazardous and trackable waste (some waste must be tracked when it is transported to ensure it does not cause harm in transit)
- disaster waste (generated by floods, bushfires and other natural disasters)
- litter
- illegally dumped waste.

Waste performance data

Unless otherwise indicated, most of the reporting in this topic is based on **NSW waste and recycling performance data** (**NSW EPA 2024c**) prepared by the NSW Environment Protection Authority (EPA).

This includes data from the **Waste and Resource Reporting Portal** (WARRP). WARRP is the EPA's online reporting tool for licensed waste facilities, including disposal and resource recovery facilities.

The portal was established in 2015. It replaced less accurate estimates of waste generation and recycling performance based on voluntary surveys.

The method of calculating recycling performance and waste generation has established best-practice benchmarks and generated more accurate waste data. Quality controls are outlined in the **Data quality statement**.

Where WARRP data was not available, the following secondary sources have been used:

- recycling data requested from scheduled waste facilities that were not reporting in the WARRP
- estimates of recycling by other scheduled waste facilities that were not reporting in the WARRP, using **Environment Protection Licence** information
- **waste export summary reports** produced by the Australian Government Department of Climate Change, Energy, the Environment and Water (or the Global Trade Atlas before 2022–23)
- consultant reports on plastics recycling, commissioned by the EPA.

Waste data collected since 2015–16 cannot be directly compared to earlier data.

> **Related topics**: **Contaminated sites** | **Economic activity and the environment** | **Extreme climate and weather** | **Population and the environment**

Status and trends

Waste and recycling indicators

This report uses five indicators to assess the environmental impacts of waste and progress towards reducing these impacts and improving resource recovery rates (see **Table P4.2**):

- **Total waste generation** reports on the amount of waste generated in NSW. It is assessed as moderate and getting worse. This is because increasing amounts of waste have cumulative effects. These effects include pollution and pressure on available landfill and recycling facilities (see **Total waste generated**).
- **Per person waste generation** reports on the amount of waste generated in NSW. It is assessed as moderate and getting worse. Per capita generation has increased from 2.4 tonnes in 2015–16 to 2.7 tonnes in 2022–23 (see **Total waste generated**).
- **Total solid waste disposal** measures how much waste is sent to landfill and is assessed as moderate but stable (see **Waste disposal and recycling**).
- **Total solid waste recycled** measures how much waste is sent for recycling. This is assessed as moderate but stable. There was a 66% recycling rate in 2022–23. This was an increase on a baseline of 63% in 2015–16 and a five-year average of 65% (see **Waste disposal and recycling**).
- **Litter items per 1,000m^2** looks at the extent of litter and trends in litter reduction. This is assessed as good and getting better. The downward trend in litter is close to, or meeting, State targets (see **Litter**).

Table P4.2: Waste and resource recovery indicators

Indicator	Environmental status	Environmental trend	Information reliability
Total waste generation	**MODERATE**	Getting worse	Good
Per person waste generation	**MODERATE**	Getting worse	Good
Total solid waste disposal	**MODERATE**	Stable	Good
Total solid waste recycled	**MODERATE**	Stable	Good
Litter items per 1,000 m^2	**GOOD**	Getting better	Good

Notes:
Indicator table scales:
- **Environmental status**: Good, moderate, poor, unknown
- **Environmental trend**: Getting better, stable, getting worse
- **Information reliability**: Good, reasonable, limited.

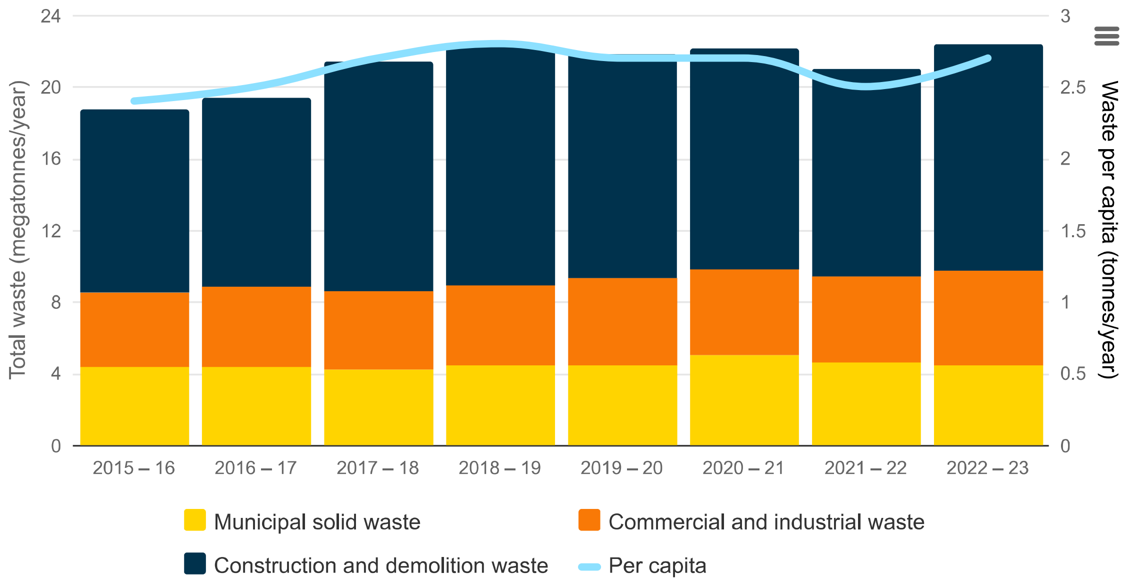
See **Indicator guide** to learn how terms and symbols are defined.

Total waste generated

Waste generation is affected by population and economic factors. These result in an upward trend over the long term despite any year-on-year peaks or troughs.

Figure P4.1 shows that total waste generated in NSW rose from 18.7 million tonnes in 2015–16 to 22.4 million tonnes in 2022–23.

Figure P4.1: Waste generated (by waste stream); total (megatonnes/year) and per capita (tonnes/year), 2015–16 to 2022–23



Source:
NSW EPA 2024c

The 2022–23 total exceeded the:

- pre-pandemic peak of 2018–19 by 72,000 tonnes
- 2021–22 total by 1.4 million tonnes (7%).

Waste generated per person in NSW followed a similar pattern. In 2015–16 the figure was 2.4 tonnes. This rose to 2.7 tonnes per capita in 2022–23. This represented a return to the pre-pandemic level and was 0.14 tonnes (6%) more than the 2.5 tonnes per capita in 2021–22.

The ***NSW Waste and Sustainable Materials Strategy*** (**DPIE 2021a**) sets a target of reducing total waste generated per capita by 10% by 2030. The results shown above suggest that NSW is not on track to meet this target.

Fluctuations in the amount of waste generated per person are primarily due to changes in the amount of construction and demolition waste. This waste type is not directly linked to individuals or households.

Waste disposal and recycling

Since 2015–16, there has been an increase in the total amount of waste generated in NSW. This has increased the amount of waste recycled and disposed of.

Waste generated in NSW may be recycled or disposed of within the State, sent interstate or exported to another country.

Waste exported from NSW

Between 2018–19 and 2022–23, waste (of all kinds) transported interstate fell from 9% of total recycling to 5%, as measured by weight. This has plateaued, remaining at 5% from 2020–21 to the end of 2022–23.

Waste that cannot be recycled in Australia due to lack of facilities may be exported to other countries for processing (**DCCEEW-Aus 2024**).

The export of waste glass, plastic, tyres, paper, cardboard and hazardous waste is regulated by the Australian Government. This is to ensure it does not cause harm to the environment or human health in transit or in destination countries.

Businesses must be licensed and/or comply with export requirements.

Australia is a signatory to the **Basel Convention**, which controls the global import and export of hazardous waste.

Since 2020, the export of certain types of waste has been banned. The bans have been phasing in over several years (**DCCEEW-Aus 2024**). As a result, generally only small amounts of waste are now exported. In 2022–23, NSW waste exported overseas accounted for 5% of total recycling.

Waste recycled and disposed of in NSW

Waste generation in NSW continues to grow, but recycling rates are plateauing.

The reasons for this are complex and vary depending on the type of waste. Socioeconomic factors and lack of infrastructure availability may also play a role.

The NSW Government's **review of the waste levy** will examine:

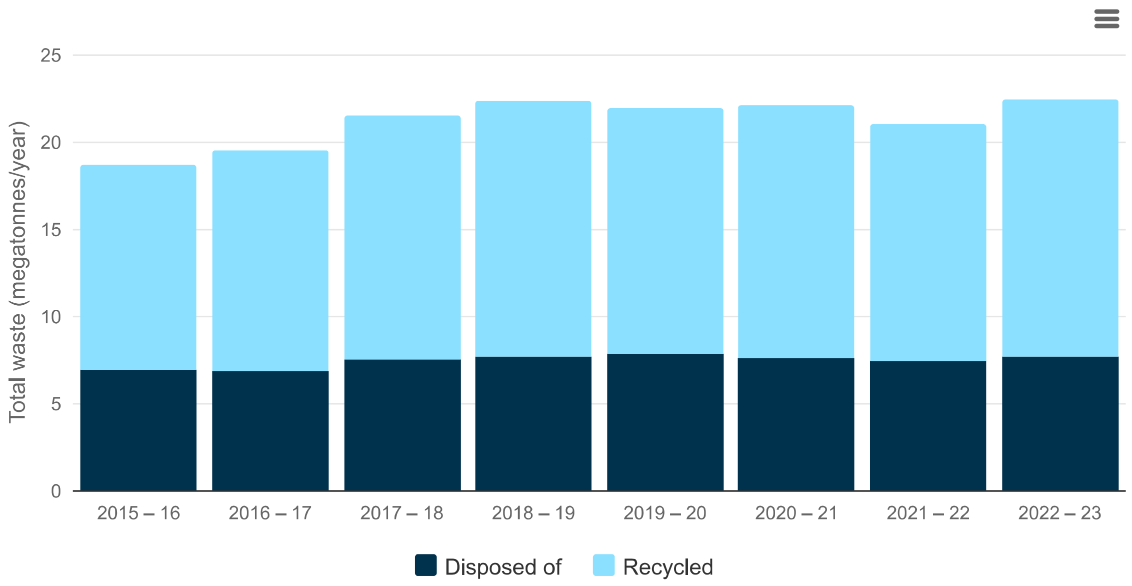
- why recycling is plateauing in NSW
- how the waste levy can be better used to reinvigorate recycling rates.

As at the end of 2022–23, the recycling rate for NSW was 66%. This was an increase on a baseline of 63% in 2015–16. However, the rate has remained stable since 2016–17 (when it was 65%) with a five-year average of 65%.

From 2015–16 to 2022–23, in NSW the amount of:

- waste disposed of increased from 6.9 million tonnes to 7.7 million tonnes
- waste recycled increased from 11.8 million tonnes to 14.7 million tonnes (see **Figure P4.2**).

Figure P4.2: Total waste disposed of and recycled (megatonnes/year), 2015–16 to 2022–23



Source:
NSW EPA 2024c

Construction and demolition waste

In the five years to the end of 2022–23, on average, construction and demolition waste (C&D) comprised:

- 57% of all waste generated
- 68% of all waste recycled.

In 2022–23, the overall recycling rate for this stream was 78%.

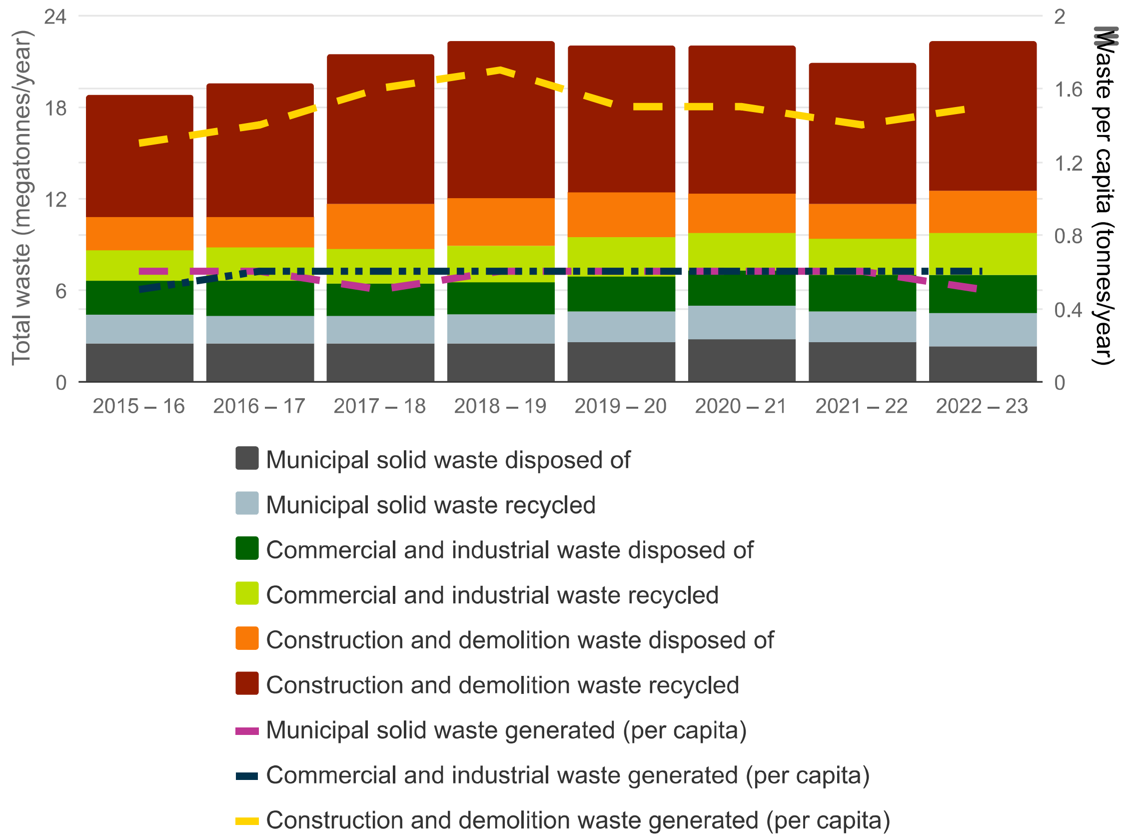
In 2022–23, 12.7 million tonnes of C&D waste were generated. Of this, 9.8 million tonnes were recycled.

Over 90% of C&D waste materials recycled were masonry. Materials such as metals, glass and plastics made up the remainder.

Comparison of waste streams

Figure P4.3 shows that the C&D waste stream accounted for the largest proportion of both waste generated and waste recycled.

Figure P4.3: Waste disposed of and recycled (by waste stream), total (megatonnes/year) and per capita (tonnes/year), 2015–16 to 2022–23



Source:
NSW EPA 2024c

C&D is the only waste stream where the per capita recycling rate has fluctuated since 2015–16. The fluctuations were related to building activity and natural disaster clean-up operations.

The per capita recycling rates for commercial and industrial (C&I) waste and municipal solid waste (MSW) remain stable.

The ***NSW Waste and Sustainable Materials Strategy*** sets a target for an average recovery rate of 80% across all waste streams by 2030. NSW is not currently on track to meet this target, with the rate changing very little between 2015–16 and 2022–23, when it was 66% (see **Table P4.3**)

Table P4.3: NSW recycling rates (%) by waste stream, 2015–16 to 2022–23

Waste stream	2015–16	2016–17	2017–18	2018–19	2019–20	2020–21	2021–22	2022–23
MSW	42%	42%	42%	43%	43%	44%	43%	49%
C&I	47%	49%	53%	53%	52%	53%	49%	51%
C&D	78%	81%	77%	77%	76%	79%	80%	78%
Total	63%	65%	65%	65%	64%	66%	65%	66%

Source:
NSW EPA 2024c

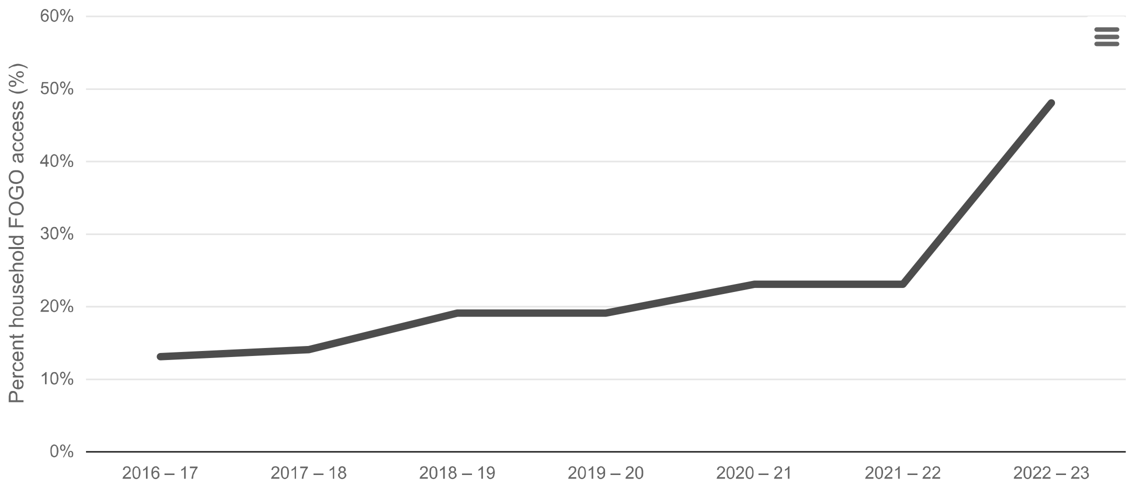
Organic waste

Between 2017–18 and 2022–23, organic waste recovery has been consistent. Annually, 1.6–2.0 million tonnes of waste is processed, primarily into compost and mulch.

In 2022–23, a total of 1,598,000 tonnes were processed, up from 1,591,000 tonnes in 2021–22. Of this, 73% was from the MSW stream (mainly food, vegetation or garden waste). Of the remainder, 20% was from the C&I stream and 6% was from C&D.

From 2021–22 to 2022–23, access to food organics and garden organics (FOGO) services improved significantly. **Figure P4.4** shows growth in access to these services from 2016–17 to 2022–23.

Figure P4.4: Proportion of NSW households (%) with access to a food and organics service, 2016–17 to 2022–23



Source:
NSW EPA n.d.

Local council waste and resource recovery reports show that, in 2022–23, of households with access to a kerbside residual waste (red bin) service, 48% also had access to a kerbside FOGO service (**NSW EPA n.d.**).

Overall, councils reported that 887,000 tonnes of organic waste were collected from domestic sources in 2022–23 (**NSW EPA n.d.**). This was comprised of approximately:

- 716,000 tonnes of organics collected at kerbside, including 426,000 tonnes of garden organics and 290,000 tonnes of FOGO
- 114,000 tonnes of drop-off collected organics
- 44,000 tonnes of other council organics from gutters, parks and gardens
- 13,000 tonnes of organics collected by clean-up services.

This was a decrease of 8% on the 968,000 tonnes reported as collected in 2021–22. Despite this, organics collection in 2022–23 remained above the five-year average of 867,000 tonnes.

The weight of organic waste is highly variable. It fluctuates based on the composition and external factors, including weather.

Litter

Litter remains a concern for the NSW community.

The NSW Government has adopted new targets for litter reduction based on 2018–19 levels (**DPIE 2021a**). This followed achievement of the previous 40% target in 2020.

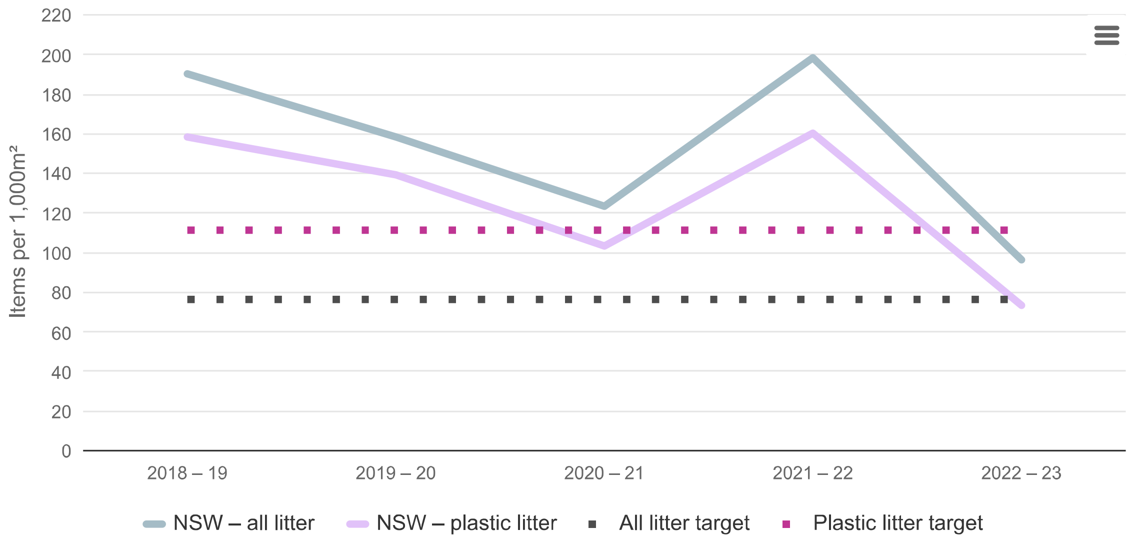
The new targets have a greater focus on items that are likely to leak into the environment and waterways. They are:

- a 30% reduction in plastic litter by 2025
- a 60% reduction in all litter by 2030.

These targets are measured by the **Key Littered Items Study**, which monitors litter in estuaries along the NSW coast. This is supported by a terrestrial litter measure, the **Australian Litter Measure**.

Figure P4.5 shows that in 2022–23 the density of littered items in NSW declined by 51% from 2021–22: from 198 items per 1,000m^2 to 96 items per 1,000m^2. Plastic litter declined more steeply, with a 55% reduction since 2021–22.

Figure P4.5: NSW average for litter density, 2018–19 to 2022–23



Source:
NSW EPA 2024a

The sharp decline across all litter follows a steep rise in 2021–22 and now represents a return to an ongoing downward trend.

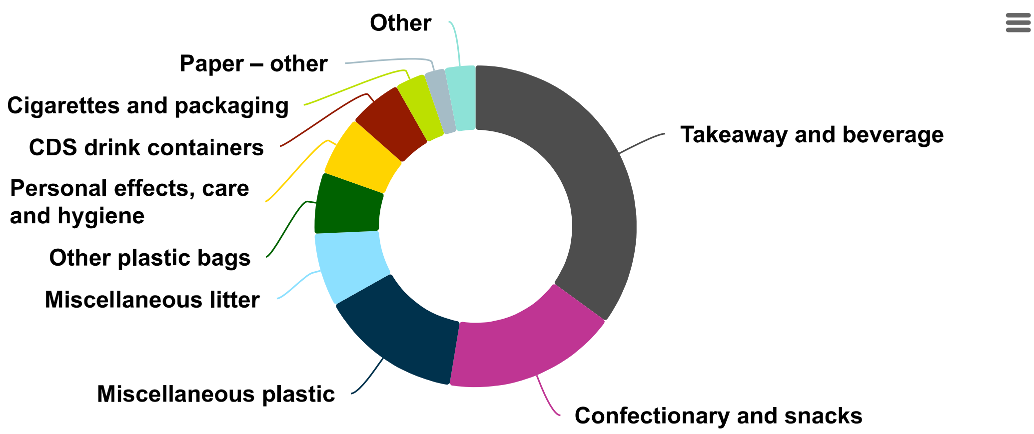
Litter data is inherently variable. Longer term results provide a more reliable insight into the change in litter over time.

Litter composition

The two measures used to monitor litter indicate a notably different litter composition:

- the composition of litter using the terrestrial count is dominated by cigarette butts, at around 50% of the total litter stream
- the composition of litter using the marine litter measure is more varied, as shown in **Figure P4.6**.

Figure P4.6: Composition of the NSW marine litter stream, 2022–23



Notes:
'Other' includes checkout shopping bags, glass, recreational fishing items and non-CDS (Container Deposit Scheme) drink containers.
'Miscellaneous plastic' includes items such as tape, plastic wrap, face masks and toys.
'Miscellaneous litter' includes items such as foil, clothing, balloons and non-plastic toys.

Source:
NSW EPA 2024a

In 2022–23, at 35%, takeaway and beverage items were the biggest contributors to litter density in NSW. This was followed by confectionary wrappers and snack bags, at 18%.

Items made of plastic easily accounted for the largest share of litter, at 79%.

The most-littered individual items were confectionery wrappers and snack bags (18%), followed by straws (10%).

Container Deposit Scheme

The NSW Container Deposit Scheme, ***Return and Earn***, was introduced in December 2017.

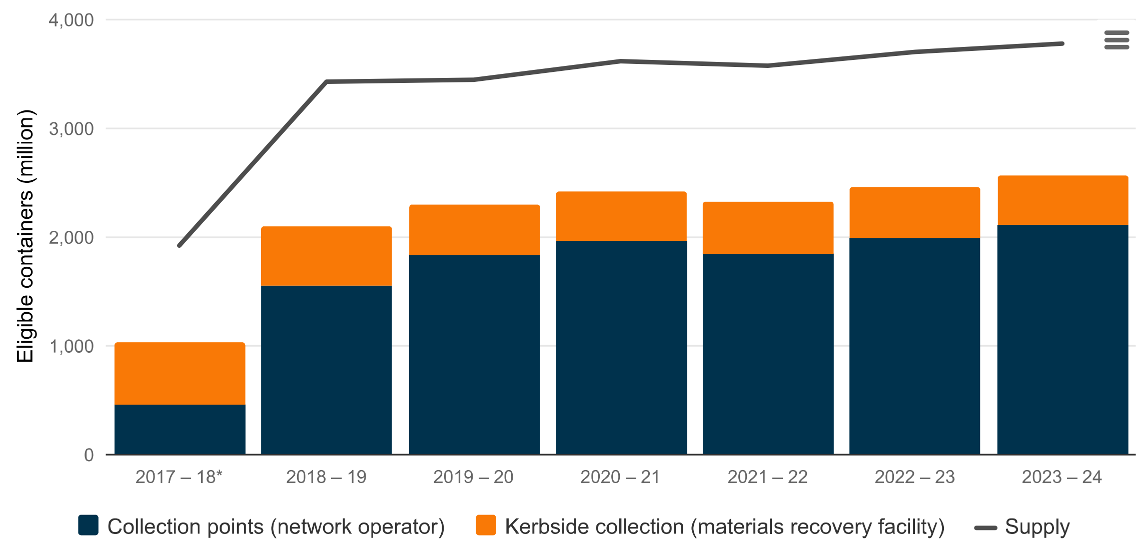
The scheme provides a 10-cent refund for eligible drink containers. In 2022–23, these containers made up 38.6% of the total volume of litter generated in NSW and 4.6% of all littered items.

Since the introduction of the scheme in 2017, the volume of litter from containers that are eligible for the scheme has decreased by 71%.

In 2023–24, *Return and Earn* had 633 network operator collection points across NSW and 84% of adults in NSW had participated in the scheme.

Between 2017 and June 2024, 15.2 billion containers were collected, including 3.4 billion containers from kerbside recycling (**Figure P4.7**). This has resulted in more than 1.08 million tonnes of materials being recycled.

Figure P4.7: NSW Container Deposit Scheme (Return and Earn) recovery rate, December 2017 to June 2024



Notes:
Data is collected by *Return and Earn* contractors and reported in Exchange for Change annual reports.

Supply refers to the number of eligible beverage containers supplied in NSW.
* The data for 2017–18 covers the period from December 2017, when the scheme was launched, and June 2018.

Source:
Exchange for Change annual reports

In 2023–24, 88% of glass and 100% of PET (Polyethylene terephthalate) collected through the scheme was sent to recycling facilities in NSW. The remaining glass was sent for recycling in Queensland and South Australia.

Since the Container Deposit Scheme started, containers returned through the *Return and Earn* network have contributed to:

- water savings of 56,505 million litres, equivalent to 22,616 Olympic swimming pools
- energy savings of 12,542,348 gigajoules, equivalent to the average yearly energy consumption of 101,271 households
- 1,157 million kilograms of carbon dioxide emissions avoided, equivalent to taking 429,382 cars off the road for a year.

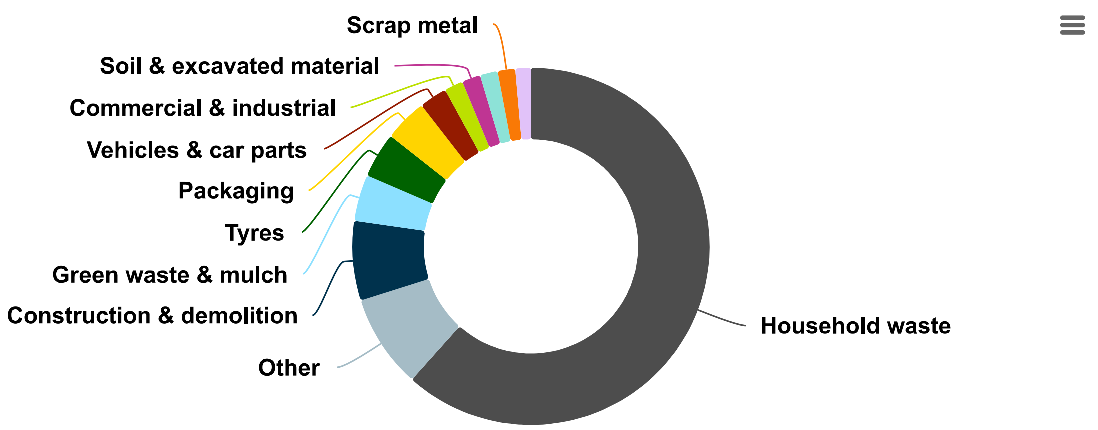
These estimates are based on the **Return and Earn Impact Calculator** developed by Lifecycles Australia.

See the **performance dashboard** for more information about the scheme's performance.

Illegal dumping

In 2022–23, household waste was the most common type of illegally dumped material. It accounted for 61.6% of all incidents recorded in the EPA's **Report Illegal Dumping online** (RIDonline) system (see **Figure P4.8**).

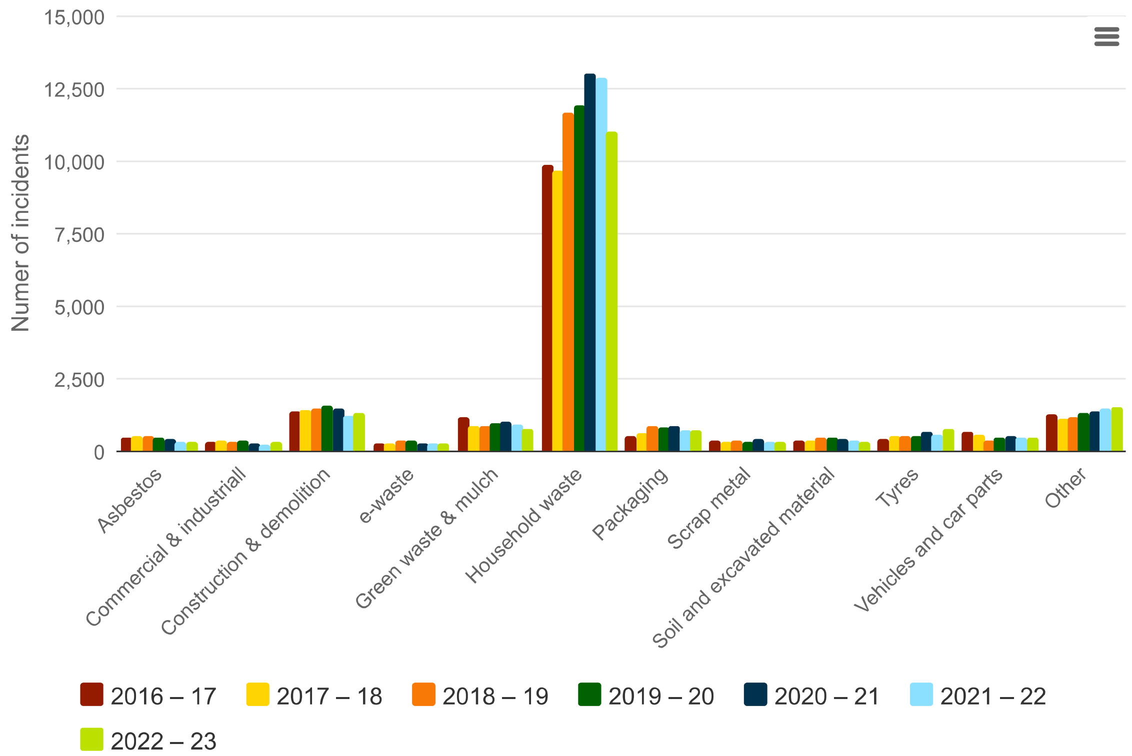
Figure P4.8: Composition of illegally dumped waste, 2022–23



Source:
RIDonline data 2024

Illegal dumping rates of household items trended downwards in 2021–22 and 2022–23 (**Figure P4.9**).

Figure P4.9: Illegal dumping incidents recorded by RIDonline by waste type, 2016–17 to 2022–23



Source:
RIDonline data 2024

Other key trends reported in RIDonline in 2022–23 include the following:

- Construction and demolition waste accounted for 7.2% of all illegal dumping incidents. While RIDonline does not capture all incidents, it appears that dumping of this type of waste has been trending downwards over the past few years.
- Green waste and mulch comprised 4.2% of reported incidents. There has been a decrease in dumping rates of this waste type over the past few years.
- Tyres accounted for 4.1% of reported incidents reported. The rate of dumping of this waste has been increasing over the past few years.

Hazardous and trackable (controlled) waste

Some types of waste are potentially more harmful to the environment and human health than others. These are referred to as controlled waste.

This waste requires specialised handling, transport, treatment, storage and disposal to effectively reduce the risk it poses to the environment and human health.

Some of this waste must be tracked while being transported within NSW or interstate to ensure that it doesn't pose a danger to the environment or the community. This is called '**trackable waste'**.

Controlled waste may include asbestos, mineral oil and industrial waste containing heavy metals or chemicals.

Some controlled wastes generated in NSW are exported interstate. These include zinc compounds sent to South Australia for recovery and oil sent to Queensland for recycling. A range of other waste types are moved to mainly Queensland and Victoria for disposal, recovery, recycling or reuse.

Controlled wastes are also imported into NSW for processing or disposal. These include oils, inorganic chemicals and acids.

Reasons for interstate export include the availability of waste treatment and disposal infrastructure and cost.

In 2022–23, an estimated 2,270,000 tonnes of controlled waste were generated and disposed of (**DCCEEW-Aus unpub.**). About 37% of this was asbestos waste and 29% was contaminated soil.

Table P4.4 shows the five waste types generated in the greatest volumes in NSW in 2022–23.

Table P4.4: The five most common types of controlled waste generated in NSW in 2022–23

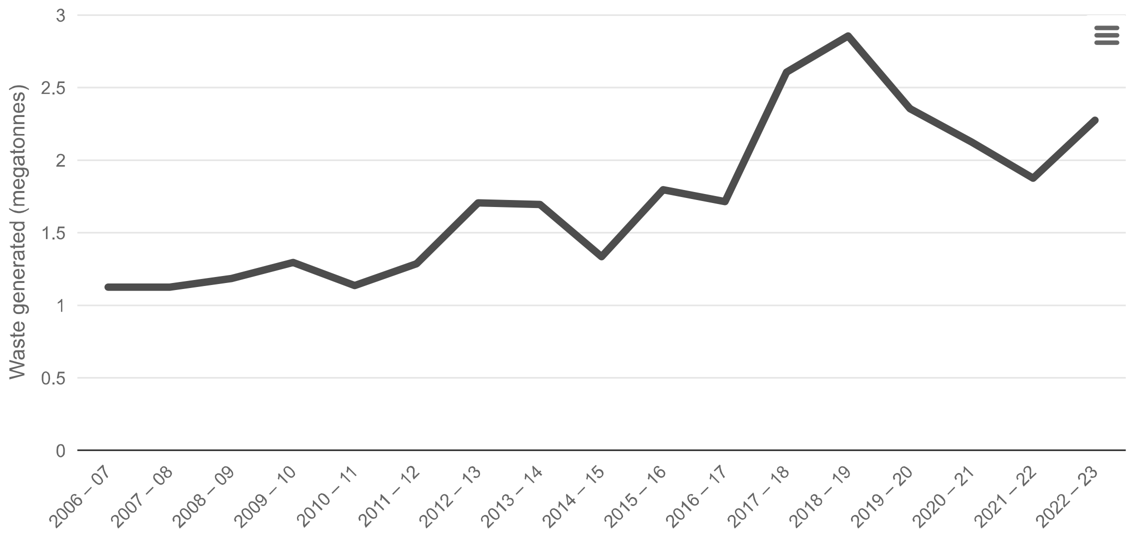
Waste type	Estimated generation (tonnes)
asbestos (including asbestos-contaminated soil)	840,000
other contaminated soil	670,000
tyres	130,000
waste mineral oils unfit for their original intended use	110,000
grease trap waste	110,000

Notes:
These five waste types represent 82% of total controlled waste generation in 2022–23. Controlled waste generation estimates are derived from tracking data or estimated using alternative data, adjustments and assumptions. This data excludes contaminated biosolids and other waste types that are not required to be tracked and for which no alternative data is available.

Source:
DCCEEW-Aus unpub.

The amount of controlled waste being generated over the long term is increasing. **Figure P4.10** indicates a peak in 2018–19. This trend reflects broader solid waste generation.

Figure P4.10: Controlled waste generation (megatonnes) in NSW, 2006–07 to 2022–23



Source:
DCCEEW-Aus unpub.

The drop between 2019–20 and 2021–22 is possibly due to weaker economic activity during the COVID-19 pandemic.

The latest data for 2022–23 represents an increase of 21% on the previous year. Generation is approaching pre-pandemic levels.

With the emergence of new technologies and industrial processes, novel types of hazardous waste are likely to be produced, possibly in significant volumes.

Soils and liquids contaminated with per- and poly-fluoroalkyl substances (PFAS) are a well-known example of an emergent form of hazardous waste in NSW. PFAS are manufactured chemicals used in a wide range of products. They do not break down and can persist for a long time in the environment.

Solar panels, vapes and e-wastes, containing lithium-ion batteries are also emerging as problem waste streams.

Household problem waste

Problem waste includes common household items, such as paint, gas bottles, fluorescent globes and tubes and batteries, that cannot be easily recycled but may be harmful if disposed of to landfill or dumped.

Two free services, Community Recycling Centres and Household Chemical CleanOut events are available to the residents of NSW for the safe disposal of problem waste.

Collection of these materials is growing as the Community Recycling Centre network continues to expand and provide greater access for residents.

There are now 100 Community Recycling Centres across the state and as many Household Chemical CleanOut event collection days each year.

In 2023–24, the programs collected over 5,400 tonnes of household problem waste, including over:

- 3,000 tonnes of paint
- 780 tonnes of gas bottles
- 300 tonnes of oil
- 120 tonnes of loose batteries.

While attendance at Community Recycling Centres is not tracked at all sites, approximately 45,000 people attended Household Chemical CleanOut events across the year.

Since the Household Chemical CleanOut events started more than 21 years ago, over 500,000 people have safely disposed of 26,000 tonnes of household chemicals and other problem wastes at these events.

The first Community Recycling Centres, in Liverpool, Lake Macquarie and Port Stephens, celebrated ten years of operations in 2024. Over 25,000 tonnes of waste has been collected through these centres since the first three opened in 2014.

Cumulatively, over 50,000 tonnes of household problem waste has been collected and safely disposed of through these programs.

Wherever possible this material is recycled, recovering valuable resources, such as metals for reuse in the circular economy. Where recycling is not possible, hazardous materials are treated so that it is safe to send them to landfill.

Pressures and impacts

Population growth

Globally, solid waste generation is strongly correlated with gross national income per capita and has grown strongly over the past half century (**Geyer et al. 2017**).

In NSW, total waste generated is growing at a faster pace than the population. See the **Population and the environment** topic for more information.

To reverse this trend, there would need to be a substantial decrease in the amount of waste we generate per person. As reported in the **Status and trends** section of this topic, per capita waste generation remains high and is approaching pre-pandemic levels.

Related to our increasing population are the challenges increased housing density may present for waste collection, sorting and disposal.

Worldwide, apartments have lower recycling rates than standalone houses. Apartment buildings have not traditionally been designed to accommodate the infrastructure (for example, many bin types) that facilitates recycling (**Middha & Horne 2023**).

Plastics

Plastics are cheap, lightweight, durable and versatile. They are an important part of many items we use today and the packaging they come in. In some cases, the use of plastic is unavoidable.

But not all plastic items are essential, and the way they are produced, used and disposed of is increasingly unsustainable. Of the 891,000 tonnes of plastic waste generated in NSW in 2022–23, only 14% was recycled (**NSW EPA unpub.**). While plastic litter has declined in recent years, plastics – particularly single-use plastic items – still make up approximately 79% of littered items in NSW.

In the environment, plastic litter can be ingested by animals or entangle them, which can harm or kill wildlife. Evidence is also emerging indicating that microplastics may have detrimental impacts on the environment and human health. 'Microplastics' refers to small pieces of plastic that are widespread in our environment and are now being found in human bodies, due to the break-down of plastics over time.

Chemical additives in plastics can also pose risks to human health. They can contaminate new products made from recycled plastics. They can also contaminate other recovered materials, such as compost made from household organic waste, when plastic food packaging is improperly disposed of in kerbside organic waste bins.

Production and packaging

As part of the global economy, NSW imports a significant amount of plastics with the products we purchase. Local production and manufacturing of plastic products is limited.

Packaging is plastic's largest market, accounting for 40% of all plastic produced. About one-third of this packaging is food packaging (**Chakori et al. 2022a**).

Food packaging has grown for two reasons:

- longer supply chains in the food production and delivery system
- an emphasis on convenience for time-poor households (**Chakori et al. 2022b**).

This has resulted in increased growth in the global plastics market. It is projected to increase from $507.16 billion in 2023 to $717.17 billion by 2030. This growth is mainly driven by demand for packaging (**Fortune Business Insights 2023**).

To reduce packaging waste and increase the circularity of packaging, Australia has a mandatory national co-regulatory framework for packaging in place. Established in 1999, it creates obligations for brand owners to design more sustainable packaging to increase recycling and reduce litter.

An independent **2021 review of this framework** found that the obligations of brand owners under the current co-regulatory arrangement are not well understood by stakeholders and aren't consistently applied. Differences in implementation between states and territories and limited monitoring and enforcement of the framework has also undermined confidence in the co-regulatory arrangement, enabling free riders and disincentivising participation.

The 2025 National Packaging Targets were established in 2018, and set targets for:

- 100% of packaging to be reusable, recyclable or compostable
- 70% of plastic packaging recycled or composted
- 50% average recycled content across all packaging
- phase out problematic and unnecessary single-use plastic packaging.

A **2023 review of these targets** by the Australian Packaging Covenant Organisation found that progress under the current co-regulatory framework was not on track to meet the targets by 2025.

Recycling capacity

As well as designing packaging and other plastics for recyclability, it is also important that sufficient infrastructure to recover and recycle plastics is in place.

The NSW Government has committed to tripling the recycling rate of plastics by 2030. This will require processing infrastructure to support the increased quantity of plastics destined for recycling over the next few years.

In 2022–23, NSW only had capacity to reprocess 165,600 tonnes of plastic waste. This was an 81% shortfall from the 891,000 tonnes that was generated. Even with future planned capacity, there will still be a shortfall of 54% relative to the 2022–23 generation (**Blue Environment unpub.**).

In addition to this capacity gap, there are other limiting factors preventing NSW from recycling all its plastic waste. These include barriers in ensuring proper source separation, access to collection, contamination, transport costs, and limited demand or end markets.

Programs such as the NSW Container Deposit Scheme, *Return and Earn*, address some of these barriers. They have significant success in improving recycling rates and the quality of recovered materials.

Landfill capacity

NSW needs to ensure it has enough capacity to safely dispose of the materials we cannot re-use, repair or recycle.

NSW facilities for the storage, treatment and disposal of hazardous waste, general and liquid waste are approaching capacity.

If the State's current rates of waste generation and recycling remain unchanged, landfills serving Greater Sydney will reach capacity by 2030 (**NSW EPA 2024d**).

Landfill capacity is also expected to run out by 2030 in some regional areas. The NSW Government's guide to future infrastructure needs (**DPIE 2021c**) reports that:

- the combined regional landfill expiry for the Hunter, Illawarra Shoalhaven, Mid North Coast and Northern Rivers regions is past 2040
- some locally managed landfills in the Northern Rivers and Coffs Harbour may reach capacity within the next 15 years
- there are looming capacity constraints for hazardous waste treatment and landfill - the only NSW landfill that can accept contaminated wastes is set to reach capacity in 2031.

Disposal of waste is usually managed within the region in which it is generated. When there is not enough viable and affordable land for landfilling, waste is compacted and transported to other destinations.

Asbestos contamination of recovered waste

The contamination of recovered materials with hazardous substances is a growing issue in NSW. A persistent problem is asbestos contamination in construction and demolition waste that is sent for recycling into new products.

It has been estimated that 6.2 million tonnes of asbestos remains present in the built environment in Australia (**Brown et al. 2023**).

If asbestos waste is not properly identified and separately managed in construction and demolition activities, and ends up in recycled construction and demolition waste, the asbestos may then flow on to products derived from the recycled waste. Such asbestos contamination poses human health risks to the processors of the waste, the producers and end users of the products derived from such waste, and the wider community.

In early 2024, asbestos was discovered in commercial mulch used in multiple public locations in NSW and caused significant public concern around the safety of the relevant public locations (**NSW EPA 2024e**). Significant costs were incurred by multiple NSW agencies to investigate, manage and clean up the asbestos contamination. The EPA is working with industry and taking a systems approach to develop options aimed at preventing the issue occurring in the future.

Emerging waste streams

NSW needs to be responsive and adaptive to emerging waste streams. Emerging waste streams could pose a significant or emerging threat or opportunity that requires near-term action.

The management of end-of-life batteries has become an area of increasing concern, in particular lithium-ion batteries. They are great at powering our smart phones, e-bikes and other devices, but if improperly disposed of they can cause fires and pollute the environment.

The waste and resource recovery industry is witnessing frequent battery-related fires in its vehicles and facilities. These fires are placing the environment, human health and property at risk.

The improper use and charging of batteries also put lives at risk, for example, two NSW residents died in February 2024 from an e-bike battery fire (**FRNSW 2024a**) – the first recorded deaths in NSW resulting from a lithium-ion battery fire.

Battery-related fires are increasing. Fire and Rescue NSW have reported a 66% increase in the number of lithium-ion battery fires attended between 2022 and 2023 – this increase has continued into 2024 (**FRNSW 2024b**; **FRNSW 2024c**).

Between 2022 and 2023, incidents involving lithium-ion batteries were also found to be four times more likely to result in injury than all fire and explosion incidents attended.

There are also challenges in managing the growing volume of vapes and e-cigarettes. These products can cause fires when disposed of in bins and then compacted or punctured through the waste supply chain.

The Australian Government has made **regulatory changes** to the supply of these products, but the safe disposal of vapes is expected to be an ongoing challenge.

Similarly, end-of-life solar panels and battery systems are forecast to generate 40,000–71,000 tonnes of waste annually by 2035 (**Florin et al. 2020**).

Other pressures and impacts

Stockpiling of waste

The Australian Government has phased in restrictions on exports of unprocessed plastic, glass and tyres. Restrictions on paper and cardboard exports came into effect in July 2024 (**DCCEEW-Aus 2024**).

The intent of these waste export bans has been to promote local processing and recycling approaches and an uplift in processing capacity and capability.

Investment in processing capacity for these recycled material streams is primarily driven by commercial considerations and the strength of demand from end markets for recycled materials.

NSW, and Australia more broadly, has a relatively low manufacturing base and high labour costs compared to other markets in the region. This impacts demand for recycled materials and the cost competitiveness of recycling relative to using virgin materials.

These controls, coupled with a shortfall in processing capacity, have led to increased stockpiling of some wastes (notably soft plastics).

Stockpiling waste can be dangerous and has been associated with catastrophic fires (**Kerr 2018**).

Human behaviour

Consumer behaviour influences the success of waste avoidance and recovery. Examples are using recycling bins correctly, choosing recycled products and storing food properly.

Illegal activities, such as littering, illegal dumping or providing contaminated material under the guise of 'clean fill' also play a role.

Behaviour is shaped by social norms, the availability of alternatives, and perceived costs and benefits.

Responses

National cooperation

Waste management in Australia is largely guided by the ***National Waste Policy Action Plan*** (**DCCEEW-Aus 2022**). This plan outlines targets and actions to complement and support the implementation of waste management plans by NSW and other jurisdictions as well as by business and industry.

NSW, represented by the EPA, participates in multiple national-level, cross-jurisdictional working groups to:

- harmonise the phase-out of problematic and unnecessary plastics, such as single-use plastics, to make it easier for businesses that operate across multiple states and territories to comply with plastic regulations
- refine existing and develop new product stewardship schemes, including new mandatory obligations on battery suppliers to participate in product stewardship to reduce the risks of end-of-life battery fires, and reduce waste from small electrical products and solar panel systems
- promote consistent waste management standards across Australia, including the development of a robust and coordinated regulatory response to the long-distance transport of waste for disposal.

In June 2024, Environment Ministers agreed that NSW, with Victoria and Queensland, would take urgent action and consider product stewardship for batteries to manage them across their lifecycle and reduce escalating fires in waste trucks and facilities.

NSW worked with Victoria to engage with industry and prepare a draft Regulatory Impact Statement, presenting options for **mandatory battery product stewardship** (PDF 256KB) to Environment Ministers in December 2024.

Packaging reform

Recognising that the current co-regulatory arrangement is no longer fit-for-purpose and will not deliver a circular economy for packaging, in October 2022, Australia's Environment Ministers agreed to reform packaging regulation by 2025.

The reforms aim to ensure all packaging available in Australia is designed to be recovered, reused, recycled and reprocessed safely in line with circular economy principles. These changes will reduce the impact of packaging on the environment.

Following on from this, in June 2023, **Environment Ministers agreed** to:

- introduce a new scheme leveraging mandatory packaging design obligations based on international best-practice
- make industry responsible for the packaging they place on the market under the new regulatory scheme
- regulate-out harmful chemicals and other contaminants in packaging.

In 2024, the Australian Government released a **consultation paper** seeking feedback on options to reform packaging regulation. Informed by feedback received on this paper, the Australian Government continues leading national packaging reform, with support from all jurisdictions.

However, progress on this reform work has been slow. Under policy measures, such as the *NSW Plastics: The Way Forward* action paper, NSW will take action to reduce packaging waste if greater protections are needed faster than this national reform process allows.

Policy measures

A number of measures are in place to work towards reducing waste from different streams in NSW, transitioning the State towards a lower emissions, circular economy.

The ***NSW Waste and Sustainable Materials Strategy 2041*** *s*ets a long-term vision for managing waste and refocusing the way NSW produces, consumes and recycles products and materials.

The ***NSW Circular Economy Policy Statement: Too Good to Waste*** presents the approach for transitioning the State to a circular economy. It provides principles to guide NSW Government decision-making on resource use and management.

NSW Net Zero Plan 2020–2030

In 2020, the NSW Government released the **NSW Net Zero Plan Stage 1: 2020–2030** (**DPIE 2020**). It sets out how NSW will:

- deliver a 50% cut in emissions by 2030 compared with 2005 levels
- be on the path to achieving net zero emissions by 2050.

By adopting a circular economy approach, we can increase our carbon efficiency by:

- designing out waste and using fewer materials in production
- making sure the materials that are used in production are less energy-intensive
- increasing the lifespan of buildings and products
- reusing or recycling materials to avoid emissions associated with raw material extraction and production.

The NSW Government will work with the property and infrastructure sectors to develop tools and guidance to promote circular design and practices. This will include establishing new circular design guidelines for buildings and infrastructure.

Opportunities will also be identified to embed circular design principles in new NSW Government buildings, infrastructure and precincts.

See the **Net Zero Plan Stage 1: 2020–2030** topic for more information.

Managing plastics

NSW Plastics Action Plan

Plastic is a substantial waste and recycling issue in NSW and abroad.

One way NSW is approaching the issue is by trying to address each phase of the plastics life cycle with a three-part approach to reducing the harm from plastic waste. This is detailed in the **NSW Plastics Action Plan** (**DPIE 2021b**).

This includes:

- removing as many unnecessary plastic items from the economy as possible
- improving product design to reduce the risks they pose
- improving the quality of plastic items so they can be recycled at the highest level.

Plastic Reduction and Circular Economy Act

The ***Plastic Reduction and Circular Economy Act 2021*** supports the objectives of the NSW Plastics Action Plan. Under the act, the supply of a number of problematic and unnecessary plastic items has been phased out since 2022.

The phased-out items include lightweight plastic shopping bags and single-use plastic straws, cutlery, stirrers, plates, bowls without lids, cotton buds and expanded polystyrene food service items. Plastic microbeads in some rinse-off personal care products have also been banned.

These bans are expected to prevent an estimated 2.7 billion plastic items from entering our bushland, coastal and marine environments over 20 years to 2042.

NSW Plastics: Next Steps and The Way Forward

To reduce plastic pollution by better managing plastic throughout its life cycle, the NSW Government is investigating ways to improve plastic recycling and minimise plastic waste.

The **NSW Plastics: Next Steps** issues paper was released for public consultation in 2023. It received over 5,000 survey responses and written submissions. The paper put forward ideas on further actions that could be taken in NSW to address issues related to plastic items and materials that are highly littered, contain harmful chemicals and release microplastics into the environment.

Findings from this consultation informed the development of more detailed proposed actions to tackle plastic waste, set out in **NSW Plastics: The Way Forward**. These aim to:

- avoid plastic waste generation by phasing-out certain problematic and unnecessary plastic items and by supporting reusable alternatives to single-use plastics
- improve plastic recycling through design standards, such as requiring single-use plastic cups, food containers and condiment packets to be recyclable
- ensure plastic waste is properly disposed and does not contaminate other recycling streams or is not littered in the environment.

NSW Plastics: The Way Forward was released for public consultation from September to November 2024. Feedback on the paper will be reviewed and will inform the further development of actions to address problematic and unnecessary plastics in 2025.

Recycling and resource recovery

Review of the NSW Waste Levy

The *Protection of the Environment Operations Act 1997* requires certain licensed waste facilities in NSW to pay a contribution for each tonne of waste received at the facility.

Referred to as the **waste levy**, the contribution aims to reduce the amount of waste being sent to landfill and promote recycling and resource recovery.

The NSW Government is reviewing the conditions of the **NSW waste levy** to look at how to improve its operation and drive further resource recovery in NSW.

NSW Waste Infrastructure Plan

The EPA is working closely with local councils and industry to develop a Waste Infrastructure Plan for NSW. The plan will be informed by robust, data-driven analysis to determine infrastructure needs across the state and will take a staged approach, starting with the most urgent capacity needs in residual waste and FOGO infrastructure, before taking a holistic approach to recycling infrastructure (including for plastics recycling).

The EPA is also working to create public data dashboards so that stakeholders can make informed decisions for planning and investment. This includes data from the commercial and industrial waste audit, an assessment of residual waste needs and material flow analysis by regions.

The plan will be action-oriented and focus on:

- establishing consensus and trust in data regarding waste generation, material flows, infrastructure capacity and future needs
- improving current strategic planning and delivery mechanisms for waste infrastructure
- improving and clarifying the policy and regulatory framework to give greater certainty to stakeholders.

Targeting materials for recovery

As waste volumes continue to grow, infrastructure and services are needed to make sure we have the capacity to collect and recycle waste materials. Some types of waste materials can be more challenging to collect and recycle. Priority areas for recovery include organics, plastics and residual waste destined to landfill (**DPIE 2021c**).

The EPA is working with stakeholders to address these problems through the development of the NSW Waste Infrastructure Plan. Key inputs to the plan include a series of data analysis projects to form a clearer view of infrastructure needs across the State.

The **2023 Commercial and Industrial Waste Audit** gives insight into what materials are being sent to landfill by businesses in different regions across NSW. The EPA conducted the audit to identify:

- the waste material types sent to landfill by different industry sectors

- recyclable materials that are being landfilled
- differences in waste composition in different areas across NSW
- industry sectors requiring targeted interventions to improve material recovery.

Four materials account for just over 70% of waste sent to landfill by businesses in NSW:

- organics 25.4%
- waste processing residues 16.2%
- plastics 15.3%
- paper and cardboard 13.4%.

The EPA is also modelling key waste material flows by region. This will provide strategic insight into the:

- tonnages of material types by waste stream
- destination of materials in different areas across NSW
- opportunities for policies, programs or infrastructure to improve material recovery.

Investment in waste and recycling infrastructure

The NSW Government is encouraging investment in waste and circular economy infrastructure. The ***NSW Waste and Sustainable Materials Strategy 2041*** outlines actions to deliver on long-term objectives to transition to a circular economy, backed by $356 million in funding.

Over the past decade, the NSW Government has awarded more than half a billion dollars in grants to deliver more than 3,000 projects.

Between 2021 and 2023, the **Remanufacture NSW funding program** was co-funded by the NSW Government and the Australian Government's Recycling Modernisation Fund. This fund was established in response to the impacts of waste export bans.

The program awarded over $37 million in funding to 36 projects through which industry could respond to the regulation of the export of glass, plastic, tyres, paper and cardboard under the *Recycling and Waste Reduction Act 2020*. These projects will deliver almost 160,000 tonnes of new processing capacity per year.

Organics recycling

NSW households' red-lid kerbside bins contain around one third food waste. This material can either go into landfill, releasing methane gas as it decomposes, or it can be collected separately and recycled into compost.

The NSW Government committed to halving this organic waste being disposed of in landfill by 2030 under the ***NSW Waste and Sustainable Materials Strategy 2041***. This commitment is part of the broader Australian Government's net zero commitment.

The NSW Government passed the **Protection of the Environment Amendment Legislation (FOGO Recycling) Bill 2024** on 20 February 2025. The bill provides for:

- the source-separated collection of food organics and garden organics (FOGO) waste from households from 1 July 2030
- the source-separated collection of food organics waste from various businesses and institutions from 1 July 2026, 2028 or 2030 based on the premises' weekly residual waste bin capacity.

These measures will significantly increase the volume of organics waste entering the recycling system.

An analysis of the proposed household mandates found that application of the mandates to all households in NSW may result in the diversion of almost 950,000 tonnes of FOGO waste each year from landfill and into circular economy products like compost.

Landfill capacity

As part of the work to develop a NSW Waste Infrastructure Plan, the EPA is assessing the infrastructure needs for landfills and transfer stations in NSW. New data will inform program and policy responses.

Funding will also be provided under the **Waste Delivery Plan** to improve landfill and waste management in NSW. This includes the $6 million **Landfill Consolidation and Environmental Improvement program** and part of the $24 million Strategic Infrastructure Investment Fund.

Asbestos contamination of recovered materials

The NSW Government has commissioned and is awaiting the advice from the Office of Chief Scientist and Engineer on the management of asbestos in recovered fines and other recovered materials from construction and demolition waste.

Separately, the NSW EPA has engaged with the construction and demolition recycling industry on a suite of regulatory proposals to minimise and better manage asbestos contamination in recovered construction and demolition waste. The NSW EPA will continue this engagement in 2025 to refine and implement the most viable proposals.

Emerging waste streams

Embedded batteries

Household products containing embedded (non-removable) batteries are becoming more prevalent. They are responsible for a growing number of fires across the waste sector.

A trial to collect vapes and other products containing embedded batteries is now underway. This includes partnering with 21 councils to collect a wide range of household products containing embedded batteries at **community recycling centres** across NSW. These products include e-scooters, vacuum cleaners, powerpacks and vapes. Vapes are also accepted at **Household Chemical CleanOut** events.

The trial, which runs for two years from September 2024, will ensure safe disposal options are available for household products containing embedded batteries.

Solar panels

Between 2021 and 2022, the **Circular Solar Grants program** targeted solar panels and their batteries to help improve their management at end of life. Over $9.5 million in funding has been awarded to projects that will provide recycling capacity for up to:

- 10,000 tonnes per year of solar panels
- 2,000 tonnes per year of lithium-ion batteries.

Disaster waste and incident responses

Disaster waste is the collective name for waste materials generated when disaster or emergency events damage property, infrastructure and assets or the environment. It also includes materials or goods disposed of during the response or recovery phase of the disaster or emergency.

From 2019–20 to the end of 2023–24, NSW residents endured 76 declared disasters. Two major events in that period produced significant amounts of disaster waste:

- about 340,000 tonnes from the 2019–20 bushfires
- over 370,000 tonnes from the 2022 floods that affected Lismore, the NSW Northern Rivers and the NSW Central West.

Human-induced climate change has increased the frequency, intensity or duration of different types of extreme weather that heighten the risk of these disasters. This has brought a focus on the amount of waste these events generate.

Additionally, landfills and other infrastructure designed to manage waste are likely to be increasingly exposed to storms, flooding and fires.

In response to these concerns, the **NSW Disaster Waste Sub Plan** (**NSW Premier's Department 2023**) was developed in 2023 to consider waste management and recovery as part of the **NSW Emergency Management Plan**.

See the **Extreme climate and weather** topic for more information on the impacts of climate extremes.

Hazardous and trackable waste

Integrated Waste Tracking Solution

The EPA – in collaboration with the Queensland Department of Environment, Science and Innovation – has developed the **Integrated Waste Tracking Solution** for tracking and reporting on hazardous and regulated waste.

The waste tracking solution is a digital tool that enables waste consignors, transporters and receivers to track and report on all types of hazardous and regulated waste in one system.

Implemented in February 2024, it is a key step towards delivering a nationally consistent hazardous waste tracking and data system. This is a commitment under the **National Waste Policy Action Plan** (**DCCEEW-Aus 2019**) and the ***NSW Waste and Sustainable Materials Strategy 2041***.

National consistency will improve the quality of data and provide better oversight of hazardous waste movement in NSW and other jurisdictions.

Community programs

Litter prevention

Under the ***NSW Litter Prevention Strategy 2022–30***, litter prevention is delivered through a comprehensive program focused on zero tolerance to littering. This approach is supported by statewide media campaigns, such as Don't be a Tosser!, through to locally-based initiatives funded by litter prevention grants.

Land managers, such as local councils, are supported to integrate bin infrastructure, behaviour change programs and engagement of local communities. This has already helped drive a 49% reduction in litter across the State (**NSW EPA 2024a**).

More recently, single-use plastic bans under the **NSW Plastics Action Plan** have seen a reduction across the State of heavily littered items, such as plastic shopping bags and plastic takeaway packaging.

Organics education

Since 2020, the **Scrap Together Food Organics and Garden Organics (FOGO) education program** has been supporting Councils to roll out FOGO services. The program provides best practice education resources to encourage behaviour change, including videos, radio ads, social media tiles and brochures.

Three program phases have been developed to date:

- **Every Scrap Counts** (launched 2021): encouraging people to put their food scraps into the bins
- **Starting Scraps** (launched 2024): for councils introducing the new service
- **How to FOGO** (launched 2024): reminding residents to keep contaminants like plastic and cardboard out of the FOGO bin.

Addressing waste in Aboriginal communities

The ongoing **Aboriginal Communities Waste Management Program** aims to reduce litter and waste and increase the amenity of Aboriginal communities across NSW. New funding will be available for programs in eligible communities from 2025 to 2028.

Filling data gaps

To be effective, responses to issues must be based on good data.

Repeated surveys on waste (such as the **Key Littered Items Study**) are noted at many points in this topic.

Audits of specific sectors are undertaken from time to time. An example is the audit of the commercial and industrial waste stream. This is noted above, under **Targeting materials for recovery**.

In addition, reports have been commissioned to address key data gaps, including the annual plastics flows and fates study.

Some of the more recent work to fill data gaps are presented below.

Textiles

Each year, NSW citizens discard more than 300,000 tonnes of textiles (**ACTA 2021**). Globally, from production to disposal, the textiles industry accounts for 8% of carbon dioxide (CO_2) emissions.

Despite this large impact, data on textiles has been poorly captured. To remedy this for NSW, the NSW Government commissioned a report on textile waste: ***Thread Count: NSW Textile Data Report***. It was completed in 2021.

The report provides the most detailed information to date on annual textile imports into NSW, and textile retention and disposal along many pathways. It provides a basis for future circular economy initiatives.

Future opportunities

Review of the Protection of the Environment Operations (Waste) Regulation 2014

The **Protection of the Environment Operations (Waste) Regulation 2014** is the key piece of legislation that sets out the regulatory framework for the management, storage, transportation and reuse of waste in NSW.

The current regulation is due for a staged repeal on 1 September 2025, in accordance with the ***Subordinate Legislation Act 1989***. This provides an opportunity for the regulatory framework to be reviewed in light of the:

- directions set out in the NSW Government's ***Waste and Sustainable Materials Strategy 2041***
- transition to a circular economy (including actions committed to in the **Towards a Circular Economy Delivery Plan**)
- objectives of the *Protection of the Environment Operations Act 1997*.

Hazardous waste

NSW is working with other Australian states and territories to investigate product stewardship approaches to improve the management of hazardous and problematic wastes, such as flammable waste solvents, waste tyres and batteries.

Batteries play a critical role in the transition to net zero. They are increasingly used in consumer electronics, vehicles and the built environment. There has been a rapid expansion in the market for batteries, particularly lithium-ion batteries.

This expansion brings increased risks to human health, the environment, and waste and resource recovery infrastructure associated with battery-related fires.

To address these risks, governments are looking at options across the battery lifecycle, including:

- battery design and manufacturing
- how they are used
- how they are handled when they reach the end of their life.

References

ACTA 2021, *Thread Count: NSW Textile Data Report*, Australasian Circular Textile Association

Blue Environment unpub., *Australian Plastic Fates and Flows FY2022–23: NSW Report (version 2)* (unpublished), Blue Environment

Brown B, Hollins I, Pickin J & Donovan S 2023, 'Asbestos Stocks and Flows Legacy in Australia', *Sustainability*, vol. 15, no. 3, 2282, DOI: 10.3390/su15032282

Chakori S, Aziz AA, Friant MC & Richards R 2022a, If the UN wants to slash plastic waste, it must tackle plastic production – and why we use so much of it, *The Conversation*, accessed 12 November 2024

Chakori S, Richards R, Smith C, Hudson NJ & Aziz AA 2022b, 'Taking a whole-of-system approach to food packaging reduction', *Journal of Cleaner Production*, vol 388, 130632, DOI: 10.1016/j.jclepro.2022.130632

DCCEEW-Aus 2018, *2018 National Waste Policy: Less waste, more resources*, Australian Government Department of Climate Change, Energy, the Environment and Water, Canberra

DCCEEW-Aus 2019, *National Waste Policy Action Plan 2019*, Australian Government Department of Climate Change, Energy, the Environment and Water, Canberra

DCCEEW-Aus 2022, *National Waste Policy Action Plan Annexure 2022*, Australian Government Department of Climate Change, Energy, the Environment and Water, Canberra

DCCEEW-Aus 2024, Waste exports, Australian Government Department of Climate Change, Energy, the Environment and Water, Canberra, accessed 10 September 2024

DCCEEW-Aus unpub., *National waste 2022–23 reporting tool* (unpublished), Australian Government Department of Climate Change, Energy, the Environment and Water, Canberra

DPIE 2020, *Net Zero Plan Stage 1: 2020–2030*, NSW Department of Planning, Industry and Environment, Sydney

DPIE 2021a, *NSW Waste and Sustainable Materials Strategy 2041: Stage 1: 2021–2027*, Department of Planning, Industry and Environment, Sydney

DPIE 2021b, *New South Wales Plastics Action Plan*, Department of Planning, Industry and Environment, Sydney

DPIE 2021c, *NSW Waste and Sustainable Materials Strategy: A guide to future infrastructure needs*, Department of Planning, Industry and Environment, Sydney (PDF 0.53MB)

FRNSW 2024a, Appeal for extra caution around battery use after apparent first Lithium-Ion fire deaths in NSW – Teralba, Fire and Rescue NSW, accessed 26 September 2024

FRNSW 2024b, *Lithium-ion battery incidents 2022–23*, Fire and Rescue NSW, Greenacre (PDF 5.9MB)

FRNSW 2024c, *Lithium-ion battery incidents 2022–23 1 January – 30 June 2024 update*, Fire & Rescue NSW, Greenacre (PDF 1.3MB)

Florin N, Wakefield-Rann R, Dominish E, Dwyer S, Gertsakis J & Hartford N 2020, *Scoping study for solar panels and battery system reuse and recycling in NSW*, prepared for NSW Department of Planning, Industry and Environment by UTS Institute for Sustainable Futures and Equilibrium

Fortune Business Insights 2023, *Plastics Market Size, Share & Industry Analysis, By Type (Polyethylene, Polypropylene, Polyethylene Terephthalate, Polyvinyl Chloride, Acrylonitrile Butadiene Styrene, Polyamide, Polycarbonate, Polyurethane, Polystyrene, and Others), By End-use Industry (Packaging, Automotive & Transportation, Infrastructure & Construction, Consumer Goods/Lifestyle, Healthcare & Pharmaceutical, Electrical & Electronics, Textile, and Others), and Regional Forecast, 2024-2032*, Plastics Polymers and Resins

Geyer R, Jambeck JR & Law KL 2017, 'Production, use, and fate of all plastics ever made', *Science Advances*, vol. 3, no. 7, DOI: 10.1126/sciadv.1700782

Kerr J 2018, As Melbourne's recycling stockpiles keep growing, so does the fire risk posed by the waste, *ABC News*, accessed 12 November 2024

Middha B & Horne R 2023, We can't keep putting apartment residents' waste in the too hard basket, *The Conversation*, accessed 12 November 2024

NSW EPA 2024a, 2022–23 litter data for NSW, NSW Environment Protection Authority, accessed 11 November 2024

NSW EPA 2024b, *NSW Plastics: The Way Forward*, NSW Environment Protection Authority, Sydney

NSW EPA 2024c, NSW waste and recycling performance data for the 2022–23 financial year, NSW Environment Protection Authority, accessed 11 November 2024

NSW EPA 2024d, Sydney landfill shortage, NSW Environment Protection Authority, accessed 4 November 2024

NSW EPA 2024e, EPA investigation into asbestos in mulch, NSW Environment Protection Authority, accessed 18 December 2024

NSW EPA n.d., Local Council Waste and Resource Recovery data, NSW Environment Protection Authority, Sydney

NSW EPA unpub., *End of life plastic generation and recovery from the Australian plastics flows and fates study 2022–23 – New South Wales report* (unpublished), NSW Environmental Protection Agency, Sydney

NSW Premier's Department 2023, *NSW Disaster Waste Sub Plan*, NSW Premier's Department, Sydney

Contaminated sites

Contaminated sites have pollutants or hazardous materials that can put ecosystems and human health at risk.

Overview

The EPA was notified of

25

significantly contaminated sites during 2021–23

Read more

The EPA assessed

18

sites as no longer significantly contaminated during 2021–23

Read more

A contaminated site is a place where the soil or groundwater has been polluted by harmful substances. The level of contaminants usually exceeds what is considered safe for people and the environment.

Harmful substances may include:

- heavy metals, such as lead, arsenic and copper
- chemical substances, such as solvents and oils
- agricultural chemicals, such as insecticides and herbicides
- ground gases or vapours
- asbestos
- radioactive materials.

There are many contaminated sites in NSW. These include large, complex sites often grouped together, typically having been used for heavy industrial purposes, such as gasworks, smelters or petroleum infrastructure (refineries and terminals).

Smaller contaminated sites can also be found in urban and rural areas previously used for agriculture or commercial purposes. These include service stations, fuel storage depots, dry cleaning premises and chemical storage areas.

Before European colonisation, the lands, waters and skies of what is now NSW were free of modern or human-made contaminants. Country was cared for by Aboriginal people through practices that nurtured and preserved the environment for thousands of years.

Since colonisation, contamination has resulted from industrial pollution, poor waste disposal and the use of persistent and toxic chemicals in domestic, agricultural and industrial settings.

Contaminants can remain in the environment for a long time, even after the cause of the contamination has ceased.

Contaminants can also move in the environment. For example, contaminants in soil can get into groundwater and flow on to affect neighbouring land and surface waters.

See the **Rivers and wetlands**, **Groundwater** and **Coastal and marine** topics for more information about water pollution.

How does contaminated land affect us?

Some contaminants in soil and in soil and water can move through the environment to plants, animals and humans.

They can travel a long distance from their original source site through the ground and enter nearby surface waterbodies.

Exposure to some types of contamination may cause immediate harm to human health. For example, some gases emitted by contaminated land create an explosion risk.

Other exposures to contaminated land that could cause harm include:

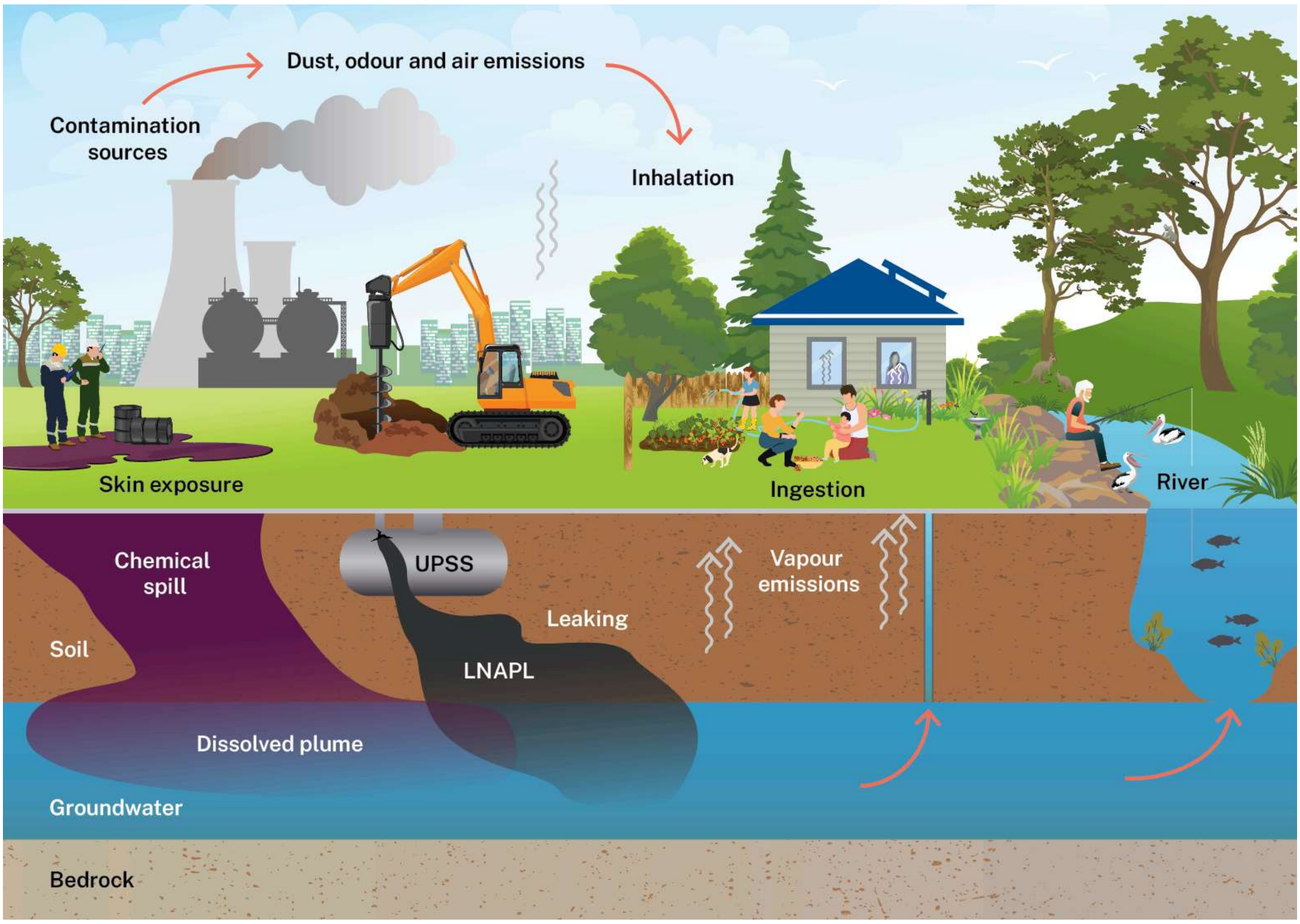
- direct skin contact, drinking the water or watering a garden with contaminated groundwater
- inhalation of vapours emissions that have entered nearby buildings
- skin exposure to contaminated soils or inhalation of vapours by construction workers during excavation or sub-surface works.

These harmful contaminants travel under the ground, meaning there is often no visible or obvious signs of contamination on the surface.

Image P5.1 demonstrates how contamination may occur and the impacts it might have on the environment and human health.

- The source of contamination, such as a chemical spill or underground petroleum storage system (UPSS) leaks a chemical substance or a light non-aqueous-phase liquid (LNAPL) into the soil.
- This causes a dissolved plume, or pathway into the soil or groundwater.
- The contaminant can then impact the environment, including harming animals, plants and waterway ecosystems. It can also affect humans if they are in contact with it. This contact could be through inhalation, ingestion or skin exposure during activities such as digging, swimming or drinking untreated bore water.

Image P5.1: Conceptual diagram of contaminated lands processes and impacts



Notes:
Underground petroleum storage system (UPSS): used to store and dispense petroleum products, typically at petrol stations. These systems consist of underground tanks and pipes, which degrade as they age, potentially resulting in contamination.
Light non-aqueous-phase liquids (LNAPL): liquids such as oil or petroleum that are less dense than water and do not mix well with it. When spilled, they can float on the surface of groundwater, potentially contaminating soil and water.
A dissolved plume: refers to a spread of contaminants that have dissolved into groundwater or another liquid and are now moving away from the original contamination source. Plumes can be hard to detect and manage, spread over large areas, and can affect drinking water supplies and ecosystems.

Source:
NSW EPA 2024

While contaminants include a broad range of substances, some are more prominent in environmental and public health discussions, usually due to their widespread historical use, persistence in the environment or potential to harm human health.

Contamination is a significant issue for Aboriginal communities throughout NSW, posing serious health risks to Aboriginal peoples' wellbeing and encompassing emotional cultural, physical and spiritual health.

In addition to the health risks, contamination issues are significantly impacting the health of Country and the ability of Aboriginal peoples to live on Country maintaining a connection with land, waters and sky for cultural and economic purposes.

Contamination in NSW

A number of contaminants of concern in NSW have been subject to dedicated programs to remove them from the environment and prevent further contamination.

Petroleum

Underground petroleum storage systems (UPSS) are a common source of land and groundwater contamination in NSW. They exist in many places where fuel is used, with examples including petrol stations, marinas, work depots and airports. As they may leak, those who operate the UPSS must prevent, report and fix leaks where they occur.

Asbestos

Asbestos was a common building material and decorator product in homes from the mid-1940s to the mid-1980s, when it was discontinued (**Asbestos Awareness 2023**). It can still be found in one in three Australian homes and in commercial and non-residential structures (**NSW EPA 2022a**).

Most asbestos contamination results from poor site management practices during construction or demolition. Inhalation of asbestos fibres can lead to serious diseases over time, such as lung cancer and mesothelioma.

PFAS

PFAS (per- and poly-fluoroalkyl substances) are durable chemicals known for accumulating and staying in the environment for a long time (**Thapa et al. 2024**). It is a group of substances that include perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA) and perfluorohexane sulfonate (PFHxS).

Due to their fire retardant, waterproofing and stain resistant qualities, these chemicals were widely used in industrial products and some types of fire-fighting foams worldwide. PFAS can also be found in low concentrations in many consumer products like food packaging, non-stick cookware, fabric, furniture and carpet stain protection applications, clothing and shampoo.

As a result, people are exposed to small amounts of PFAS in everyday life. Products containing PFAS are being phased out around the world. Research into the effects of PFAS on organisms, such as potential multigenerational effects on aquatic wildlife, is ongoing. Work is also underway to understand and predict the behaviour of different PFAS in the environment.

Lead

Lead does not break down in the environment and past contamination can still affect us today.

Sources of lead contamination include paint from before the 1970s, the fallout from vehicle exhaust fumes before leaded petrol was banned in 2002, waste from mines and industrial sources in soil.

For example, lead has been mined in Broken Hill for many years and is present in the dust and soil, resulting in elevated blood lead levels in the community, particularly in children.

It is a naturally occurring metal and is still in use in a range of household, recreational and industrial products.

Exposure to lead is linked to harmful effects on organs and bodily functions. Elevated blood lead levels can cause anaemia, kidney disease and neurological or developmental harms.

Other contaminants of concern

There are many substances that are known to have caused contamination in NSW. These can all have various impacts on the environment, including animals and plants, soil, waterways and human health.

These include, but are not limited to:

- heavy metals, such as zinc (from galvanised iron and tyres) and chromium (from tanneries)
- polycyclic aromatic hydrocarbons, from coal tar
- perchloroethylene, from dry cleaning chemicals
- agricultural pesticides, from past and current agricultural practices.

See the **EPA website** for more information about contaminants.

Regulation of contaminated sites

In NSW, contaminated sites are regulated under the ***Contaminated Land Management Act 1997***. This regulation is carried out by various government agencies depending on the level of contamination.

'Significantly contaminated' sites are regulated by the NSW Environment Protection Authority (EPA) to ensure that the land is managed or remediated appropriately by the person responsible for the contamination. The responsible person could be the polluter, the landowner or another appropriate person.

To determine whether land is 'significantly contaminated', the EPA assesses:

- any harm caused or which could be caused by the contamination
- the toxicity, persistence, bioaccumulation and concentrations of the contaminants
- how humans or the environment could be exposed to the contamination

- whether the contamination has migrated or could migrate to other land.

Polluters or landowners must **report contamination to the EPA** where:

- the concentrations of contaminants exceed a set limit
- whether people have been, or could be, exposed to those contaminants
- whether the contamination has migrated, or could migrate, to neighbouring land.

Contaminated land that is not determined to be 'significantly contaminated' is managed by planning authorities, including local councils, through the land use planning and development process.

Planning authorities must consider whether the contamination will affect the suitability of a site if the land use changes.

In some instances, particularly when the land use has involved hazardous substances, the legacy may threaten humans or the environment, or it may affect the current or future use of the land. Not all contamination precludes future productive land uses (**NSW EPA 2015**).

Contaminated land is managed through a combination of legislation and policies at a state and federal level (see **Table P5.1**).

Table P5.1: Current key legislation and policies relevant to contaminated sites in NSW

Legislation or policy	Purpose
Contaminated Land Management Act 1997	Regulates the identification, management and remediation of significantly contaminated land in NSW.
Environmental Planning and Assessment Act 1979	Outlines provisions for creating environmental planning instruments, processing development applications, and issuing planning certificates for land. It also sets out the need for planning authorities to consider the ***Managing Land Contamination – Planning Guidelines.*** These guidelines provide advice to planning authorities on how contamination must be considered in rezoning and development applications.
Protection of the Environment Operations Act 1997	Provides legislation for the EPA and other public authorities to prevent, control and investigate pollution in NSW.
National Environment Protection (Assessment of Site Contamination) Measure 1999 (revised 2013)	Sets out the national risk assessment framework for the assessment of contaminated sites in NSW. It includes schedules which cover a range of subjects including human health and ecological investigation criteria, site characterisation, laboratory analysis, health risk assessment, ecological risk assessment and community engagement.
Guidelines for Fresh and Marine Water Quality, (Australian and New Zealand) 2018	Provides key guidelines for the assessment of environmental water quality in NSW, applicable to both marine and fresh waters.
State Environmental Planning Policy (Resilience and Hazards) 2021	Provides a statewide planning approach for the remediation of contaminated land where development is proposed. A planning authority must not consent to any development on land unless it has considered whether the land is contaminated, and if so, whether the land is suitable (or will be suitable, after remediation) for the purpose for which the development is proposed.
PFAS National Environmental Management Plan 2.0 (HEPA) 2020	Sets guidance and approaches to the management of PFAS contamination in Australia. It includes detailed sections on PFAS-contaminated site assessment, management, transport and remediation.

Notes:
The EPA website has a list of **statutory guidelines** and **non-statutory guidelines** for dealing with different types of contamination and additional guidance documents.

See the **Responses** section for more information about how **Contaminated sites** are managed in NSW.

Related topics: **Coastal and marine** | **Groundwater** | **Population and the environment** | **Rivers and wetlands** | **Soil condition** | **Waste and recycling**

Status and trends

Contaminated sites indicators

Two indicators are used to assess the state of contaminated sites in NSW:

- **Number of regulated contaminated sites** are those determined to be 'significantly contaminated' and requiring oversight by the EPA (see **Number of contaminated sites**).
- **Number of sites where the regulation has ended** are those assessed as being no longer significant enough to warrant regulation by the EPA (see **Remediation of contaminated sites** and **Regulation and assessment of sites**).

Both the number of regulated contaminated sites in NSW that required regulatory oversight by the EPA and the number of sites assessed as being no longer significant enough to warrant regulatory oversight remained moderate and stable in the 2023–23 period (see **Table P5.2**).

Table P5.2: Contaminated sites indicators

Indicator	Environmental status	Environmental trend	Information reliability
Number of regulated contaminated sites	MODERATE	Stable	Good
Number of sites where the regulation has ended*	MODERATE	Stable	Good

Notes:
*The EPA ends regulation on a site when there is evidence that the land contamination is no longer significant, for example because the site has been remediated or the contamination is appropriately managed so that it does not pose a risk to human or environmental health.

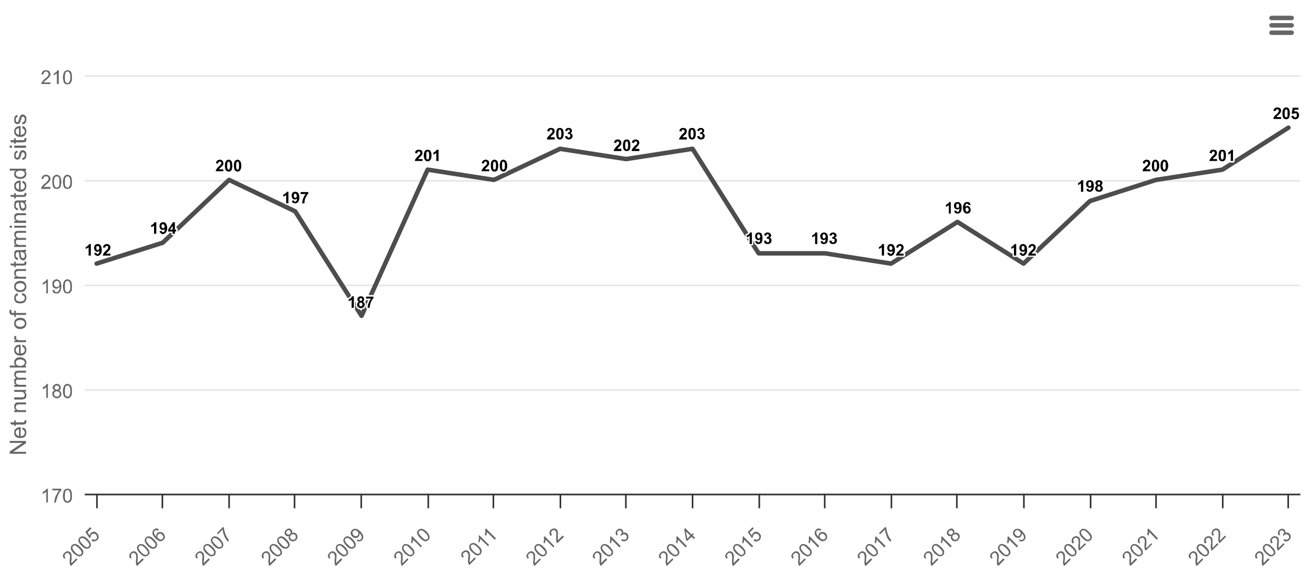
Indicator table scales:
- **Environmental status**: Good, moderate, poor, unknown
- **Environmental trend**: Getting better, stable, getting worse
- **Information reliability**: Good, reasonable, limited.

See **Indicator guide** to learn how terms and symbols are defined.

Number of contaminated sites

The net number of EPA-regulated contaminated sites remained stable at an average of 202 sites per year between 2021–23 (see **Figure P5.1**).

Figure P5.1: Net number of EPA-regulated contaminated sites in the period, 2005–23



Notes:
Regulation is managed by the EPA under the *Contaminated* Land *Management Act 1997*.
Calculated as cumulative total sites regulated minus cumulative total sites remediated.

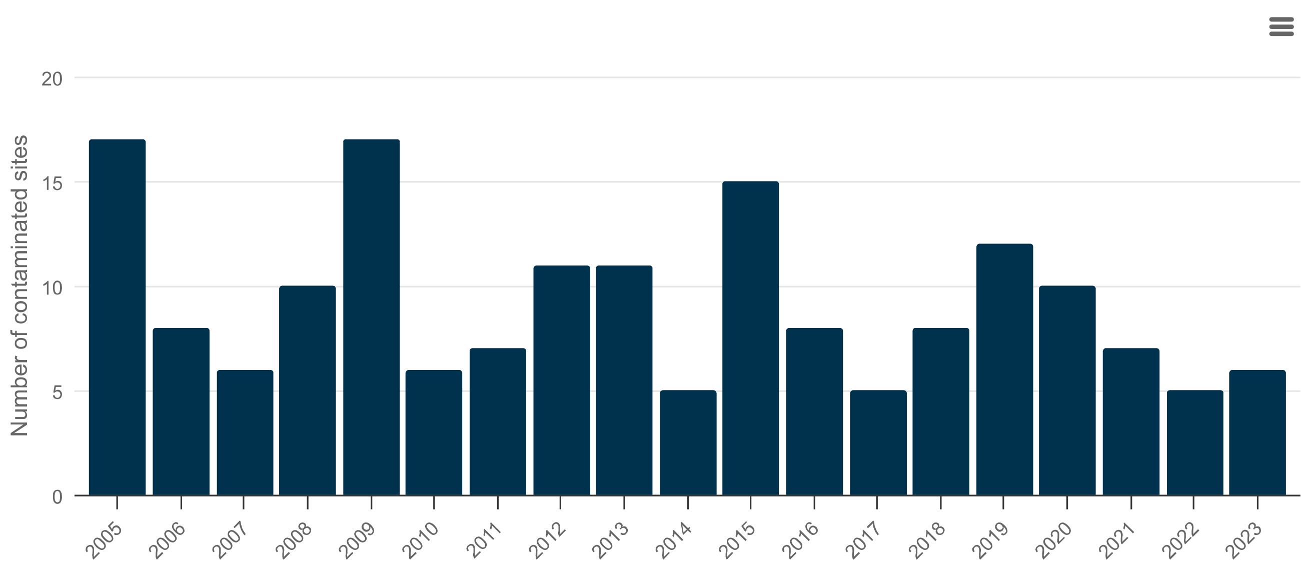
Source:
NSW EPA data 2024

Remediation of contaminated sites

The number of EPA-regulated contaminated sites where regulation has ended continues to fluctuate but remain mostly stable between 2021–23 (see **Figure P5.2**).

EPA regulation ends once a contaminated site has been remediated or the risks from contamination are being appropriately managed.

Figure P5.2: Contaminated sites where regulation was ended, 2005–23



Notes:
Regulation is managed by the EPA under the *Contaminated Land Management Act 1997*.

Source:
NSW EPA data 2024

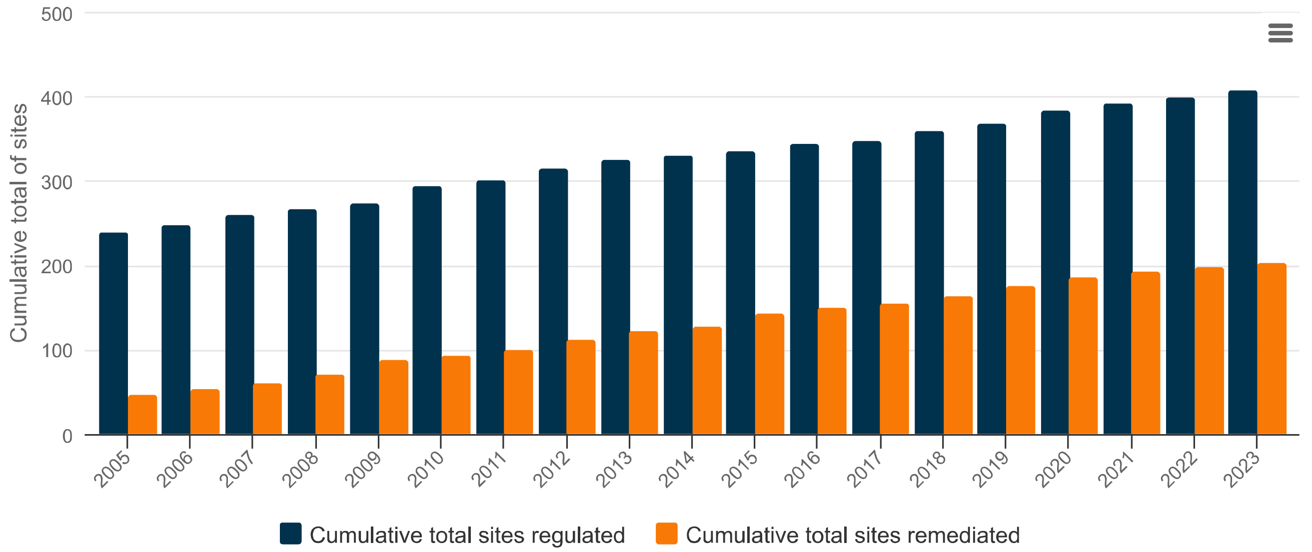
Regulation and assessment of sites

Between 2005 and the end of 2023, the EPA declared 408 sites to be significantly contaminated under the *Contaminated Land Management Act 1997*. The EPA has ended the regulation on 203 sites, for example, this may be because a site had been remediated or the contamination had been managed.

Figure P5.3 shows that both numbers of regulated sites and the number of sites where regulation has ended rose steadily between 2005 and the end of 2023.

- Between 2021–23, 133 new sites were reported. Of these, 25 were declared as significantly contaminated land by the EPA.
- In this same period, EPA regulation was ended at 18 sites.

Figure P5.3 Cumulative total of sites regulated and number of sites where regulation was ended, 2005–23



Notes:
Regulation is managed by the EPA under the *Contaminated Land Management Act 1997*.

Source:
NSW EPA data 2024

Regulated sites by contamination type

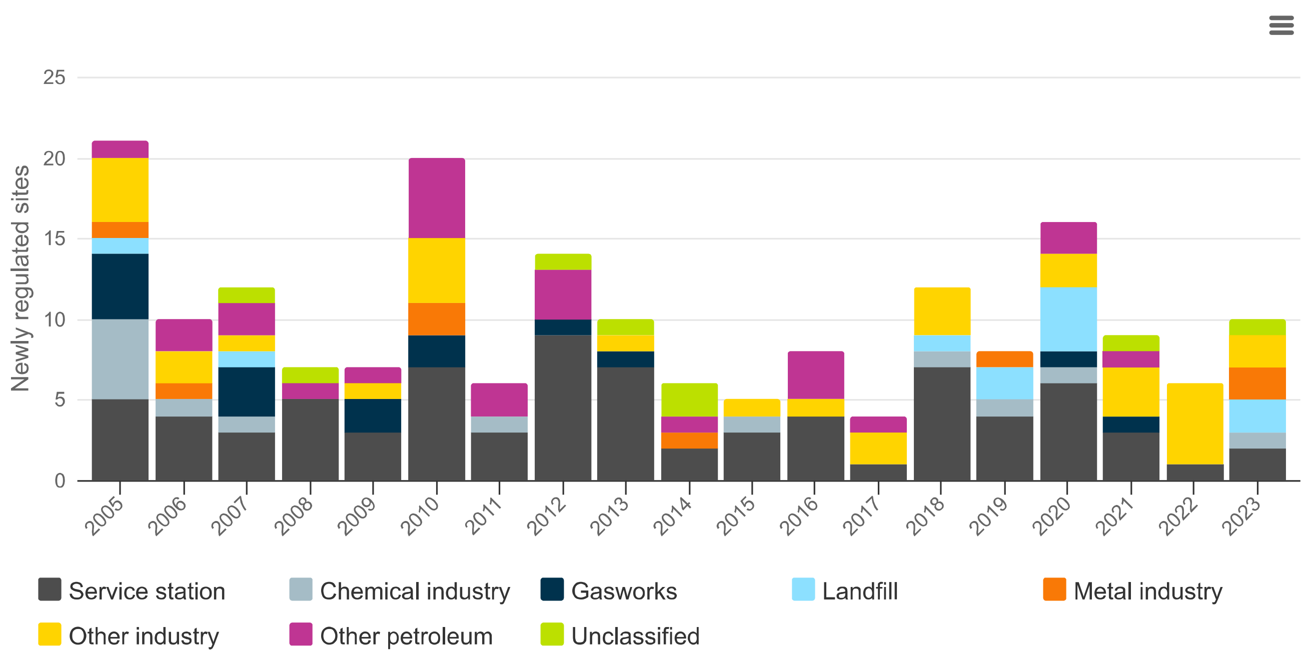
Land declared to be significantly contaminated between January 2021 and December 2023 was associated with:

- service stations (24%)
- landfills (8%)
- the metal industry (8%)
- gasworks (4%)
- the chemical industry (4%)
- other petroleum industries (such as fuel depots and terminals) (4%)
- other industry (includes transport depots, timber yards, mines, power stations) (40%)
- unclassified (such as contaminated fill, railway uses and commercial activities) (8%).

Since 2021, service stations and other petroleum industries have accounted for 28% of newly regulated sites, primarily in relation to underground petroleum storage systems.

Figure P5.4 shows fluctuations in the number and type of new sites regulated every year from 2005 to 2023. While service stations are the largest category throughout, the number of 'other industry' regulated sites increased in 2022.

Figure P5.4: Newly regulated sites by contamination type, 2005–23

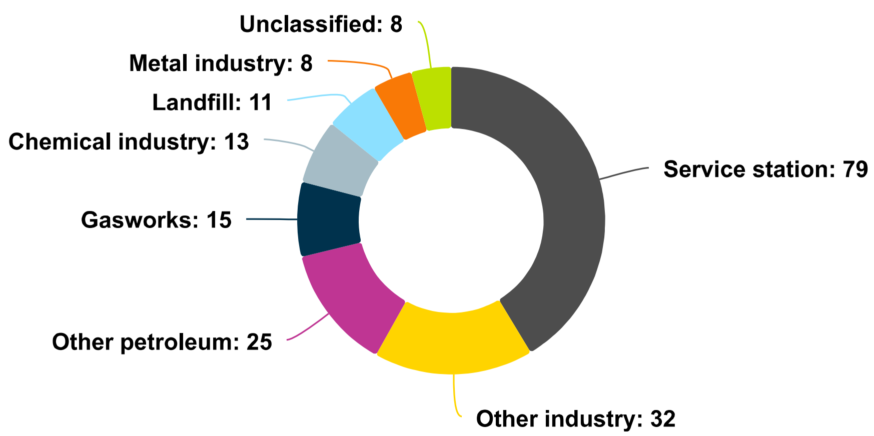


Notes:
Regulation is managed by the EPA under the *Contaminated Land Management Act 1997*.

Source:
NSW EPA data 2024

Since 2005, service stations have been the largest category of contamination type at 79% (see **Figure P5.5**).

Figure P5.5: Cumulative total of newly regulated sites by contamination type, 2005–23



Notes:
Regulation is managed by the EPA under the *Contaminated Land Management Act 1997*.

Source:
NSW EPA data 2024

Contamination affecting Aboriginal communities

Of particular concern is legacy contamination on lands returned to Aboriginal communities under the NSW ***Aboriginal Land Rights Act 1983*** or the Commonwealth ***Native Title Act 1993***.

The level and type of contamination on discrete Aboriginal community lands have not been properly documented and legacy contamination continues to be a major issue and concern.

A discrete Aboriginal community is typically a former Aboriginal reserve or mission where Aboriginal people were forced to live during the 1900s.

These homes, and the land they are on, were transferred from the NSW Government to Local Aboriginal Land Councils under the NSW *Aboriginal Land Rights Act 1983*. There are 61 of these communities across NSW where Aboriginal peoples still live today.

These communities experience high levels of legacy contamination, as they were often built on or next to landfills, mines and heavy industry. When the land was returned to Local Aboriginal Land Councils, it was generally handed back as is, including any legacy contamination.

A first-hand account highlights the impact of legacy contamination on current living conditions (see the **Voice of Country** topic's **Truth Telling** section for the full story):

> *'In my community's history, we were forced to live on the actual living rubbish tip.*
>
> *I'm only 43 years of age. I grew up with the rubbish being dumped in our backyards as kids, we didn't know any better and we played in that. There's medical waste. There's asbestos. There's development waste, industrial waste. Everything you could think of was just dumped in our places. None of that has been dealt with.'*
>
> ***Steven Ahoy, member EPA Aboriginal Peoples Knowledge Group 2024***

> A response to this **Truth Telling** can be found in **Truth Listening** within the **Responses** section of this topic.

Contamination issues due to illegal dumping, inadequate waste management services and the high prevalence of asbestos in houses also affect these communities.

Poor government housing practices in some Aboriginal communities resulted in the demolition of asbestos-containing buildings and the abandonment of waste materials on site.

Affordable housing options for Aboriginal communities are often located in high-risk areas. As a result, Aboriginal people are disproportionately affected by airborne industrial contamination. The lack of ongoing maintenance to the properties also exposes residents to contaminated air, water and soil.

This is the case in **Broken Hill**, where exposure to mining dust and flaking lead-based paint in homes has resulted in high rates of lead poisoning in residents (**LeadSmart NSW n.d.**).

Infants and children living in these homes are exposed to lead and are at risk of impaired brain and nervous system development. This can result in global developmental delay, behavioural and learning difficulties and intellectual disabilities.

Programs to reduce lead exposure by capping dust sources, educating communities and improving housing have significantly reduced lead levels since the early 1990s (**Lyle et al. 2021**).

Despite these programs, blood lead levels in children in Broken Hill are still among the highest in the developed world (**Ericson et al. 2021**). The risk of lead poisoning increases significantly for Aboriginal children.

In 2023, levels exceeded 5 micrograms per decilitre (the national limit) in 74% of Aboriginal children and 37% of non-Aboriginal children in Broken Hill aged one to four years (**NSW Ministry of Health 2024**).

Pressures and impacts

Population

As the population of NSW increases, our reliance on potentially polluting industries, such as mining, intensive agriculture and electricity generation, may increase. A potential by-product of these industries is the increase in harmful chemicals and pollutants entering the soil, water and air.

Hazardous chemical substances can cause serious to the environment and human health. Although exposure from many of these chemicals have dropped, exposure to some substances with unknown effects still remains.

As the State's population grows, the demand for housing increases, prompting redevelopment of contaminated, former industrial or agricultural land for residential use, particularly in major coastal cities, such as Sydney.

Planning authorities must consider whether contamination will compromise the suitability of a site for a proposed land use (**NSW EPA 2022b**).

See the **Population and the environment** topic for more information.

Impact on Aboriginal communities

Exposure to contamination through dust, waters, air or food causes serious harms to human health. In addition, contamination of Aboriginal lands, places, communities and culture significantly impacts connection with Country.

Contamination limits the options for Aboriginal peoples to continue cultural practices, such as hunting and gathering of food or medicine and sharing these traditions with their community. Contamination both removes access to Country and eliminates the option of a place of belonging or knowing, therefore eroding safe and healthy communities.

The presence of contamination can also impede or delay other government initiatives and investments aimed at assisting Aboriginal communities. For example, the **Roads to Home program** provides significant infrastructure, such as roads and lighting and opportunities to subdivide land. Asbestos is a significant barrier to this program, preventing government investment from achieving its purpose and blocking economic advantage for Aboriginal communities (**NACC n.d.**).

Remediation

Remediation of contaminated land is expensive, complex and involves a number of different stakeholders.

In NSW, the 'polluter pays' model requires the polluters to clean it up. Some polluters may lack the funds or may no longer exist as companies, which potentially passes the burden on to the owner of the land, or in rare cases the State or Local Government.

The demand and financial incentives for remediating contaminated land are not as available in more regional or rural areas, which can increase the challenges of cleaning-up sites in these communities.

The nature and extent of land contamination is often difficult to fully understand and manage. Given the large range of potential contaminants, many of which behave in different ways, there is no single way of investigating or cleaning up a contaminated site. Every site needs to be considered individually, considering the contamination and the site conditions.

Assessing the risk from contaminants relies on obtaining a lot of information about them, the site characteristics and how the contamination may affect human health and the environment. This complex work needs to be done by highly-qualified specialists.

Many different stakeholders can be involved in the management of contaminated land, including the site owners, neighbours, the community and regulators. This means contaminated land management must consider the views of many different people.

Waste disposal

Regulating unlawful disposal of waste is difficult and costly.

Over the last reporting period, unauthorised waste management and disposal practices have caused several problems to emerge. These can result in land pollution or contamination, increasing pressure on regulatory systems.

The use of materials that are non-compliant with the **NSW Resource Recovery Framework** (such as asbestos) in construction and other industries can also pollute or contaminate land.

See the **Waste and recycling** topic for more information.

Climate change

Climate change, driven primarily by human activities, such as burning fossil fuels, deforestation and industrial processes, is significantly altering Earth's climate patterns.

Scientists and regulators consider the impacts of climate change in their assessment and management of contaminated sites and the measures needed to adapt (**Morton 2016**).

Extreme climate and weather, such as extreme rainfall, can have many effects on contaminants (**Bolan et al. 2024**).

Extreme rainfall can transport pollutants and contaminants, such as sewage, chemicals and microplastics, into waterways, posing risks to wildlife and human health (**Bolan et al. 2024**).

These contaminants, which may have settled in soil and groundwater, can be disturbed and spread over larger areas during flooding, potentially contaminating new sites, including sources of drinking water and agricultural land.

Responses

Managing contaminated sites

In April 2024, the NSW Government amended eight Acts and three regulations under the ***Environment Protection Legislation Amendment (Stronger Regulation and Penalties) Act 2024***.

This strengthened regulatory requirements and penalties across environment protection legislation to present a strict deterrent for non-compliance. It enabled the EPA to issue preliminary investigation notices to determine whether substances pose potential risks to human health exist or have existed in a location.

This included an increase in the jurisdictional limit of local courts and maximum penalties for certain offences and simplified the process for setting policies. The amendments are summarised on the **EPA website**.

In October 2023, the NSW Government amended the ***Waste Recycling and Processing Corporation (Authorised Transaction) Act 2010***. Government agencies now have the option to transfer government-owned contaminated land managed by them to the Waste Assets Management Group or engage it to coordinate rehabilitation.

EPA Strategic Plan 2024–29

In its **Strategic Plan for 2024–29**, the EPA is focusing on stronger protection of the environment and community:

- from high-risk legacy contamination and emerging chemicals
- through providing planning development advice and regulating pollution from industry.

Addressing contamination issues on Aboriginal lands

NSW Crown Lands is aware of legacy contamination on Aboriginal lands returned to traditional owners under the NSW *Aboriginal Land Rights Act 1983*. A procedure established in 2016 is used to assess risks and consult with recipients. Crown Lands is developing policies and procedures to reduce the risk of contamination, in addition to pests, weeds and poorly maintained infrastructure, on lands returned to Aboriginal communities.

The EPA works closely with the NSW Asbestos Coordination Committee to safely manage asbestos in discrete Aboriginal communities and Aboriginal-owned housing, and to increase Aboriginal peoples' understanding of the risks, how to stay safe and whom to ask for help.

The EPA has been working with NSW Public Works since 2019 to remediate legacy asbestos contamination in communities identified in a **2017 Ombudsman's report**. During remediation, the EPA has offered free training in asbestos removal and temporary employment to help upskill and educate the community on asbestos.

Asbestos and other contaminants in housing remain significant issues in other Aboriginal communities.

The NSW Government is providing support to reduce lead exposure in Broken Hill by offering free blood lead screening, providing community education, reducing dust sources and improving housing.

The impact of contamination on the health of Country and the obligations of Aboriginal people to care for it was recognised in a 2023 compensation settlement between the Commonwealth and the Wreck Bay Aboriginal community in relation to PFAS (per- and polyfluoroalkyl substances) on their lands and in their waters (**FCA 2023**).

Truth Listening

Truth Telling, within **Voice of Country**, is a personal story from Steven Ahoy, Anaiwan man and a member of the EPA's **Aboriginal Peoples Knowledge Group** (APKG).

Truth Telling is a way to acknowledge the ongoing impact of past injustices through the contemporary experiences of Aboriginal peoples (**Payne & Norman 2024**).

Truth Listening is implicit to this process. It requires us to accept discomfort and be open to complexity and uncertainty. It helps ensure truths are heard, which is essential for those who have suffered to feel recognised or respected.

The EPA is committed to Truth Listening. The goal of Truth Listening in the *State of the Environment 2024* is to help drive positive change for Aboriginal peoples and for the environment.

Consistent with the its **Statement of Commitment to Aboriginal peoples**, the EPA is committed to actively learn from, and listen to, Aboriginal voices, cultures and knowledge. Part of this learning and listening includes welcoming Truth Telling and engaging in the practice of Truth Listening.

For information about the EPA's investigation into the environmental issues raised in this Truth Telling story, visit the **EPA website**.

Voice of Country

The welcoming of Truth Listening in the *State of the Environment 2024* also aligns with the invitation offered in the Voice of Country being to *ngarragi* – 'to listen, learn and remember'. See the **Voice of Country** theme for more information.

NSW site auditor scheme

In 2022, the EPA accredited six new auditors for the **NSW site auditor scheme**, bringing the total to 51 across NSW.

Auditors in this scheme review investigation, remediation and validation work done by contaminated land consultants, increasing the certainty that contamination assessments and remediation have been completed to the right standard.

The scheme is important in assisting planning authorities in their decision-making. For example, where land is being redeveloped for a more sensitive land use, such as housing, auditors can help consent authorities feel confident the land is suitable for that use.

The scheme is administered by the EPA under Part 4 of the ***Contaminated Land Management Act 1997***.

Investigation of PFAS (per- and poly-fluoroalkyl substances)

In 2022, a new law was introduced through the **Protection of the Environment Operations (General) Regulation 2022**.

This law bans and restricts the use of PFAS firefighting foam in NSW, reducing its impact on the environment while still allowing its use for preventing or fighting catastrophic fires by authorised agencies (**NSW EPA 2023a**).

See the **NSW Government PFAS Investigation Program** website for more information.

The **EnHeath guidance statement on PFAS** provides updated PFAS health guidance in light of recently completed research into the human health effects of PFAS and exposure in Australia.

In 2024, the Australian Department of Climate Change, Energy, the Environment and Water released the **draft PFAS National Environmental Management Plan (NEMP) version 3.0**.

This draft contains new guidance and standards for investigating, assessing and managing PFAS waste and contamination. It will be released in early 2025.

See the **Australian Government PFAS Taskforce** website for more information about the whole-of-government coordination and oversight of Australian Government responses to PFAS contamination.

The National Health and Medical Research Council is currently working with the Australian Government Department of Health, Food Standards Australia New Zealand, EnHealth and NSW Health to review the **Australian Drinking Water Guidelines**.

Under the ***NSW Public Health Act 2010***, NSW Health is the regulator of drinking water and monitors water suppliers' compliance with the Australian Drinking Water Guidelines. The guidelines, developed by the National Health Medical Research Council include health-based guideline values for PFAS in drinking water and are currently being **reviewed**.

WaterNSW is responsible for many of the State's drinking water dams. While drinking water guidelines do not apply to raw, untreated water, WaterNSW can undertake investigations where PFAS are found in the drinking water catchments of the dams.

Water utilities, such as Sydney Water and Hunter Water, are responsible for the drinking water from the tap. If a risk from PFAS is identified to treated drinking water, the water utility will monitor and manage any risks.

Managing asbestos contamination

Legacy fill sites

Since 2017, under the **James Hardie Program**, the EPA has reviewed and assessed 50 sites in NSW where asbestos waste was historically used to fill land. These sites, mainly in Western Sydney, have residential, business, industrial or open space uses. Of the 50 sites, 29 had already been significantly remediated, redeveloped or capped. It is possible that additional sites remain to be found.

At various sites, asbestos management plans have been implemented to protect residents, workers and the public. These plans provide guidance on maintaining grass cover, minimising dust generation and managing asbestos-containing materials safely.

NSW Asbestos Coordination Committee

The committee was formed in 2020. Its longer-term agenda is set out in ***Asbestos in NSW: Next Horizon***. It identifies priorities over the next five years that will be driven by Australian, State and Local Governments on the committee, as well as Aboriginal land councils.

The committee focuses on three immediate priority areas:

- keeping people safe through awareness and training
- dealing with legacy asbestos in discrete Aboriginal communities
- improving asbestos waste disposal and disaster waste management.

Asbestos in Aboriginal community-owned housing will continue to be a focus for the medium-term.

Managing lead contamination

The NSW Government is undertaking a range of actions and programs to support the management of historical lead contamination.

Broken Hill Environmental Lead Program

The NSW Government continues to work on addressing community concerns surrounding lead and high blood lead levels, especially in children.

This educational, environmental and health **campaign** is designed to help the population of Broken Hill to manage exposure to lead and to support the identification and prevention of potential lead-related health risks.

It aims to undertake annual blood lead level screening of all resident children aged under five years. A blood lead level equal to or above 5 micrograms per decilitre (µg/dL) is a notifiable condition in NSW.

Its **LeadSmart** community awareness and education program is designed to manage the risks of lead in pregnancy, hygiene, diet and lifestyle. LeadSmart saw a 10% increase in participation rates in blood lead testing of children from 2015 to 2019 (**LeadSmart NSW 2021**).

More information can be found under the **Contamination affecting Aboriginal communities** section.

Captains Flat Soil Sampling Program

In February 2020, elevated levels of lead were discovered near the legacy Lake George Mine at Captains Flat, a small former mining town south-east of Queanbeyan (**NSW EPA 2023b**).

In November 2023, the NSW Government began remediation work on the site. The EPA collected samples on public and private land, provided advice on remediation strategies, and helped in developing a lead management plan for the area. Soil samples from 80 locations on public land and 65 homes have so far been tested.

In 2022, the program published a Lead Management Plan for Captains Flat. The remediation project will involve management of the mine and eventually will see the revegetation of the site by mid-2026 (**NSW EPA 2021**).

See the **Captains Flat Contamination** webpage for more information.

Lead management in North Lake Macquarie

In 2013, investigations found lead oxide fallout from the Pasminco smelter on North Lake Macquarie had affected surface soils in Boolaroo, Argenton and Speers Point. Black slag was also found, containing high levels of leachable heavy metals, being used as fill material (**NSW EPA 2024c**).

The Lead Abatement Strategy was developed to minimise exposure to contaminated soil on residential properties. Soil lead levels were tested and abatement works were conducted to ensure an effective physical barrier between residents and contaminated soil.

Work continues with the strategy, and is a collaboration between EPA and Lake Macquarie City Council and other agencies.

See the **Lead soil disposal for Lake Macquarie residents** website for more information.

Recent government remediation

The projects below provide examples of sites that have been or are in the process of being remediated or managed by the NSW Government.

Underground petroleum storage systems in groundwater-dependent communities

Since 2022, from a dataset containing 7,559 potential underground petroleum storage system sites in NSW, the EPA has identified 16 sites in groundwater-dependent communities as priorities for further investigation.

The EPA has investigated these sites (in collaboration with the local council), with site inspections and sampling (where possible) at 10 sites.

Groundwater contamination was found at two sites, which are being managed by the local council with assistance from the EPA.

Old Radium Hill Refinery, Hunters Hill – site remediation

The contamination stems from a radium processing plant and a carbolic acid plant that operated in the late 1800s through to the early 1900s. Elevated concentrations of coal tar waste material and heavy metals were present at the site.

The site was approved for remediation in 2021. The **Hunters hill site remediation** was completed 2024, allowing the site to be used for housing.

Waratah Gasworks, Newcastle – site remediation

Substances associated with former gasworks sites typically include tars, oils, hydrocarbon sludges, spent oxides (including complex cyanides), ash and ammoniacal recovery wastes.

In 2021, the EPA declared the site at the former **Waratah Gasworks** (1889–1926) as significantly contaminated and ordered a clean-up of the site.

Under the Property and Development NSW (PDNSW) and Waste Assets Management Corporation (WAMC)'s action plan, remediation work to demolish, excavate and remove tar pits and a gasholder began in September 2023 and is expected to finish by September 2025.

Truegain, Rutherford – site remediation

After the EPA suspended **Truegain's** environment protection licence in 2016 and the company entered liquidation, PDNSW and WAMC took over responsibility for remediating the contaminated Truegain waste oil processing site in Rutherford.

They have focused on soil and groundwater clean-up, including removing above-ground liquid infrastructure and treating 11,000 tonnes of industrial wastewater and 135 steel tanks.

They are now planning for soil remediation to prevent contaminants from spreading (**PDNSW n.d.**).

Pasminco, Cockle Creek, Boolaroo – land management

Pasminco Cockle Creek Smelter Pty Ltd operated a lead and zinc smelter in Boolaroo for more than a hundred years, causing significant soil contamination.

Following the smelter's closure in 2003, the NSW Government assumed ownership and management of the site to ensure community and environmental safety.

The ***Lake Macquarie Smelter Site (Perpetual Care of Land) Act 2019*** facilitated the transfer of the site to the Hunter Central Coast Development Corporation, with PDNSW now responsible for managing containment cells to protect residents and the environment.

Bare Creek Bike Park, Belrose – site remediation and management

The WAMC has remediated a former landfill in Belrose, Sydney, transforming it into public open space with a **new bike park**.

This project shows how government-owned land can be repurposed for community benefit. Working closely with the local council and residents, WAMC designed, built and manages the site.

The waste mass continues to generate gas and contaminated liquid, which are safely managed by WAMC.

Ampol Newcastle terminal – regulation of significant contamination

The former fuel terminal in Wickham operated for more than 70 years. The site is surrounded by light industry and commercial properties, with homes nearby.

In 2016 and 2019, the EPA declared the terminal and a portion of the adjacent land as significantly contaminated under the ***Contaminated Land Management Act 1997***. Contamination is known to have spread beneath other properties.

The first stage of the clean-up is nearing completion.

Investigations are progressing to determine whether more clean-up work is needed, with a site plan including assessment, monitoring, remediation and keeping the community informed.

Future opportunities

Improving asbestos management

There is a need for more consistent standards in the management of asbestos contamination.

One area, for example, is the overlap between the contaminated land and waste regulatory frameworks. This inconsistency can complicate on-site reuse of asbestos-contaminated soil (**OCSE 2024**).

The Office of the NSW Chief Scientist and Engineer is doing **an independent review** and advising on the management of asbestos contaminants in waste and recovered materials in NSW.

This work is a continuation on improving the EPA's **Resource Recovery Framework**. The framework facilitates the recovery of resources in NSW, by keeping materials circulating in the economy.

The advice, expected in late 2024, will inform how the existing approach could be refined and improved.

It is an important step in ensuring better asbestos management outcomes for both human health and the environment.

Treatment and disposal of harmful substances

There is an ongoing challenge in the treatment and disposal of legacy contaminants. There are varying treatment standards for contaminants across jurisdictions.

HEPA (the Heads of EPA Australia and New Zealand) is an informal alliance of environmental regulation leaders from Australia and New Zealand. The EPA represents NSW in this alliance.

This collaboration seeks to establish better methods for handling harmful substances and implementing best practices for managing new, potentially harmful chemicals.

Work on this has begun through the harmful substances focus area of the **HEPA Strategic Plan 2022–25**, which aims to reduce environmental and human health impacts from legacy contaminants. It will do this through improved treatment and disposal options and environmentally sound management of emerging harmful substances.

For example, all Australian governments are working to implement the **Industrial Chemicals Environmental Management Standard** (IChEMS).

Released in March 2022 following agreement by all Australian environment ministers, Australia's **industrial chemicals roadmap** guides the regulation and management of industrial chemicals.

In NSW, the IChEMS Register is implemented by the EPA under the ***Protection of the Environment Operations Act 1997***.

Certain PFAS chemicals have been added to the IChEMS register and will be prohibited from import, manufacture and export from 1 July 2025.

Future updates to IChEMS will continue to address regulatory gaps as new chemicals are identified.

References

Asbestos Awareness 2023, Asbestos 101, Asbestos Awareness, accessed 05 July 2024

Bolan S, Padhye LP, Jasemizad T, Govarthanan M, Karmegam N, Wijesekara H, Amarasiri D, Hou D, Zhou P, Biswal BK, Balasubramanian R, Wang H, Siddique KHM, Rinklebe J, Kirkham MB & Bolan N 2024, 'Impacts of climate change on the fate of contaminants through extreme weather events', *Science of The Total Environment*, vol. 909, 168388

DPHI 2022, State Environmental Planning Policy (Resilience and Hazards) 2021, NSW Department of Planning, Housing and Infrastructure, accessed 05 July 2024

Ericson B, Hu H, Nash E, Ferraro G, Sinitsky J & Taylor M 2021, 'Blood lead levels in low-income and middle-income countries: a systematic review', *The Lancet Planetary Health*, vol. 5, no. 3, pp. e145–53

FCA 2023, *Notice as to the Wreck Bay PFAS land contamination class action*, Federal Court of Australia (PDF 0.55MB)

LeadSmart NSW 2021, *Broken Hill Environmental Lead Program – Annual Report (2019–2020)*, NSW Government, Sydney

LeadSmart NSW n.d., Learn about avoiding lead in Broken Hill, NSW Lead Smart Broken Hill, accessed 08 July 2024

Lyle DM, Boreland FT & Quartermain SJ 2021, 'Blood lead levels among Broken Hill children born 2009–2015: a longitudinal study to inform prevention strategies', *Public Health Research Practice*, vol. 32, no. 1, e31122107

Morton D 2016, *Climate change impacts on contaminated land in the coastal zone*, CoastAdapt Impact Sheet 10, National Climate Change Adaptation Research Facility, Gold Coast

NACC n.d., Asbestos in discrete Aboriginal communities, NSW Asbestos Coordination Committee, accessed 21 May 2024

NSW EPA 2021, *Captains Flat surface soil testing report*, NSW Environment Protection Authority, Sydney

NSW EPA 2022a, Legacy asbestos fill sites in NSW, NSW Environment Protection Authority, accessed 5 July 2024

NSW EPA 2022b, Role of planning authorities, NSW Environment Protection Authority, accessed 5 July 2024

NSW EPA 2023a, Regulation of PFAS firefighting foams, NSW Environment Protection Authority, accessed 5 July 2024

NSW EPA 2023b, Important Captains Flat community notice, NSW Environment Protection Authority, accessed 5 July 2024

NSW EPA 2024a, Act summaries, NSW Environment Protection Authority, accessed 5 July 2024

NSW EPA 2024b, *Guideline for Authorised Officers and Enforcement Officers under the Protection of the Environment Operations Act 1997*, NSW Environment Protection Authority, Sydney

NSW EPA 2024c, Lead soil disposal for Lake Macquarie residents, NSW Environment Protection Authority, accessed 5 July 2024

NSW Ministry of Health 2024, *Lead Program Annual Report 2023: Broken Hill children less than 5 years old*, WNSW LHD Public Health Unit, Health Protection, Dubbo

OCSE 2024, *Management of asbestos in recovered fines and recovered materials for beneficial reuse in NSW – Discussion Paper*, NSW Office of the Chief Scientist & Engineer, Sydney

Payne AM & Norman H 2024, *Coming to terms with the past? Identifying barriers and enablers to truth-telling and strategies to promote historical acceptance*, Indigenous Land and Justice Research Group, School of Humanities & Languages, UNSW Sydney

PDNSW n.d., Waratah Gasworks site remediation, Property and Development NSW, accessed 05 July 2024

Thapa BS, Pandit S, Mishra RK, Joshi S, Idris AM & Tusher TR 2024, 'Emergence of per- and poly-fluoroalkyl substances (PFAS) and advances in the remediation strategies', *Science of The Total Environment*, vol. 916, 170142

This page intentionally
left blank

Drivers

soe.epa.nsw.gov.au

This page intentionally left blank

Drivers

Increases in population and economic activity are driving significant changes in the environment and human health. Planning for sustainable growth can help to alleviate these impacts.

The topics in this theme describe how **population and the environment** and **economic activity and the environment** drive impacts on the environment and human health.

Population and the environment

Our population's increasing demands on resources and high levels of waste place increasing strain on nature's ability to support us.

Economic activity and the environment

Our economy depends on natural resources for food, water, air, minerals and for the disposal of waste. Valuing nature will help us to consider the environment in decision-making.

The State's population is expected to reach

10.1 million

people by 2041

More than

80%

of the NSW economy is services-based

Population and the environment

Our current use of the natural resources we rely on, including food, water, shelter and medicine, is putting significant strain on nature's ability to support us. This impact will increase as our population continues to grow.

Many issues facing the environment are caused or exacerbated by post-colonial human activities. Resource extraction and use, infrastructure increase, and waste generation all contribute to environmental impacts.

The impacts include land, water and air pollution; damaged ecosystems; threats to plant and animal species; and climate change.

They affect our ability to produce food and access safe drinking water.

Climate change is increasing the likelihood of extreme climate and weather events and is threatening ecosystem collapse in some areas.

Key findings from the 2024 report

- By June 2023, of the 8.34 million people living in NSW, 5.1 million (61%) Greater Sydney, 1.9 million (23%) in coastal areas and 1.3 million (16%) inland.
- By 2041, the NSW population is expected to grow to 10.1 million people. Greater Sydney's population is forecast to reach about 6.3 million.
- Population growth is decoupling (separating) from some key environmental trends. While population is growing, energy use and greenhouse gas emissions are declining.
- Waste generation is outpacing population increase. Total waste generation rose from 18.7 million tonnes in 2015–16 to 22.4 million tonnes in 2022–23.

Economic activity and the environment

All the elements have Lore, cultural Lore, right LORE.

Our trading practices included the exchange of cultural knowledge, various items and plant life. The seeds for trade would be wrapped up in a clay ball, which is how they're usually carried. So, you were carrying around five or seven clay balls, and inside those five or seven clay balls there could be anywhere between 10 to 15 to 50 different seeds in that ball.

If seeds were traded with other people, an explanation was given to how and when to plant and water.

As our population grows, so too does our economy, including producing, consuming and exchanging goods and services. Our economy depends on natural resources to convert into products, to dispose of waste and to supply critical life-support services like food, water, air and wellbeing.

Environmental impacts vary depending on the nature of the economic activity and are influenced by policy settings and regulatory frameworks, industry, whether an economy uses domestic or imported resources and whether the goods and services produced are consumed locally or exported.

Decoupling economic growth from potential environmental impacts is important in creating a sustainable future. It will allow for a continued improvement in quality of life for our communities without placing the environment at risk.

Valuing nature as an asset (natural capital) is becoming more important for the continued protection of the environment. Natural capital accounting is a new economic tool that can help governments include environmental considerations in decision-making.

Current economic approaches that aim to address environmental considerations include cost-benefit analysis, taxes and offsets.

Key findings from the 2024 report

- Since 1990, the NSW economy has grown on average by 2.4% a year (measured by gross state product).
- Economic growth is decoupling (separating) from some key environmental trends. Gross state product is growing, while energy consumption and greenhouse gas emissions are declining.
- Recent shifts towards natural capital accounting provide opportunities to reduce environmental impacts of economic development.
- Global reporting requirements (such as nature-related financial disclosures) may provide opportunities for more comprehensive reporting on biodiversity impacts.

This page intentionally
left blank

Population and the environment

Population change and human behaviour are major drivers of environmental change and have widespread impacts.

Overview

The State's population is expected to reach

10.1 million

people by 2041

Read more

The NSW population grew by

387,000

people from 2018 to 2023

Read more

The human population of earth has been increasing exponentially since the late 1800s and now exceeds 8 billion people (**UN 2023**).

Humans have always relied on the natural resources that our environment provides, including food, water, shelter and medicines. Our interactions with the environment continue to shape our cultures and societies. With current patterns of resource use and environmental modification, our increasing population puts significant strain on nature's ability to support us.

Considering trends and changes in human populations is an important aspect in examining environmental conditions and trends, because many issues facing the environment are caused or exacerbated by human actions (**Dovers & Butler 2015**; **UN 2023**).

Since the Industrial Revolution of the late 1700s, there has been continued improvement in our ability to acquire and process environmental resources, as well as an acceleration in our rates of resource use. These have allowed us to substantially improve human health and living conditions, which in turn has led to the increase in the global population.

The relationship between populations and environmental damage is complex. Population growth alone is not the most important factor: human behaviour also plays a part (**Bongaarts 2023**), as do demographic trends, such as population density (**Dovers & Butler 2015**). The types of technology and infrastructure used to convert resources and energy to the goods and services that humans consume are also important (**UNEP 2014**).

In wealthy countries such as Australia, the standard of living has also increased significantly, especially since the Second World War. Technological innovations over this period have made it possible to use resources such as energy, water and minerals much more efficiently, which can help offset the potential impacts of population growth. However, these benefits are undermined if the consumption of resources and generation of waste products and emissions continue to outpace what nature can safely provide (**Dovers & Butler 2015**). See the **Economic activity and the environment** topic for more information.

Significant environmental issues of our time, such as climate change, land, air and water pollution, habitat degradation and fragmentation, and species extinction rates, are tied to increasing demands on resources, energy and land, and the associated pollution and waste. These impacts are getting worse, and some ecosystems are now at risk of collapse (**Ripple et al. 2017**; **Williams & Taylor 2021**).

These impacts on environmental health can have serious consequences for human health and wellbeing. For example, extreme heat events are increasing with climate change and the removal of trees and urban development are amplifying them. This is likely to cause health problems for people exposed to them. See **Extreme climate and weather** and **Transport** topics for more information.

Other threats related to increasing environmental degradation include impacts on food production, reduced access to drinkable water, and increased exposure to illness caused by pollution and diseases related to destruction of habitat (**Williams & Taylor 2021**).

> **Related topics**: **Economic activity and the environment** | **Energy consumption** | **Waste and recycling** | **Water use**

NSW population trends

There were 8.3 million people living in NSW as at June 2023 (**ABS 2023b**). Of these:

- 5.1 million (61%) lived in Greater Sydney
- 1.9 million (23%) lived in coastal areas
- 1.3 million (16%) lived inland.

Over the five-year period from June 2018 to June 2023, the State's population grew by more than 387,000 people (**ABS 2023b**).

The key trends in the growth and distribution of the NSW population include:

- movement of young people from rural areas to cities, or interstate, for education and employment
- an ageing population – 17.5% of the NSW population is currently 65 years or older, and this group will get larger (**ABS 2023a**)
- movement of retirees ('tree changers' and 'sea changers') to popular areas on the coast, along the Murray River and to locations within easy driving distance of cities
- movement of young families to regional areas
- predominance of young adults immigrating from overseas, especially temporarily.

Overall, these trends have led to growth in our cities and large towns. This growth is accompanied by a high demand for housing, consumer products and transport services, putting continued pressure on our environment.

In regional areas especially, the environmental impacts of these trends include land clearing or repurposing for housing and infrastructure, increased use of local resources such as water, and increased waste and emissions.

Understanding how the NSW population is changing is critical to planning processes for:

- managing the impacts of population growth on the environment and biodiversity
- reducing resource and energy use associated with population growth
- reducing pollution, waste and emissions
- enhanced liveability
- sustainable land use.

Two major factors governing population change in NSW are:

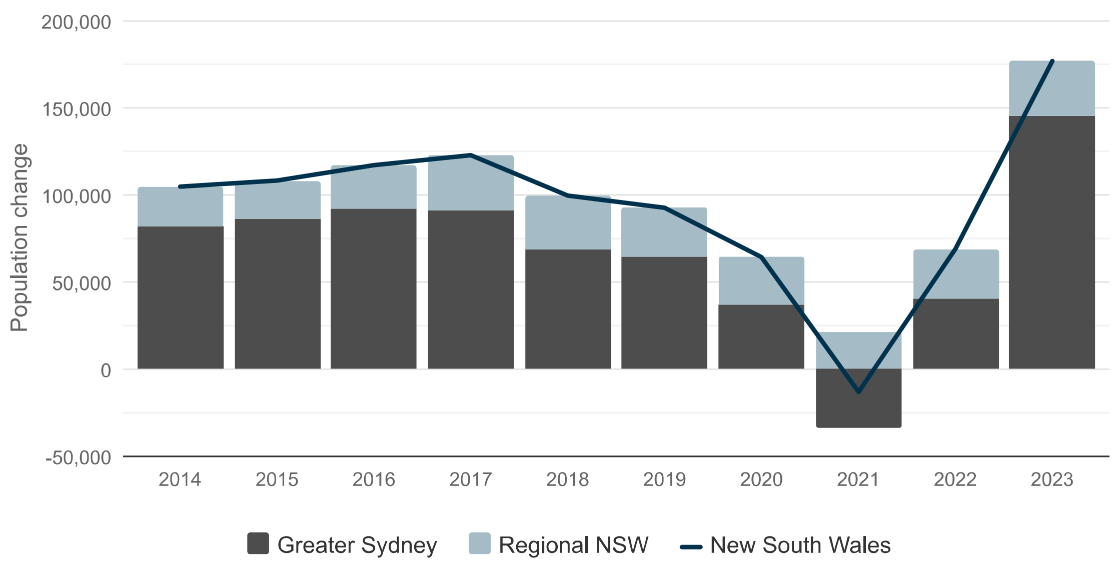
- natural change – the difference between births and deaths, which can be positive or negative
- migration – both within Australia and from overseas.

Over the past 40 years, net overseas migration has been the most significant contributor to population growth in NSW, while the rate of natural change has remained relatively stable.

Figure D1.1 shows that the population growth rate in NSW was slowing before the COVID-19 pandemic but has since rebounded. As international travel restrictions were eased in early 2022, the rise in overseas arrivals contributed to record growth of 2.1% in 2023, the fastest annual growth rate since 1981 (**DPE 2023**).

Regional NSW is home to a relatively small share of overseas immigrants. Population growth in regional areas is more likely related to the migration of city residents to rural areas.

Figure D1.1: Population change in NSW, Greater Sydney and regional NSW, 2014–23



Notes:
Greater Sydney extends from Hawkesbury River in the north to the Royal National Park in the south and includes the Blue Mountains, Wollondilly and Hawkesbury local government areas in the west. The historic results have been updated to reflect the definition of Greater Sydney as not including the Central Coast.

Figures up to 2021 are final. Figures for 2022 and 2023 are preliminary and subject to change.

Source:
ABS Data Explorer, calculations by DPHI

Population density

Population density is measured as the number of people per square kilometre. Increasing density is related to an increase in population size combined with increasing urbanisation.

Population density in NSW has risen. In June 2023, there were an average of 10.4 people per square kilometre – a 12% rise in the 10 years since 2013.

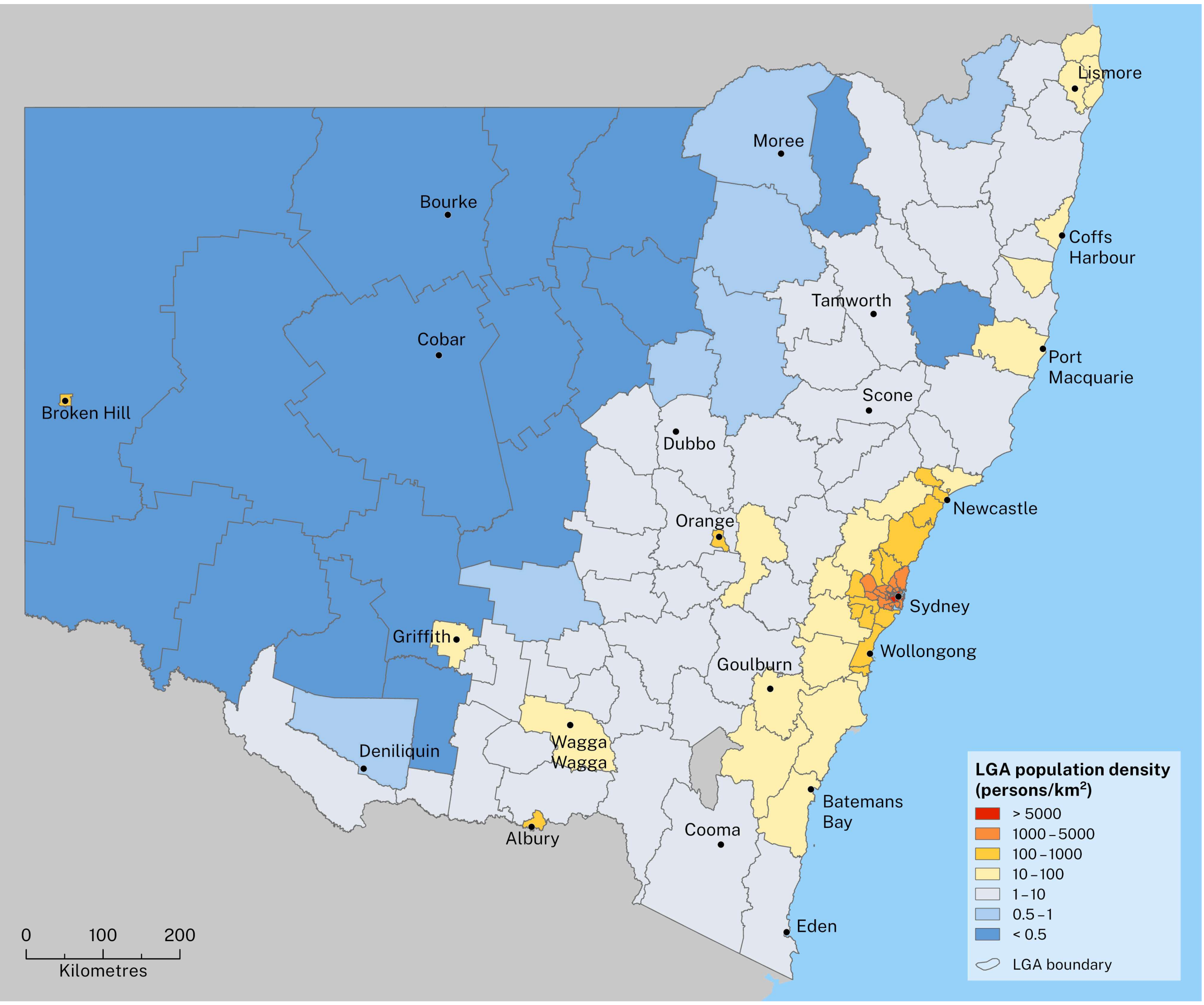
These changes in density are due to increased medium- and higher-density housing developments across Greater Sydney and regional cities on vacant or under-used land, often replacing low-rise buildings. Greenfield areas on the urban fringes are also being transformed, from large rural lots to detached and semi-detached houses on smaller lots and low- and mid-rise apartment developments (**DPHI 2024**).

Across Greater Sydney, the average population density grew by 17% during 2013–2023, reaching 488 people per square kilometre in 2023 – about 70 people per square kilometre more than 10 years earlier.

Map D1.1 shows that population density is highest in Greater Sydney. Densities range from fewer than one person per square kilometre in the Far West region of NSW to more than 17,000 people per square kilometre in the inner-city suburbs of Haymarket, Chippendale, Wolli Creek and Zetland.

There is also a large variation in population density within Sydney, which has as few as 50 people per square kilometre in some areas.

Map D1.1: Population density of NSW, 2023



Source:
ABS 2023c

Outside of Sydney, higher population densities are found in parts of Newcastle, Shellharbour, Lake Macquarie, Wollongong, Albury and Orange.

Differences in population density around the State have implications for the provision and sustainability of services and infrastructure. Policies that aim to improve connectivity, such as **transport-oriented development**, can increase the trend towards high-density housing.

In areas with more people, medium- and high-density housing can increase the efficiency of service delivery and reduce the per person use of energy, water, waste removal services and demand for land (**Lehmann 2016**).

Cities and urban areas that have higher density and good public transport have lower transport energy use per capita (**Rickwood et al. 2008**) and lower car ownership and use. These characteristics can provide overall benefits in urban amenity. Increasing urban density can also free up land for open space.

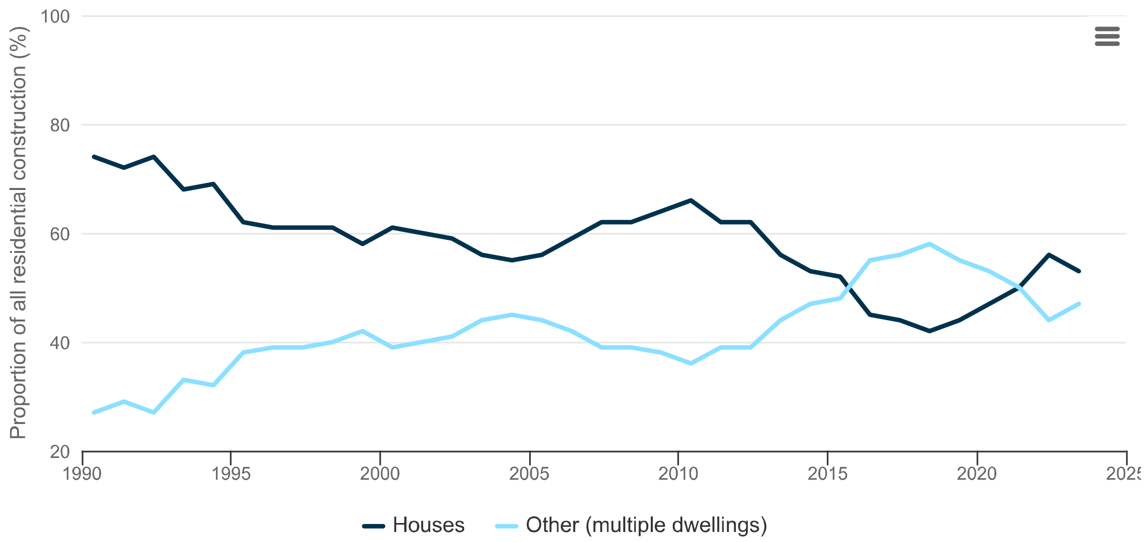
In the absence of careful land use planning, high-density populations can put more pressure on the local environment and increase noise pollution and traffic congestion (**Lehmann 2016**; **Bibri et al. 2020**). People living in high-density areas may be more exposed to air pollution and urban heat (**Borck & Schrauth 2021**; **Nieuwenhuijsen 2021**).

These problems can be offset by providing more green space, improving public transport, urban design that encourages walking and cycling, and electrification of transport.

Tracking investment in housing shows that single dwellings constructed in NSW fell from 74% of private dwellings in 1990–91 to 53% in 2022–23. Multiple-dwelling (apartment) construction peaked in 2017–18 at 58% (**Figure D1.2**).

A continued focus on redevelopment of land for medium-density housing means a likely fall in the share of single dwellings in the future, which will reduce biodiversity impacts but may increase the amount of waste generated by demolishing existing dwellings.

Figure D1.2: Percentage of single and multiple dwellings



Notes:
The annual value of private residential construction.

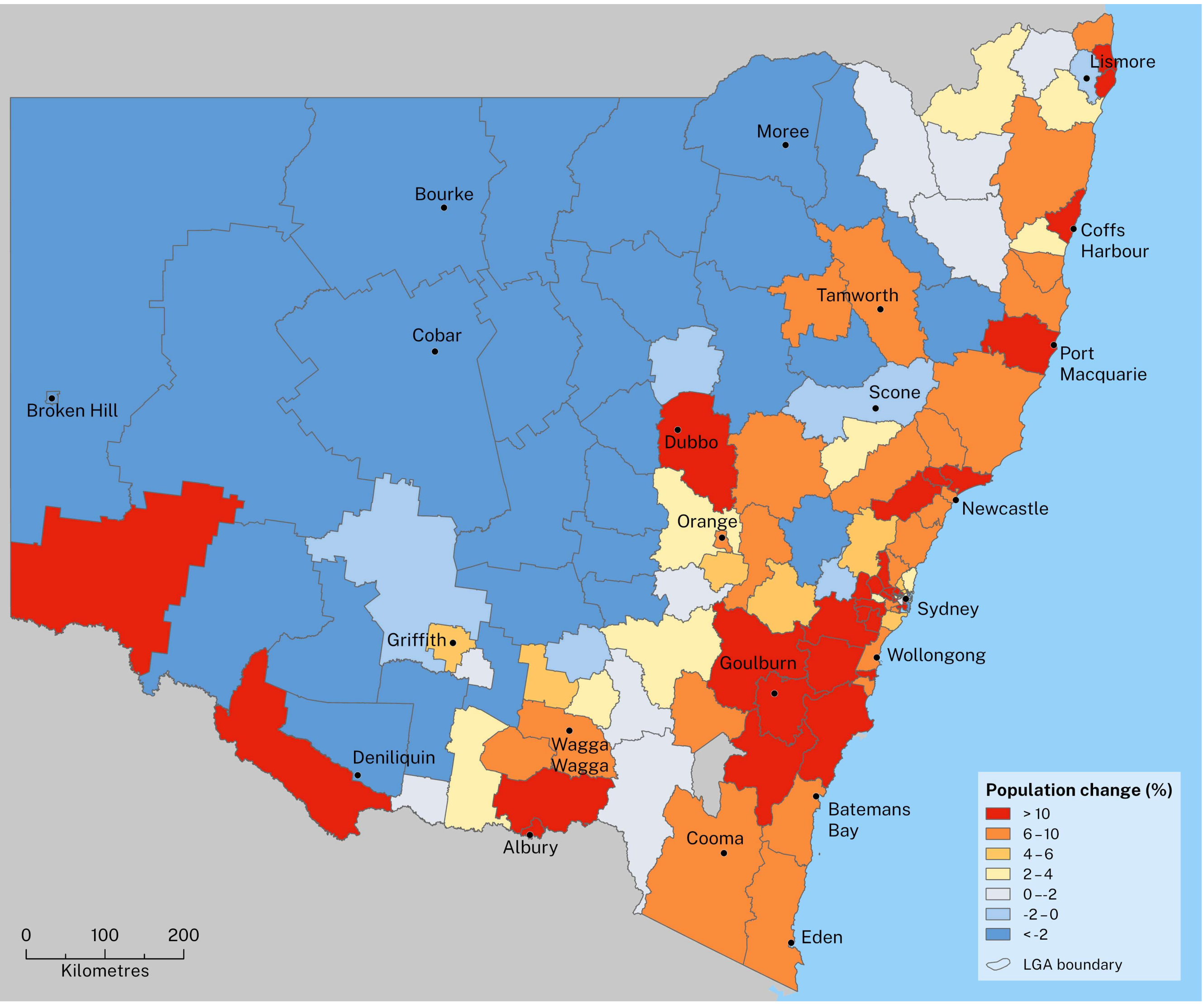
Source:
ABS 2024b, calculations by DCCEEW

Where are we growing?

Between 2013 and 2023, the urban fringe areas in the north-west and south-west of Greater Sydney showed the highest growth in the State, along with Maitland and Cessnock in the Hunter region. The lowest growth rates occurred in far western NSW (see **Map D1.2**). More detailed information is available on the **Australian Bureau of Statistics website** (**ABS 2023c**).

Higher growth rates in areas of high density will put increased pressures on services and infrastructure.

Map D1.2: Population change in NSW, 2013–23



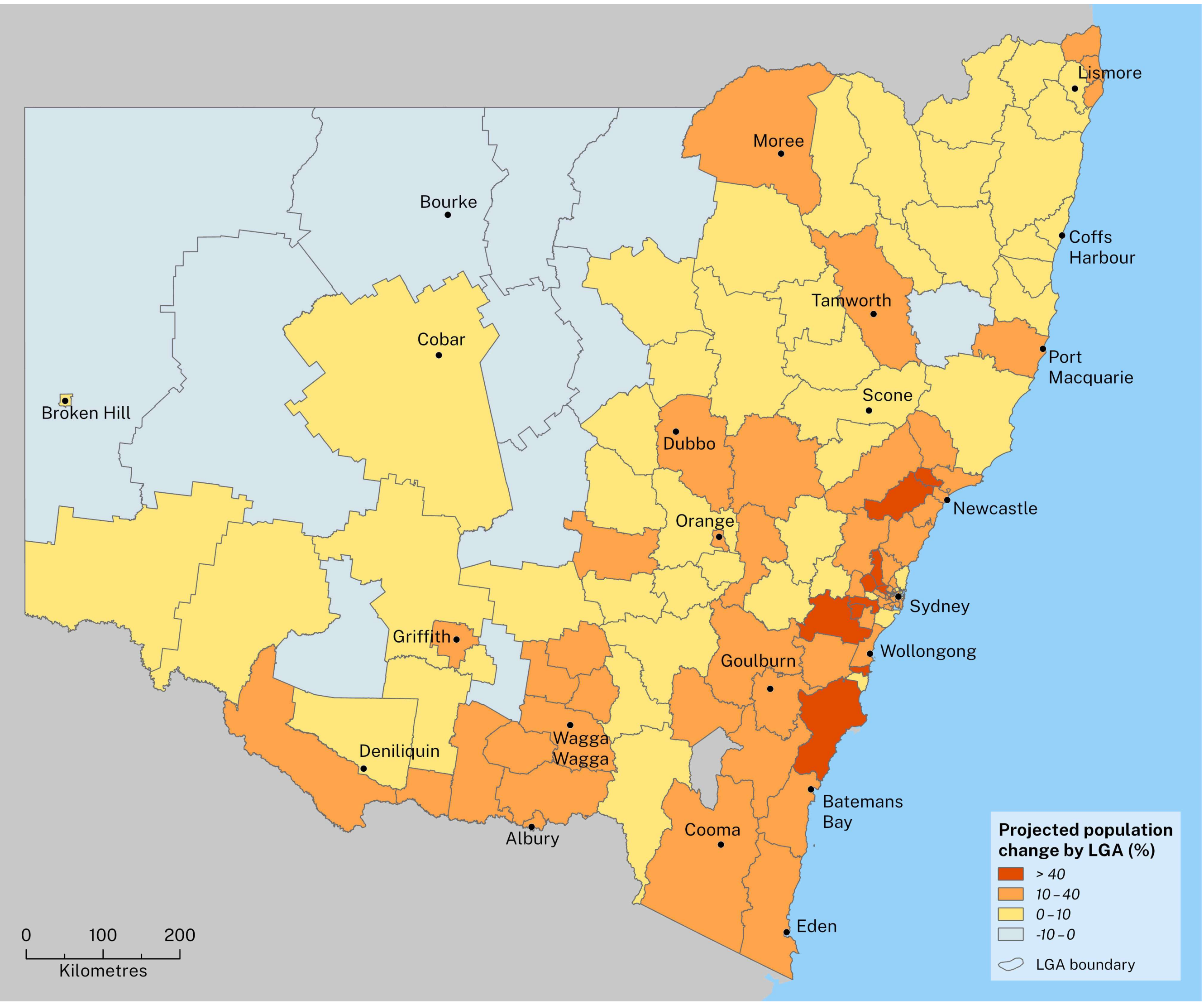
Notes:
Access the interactive version of this map.

Source:
ABS 2023c

Future growth

By 2041, the NSW population is expected to grow to 10.1 million people, and that in Greater Sydney to about 6.3 million. **Map D1.3** shows projected population change across the State between 2021 and 2041. Further detail on these projections is available on the **Department of Planning, Housing and Infrastructure (DPHI) website**.

Map D1.3: Projected population change, 2021–41



Source:
DPHI population projections 2024

An ageing population

Understanding the age patterns in the population helps government make decisions, such as the best locations for particular types of new housing, and where to provide services, such as education and healthcare.

The NSW population continues to get older. The age profile of communities varies throughout NSW, with some a lot older than others. These variations are influenced by where people decide to live. For example, older people may retire from the cities to the coast or nearby inland towns putting more pressure on local resources in those areas. Older people are more vulnerable to the impacts of environmental threats, such as heatwaves and floods (**Harrington & Otto 2023**; **Haq 2023**).

Greater Sydney has a younger population than regional NSW (see **Figure D1.3**), due to natural increase (births outnumbering deaths), overseas migration, which is dominated by young adults, and the arrival of young people from around Australia. Regional areas lose young people to the bigger regional cities and Greater Sydney. With fewer young adults and proportionally more older people, some regional areas are in natural decline (deaths outnumber births). While the arrival of people around retirement age contributes to growth, it slows the pace of growth.

The number of retirees is similar between regional NSW and Greater Sydney, despite the difference in total population.

Figure D1.3: Age profile of Greater Sydney and regional NSW, 2023

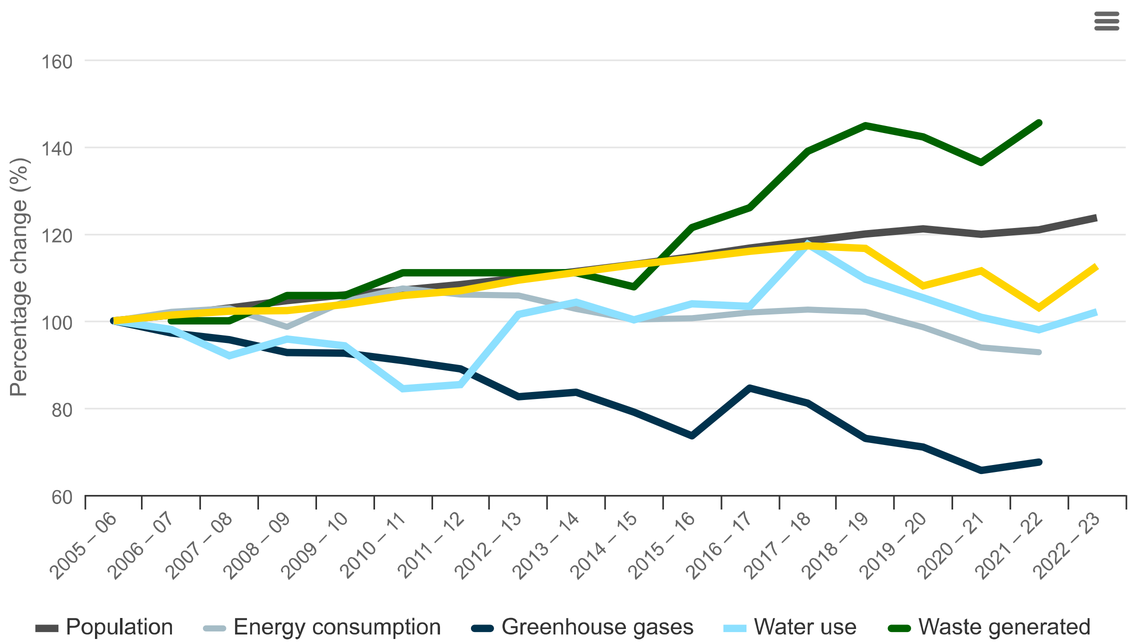
Source:
ABS 2024a

Environmental impacts

The NSW Government implements policies and programs that aim to reduce the environmental impacts of population growth. Comparing trends in population growth with measures of impact can help assess the effectiveness of these policies.

Figure D1.4 compares population growth with trends in resource use and pollution since 2005. It shows that between 2005 and 2023, waste generation outpaced population growth, while other environmental indicators grew at a slower rate or even decreased.

Figure D1.4: NSW population growth compared with trends in energy, greenhouse gas emissions, transport, water and waste, 2006–23



Notes:

All values for each indicator have been adjusted to a baseline of 100% for that year.

Population figures (**ABS 2023b**) are regularly revised for each quarter, until the final update, 22 months after each Census.

Data for greenhouse gas emissions are available only to 2021.

Before 2015–16, waste generation data were available only on a two-yearly basis. The most recent data used to project emissions come from 2020–21.

Source:

Population: ABS Data Explorer, calculations by DPHI | Urban water: Sydney Water (2024); Hunter Water (2024); DCCEEW (2024) | **Energy includes the ACT: Table F: Australian energy consumption, by state and territory, by industry and by fuel, energy units** | **Greenhouse gas emissions: National Greenhouse Accounts 2021: State and Territory Greenhouse Gas Inventory** | **Waste generation: Waste and Resource Reporting Portal** | **Vehicle kilometres travelled: BITRE 2023, Australian Infrastructure and Transport Statistics – Yearbook 2023**

Figure D1.4 shows the following:

- Vehicle kilometres travelled, which is a measure of transport pressure, was increasing at the same rate as population growth and is rebounding after a sharp decline related to COVID-19 restrictions from 2019 to 2021. See **Transport** for more information.
- Total energy use has been steadily declining since 2010–11, with minor fluctuations. Energy consumption is decreasing primarily owing to energy efficiency measures and increased uptake of renewable energy, such as rooftop solar electricity. See **Energy consumption** for more information.
- Emissions of greenhouse gases have generally decreased, although there was a slight increase in 2017–18. See **Greenhouse gas emissions** for more information.
- After dipping during the COVID-19 lockdowns, total waste generation is again increasing. In populated areas, waste products (including solid waste, sewage, hazardous waste and atmospheric emissions) need to be managed to reduce stress on natural ecosystems. See **Waste and recycling** and **Air quality** for more information.
- Water usage is sensitive to weather patterns and water availability. Before the 2017–20 drought, urban water consumption was increasing, generally tracking population growth. More recently, consumption has trended downwards, reaching as low as 849 gigalitres in 2021–22 (2% less than was used in 2005–06). This decrease is most likely a result of water restrictions, water efficiency measures and behaviour change among users. For more detail on water extraction and use by industry and agriculture and the environmental share of available water, see **Water use** for more information.

While overall these trends are positive, **Figure D1.4** does not show whether the levels are sustainable. The NSW environment's 'carrying capacity' – that is, its capacity to provide resources without causing environmental harm (**Dovers & Butler 2015**; **Rockström et al. 2009**) – has not been estimated, and so these trends cannot be compared to sustainable levels of consumption or output.

The chart also does not reflect the potential environmental impacts of NSW exports (such as coal and minerals) in other countries or the contribution of imported goods (such as clothing and electronic goods) to waste and pollution in NSW.

It is not possible to show the relationship of changing human populations to wildlife and biodiversity in **Figure D1.4** because these have not been calculated for NSW. At a national level, it is estimated that between 1950 and 2009, almost one (0.95) species became extinct for every extra one million people in the population (**Dickman & Lindenmayer 2021**).

Urban expansion has devastating impacts on wildlife in Queensland (**Taylor-Brown et al. 2019**). This is largely related to vehicle collisions (see **Transport** topic for similar information about NSW).

The national **State of the Environment report** report provides further information about the potential impacts of **urban development**, especially in **coastal areas**, and **light pollution**.

Sustainable planning

Although the NSW Government uses population projections to inform its strategic planning, infrastructure investment and service delivery, it does not develop specific population targets or set limits on population growth.

Some of the harmful impacts of population growth and urbanisation can be mitigated through approaches to urban design, planning and development that aim to balance environmental and human needs. For example:

- Well-designed urban areas with adequate green space can improve liveability and provide habitat for urban wildlife (**Dexter et al. 2016**; **Hess et al. 2014**), although it may not be an adequate substitute for the original habitat that was displaced by development.
- The impacts of transport and its associated energy use can be reduced by improving access to active transport (such as walking and cycling) and public transport (**Rickwood et al. 2008**).

The NSW Government has developed a range of long-term plans and strategies that aim to promote more sustainable use of land and resources and manage pollution and waste. These include:

- the ***Waste and Sustainable Materials Strategy***
- the **Greater Sydney Region Plan – A Metropolis of Three Cities**
- 7 plans for **regional NSW**
- the **Greener Places Framework**
- **Future Transport**
- the **Net Zero plan**
- the ***NSW Water Strategy***.

See the **Energy consumption**, **Transport**, **Greenhouse gas emissions**, **Water use** and **Waste and recycling** topics.

Opportunities

There are opportunities to change the way we manage the problems associated with population change and consumption patterns. A range of approaches and frameworks, which are being debated and implemented around the world, seek to improve quality of life for everyone on the planet without causing irreversible environmental harm. These include:

- the **Sustainable Development Goals**, which provide a blueprint for shared peace and prosperity that promotes economic and social equality and prioritises protection of the environment
- the **Planetary boundaries framework**, which identifies the safe limits for human impacts on environmental services such as freshwater and biodiversity
- natural capital accounting, an economic approach that includes measurement and valuation of the benefits (such as water) provided by the environment

- **Doughnut economics**, which combines the Planetary boundaries framework with the concept of a social foundation; that is, the level of resource use that's required to ensure that all people have a good standard of living
- framing legislation, policy, planning and programs to ensure that nature can be repaired and regenerated rather than degraded by development.

See the **Economic activity and the environment** topic and **Global reporting models** page for more information.

While these frameworks and approaches provide hope that we can reduce human impacts on the environment, some scientists are concerned that population growth has outpaced our capacity to manage them through planning (**Ripple et al. 2017**; **Williams & Taylor 2021**).

Addressing our patterns of behaviour and the types of technology and infrastructure deployed in the consumption of resources and energy will also be essential for reducing resource use and pollution.

References

ABS 2023a, *Components of population change – states and territories*, Australian Bureau of Statistics, Canberra, accessed 10 May 2024

ABS 2023b, *Population – states and territories*, Australian Bureau of Statistics, Canberra, accessed 19 July 2024

ABS 2023c, Regional population, Australian Bureau of Statistics, Canberra, accessed 10 May 2024

ABS 2024a, Regional population by age and sex, released 29 August 2024. Australian Bureau of Statistics, Canberra, accessed 2 February 2025

ABS 2024b, TABLE 06. Value of Building Work Commenced by Sector, States and Territories – Chain Volume Measures, Australian Bureau of Statistics, Canberra, accessed July 2024

Bibri SE, Krogostie J & Kärrholm M 2020, Compact city planning and development: Emerging practices and strategies for achieving the goals of sustainability, *Developments in the Built Environment*, vol. 4. no. 20, 100021, DOI: 10.1016/j.dibe.2020.100021

Bongaarts J, 2023, Population and environment: the evolution of the debate between optimists and pessimists, *Population and the Environment*, vol. 45

Borck R & Schrauth P, 2021, Population density and urban air quality, *Regional Science and Urban Economics*, vol. 86

Dexter CE, Appleby RG, Edgar JP, Scott J & Jones DN 2016, 'Using complementary remote detection methods for retrofitted eco-passages: A case study for monitoring individual koalas in south-east Queensland', *Wildlife Research*, 43, pp. 369–79

Dickman CR 2021, 'Ecological consequences of Australia's "Black Summer" bushfires: Managing for recovery', *Integrated Environmental Assessment and Management, vol. 17*, issue 6 pp. 1,162–7

Dovers S and Butler C, 2015, *Population and environment: a global challenge*, Australian Academy of Science, accessed 24 July 2024

DPE 2023, *NSW Population Trends,* Department of Planning and Environment, Sydney, 2023

DPHI 2024, written advice from the Department of Planning, Housing and Infrastructure, July 2024

Harrington LJ & Otto FEL, 2023, Underestimated climate risks from population ageing, Nature, accessed 24 July 2024

Haq G, 2023, Ageing population more at risk from environmental threats, *The Conversation*, accessed 24 July 2024

Hess GR, Moorman CE, Thompson J & Larson CL 2014, 'Integrating wildlife conservation into urban planning', *Urban Wildlife Conservation: Theory and Practice*, pp. 239–78, doi: 10.1007/978-1-4899-7500-3_12 (PDF 1.6MB)

Lehmann S 2016, Sustainable urbanism: towards a framework for quality and optimal density? *Future Cities and Environment*, vol. 2, no. 8

Nieuwenhuijsen MJ 2021, 'New urban models for more sustainable, liveable and healthier cities post covid19; reducing air pollution, noise and heat island effects and increasing green space and physical activity', *Environment International*, vol. 157, 106850, DOI: 10.1016/j.envint.2021.106850

Rickwood P, Glazebrook G & Searle G 2008, 'Urban Structure and Energy—A Review', *Urban Policy and Research*, vol. 26, no. 1, pp. 57–81, DOI: 10.1080/08111140701629886

Ripple WJ, Wolf C, Newsome TM, Galetti M, Alamgir M, Crist E, Mahmoud MI, Laurance WF, & 15,364 scientist signatories from 184 countries 2017, 'World Scientists' Warning to Humanity: A Second Notice', *BioScience*, vol. 67, no. 12, pp. 1,026–1,028, DOI: 10.1093/biosci/bix125

Rockström J, Steffen W, Noone K, Persson Å, Chapin FS III, Lambin EF, Lenton TM, et al. 2009, 'Planetary Boundaries: Exploring the Safe Operating Space for Humanity', *Ecology and Society*, vol. 14, no. 2, 32

Taylor-Brown A, Booth R, Gillett A, Mealy E, Ogbourne SM, Polkinghorne A & Conroy GC 2019, 'The impact of human activities on Australian wildlife', *PLoS ONE*, vol. 14, no. 1, e0206958, DOI: 10.1371/journal.pone.0206958

UN 2023, As the World's Population Surpasses 8 Billion, What Are the Implications for Planetary Health and Sustainability?, United Nations, accessed 25 July 2024

Williams SJ & Taylor R 2021, *Sustainability and the new economics* (Edition), Springer, Cham

UNEP 2014, *Decoupling 2: technologies, opportunities and policy options*, United Nations Environment Program, Nairobi (PDF 7.9MB)

Economic activity and the environment

New approaches to economic management consider the health of our natural environment.

Overview

More than

80%

of the NSW economy is services-based

Read more

Gross State Product average annual growth has been

2.4%

since 1990

Read more

All the elements have Lore, cultural Lore, right Lore.

Our trading practices included the exchange of cultural knowledge, various items and plant life. The seeds for trade would be wrapped up in a clay ball, which is how they're usually carried. So, you were carrying around five or seven clay balls, and inside those five or seven clay balls there could be anywhere between 10 to 15 to 50 different seeds in that ball.

If seeds were traded with other people, an explanation was given as to how and when to plant and water.

An economy is a complex system of human activities linking production, consumption and exchange of goods and services within a country or region.

According to the **World Economic Forum**, more than half the world's economic output – about US$44 trillion – is moderately or highly dependent on nature.

Globally, construction, agriculture, and food and beverages are the largest highly nature-dependent industries. These industries could be significantly disrupted if ecosystem services are reduced or lost (**WEF 2020**).

There are many different frameworks that can be used to understand the complex relationship between the economy and the environment. It's an understanding that continues to improve, as do solutions for alleviating pressures on the environment.

In this topic, the focus will be primarily on key features of the NSW economy and environmental impacts, although a global perspective is also considered.

Opportunities for using new economic frameworks to improve environmental outcomes, such as nature positive, sustainability disclosures and circular economy initiatives, will be discussed.

Table D2.1 defines some important economic terms that are used throughout this topic.

Table D2.1: Key economic terms

Term	Definition
Decoupling	Decoupling occurs when two or more activities grow at different rates, when in the past they may have grown at the same rate.
Gross state product	Gross state product is a measure of the value of all the goods and services produced in the state or territory in a given time period. It captures price and output volume changes.
Real gross state product	Real gross state product is a value measure of the volume of all goods and services produced. It removes the impact of price changes on the value of gross state product.
Gross value added	Gross value added is the value a sector or industry adds to the economy through its activity. Gross state product can be calculated by adding up the Gross value added for all sectors of the state economy.
Natural capital accounting	Describes the state of the natural environment and its links to the economy in a standardised way. Also known as environmental-economic accounting (**DCCEEW-Aus n.d.-a**).
Cost-benefit analysis	Cost-benefit analysis is a holistic appraisal method that estimates the economic, social, environmental and cultural costs and benefits of an initiative, and expresses them in monetary terms.
Ecosystem services	A set of assets (natural resources as well as entire ecosystems) that generate benefits on which humans rely, such as clean air and water.
Circular economy	The **circular economy** refers to a systems transformation from a linear economy (extraction, use, disposal) to the circularisation of material (manufacture, reuse, repair, recycling, re-manufacture).

Source:
DCCEEW 2024 | DCCEEW-Aus n.d.-a | NSW EPA 2024

Relationship between economy and environment

Human wellbeing and the economy depend on nature as a:

- source of resources to be converted into products
- sink for waste products
- supplier of critical ecosystem services, such as carbon sequestration or water filtration services.

Population growth and rising standards of living lead to economic growth, and in turn, economic activity leads to pressures on the environment.

Population growth is one driver of economic growth in industrial economies due to the increased need for essentials, such as food and housing, as well as other goods and services. The resulting economic growth is often related to increased consumption, resource use and the generation of waste and pollution (**Levinson 2015**).

See the **Population and the environment** and **Transport** topics for more information.

Economic growth is the increase in the production of goods and services over time. If economic growth is greater than population growth, this increase enables people to improve their living standards and lead safer and more comfortable lives.

In turn, this increased economic activity can lead to pressures on the environment, as the way we produce goods and services can have substantial negative impacts on the environment and human health.

The relationship between economic growth and the environment is complex, with different sectors of an economy having different levels and types of environmental impacts.

Environmental impacts depend on the nature of the economic activity, the changing structure of industry, and the policy settings and regulatory framework in which that economic activity takes place.

Environmental impacts within a state, such as NSW, also depend on whether an economy uses domestic or imported resources and whether the goods and services produced are consumed locally or exported.

Because economies are linked globally, the environmental impacts of a state economy may include impacts on the environment in that state, as well as other parts of the country or overseas.

Economic growth can be responsible for generating more pollution as people consume more goods and services (**Levinson 2015**). However, economic growth often improves environmental outcomes, as richer countries can afford to devote more of their resources to environmental regulation and to nature protection and improvement (**Levinson 2015**). For example, policies to reduce carbon emissions can provide new opportunities for farmers to generate renewable energy alongside other land uses.

Slowdowns in economic growth don't necessarily lead to better results for the environment. Brief reductions in economic activity can lead to improved environmental outcomes – for example, NSW recorded a reduction in the number of littered items during the COVID-19 emergency, only to return to baseline levels afterwards (**NSW EPA 2024a**).

However, extended recessions can also cause extra damage or degradation as business enterprises struggle to maintain viability. This may result in pressure for short-term exploitation of available natural resources or less care and attention paid to the generation and management of waste.

Natural capital

The concept of nature as an asset that provides benefits to humanity is becoming more important in economic policy and strategy (**OECD 2021**; **World Bank 2021**). This means valuing nature explicitly for its economic benefits and ensuring our environment is managed so that it can continue to benefit future generations.

Natural capital refers to the framing of nature as an asset that generates value.

One tool to implement this way of thinking is known as natural capital, or environmental-economic accounting, which is a technique to measure how the amount, quality and uses of natural capital change through time. It supplements conventional economic accounts and enhances government decision-making by enabling environmental factors to be considered in decisions that have traditionally been based on economic factors alone.

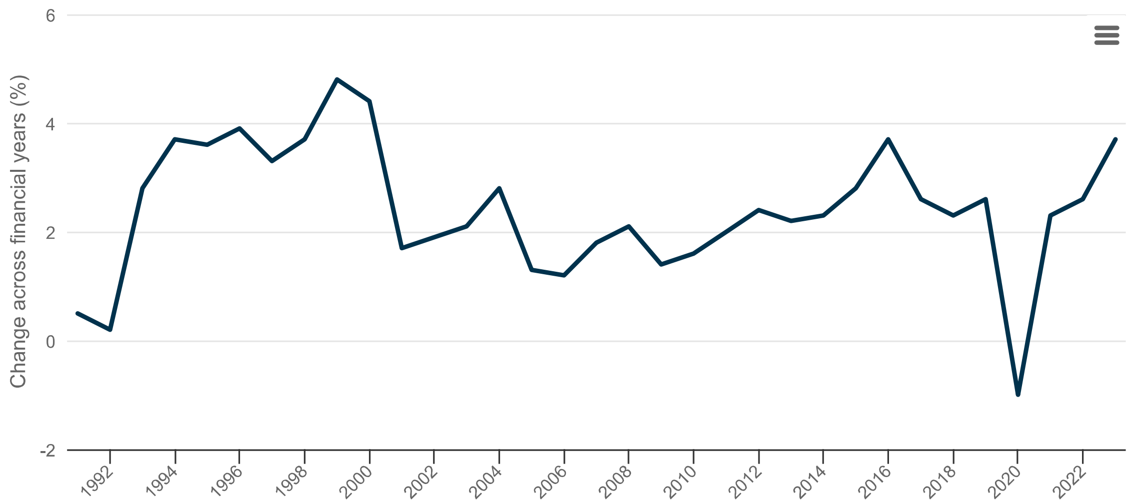
Other economic tools that are used by governments to prevent or mitigate environmental impacts include cost benefit analysis, taxes, offsets and market-based mechanisms, such as offsets and tradeable permits.

Related topics: **Climate change** | **Energy consumption** | **Population and the environment** | **Protected areas and conservation** | **Transport** | **Waste and recycling**

The NSW economy

NSW has the largest economy in Australia, contributing about one-third of national economic output in 2023. Between 1990–91 and 2022–23, NSW economic output doubled as the NSW economy grew by an average 2.4% a year, as measured by gross state product (see **Figure D2.1**).

Figure D2.1: Economic growth (annual percentage change in real gross state product), 1990–91 to 2022–23



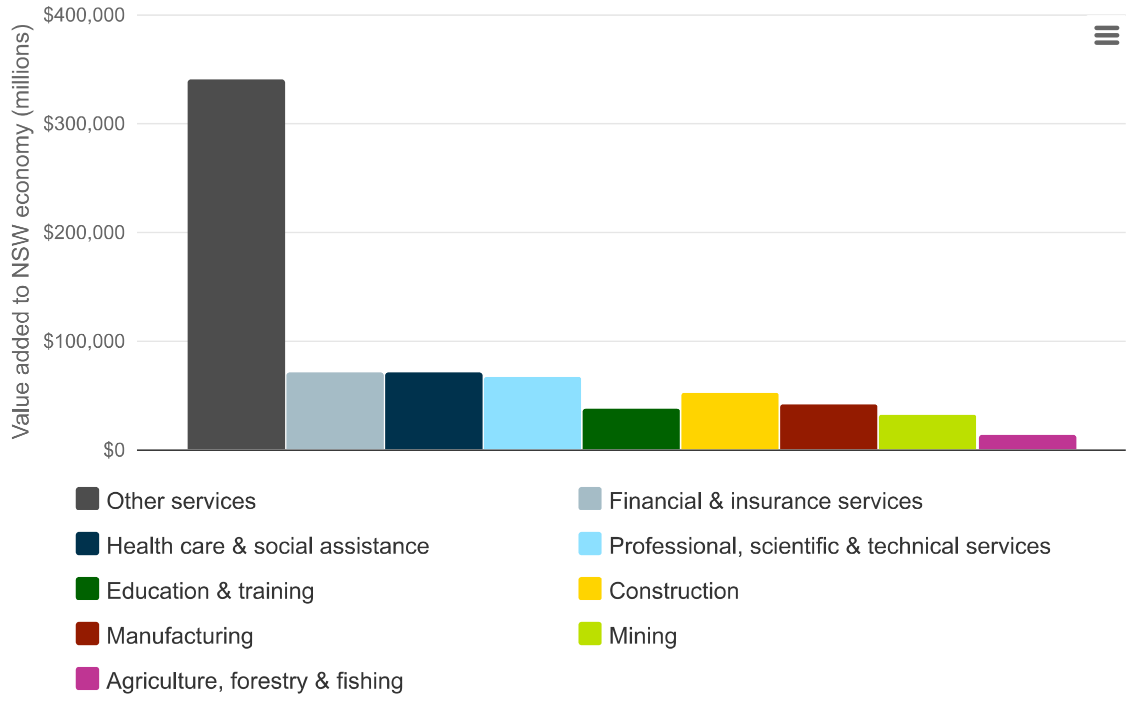
Source:
ABS 2023a

As a result of this sustained economic growth, NSW gross state product per person increased by about $32,136 in real terms between 1990–91 and 2019–23, reaching $89,314 in 2023 (**ABS 2023a**). This means the share of state wealth per person has increased and people would, on average, have higher living standards now compared with 1990–91.

Over the past 30 years, the NSW economy has been shifting from resource-intensive industries, such as manufacturing, mining and agricultural production, to the services and technological sectors. These sectors are less dependent on the use of natural resources, and typically involve lower environmental impacts than primary and secondary industries, such as farming, mining and manufacturing.

Figure D2.2 shows that NSW is now primarily a service-based economy, with services contributing more than 80% of gross state product in 2022–23 (**ABS 2023b**).

Figure D2.2: Sectors of the NSW economy (share of gross state product), 2022–23



Notes:
Each sector's share is shown in nominal dollar values, which capture changes in prices as well as volumes produced.

'Other services' includes sectors such as public administration, media and information technology, rental and hire services, retail and utilities, such as water and gas.

Source:
ABS 2023b

While manufacturing remains a major sector in the NSW economy, its share of the economy has fallen from 12.5% of gross value added (**ABS 2020**) in 1990 to 5.3% in 2023.

Over the same period, the financial and insurance services sector share of the economy grew from 6% to 9.2%, overtaking manufacturing as the State's largest sector in 2005, and the information, media and telecommunications sector grew the fastest, with real annual average growth of 5.35%.

While the share of services sectors increased over the period from 1990–91 to 2022–23, growth in resource-intensive industries continues. Average annual growth was 11.6% for mining, 2.5% for manufacturing, and 4.6% for agriculture, forestry and fishing (**ABS 2023b**).

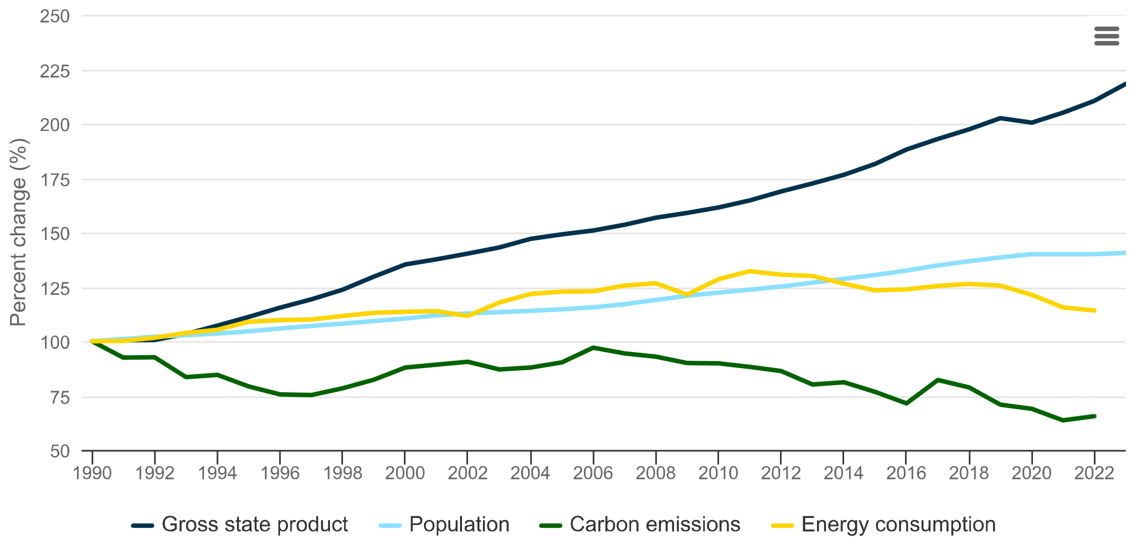
Economic growth and environmental impacts in NSW

There is evidence that there has been a reduction in some environmental impacts while the NSW economy has been growing. A doubling in the size of the NSW economy (measured as gross state product) and a 40% increase in population over the past 30 years have not generated proportionate increases in energy consumption and carbon emissions.

During this period, as shown in **Figure D2.3**:

- Gross state product average annual growth was 2.4%, a total increase of 118%
- the NSW population grew by an annual average of 1.0% a year, a total increase of 41%
- net carbon emissions fell by an annual average of 1%, a total fall of 31% (from 169,166 kilo tonnes to 110,997 kilo tonnes)
- total energy consumption annual average growth was 0.6%, a total increase of 20.7%.

Figure D2.3: Relative change (%) in economic performance, population, energy consumption and carbon emissions in NSW, 1989–90 to 2022–23



Source:
Population ABS Data Explorer | Greenhouse gas emissions (DCCEEW 2023) | Gross state product (ABS 2023a)

Total carbon emissions have been declining since 2007, and energy consumption, while growing over the period, started to decline in 2011. These trends are likely due to:

- adoption of more energy efficient technologies
- industries transitioning towards low-emissions, renewable energy sources to generate electricity
- changes to government policy, including greenhouse gas emissions regulation and sustainability disclosure requirements
- greater consumer engagement and attention to energy use and cost, including increasing the amount of generation for own use.

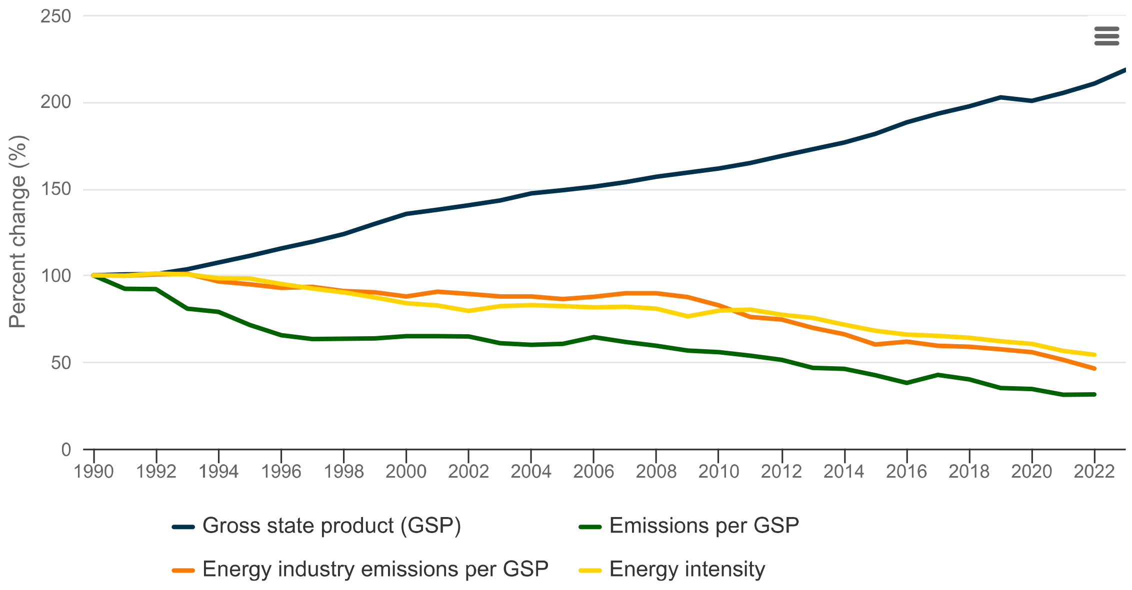
See the **Energy consumption** topic in this report for more information.

A deeper analysis of economic growth, carbon emissions and energy use shows a fall over time in the intensity of carbon emissions and energy consumption in the NSW economy (see **Figure D2.4**). This means the emissions produced and the energy used for each dollar of gross state product are falling while the economy continues to grow.

- Carbon emissions in tonnes per dollar of gross state product fell by 63% from 1990 levels.
- Energy intensity fell to a lesser extent, to about 46% of 1990 levels.

See the **Greenhouse gas emissions**, **Energy consumption** and **Transport** topics in this report for more information on emissions and energy use by sector.

Figure D2.4: Relative change (%) in NSW economic performance, emissions and energy intensity 1990–1991 to 2021–2022



Notes:
Energy intensity is measured by energy consumption per unit of gross state product.

Source:
ABS 2023a

Current economic approaches in NSW

Cost-benefit analysis

Cost-benefit analysis is a method that estimates the economic, social, environmental and cultural costs and benefits of an initiative and expresses them in monetary terms. It can be used to assess whether the trade-offs between economic activity and particular environmental outcomes are appropriate.

Cost-benefit analysis is the NSW Government's preferred **economic evaluation** method. It is required as part of a business case to support funding proposals.

Under the ***NSW Government Guide to Cost-Benefit Analysis*** **(Treasury Policy and Guidelines 23-08)**, cost-benefit analyses are required for NSW Government policies and programs with an estimated cost of $10 million or more. These decisions can be complex, with many stakeholders and competing interests involved.

For example, while the community benefits from new roads, housing, infrastructure and other developments, these should be weighed up against the environmental assets, such as a threatened species, that are impacted when land is cleared.

Examples of environment-related benefits in cost-benefit analyses could include:

- reduced impacts from climate change resulting from greenhouse gas emissions reductions
- lower health costs from reduced air pollution and improved water quality
- improved natural sites that provide recreation benefits for hikers and campers.

Examples of environment-related losses may include:

- fragmentation and loss of habitat for vulnerable species of plants and animals
- increased air pollution
- impacts on water quality and supply.

The NSW Government's ***NSW Climate Change Policy Framework*** commits to developing a benchmark value for emissions savings and applying this consistently in government economic appraisal. This means cost-benefit analysis for all new policies and programs will use the same value for benefits from emissions savings.

The **Framework for Valuing Green Infrastructure and Public Spaces** provides a standardised way to identify and quantify costs and benefits associated with green infrastructure and public space projects.

The NSW Treasury's **Centre for Economic Evidence** collects data on conservation programs where cost-benefit analysis has been used to better understand how well this tool is working. This work will continue to contribute to insights about the potential environmental impacts of different types of development that can be incorporated in future analyses.

This data may also help the government estimate potential environmental impacts for projects where not enough information is available.

For example, ecosystem and species credits issued under the **NSW Biodiversity Offsets Scheme** are bought and sold, and the price for such credits can be used to indicate the value of the ecosystem or species concerned. These prices may be used to show the economic value of species conservation and of ecosystem preservation.

This cost-benefit analysis approach was used to quantify species conservation benefits in the NSW **Saving Our Species program**.

Economic incentives

Economic instruments and market-based mechanisms are policies, tools and programs that provide incentives for businesses and the community to consider the wider social impacts of their behaviour. They include taxes, subsidies, offsets, tradeable permits and similar financial incentives.

An aim of economic instruments is to allow economic growth and efficient allocation of resources. The main advantage of using economic instruments is that, by harnessing incentives to reduce costs, they can achieve desired environmental outcomes at lower costs than via alternative (usually regulatory) means.

A range of economic instruments designed and managed by the NSW Government use financial incentives to modify the choices and actions of businesses and residents of NSW in relation to environmental impacts.

These include:

- the **waste levy**, which provides financial incentives for residents and businesses to reduce the amount of waste they send to landfill
- **solar feed-in tariffs**, providing an incentive for investing in household solar generation capacity
- **load-based licensing**, which imposes a charge on industrial facilities for each tonne of pollution they emit, encouraging these businesses to incorporate the wider social costs from pollution into their production decisions
- **risk-based licensing**, which matches the degree of regulatory oversight with the level of environmental risk posed by licensed operations by targeting poor performers and creating a financial incentive for facilities to improve their systems and performance
- the financial incentives provided by the NSW Container Deposit Scheme ***Return and Earn***, which encourages the return of used drink containers for recycling.

Environmental instruments and markets

Environmental markets aim to encourage people to take action to protect or restore the environment by investing in environmental goods and services. Participants can buy, sell or trade these goods or services for potential financial gain.

Environmental markets are new and evolving. As markets develop, continuous improvements and adjustments will be required to ensure they function effectively and efficiently.

Examples of environmental markets within NSW include:

- the **Biodiversity Credits Market**, which enables landholders to establish biodiversity stewardship sites to generate biodiversity credits that can be sold to development proponents to meet their offsetting obligations under the **Biodiversity Offsets Scheme**

- the **Hunter River Salinity Trading Scheme**, which allows industry participants to trade with each other for the right to discharge saline wastewater to manage pressure on the river's ecosystem
- the **NSW Energy Savings Scheme**, which creates an incentive to reduce the consumption of electricity and gas by requiring electricity retailers and some large users to meet targets for energy savings certificates that are created on a voluntary basis by private sector service providers
- the **Peak Demand Reduction Scheme**, which sets a target for electricity retailers and large users to reduce energy demand during peak hours by creating or buy peak reduction certificates.

Some of the challenges associated with environmental markets are:

- Establishing effective scheme design and operation that minimise barriers to market entry and exit, minimise transaction costs on market participants, and minimise the administrative burden on the government responsible for managing the market (or scheme).
- Integrating economic instruments, including regulatory ones, into a larger system of environmental protection initiatives. When poorly implemented, it can limit their effectiveness (**Climate Council 2023**).
- Information issues where it is difficult and expensive for market participants to get trustworthy information on products and services. For example, in environmental markets there are risks of 'greenwashing'. This is where environmental claims aren't backed up by reliable evidence, making products, services or operations appear more sustainable than they really are (**ACCC n.d.**; **Macintosh et al. 2024**).

Biodiversity offsetting

The **Biodiversity Offsets Scheme** (established by the ***NSW Biodiversity Conservation Act 2016***) provides for development impacts on biodiversity to be offset by gains secured through stewardship agreements.

The scheme requires proponents of activities that will have a significant impact on biodiversity to first avoid and minimise those impacts before offsetting any residual impact.

Landholders who enter into these stewardship agreements are required to set up biodiversity stewardship sites to conserve and restore habitat, with the aim of delivering 'no net loss' to biodiversity. A transparent, consistent and scientific method is used to calculate and unitise the loss and gain in biodiversity values.

See the **Plants** and **Animals** topics for more information about biodiversity.

Monitoring the NSW biodiversity credits market

The Biodiversity Offsets Scheme is an example of an economic instrument that has been the subject of public scrutiny.

The **Independent Pricing and Regulatory Tribunal** (IPART) has been asked by the NSW Government to monitor the biodiversity credits market, for three years from 2022–23 and make findings and recommendations.

In December 2023, the first **monitoring report** found several challenges affecting fundamental aspects of the market such as pricing, transaction costs and barriers to entry. The report made recommendations to remove price distortions, and other actions to reduce entry costs and make the market more accessible for landholders and development proponents to trade credits.

IPART conducted its **second annual review** of the credits market in late 2024, released in December. The review is expected to consider trends in the performance of the market in 2023–24, including any NSW Government responses to the recommendations from the first report.

The *Biodiversity Conservation Act 2016*, which establishes the NSW Biodiversity Offsets Scheme was reviewed in 2023. The ***NSW Plan for nature*** is the NSW Government's response to the independent statutory reviews of the *Biodiversity Conservation Act 2016* and the native vegetation provisions of the *Local Land Services Act 2013*. The NSW Government is implementing a range of reforms to strengthen and improve the offsets scheme, including legislative reform.

NSW DCCEEW also administers the **Biodiversity Credits Supply Fund**, to increase the supply of in-demand biodiversity credits and enhance confidence in the biodiversity credit market. Through the **Stewardship Support Program**, eligible landholders are supported to identify and access stewardship opportunities under the **Biodiversity Offsets scheme**.

Greenhouse gas offset schemes

Greenhouse gas offset schemes (including carbon offset schemes) are economic instruments that encourage people and businesses to carry out activities that reduce emissions or store carbon.

Offset schemes in Australia include:

- the **Australian Carbon Credit Unit Scheme**, which encourages people to reduce emissions by using new technology, upgrading equipment, changing business practices or changing the way vegetation is managed
- **Safeguard Mechanism credit units**, which are tradeable credits that businesses liable under the **Safeguard Mechanism** (the highest greenhouse gas emitting facilities in Australia) can earn by reducing greenhouse gas emissions beyond their baseline.

See the **Net Zero Plan Stage 1: 2020–2030** topic for more information.

Economic growth and net zero

Getting to net zero emissions is an important part of the NSW Government's plan to grow a sustainable low carbon economy.

The ***Climate Change and Net Zero Future Act 2023*** ensures that economic outcomes are a priority of NSW action on climate change through the Net Zero Plan. The Act notes among its guiding principles that action to address climate change should be taken in a way that:

- is fiscally responsible
- promotes sustainable economic growth
- considers the economic risks of delaying action to address climate change
- considers the impact on rural, regional and remote communities.

See the **Net Zero Plan Stage 1: 2020–2030** topic for more information.

Environmental limits to economic growth

Decoupling and its limitations

By definition, because the economy is critically reliant on environmental inputs, it is not possible to completely 'decouple' economic growth from the environment. However, separating or 'decoupling' economic growth from its potential negative environmental impacts is important in creating a sustainable future.

Decoupling can involve:

- reducing the amount of resources, such as fossil fuels, used to drive economic growth through more efficient practices to reduce their overall negative environmental impact (**UNEP 2011**)
- using resources more efficiently or cleanly, without reducing the amount of resources used or the cost of production (**UNEP 2011**).

In NSW, carbon emissions have been decreasing while the State is still experiencing economic growth, indicating some decoupling of carbon emissions from economic growth. See **The NSW economy** section of this topic for more information.

Although decoupling shows encouraging signs, decoupling alone will not be enough to achieve the scale of changes required to prevent irreversible environmental degradation (**Ward et al. 2016**; **Vadén et al. 2020**).

There are challenges for decoupling other aspects of the economy from environmental impacts, particularly in international trade, due to Australia being a large exporter of natural resources (**UNEP 2011**).

Economic innovation and sustainable resource management strategies are still needed to support decoupling of economic growth from resource consumption and their negative environmental impacts (**UNEP 2011**).

Living within environmental limits

The frameworks we use to understand the relationship between the economy and the environment have changed over time. These frameworks explore limits of the capacity of the global environment to support continuing, and increasing, economic activity.

The extent to which humanity is pushing up against planetary limits is a recurring economic question.

Up until the early 21st century, consideration of the environment had mostly not been integrated into mainstream economic thinking (**Williams & Taylor 2021**). However, this is changing as societies and governments around the world increasingly recognise that nature must be included in economic theory and policy so that the benefits it gives us can be protected. An example is ***The Economics of Biodiversity: The Dasgupta Review***, commissioned by UK Treasury in 2021.

See the **Global reporting models** page for more information.

Table D2.2 outlines the development of various frameworks for addressing environmental limits. The evolution of frameworks reflects growing understanding of what drives economic growth, and the role innovation plays in decoupling growth from unwanted environmental impacts.

Earlier works tended to propose definite and time-bound forecasts of global crises or failures of economies caused by depleting natural resources and food supplies. While these predictions have not come to pass, it is important to consider the context in which these reports were published. The quality of economic forecasts has improved due to a better understanding of the links between nature and the economy.

More recent works have tried to define and diagnose problems and solutions based on a perception of planetary limits and the human systems operating within them. Significantly, what these recent economic reports have in common is a focus on the limits of the global environment to support continuing, and increasing, economic activity.

These more recent frameworks make recommendations for policy responses in the face of human society pushing up against these planetary limits.

These ways of thinking about the relationship between the environment and economic activity have influenced how governments respond to environmental issues.

New and emerging economic approaches can also help governments better align policies across different departments to ensure a consistent approach to environment protection and restoration across the state.

Table D2.2: Developments in consideration of nature in economics	
Work and year published	**Summary**
An Essay on the Principle of Population	Predicted that population growth would overwhelm economic gains in food production, based on the observation that the majority of the population usually lived at subsistence levels. The author, Robert Malthus, thought the result would be wars, famines and societal breakdown (**Weir 1991**). Malthus' insight was valid for its time, but the great increases in production and living standards associated with the Industrial Revolution have since disproved Malthus' predictions. It is worth noting that Malthus' argument was based on repeated observations of the vast majority of the population living at subsistence levels for much of the time.
The Population Bomb (**Erlich 1968**)	Predicted worldwide famines due to overpopulation and advocated immediate action to limit population growth. This book updated a Malthusian-style prediction of economic and societal collapse resulting from overpopulation. Strict population control measures were advocated in the book. The book's predictions have not come to pass.
The limits to growth (1972)	Examined development trends of population growth, industrialisation, malnutrition, exploitation of raw materials and destruction of the living environment. It contained forecasts of 'overshoot and collapse' based on exhaustion of supplies of critical resources. The report was widely criticised, including by economists, for ignoring technical change, resource substitution and the role of prices as allocative mechanisms.
Our Common Future (1987)	Also known as the Brundtland Report, this introduced the concept of sustainable development as 'Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.' Broadly consistent with asset-based natural capital view (discussed below): that current generations should pass on a sufficient (and diversified) portfolio of assets to enable future generations to thrive.
The Economics of Climate Change: The Stern Review (2006)	The review found that the benefits of strong and early action to limit climate change far outweigh the economic costs of not acting.
The Garnaut Climate Change Review (2008)	Garnaut's report set targets for climate action and recommended an emissions trading scheme as the key policy mechanism to achieve the targets.
Planetary boundaries (2009)	The planetary boundaries concept was developed to help identify the environmental limits within which we can live safely on earth. It proposes boundaries for nine essential earth systems, based on what we take from the earth (such as water and land use) and the waste that is returned to the environment (such as greenhouse gases and aerosols). The Potsdam Institute for Climate Impact Research produces a yearly update to the framework, called the **Planetary Health Check**. The 2024 report showed that six of the nine boundaries have already been exceeded.
Doughnut economics (2012)	The doughnut economics model combines the planetary boundaries with the sustainable development goals for economic and social justice. The model aims to recognise that all people should have the resources to ensure they have a safe and comfortable standard of living, while not collectively overshooting the planetary boundaries.

Work and year published	Summary
The Economics of Biodiversity: The Dasgupta Review (2021)	The review calls for changes in how we think, act and measure economic success to protect and enhance our prosperity and the natural world. Grounded in a deep understanding of ecosystem processes and how they are affected by economic activity, the new framework presented by the review sets out how we should account for nature in economics and decision-making.

Notes:
Links or references to works are included on each listing above.

New and emerging approaches

Nature as an asset

Globally, governments and businesses are beginning to examine nature as an asset that provides benefits to society and which should not be treated as a 'free' good. One way of measuring the relationship between the economy and the environment is known as natural capital accounting (see below for more detail).

This approach categorises nature as a set of assets – natural resources as well as entire ecosystems – that generate the benefits (known as ecosystem services) on which humans rely. An example is the provision of clean air and water.

This framing puts nature on par with other produced assets whose value is recorded in both company and national accounts. It repositions nature from being 'outside' regular human economic activity, to being something that underpins it (**Barbier 2019**).

Using this approach, the UN World Economic Forum estimated that more than 50% of the world's gross domestic product relied on nature (**WEF 2020**).

In 2022, the NSW Government released the ***NSW Natural Capital Statement of Intent*** (**DPE 2022**). The statement sets out a series of objectives, including:

- recognising the value of, and our impact and dependencies on natural capital, while mitigating risks against losses
- recognising the importance of land managers' ability to support ecosystem services
- recognising Aboriginal peoples' connection to Country and traditional land knowledges
- building on existing initiatives that integrate the enhancement of natural capital
- fostering an enabling environment that supports the economic transition towards a nature-positive economy.

The statement provides a pathway to guide and inform NSW Government decision-making, aiming to conserve and enhance the environment while ensuring economic prosperity.

The statement also supports several **natural capital programs**.

Natural capital accounting

Natural capital accounting is an umbrella term that describes accounting for the environment and its natural assets in a way that is similar to how we account for what happens in the economy. It refers to a systematic, standardised and repeatable framework in which information on natural capital and the resulting ecosystem services it provides are recorded, whether or not those services have a market value.

Natural capital accounting in Australia and NSW uses the internationally endorsed **System of Environmental-Economic Accounting (SEEA) Central Framework**, which was developed by the United Nations (**UN 2014**).

SEEA uses a systems approach to linking environmental and economic information to describe the stocks and flows of natural resources. It does this by integrating environmental and economic data into a standard measurement system.

The framework expands the boundaries of the **Australian System of National Accounts**, the conventional method of recording and tracking changes in economic activity at national and state levels.

The standard national accounts focus on changes in economic activity, and do not include environmental pressures or environmental assets – 'natural capital' – which includes renewable and non-renewable resources, as well as entire ecosystems.

Data from environmental-economic accounts can be used to show links between economic activity and various aspects of natural resource use, including the generation of 'residuals', such as waste products and pollutants.

The data can also be used to explore trends in the use of natural resources and how these trends affect the extent and condition of remaining stocks and patterns of pollution and waste discharged to the environment. This helps decision-makers explore relationships between the economy and the environment.

Australian natural capital accounts

National environmental-economic accounts, including experimental accounts, have been developed to assist national-scale planning. Some accounts are called 'experimental' because this style of accounting is a relatively new and emerging field of measurement.

The national environmental-economic accounts that have been developed so far include:

- **Water Account, Australia 2021–22**
- **Energy Account, Australia 2022–23**
- **Energy Use and Electricity Generation, Australia (Businesses) 2017–18**
- **Waste Account, Australia 2018–19** – experimental estimates
- **National Land Cover Account 2020**
- **National Land account 2021** – experimental estimates
- **National Ocean Account 2022** – experimental estimates.

More information is available at **Natural Capital Accounts**, and on an interactive dashboard for **land and ocean** accounts.

NSW natural capital accounts

NSW can use the national environmental-economic accounts to identify differences in resource use and impact between the states and jurisdictions.

In July 2024 NSW launched a **Natural Capital Accounting Hub** on **SEED**, the NSW Government's environmental data portal. Experimental accounts for NSW published to date include:

- biodiversity accounts using data from the **NSW Biodiversity Offsets Scheme** and the prior Biobanking Scheme
- soil condition and land use accounts
- soil carbon accounts.

The NSW Government is also developing an experimental marine ecosystem account and several pilot accounts in the Hunter Functional Economic Region.

Biodiversity targets

Australia is a party to the United Nations Convention on Biological Diversity (CBD), a global treaty for conserving biodiversity, the sustainable use of its components and the equitable sharing of benefits from using its genetic resources.

In 2022, the 15th Conference of the Parties to the Convention (**COP15**) adopted the **Kunming–Montreal Global Biodiversity Framework** (GBF).

Among the framework's key elements are four goals for 2050 and 23 targets for 2030, including the **30 by 30 target** whereby governments commit to designate 30% of earth's land and ocean area as protected areas by 2030.

As a party to the CBD, Australia is required to have a national biodiversity strategy and action plan that outlines how it will contribute to the GBF. The current plan, ***Australia's Strategy for Nature 2024–2030***, commits to a suite of nationally agreed **biodiversity targets**. The strategy recognises that the decline of Australia's biodiversity is a source of systemic risk for the economy. It also recognises a need to develop options for measuring of natural capital and ecosystem services through national environmental-economic accounts (**DCCEEW-Aus 2024**).

The Australian government is working with states and territories to deliver the plan. This will include efforts to incorporate biodiversity considerations into government and business decision-making in NSW (**DCCEEW-Aus 2024**).

With natural capital accounts, used to measure progress against biodiversity targets and the ecosystem services provided as a result, it is possible to determine the economic impact of achieving targets.

See the **Protected areas and conservation**, **Plants** and **Animals** topics for more information.

Transitioning to a circular economy

The ***NSW 2040 Economic Blueprint*** identified that one of the 'megatrends' shaping the State's economic future over the next 20 years is the need to change the way we produce and consume goods and services to reduce our impact on the environment (**NSW Treasury 2019**).

NSW is transitioning to a circular economy over the next 20 years (**NSW EPA 2024b**). A circular economy is an economic system aimed at minimising waste and promoting the continual reuse of resources.

The circular economy aims to keep products, equipment and infrastructure in use for longer, thus improving the productivity of these resources. This regenerative approach contrasts with the traditional linear economy, which has a 'take, make, dispose' model of production. Examples of circular processes include:

- designing products that last longer and can be easily repaired
- using recycled materials in manufacturing
- repairing household goods before buying new ones
- ensuring the materials used in a product are still valuable for other purposes when consumers have finished using it.

The **CSIRO** reports that Australia's circularity rate is close to 4%, which is half the global average of 8% (**Miatto et al. 2024**).

Circular economy initiatives underway in NSW and Australia include:

- reviewing the **waste levy** – exploring how adjustments to the operation of the waste levy could reinvigorate the incentive to recycle while minimising impacts on cost-of-living and making it easier for waste operators to do the right thing
- enhancing the NSW resource recovery framework – responding to recommendations contained within the ***Independent Review of the NSW Resource Recovery Framework*** to ensure regulatory settings and requirements are fit for purpose to enable circular economy in NSW
- expanding the ***Return and Earn*** scheme – accepting more types of beverage containers, including glass wine and spirit bottles and larger containers
- setting up new and expanded **product stewardship schemes** – these are key enablers of a circular economy approach because they provide incentives for businesses to design products with reduced environmental and social impacts, and encourage reuse and recycling. They can include financial or other incentives to avoid waste.

See the **Waste and recycling** topic for more information.

Sustainable finance

Sustainable finance is the integration of environmental, social and governance (ESG) matters into economic and financial decision-making. **Sustainable finance** can be used as a tool to promote sustainable economic growth.

For example, the **NSW Sustainability Bond Programme** allows investors to finance a range of green and social projects, such as low carbon transport, sustainable water and wastewater management, affordable housing, affordable basic infrastructure and access to essential services.

Australia is party to the **Paris Agreement**. Part of the agreement includes working to make finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development (**AdaptNSW n.d.**).

Read more about Australia's international cooperation on **climate finance projects**.

See the **Net Zero Plan Stage 1: 2020–2030** for more information.

Australian sustainable finance roadmap

The **Australian Sustainable Finance Institute** has released a **Sustainable Finance Roadmap**, to realign the Australian financial services system so that more money flows to activities that will create a sustainable, resilient and inclusive Australian economy (**ASFI 2020**).

The roadmap sets out sustainable finance reforms and related measures, including:

- **mandatory climate-related financial disclosure requirements** for large businesses and financial institutions
- developing an **Australian sustainable finance taxonomy**
- improving market supervision and enforcement of governance and disclosure standards
- identifying and responding to financial risks, for example through **climate vulnerability assessments**
- issuing Australian sovereign **green bonds**.

NSW environmental, social and governance review

Responsible investment involves considering environmental, social and governance issues when making investment decisions and influencing companies or assets (known as active ownership or stewardship).

A 2022 **review of State Government investment funds** looked at how funds managed by NSW Treasury Corporation on behalf of NSW Government entities, considered environmental, social and governance principles.

It also examined how the NSW Government processes and practices could be improved while promoting a better future and a resilient economy.

Priority recommendations from this review included:

- further developing decarbonisation and net zero approaches
- comprehensive public reporting
- clearer guidance on environmental, social and governance expectations.

A **response to the review** was published in 2023.

Sustainability disclosures

Sustainability disclosures are a way for organisations to report and act on their sustainability risks and opportunities, including environmental, social and governance risks.

Sustainability disclosure frameworks include:

- climate-related financial disclosures
- nature-related financial disclosures
- inequality and social-related financial disclosures.

There is a growing momentum behind improving sustainability-related disclosures, including climate-related and nature-related financial disclosures. These disclosures can provide valuable insights into current practices impacting the environment, add to the recognition of natural capital as a valuable asset category, and be a catalyst for investment in natural capital and nature positive initiatives. They can also highlight the economic and financial risks associated with depleting and degrading the environment.

The Australian Government has passed legislation to mandate **sustainability reporting** for large companies from January 2025. This will provide Australians and investors with greater information and certainty when it comes to considering their climate-related plans, financial risks and opportunities.

Mandatory climate-related financial disclosure requirements are expected to reduce greenwashing, as reporting climate-related information will become more standardised and transparent (**ASIC 2024**).

In NSW, **Treasury's annual report framework** requires government entities to include 'sustainability' as a mandatory heading in annual reports.

Disclosure information could also provide better understanding of how economic activity in one state may impact the environment in other parts of the country or overseas.

The increasing adoption of natural capital accounts also presents an opportunity to provide credible underpinnings for nature-related and climate-related financial disclosures, supporting benchmarking for the development of nature repair and restoration markets to operate with integrity.

The emergence of **inequality and social-related financial disclosures** will also encourage businesses to improve the identification, assessment and reporting of social and inequality issues. There is a strong relationship between the environmental, economic and social aspects of sustainable development (**TISFD 2024**).

Climate-related financial disclosure

Climate-related financial disclosure is a reporting framework that organisations can use to identify and understand climate-related issues that influence how they do business.

Disclosures are structured around four thematic areas that represent core elements of how business and entities operate:

- governance
- strategy
- risk management
- metrics and targets.

The information is released (disclosed) publicly. The aim of this reporting is to increase transparency and accountability about the impacts of climate-related risks and opportunities on business strategies, financial planning and organisational management.

It is complemented by the final recommendations of the **Taskforce on Climate-related Financial Disclosures**, which, together with other guidance documents, provides a framework to support corporate reporting.

In Australia, climate-related financial disclosures will be **mandatory from 1 January 2025**, for many large Australian businesses and financial institutions. These businesses will be required to disclose information about climate-related risks and opportunities that could reasonably be expected to affect the entity's cash flows, its access to finance or cost of capital over the short, medium or long term, in line with **Australian Sustainability Reporting Standards**. These requirements will be phased in for other businesses during 2026 and 2027.

For NSW Government entities, NSW Treasury has issued **guidelines** setting out minimum requirements for disclosing public sector entities' material climate-related risks and opportunities, including the actions entities are taking to manage these issues.

NSW Government agencies will implement these requirements in a staged approach. Pilot statements have already been released by NSW National Parks and Wildlife Service, Essential Energy and NSW Environment Protection Authority.

The NSW reporting framework is closely informed by the **Australian Sustainability Reporting Standards**, developed by the Australian Accounting Standards Board, with some modifications to reflect NSW Government circumstances and reporting entity capability and capacity.

See the **Net Zero Plan Stage 1: 2020–2030** for more information.

Nature-related financial disclosure

Nature-related financial disclosure is a reporting framework that organisations can use to identify and understand nature-related issues that are connected to how they do business.

These issues fall into four categories:

- dependencies – how the organisation depends on nature (for example, it may need water for processing materials)
- impacts – that the organisation causes or contributes to (such as pollution)
- risks – to the organisation that result from their dependencies and impacts (such as fines or loss of reputation)
- opportunities – to benefit nature and to mitigate negative impacts (for example, bush restoration after a mining operation).

The information is released (disclosed) publicly. The aim of this reporting is to increase transparency and accountability about nature-related risks and opportunities and encourage nature positive outcomes.

This reporting is supported by the **Global Biodiversity Framework**. The framework's **Target 15** is a key driver, committing signatories, including Australia, to ensure that businesses monitor, assess and disclose their biodiversity impacts.

It is complemented by the final recommendations of the **Taskforce on Nature-related Financial Disclosures** (TNFD) which, together with other guidance documents, provides a voluntary, market-led framework to support corporate reporting.

The Australian Government has published the **TNFD Pilots – Australian case study report** to help organisations undertaking TNFD-aligned risk and opportunity assessments. The report details how piloting Australian businesses approached their assessments.

The TNFD framework is currently voluntary, noting the Australian Government has outlined its intention to improve market supervision and enforcement as part of the **Sustainable Finance Roadmap**.

Future opportunities

Environmental markets for nature positive outcomes

There is an emerging emphasis on nature positive outcomes, where nature is being repaired and regenerated, and biodiversity decline is halted and reversed.

Viewing nature as a valuable collection of assets highlights the need to *invest* in nature, as opposed to simply *conserving* it.

Increasing investment in nature positive initiatives is being driven by several factors.

The first is the move towards legislated nature markets, such as the Commonwealth **Nature Repair Market** underpinned by the ***Nature Repair Act 2023***. Such markets are not designed around regulatory compliance but instead are designed to foster voluntary investments in actions to increase and improve natural capital.

Nature investments are expected to be increasingly relied on in the future for natural capital replacement, restoration and improvement, as the quantum of investment required is likely to far exceed the capacity of government to take sole responsibility.

For example, several attempts have been made to identify and quantify the funding requirements likely to be needed to meet restoration and improvement targets, globally (**Financing Nature: Closing the Global Biodiversity Financing Gap - Paulson Institute**) and for Australia (**Blueprint to Repair Australia's Landscapes**).

The Australian and NSW Governments jointly hosted the **Global Nature Positive Summit** in October 2024, to help build momentum towards increasing investment in nature, and repairing and restoring natural environments. The forum connected decision-makers from across sectors on:

- economic settings needed to increase investment in nature
- best practice and pathways for program implementation
- innovative tools and approaches underway in Australia and the Pacific that enable nature positive outcomes.

Taking action to repair nature

The Australian Government has set out its commitment to reform the *Environment Protection and Biodiversity Conservation Act 1999* to deliver better environmental protections that support nature positive initiatives through its **Nature Positive Plan: better for the environment, better for business**.

In NSW, two recent statutory reviews considered the State's primary biodiversity laws: the ***Biodiversity Conservation Act 2016*** and the native vegetation provisions of the ***Local Land Services Act 2013***.

In July 2024, the NSW Government released its response to the reviews, ***NSW plan for nature***. The plan aims to:

- reform the biodiversity offsets scheme
- end excess land clearing
- strengthen environmental protections.

It also outlines the legislative, policy and program directions the NSW Government commits to take to respond to the statutory reviews and deliver on its commitments.

The reviews and the plan focus on the performance of the **Biodiversity Offsets Scheme**, and opportunities for investment in natural capital and the development of a voluntary market to improve biodiversity outcomes.

Under the plan, the NSW Government has piloted and implemented a natural capital accounting framework and launched the **Natural Capital Accounting Hub**.

The NSW Government has also committed to work with the Australian Government on the development of the national **Nature Repair Market** and national carbon market, and design NSW natural capital programs and projects to leverage national schemes.

The Nature Repair Market, underpinned by the *Nature Repair Act 2023*, is an Australian government initiative to restore and protect the environment. It encourages nature positive land management practices that deliver improved biodiversity outcomes (**DCCEEW-Aus n.d.-b**).

The scheme establishes a marketplace where individuals and organisations can undertake nature repair projects to generate a tradeable certificate (**DCCEEW-Aus n.d.-b**). The market is expected to open in 2025.

Climate change

Climate change will increase stress on ecosystem services and have a significant effect on many activities. These include agriculture, forestry, fisheries, water security, energy security, infrastructure, transport, health, tourism, finance and disaster risk management.

The World Economic Forum's ***Global Risks Report 2024*** identified extreme weather as one of the top risks most likely to present a material crisis (**WEF 2020**). Biodiversity loss and ecosystem collapse have also been consistently ranked as mid- to high-level global risks in previous reports.

The ***Australian National Outlook 2019*** report shows that stronger action on environmental measures does not necessarily come at the expense of economic outcomes (**CSIRO 2019**).

See the **Climate change** topic for more information.

Impact of climate change on the NSW economy

The health of the NSW economy is strongly linked to the environment and the natural resources and ecosystem services it provides. Climate change is already affecting the NSW economy and will continue to do so.

The ***2021–22 NSW Intergenerational Report*** is a snapshot of the future to inform future policies (**NSW Treasury 2022**). The report projects 40 years ahead to 2061 to understand how the State's population, economy and finances may change based on global and local trends and current policies.

The report findings include:

- Climate change is likely to increase the risk of extreme weather events such as bushfires and floods, having a significant impact on livelihoods and the State's productivity (**NSW Treasury 2022**).
- More frequent and severe natural disasters could cost NSW between $15.8 billion and $17.2 billion per year on average by 2060–61 (**NSW Treasury 2022**).
- If climate change is more severe than expected and temperatures increase by 2.8°C by 2060–61, the NSW economy would lose $4.5 billion in annual income by 2060–61 compared to the moderate warming scenario (**NSW Treasury 2022**).
- If warming is limited to a 1.5°C increase, total economic income in NSW would be $3.8 billion higher every year by 2060–61 (**NSW Treasury 2022**).

There could also be significant costs from rising sea levels, heatwaves and the impact of changing climatic conditions on agricultural production.

This has flow-on effects on the economy, such as:

- changes to the productivity of primary industries, including fisheries and aquacultures, due to increasing ocean temperatures and marine heatwaves (**Fulton et al. 2018**)
- reduced agricultural output in the Murray–Darling Basin due to extreme weather events, such as droughts, heatwaves, cyclones and floods (**AdaptNSW n.d.**)
- property loss and damage, increased infrastructure and service costs, and risks to financial stability (**AdaptNSW n.d.**)
- impacts on health and wellbeing, which can affect people's ability to work and contribute to society and increase demand for healthcare services (**AdaptNSW n.d.**)
- damage to critical infrastructure, affecting transport, electricity, water, telephone and Internet services, which can disrupt businesses and delivery of services (**AdaptNSW n.d.**)

- changes in land use, the change in seasonal conditions, such as increasing temperature and changed rainfall patterns may render the land unsuitable for agriculture (**Moore et al. 2021**).

See the **Climate change** and **Extreme climate and weather** topic for more information.

References

ABS 2020, *Waste Account, Australia, Experimental Estimates, 2018–19 financial year*, Australian Bureau of Statistics, Canberra

ABS 2023a, Table 1. Gross State Product, Chain volume measures and current prices, Australian Bureau of Statistics, Accessed 21 August 2024

ABS 2023b, Table 2. Expenditure, Income and Industry Components of Gross State Product, New South Wales, Chain volume measures and current prices, Australian Bureau of Statistics, Accessed 21 August 2024

ACCC n.d., Environmental and sustainability claims, Australian Competition and Consumer Commission, accessed 1 November 2024

AdaptNSW n.d., Climate change impacts on our economy, AdaptNSW, accessed 7 August 2024

ASFI 2020, *Australian Sustainable Finance Roadmap: a plan for aligning Australia's financial system with a sustainable, resilient and prosperous future for all Australians*, Australian Sustainable Finance Initiative, Melbourne

ASIC 2024, Greenwashing: A view from the regulator, Australian Securities and Investments Commission, accessed 1 November 2024

Barbier EB 2019, 'The concept of natural capital', *Oxford Review of Economic Policy*, vol. 35, no. 1, pp.14–36, DOI: 10.1093/oxrep/gry028

CSIRO 2019, Australian National Outlook, Commonwealth Scientific and Industrial Research Organisation, accessed 6 December 2024

DCCEEW-Aus 2024, *Australia's Strategy for Nature 2024–2030*, Australian Government Department of Climate Change, Energy, the Environment and Water, Canberra

DCCEEW-Aus n.d.-a, Natural Capital Accounts, Australian Government Department of Climate Change, Energy, the Environment and Water, accessed 6 December 2024

DCCEEW-Aus n.d.-b, Nature Repair Market, Australian Government Department of Climate Change, Energy, the Environment and Water, accessed 6 December 2024

DPE 2022, *NSW Natural Capital Statement of Intent: Recognising the value of nature*, NSW Department of Planning and Environment, Sydney

Erlich PR 1968, 'The Population Bomb (1968)' in Robin L, Sörlin S & Warde P (eds), *The Future of Nature: Documents of Global Change*, Yale University Press, New Haven, pp. 54–62, DOI: 10.12987/9780300188479-007

Fulton EA, Hobday AJ, Pethybridge H, Blanchard J, Bulman C, Butler I, Cheung W, Gorton B, Hutton T, Lozano-Montes H, Matear R, Pecl G, Villanueva C & Zhang X 2018, *Decadal scale projection of changes in Australian fisheries stocks under climate change*, Fisheries Research and Development Corporation and Commonwealth Scientific and Industrial Research Organisation

Levinson A 2015, Does economic growth reduce pollution?, World Economic Forum, accessed 1 November 2024

Macintosh A, Butler D, Larraondo P, Evans MC, Ansell D, Waschka M, Fensham R, Eldridge D, Lindenmayer D, Gibbons P & Summerfield P 2024, 'Australian human-induced native forest regeneration carbon offset projects have limited impact on changes in woody vegetation cover and carbon removals', *Communications earth & environment*, vol. 5, 149, DOI: 10.1038/s43247-024-01313-x

Miatto A, Schandl H & Dowse J 2024, *Australian material flow analysis to progress to a circular economy*, Commonwealth Scientific and Industrial Research Organisation, Australia

Moore CE, Meacham-Hensold K, Lemonnier P, Slattery RA, Benjamin C, Bernacchi CJ, Lawson T & Cavanagh AP 2021, 'The effect of increasing temperature on crop photosynthesis: from enzymes to ecosystems', *Journal of Experimental Botany*, vol. 72, no. 8, pp. 2,822–44, DOI: 10.1093/jxb/erab090

NSW EPA 2024a, 2022–23 litter data for NSW, NSW Environment Protection Authority, accessed 1 November 2024

NSW EPA 2024b, Sydney landfill shortage, NSW Environment Protection Authority, accessed 1 November 2024

NSW Treasury 2019, *NSW 2040 Economic Blueprint*, NSW Treasury, Sydney (PDF 12.5MB)

NSW Treasury 2022, *2021–22 NSW Intergenerational Report*, NSW Treasury, Sydney

OECD 2021, 'Biodiversity, natural capital and the economy: A policy guide for finance, economic and environment ministers', *OECD Environment Policy Papers, No. 26*, Organisation for Economic Co-operation and Development Publishing, Paris

TISFD 2024, *People in scope: An overview of the proposed scope, approach, governance structure, and work plan of the Taskforce on Inequality and Social-related Financial Disclosures*, Taskforce on Inequality and Social-related Financial Disclosures

UN 2014, *System of Environmental – Economic Accounting 2012: Central Framework*, United Nations, New York

UNEP 2011, *Decoupling natural resource use and environmental impacts from economic growth, A Report of the Working Group on Decoupling to the International Resource Panel*, United Nations Environment Programme, Nairobi, Kenya

Vadén T, Lähde V, Majava A, Järvensivu P, Toivanen T, Hakala E & Eronen JT 2020, 'Decoupling for ecological sustainability: A categorisation and review of research literature', *Environmental science & policy*, vol. 112, pp. 236–44, DOI: 10.1016/j.envsci.2020.06.016

Ward JD, Sutton PC, Werner AD, Costanza R, Mohr SH & Simmons CT 2016, 'Is Decoupling GDP Growth from Environmental Impact Possible?', *PLoS ONE*, vol. 11, no. 10, e0164733, DOI: 10.1371/journal.pone.0164733

WEF 2020, Half of World's GDP Moderately or Highly Dependent on Nature, Says New Report, World Economic Forum, accessed 2 August 2024

Weir DR 1991, 'Malthus's Theory of Population' in Eatwell J, Milgate M & Newman P (eds), *The World of Economics*, The New Palgrave, Palgrave Macmillan, London, pp. 401–6, DOI: 10.1007/978-1-349-21315-3_52

Williams SJ & Taylor R 2021, *Sustainability and the new economics* (Edition), Springer, Cham

World Bank 2021, *The Changing Wealth of Nations 2021: Managing Assets for the Future*, World Bank, Washington, DC

This page intentionally
left blank

Appendices

This page intentionally left blank

NSW biogregions

Land bioregions

The 18 bioregions in NSW cover a wide diversity of landscapes. NSW has a total area of 80,160,000 hectares. Eighteen of the 89 Australian bioregions are represented in NSW, but only two of these 18 bioregions, Cobar Peneplain and NSW North Coast, lie wholly within the NSW boundary. The other 16 are shared with the bordering states and territories.

The diversity of NSW landscapes is evident in the wide range of the state's bioregions, see **Tabled BR.1**.

Western NSW

- Sandy deserts – Simpson-Strzelecki Dunefields, Channel Country, Murray–Darling Depression
- Riverine plains – Riverina, Darling Riverine Plains
- Rocky ranges – Mulga Lands, Broken Hill Complex
- Rolling downs – Cobar Peneplain.

Eastern NSW

- Lush rainforests – NSW North Coast, South East Corner, South East Queensland
- Rugged mountains – Sydney Basin, New England Tableland, Australian Alps, South Eastern Highlands
- Undulating ranges – Brigalow Belt South, Nandewar
- Fragile, wooded grasslands – NSW South Western Slopes.

Table BR.1: NSW bioregions and the proportion of each in NSW		
IBRA Region Name	**IBRA Area in NSW (ha)**	**% Percentage of bioregion in NSW**
Australian Alps (AUA)	464,034	37.64
Brigalow Belt South (BBS)	5,623,054	20.66
Broken Hill Complex (BHC)	3,766,741	66.84
Channel Country (CHC)	2,335,604	7.68
Cobar Peneplain (COP)	7,385,346	100.00
Darling Riverine Plains (DRP)	9,413,084	87.97
Mulga Lands (MUL)	6,581,779	26.13
Murray Darling Depression (MDD)	7,949,169	39.83
Nandewar (NAN)	2,072,816	76.71
New England Tablelands (NET)	2,857,082	95.17
NSW North Coast (NNC)	3,996,591	100.00
NSW South Western Slopes (NSS)	8,114,379	93.47
Riverina (RIV)	7,030,950	72.45
Simpson Strzelecki Dunefields (SSD)	1,094,314	3.91
South East Corner (SEC)	1,206,479	47.65
South Eastern Highlands (SEH)	4,945,318	59.04
South Eastern Queensland (SEQ)	1,655,317	21.21
Sydney Basin (SYB)	3,622,939	99.82
Total	**80,115,007**	

Notes:
Area is based on calculated GIS_AREA data. GIS_AREA is the area in hectares based on current spatial data and an Albers equal area projection for Australia.

Source:
OEH 2021

Marine bioregions

There are six bioregions in NSW – five off the coast and one surrounding Lord Howe Island, **Aquatic reserves**.

The 5 adjacent bioregions are defined by the Integrated Marine and Coastal Regionalisation of Australia (IMCRA), **A Guide to the Integrated Marine and Coastal Regionalisation of Australia version 4.0**. The guide is dated June 2006.

As seen in **Map BR.1**, the five bioregions are (north to south):

- Tweed-Moreton

- Manning Shelf
- Hawkesbury Shelf
- Batemans Shelf
- Twofold Shelf.

Map BR.1: Map of the five bioregions along NSW coastline

Notes:
Cropped and edited original map for web format.

Source:
Australian Marine Conservation Society

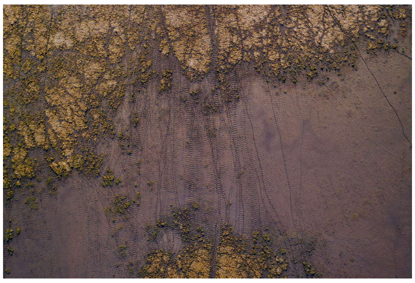
Photo and artistic credits

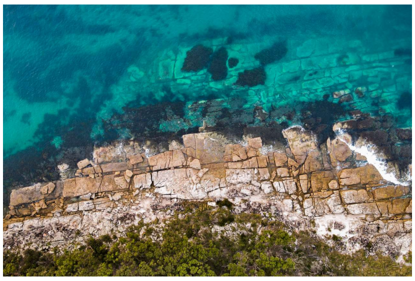
Across the website, photo credits are now available directly on each topic page. As part of the NSW Environment Protection Authority's (EPA) ongoing commitment to Aboriginal peoples, from 2024, all image banners include acknowledging the traditional Country name.

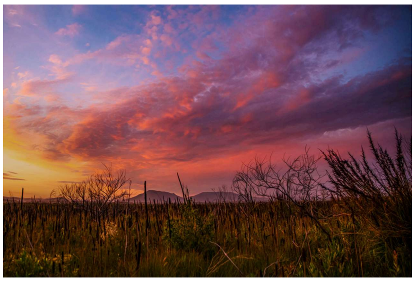
The EPA acknowledges the contribution of many government employees who have willingly shared personal photos that capture various Country from across our diverse state.

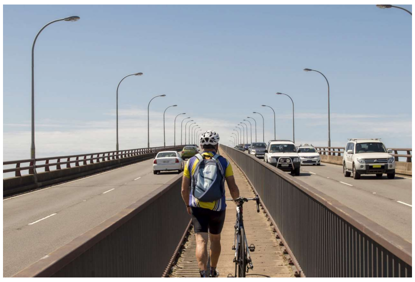
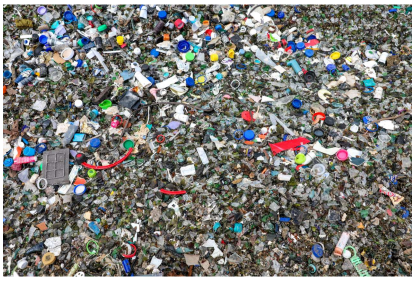
See **Figure A.1** for all photographs and artwork used in the 2024 report, as per their order in the Tabled Report.

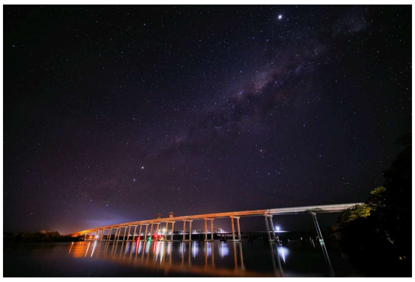
Figure A.1: Photographs and artwork included in SoE 2024

Location	Photo and artwork credit	Thumbnail
Homepage: **NSW State of the Environment**	Tim Johnson/NPWS (2020). Sunset view at Mt Hay with grass trees (Xanthorrhoea) in the foreground. Blue Mountains National Park. Dharug. Staff contribution. Image copy on Tabled report cover has been lightened for printing purposes.	
Page banners (background)	Gerard Black (2024). *Butjin Wanggal* (Dilly bag dance). NSW EPA commissioned artwork. This altered version has been prepared specifically for this report. See **Artwork** on **Acknowledgements** for learn more from the artist and artwork.	
Soil condition	**Current & 2021 tab**: Stuart Murphy (2020). Aerial view of Clarence floodplain backswamp showing kangaroo tracks. Clarence floodplain. Bundjalung. Special conditions apply to the use of this staff contributed image. **2018 tab**: John Spencer/EPA (2017). Aerial view of paddocks adjacent to bush in the Narrabri area. Accessed from EPA Image Library.	
Protected areas and conservation	**Current & 2024 tab**: Hao Li/DCCEEW (n.d.). Mungo National Park. Paakantji, Ngyiampaa and Mutthi Mutthi lands. Supplied by NSW EPA. **2021 tab:** Brian Rosenberg/DPIE (2017). Snow on Rams Head north. DPIE staff contribution. **2018 tab**: John Spencer/OEH (2012). Honeysuckle Forest track, Barrington Tops National Park. Accessed from OEH Image Library.	
Rivers and wetlands	**Current & 2024 tab**: John Spencer/DCCEEW (n.d.). Macquarie Marshes. Wailwan. This topic structure is new in 2024 – previously split between **River Health 2021** and **Native Fauna 2021** and **Invasive Species 2021**. See **Previous topics** below for further banner credits.	

Location	Photo and artwork credit	Thumbnail
Groundwater	**Current, 2024 & 2021 tabs**: Water efficiency team/DPIE (2020). Aerial photo of artesian bore to be replaced and plugged under IGABDR program in 2021 south of Moree. Gamilaroi. DPIE staff contribution. **2018 tab**: John Spencer/EPA (2017). Aerial view of dam irrigation storage ponds adjacent to ploughed land. Accessed from EPA Image Library.	
Coastal and marine	**Current & 2024 tab**: Silvan Bluett/DPIE (2021). Aerial image of coast meeting land at Turtle Row. Beecroft Peninsular. Yuin. **2021 tab**: Stuart Murphy/EPA (undated). Beach aerial photo with boat floating in shallow water. Special conditions apply to the use of this staff contributed image. **2018 tab**: John Spencer/OEH (2014). Dolphins surfing the ocean swell near Nadgee Nature Reserve. Accessed from OEH Image Library.	
Air quality	**Current, 2024 & 2021 tabs**: Brian Rosenberg/DPIE (2017). Grazing pastures in Millthorpe. Wiradjuri. DPIE staff contribution. **2018 tab**: EPA (2018). View from a plane over Blue Mountains – smoke from hazard reduction burns. Accessed from EPA Image Library.	
Greenhouse gas emissions	**Current, 2024 & 2021 tabs**: John Spencer/EPA (2016). Powerplant pictured across water. Muswellbrook. Wonnarua. Accessed from EPA Image Library. **2018 tab**: John Spencer/EPA (2016). Smoke stacks and powerplant at Muswellbrook. Accessed from EPA Image Library.	
Plants	**Current, 2024 tabs** (and used in **2021 tab** for **Fire 2021** topic) Genevieve Wright/DCCEEW (2020). Grass trees and Eucalypts re-sprout following the 2020 bushfires in Mt Imlay. Bidwell. DPIE staff contribution. This topic structure is new in 2024 – previously split between **Threatened Species 2021**, **Invasive Species 2021** and **Native Vegetation 2021**. See **Previous topics** for further banner credits.	

Location	Photo and artwork credit	Thumbnail
Animals	**Current & 2024 tabs**: Mick Bettanin/DPI (2021). New Holland honeyeater (Phylidonyris novaehollandiae) enjoying a rain shower. Aislings Beach, Eden. Yuin. Staff contribution. This topic structure is new in 2024 – previously split between **Threatened Species 2021**, **Native Fauna 2021** and **Invasive Species 2021**. See **Previous topics** for further banner credits.	
Health of Country	**Current & 2024 tabs**: Naomi Clare/DCCEEW (n.d.) Sunset view across Crowdy Bay National Park. Biripi. Supplied by NSW EPA.	
Climate change	**Current, 2024 & 2021 tabs**: Victoria Seeck/EPA (2021). View of dry paddock with windmill and water tank, Hay. Wiradjuri. EPA staff contribution. **2018 tab**: Michael Jarman/OEH (2009). Trees in bushfire at Murramarang National park. Accessed from OEH Image Library.	
Extreme climate and weather	**Current & 2024 tabs**: Greg West/DPI (2021). Lightning at Port Stephens. Boat Harbour, Port Stephens. Worimi. Special conditions apply to the use of this staff contributed image.	
Net Zero Plan Stage 1: 2020–2030	**Current & 2024 tabs**: Neil Fenelon/DPE (2015). View across solar farm with sun behind stormy clouds, Moree. Gamilaroi. Access from NSW Planning Image Library. **2021 tab**: EPA (2018). View from a plane over Blue Mountains – smoke from hazard reduction burns. Accessed from EPA Image Library.	

Location	Photo and artwork credit	Thumbnail
Energy consumption	**Current, 2024 & 2021 tabs**: John Spencer/EPA (2016). Morning light on Newcastle Industry. Awabakal. Accessed from EPA Image Library. **2018 tab**: Caz Nowaczyk/EPA (2017). Night time view across the Illawarra from Mount Keira, showing residential and industrial lights. Accessed from EPA Image Library.	
Transport	**Current, 2024 & 2021 tabs**: John Spencer/EPA (2016). Cyclist walking over bridge with bike, Newcastle. Awabakal. Accessed from EPA Image Library. **2018 tab**: John Spencer/EPA (2016). Cars, trucks and bus on four lane highway near Newcastle Port. Accessed from EPA Image Library.	
Water use	**Current, 2024 & 2021 tabs**: Martin Asmus/DPI (2020). Hay Weir, Murrumbidgee River. Nari Nari. DPI staff contribution. **2018 tab**: Phil Molyneaux/EPA (undated). Bales of crushed steel cans at a waste recycling facility. Accessed from EPA Image Library.	
Waste and recycling	**Current & 2024 tab**: Nick Ryan/EPA (2020). Lismore waste sorting facility post floods. Bundjalung. Access from EPA Image Library. **2021 tab**: Evolving Images/EPA (2013). Man working at MRF: Materials Recycling Facility. Bundjalung. Accessed from EPA Image Library. **2018 tab**: Bottlebrush Media/EPA (2017). Close up of contaminated soil being sampled. Accessed from EPA Image Library.	
Contaminated sites	**Current & 2024 tabs:** Bottlebrush Media/EPA (2017). Close up of contaminated soil being sampled. Dharug. Accessed from EPA Image Library. **2021 tab:** Sarah Ryan/EPA (2017). Treated effluent liquid moving through stages at a water recycling plant. Accessed from EPA Image Library. **2018 tab**: EPA (2015). Gaswork remediation site. Accessed from EPA Image Library.	

Location	Photo and artwork credit	Thumbnail
Population and the environment	**Current & 2024**: John Spencer/EPA (2017). Aerial view of a residential area in Sydney. Dharug. Accessed from EPA Image Library. **2021 tab**: Roger Laird/DPI (2012). Oblique aerial photograph showing Sydney's Bondi Beach, residential and high-rise development. DPI staff contribution. **2018 tab**: John Spencer/EPA (2017). Aerial view of a residential area in Newcastle. Accessed from EPA Image Library.	
Economic activity and the environment	**Current & 2021 tabs**: Stephen Ward/DPI (2020). New road bridge over the Clarence River. Harwood. Bundjalung and Gumbaynggirr. DPIE staff contribution. **2018 tab**: Sarah Ryan/EPA (2017). Waterfront in Wollongong showing recreational activity and tourist development. Accessed from EPA Image Library.	

Notes:
The EPA is on a journey to inclusiveness of Aboriginal people and cultures, and notes the names of traditional Country may be contestable. These names demonstrate the EPA's commitment, but should not be regarded as fact.

Previous topics

In 2024, some topics were merged and no longer follow the same structure. The closest matched topic retains its link to the current tab. Please see credits for past banners below.

Invasive species

2021 tab: Brian Rosenberg/DPIE (2021). Senicio weeds near Millthorpe. DPIE staff contribution.
2018 tab: John Yurasek/OEH (2012). Lantana. Timber detail of buildings, part of the Arndell family homestead built in 1821, Cattai National Park. Accessed from OEH Image Library.

Native fauna

2021 tab: Brian Rosenberg/DPIE (2020). Crimson rosella (*Platycercus elegans*) near Cowrigga, NSW. DPIE staff contribution.
2018 tab: John Yurasek/OEH (2012). Goanna in Bouddi National Park. Accessed from OEH Image Library.

Native vegetation

2021 tab: Greg West/DPI (2019). Rainforest floor view within Barrington Tops National Park. DPI staff contribution.
2018 tab: Brent Mail Photography/EPA (2017). Straight red gums captured with forest floor in background. Accessed from EPA Image Library.

River health

2021 tab: Martin Asmus/DPI (2020). Drowned trees in Hay Weirpool, Murrumbidgee River. DPIE staff contribution.
2018 tab: Gavin Hansford/OEH (2013). Kayakers on the Murrumbidgee River. Accessed from OEH Image Library.

Threatened species

2021 tab: Jennifer O'Meara/Sydney Olympic Park (2020). Juvenile endangered Green and Golden Bell Frog observed in the Brickpit - part of extensive threatened species habitat managed by the Sydney Olympic Park Authority in a long-term commitment to bell frog conservation. DPIE staff contribution.

2018 tab: John Spencer/OEH (2014). A pair of Glossy black-cockatoos (*Calyptorhynchus lathami*) sit on a tree branch at Captain Cook's Lookout in Hat Head National Park. Accessed from OEH Image Library.

Wetlands

2021 tab: Jo Erskine/NPWS (2020). Aerial photo over Tomago Wetlands. DPIE staff contribution.

2018 tab: John Spencer/OEH (2012). Seaham Swamp Nature Reserve. Accessed from OEH Image Library.

Indicator guide

What are indicators?

NSW State of the Environment 2024 assesses the status and trends of each of 77 environmental indicators, along with the reliability of the information used to provide an indicator rating. See **Table IG.1** for an example of a topic's indicator table.

See the **Indicator summary** page for the full list of indicators in this report.

Table IG.1: Example of a topic's indicator table

Indicator	Environmental status	Environmental trend	Information reliability
Ozone (O_3)	MODERATE	Stable	Good
Carbon monoxide (CO)	GOOD	Stable	Good

Notes:
Indicator table scales:
- **Environmental status**: Good, moderate, poor, unknown
- **Environmental trend**: Getting better, stable, getting worse.
- **Information reliability**: Good, reasonable, limited.

See **Indicator guide** to learn how terms and symbols are defined.

Indicator tables appear in all 2024 topics' **Status and trends** section, except for the following topics: **Voice of Country** (and sub pages), **Extreme climate and weather**, **Population and the environment** and **Economic activity and the environment**.

Indicator status

'Indicator status' refers to the environmental condition of the indicator. It is based on new information or data from the reporting period between the previous and current State of the Environment reports. See **Table IG.2** for the interpretation of each indicator status.

Table IG.2: Indicator status icons and interpretation

Indicator rating	Interpretation
GOOD	**Green:** Good – the data shows a positive or healthy environmental condition.
MODERATE	**Blue:** Moderate – the data shows that the environmental condition is neither good nor poor, or results may be mixed.
POOR	**Red:** Poor – the data indicates poor environmental condition or condition under significant stress.
UNKNOWN	**Grey:** Unknown – insufficient data or information is available to make an assessment.

Notes:
Indicator statuses are assessed by NSW EPA, based on the data provided each.

Indicator trend

'Indicator trend' describes the direction of significant change in environmental condition. The trend takes the new 'status' information and previous data into account, whenever possible, to help understand the level of background variation that may be present.

The trend reported, if maintained, may have an impact on the overall status of the indicator in the future. See **Table IG.3** for interpretations of indicator trends.

Table IG.3: Indicator trend and reliability	
Indicator trend	Interpretation
Getting better	The trend in environmental condition for the indicator is clearly improving (environmental impacts are decreasing). While a trend may be positive in direction, it may still be many years before the change is enough to warrant a revision to the status.
Stable	No significant change in condition is evident, usually allowing for some level of fluctuation due to the background variability that occurs in most naturally occurring systems.
Getting worse	The trend in environmental condition for the indicator is clearly deteriorating (environmental impacts are increasing).
Unknown	Insufficient data available over time to provide an accurate trend.

Notes:
Indicator trends are assessed by NSW EPA.

Indicator reliability

'Indicator reliability' describes the level of confidence in the data or information used to make these assessments. It considers the statewide extent of data coverage, the accuracy and 'fitness for use' of the data and the reliability of the information and its interpretation in assessing the status and trend for the indicator.

This is represented in **Table IG.4**.

Table IG.4: Indicator reliability and interpretation	
Indicator reliability	Interpretation
Good	The data or information is sufficient to interpret the outcome with confidence.
Reasonable	The data coverage may not be complete or the supporting information drawn on is not ideally fit for purpose (often it is collected for some other purpose) but is still adequate for use in this context and the interpretations are sound.
Limited	The data coverage is patchy and uneven in quality or there may be some inconsistencies in the supporting information, so caution is needed in considering the ratings and interpretations.
n/a	Insufficient information data to be reliable.

Notes:
Indicator reliability is assessed by NSW EPA.

Glossary

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

A

- **acid sulfate soils:** low-lying clays and sands near coastal or inland waters that contain sulfur-bearing compounds at concentrations above 0.05% in clays and 0.01% in sands, which produce sulfuric acid when drained or exposed to air, affecting surrounding waters and ecosystems
- **adaptation:** decisions and actions to manage risks and capture potential opportunities in response to climate change
- **air toxics:** gaseous, aerosol or particulate contaminants present in ambient air in trace amounts with characteristics (toxicity, persistence) which make them a hazard to human health, and plant and animal life
- **algal bloom:** dense and visible growth of algae in a waterbody, resulting from proliferation caused by increased nutrients (such as phosphorus) and/or warm weather, generally resulting in reduced oxygen availability in the water for other organisms and possibly release of toxic substances
- **alluvium:** clay, silt, sand, gravel or similar material deposited by running water, especially during recent geological time
- **anthropogenic:** produced or caused by human activity
- **aquaculture:** cultivation for commercial purposes of aquatic organisms including fish, molluscs and plants in fresh or salt water
- **aquifer:** rocks and porous sediments which hold and yield groundwater
- **atmosphere:** the mixture of gases surrounding a planet, such as the Earth
- **Australian Carbon Credit Units (ACCUs):** a tradable financial product, which represents a reduction in greenhouse gas emissions achieved through activities that store carbon or reduce emissions, such as reforestation, soil carbon management, and energy efficiency improvements. Each ACCU represents one metric tonne of carbon dioxide equivalent (CO_2-e) emissions avoided or removed from the atmosphere

B

- **ballast water**: water carried in tanks to maintain stability when a ship is lightly loaded and normally discharged to the sea when the ship is loaded with cargo
- **bioaccumulation:** the accumulation in an organism of substances such as pesticides or other chemicals, which occurs when the organism absorbs a substance known to have toxic effects at a faster rate than the substance is lost
- **biodiversity:** the variety of all life forms: the different plants, animals and microorganisms, the genes they contain and the ecosystems they form
- **biomass:** the total mass of living material occupying a specific part, or the whole of, an ecosystem at a given time
- **bioregion:** relatively large areas characterised by similar broad, landscape-scale natural features and environmental processes that influence the functions of ecosystems – these landscape patterns are linked to fauna and flora assemblages and processes at the ecosystem scale, providing a useful means for simplifying and reporting on more complex patterns of biodiversity
- **Biosecurity:** protecting the economy, environment and community from the negative impacts of pests, weeds and diseases
- **biota:** collectively, the plants, microorganisms and animals of a region
- **black water:** occurs naturally due to the breakdown of leaf litter, inundated crops and other vegetation which results in the release of tannins and lignin causing water discolouration and is associated with low dissolved oxygen levels
- **Black Summer bushfires:** one of the most intense and catastrophic fire seasons occurred in Australia from late 2019 to early 2020
- **bulk water:** water harvested, stored and transported before being provided to retail water supply systems
- **bycatch:** species taken incidentally in a fishery along with the target species; often discarded

C

- **calcitic:** in marine organisms, skeletons, shells, structures etc. that are based on calcium carbonate (calcite)

- **carbon credits:** certificates representing the reduction or removal of one tonne of carbon dioxide or equivalent greenhouse gases from the atmosphere. They are created through projects that reduce emissions, such as renewable energy, and can be bought and sold to help meet emission reduction targets. Projects earn one carbon credit for every tonne of carbon dioxide or carbon dioxide equivalent (CO_2-e) stored or avoided by a project
- **carbon cycle:** the process that moves carbon between atmosphere, soils, living creates, the ocean, and human sources
- **carbon dioxide equivalent (CO_2-e):** a metric measure used to compare the global warming potential (GWP) of various greenhouse gases relative to the concentration of CO_2 (which is defined as having a GWP of 1). For example, methane is 25 times more effective than CO_2 at heating the atmosphere and therefore has a GWP of 25; thus five tonnes of methane is equivalent to $5 \times 25 = 125$ tonnes of CO_2
- **Carbon offsets:** a series of activities aimed at reducing greenhouse gas emissions, for example investing in renewable energy, to compensate for emissions generated elsewhere in order to help achieve carbon neutrality
- **carbon sink:** natural processes that absorb carbon dioxide as part of the carbon cycle, including land, soils, plants, and oceans
- **chain volume measures:** volumes of economic activity or production that are weighted annually to remove the effect of changing prices and linked (or chained), to enable description and comparison of changes in levels of production or activity over time, particularly relevant where the prices of resources (like oil) or commodities (like computers) are subject to rapid change or variability
- **circular economy:** keeping products and materials in use for as long as possible, for example by designing products so that all components can be recycled or re-used
- **climate change adaptation:** the process of adjusting systems, practices, and policies to minimize the negative impacts of climate change
- **climate change mitigation:** any efforts to reduce or prevent the emission of greenhouse gases, including transitioning to renewable energy
- **climate variation/climate variability:** long-term changes in the patterns of average weather of a region or the Earth as a whole due to natural cycles of variability
- **Climdex:** a set of climate indices used for climate change detection and attribution studies, climate model evaluation, and operational monitoring of extreme climatic events
- **Combined Drought Indicator:** a tool used to assess the severity of drought conditions by combining multiple climate and soil moisture indicators, including rainfall, soil moisture, plant growth, and drought trends
- **Commercial sector:** the commercial sector includes a wide range of sub-sectors including services, construction, retail & wholesale, health, education, public administration, recreation & entertainment, communications, finance, and property
- **connectivity:** the degree to which partially cleared landscapes facilitate animal or plant movement or spread and ecological flows (compared to natural flows)
- **Country:** the term used to describe both the land and waters, including the sea, to which groups of Aboriginal people have a cultural connection
- **critically endangered species:** species (or population or ecological community) facing an extremely high risk of extinction in NSW in the immediate future

D

- **Decarbonise:** to reduce greenhouse gas emissions
- **Decoupling:** the process of separating economic growth from environmental degradation, so that increases in economic activity do not lead to proportional increases in resource use or environmental harm
- **derived grasslands:** areas of native grasses that were previously forest or woodlands
- **deseasonalised:** the process of removing seasonal effects from data to reveal underlying trends or patterns, allowing for the analysis of long-term trends without the influence of regular seasonal variations
- **diffuse source:** (pollution of waterways) where contaminants from a dispersed range of urban or rural land use activities pollute waterways, mainly resulting from rainfall runoff after storms
- **Discrete Aboriginal Communities:** are former Aboriginal reserves or missions transferred from the NSW Government to Local Aboriginal Land Councils under the *NSW Aboriginal Land Rights Act 1983*. There are currently 61 Discrete Aboriginal Communities across NSW and many have high levels of legacy contamination

- **disturbance:** (ecology) any process or event which disrupts ecosystem structure and resource availability
- **diversion:** volume of water taken from a stream or aquifer on a sustained basis to supply water for rural, urban and industrial uses; includes diversions undertaken by a water authority, private company or a group of individuals authorised to act as a water supply authority

E

- **ecological carrying capacity:** the maximum population size of a species that an environment can sustain indefinitely without degrading the natural resources and ecosystem services on which that population depends
- **ecological community:** an aggregation of organisms characterised by a distinctive combination of two or more species
- **ecosystem processes:** the numerous interactions between different components (both living and non-living) of an ecosystem that support the biological elements of the system, including the storage and cycling of energy, nutrients and minerals; predation and competition; disturbance; weathering; and succession
- **ecosystem services:** any biophysical functions provided by an ecosystem, such as the provision of clean air and water, the maintenance of soil fertility and the removal of wastes, that benefit humankind
- **El Niño – Southern Oscillation (ENSO):** a natural oscillation in the state of the ocean–atmosphere system that leads to substantial changes in atmospheric circulation throughout the Asia–Pacific region and generally drier conditions in eastern Australia
- **electrical conductivity:** a measure of charged particles in water used to estimate salinity, measured in microSiemens per centimetre (µS/cm)
- **electrolysis:** a chemical process that uses an electric current to drive a non-spontaneous chemical reaction
- **embodied carbon:** the total amount of carbon dioxide (CO_2) emissions associated with the entire lifecycle of a product, material, or building
- **emissions trading:** a scheme to provide for market-based allocation of discharge opportunities; the environmental regulator first determines total acceptable emissions and then divides this total into tradable units (often called credits or permits); these units are then allocated to scheme participants
- **endangered species:** a species (or population or ecological community) facing a very high risk of extinction in NSW in the near future, but not considered to be critically endangered
- **endemic:** species that are native to a specific area and not found anywhere else
- **energy intensity:** a measure of the energy efficiency of an economy, it is typically calculated as energy use per unit of gross domestic product (GDP)
- **environmental flows:** flows of water (by volume and season) necessary to maintain aquatic biota and ecosystem processes
- **ephemeral plants:** plants with a short life cycle – either perennial plants that produce new growth in a short seasonal cycle or plants that emerge and grow in response to short wet periods in arid climates
- **estuary:** the part of the river mouth or lower course of a river in which its current meets the sea’s tides, and is subject to the effects of both, and where fresh water and salt water are mixed. A transition zone between riverine and marine environments
- **eutrophication:** the over-enrichment of a body of water with nutrients, primarily nitrogen and phosphorus, resulting in excessive growth of some plants and algae and the subsequent depletion of dissolved oxygen
- **evapotranspiration:** the term used to describe the sum of all processes by which water moves from an area to the atmosphere via evaporation and transpiration
- **e-waste:** used (‘end-of-life’) electrical and electronic equipment, commonly composed of many component materials that are difficult and expensive to separate in order for them to be reused. Many of these materials, such as copper and gold, are valuable non-renewable resources; others, such as heavy metals, carbon black and brominated-flame retardants, are hazardous
- **extinct species:** species that has not been recorded in its known or expected habitat in NSW over a time-frame appropriate to its life cycle and form and is therefore presumed to be extinct
- **extraction:** taking water from a waterbody or aquifer for human use (also called abstraction)

F

- **faecal coliforms:** a group of bacteria found in animal (including human) intestines and used as an indicator of the sanitary quality of water
- **faecal enterococci:** a group of bacteria found in animal (including human) intestines and used as an indicator of the sanitary quality of water
- **fire regime:** the typical frequency, intensity, duration, aerial extent, and seasonality of wildfire disturbance in a particular ecosystem
- **fire weather:** the atmospheric conditions that influence the size, intensity, speed and predictability of wildfires
- **fish kill:** any sudden and unexpected mass mortality of wild or cultured fish due to water contamination or natural causes of oxygen deletion (algal blooms or back water)
- **fishway:** a structure placed on or around a constructed barrier (such as a dam or weir) to give fish the opportunity to migrate, also known as a fish ladder or fish pass
- **food web:** a network describing the feeding interactions of the species in an area
- **Forcings (atmospheric forcings, Natural forcing, anthropogenic forcing – see Climate change):** factors that drive changes in the Earth's climate system, influencing long-term changes in climate patterns
- **Forest fire danger index (FFDI):** a numerical scale is used to assess the potential for fire ignition and spread based on weather conditions, including temperature, humidity, wind speed, and rainfall
- **fossil fuels:** any of a class of carbon- or hydrocarbon-containing materials of biological origin occurring within Earth’s crust that can be used as a source of energy
- **fragmentation:** the division of continuous habitat by the clearing (or disturbance) of native vegetation for human land-use activities, which isolates the remnant patches of natural vegetation and the species within them, and limits the passage of organisms and genetic flow between populations
- **fugitive emissions:** releases of gases or vapours from mines or industrial equipment due to unintended or irregular occurrences (e.g. leaks)

G

- **Greater Capital City Statistical Area (GCCSA):** is defined by the Australian Bureau of Statistics as representing the socioeconomic extent of each of the eight State and Territory Capital cities. GCCSAs contain not only the urban area of the city but also areas of non-urban land where much of the population has strong links to the capital city, through for example, commuting to work.
- **Greater Metropolitan Region (GMR):** the GMR comprises all local government areas in Sydney, Illawarra, Central Coast, Lower Hunter and the Upper Hunter regions
- **Greater Sydney:** extends from the Hawkesbury River in the north to the Royal National Park in the south; towards the west, the region includes the Blue Mountains, Wollondilly and Hawkesbury local government areas
- **green hydrogen:** hydrogen produced by electrolysis of water using renewable energy, which generates no carbon emissions in the process
- **greenhouse effect:** refers to the blanketing effect of atmospheric greenhouse gases on the Earth, which absorb and re-radiate a proportion of the sun’s energy back to the Earth. Without this blanketing effect, the Earth would be about 33 degrees Celsius cooler. The greenhouse effect has been enhanced by the increased concentrations of greenhouse gases in the atmosphere arising from human activities such as burning fossil fuels and deforestation
- **greenhouse gases:** atmospheric gases, including carbon dioxide, methane, chlorofluorocarbons, nitrous oxide, ozone and water vapour, which trap heat reflected from the Earth’s surface
- **Gross State Product (GSP):** an economic indicator, referring to the total value of goods and services produced within a state during a specific period
- **groundwater:** the water beneath the earth’s surface that has filtered down to the zone where it is captured and the sediments or rocks are fully saturated
- **groundwater-dependent ecosystem (GDE):** ecosystems where the species composition or natural functions depend on the availability of groundwater
- **growth form:** (vegetation) the general morphology or form of a plant type e.g. tree, shrub, herb, grass etc.

H

- **Heatwaves:** the maximum and the minimum temperatures are unusually hot over a three-day period in a specific location
- **High resolution:** the level of detail or clarity in an image, map, or data set, typically characterized by a large number of pixels or data points
- **Hot days:** days with maximum temperatures exceeding 35 degrees Celsius
- **hydrogeology:** relates to the distribution and movement of groundwater in soil and rocks
- **humidity:** a measurement of how much water there is in the air

I

- **industrial sector:** the Industrial Sector includes the agriculture, mining and manufacturing sectors
- **inter-annual:** variations or changes that occur between two or more years
- **Intergovernmental Panel on Climate Change (IPCC):** an intergovernmental body of the United Nations that assesses the science related to climate change
- **invasive species:** a general term for plants, animals, weeds or other organisms such as pathogens that are introduced to places outside their natural range, where they negatively affect local ecosystems and species
- **invertebrates:** animals without backbones, such as insects, worms, snails, mussels, prawns and cuttlefish

K

- **key threatening process (KTP):** under the *Biodiversity Conservation Act 2016*, a process that significantly threatens, or may have the capability to significantly threaten, the survival or evolutionary development of native species, populations or ecological communities

L

- **Land use, land use change and forestry (LULUCF):** a greenhouse gas inventory sector that covers emissions and removals of greenhouse gases resulting from direct human-induced land use
- **long-term average annual extraction limit (LTAAEL):** the average level of groundwater that can be extracted annually from an aquifer for extraction to be sustainable over the longer term
- **longwall mining:** the main method of underground coal mining in Australia, it involves progressively shaving slices of coal from a longwall face under the protection of hydraulic roof supports. The coal is removed on a conveyer and as the machinery and roof supports move forward the roof and overlying rock collapse into the void left behind

M

- **macroinvertebrates:** invertebrates visible to the naked eye, having a body length exceeding 1 millimetre
- **Mean**: the average, which is a measure of central tendency in a set of numbers
- **Millenium Drought:** A severe drought event recorded in southeastern Australia from 2001 to 2009
- **mitigation:** decisions and actions to reduce the severity of climate change impacts. Usually referring to reducing the levels of greenhouse gas emissions
- **montane:** of or inhabiting mountainous country
- **mosaic:** (vegetation) a combination of distinct vegetation types within a spatial unit that often cannot be discriminated by the mapping techniques employed

N

- **The NSW and Australian Regional Climate Modelling (NARCliM):** the NSW Government's trusted source for regional climate projections data and associated information for NSW
- **national energy market (NSW):** the National Electricity Market includes Queensland, NSW, the ACT, South Australia, Victoria, and Tasmania
- **non woody vegetation:** for vegetation monitoring using Landsat MSS satellite sensors, vegetation formations that are less than two metres high or with less than 20% canopy cover (mainly grasslands, arid shrublands and woodlands)
- **NOx:** a generic term for a combination of the gases nitric oxide (NO) and nitrogen dioxide (NO_2); other oxides of nitrogen (e.g. nitrous oxide, N_2O are usually not regarded as a component of NOx)

P

- **pathogen:** a disease-causing organism
- **per capita:** also referred to as per person or per head. This term is used when a unit of measure has been calculated as an amount or rate against the number of persons in the community
- **pest animal:** an animal (usually non-native) having, or with potential to have, adverse environmental, economic, or social impacts
- **phreatic aquifer:** the body of groundwater closest to the surface, the upper boundary of which corresponds to the water table
- **phreatophytic vegetation:** deep-rooted plants that obtain a significant portion of the water they need from below the water table
- **planned environmental water:** water committed to the environment by water rules in **water sharing plans**
- **point source:** (pollution) a source of pollution that can be pinpointed, such as a pipe outlet or chimney stack (see also *diffuse source*)
- **potable:** water safe enough for drinking and food preparation
- **productivity:** (biology) the rate of accumulation of organic material in an ecosystem
- **projected/projection:** an estimate or forecast of a future situation based on a study of present trends
- **pyrocumulonimbus storms:** a type of thunderstorm that forms as a result of intense heat generated by wildfires

R

- **recharge:** the process whereby surface water from rain, irrigation or streams infiltrates into groundwater; the amount of water added to or absorbed into a groundwater system; or groundwater that feeds surface waters (also known as baseflow)
- **regulated rivers:** (water resources) those rivers proclaimed under the *Water Act 1912* as having their flows controlled by the major dams where 'regulated' means that flows along the length of these rivers are controlled by releases from major dams to meet the needs of licensed users; (hydrology) rivers affected by major dams, weirs, canalisation and water transfers
- **remnant:** (ecology) a small, fragmented portion of vegetation that once covered a broader area before the surrounding vegetation was cleared
- **remote sensing:** a means of acquiring information using airborne equipment and techniques to determine the characteristics of an area, commonly using satellite imagery or systematic photography from aircraft
- **renewable energy target:** a policy target to encourage the development of new renewable energy generation
- **riparian:** occurring on or adjacent to a river, stream or other waterway
- **riparian zone:** the riparian zone is the interface between land and creeks, streams, rivers and wetlands. It includes the immediate vicinity of the stream, which consists of the bed, banks and adjacent land including floodplains, which carry large floods as well as the emergent aquatic plants growing at the edge of the waterway channel and the ground cover plants, shrubs and trees within the riparian zone
- **runoff:** water from rain or snow (and the substances it carries) which flows off the surface of the land into rivers, catchments or drainage systems

S

- **sclerophyll:** vegetation with hard leaves and short internodes, adapted to dry conditions and often low levels of soil phosphorus, usually with an over-storey of eucalypts
- **sequestration:** carbon sequestration is the general term used for the capture and long-term storage of carbon dioxide. Capture can occur at the point of emission (e.g. from power plants) or through natural processes (such as photosynthesis), which remove carbon dioxide from the earth's atmosphere
- **simulation:** the imitation or modelling of a real-world process, system, or phenomenon to study its behaviour under different conditions
- **stationary energy:** stationary energy is a term used in the estimation of greenhouse gas emissions. It includes emissions arising from: electricity and heat production, petroleum refining, solid fuel manufacture, manufacturing and construction industries, and fugitive emissions from fuels

- **suspended solids:** any solid substances present in water in an undissolved state, usually contributing directly to turbidity (of physical origin usually – fine clay and silt, sometimes also of biological origin – plant material or animal waste)
- **Sydney metropolitan area:** comprises 41 local government areas – Ashfield, Auburn, Bankstown, Blacktown, Blue Mountains, Botany, Burwood, Canada Bay, Camden, Campbelltown, Canterbury, Fairfield, Hawkesbury, Holroyd, Hornsby, Hunters Hill, Hurstville, Kogarah, Ku–Ring–Gai, Lane Cove, Leichhardt, Liverpool, Manly, Marrickville, Mosman, North Sydney, Parramatta, Penrith, Pittwater, Randwick, Rockdale, Ryde, Strathfield, Sutherland, Sydney, The Hills, Warringah, Waverley, Willoughby, Wollondilly and Woollahra; does not include Gosford and Wyong local government areas

T

- **temperature anomaly:** the difference between the observed temperature for a specific location or period and a reference or average temperature over a defined baseline period
- **thermal expansion:** the increase in the volume or size of a material as it is heated
- **threatened species:** a generic term for any species listed as having a high threat of extinction under the *Biodiversity Conservation Act 2016* or the *Fisheries Management Act 1994*, due to a reduction in population size, restricted geographical distribution or there being few mature individuals in the population. Threatened species are listed in one of four categories in increasing order of severity: vulnerable; endangered; critically endangered; extinct
- **tidal inundation:** the flooding of land or coastal areas caused by the rise of tidal waters
- **Tinderbox Drought:** southeast Australia experienced three consecutive years of intense drought, from 2017 to 2019. This extreme climate threatened water supplies, damaged agricultural and ecological systems, and contributed to Australia's Black Summer fire disaster, so it has been named the Tinderbox Drought to highlight the connection between drought and fire that typified this event
- **translocated native species:** a plant or animal that occurs naturally in some part of Australia but has been introduced to another region and become established where it does not naturally occur
- **transmission (electricity supply):** the bulk movement of electrical energy from a generation site (such as a power plant) to an electrical substation. The interconnected lines which facilitate this movement are known as a transmission network. The distribution network then moves this energy from the substation to the end user. Transmission and Distribution losses refer to the proportion of electrical energy lost between the generation site and the end user, the magnitude of which is influenced by the ambient temperature and length of transmission and distribution lines
- **turbidity:** a measure of the amount of suspended solids (usually fine clay or silt particles) in water and thus the degree of scattering or absorption of light in the water

U

- **unregulated rivers:** (water resources) rivers without major dams or regulating structures (see also *regulated rivers*)
- **urban heat island effect:** the phenomenon where urban areas experience higher temperatures than their surrounding rural areas due to human activity and the built environment
- **upwelling:** divergence of water currents or the movement of warm surface water away from land leading to a 'welling up' of deeper water that is commonly richer in nutrients, with the combination of nutrients and warmth leading to abundant algal growth

V

- **Vascular plants:** plants found on land that have specialised tubes (such as stems and roots) to transport water, minerals and food throughout the body of the plant
- **vegetation class:** a more detailed description of vegetation than formations, based on the dominant structure or growth-form, supplemented by selected details of plant composition, location or environmental characteristics that help to best identify it. In NSW, there are 99 vegetation classes as defined by Keith **(2004)**
- **vegetation community:** a group or assemblage of plant species that tend to grow together in similar environmental conditions, where the association of species helps to identify or describe the plant community
- **vegetation condition:** the health of native vegetation communities which reflects the level of naturalness and is commonly assessed against a benchmark taking account of factors such as structural integrity, species composition, presence or absence of weeds and diseases and reproduction of species
- **vegetation formation:** broad groups of plants distinguished by major structural and physiognomic features (relating to physical appearance or form). In NSW, there are 12 vegetation formations (**Keith 2004**)

- **vegetation structure:** the organisation of plants within a plant community or assemblage, consisting of one or more layers or strata and the dominant growth form for each strata
- **vehicle kilometres travelled:** a function of the number of motor vehicles on the road and the average distance travelled by each vehicle
- **vertebrates:** animals that have a backbone and spinal column – vertebrates include fishes, sharks and rays, amphibians, reptiles, mammals, and birds
- **vulnerable species:** a species (or population or ecological community) facing a high risk of extinction in NSW in the medium-term future, but not considered to be endangered

W

- **Weed:** a non-native plant or native plant removed from its natural habitat having, or with the potential to have, negative environmental, economic, or social impacts
- **wilderness:** an area which, together with its plant and animal communities is relatively natural and has not been significantly modified by humans and that is of sufficient size to make its maintenance in such a state feasible; it can provide opportunities for solitude and self-reliant recreation
- **woody vegetation:** for vegetation monitoring using Landsat MSS satellite sensors, vegetation formations (mainly woodlands and forests) that are over two metres high and with more than 20% canopy cover; also known as ‘detectable native forest’

Abbreviations and acronyms

Abbreviation	Definition
AAQ NEPM	National Environment Protection Measure for Ambient Air Quality
AAS	Australian Academy of Science
ABS	Australian Bureau of Statistics
AC	alternating current
ACCC	Australian Competition and Consumer Commission
ACCUs	Australian Carbon Credit Units (see **Glossary**)
ADWG	Australian Drinking Water Guidelines
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
AHD	Australian Height Datum
AI	artificial intelligence
AIDR	Australian Institute for Disaster Resilience
AIMS	Australian Institute of Marine Science
ALCA	Australian Land Conservation Alliance
APKG	Aboriginal Peoples Knowledge Group
ARENA	Australian Renewable Energy Agency
AS	Australian Standards
ASC NEPM	National Environment Protection (Assessment of Site Contamination) Measure 1999
ASIC	Australian Securities and Investments Commission
ATM	Aggregate Trailer Mass
ATO	Australian Tax Office
ATSE	Australian Academy of Technological Sciences & Engineering
AWD	available water determination
BAM	Biodiversity Assessment Method
BBS	Brigalow Belt South
BCT	Biodiversity Conservation Trust
BFCC	NSW Bush Fire Coordinating Committee

Abbreviation	Definition
BGS	Botanic Gardens of Sydney
BioBanking	Biodiversity Banking and Offsets Scheme
BITRE	Bureau for Infrastructure and Transport Research Economics
BoM	Bureau of Meteorology
BPEOM-Fish	Basin Plan Environmental Outcomes Monitoring for Fish
BSA	Biodiversity Stewardship Agreement
C&D	Construction and demolition (waste)
C&I	Commercial and industrial (waste)
CAPAD	Collaborative Australian Protected Areas Database
CAPO	NSW Coalition of Aboriginal Peak Organisations
CAR	comprehensive, adequate and representative
CAUL	The Clean Air and Urban Landscapes Hub
CBD	The United Nations Convention on Biological Diversity
CCF	Climate Change Fund
CDS	container deposit scheme
CH_4	methane
CIS	Capacity Investment Scheme
CLM Act	*Contaminated Land Management Act 1997*
CM Act	*NSW Coastal Management Act 2016*
CM SEPP	*State Environmental Planning Policy (Coastal Management) 2018*
CMP	Coastal Management Program
CO	carbon monoxide
CO_2	carbon dioxide
COP	Cobar Peneplain
COP15	The 15th Conference of the Parties to the Convention
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CWANZ	Cycling and Walking Australia and New Zealand
CWP	cold water pollution

Abbreviation	Definition
DAFF	Department of Agriculture, Fisheries and Forestry
DC	direct current
DCCEEW	NSW Department of Climate Change, Energy, the Environment and Water
DCCEEW-Aus	Federal Department of Climate Change, Energy, the Environment and Water
DCS	NSW Department of Customer Service
DEC	NSW Department of Environment and Conservation
DECC	NSW Department of Environment and Climate Change (formerly DEC)
DECCW	Department of Environment, Climate Change and Water (formerly DECC)
DEWHA	Federal Department of the Environment, Water, Heritage and the Arts
DHAC	Department of Health and Aged Care
DIWA	Directory of Important Wetlands of Australia
DoE	NSW Department of Education
DPE	Department of Planning and Environment
DPHI	Department of Planning, Housing and Infrastructure
DPIE	Department of Planning, Industry and Environment
DPIRD	Department of Primary Industries and Regional Development
DRP	Darling Riverine
eDNA	environmental DNA
ECL	East Coast Lows
EEA	European Environment Agency
ELA	Eco Logical Australia
EnergyCo	Energy Corporation of NSW
ENSO	El Niño – Southern Oscillation (Index) (see **Glossary**)
EPA	NSW Environment Protection Authority
EPBC Act	*Environmental Protection and Biodiversity Conservation Act 1999*
ESC	Energy Security Corporation
ESCC	Earth Systems and Climate Change
ESD	ecologically sustainable development

Abbreviation	Definition
ESFM	Ecologically Sustainable Forest Management
ESG	environmental, social and governance
ESS	Energy Savings Scheme
EVC	Electric Vehicle Council
EVs	electric vehicles
FCAI	Federal Chamber of Automotive Industries
FFDI	Forest Fire Danger Index
FM Act	*Fisheries Management Act 1994*
FMS	fire management strategy
FOGO	food organics and garden organics
FRNSW	Fire and Rescue NSW
GBF	Kunming-Montreal Global Biodiversity Framework
GCCSA	Greater Capital City Statistical Area (see **Glossary**)
GDE	groundwater-dependent ecosystem (see **Glossary**)
GDP	gross domestic product
GIS	Geographic Information System
GMR	Greater Metropolitan Region (see **Glossary**)
GSP	gross state product (see **Glossary**)
GVA	gross value added
GVM	Gross Vehicle Mass
GWP	global warming potential
HEI	Health Effects Institute
IBRA	Interim Biogeographic Regionalisation for Australia
IChEMS	Industrial Chemicals Environmental Management Standard
IEA	International Energy Agency
IFOA	Integrated Forestry Operations Approval
IGCC	Investor Group on Climate Change
IIO Report	Infrastructure Investment Objectives Report

Abbreviation	Definition
IMOS	Integrated Marine Observing System
IOD	Indian Ocean Dipole
IPA	Indigenous Protected Area
IPART	Independent Pricing and Regulatory Tribunal
IPCC	Intergovernmental Panel on Climate Change (see **Glossary**)
IUCN	International Union for the Conservation of Nature
KTP	key threatening process (see **Glossary**)
Landsat	Land and Earth Observation Satellite
LAT	Lowest Astronomic Tide
LBL	load-based licensing
LCV	light commercial vehicle
LGA	local government area
LHIB	Lord Howe Island Board
LiDAR	Light Detection and Ranging
LLS	Local Land Services
LNAPL	light non-aqueous-phase liquid
LSC	land and soil capability
LTAAEL	long-term average annual extraction limits (see **Glossary**)
LULUCF	land use, land use change and forestry (see **Glossary**)
LWU	local water utility
MAC	microbial assessment category
MDB	Murray–Darling Basin
MDBA	Murray–Darling Basin Authority
MEMA	NSW Marine Estate Management Authority
MER	monitoring, evaluation and reporting
MLDRIN	The Murray Lower Darling Rivers Indigenous Nations
MSW	municipal solid waste
NABERS	National Australian Built Environment Rating System

Abbreviation	Definition
NARCliM	NSW and Australian Regional Climate Modelling (see **Glossary**)
NATA	National Association of Testing Authorities
NCEI	National Centers for Environmental Information
NEAP	NSW Estuary Asset Protection
NEM	National Electricity Market
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NGOs	non-government organisations
NHMRC	National Health and Medical Research Council
NIAA	National Indigenous Australians Agency
NLWRA	National Land and Water Resources Audit
N_2O	nitrous oxide
NO_2	nitrogen dioxide
NO	oxides of nitrogen
NOAA	National Oceanic and Atmospheric Administration
NOAA Fisheries	National Oceanic and Atmospheric Administration, the National Marine Fisheries Service
NOx	oxides of nitrogen (see **Glossary**)
NPI	Nature Positive Initiative
NPW Act	*National Parks and Wildlife Act 1974*
NPWS	NSW National Parks and Wildlife Service
NRC	Natural Resources Commission
NRM	natural resource management
NRS	national reserve system
NSS	New South Wales South Western Slopes
NSWRFS	NSW Rural Fire Service
NWQMS	National Water Quality Management Strategy
O_3	ozone

Abbreviation	Definition
OCHRE	Opportunity, Choice, Healing, Responsibility, Empowerment
OCSE	Office of the NSW Chief Scientist & Engineer
OECC	Office of Energy and Climate Change
OECD	Organisation for Economic Cooperation and Development
OECM	National Other Effective Area-based Conservation Measures
OEH	Office of Environment and Heritage (formerly DECCW)
PAH	polycyclic aromatic hydrocarbon
PET	polyethylene terephthalate
PFAS	per- and poly-fluoroalkyl substances
PFHxS	perfluorohexane sulfonate
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate
PM	particulate matter
PM_{10}	particulate matter less than 10 micrometres
$PM_{2.5}$	particulate matter less than 2.5 micrometres
POEO Act	*Protection of the Environment Operations Act 1997*
PV	photovoltaic (solar energy)
PVP	property vegetation plan
pyroCb	pyrocumulonimbus (see **Glossary**)
Qx	Queensland unknown
RA	Reconstruction Authority
RCP	Representative Concentration Pathway
REZs	Renewable Energy Zones
RIDonline	Report Illegal Dumping online system
RIS	Regulatory Impact Statement
RIV	Riverina
RSWMP	Regional Strategic Weed Management Plan
SAFS	Status of Australian Fish Stocks

Abbreviation	Definition
SCA	state conservation area
SEEA	System of Environmental-Economic Accounts
SEED	The Central Resource for Sharing and Enabling Environmental Data in NSW
SEPP	State Environmental Planning Policy
SLATS	Statewide Landcover and Tree Study
SO_2	sulfur dioxide
SSP	Shared Socioeconomic Pathway
STGGI	State and Territory Greenhouse Inventories
SUV	sport utility vehicle
SVTM	NSW State Vegetation Type Map
TAP	threat abatement plan
TARA	threat and risk assessment
TERN	Australia's Terrestrial Ecosystem Research Network
TfNSW	Transport for NSW
TISFD	Taskforce on Inequality and Social-related Financial Disclosures
TN	total nitrogen
TNFD	Taskforce on Nature-related Financial Disclosures
TOD	Transport Oriented Development (TOD) Program
TP	total phosphorous
TSR	Threatened Species Recovery Hub
TSRs	travelling stock reserves
TSS	total suspended solids
UN	United Nations
UNECE	United Nations Economic Commissions for Europe
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UPSS	underground petroleum storage system
VKT	vehicle kilometres travelled

Abbreviation	Definition
VOC	volatile organic compound
WAMC	Waste Assets Management Corporation
WARR	Waste Avoidance and Resource Recovery
WARRP	Waste and Resource Reporting Portal
WAS	NSW Water Accounting System
WEF	World Economic Forum
WHO	World Health Organization
WSAA	Water Services Association of Australia
XDI	Cross Dependency Initiative

Units and measurements

Table 1: Units and measurements

Quantity	Unit	Symbol
Acidity/alkalinity	pH	pH
Area	hectare	ha
	square metre	m^2
	square kilometre	km^2
Concentration	grams per litre	g/L
	parts per million	ppm
	parts per billion	ppb
	parts per thousand	ppt
	micrograms per cubic metre	$\mu g/m^3$
	micrograms per decilitre	µg/dL
	tonnes per hectare	t/ha
Electrical conductivity	microsiemens per centimetre	µS/cm
Length	micrometre	µm
	millimetre	mm
	centimetre	cm
	metre	m
	kilometre	km
Mass	microgram	µg
	kilogram	kg
	tonne	t
	megatonne	Mt
	gigatonne	Gt
Power	megawatt	MW
	gigawatt	GW
	kilowatt hour	kWh
	megawatt hour	MWh

Quantity	Unit	Symbol
	gigawatt hour	GWh
Velocity and speed	kilometres per hour	km/hr
Volume	cubic metre	m^3
Volume (fluids)	litre	L
	megalitre	ML
	gigalitres	GL
	gigalitres per year	GL/y
Work and energy	petajoule	PJ
	gigajoules	GJ
Other abbreviations	carbon dioxide equivalent units	CO_2-e
	watts per square metre	W/m^2
	degrees celsius	°C
	tonnes per hectare per year	t/ha/yr

Table 2: Prefixes for the International System of Units (SI)

Fraction	Prefix	Symbol
10^{-6}	micro	μ
10^3	kilo	k
10^6	mega	M
10^9	giga	G
10^6	peta	P