**Submission No 117**

# INQUIRY INTO PROPOSED AERIAL SHOOTING OF BRUMBIES IN KOSCIUSZKO NATIONAL PARK

**Organisation:** Centre for Ecosystem Science UNSW Sydney

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**Centre for Ecosystem Science, UNSW, Sydney**

**12th October 2023**

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**Centre for Ecosystem Science, UNSW Sydney**

The Centre for Ecosystem Science (CES), UNSW Sydney, supports policies and management of government, focused on improving effectiveness of biodiversity conservation and natural resource management, founded on a strong evidence base. Current rates of biodiversity loss around the world and in Australia are unprecedented. Researchers in CES have established track records in the research and management of Australia's biodiversity, both within and outside protected areas. Our researchers also work on the impacts of invasive species. In particular, our researchers focus on policy and management in the three main realms of biodiversity (freshwater, terrestrial, marine) in the natural world (https://www.ecosystem.unsw.edu.au/ ). We have considerable experience working in Kosciuszko National Park and we welcome the opportunity to provide this submission into proposed aerial shooting of brumbies in Kosciuszko National Park, given the significant impacts of this species on the protected natural values which are meant to be protected by government.

Wild or feral horses, also called brumbies, cause significant damage to ecosystems and dependent biodiversity in Kosciuszko National Park (Image: David Eldridge).

We address the following inquiry's eight terms of reference.

**a. The methodology used to survey and estimate the brumby population in Kosciuszko National Park**

Aerial surveys remain the only practical way of estimating changes in abundance and distribution of large animals over large areas, in operation for almost 80 years (Caughley and Sinclair, 1994). Aerial surveys are used all over the world to estimate animal populations from elephants (Dunham 2012), kangaroos (Caughley and Grigg, 1981) to waterbirds (Kingsford and Porter, 2009). Aerial surveys of wild horses (*Equus caballus*) or brumbies are the most appropriate methodology for surveying and estimating their population in Kosciuszko National Park.

Aerial surveys are a dependable methodology for collecting requisite information on large animal populations. All surveys, including aerial surveys, inevitably require sampling of the area to be surveyed and are thus affected by sampling error (Caughley, 1977). This produces an estimate of brumbies with confidence intervals (Cairns 2015, 2020, 2022). There are inevitable reasons for why there will be considerable uncertainty, including the terrain (e.g forested areas) and visibility. These are captured in the confidence intervals. Wildlife management can be informed by such estimates which can be also considered as indices tracking changes over time. Importantly, these indices can track populations and, if methodology remains the same, are a powerful method for comparative analysis over years.

Employing large spatial scale aerial surveys on wildlife, including invasive species such as brumbies, is fundamental for supporting and evidence-based approach to management and decision-making. There are no other practical alternatives. There are key principles for all surveys, including ensuring that the scale and the focus area are relevant, timing is defined and technique appropriate. For long-term understanding, it is also critical that surveys are repeatable in their timing, technique, and scale. For management of invasive or native large herbivores, the size and changes to populations need to be known for effective management. Over time, this can provide the baseline for understanding changes in range and abundance.

Aerial surveys of horse populations in Kosciuszko National Park are essential to adequately track their abundance and distribution. They are effective and provide valuable information for management (Walters and Hone, 2003; Cairns 2015, 2020, 2022). These need to be continued, utilizing the same methodology over time and so results from year to year are comparable.

**b. The justification for proposed aerial shooting, giving consideration to urgency and the accuracy of the estimated brumby population in Kosciuszko National Park**

If unchecked, all feral horse populations increase rapidly (Garrott, 2018). The feral horse or brumby population has increased rapidly from the late 1950s in New South Wales and Kosciuszko National Park. From aerial surveys in New South Wales part of the Australian Alps, there were an estimated 7,150 horses, with most 6,150 in Kosciuszko National Park in 2014 (Cairns and Robertson, 2015). Their range have extended over 3,000 $km^2$ of the Australian Alps National Parks of NSW and Victoria (Dawson and Hone, 2012). They varied in density, reaching a high recorded value of 2.74 individuals per $km^2$ in the northern Kosciuszko National Park (Cairns and Robertson, 2015). The Kosciuszko horse population was estimated to be increasing by 6-17 % annually (Cairns, 2015).

By November 2020, the number of horses had increased by nearly 40% to 14,380 feral horses (± 95% confidence interval of 8798–22,555) (Cairns, 2020). By November 2022, there were an estimated 18,814 feral horses (±95% confidence interval of 14501–23,535) (Cairns, 2022). They now range over 53% of the Kosciuszko National Park (NSW National Parks and Wildlife Service and Draft Amendment 2023).

Feral horses are difficult to maintain at a sustainable low level. They also concentrate, particularly in freshwater areas in the summer (Beever and Brussard, 2000; Beever and Herrick, 2006). Populations of feral horses also rapidly grow, because they can breed from 3 years of age (or 2 years at low densities with high food availability) and continue to breed until 15–18 years (Dawson and Hone, 2012). They have a maximum finite rate of increase of between 1.21 and 1.36 (Dawson and Hone, 2012). They have high annual fecundity ranging from 0.21 to 0.31 young per adult female, with high juvenile survival from 0.83 to 0.90 per annum and annual adult survival averaged 0.91 per annum (Dawson and Hone, 2012).

There are many reasons for the need for significant control of feral horses in Kosciuszko National Park, including removing all feral horse populations from Kosciuszko National Park and ensuring appropriate management to ensure that they no longer occur. This is essential, given that horse management needs to be compatible across the Alps and jurisdictional areas in Victoria and ACT, consistent with management in Kosciuszko National Park. Inadequate effective management across different jurisdictional area makes overall management of wild horses in the Australian Alps national parks is problematic (Australian Alps National Parks 2021).

Ongoing control is standard practice and control of brumbies would be required following any culling, but this would be small to prevent populations expanding. This may require ongoing aerial shooting (depending on access, horse density, social considerations and budgets; Driscoll et al. 2019). On-going costs could also use other potential options of control (e.g., ground shooting). If brumby populations are appropriately controlled, their numbers and control effort would inevitably decline over time.

**c. The status of, and threats to, endangered species in Kosciuszko National Park**

Studies from the Australian Alps have documented substantial negative effects of feral horses on a range of threatened fauna, from reptiles to fish and amphibians (Worboys et al., 2018). Horses or brumbies represent a significant threat to endangered species in Kosciuszko National Park. Generally, they have significant, negative impacts on alpine ecosystems (Driscoll, 2018; Driscoll et al., 2019). In 2018, the NSW Threatened Species Scientific Committee determined that "Habitat degradation and loss by feral horses" was a key threatening process. Further, in 2011, feral horses were listed as a Key Threatening Process under the federal environment legislation: the Environment Protection and Biodiversity Conservation Act - *EPBC Act 1999*. In the assessment of the impact of feral horses, the independent NSW Threatened Species Scientific Committee determined that 79 native plant and animal species were impacted, with six of these species found only in Kosciuszko National Park. Brumbies have impacts on terrestrial and freshwater ecosystems and their biodiversity, including threatened species, in Kosciuszko National Park. Feral horse activity reduces habitat quality for the endangered broad-toothed rat (*Mastacomys fuscus mordicus*), which depends on large native grasses for habitat and foraging, particularly in winter (Carron et al., 1990; Schulz and Green, 2018).

Horses also have indirect effects on endangered species by reducing habitat structure and spoiling waterways for a range of biota (Martin and Fahrig, 2012). Sphagnum bogs are particularly impacted with legacy effects because of their slow growing trajectory with peat soils permanently damaged by horse hooves. The sphagnum bogs are essential for the Critically Endangered corroboree frogs (*Pseudophryne corroboree)*, with their habitats disturbed, trampled, channelized and drained (Hope et al. 2012). Horse activity reduces litter depths to levels that impede nest construction by corroboree frogs, potentially exacerbating effects of egg desiccation that lead to reproductive failure (Scheele et al., 2012).

Other threatened wetland and river species are also affected including the stocky galaxis *Galaxis tantangara*, alpine spiny crayfish *Euastacus crassus*, alpine she-oak skink *Cyclodomorphus praealtus*, alpine water skink *Eulamprus kosciuskoi* (Hunter et al. 2009; Driscoll et al., 2019; Cherubin et al., 2019; Foster and Scheele, 2019; Ward-Jones et al., 2019) and alpine tree frog *Litoria verreauxii alpina* (Robertson et al. 2015). Riparian areas are also affected by wild horses, forming critical habitats for threatened species including alpine skinks (*Pseudemoia cryodroma, Cyclodomorphus praealtus, Eulamprus kosciuskoi*), the alpine spiny crayfish (*Euastacus crassus*), alpine tree frog (*Litoria verreauxii alpina*), as well as the broad-toothed rat (O'Brien et al., 2008).

Comparative difference between a natural wetland area, fenced off from feral horses, and highly eroded and damaged area affected by feral horses, which affect threatened native species (Image: David Eldridge)

**d. The history and adequacy of New South Wales laws, policies and programs for the control of wild horse populations, including but not limited to the adequacy of the 'Aerial shooting of feral horses (HOR002) Standard Operating Procedure'**

In general, New South Wales laws, policies and programs, relevant to wild horse populations have been inadequate. They have not effectively controlled the damaging impacts of wild horse populations on the environmental and cultural values of one of our more important alpine protected areas, Kosciuszko National Park. In particular, this has been exacerbated by the Kosciuszko Wild Horse Heritage Act 2018, which should be repealed. The well developed, well consulted and considered ‘Aerial shooting of feral horses (HROR002) Standard Operating Procedure’ is effective for procedural instrument for aerial shooting of feral horses.

**e. The animal welfare concerns associated with aerial shooting**

Aerial shooting is highly effective, with studies in Western Australia showing that most horses were killed instantly, with less than 1% non-fatally wounded (Hampton, et al. 2017). These rates are consistent with industry standards in abattoirs (Edge 2009). Shooting of feral horses is ethically valid, given a range of other animal welfare issues that are relevant if there is not effective aerial shooting (outlined in Driscoll et al. 2019). These include concerns about (1) prolonged suffering of horses during droughts and/ or following wildfire, when they can starve; (2) suffering of native animals affected by horse activity which destroys habitat, and; (3) damage to water supplies, endangered flora and fauna, threatened ecosystems, and increased extinction risk for native species (Fraser 2012; Fraser and MacRae 2011). Further, horses trapped above the snowline can suffer a long and painful death (Driscoll and Banks 2014).

Aerial shooting is an efficient and effective method of reducing feral horse numbers, compared with other methods such as trapping and transportation to abattoirs (Dobbie, et al. 1993; Driscoll et al. 2018, 2019). It is used widely in other states (ACT, NT), with reliability where non-target and non-fatal injuries are low (Hampton et al. 2017). Hampton et al. (2017) report that during aerial culling of horses in WA, 37% of horses not killed instantly were dead within 0.1 to 4 minutes, considerably shorter than reported slow deaths following fire and drought (Becker 2018; English 2000; Garrott 2018).

### f. The human safety concerns if Kosciuszko National Park is to remain open during operations

We work regularly with the NSW National Parks and Wildlife Service in relation to the shooting of feral animals in some of our research sites (e.g. Macquarie Marshes). There are strict and clear protocols for closing areas when there are feral animal control operations. These can be effectively programmed to occur in spatially and temporally explicit areas, so that human safety concerns can be eliminated in Kosciuszko National Park.

### g. The impact of previous aerial shooting operations (such as Guy Fawkes National Park) in New South Wales

An aerial cull at Guy Fawkes National Park was highly successful, with only one case of prolonged suffering and 606 horses culled effectively (English 2000, Chapple 2005). The Guy Fawkes cull occurred at a time, when feral horses were dying due to food shortage after fire, so the cull was a humane and an appropriate response to an animal welfare issue (Driscoll et al. 2019).

### h. The availability of alternatives to aerial shooting

There are a range of control methods for horses: trapping and culling or removal, ground or aerial mustering and culling or removal, ground shooting, fertility control and fencing. The Draft Wild Horse Management Plan, Kosciuszko National Park (2016) identified trapping (with culling or removal), ground or aerial mustering (with culling or removal), ground shooting, fertility control and fencing (Driscoll et al. 2019) as potential control methods. Each method complies with Commonwealth or State animal welfare codes, regulations, or standard operating procedures (NPWS 2016).

Mustering and translocating wild horses have impacts on horse welfare outcomes because of the stress caused by mustering, handling and trapping (Beeton and Johnson, 2019). This can be exacerbated by 'capture myopathy', leading to degenerative muscle condition (Breed et al. 2019), which is often lethal and increases death of foals (Dechen Quinn et al. 2014). Trapping of feral horses in portable yards using salt block lures, helicopters or ground mustering is used extensively in Kosciuszko National Park. Trapping success is limited in alpine areas and requires continual checking to prevent interference to yards. Helicopter or ground-based mustering is inappropriate in inaccessible areas, where the population density is low, and in areas of high visitor densities. Trapping requires luring horses into portable yards and mustered with helicopters. Removal of wild horses to abattoirs is often difficult due to the terrain, so animals need to be controlled on-site. Trapping is susceptible to interference by third parties. Mustering on horseback could be used in some areas but is extremely cost effective and inappropriate in fragile alpine environments. Mustering and trapping are extremely stressful for wild horses. Roping under contract involves capturing horses from horseback and leading them to yards. This can work in rugged, but success is mixed, can be dangerous even for skilled riders, and may be inappropriate in fragile alpine environments.

Fertility control has been deemed ineffective in Kosciusko National Park because of 1) the rugged terrain, 2) large numbers of animals, 3) the probability of immigration, and 4) the paucity of suitable vaccines (Hobbs and Hinds 2017). Fertility control cannot extend across the range of feral horses and is also extremely expensive and ineffective because horses move widely inside and outside Kosciuszko National Park (Hobbs and Hinds, 2018). It is unlikely to be effective in Kosciuszko National Park because; the terrain is extremely rugged and the horse population is widely dispersed, making it difficult to trap sufficient number of animals, at regular intervals, and to identify treated and untreated animals across a large population size, even if suitable vaccines were available in Australia (Hobbs and Hinds, 2018). The NSW Independent Technical Review Group on Wild Horses concluded that fertility control, in the absence of other methods, would be ineffective at Kosciusko National Park (Driscoll et al. 2019). For example, fertility control would require that females be treated every 2-4 years and reductions would be unlikely with a decade (Hobbs and Hinds 2018).

Fencing of sensitive areas is effective but extremely costly and only applicable for small areas (Durant et al., 2015, see photo above). Fences are also difficult to maintain, particularly in rugged alpine areas, and may exclude native herbivores from accessing vital resources. Also, fencing of sensitive areas is not an option due to maintenance, cost and the risk of interference and vandalism.

Aerial shooting of feral horses is the most humane and only practical method of population control (Dobbie et al. 1993) and is used widely in other jurisdictions within Australia (e.g., ACT, Northern Territory). Aerial shooting is an extremely efficient and effective method of reducing feral horse numbers compared with other methods such as trapping and transportation to abattoirs (Dobbie, et al. 1993; Driscoll et al. 2018, 2019). It is used widely in other states (ACT, NT), extremely reliable, and non-target and non-fatal injuries extremely low (Hampton et al. 2017).

### i. Any other related matters: environmental impacts of wild horses or brumbies

Wild or feral horses, also known as brumbies or mustangs, are a major invasive species around the world, presenting considerable ecological, social, cultural and ethical challenges for land managers, conservationists and governments on several continents (Scasta et al., 2016). There is a considerable body of research on the environmental impacts of wild horses or brumbies. Wild horse grazing in Kosciuszko National Park was recognised as an ecological threat in the late 19$^{th}$ Century by Helms (1893), but their impacts in the Australian Alps were not explored exclusively until the mid-20$^{th}$ century (Costin, 1954).

Wild horses were introduced into the Australian Alps more than 150 years ago (Walter, 2002). The extent of environmental impacts of wild horses in the Australian Alps is supported by scientific evidence spanning more than 30 years. Beyond threatened species, they cause significant damage to other species and environments in terrestrial and freshwater ecosystems, including threatened ecosystems. Reductions in vegetation structure by feral horses affects invertebrates (Ostermann-Kelm et al., 2009), small mammals (Beever and Brussard, 2004), birds (Zalba and Conzzani, 2004) and estuarine fauna (Levin et al., 2002).

***Terrestrial ecosystems***

Feral horses impact terrestrial ecosystems in a range of different ways. Wild horses affect soil biology (Brim-Box et al., 2014); alter landscape hydrology *via* structural changes to the soil and vegetation (Worboys and Pulsford, 2013); and influence the community composition of many organisms (Levin et al., 2002; Zalba and Cozzani, 2004; Beever and Brussard, 2004; Beever and Herrick, 2006). Wild horses also ringbark trees and spread weeds and pathogens. In particular, they change nutrient cycles with concentrated urine and faeces (dung heaps), which then become a key mechanism for spreading weeds (Loydi and Zalba, 2009). They also spread weeds by directly transporting them (Weaver and Adams, 1996).

Wild horse dung heaps are serious vectors for the spreading of weeds in Kosciuszko National Park (Image: David Eldridge).

Further damage to plants and vegetation can occur when horses trample and rub against vegetation, browse the growing tips, and compact soils with their hard hooves, causing disturbance and increasing erosion (Schott 2005). Much of the research on impacts of feral horses over the past quarter century has focused on vegetation impacts, with long-term legacy effects of brumby activity in both the Victorian and NSW alpine and sub-alpine communities. There is extensive scientific literature documenting wild horse impacts on plant community structure and composition (Venn and Williams, 2018; Eldridge et al., 2019), with strong focus on terrestrial systems (Prober and Thiele, 2007). Brumbies do this damage by feeding on grasses and sedges, and also bark and roots, but also their physical impact with their weight and hard hooves, impacting vegetation and compacting soil. High densities of wild horses negatively impact many alpine plant species, including the anemone buttercup *Ranunculus anemoneus* (Doherty et al., 2015). They also change the structure of the habitat, affecting specialist alpine mammals such as the broad-toothed rat *Mastacomys fuscus* (O'Brien et al., 2008; Schulz and Green, 2018; Cherubin et al., 2019; Eldridge et al., 2019; Schulz et al., 2019) and mountain pygmy-possum *Burramys parvus*.

Using a global database, data were extracted from studies in Kosciuszko National Park of the effects of wild horses on a range of ecosystem processes and properties (Eldridge et al. 2019). There were consistent declines in native animal abundance, grass cover and height;

sedge, subshrub, shrub and biocrust cover; and soil moisture, soil infiltration, Nutrient index and soil stability (Table 1). With increased feral horse activity, there are increases in the cover of bare soil, forbs and weeds, and soil nitrogen, respiration and electrical conductivity (Table 1). There were no changes in soil bulk density, enzymes, carbon, C:N ratio, erosion, pH and phosphorus, and grass density and fungal diversity, litter cover, plant abundance, plant biomass, plant cover, plant richness with effects of horse activity (Table 1).

**Table 1**. Effects of increasing levels of horse grazing on a range of plant, animal and soil attributes from studies in the alpine regions of eastern Australia in terrestrial and freshwater ecosystems. Source: Eldridge et al. (2019) OEH (2017) and OEH (2019) unpublished data.

| **Attribute** | **Location** | **Effect** | **Reference** |
|---|---|---|---|
| **Terrestrial impacts** | | | |
| Animal abundance | Kosciuszko National Park | Decline | Schulz and Green (2018) |
| Animal abundance | Kosciuszko National Park | Decline | OEH (2017) |
| Bacterial diversity | Kosciuszko National Park | Decline | OEH (2017) |
| Bare soil | Kosciuszko National Park | Increase | OEH (2017) |
| Bare soil | Victoria | Increase | de Bies and Vesk (2014) |
| Bare soil | Victoria | Increase | Prober and Thiele (2007) |
| Bare soil | Victoria | Increase | Thiele and Prober (1999) |
| Biocrust cover | Kosciuszko National Park | Decline | OEH (2017) |
| Forb cover | Kosciuszko National Park | Increase | OEH (2017) |
| Fungal diversity | Kosciuszko National Park | No change | OEH (2017) |
| Grass cover | Kosciuszko National Park | Decline | OEH (2017) |
| Grass density | Kosciuszko National Park | No change | OEH (2017) |
| Grass height | Kosciuszko National Park | Decline | OEH (2017) |
| Litter cover | Kosciuszko National Park | No change | OEH (2017) |
| Litter cover | Victoria | Decline | Prober and Thiele (2007) |
| Litter cover | Victoria | No change | Thiele and Prober (1999) |
| Nutrient index | Kosciuszko National Park | Decline | OEH (2017) |
| Plant abundance | Victoria | Increase | Prober and Thiele (2007) |
| Plant abundance | Victoria | No change | Thiele and Prober (1999b) |

| | | | |
|---|---|---|---|
| Plant biomass | Victoria | Decline | de Bies and Vesk (2014) |
| Plant biomass | Victoria | Decline | Prober and Thiele (2007) |
| Plant biomass | Victoria | No change | Thiele and Prober (1999) |
| Plant cover | Victoria | Decline | de Bies and Vesk (2014) |
| Plant cover | Victoria | Decline | Dyring (1990) |
| Plant cover | Victoria | Decline | McDougall (2007) |
| Plant cover | Victoria | No change | Prober and Thiele (2007) |
| Plant cover | Victoria | No change | Thiele and Prober (1999) |
| Plant cover | Victoria, ACT and NSW | No change | Robertson et al. (2015) |
| Plant height | Kosciuszko National Park | Decline | OEH (2017) |
| Plant richness | Cabramurra, NSW | Decline | Schulz and Green (2018) |
| Plant richness | Kosciuszko National Park | Increase | OEH (2017) |
| Plant richness | Victoria | Decline | Dyring (1990) |
| Plant richness | Victoria | Increase | de Bies and Vesk (2014) |
| Plant richness | Victoria | Increase | McDougall (2007) |
| Plant richness | Victoria | Increase | Thiele and Prober (1999) |
| Plant richness | Victoria | Increase | Weaver and Adams (2008) |
| Plant richness | Victoria | No change | Prober and Thiele (2007) |
| Plant richness | Victoria, ACT and NSW | No change | Robertson et al. (2015) |
| Sedge cover | Kosciuszko National Park | Decline | OEH (2017) |
| Shrub cover | Kosciuszko National Park | Decline | OEH (2017) |
| Subshrub cover | Kosciuszko National Park | Decline | OEH (2017) |
| Soil bulk density | Kosciuszko National Park | No change | OEH (2017) |
| Soil bulk density | Victoria | Decline | Dyring (1990) |
| Soil carbon | Kosciuszko National Park | No change | OEH (2017) |
| Soil carbon | Victoria | No change | Dyring (1990) |
| Soil C:N ratio | Kosciuszko National Park | No change | OEH (2017) |
| Soil EC | Kosciuszko National Park | Increase | OEH (2017) |

| | | | |
|---|---|---|---|
| Soil enzymes | Kosciuszko National Park | No change | OEH (2017) |
| Soil erosion | Victoria | Decline | Dyring (1990) |
| Soil erosion | Victoria | Increase | Prober and Thiele (2007) |
| Soil erosion | Victoria | Increase | Thiele and Prober (1999) |
| Soil erosion | Victoria, ACT and NSW | Decline | Robertson et al. (2015) |
| Soil infiltration | Kosciuszko National Park | Decline | OEH (2017) |
| Soil moisture | Victoria | Decline | Dyring (1990) |
| Soil nitrogen | Kosciuszko National Park | Increase | OEH (2017) |
| Soil phosphorus | Kosciuszko National Park | No change | OEH (2017) |
| Soil pH | Kosciuszko National Park | No change | OEH (2017) |
| Soil respiration | Kosciuszko National Park | Increase | OEH (2017) |
| Soil stability | Kosciuszko National Park | Decline | OEH (2017) |
| Soil stability | Victoria, ACT and NSW | Decline | Robertson et al. (2015) |
| Weed cover | Victoria | Increase | Dyring (1990) |
| **Freshwater impacts** | | | |
| Stream size | Victoria | Decline | Thiele and Prober (1999) |
| Riverbank fish habitat | Kosciuszko National Park | Decline | OEH (2019) |
| Pollution tolerant macroinvertebrates | Kosciuszko National Park | Decline | OEH (2019) |
| Native *Galaxia olidus*. abundance | Kosciuszko National Park | Decline | OEH (2019) |
| Trout biomass | Kosciuszko National Park | Decline | OEH (2019) |
| Macroinvertebrate richness | Kosciuszko National Park | Decline | OEH (2019) |
| Stream size | Victoria | Increase | Prober and Thiele (2007) |
| Streambed fine sediment | Kosciuszko National Park | Increase | OEH (2019) |
| Turbidity | Kosciuszko National Park | Increase | OEH (2019) |
| Water temperature | Kosciuszko National Park | Increase | OEH (2019) |

| | | | |
|---|---|---|---|
| Streambank compaction | Kosciuszko National Park | Increase | OEH (2019) |
| Water conductivity | Kosciuszko National Park | Increase | OEH (2019) |
| *Escherichia coli* concentration in water | Kosciuszko National Park | Increase | OEH (2019) |

***Freshwater ecosystems***

Wild horses damage freshwater ecosystems, including streams, wetlands and riparian systems (Dawson, 2009). In swamps, emergent and sub-emergent plants are an important source of food for horses. They graze in wetlands and trample areas, create tracks, and compact the soil. They also bathe in water by wallowing or in dust baths. This changes streams and rivers, causing erosion and bank slumping, affecting nutrient dynamics (Dyring, 1990). They reduce streambank stability (Prober and Thiele, 2007), increase run-off by creating paths (Pittock and Finlayson, 2018), and increase sedimentation of rivers and wetlands (Porfiriro et al., 2017; Robertson et al., 2019). They may also have impacts on run-off (Worboys et al., 2010). This also reduces water quality. Analyses of stream turbidity in Kosciuszko National Park streams indicated significant increases, much greater than at control sites, exceeding 50 times the national turbidity guidelines (Scanes et al., 2021). Such increases in turbidity can lead to loss of aquatic biodiversity and function, with a clear link to impacts of wild horses (Scanes et al., 2021).

For the peatlands of Kosciuszko National Park, there are widespread effects of horse damage. They create paths which channel water and drain peatland communities, significant storages of carbon (Hope et al., 2012), which are destroyed by drying which releases carbon into the atmosphere, contributing to greenhouse gases. These peat soils are ancient, formed over thousands of years, but quickly destroyed by brumbies (Hope, 2018). Even low numbers of horses are destructive (Williams, 2019). Wild horses are particularly damaging to sphagnum bogs (Berman, 2008; Prober and Thiele, 2007; Tolsma, 2009; Warboys and Pulsford, 2013; Robertson et al., 2015). This impact is becoming more evident with increasing numbers of wild horses (Worboys and Pulsford, 2013).

Example of serious erosion effects of wild horses on stream in the Kosciuszko National Park, destroying habitats with their hard hooves and deteriorating water quality. (Image: David Eldridge)

In aquatic systems, increasing horse activity has resulted in declines in stream size, fish biomass and macroinvertebrate richness, and increases in water pH, turbidity, conductivity and fine sediment (Table 1). Horse impacts on freshwater systems are also likely to cause significant effects on platypus populations throughout Kosciuszko National Park. Removal of riparian vegetation and trampling of banks causes significant issues for platypuses (*Ornithorhynchus anatinus*), which rely on riverbanks to build resting burrows and nesting burrows for their dependent young. Changes to water quality and impacts on their macroinvertebrate prey will also significantly impact the species distribution.

Horses also regularly impact freshwater areas to drink but pug and dig up stream beds, affecting freshwater ecosystems (see photos). Impacts on water quality can affect unique karst systems within the park, such as at Blue Waterholes and Yarrangobilly Caves. High levels of sediments in the groundwater rising at Blue Waterholes probably reflect past feral horse grazing activity, affecting the system for several millennia (Spate 2004). This legacy effect of brumby grazing is particularly problematic for fragile karst systems which are essentially unrenewable and are irreparable within human time frames (Spate 2004).

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