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Our Ref: 09/338

The Committee Manager
Standing Committee on Natural Resource Management (Climate Change)
Parliament House
Macquarie St
Sydney NSW 2000

22 April 2009

Dear Ms Buchbach

Re: Managing Climate Change Impacts on Biodiversity

We thank you for the opportunity to provide comments on the above inquiry. Our detailed responses to the Terms of Reference can be found in the attached submission.

This submission has been prepared by a team of scientists from across CSIRO with experience and international recognition in many facets of climate and biodiversity research. In this submission, we briefly review the issue of biodiversity conservation with particular reference to climate change and bring to the Committee's attention relevant conclusions, based on past and current research.

The likely consequences of human induced climate change for biodiversity in NSW are significant. Biodiversity is highly vulnerable to climate change and the projected warming trends will make biodiversity conservation in the State challenging as we move into the future. Building the resilience of natural systems will be important.

There is a range of policy and management options for enhancing the conservation of biodiversity under climate change and in the face of uncertainty about the details of impacts.

If you have any queries regarding the content of our submission or would like any further information, please do not hesitate to contact Dr Kilian Perrem at CSIRO Government and International (kilian.perrem@csiro.au; 02 6276 6480)

Yours sincerely

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CSIRO Group Executive - Environment

CSIRO Submission 09/338

Managing Climate Change Impacts on Biodiversity

NSW Legislative Assembly Standing Committee on Natural Resource Management

April 2009

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Terms of Reference

On 4 March 2009, the Standing Committee on Natural Resource Management (Climate Change) (Parliament of New South Wales) commenced a new inquiry into the quality of management strategies to address the impacts of climate change on biodiversity.

The Committee has recognised that there is increasing scientific evidence that climate change is already having significant impacts on biodiversity and that appropriate and adequate management strategies are required to enhance the ability of species and ecosystems to survive.

The Committee is also interested to learn about adaptation options to climate change impacts on biodiversity that will also protect industries dependent on biodiversity and healthy ecosystems, such as the fishing and aquaculture industries and the tourism industry.

The Committee will inquire into and report on:

- the adequacy of management strategies to address the impacts of climate change on biodiversity in New South Wales ecosystems and
- any options for improving these strategies

in order to ensure that these ecosystems are resilient to the likely impacts of climate change including:

a. increasing invasion of weed and pest species;
b. changes to species' distribution and ecosystem composition including increased risk of extinction;
c. changes to species' life cycle events (such as flowering, egg-laying and migration); and
d. other threats to species or ecosystem health.

Contents

Acronyms Used

CSIRO	Commonwealth Scientific and Industrial Research Organisation
IPCC	Intergovernmental Panel on Climate Change
NARP	National adaptation research plan
NRM	Natural resource management
NSW	New South Wales
R&D	Research and Development

Executive Summary

This submission has been prepared by a team of scientists from across CSIRO with experience and international recognition in many facets of climate and biodiversity research. In this submission, we briefly review the issue of biodiversity conservation with particular reference to climate change and bring to the Committee's attention relevant conclusions, based on past and current research. The likely consequences of human induced climate change for biodiversity in NSW are significant. Biodiversity is highly vulnerable to climate change and the projected warming trends will make biodiversity conservation in NSW challenging as we move into the future. Building the resilience of natural systems will be important.

Climate change will impact on biodiversity in complex ways depending on location, the levels of other stressors in the system, and interactions at the species, community and landscape scales. In NSW, different studies have identified significant potential impacts of climate change on biodiversity in the rangelands, highly fragmented areas, the alpine zone, rivers and wetlands, coasts (near-shore through to salt marshes), the western slopes and the south eastern region. Most studies have focussed on how individual species may respond to changes in temperature and rainfall, rather than how ecosystem processes and threats to biodiversity may change.

The impacts of climate change on biodiversity lead to a range of implications for the strategic approach to managing native species and ecosystems. Strategies to deal with these impacts in the future, whether management or policy based, will be faced with the strong evidence that significant and continuous changes in species and ecosystems are now occurring. The current science indicates that only whole-of-system approaches to tackling any negative effects of climate change on biodiversity, rather than attempts to prevent change to individual species or ecosystems, will be truly effective. The overarching strategy for biodiversity conservation should increasingly focus on developing approaches that deal with changes in species and ecosystems that are impossible to predict in most circumstances. This requires developing an effective monitoring system now to provide the information that can inform longer term management options.

There is a range of policy and management options for enhancing the conservation of biodiversity under climate change and in the face of uncertainty about the details of impacts. These involve:

- ensuring that a wide range of possible changes resulting from climate change (including changing abundances and distributions and changing threats) are considered in policy and management plans;
- aiming to conserve a high diversity of native habitats, as well as a large area of habitat; especially that threatened by local activities;
- anticipating how the action and impact of various threats to biodiversity may change in order to be better prepared to respond to them in ways that minimise losses to biodiversity;
- anticipating how the action and impact of threats to biodiversity, including altered fire regimes, changed land uses (habitat loss and degradation), establishment of new exotic and native species, overharvesting and altered hydrological regimes, may change; and
- increasing coordination of different conservation and NRM programs to enable improved management at landscape and regional scales.

Afforestation, which may be associated with the introduction of an emissions trading system, might provide opportunities for desirable outcomes for biodiversity and ecosystem restoration. However, careful planning would be required to avoid negative outcomes related to water supply, pests and biodiversity, as well as rural livelihoods.

Information relevant to impacts of climate change on biodiversity dependent industries is often not well developed. So, adaptation options should focus largely on improving knowledge of the requirements of relevant species and ecosystems. For example, regional studies on the relationship between climate variables and species of interest are one way to improve understanding of the potential impacts of climate change on the fisheries and aquaculture industries. However, industries will also need to adapt to increasing unpredictability as well as future change.

Introduction

CSIRO and climate change impacts on biodiversity

CSIRO is a leading internationally recognised research and development (R&D) provider in the field of climate change and biodiversity. CSIRO has conducted research relevant to this inquiry in areas including climate modelling, climate forecasting, biodiversity conservation and management, as well as adaptation to climate change.

This submission has been prepared by a team of scientists from across CSIRO with experience and international recognition in many facets of climate and NRM research. In this submission, we briefly review the issues concerned with climate change and biodiversity, and bring to the Committee's attention relevant conclusions based on past and current research. Not only impacts of climate change on biodiversity are described, but also appropriate adaptations to enhance the ability of species and ecosystems to survive.

The need for climate adaptation research and CSIRO's response

In recent times the climate challenge facing Australia has become more severe and more urgent. Parts of Australia continue to experience the worst drought in recorded history and bushfires associated with extreme weather conditions, while other areas have experienced extreme flooding. These issues have brought to the public mind appreciation of the reality of global climate change, of the massive impacts that it is likely to have upon our continent, and of the opportunities and challenges stemming from those impacts.

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC 2007) reinforced the evidence that most of the warming observed in the past 50 years is attributable to human activities, that there will be considerably more warming in the 21st Century, and that this warming will be accompanied by many other changes in the global climate system, including changes in wind, precipitation and weather extremes.

An international scientific congress on 'Climate Change: Global Risks, Challenges & Decisions' held in Copenhagen in March 2009 was attended by more than 2,500 delegates from nearly 80 countries and reviewed the latest evidence. Recent observations confirm that, given high rates of observed emissions, the worst-case IPCC scenario trajectories (or even worse) are being realised. While the global economic recession may cause some temporary slowing in the rate of increase of greenhouse gases in the atmosphere, the situation remains urgent. On her return to Australia from the Copenhagen conference, Dr Penny Sackett, the Government's Chief Scientist, delivered the blunt message that "if we do not act, and act quickly and decisively, the effects will be devastating". The particular importance of climate change to biodiversity is reflected in the vision for Australia's draft Biodiversity Conservation Strategy 2010-2020, which is that 'Australia's biodiversity is healthy, resilient to climate change and valued for its essential contribution to our existence'(National Biodiversity Strategy Review Task Group 2009). The scale and gravity of climate variability and change are such that R&D must be marshalled to assist in the national response if this vision is to become reality. Science can add significant value to how we adapt to climate change through informing responses.

The National Research Flagships Program is delivering scientific solutions to advance Australia's most vital national objectives. Flagships are partnerships of leading Australian scientists, research institutions, commercial companies, CSIRO and selected international partners. The CSIRO Climate Adaptation Flagship became fully operational in July 2008. It is developing adaptation options to minimise the economic, social and environmental impacts of climate change, as well as to maximise new opportunities in response to climate change and variability. One of the Flagship's four themes entitled 'Managing species and natural ecosystems' focuses particularly on developing adaptation options to reduce the impacts of climate change on biodiversity.

Addressing the Terms of Reference

1. The likely consequences of human induced climate change

(i) Climate projections

The consequences of human induced climate change are a current research focus in Australia and around the world. CSIRO has contributed to projections of climate change for Australia (CSIRO 2007). Evidence is clear that climate change is happening now and that human activity is a contributor to climate change. Projections indicate a warming climate with changes in temperature extremes, precipitation and wind, along with an increased frequency of drought and extreme fire weather and sea level rise. The most recent climate change projections for Australia can be found at www.climatechangeinaustralia.gov.au.

By 2030 annual average temperatures over central and southern NSW are projected to increase by up to 0.9°C by 2030, with a range of 0.6 to 1.3°C. In the state's north the increase is projected to be 1.0°C, with a range of 0.7 to 1.5°C. By 2070 this increase is around 1.7°C (range of 1.2 to 2.5°C) across the state under a low emissions scenario or 3°C (range of 2 to 4.5°C) under a high emissions scenario, with warmings slightly larger in the north-west.

Winter and spring rainfall is likely to decrease in NSW and annual rainfall is likely to decrease in southern areas. Changes in summer and autumn rainfall are less certain. By 2030 annual rainfall in NSW is projected to change by -10 to +5%. By 2070 the change is projected to be -15 to +5% under a low emission scenario, or -30 to +15% under a high emission scenario.

(ii) Native species and ecosystems

Observations and modelling over the last decades has provided compelling evidence that the impacts of climate change on the world's biodiversity are likely to be significant. Many impacts have been observed or hypothesised, including: upward and poleward shifts in species ranges, changes in the timing of many critical life history stages, changes in plant and animal physiology, changes in sex ratios, changes in ecosystem net primary production, nutrient cycling, and water relations, changes in disturbance regimes, changes in ecosystem structure and function, and changes in competition, parasitism, predation, dispersal, habitat provision and other interactions between species. There are now many independent studies that have modelled various of these potential impacts on biodiversity over the remainder of this century in different regions and concluded that a significant fraction of terrestrial species are likely to become extinct during this time. While these studies are necessarily based on a range of assumptions, the consensus results are stark and it is reasonable to conclude that climate change will have a significant impact on biodiversity, possibly similar in magnitude to that of habitat loss. Australian studies have found similar potential impacts to others around the world.

Dunlop and Brown (2008a, b) have reviewed the likely impacts of climate change on biodiversity in Australia in a report focussing particularly on the implications for Australia's National Reserve System. Species and ecosystems will be affected directly by impacts cascading from individuals to populations to ecosystems, and indirectly via changes to the interactions between species, provision of habitat, regulation of ecosystem processes and feedbacks on the climate. Given the range of impacts, climate change should not be seen as a singular additional threat to biodiversity, rather it is a systematic issue affecting almost all aspects of biodiversity conservation. In particular, climate change will amplify and further complicate the management of existing threatens to biodiversity, including:

- changed availability and use of water;
- spread of native and exotic species into new areas;
- changes in land use; and
- altered fire regimes.

For example, a CSIRO-led report has been prepared by experts on the impacts of climate change on fire and biodiversity (Williams et al. 2009). This considers how climate change may affect fire weather and fuels, how fire regimes may alter, and how this might then affect the dynamics of Australian ecosystems and the management of their biodiversity. It considers contentious issues such as the frequency of prescribed burning. However, there are complicated and poorly understood interactions amongst variables associated with fire activity, and much targeted research is needed to quantify variations in risk to different assets across the landscape.

Importantly, Dunlop and Brown (2008a) concluded that observation and modelling studies consistently report that the details of the impacts of climate change vary considerably between species, ecosystems and regions. And, while it is clear that we can expect many types of changes (including changes in abundance, distribution, interactions, ecosystem processes and threats), the details cannot yet be predicted at the level of specific species and ecosystems due to the many complex interactions in ecosystems. This has important strategic implications for how biodiversity conservation can effectively respond to this challenge.

In Australia, different impacts may predominate in different regions, but it is difficult to say which regions' biodiversity will be more affected or less able to cope with climate change. In NSW, different studies have identified significant potential impacts in the rangelands, highly fragmented areas, the alpine zone, rivers and wetlands, coasts (near-shore through to salt marshes), the western slopes and the south eastern region (Pittock 2003, IPCC 2007, Stokes and Howden 2008, Dunlop and Brown 2008a). Most studies have focussed on how species may respond directly to changes in temperature and rainfall (e.g. through shifts in range), rather than how ecosystem processes and threats to biodiversity may change. Focussing on the latter can identify a different range of impacts, implications and priority regions (see Dunlop and Brown 2008a, b for a first-cut at such an assessment).

2. Management strategies and options for improvement

(i) Establishing and managing conservation areas

The Dunlop and Brown (2008a, b) report considered many of the important issues relevant to helping species and ecosystems survive climate change. While the report concentrated mainly on the formally protected conservation areas within the National Reserve System many of the conclusions are generally applicable to enhancing the ability of species and ecosystems to survive in all environments.

Climate change impacts will vary considerably between species and will be very difficult to predict. Therefore probably the best approach to minimise loss will be to make sure many different types of habitat are protected. This way even if the ecosystems and habitats change, a wide range of environmental conditions will be available to help native species survive as they respond in many different ways over time. Larger areas of habitat, and more of them, will also be required to help species adapt to changing conditions. It is important that the protection focus on habitats that would otherwise be altered, rather than on habitats under no threat from local activities.

The 'bioregional framework' used for building the National Reserve System is very well suited to this new challenge. It is already designed to develop a system of protected habitats across the continent that helps our biodiversity adapt to a broad range of environmental conditions.

The National Reserve System already covers more than 11 per cent of the continent and it contains many areas that are vital for the survival of Australia's plants and animals. Some of the native ecosystems only occur inside parks and reserves, or are limited elsewhere. The National Reserve System includes core habitats for many native species of high conservation value. Unfortunately, many of Australia's ecosystems, in NSW as elsewhere, are not yet adequately protected. As a result of climate change it is more urgent than ever that more key habitats are added to the National Reserve System, or effectively protected in some other way. New additions need to target a diversity of ecosystems across poorly protected environment types, with a particular focus on minimising loss of key species.

Systematically providing as much diversity of habitat types as possible for native species, for example through building a comprehensive, adequate and representative National Reserve System is an essential part of the fight against the impacts of climate change on Australia's biodiversity. It will also have many positive benefits for the wider Australian landscape. The developing National Representative System of Marine Protected Areas will have similar benefits for the marine environment.

As climate change takes effect, there will be changes in the abundance, diversity and distribution of species and ecosystems. There have already been important changes to native ecosystems and species in some areas. The challenge now is to more effectively manage threats such as fire, weeds and feral animals in protected areas, to help native species respond and adapt to changing environmental conditions, so we minimise the loss of key species and their habitat.

(ii) General management strategies

Considering the likely impacts of climate change on biodiversity leads to a range of general management strategies for managing native species and ecosystems across entire multi-tenure landscapes and seascapes:

- Accommodate significant and continuous changes in species and ecosystems, rather than attempt to prevent change to individual species. For example, pre-European vegetation types will not be suitable long term benchmarks for vegetation; ecological communities will change, some will disappear and new ones will form as different species respond in different ways; and observed declines in species abundance and distribution will not necessarily indicate a threat to viability, especially at the local scale. There is a need to systematically reassess what characteristics of the many aspects of biodiversity are suitable as conservation objectives, and which will change inevitably.
- Monitoring in the short-term to build up the knowledge base on management and response necessary to succeed in the long term. Many different aspects of biodiversity will be affected, including the relative abundance of different species, species distributions, ecosystem processes and threats to species and ecosystems; and, in general it will be very difficult to predict the details of changes, which types of changes will dominate, and which are most important from a management perspective. This suggests that the overarching strategy for biodiversity conservation should increasingly focus on developing management approaches that are effective in the face of changes in species and ecosystems that will be difficult to predict.
- Analyse how climate change will interact with existing threats. Climate change will have many direct and indirect impacts on species and ecosystems that may threaten the persistence of some species. However, it is more useful to consider how climate change will affect existing threats and their impacts, rather than to think of climate change as a threat to be managed separately.

Considering these issues, there is a range of policy and management options for enhancing the conservation of biodiversity under climate change (Dunlop and Brown 2008a):

- Ensure that the full range of possible changes resulting from climate change (including changing abundances and distributions and changing threats) are considered from a policy and management plan perspective. In particular, ensure such plans are not based on an assumption that species and ecosystems will or should remain static (i.e. as they are now or were 200 years ago). In doing so, it will be necessary to understand what types of changes and how much change might be “acceptable”; this will have both scientific and societal dimensions.
- Aim to conserve a high diversity of native habitats, as well as a large area of habitat, particularly those likely to be threatened if no conservation management occurs. As ecosystems and habitat requirements change, increasing the diversity of habitat (or ecosystem) types that are protected will increase the opportunity for a large number of native species to adapt to climate change and persist in the long term. The comprehensiveness and representativeness criteria applied through the Interim Biogeographic Regionalisation of Australia (as used in the National Reserve System) is a very effective framework for identifying and protecting habitat diversity (Parks Australia 2007). Indeed such criteria almost certainly provide a more strategic and effective basis for protecting as many species as possible in the long term than any criteria based on individual threatened species. The framework could also be used to prioritise conservation on private land, habitat restoration and incentive schemes.
- Anticipate how the action and impact of various threats to biodiversity may change. Four threats in particular are likely to be affected by climate change:
    - changed availability and use of water;
    - spread of native and exotic species into new areas;
    - changed land use (habitat loss and degradation); and
    - altered fire regimes.

  By anticipating how these threats may change, society and managers will be better prepared to respond to them in ways that minimise losses to biodiversity and negative impacts on other societal values.
- Many ecosystem processes and many of the changes that occur to biodiversity and threats will do so at large scales. Increased coordination of different conservation and NRM programs would enable improved management at landscape and regional scales. In some situations increasing the connectivity of native habitat will increase the ability of species to adapt to climate change. However, increasing connectivity may add pressures for some species by facilitating colonisation

of competitors, pathogens, predators and fire. Hence, isolated habitat patches will also be of conservation value, especially if they add to the diversity of habitats protected.

(iii) Biodiverse carbon plantings

If an emissions trading scheme is introduced in Australia, a possible consequence may be a marked increase the number and size of afforested areas. Afforestation provides the opportunity for many desirable outcomes for biodiversity and ecosystem restoration as well as salinity abatement and improvement of stream water quality. However, their extensive unplanned application may lead to adverse outcomes for other environmental benefits including water supply, pests and biodiversity, as well as creating the potential to negatively impact rural livelihoods and commodity supplies.

Vegetation plantings/management for carbon credits that are likely to have some biodiversity benefits include:

- Forest plantations using native species effectively as monocultures or simple mixes (e.g. mallee, eucalypts). These can be as standalone plantations or as corridors in an agricultural landscape
- Revegetation/reconstruction using a diversity of native species
- Natural regrowth of previously cleared woodland

The first option will provide the most carbon storage and will most likely make up the bulk of the carbon market. Native plantations provide different habitats for biodiversity that can complement neighbouring cropland or cleared grazing land, but their structural and functional simplicity means that species abundance and diversity is considerably less than native forests.

The second and third options are likely to provide much lower carbon gains per hectare but provide significant biodiversity benefits in their own right, and if planned appropriately can provide additional biodiversity benefits through increasing connectivity across landscapes. Natural regrowth of diverse native plantings may provide carbon sinks that are more resilient and less vulnerable to pests, drought and other disturbance. This concept requires testing, but given the necessity for long-term sequestration it may be an important consideration in designing carbon sinks.

There is a need for more research to quantify biodiversity and derived benefits at different scales of space and time, as well as how to identify what are the best species to use for a given location that provide the optimal biodiversity outcome.

3. Adaptation options that will also protect industries dependent on biodiversity and healthy ecosystems

(i) Fishing and aquaculture

Hobday and Poloczanska (2008) reviewed the impacts of climate change on fisheries and aquaculture. The East Australian Current, which runs down the NSW coast bringing warm waters from the north, is predicted to change the distribution of species targeted in wild fisheries and modify the locations of suitable environments for aquaculture species. Consideration of changes in distributions may allow fisheries management to facilitate adaptation to climate change. Selective breeding of aquaculture species may allow adaptation to warmer conditions, although changes in location may be inevitable for some operations.

Focused regional studies on the relationship between climate variables and the species of interest are one way to improve understanding of the potential impacts of climate change. However, the level of information available for many fisheries and aquaculture species is poor, so the adaptation options recommended by Hobday and Poloczanska (2008) focused largely on improving knowledge of species requirements. These adaptation options include:

- Undertake research on how fisheries and aquaculture management and policy can facilitate flexibility by operators seeking to adapt to climate change – are current management approaches suited to a changing climate?
- Collect and analyse data on the impacts of climate variability and trends on marine biology to give insight into the impacts of climate change on fisheries and aquaculture. Develop methods for assessing the vulnerability of fished and aquaculture species to environmental variables under climate change, including means, extremes, and cumulative impacts.

- Develop robust genetic strains for aquaculture species that perform well in future environments, and examine industry locations and opportunities under future climate scenarios.
- Develop predictive models for the occurrence of extreme events, and the thresholds for the biology (particularly for aquaculture). Deliver these warnings at a time in the production cycle that is useful to operators and build the capacity of these operators to integrate this information into their management plans.
- Investigate regional case studies for the impacts of climate change on the biological, social and economic relationships in fisheries and aquaculture.

(ii) Tourism

The general management strategies and adaptation options outlined in section (2) for conservation areas are applicable in many areas for protecting terrestrial biodiversity assets important to the tourist industry and other biodiversity dependent industries. A draft Marine Climate Impacts and Adaptation Report Card for Australia (Poloczanska et al. 2008) has been prepared by the Climate Adaptation Flagship. This considers sea grasses and mangroves, coastal areas, coral reefs, plankton, and fish as well as seabirds, reptiles and mammals. It outlines recent observations, what is expected by 2070 and suggests science and policy responses.

(iii) Information gaps and research needs

This submission has concentrated on identifying likely impacts as well as suggesting appropriate management strategies and adaptation options. There is a great need for more research on which to base these recommendations. CSIRO led a review of 'Biodiversity Conservation in a Changing Climate' (Hilbert et al. 2007) that identified information gaps and research needs. The Dunlop and Brown (2008a) report also includes details of information and research needs for effective future management of a wide range of conservation issues.

CSIRO has contributed to the development of a National Adaptation Research Plan (NARP) for marine biodiversity and resources (Mapstone et al. 2008) and is currently contributing to the preparation of a NARP for terrestrial biodiversity.

CSIRO is also contributing to a strategic assessment of the vulnerability of Australia's biodiversity to climate change that has been commissioned by the Department of Climate Change and should be released in mid 2009 (Steffen et al. forthcoming). This report recognises that there are both direct and indirect effects of climate change. The direct effects include temperature, changes in water regimes, acidification and CO_2 fertilisation while the indirect include effects on disturbance regimes like fire and invasive species, as well as impacts such as land clearing which are mediated through the human social and economic system's response to climate change. The direct impacts will eventually be massive, especially in the absence of strong mitigation, but the indirect effects and their interactions with existing stressors will dominate initially.

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