FERAL HORSE **IMPACTS**

THE KOSCIUSZKO SCIENCE CONFERENCE

CONFERENCE ABSTRACTS

Australian National University

DEAKIN UNIVERSITY

Australian Academy of Science

Feral Horse Impacts: The Kosciuszko Science Conference
Conference Abstracts

A co-convened conference of the Australian Academy of Science; Fenner School of Environment and Society, The Australian National University; and Deakin University.

Academy of Science Shine Dome
8 November 2018

Publishers

This *Conference Abstracts* book is published by the Australian Academy of Science; Fenner School of Environment and Society, The Australian National University; and Deakin University.

Citation

Worboys, G. L., Driscoll, D. and Crabb, P. (2018) *Feral Horse Impacts: The Kosciuszko Science Conference – Conference Abstracts*, Australian Academy of Science, The Australian National University and Deakin University, Canberra.

Sponsor

A generous financial sponsorship contribution from the National Parks Association (ACT) facilitated the copyediting, design and printing of this *Conference Abstracts* book.

Supporter

Recognition is provided to special volunteer contribution of the Ecological Society of Australia in the production of this book.

ISBN 978 0 85847 598 4

Cover Photo

The endangered Anemone Buttercup (*Ranunculus anemoneus*) on the flanks of Blue Cow Mountain, Kosciuszko National Park. This most magnificent of alpine flowers was almost wiped out by stock grazing. The gradual return of the Anemone Buttercup has become the symbol of the conservation success of stock removal from the Park. (Source: Mel Schroder.)

Rear Cover Photo

Mountain Pygmy-possum (*Burramys parvus*), Kosciuszko National Park. (Source: Mel Schroder.)

FERAL HORSE IMPACTS: THE KOSCIUSZKO SCIENCE CONFERENCE

CONFERENCE ABSTRACTS

Edited by Graeme L. Worboys,[1] Don Driscoll[2] and Peter Crabb[1]

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ACKNOWLEDGEMENTS

Professional staff of the Australian Academy of Science contributed to the planning, organising and professional development of all aspects of the Kosciuszko Science Conference, including design, invitation management, media management, event management and the provision and operation of the Shine Dome venue. Dr Stuart Barrow was particularly helpful in co-ordinating this assistance. The generous contribution of the Academy is gratefully recognised here.

The Australian National University's Fenner School of Environment and Society, under the leadership of Professor Saul Cunningham, facilitated all aspects of the Conference planning and preparation, provided peer reviews of Speaker Abstracts and provided financial support through a combined Fenner School contribution and an Environment and Society Synthesis Programme Grant. This covered operational costs, printing and facilitated the attendance of speakers and young environmental management professionals. A Fenner PhD researcher, Renée Hartley, and an early career researcher, Dr Benjamin Scheele, contributed directly to the organisation of the Conference as members of the Conference Organising Committee. Dr Peter Crabb completed an essential copyedit and refinement of the *Conference Abstracts* text. Former Fenner School staff member Clive Hilliker developed some of the maps published in this book. Fenner communications officer Rosanna Stevens helped organise many aspects of the Conference.

Deakin University contributed the substantial time of Professor Don Driscoll as a member of the Organising Committee and as a peer reviewer of the Abstracts.

The National Parks Association (NPA) of the Australian Capital Territory (ACT) helped sponsor the copyediting, design and printing of this book. The contribution of President Esther Gallant in facilitating this sponsorship is particularly appreciated. NPA (ACT) members volunteered at the conference.

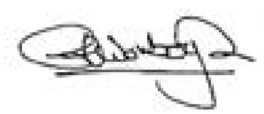
Our speakers were asked to generate Abstracts and respond to peer-review comments with short turnaround times. Their positive assistance made the preparation of this book in time for the Conference possible, and this commitment is recognised here with great appreciation.

Many photographers have contributed work to this book. Their contributions have helped to tell the story of feral horse impacts in the Australian Alps national parks, and this is gratefully acknowledged. The source of each image published has been identified.

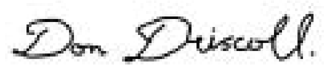
Doug Mills generated some of the maps published in this book. His good work is recognised.

The professional work of copyeditor and proofreader Emily Hazlewood and designer Teresa Prowse within a tight time frame has been greatly appreciated. Trish McDonald directly assisted with the Conference organisation.

The Editors



(Honorary) Associate Professor Dr Graeme L. Worboys, Fenner School of Environment and Society, The Australian National University



Professor Don Driscoll, Director, Centre for Integrative Ecology, Deakin University

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FOREWORD

Australian researchers have had a long and active interest in the scientific significance and conservation protection of the area recognised as the Australian Alps national parks.

In May 1957, for example, the recently established Australian Academy of Science published a landmark report *On the Condition of the High Mountain Catchments of New South Wales and Victoria* (Australian Academy of Science 1957).

Among other things, this report called for the complete exclusion of all stock animals in catchments above 4,500 feet (1,350 metres). It was instrumental in achieving a decision by the NSW Government to discontinue sub-alpine Snow Leases in Kosciuszko State Park, and to ban stock from the high mountain catchments.

In 1958, the Academy provided scientific input into planned tunnelling and aqueduct engineering works of the Snowy Mountains Scheme around the summit area itself. The Academy's direct involvement in this debate helped establish a new 'Kosciuszko Primitive Area' in 1963, which established engineering development limits and has contributed to the untouched alpine environment around the summit today.

This longstanding scientific involvement in Australia's alpine areas is ongoing.

For example, the Fenner School of Environment and Society at The Australian National University and Deakin University both have specialised programs of research and teaching on the ecology of many Australian alpine reptile, amphibian and mammal species; on alpine fire management; and on invasive species and the study of catchments. All of these efforts contribute to the improved conservation management of the Australian Alps national parks.

And the need for informed scientific input into alpine conservation management has never been greater.

In June 2018, the NSW Government passed the *Kosciuszko Wild Horse Heritage Act 2018*. An open letter from Fellows of the Academy and other researchers pointed out that the legislation effectively gave priority to a single invasive species, the feral horse, over many native species and ecosystems, some of which are found nowhere else on Earth. It also noted that the legislation was not consistent with the principles that underpin Australia's world-leading protected area system, nor with Australia's obligation as signatory to the Convention on Biological Diversity.

This is one of the reasons why the Academy, in partnership with The Australian National University and Deakin University, has co-convened this Kosciuszko Science Conference.

Together, we aim to provide an opportunity for scientists to speak up and present their research and observations in a science-based forum.

This book presents 21 peer-reviewed Abstracts prepared by highly qualified researchers that describe the existing and forecast impacts of feral horses in Kosciuszko National Park and the Australian Alps national parks of Victoria and the ACT. The papers deal with catchments, water, habitats, native animals and native plants. It has been prepared as a contribution to an informed future for the conservation, management and protection of the priceless natural heritage of Kosciuszko National Park and the Australian Alps national parks.

Dr T. J. Higgins,
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Professor Saul Cunningham,
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Environment and Society,
The Australian National
University

Professor Don Driscoll,
Director, Centre for Integrative
Ecology, Deakin University

Reference

Australian Academy of Science (1957) *A Report on the Condition of the High Mountain Catchments of New South Wales and Victoria*. Australian Academy of Science, Canberra.

PREFACE

Alec Costin AM FAA DScAgr

One of the great privileges that I have had in my life has been to work as a scientist in the area now known as the Australian Alps national parks. What an amazing place these Australian mountains are: ancient uplands, escarpments and valleys, biologically diverse and the headwater source of some of our country's greatest rivers. What a contrast they are to the immensity of our huge, flat and dry continent, and how refreshing this is. Like many others before me, the mood, ambiance, aesthetics and special scientific values of these mountains totally captured me as a young scientist. I had the opportunity to study these landscapes and their ecology; to immerse myself in the greater understanding of the diversity of life, ecological and geological processes; and to be alarmed at certain land practices. In 1954 I wrote:

> In natural systems on which human influences have been superimposed, the ecologist should not ignore the practices of land use or their effects; to do so would be to fail in his full function as ecologist. In his treatment of the human factor in relation to a particular system he may observe cases of maladjusted land use, as indicated by a progressive loss of stability leading ultimately to the destruction of the system as a whole (Costin 1954).

I never thought that we would need to revisit this 64-year-old statement. The damaging impacts of stock grazing to the mountain catchments were removed from Kosciuszko National Park by three visionary policy decisions of government and great leaders that banned grazing—in 1944, 1957 and 1969. Science and an understanding of mountain ecology helped to underpin these land use decisions. It took a long time (26 years) and millions of dollars of investment to heal the soil erosion in the summit area. This was a big cost to the community that should have been avoided. In the stock-free Kosciuszko National Park, I have personally witnessed its gradual recovery, though some of it will take generations to heal to a stable state. Kosciuszko was on the mend: the catchments were healing and ecologically based catchment management was being implemented.

So why change this? Why legislate through the *Kosciuszko Wild Horse Heritage Act 2018* in favour of a known agent of environmental damage to the mountain catchments, the feral horse, undoing 75 years of catchment-healing investments by multiple governments? Thousands of feral horses will continue to impact water catchments and water delivery of national economic importance for so many people downstream. Endangered Australian species will also be impacted. There is a need to repeal this regressive Act.

This brings me to this 2018 Feral Horse Impacts Conference and its purpose. I am very pleased that scientists are being provided with the opportunity to speak up on this issue. From their papers, it is clear scientists are not ignoring 'the practices of land use or their effects' in presenting their evidence. Contributions in this scientific forum will help Australian society fully understand the impacts of the feral horse in Kosciuszko's sensitive mountain catchments and will contribute to this unfinished debate.

Dr Alec Costin, celebrating 50 years since *A Study of the Ecosystems of the Monaro Region of New South Wales* was published, Jindabyne, 11 December 2004.
Source: Graeme L. Worboys.

Reference

Costin, A. B. (1954) *A Study of the Ecosystems of the Monaro Region of New South Wales, with Special Reference to Soil Erosion*. NSW Government Printer, Sydney.

ABOUT THE KOSCIUSZKO SCIENCE CONFERENCE

Kosciuszko Wild Horse Heritage Act 2018 (NSW)

The NSW Wild Horse Heritage Act was assented to on 15 June 2018. It was an Act to recognise heritage values of sustainable wild horse populations within parts of Kosciuszko National Park and to protect that heritage. It was introduced by NSW Deputy Premier and NSW National Party Leader The Honourable John Barilaro MP. The legislation gave priority to feral horses over native species and the mountain catchments, over-rode the 2006 Kosciuszko National Park Plan of Management for areas identified as 'horse areas', and introduced management by a Community Advisory Panel that precluded the involvement of scientists or professional protected area managers. The Act undermines the integrity of the NSW National Parks and Wildlife Act and threatens the status of the Park as a National Heritage–listed place. The Act has been described as the single biggest act of environmental regression for Kosciuszko National Park in its 75-year history.

Purpose of the Conference

The 'Feral Horse Impacts: The Kosciuszko Science Conference' is a science-based conference that provides an opportunity for scientists to speak up, to have a voice about this contentious issue: the feral horse in a protected area. It provides an opportunity to present scientific evidence of feral horses as a threat to natural heritage values and to respond to the ramifications of the *Kosciuszko Wild Horse Heritage Act 2018* (NSW). It is an opportunity for researchers to account for the natural National Heritage values that are being impacted by feral horses, and for the wider community to have access to this information through these published peer-reviewed *Conference Abstracts*, and through longer peer-reviewed papers that will be published in the *Journal of Ecological Management and Restoration*.

Aims: The Kosciuszko Science Conference

The Kosciuszko Science Conference aims to:

1. Provide a forum for scientists to present research information on the condition and trend in condition of the catchments and streams, ecosystems and native fauna and flora species of the Australian Alps national parks and specifically Kosciuszko National Park, the Victorian Alpine National Park and Namadgi National Park.[1]
2. Identify feral horse impacts (and other vertebrate pest animal threats) to the natural National Heritage values of Kosciuszko National Park and the Victorian Alpine National Park.
3. Provide a forum to discuss the implications of feral horse impacts (and other vertebrate pest animal threats) on scientific and natural National Heritage values.

1 These phenomena are recognised as natural National Heritage values of the Australian Alps national parks, including Kosciuszko National Park.

4. Provide a forum to discuss the implications of the NSW *Kosciuszko Wild Horse Heritage Act 2018* on the protection of protected areas and National Heritage Places in Australia.
5. Publish and make available a book of *Conference Abstracts*, to (separately) publish key papers arising from the Conference and to generate a 'Kosciuszko Science Accord' arising from the Conference.

The 'Kosciuszko Science Accord'

The Kosciuszko Science Accord will provide a succinct statement from scientists and organisations concerning feral horses in Kosciuszko National Park and their impacts on natural National Heritage values. It will identify the regressive implications of the 'Wild Horse Heritage Legislation' for protected areas and National Heritage–listed places. The Accord will be prepared as a statement for policy makers and politicians. The Accord will be introduced during the Conference. It will be separate to this book.

Feral horses at Blue Waterholes Campground, Kosciuszko National Park, September 2018.
Source: Di Thompson.

THE AUSTRALIAN ALPS NATIONAL PARKS

> Although occupying less than 0.3 percent of the continent, the Australian Alps present to the World a large and irreplaceable sample of Australian natural history (Costin 1989).

The Australian Alps national parks are a small area of Australia with a big influence. They include 11 national parks and reserves and extend over 1.644 million ha across the ACT, NSW and Victoria (Figure 1). These high mountain catchments occupy only 0.3% of Australia, but they contribute an estimated average 9,600 GL of water to the Murray–Darling Basin system worth billions of dollars each year, which helps support millions of people downstream all the way to Adelaide and the Coorong.

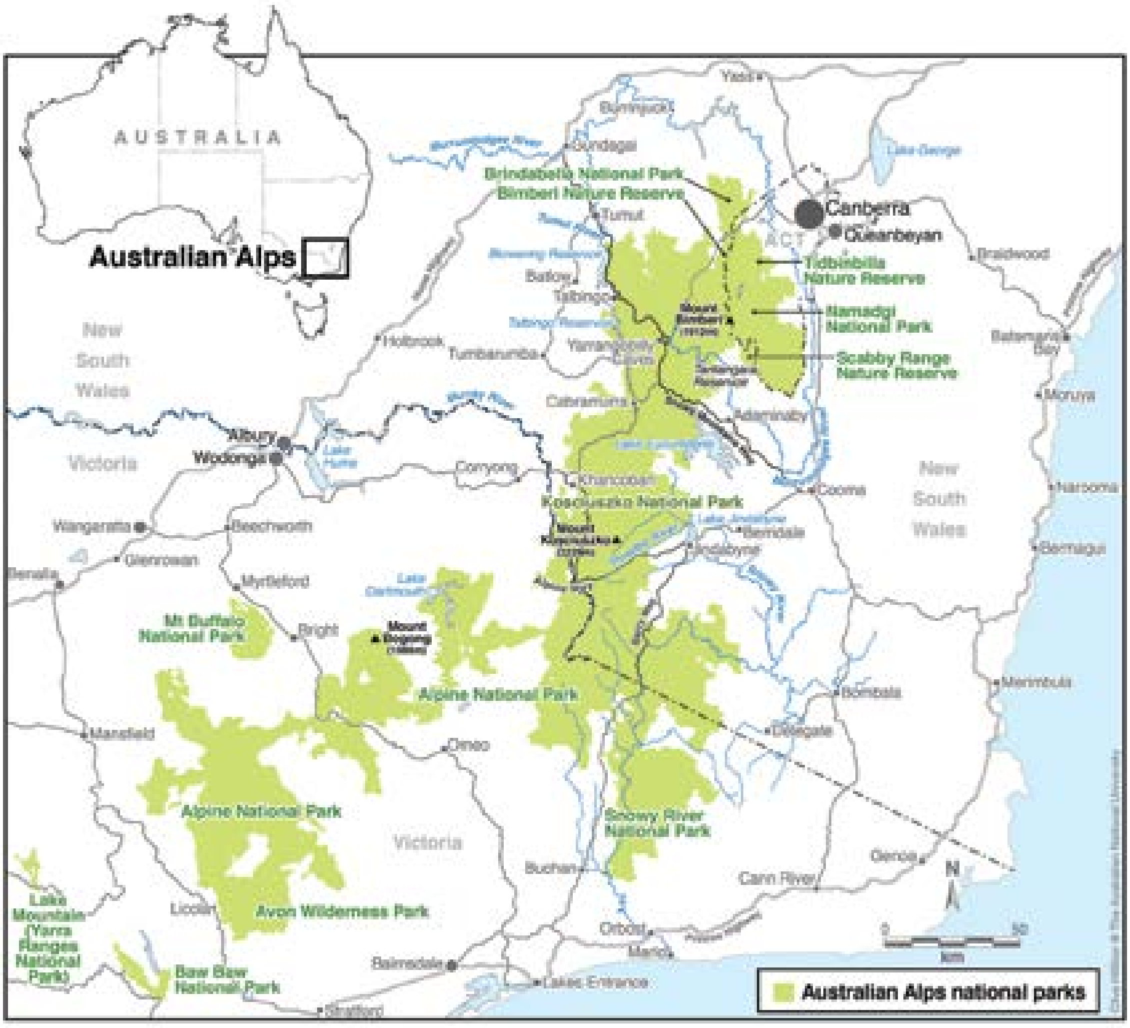


Figure 1. Australian Alps national parks.
Source: Prepared by Clive Hilliker.

Reference

Costin, A. B. (1989) The Alps in a Global Perspective. In R. Good (ed.), *The Scientific Significance of the Australian Alps: The Proceedings of the First Fenner Conference on the Environment*, pp. 7–19. Australian Alps National Parks Liaison Committee and Australian Academy of Science, Canberra.

Feral horse damage to creek, Bill Jones Hut, Northern Kosciuszko, September 2018.
Source: Di Thompson.

2011 DISTRIBUTION OF FERAL HORSE IMPACTS: AUSTRALIAN ALPS NATIONAL PARKS

In 2010, protected area managers from the ACT Parks and Conservation Service, NSW National Parks and Wildlife Service and Parks Victoria provided expert advice for a study that assessed the condition and trend in condition of the natural mountain catchments. The assessments were based on their detailed personal knowledge of their particular sub-catchments. As part of this work, they identified and mapped areas where damage from pest animals was prominent, in particular feral horses (Figure 2) (Worboys et al. 2011).

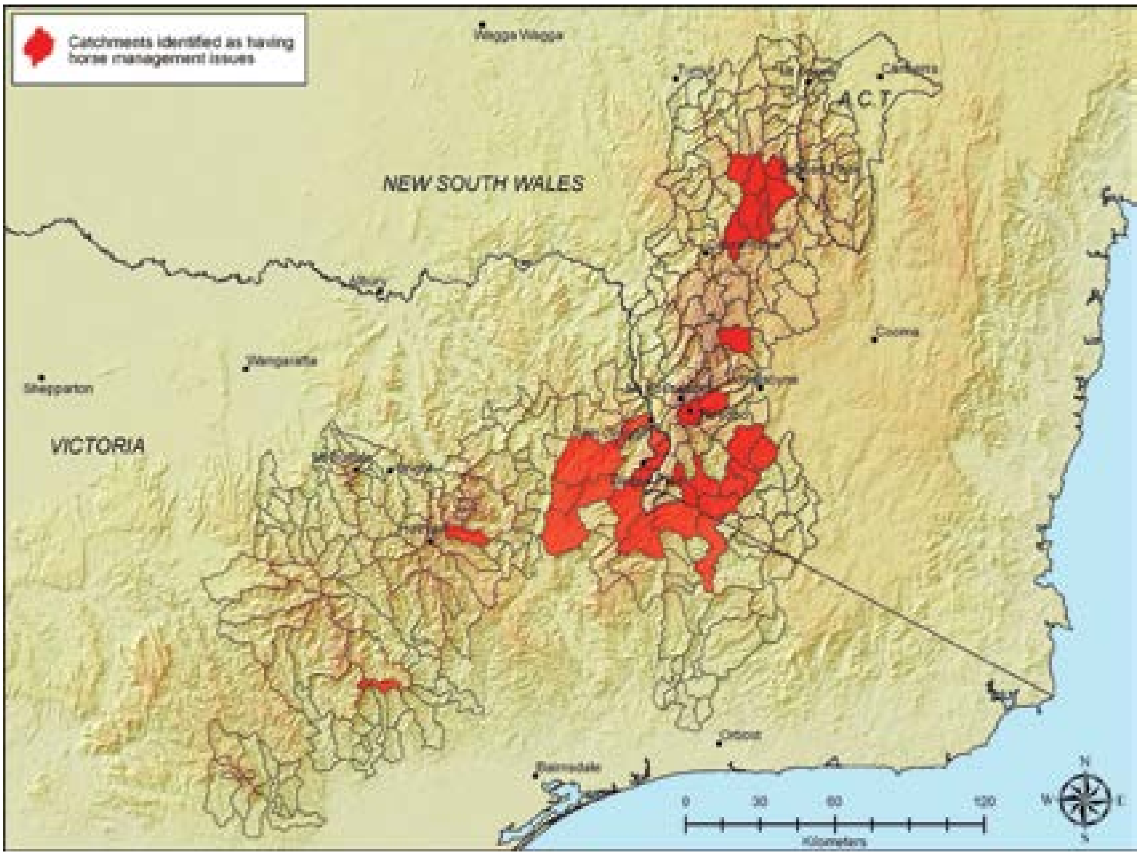


Figure 2. Australian Alps national parks sub-catchments identified by protected area managers in 2010 as having serious feral horse impacts.

Source: Doug Mills in Worboys et al. (2011).

Reference

Worboys, G. L., Good, R. B. and Spate, A. P. (2011) *Caring for Our Australian Alps Catchments*. Technical Report to the Australian Alps Liaison Committee, Canberra.

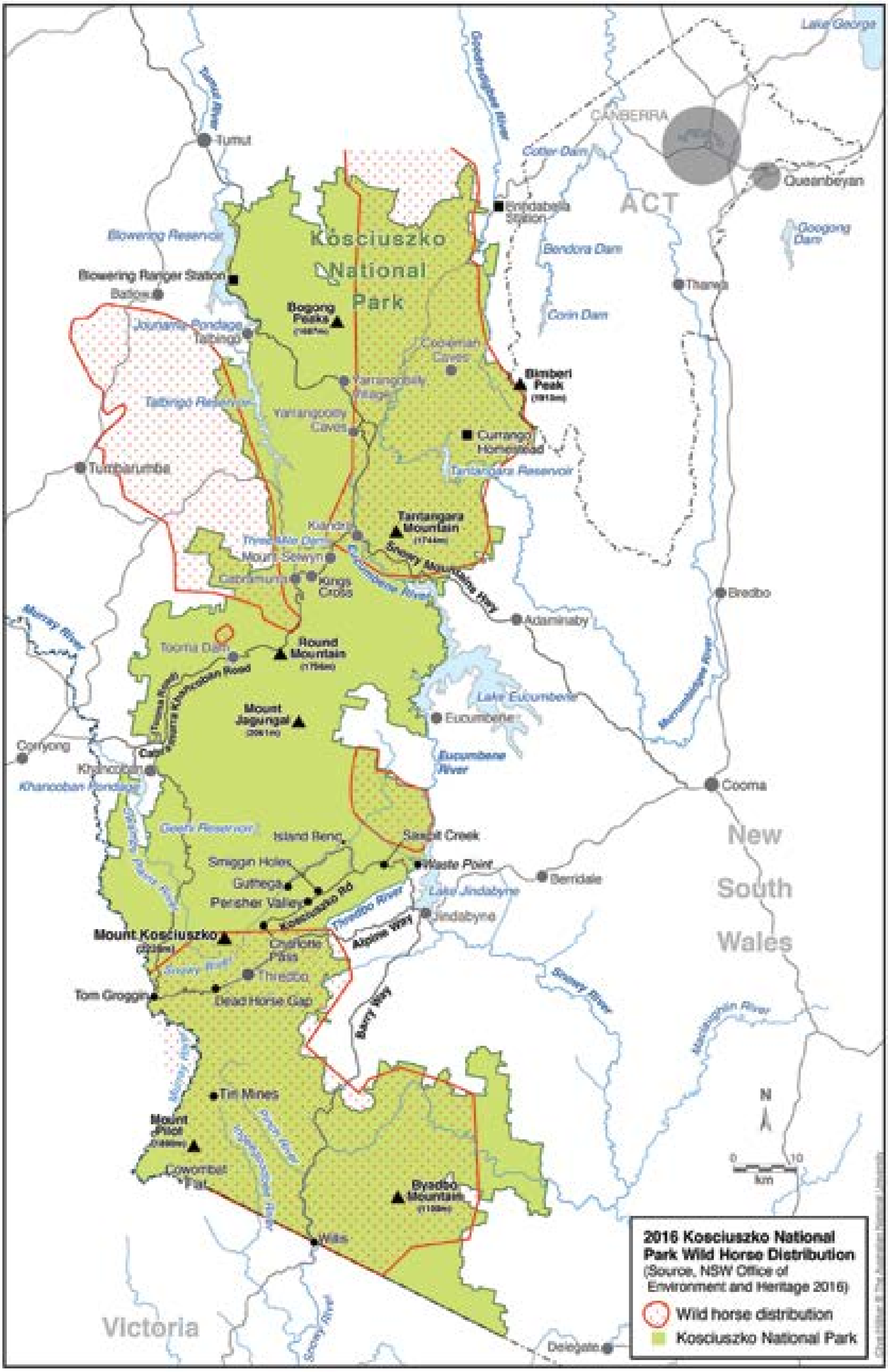


Figure 3. New South Wales Office of Environment and Heritage 2016 wild horse distribution map.
Source: Clive Hillicker, map sourced from NSW Office of Environment and Heritage (2016).

2016 FERAL HORSE DISTRIBUTION: KOSCIUSZKO NATIONAL PARK

In 2016, the NSW Office of Environment and Heritage released a draft Wild Horse Management Plan for public comment that had been developed by park management professionals with input from the community, scientists and an Independent Technical Reference Group. It identified the geographic distribution of feral horses in the Park in 2016 (Figure 3). This draft plan was not finalised by the NSW Government.

Management of Feral Horses

Until the provisions of the *Kosciuszko Wild Horse Heritage Act 2018* are implemented, the *2006 Kosciuszko National Park Plan of Management* (NSW DEC 2006) provides legal guidance for the management of feral horses. This 2006 plan technically requires the distribution and abundance of feral horses to be reduced and populations eradicated wherever feasible. This includes control programs using multiple methods, the exclusion of feral horses from multiple management units and horse free areas, and the implementation of the 2008 *Kosciuszko National Park Horse Management Plan* (NSW NPWS 2008). The 2006 Plan and the 2018 Act are contradictory. Post-June 2018, there has been no action to control feral horses in the Park.

Reference

NSW DEC (Department of Environment and Conservation) (2006) *2006 Plan of Management, Kosciuszko National Park*. NSW National Parks and Wildlife Service, Sydney.

NSW NPWS (National Parks and Wildlife Service) (2008) *Kosciuszko National Park Horse Management Plan*. Department of Environment and Climate Change, Tumut.

NSW Office of Environment and Heritage (2016) *Draft Wild Horse Management Plan: Kosciuszko National Park*. https://www.environment.nsw.gov.au/research-and-publications/publications-search/draft-wild-horse-management-plan-kosciuszko-national-park (accessed 9 October 2018).

Right: Kosciuszko alpine area and treeline.

In successive summers from 2016 to 2018, feral horses have been reported from the very heart of the Kosciuszko Alpine Area including the Lake Cootapatamba Valley, Lake Albina Valley, Wilkinson's Valley and the Ramsheads above Thredbo.

Source: Graeme L. Worboys.

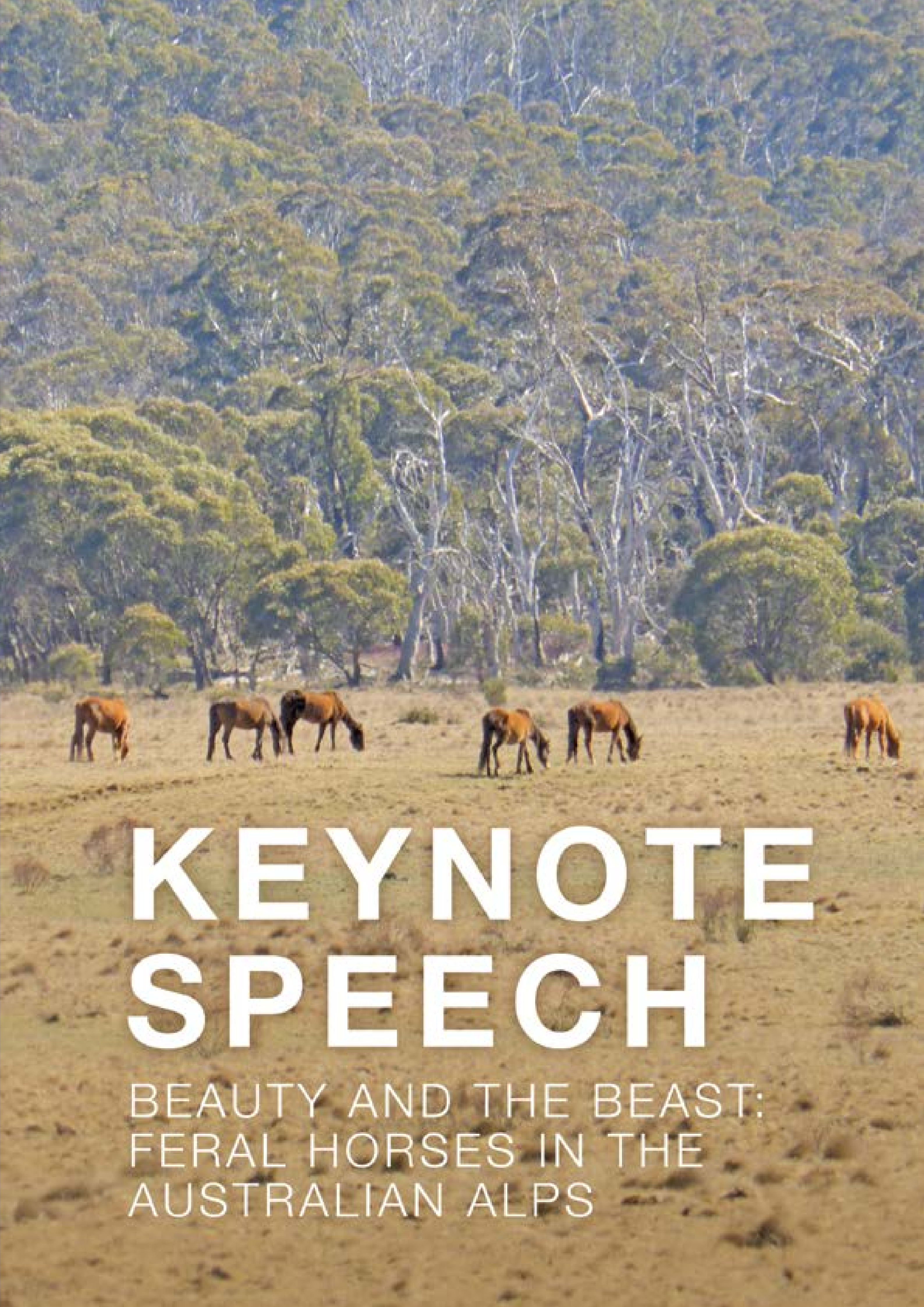
PROGRAM

THE KOSCIUSZKO SCIENCE CONFERENCE PROGRAM

FERAL HORSE IMPACTS: THE KOSCIUSZKO SCIENCE CONFERENCE	
8.00am – 9.00am	Conference registration
8.30am	Tea and coffee
OPENING SESSION	
9.00am	**Welcome** Lorraine Cairnes, Master of Ceremonies Welcome and introductory comments: A Kosciuszko Science Conference precipitated by the NSW *Kosciuszko Wild Horse Heritage Act 2018*, legislation that threatens the integrity of Kosciuszko National Park, its National Heritage values and the integrity of its significant scientific values.
9.10am	**Welcome to Country** Tyronne Bell, Thunderstone Aboriginal Culture and Land Management Services
9.20am	**Official Opening** Dr Alec Costin AM FAA DScAg Distinguished Alpine Ecologist
9.30am	**Keynote Speech** Dr Dick Williams, 'Beauty and the Beast: Feral Horses in the Australian Alps'
THEME ONE: AUSTRALIAN ALPS WATER CATCHMENTS	
10.00am	**Setting the Scene** Deirdre Slattery, 'Science and Community Knowledge and Opinion'
10.15am	**Whole-of-Australian Alps Impacts** Professor Brendan Mackey, 'A Whole-of-Alps Bioregional Approach to Managing Feral Horses in Kosciuszko National Park'
10.30am	**High Mountain Catchment Impacts** Dr John Wright, 'Impacts of Feral Horses on Treeless Drainage Lines in National Parks and State Forests of the Australian Alps'
10.45am	**Rain Shadow Catchment Impacts** Jessica Ward-Jones, 'Impacts from Introduced Herbivores in White Cypress Pine – White Box Communities in Kosciuszko National Park'
11.00am – 11.30am	MORNING TEA
11.30am	**Bogong High Plains Impacts** Daniel Brown, 'Impacts of Feral Horses on Alpine Bogs, Treeless Drainage Lines and Alpine/ Sub-alpine Vegetation Communities on the Bogong High Plains, Alpine National Park, Victoria
11.45am	**Victorian Alps Impacts** Dr Mark Norman, 'Evidence, Process and Progress for Feral Horse Control in the Victorian Alps'
12.00pm	**Northern Kosciuszko Impacts** Dr Ben Scheele, 'Feral Horse Impacts on Corroboree Frog Habitat in Kosciuszko National Park'
12.15pm	**Peat Bog and Fen Impacts** Emeritus Professor Geoffrey Hope, 'Feral Horse Damage to Soft Terrain: Bogs and Fens in the Snowy Mountains
12.30pm	**Modelling Management Approaches** Dr Nicholas Beeton, 'Modelling Feral Horse Management in the Australian Alps National Parks'
12.45pm	**Global Impacts** Professor David Eldridge, 'A Global Assessment of Feral Horse Impacts on Environmental Quality'
1.00pm	**Introducing the Kosciuszko Science Accord** Lorraine Cairnes

FERAL HORSE IMPACTS: THE KOSCIUSZKO SCIENCE CONFERENCE	
1.05pm – 2.00pm	LUNCH
THEME TWO: AUSTRALIAN ALPS WATER	
2.00pm	**Impacts to Water** Associate Professor Jamie Pittock, 'Feral Horse Impacts and Water Resources in South Eastern Australia'
2.15pm	**Streambank Impacts** Dr David Paull, 'Using Drones to Monitor Streambank Impacts of Feral Horses in Kosciuszko National Park'
THEME THREE: ALPINE AND SUB-ALPINE NATIVE ANIMALS	
2.30pm	**Amphibian Conservation: The Northern Corroboree Frog** Dr Murray Evans, 'The ACT Recovery Program and Availability of Suitable Habitat for its Reintroduction'
2.45pm	**Mammal Conservation: The Mountain Pygmy-possum** Dr Hayley Bates, 'Indirect Impacts of the Feral Horse on the Mountain Pygmy-possum'
3.00pm	**Mammals: Impacts of Feral Horses—The Broad-toothed Rat** Dr Martin Schulz,'The Broad-toothed Rat (*Mastacomys fuscus*) and Feral Horse Impacts'
3.15pm	**Reptiles: Impacts of Feral Horses—The Alpine Water Skink** Rebecca Cherubin, 'Feral Horse Impacts on a Threatened Lizard and a Nationally Endangered Ecological Community in Victoria's Sub-alpine Region'
3.30pm	**Fish: Impacts of Feral Horses—Stocky Galaxias** Associate Professor Mark Lintermans, 'The Threat from Feral Horses to a Critically Endangered Fish'
3.45pm – 4.15pm	AFTERNOON TEA
THEME FOUR: THREATENED NATIVE FLORA	
4.15pm	**Introduced Stock Impacts on Alpine and Sub-alpine Flora** Dr Susanna Venn, 'Flora: A Short Review of Grazing Effects'
THEME FIVE: OVERVIEW	
4.30pm	**Impacts of Feral Horses: An Overview** Professor Don Driscoll, 'Impacts of Feral Horses: Knowledge, Gaps, Directions'
4.45pm	**Championing Science Information** Professor David Watson, 'Marshalling Expert Opinion for Policy Development: Personalised Engagement Complements Group Efforts'
PLENARY SESSION	
5.00pm – 6.15pm	**Speakers' Panel** Professor Catherine Pickering, 'What is at Stake?—A Summary: Threatened National Heritage Values Impacted and the Reality of these Impacts in a Climate Change Context' Professor Brendan Mackey, 'Implications of the Barilaro Legislation for Kosciuszko National Park, for the Concept of Protected Areas and for Australia's National Heritage' Lorraine Cairnes, 'The 2018 Kosciuszko Accord: What It Is and Where It Will Be Directed' **Open Forum**
6.15pm	**Closing** Lorraine Cairnes Dr Alec Costin, Reflections on the Day
6.30pm	CONFERENCE CLOSES

Right: Feral horses, Northern Kosciuszko National Park, September 2018.
Source: Di Thompson.



KEYNOTE SPEECH

BEAUTY AND THE BEAST: FERAL HORSES IN THE AUSTRALIAN ALPS

KEYNOTE SPEECH

Dr R. J. (Dick) Williams

Research Institute for the Environment and Livelihoods, Charles Darwin University, Darwin

There is no question that urgent action is needed to substantially reduce feral horse numbers in Australia's alpine national parks. This is because we know unequivocally that:

1. The natural values—whether soil, water or nature conservation values—are the primary values of the network of parks in the Australian Alps (the Alps). These values are world-renowned. Governments have responsibilities under both state and federal legislation to protect these natural values.
2. Feral horses, like all ungulates, damage the natural values of the alpine national parks, in ecosystems that are very fragile and slow to recover from damage.
3. Feral horses in the Alps are abundant (over 6,000 in 2014), their numbers are increasing year on year (expected 20% increase per annum at range boundaries), and their range is expanding.
4. Failure to reduce numbers now will lead, in the near future, to substantially more damage to natural values, greater management costs and poor animal welfare outcomes.

Instead of rapid action to reduce numbers, we have the bizarre situation in NSW where feral horses have been protected under 'Wild Horse Heritage Legislation'. In Victoria, we have had calls from the pro-brumby lobby for the maintenance of a 'sustainable population' of horses on the Bogong High Plains. Propositions such as these have no basis in science, undermine statutory plans of management and threaten National Heritage values. However, they have popular appeal, traction and, now, in the case of NSW, are backed by legislation.

So, we may ask ourselves, how did we get here? We can perhaps explore that question by looking at the way the issue of feral horses in the Alps has been differentially framed: the story as told by science on the one hand, and the stories of the pro-brumby lobby on the other. Science has told its story on the basis of evidence, rationality, history and authority: livestock and the Alps do not mix. The pro-brumby lobby have told a different story—one of the companions to the heroic settler, the free-range iconic animal.

We know a lot about the impacts of livestock on alpine environments because of the best part of a century's worth of science devoted to the issue. Large, hard-hoofed, non-native animals (ungulates) are entirely foreign to Australia's alpine environments; they easily disturb alpine ecosystems. Like sheep and cattle, feral horses are free-range. They graze selectively, in preferred communities on preferred plants. They leave considerable evidence of their activities—dung, tracks, dust baths, damaged streams. Their impacts are especially acute in alpine wetlands and short herbfields. The evidence for these impacts is compelling and well-documented.

The brumby lobby has framed their story very differently, combining the legacy of the heroic settler and the romance of the hard-working, now free-running, animal. This has proved to be a very effective marketing strategy, based primarily on emotion, as it was for the mountain cattlemen before them. The emotional hooks of the story are strong—Banjo, the Light Horse, free-running animals, passionate devotion to animal liberation and welfare. Framed thus, scientific evidence is irrelevant.

Feral horse, Lower Snowy, October 2018.
Source: Richard Swain.

And so we need a counteracting story. This is the rationale for this Conference and ensuing action. One that is, of course, evidence-based, authoritative and compelling, but is also emotionally engaging. One that sells the beauty of the Alps, and contrasts this with the damage done by the beast, and—importantly—the damage the beast will do to itself if there is no action to control numbers. Our story must also be a story of passion and devotion: why we have invested time and energy in gathering quality evidence; the legitimacy of science; and how it helps us know what we stand to lose if feral horses and other alien species are not controlled.

And so, a few ideas:

Science can, and should, be activist. Alec Costin took on the alpine grazing industry in the Kosciuszko area in the 1950s and 1960s and, with the help of the Australian Academy of Science, won.

Terminology is vital—these animals are *feral* horses. We should never refer to them as 'wild horses' or 'brumbies'. Science has a duty to call out nonsense terms and ideas.

Hold governments and agencies to account. The governments of NSW, the ACT, Victoria and past federal governments have set strong precedents, based on sound scientific evidence, for protecting the natural values of Australia's alpine parks by banning livestock grazing. The conservation gains that thus ensued are already being eroded and will continue to worsen if feral horse numbers are not reduced drastically in the very near future.

Follow the money. Plans to accommodate feral horses in today's alpine parks will not only threaten natural values, but will come at a considerable cost to the public purse. We need to start controlling horses now so that we can also deal with another emerging and rapidly growing threat to the Alps—feral deer.

Include art in the framing of science. The environmental history of the Alps is a cracker story. The creation of the Kosciuszko National Park is a ripping, gripping yarn—just ask Alec Costin, who is here with us today! We have a veritable gallery of images thanks to artists like Colin Totterdell. The men and women who have told the rich scientific story of the Alps should be celebrated. These are all compelling emotional hooks and should be used to build a social licence to act.

The Alps are not one long horse paddock, the plaything of a loud, single-interest group. They are part of Australia's exceptional network of protected areas. The natural and scientific values are their defining values—values for all Australians. The Alps are to be cherished as a small cold and wet island with unique natural heritage values in an otherwise vast, hot, dry continent, and should be managed to protect such values.

Right: Feral horse streambank and stream erosion damage to the Ingeegoodbee River, Tin Mines, Kosciuszko National Park, NSW, 2013.

The Ingeegoodbee River is an undammed NSW–Victoria transboundary headwater tributary to the Lower Snowy River; it delivers high mountain and catchment-divide snowmelt waters to downstream Victorian farmers.

Source: Graeme L. Worboys.

THEME ONE

AUSTRALIAN ALPS WATER CATCHMENTS

1.1

SETTING THE SCENE

SCIENCE AND COMMUNITY KNOWLEDGE AND OPINION

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Science is the best tool we have for informing land use policy and practice, but it is not enough. The practices of contesting information as 'alternative facts' and rejecting 'so-called science' have been successful in winning the feral horse issue against what might seem to scientists like a very obvious case. Why do the ideas of small minority groups dominate such issues? Because things that are obvious to scientists may not be obvious to the general public.

When ordinary visitors look at Tantangara Plain, they do not readily 'see' trampled, degraded waterways and wetlands, weeds and large mobs of horses. And they certainly don't see the more abstract concerns of scientists: loss of catchment capacity; threats to habitat of tiny plants and animals; and impairment of the idea that nature conservation is of, and for, Australian species (Axford and Brown 2013).

Many do see an exciting sight, an 'iconic' animal in its element (Gibson 2015). To the uninformed visitor or citizen who knows little of such things, over-blown cultural claims and their use in the politics of the feral horse issue speak louder than the science.

There has not been an effective alternative argument, education or vision aimed at the middle ground of public interest and knowledge. As Nimmo concludes:

> … increasing the public's knowledge of the environmental impact of horses, will increase the level of perceived harm, and hence alter the perception of wild horses from a species that belongs in the Australian environment to one which does not (Nimmo and Miller 2007).

Two examples are used to illustrate the point that community attitudes to scientific knowledge in the alpine area can be influenced and do make a difference.

The first is the story of the changing cultural attitude to feral horses, or brumbies. From the 1860s to the present, the goalposts have been moved to romanticise what *was* a practical approach to pest animal control for most of the 19th century. The perception of the value of the horses has undergone a massive shift.

Evidence from newspapers and journals throughout the 19th century shows that 'traditional attitudes' to brumbies were that they were a pest to be eliminated, shot or have their throats slit for their hides, taken live to abattoirs or left to rot in the bush. 'Traditional management' methods were brutish and cruel. But the economics of a colonial society underpinned such attitudes. The brumbies were a threat to grazing land, and to the quality of domesticated stock horses. Today, the brumbies don't wreck

Feral horse pugging damage to wetland, Ingeegoodbee River, Pilot Wilderness, Kosciuszko National Park, 2013.
Source: Graeme L. Worboys.

good grazing land; they just wreck national parks, which is not the landowners' problem, nor that of the brumby advocates. Traditionally, the brumby has been a problem when it impacts economically, not environmentally.

The second example relates to the broader issue of catchment health and the understanding of its importance by the wider community. In the 1960s, the Australian Academy of Science informed and led public opinion in a successful campaign to protect the Kosciuszko summit area and the Geehi Wall from Snowy Mountains Scheme engineering works. The Primitive Area dispute of 1958–65 is a seminal episode in the development of a nature conservation philosophy in Australia (Slattery 2010). The scientists were successful in the conflict because, over a long period, they had thoroughly informed relevant community groups about their research findings and their significance. In doing so, they not only established ecology as a scientific basis for conservation thinking, their arguments also foreshadowed the current idea that management of healthy country involves recognition of the links between aesthetic *and* scientific thinking. In this respect, science had the capacity to offer alternative visions to the community about the relationship between natural resource management and land health.

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1.2

WHOLE-OF-AUSTRALIAN ALPS IMPACTS

A WHOLE-OF-ALPS BIOREGIONAL APPROACH TO MANAGING FERAL HORSES IN KOSCIUSZKO NATIONAL PARK

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Park management in complex landscapes spanning jurisdictions is often limited by conflicting policies, disjointed management priorities and no common spatial information system. Kosciuszko National Park lies at the heart of the 1.6 million ha Australian Alps national parks network, which comprises 11 protected areas across Victoria, NSW and the ACT. The Alps network has a co-operative management program and the parks are listed as National Heritage, but there is no common geographic information system (GIS) on natural and built assets—or the threats to them, such as from feral horses—to underpin strategic systematic conservation planning.

We generated a GIS database of key environmental variables, assimilating data and information from across the three jurisdictions, to provide a common information system in support of systematic conservation planning for the Alps network (Mackey et al. 2016). Critically, this approach enabled the assessment of threats to the environment and biodiversity across state and territory borders, providing the basis for shared management strategies and actions reflecting the geographic distribution and impacts of feral animals, weeds and bushfires. This kind of landscape-wide approach provides a pathway for identifying cross-jurisdictional park management decision-making around priority actions, and more effective resource allocation and harmonisation of management strategies and tactics.

Until our 2015 publication (Mackey et al. 2015), there was not even a common vegetation classification system and map available for the Alps network at a scale suitable for management. This new classification used existing state vegetation classes and mapping to produce a common system of vegetation mapping. Expert knowledge was used to match vegetation groups and classes. Building upon this new dataset, our Alps network GIS brought together additional data on the major threats residing in the three jurisdictions. Examples of threatening processes include invasive plant and animal species, recreation and tourism activities, infrastructure development, climate change, and altered fire regimes. Drawing upon the new GIS database, we were able to identify seven iconic landscapes that characterise the biodiversity and natural heritage values of the Alps network and that represent landscape-level foci for prioritising threat management and strategic management responses (Table 1). For the Alps network, our research found that the worst threats at a landscape level were identified as (1) feral horses and (2) the invasive plants hawkweeds, willows and Oxeye daisy.

Table 1. Brief description of the natural icons of the Australian Alps network.

Alpine Peaks	The Alpine Peaks are the distinctive, lofty treeless peaks and high ridges prominent in the landscape, characterised by steep slopes positioned above the tree line.
Treeless High Plains and Frost Hollows	The High Plains are expansive and treeless flat to undulating features at higher elevations, snow covered in winter and spring. The undulating nature of the topography leads to associated frost hollows where cold air drains, leading to conditions too cold for tree growth.
Alpine Wetlands	The Alpine Wetlands describe the bogs and peatlands that occur in high-altitude wetlands and waterways at the tops of the extensive water catchments.
Snow Gum Woodlands	Snow Gums cover extensive areas at the highest elevations that trees can grow and embody much of what people recognise as typifying the Alps landscape.
Tall Wet Forests	The Tall Wet Forests are dominated by Alpine Ash (*Eucalyptus delegatensis*) and Mountain Ash (*E. regnans*) canopy species.
Rain Shadow Woodlands	The Rain Shadow Woodlands are a distinctive landscape feature occurring in the upper Snowy River Valley.
Heritage Rivers	The mighty river systems draining to both sides of the Great Dividing Range. The best known is the Snowy River; rich in folklore, it feeds water from the summit of Mt Kosciuszko to the ocean.

We then examined in more detail the ecological damage caused by feral horses and explored the use of satellite data to monitor their impacts (Porfirio et al. 2017). We used field observations of vegetation condition at a network of sites in the Alps where feral horses have been observed as being present or absent (Figure 4). These data were then analysed using satellite data from the NASA MODIS sensor. We used an index of vegetation health called 'fPAR' (fraction of photosynthetically active radiation), which is sensitive to the health of the vegetation cover. The ecological condition of the vegetation was assessed in the field by rangers using a modified version of the Landscape Function Analysis (LFA) index. We found significant differences in the LFA index between sites where horses were present or absent. We also found that sites where horses were present have 10% lower fPAR values than sites where horses were absent. The results also revealed a significant correlation between LFA and fPAR. This means the extent of the ecological damage caused by the feral horses—whose impacts include soil compaction and increased runoff, reduced vegetation abundance, increase in bare soil and the trampling of new plant growth—can be detected from space. Our analyses therefore provide further support for the well-established fact that feral horses have a negative impact on the condition of Australian alpine vegetation and demonstrate that satellite data can be used in conjunction with field surveys to monitor the impacts of feral horses in the Alps network, including Kosciuszko National Park. This approach may also be relevant to evaluating the damaging impacts of feral deer and pigs. The approaches, data and results presented here can be used to support improved collaborative decision-making by the Australian, NSW, Victorian and ACT governments, and more coherent, conjoined management interventions for the Alps network.

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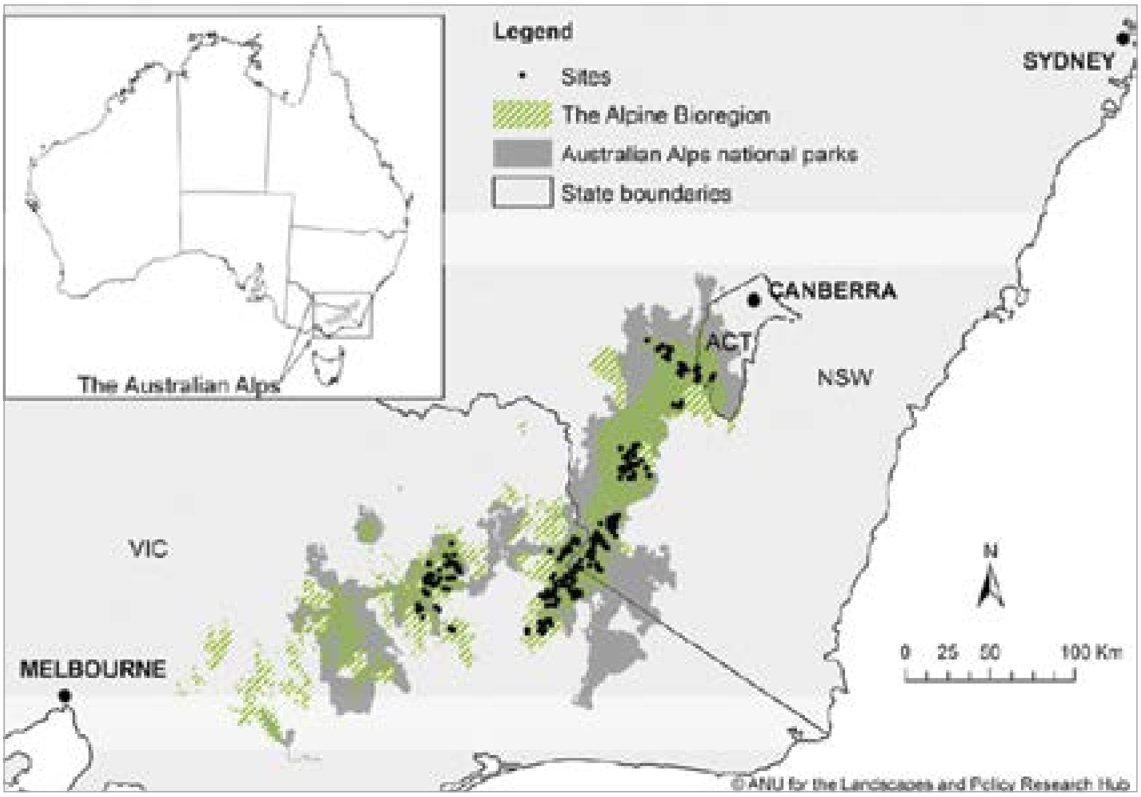

Figure 4. The Australian Alps national parks and the sites where the Landscape Function Analysis index was assessed.

Alps national parks – grey; Australian alpine bioregion – hatched.

Feral horse damage to Sphagnum, Tin Mines area, Pilot Wilderness, Kosciuszko National Park, 2013.

Source: Graeme L. Worboys.

1.3

HIGH MOUNTAIN CATCHMENT IMPACTS

IMPACTS OF FERAL HORSES ON TREELESS DRAINAGE LINES IN NATIONAL PARKS AND STATE FORESTS OF THE AUSTRALIAN ALPS

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Feral horses are widespread across the Australian Alps, including national parks and state forests, and have been present in the landscape since the 1890s (Dyring 1990). They degrade alpine and sub-alpine ecosystems and damage habitat of a range of threatened species. Concerns about their impacts across the Alps have existed since at least the 1950s (Costin 1954, 1957). Impacts on riparian and wetland ecosystems, especially those impacts associated with erosion and damage to streams, are of particular concern. These ecosystems include the Commonwealth-listed Alpine Sphagnum Bogs and Associated Fens Endangered Ecological Community, and synonymous communities listed under NSW and Victorian state legislation. They also provide important habitat for a range of Commonwealth- and/or state-listed threatened species, including the Alpine She-oak Skink (Clemann 2001), Alpine Water Skink (Meredith et al. 2003; Steane et al. 2005), Alpine Bog Skink (Clemann et al. 2001) and Guthega Skink (Green and Osborne 2012).

Despite concerns about impacts on natural values and increasing feral horse abundance (Dawson 2009; Cairns 2014), there has been little research to quantify the impacts of feral horses on natural values of the Alps. Furthermore, studies examining feral horse impacts have generally focused on localised areas. These studies are useful for understanding the nature of impacts at a site-scale; however, developing effective management strategies across the Australian Alps national parks and state forests requires an understanding of how widespread these impacts are.

Our study attempted to address this knowledge gap by investigating impacts of feral horses on treeless drainage lines across the Alps. The study included 186 sites across Namadgi National Park in the ACT, Kosciuszko National Park and Bago and Maragale state forests in NSW, and the Alpine National Park in Victoria. We assessed nine variables related to soil and stream stability and vegetation cover, which in turn influence ecosystem function and habitat quality. These variables include damage to streambanks, soil and vegetation disturbance, sedimentation, erosion and projected foliage cover. We also recorded evidence of the presence of horses, wombats, macropods, feral goats, rabbits, feral pigs and deer. In addition, we noted any evidence of a site being burnt and whether it contained the Alpine Sphagnum Bogs and Associated Fens Endangered Ecological Community listed under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth).

We found significant differences among feral horse–occupied and feral horse–free sites for all soil and stream stability variables assessed. For all variables assessed, the average score (and hence, condition) was lower in horse-occupied areas. No significant differences were detected among horse-present and horse-free sites for projected foliage cover and the proportion of foliage cover that is native.

To remove the potential influence of grazing and browsing mammals other than feral horses, data were re-analysed excluding sites where evidence of the presence of any of these other species was detected. Mean scores were very similar to those for the full dataset, suggesting that the influence of other grazers and browsers is minor.

Separate analyses were done considering only sites classified as the Alpine Sphagnum Bogs and Associated Fens Endangered Ecological Community. Seventy-eight sites were included in this analysis (46 horse-present; 32 horse-free). Results were similar to those for the full dataset, providing clear evidence that horses degrade this threatened community.

The sites in poorest condition were occupied by horses, and even some sites in extremely remote areas were degraded. Damage included heavily grazed vegetation, pugging damage, large areas of exposed soil and streambank collapse. Left unchecked, this degradation will continue. Active management is necessary to reduce the impacts of feral horses and allow the ecosystem to recover. Even with active management, feral horse impacts may persist for a long time (Wimbush and Costin 1979, 1983). However, when the pressure of feral horses is reduced sufficiently, recovery can occur (Prober and Thiele 2007; Wild and Poll 2012). The next major step is to see whether recovery seen at a localised scale can be achieved across wider areas of the landscape, and how the techniques available to land managers can best achieve this. Adaptive management offers an efficient way to address this challenge.

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Wetland damage near the Tin Mines Trail, Pilot Wilderness, Kosciuszko National Park, 2013.
Source: Graeme L. Worboys.

1.4

RAIN SHADOW CATCHMENT IMPACTS

IMPACTS FROM INTRODUCED HERBIVORES IN WHITE CYPRESS PINE – WHITE BOX COMMUNITIES IN KOSCIUSZKO NATIONAL PARK

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White Cypress Pine (*Callitris glaucophylla*) – White Box (*Eucalyptus albens*) communities dominate steep, dry slopes below about 650 m above sea level (asl) along the Lower Snowy River in Kosciuszko National Park in NSW and Snowy River National Park in Victoria. These communities are a unique and important representation of the broader White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grasslands that is listed as a critically endangered ecological community (EEC) under the *Environment Protection and Biodiversity Conservation Act 1999*. Grassy Box-Gum communities are mostly found on relatively fertile soils of the lower slopes on the tablelands and western slopes of NSW. They have been drastically reduced in area, are highly fragmented and modified by clearing for cropping and grazing, urban development and transport infrastructure (Office of Environment and Heritage 2017).

Commencing in 1984, an investigation into the condition and history of disturbances to these White Cypress Pine – White Box communities was undertaken (Pulsford 1991). This was in response to concerns raised firstly by Costin (1954), who called for state intervention, and by Clayton-Greene and Worboys (Clayton-Greene and Ashton 1990; Worboys 1982). They reported on the severely degraded condition of these communities, large numbers of rabbits, and widespread sheet and gully erosion. Changes in vegetation condition were assessed by compiling a chronology of disturbance events from historical records, oral anecdotal evidence and field-based studies, providing a strong foundation for further investigations. This included tree ring analysis of *C. glaucophylla* to estimate stand age of regrowth and old growth and to corroborate evidence of disturbance events (Pulsford 1991; Pulsford et al. 1993).

Pulsford found that the grassy woodland with large, widely spaced trees and rich, dark chocolate–coloured soils described by early explorers had been replaced by tall, dense, locked regrowth stands of *C. glaucophylla* (Pulsford 1991; Mackaness 1941). Widespread massive sheet and gully erosion were evident, particularly on steep northerly aspect slopes. Topsoil had been eroded, leaving an often bare lithosolic surface (Costin 1954; Pulsford 1991). This was attributed to the impacts of 150 years of grazing by hard-hooved cattle and sheep, frequent lighting of fires and plagues of rabbits, which arrived in about 1900 (Harnett 1948).

In 1984, rabbit populations were the major concern requiring further investigation. Six 20 x 20 m herbivore-proof exclosures, each paired with a control plot, were constructed. The control plots were subject to grazing from any herbivores present. All plots were on north-facing $23^{o}\pm3^{o}$ slopes, between 300 and 450 m asl. In 2017, a new research project was undertaken, which aimed to assess if any ecological recovery within the exclosures had occurred since their establishment. Our expectation was that the cessation of livestock grazing by 1970, and an apparent reduction in rabbits, would by 2017 have produced measurable signs of ecosystem recovery. If grazing pressure had been substantially reduced, we expected few differences inside and outside the exclosures. This was not the case.

Inside the exclosures, soil-landscape functionality, understorey and midstorey vegetation were all moderately to significantly ($p<0.05$) improved. The exclosures exhibited significantly less bare soil and improved condition. Surface organic material was significantly higher, improving soil stability and reducing nutrient runoff. Increased surface condition in the exclosures supported greater abundance of ground dwelling and bio-turbating invertebrates. Improved nutrient cycling also increased nitrogen content in the soil.

The understory condition was significantly improved inside the exclosures but remains sparse and patchy after 33 years of herbivore exclusion (Figure 5). The exclosures on average exhibited 31% ground cover, more than double that of the grazed control plots. This cover was also on average significantly taller and more structurally diverse. The midstorey was denser and taller in the exclosures. However, the long-lived overstorey of *C. glaucophylla* remains generally unchanged.

In contrast, outside the grazing exclosures, organic material and ground cover were sparse and sheet erosion of soil was active and extensive. Soil condition was poorer and there were fewer ground-dwelling invertebrates. There was a decreased presence of midstorey species in the grazed control plots.

Comparison of measurements made in 1987 and in 2018 indicate a fourfold increase in herbivore dung density. In June 2018, 84% of the dung was from horses, 13% from deer, 2% from macropods and 1% from rabbits. In 1987, small amounts of rabbit and macropod dung were present, and no horse or deer dung were recorded. The presence of horses and fallow deer (*Dama dama*) and sambar deer (*Rusa unicolor*) was further confirmed by camera traps at the exclosure/control sites. Horse and deer dung and numerous networks of tracks are apparent throughout the landscape. We observed substantial widespread trampling disturbance to streambanks, grazing and intense browsing of hill slope and riparian vegetation, and highly grazed 'lawns' on cool south aspect slopes and along the banks of the Snowy River.

We conclude that this community continues to be greatly affected by introduced herbivores, predominantly large numbers of horses and deer trampling, grazing and browsing, reducing ground cover, compacting and baring the fragile soils and inhibiting regeneration. This unique occurrence of a *C. glaucophylla – E. albens* woodland is under siege by a new wave of introduced horses and deer that are suppressing recovery of this fragile ecosystem.

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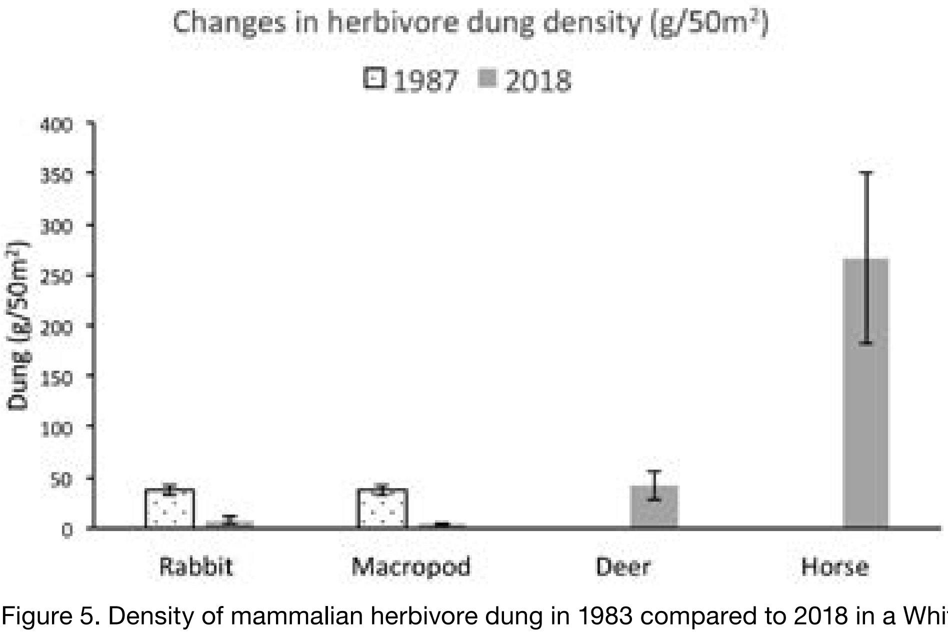

Figure 5. Density of mammalian herbivore dung in 1983 compared to 2018 in a White Cypress Pine – White Box community along the Lower Snowy River in Kosciuszko National Park.

Source: Ward-Jones (2017).

A typical fence-line contrast: Inside the exclosure (left) plant cover remains sparse and patchy on these steep (23º) and highly sheet- and gully-eroded slopes. Note the absence of topsoil and exposure of loose eroding lithosols.

Source: Ian Pulsford, 13 April 2017.

Contrasting inside an exclosure (left) with immediately outside the same exclosure (right) where introduced herbivores graze.

Source: Ian Pulsford, 13 April 2017.

1.5

BOGONG HIGH PLAINS IMPACTS

IMPACTS OF FERAL HORSES ON ALPINE BOGS, TREELESS DRAINAGE LINES AND ALPINE/SUB-ALPINE VEGETATION COMMUNITIES ON THE BOGONG HIGH PLAINS, ALPINE NATIONAL PARK, VICTORIA

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Feral horses have occurred in the Victorian Alps since the late 1800s, particularly in the far east of the state, but also on the Bogong High Plains, Victoria's largest area of alpine treeless vegetation and part of the Alpine National Park. The area is part of the Australian Alps national parks and reserves, listed on Australia's National Heritage Register in recognition of its outstanding significance. In May 2018, an aerial survey estimated there were 109 feral horses on the Bogong High Plains (Curran 2018). The separate eastern Alps population is much larger, with 2,350 horses estimated in 2014 (Cairns and Robertson 2015).

Activity by horses (and other large ungulates such as deer and cattle) represents a type and intensity of impact to which Victoria's alpine vegetation communities are not adapted; this fact was recognised by the 2011 listing of degradation by feral horses as a threatening process under the Victorian *Flora and Fauna Guarantee Act 1988*.

The broad aims of this study were to:

1. Gather visual (including photographic) and descriptive evidence that documented the nature and geographic extent of negative impacts of feral horses on environmental values in the Bogong High Plains area.
2. Describe any changes in the nature, extent and intensity of negative impacts of feral horses on environmental values through repeat surveys of sites assessed in two previous studies: 'alpine bog' and 'riparian' sites.

Horse-occupied areas on the Bogong High Plains were identified and field inspections undertaken to record and map visual and photographic evidence of horse activity and impacts, including the presence and intensity/extent of dung piles, trampling and pugging, browsing/grazing damage, streambank damage and bare ground. Care was taken to record only those impacts attributable to feral horses.

Between 2006 and 2008, 99 representative alpine bogs across the Bogong High Plains had been assessed to quantify disturbance from a range of agents, including horses. As many of these 'alpine bog' sites as possible (56 sites) were revisited and reassessed for horse damage, providing robust, quantitative activity data to inform whether horse damage had changed in intensity or geographic extent.

Each bog was assessed for feral horse activity, and an estimate made of the total proportion of the bog impacted by trampling, pugging, dung, bare ground, vegetation pulling, etc.

'Riparian' sites surveyed in 2012 were part of a separate Australian Alps–wide assessment of horse damage in treeless streamside areas (Robertson et al. 2015). Fourteen of the 22 'riparian' sites previously assessed on the Bogong High Plains were reassessed. Each riparian site was relocated, and 10 parameters reassessed within 20 m either side of a 50 m transect line. Measures included the number and impact of horse tracks, the degree of pugging and trampling damage on streambanks, the intensity of horse grazing and the number of dung piles. This allowed direct comparison with the original variables from the 2012 data. Photographs were taken at each site from approximately the same location as previous surveys.

During November and December 2017, 106 sites (70 resurveyed from the prior 'alpine bog' and 'riparian' studies and 36 new sites) were assessed across the Bogong High Plains. Horse activity was noted at 60 of these sites (57%).

The assessments indicated that feral horses were impacting on environmental values across an extensive area of the Bogong High Plains, with streambank damage, pugging, trampling of wet areas, dung deposition, creation or widening of tracks, roll pits, pulling of vegetation and general trampling. Activity was most noticeable in grasslands and around watering points, but was also common in riparian zones and on the edges of alpine bogs that are listed under both state and federal threatened species legislation.

Over the period 2006–08, less than 4% of bogs assessed on the Bogong High Plains showed evidence of feral horse impacts. By 2017, this has increased to approximately 32%, with evidence of horses expanding their range into new areas. Not only did the proportion of impacted sites increase, so too did the intensity of impacts, with approximately 30% of alpine bogs showing impacts over a greater proportion of these bogs, and 35% of riparian areas assessed showing more severe damage in 2017 than in previous assessments.

The reassessment of 14 riparian sites first assessed in 2012 supported the range expansion indicated by the alpine bog data. An increase in the intensity of activity was also evident in riparian zones where horses have been present for many years. Seven riparian sites were reassessed in that region, and four were found to be in a worse state. No sites in that region experienced an improvement in condition score. Soil and vegetation conditions have measurably declined in many sites, supporting the concept of cumulative damage.

Despite a relatively small number of horses being present on the Bogong High Plains, horse damage is substantial, widespread and expanding. There is unlikely to be a minimum population size that would avoid incremental, ongoing degradation. Adverse impacts on streams, wetlands, soil, vegetation, fauna habitat and catchment condition, with even a small number of feral horses, will continue to increase, compromising the environmental values of what is Victoria's largest, and arguably most important, alpine treeless region.

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Feral horse dung pile and disturbed wetland, Tin Mines Trail, Pilot Wilderness, Kosciuszko National Park, 2013.
Source: Graeme L. Worboys.

1.6

VICTORIAN ALPS IMPACTS

EVIDENCE, PROCESS AND PROGRESS FOR FERAL HORSE CONTROL IN THE VICTORIAN ALPS

Dr Mark Norman

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Representing just 0.3% of the Australian mainland, Australia's alpine ecosystems are both rare and unique. Today, they endure a wide range of human-derived pressures, from diverse invasive species, to impacts of recreational activities, infrastructure development and the many manifestations of climate change.

Over the past two years, Parks Victoria and the Victorian State Government have been developing the *Protection of the Alpine National Park – Feral Horse Action Plan 2018–2021* (adopted June 2018). This presentation will review some of the history of Victorian feral horse research and management, and the evidence underpinning this plan. It will also discuss the social and political context and issues, the process by which the plan was developed, the proposed approach and the ongoing challenges.

Feral horses are present in two separate Victorian alpine regions: the eastern Alps adjacent to Kosciuszko National Park (about 2,500 horses based on 2014 aerial survey); and the more isolated Bogong High Plains (estimated 106 horses, 2018 aerial survey).

Victoria has a long history of alpine ecological research and active management of feral horses. Australia's second longest-running ecological monitoring site was established in 1944 by botanist Maisie Carr at Pretty Valley in the Bogong High Plains (Carr and Turner 1959a, 1959b). Exclosure plots and impact assessments of domestic stock at this and nearby sites led to the total removal of sheep and horses from the Bogong High Plains in 1946. Feral horses have since returned to the Bogong High Plains, with a recent census finding that horse damage has increased from just 4% of 70 monitoring sites to 33% in 11 years. In 1999, similar exclosure plots were established at Native Cat Flat and Cowombat Flat in the eastern Victorian alps, which provided critical evidence of vegetation, habitat and waterway recovery on exclusion of feral horses. These sites, particularly Cowombat Flat, not only provided empirical evidence, but also supplied dramatic visual representation of vegetation and waterway damage—imagery critical in garnering public and political support for action.

Parks Victoria's current program for removal of feral horses from the Victorian Alps dates back to at least 1999, using a combination of passive baited trap yards and roping ('brumby running'). Since 2004, around 1,900 horses have been captured and removed at an average of around 150 a year, with approximately two-thirds having been captured using roping.

The impetus to expand Victoria's feral horse control program arose from increasing public and on-ground staff concerns of deteriorating alpine habitats, and the failure of the current program to reduce horse impacts. Rising awareness of climate change threats to the Australian Alps also drove the call for increased management of both feral horses and other invasive species.

As in NSW and the ACT, feral horse management in national parks has been a prolonged and complicated issue due to the highly polarised views and values associated with the presence of horses in the 'High Country'. The spectrum of interested parties includes conservation and green groups, traditional owners, land managers, licensed tour operators, alpine ecologists, mountain cattlemen, animal welfare organisations and pro-brumby associations and community groups. All groups were drawn by Parks Victoria into a detailed consultation and engagement process over a period of 18 months, commencing in late 2016. The connections, perspectives and values of all participants were respected and duly considered in the development of the new plan.

While all consulted groups accepted that there are areas of over-abundant feral horses where control may be necessary, there was considerable disagreement on whether there should be an ongoing presence of feral horses in the Victorian Alps as a representation of post-settlement pioneer and agricultural heritage versus the need to totally remove a non-native species from alpine ecosystems. For the eastern Victorian Alps, this issue is likely to be a moot point, as the wide extent of horse distribution and presence in remote areas makes it highly unlikely that total eradication is possible. By contrast, the smaller and isolated population on the Bogong High Plains is a candidate for total removal.

Informed by direct consultations and the roundtable process, the draft plan was completed in late 2017 and had two primary aims: to protect Victoria's natural alpine environments and to set the highest animal welfare standards for feral horse control. The plan proposes passive yard trapping as the primary capture technique and the maximising of viable rehoming options for as many captured horses as possible. For those horses for which rehoming options cannot be found, or for those that are ill, injured or aged, the plan proposes culling of horses by shooting in trap yards under strict protocols. A total target of up to 1,200 horses to be removed over three years was proposed, along with the total removal of the Bogong High Plains population. The target in Victoria's eastern Alps was chosen on the basis of halving the estimated total horse population over the three-year duration of the plan, with the aim of increasing monitoring of horse numbers and environmental conditions to inform the subsequent iterations of feral horse management in the Alpine National Park.

The draft plan was publicly released for comment for eight weeks on the *Engage Victoria* website in early 2018. Over 1,000 submissions were received, with 81% support for feral horse control as outlined in the plan. On the basis of this consultation, animal welfare considerations in the plan were further strengthened.

As the plan moves into an operational phase, a number of challenges remain, including building appropriate rehoming partnerships and outcomes; potential need to develop temporary holding facilities (lairages); protocols and decision triggers for culling; building trust with community; and strengthening communications and proactively managing media.

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Feral horse exclosure plot, Cowombat Flat, Alpine National Park, Victoria.

The exclosure plot was established in 1999 just a few hundred metres from the NSW–Victorian border and Kosciuszko National Park. In this 2013 image, the plot shows 14 years of growth without horses.

Source: Graeme L. Worboys.

Cowombat Flat exclosure plot at a distance and showing surrounding grazing pressures from feral horses.

Source: Mark Norman.

1.7

NORTHERN KOSCIUSZKO IMPACTS

FERAL HORSE IMPACTS ON CORROBOREE FROG HABITAT IN KOSCIUSZKO NATIONAL PARK

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Introduced ungulates can substantially alter ecosystems and have both direct and indirect effects on native animal species (Suominen and Danell 2006; Nuñez et al. 2010). Direct impacts of herbivores on other animals include incidental consumption, trampling and interference (Pavel 2004). However, these effects are often minor compared to the indirect effects that herbivores can have on other species by modifying habitats and food resources (Pavel 2004) by way of changes in the structure, biomass and composition of vegetation, impacts on the physical environment (e.g. soil disturbance, compaction or erosion), and redistributing nutrients (Suominen and Danell 2006; Foster et al. 2014).

In the Australian Alps national parks, concerns have been raised about feral horse impacts, particularly in Sphagnum bogs and fens, which are recognised as an Endangered Ecological Community under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) and which provide key habitat for several endemic species (Prober and Thiele 2007; Dyring 1990). In wetland and riparian environments, feral horse grazing and trampling can reduce vegetation cover, increase soil compaction, erosion and siltation, damage streambanks, and reduce water quality (Nuñez et al. 2010; Prober and Thiele 2007; Nimmo and Miller 2007; Belcher and Leslie 2011; Rogers 1991). Horses tend to preferentially use open, riparian habitats, meaning that even very low densities of horses can have a substantial impact when wetland or riparian areas are small in comparison with other habitat types (Rogers 1991; Crane et al. 1997).

Here, we report on the impact of feral horses on wetland habitats used by the Northern Corroboree Frog (*Pseudophryne pengilleyi*), a species with a highly restricted distribution in montane and sub-alpine regions of protected areas in south eastern NSW and adjacent areas of the ACT. The Northern Corroboree Frog has experienced major declines associated with the introduction of the amphibian disease Chytridiomycosis (Scheele et al. 2017), and is now listed as critically endangered under both NSW and Commonwealth legislation. From early January to mid-March, adults enter bogs and seepages from the surrounding forest to breed (Pengilley 1971, 1973). Males construct and call from terrestrial nests, which are located in the dense matrix of vegetation, moss and/or grass litter (hereafter litter matrix) surrounding the edges of small seasonal pools that are typically dry when eggs are laid (Pengilley 1971, 1973). Northern Corroboree Frogs construct nests in a range of vegetation types where the litter matrix surrounding pools is conducive to male calling activity and embryonic survival (Hunter et al. 2009; Osborne 1990).

Horse exclosure plots were established at eight Northern Corroboree Frog breeding sites in Northern Kosciuszko National Park in 2011. Exclosures prevented entry of horses, but allowed access for smaller herbivores, such as wallabies, wombats and feral pigs. In 2010, prior to plot establishment, and again in 2015, we measured the litter matrix depth inside and outside these exclosures. We focused on the depth of the litter matrix surrounding pools as this represents a critical component of the breeding habitat for the Northern Corroboree Frog. At each site, we collected 10 measurements inside and 10 measurements outside the horse exclosures (giving a total of 80 measurements inside and 80 measurements outside exclosures). In 2015, we also collected depth measurements at an additional three Northern Corroboree Frog breeding sites that were outside the region occupied by horses at the time of sampling, but within the distribution of feral deer and pigs. At each of these horse-free control sites, we established a quadrat the same size as the exclosures at a random point within the site and recorded 10 litter depth measurements within this quadrat using the same methodology as for the exclosure sites.

We used linear mixed models to compare the depth of the litter matrix surrounding pools from sites inside horse exclosures with those outside exclosures. We found that the depth of the litter matrix was strongly affected by the presence of horses (Figure 6), with the litter 1.9 times deeper in areas without horses than in areas accessible to horses. Neither scat nor tracks of feral deer or pigs were observed at the exclosure sites in 2015.

Our results provide clear evidence that the presence of feral horses in Northern Corroboree Frog breeding habitat is associated with a significant reduction in the depth of the litter matrix. In the presence of horses, the depth of the litter matrix was less than the mean nesting depth of Corroboree Frog nests (Scheele 2010). The reduced depth of the litter matrix associated with horse presence could force frogs to construct nests and deposit eggs in shallow nests that are sub-optimal for male calling and have increased risk of egg desiccation (Mitchell 2001). This, in turn, could exacerbate drought impacts and associated reproductive failure (Pengilley 1973; Osborne 1990; Scheele et al. 2012). Under severe grazing pressure, reduced vegetation and litter matrix depth may also prevent the construction of nests altogether.

While the decline of the Northern Corroboree Frog is due primarily to the disease Chytridiomycosis, preventing degradation of its breeding habitat is critical to the long-term future of the species. Captive-breeding populations have been established for the Northern Corroboree Frog, with reintroductions to the wild dependent on the maintenance of high-quality habitats.

Acknowledgements

The authors thank Dave Hunter and Geoff Robertson for their many contributions to this work.

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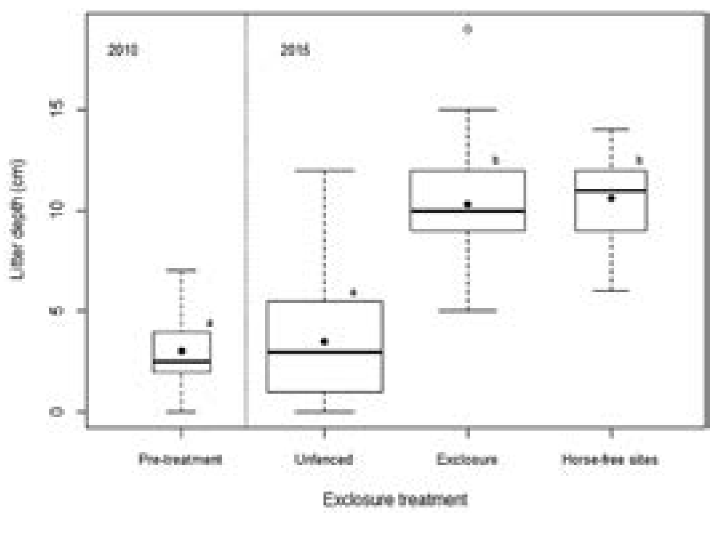


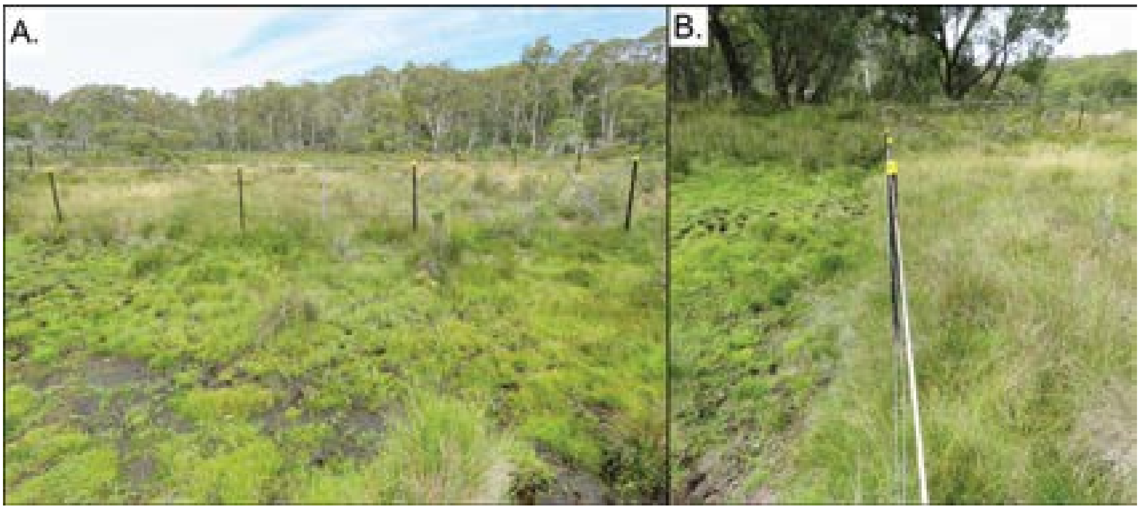
Figure 6. Difference in litter matrix depth among the horse exclosure treatments.

Boxplot widths are proportional to sample size. Boxplots show median, 25th and 75th quantiles, and range (whiskers). Solid points show group mean. Different letters indicate significant differences in mean depth using Tukey post-hoc tests at p<0.05.

Male Northern Corroboree Frog (*Pseudophryne pengilleyi*) in breeding habitat.

Corroboree Frogs breed in terrestrial nests that they construct in the litter matrix found above the mineral soil.

Source: Rohan Bilney.



Horse exclosure fence constructed at a Northern Corroboree Frog (*Pseudophryne pengilleyi*) breeding site, 2018.

Photo B shows the same fence line featured in photo A. Both photos show damage to wetland habitat associated with horse presence, including trampling, pugging and substantial reductions in the depth of the litter matrix.

Source: Ben Scheele.

1.8

PEAT BOG AND FEN IMPACTS

FERAL HORSE DAMAGE TO SOFT TERRAIN: BOGS AND FENS IN THE SNOWY MOUNTAINS

Emeritus Professor Geoffrey Hope

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The Snowy Mountains, including the higher areas of Kosciuszko National Park, are cooler and wetter than 98% of Australia, and in consequence support some of the outstanding examples of sodden vegetation that builds up deep organic soils. These peat soils and their dense vegetation cover are important to the ability of the mountains to intercept rainfall. They also act as an armour to reduce the erosion of mineral soils, efficiently trapping sands and silts that wash into the valley floors. At higher altitudes, peatlands host snow for longer. The result is very clean water, released steadily to streams, and a stable, moist environment that is fire resistant. This has allowed a specialised biota to develop, which include animals like the Corroboree Frog and Alpine Crayfish. The Alpine Sphagnum Bogs and Associated Fens Endangered Ecological Community is a Threatened Community (Australian Government 2009) and included in two Ramsar sites: Ginini Wetland Complex, ACT, and Blue Lake, Mt Kosciuszko, NSW.

Recent mapping has found 8,000 ha of peatland above 800 m in the Snowy Mountains and ACT Ranges, occurring as 9,200 individual patches spread like islands across the mountains (Hope et al. 2012). Above 1,700 m, there are also large areas of humus soils forming a blanket bog on slopes. The modern peatlands represent a fraction of the bogs and fens that were probably present before the arrival of stock animals in the 1840s, as wide areas of swamp were trampled and burnt, and in a few cases drained, leading to the oxidation of organic soils and soil erosion. Tussock grassland spread onto former peat areas. Since stock was removed in the 1950s, the wetland vegetation has partly recovered; however, dated sections (Hope and Nanson 2015) through the peat soils show that it will take millennia to replace lost peat.

Horses are now reversing this recovery and causing further damage. McDougall and Walsh (2007) note:

> The chief threatening process for peat communities in the Australian Alps is physical damage by trampling leading to loss of cover and alteration of local hydrology which leads to channelling of waterflow through the bog. This alteration of drainage patterns within and immediately outside the bog reduces its water-holding capacity, which in turn accelerates the degradation process.

Examples of stream widening, incision of peatlands, pugged peat and drying peat at risk from fire have been described in all areas of horse occurrence in Kosciuszko National Park. Soft moss hummocks that are key to raised water tables are readily destroyed by trampling, thus losing the mosaic of small pools that are essential to frog breeding success. During drier periods, the soft sedges of fens are grazed and horse trackways become drainage lines that concentrate flows.

Actively growing peatlands fix carbon and are a net carbon store of critical international importance (World Conservation Congress 2018). In the Snowy Mountains, intact bogs have up to 2 m of peat, while fens have up to 6 m. These bogs and fens contain an estimated 3.55 Tg (Teragram or 10^{12} gram) of carbon that is at risk of being washed into streams or being emitted as methane and carbon dioxide as the peat dries and degrades (Hope and Nanson 2015). Given that the Australian Alps national parks must be managed to maintain natural values, the way to support the recovery of the peatlands is to reinforce natural processes of vegetation succession and enhance the retention of water, carbon and sediment stores. Control of access, control of large feral animals and weeds, and fire suppression are already considered in plans of management for the Kosciuszko National Park and in consultation with relevant land managers in NSW, Victoria and the ACT.

Horse control in particular is becoming critical to the preservation of mires in many areas. Deer have also started to increase and reach higher altitudes, causing similar damage to recovering vegetation. However, their effect to date has been minor compared with that of horses. Trials on rehabilitating peatlands that have been damaged include small organic barriers (straw, coir or wood) in streams (see photo), fertiliser and replanting Sphagnum clumps (Whinam et al. 2010). These have met with reasonable success and could be rolled out more widely. However, there is no point in doing so unless heavy-hoofed animals are reduced to very low numbers or excluded from stream lines and soft soils. An immediate priority is to exclude animals that are reaching the fragile and slow-growing alpine area above 1,800 m in the summer months.

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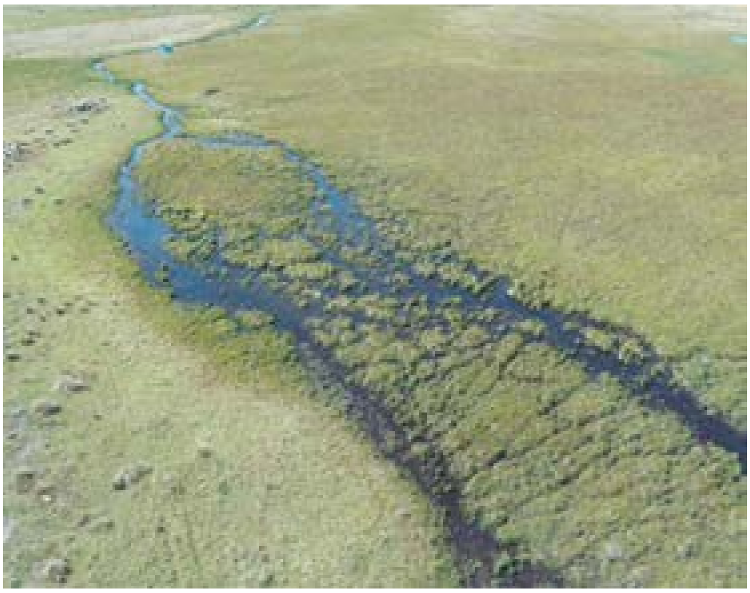
A straw bale and coir barrier across a streamline on Mt Scabby, ACT, placed to impede incision after the 2003 fires.
Source: Geoff Hope.



Feral horses near Tantangara have channelised a large sedge fen exposing it to headward erosion.
Source: Geoff Hope.

1.9

MODELLING MANAGEMENT APPROACHES

MODELLING FERAL HORSE MANAGEMENT IN THE AUSTRALIAN ALPS NATIONAL PARKS

Dr Nicholas J. Beeton[1] and Professor Christopher N. Johnson[2]

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Feral horses in the Australian Alps national parks are currently managed by trapping, with no options for culling being considered. While trapping has been so far unsuccessful (Office of Environment and Heritage 2016), evaluating the effectiveness of alternative approaches is difficult. Information regarding ecology and distribution of horses, and the cost and effectiveness of management strategies, is often unknown or uncertain. Addressing these issues requires an objective approach with the flexibility to incorporate different potential scenarios.

We used a spatially explicit population model (SPADE) (Beeton et al. 2015) to simulate and compare the potential effects of two different management strategies to reduce populations of horses in the Alps: culling (shooting) from helicopters versus a combination of on-ground trapping and mustering. Aerial culling has proved controversial and difficult to implement in the Alps for political reasons, despite it being recognised as a humane method by the RSPCA and being used elsewhere in Australia (GNRBA 2014; Northern Territory Government 2018; Queensland Government 2018; ACT Parks, Conservation and Land 2007). Trapping and mustering is the preferred approach of current governments, but it has been unsuccessful previously in the Alps (ACT Parks, Conservation and Land 2007).

We used the results of aerial population surveys conducted in 2014, vegetation data and cost estimates to inform our modelling. We then provided an estimate of the effect of each strategy on population size across the Alps, and their corresponding costs, compared to no management. To account for uncertainties, we simulated different scenarios for horse population densities, dispersal rates and population growth rates.

The results were highly dependent on the growth and dispersal rates of horses. At higher rates, effective population reduction proved impossible under any modelled management plan, though population maintenance was more feasible. Management using aerial culling was three to six times cheaper than mustering, depending on the growth and dispersal scenario. Despite the lower cost, it was also more effective in every scenario modelled. Though aerial culling was slightly more effective within its control region, as mustering is necessarily restricted by road access, this translated to a substantial improvement in population control, especially where growth and dispersal rates were high.

Our results unequivocally suggest aerial culling as the most cost-effective strategy to effectively control horses within the range of currently realistic scenarios that we modelled (Figures 7 and 8). Population control via culling at high growth and dispersal rates may require more intensive control; however, given the relatively low costs predicted this may be feasible—especially if control is targeted to priority areas.

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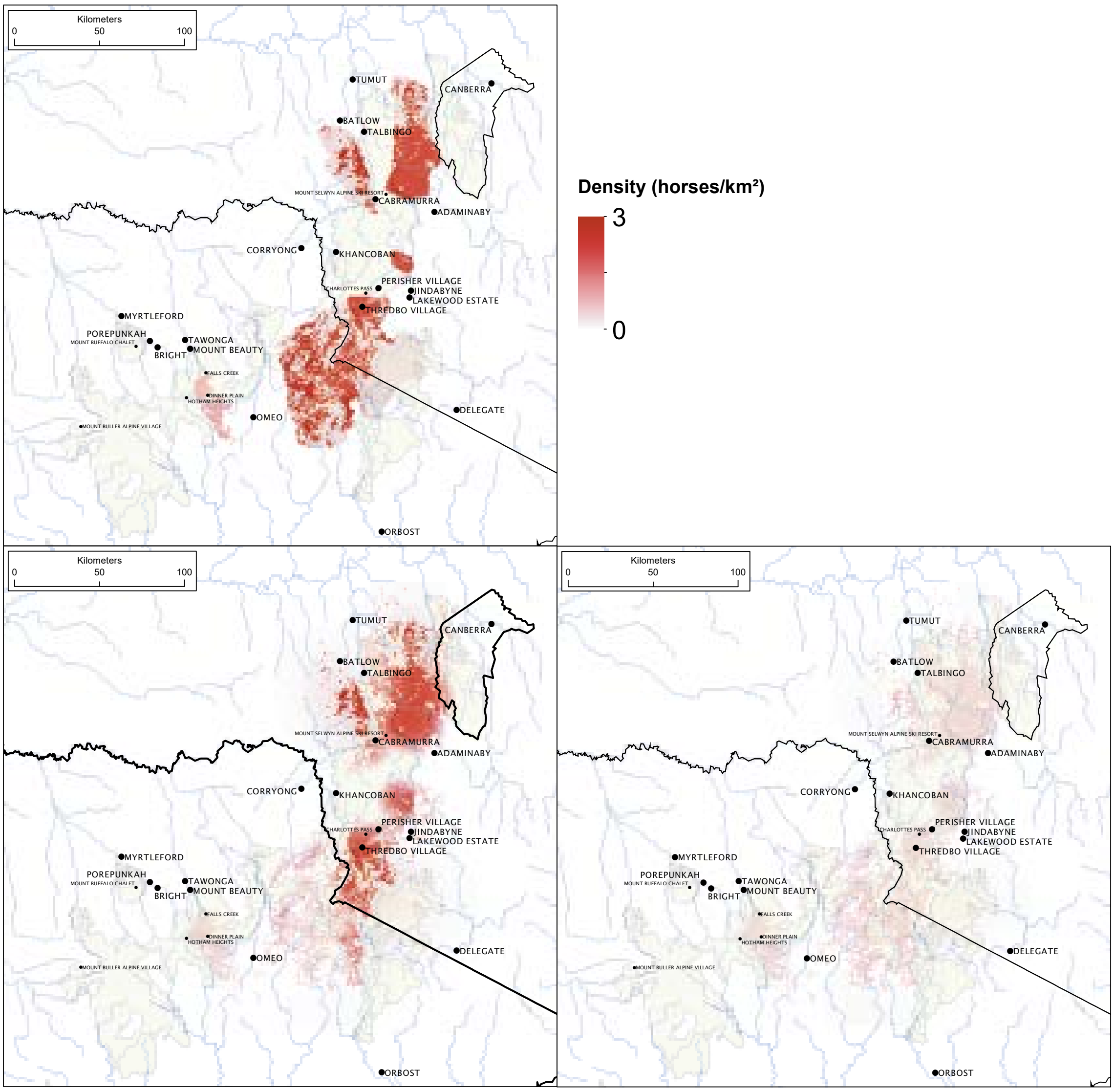

Figure 7. Predicted horse population density before any management (top), after 10 years of trapping and mustering in Victoria (bottom left) and aerial culling across the Australian Alps (bottom right).

Predictions are given for low growth and dispersal rates only. State and territory boundaries are given by black lines, major rivers by blue lines, and national parks are denoted by the yellow shaded regions.

Source: N. Beeton.

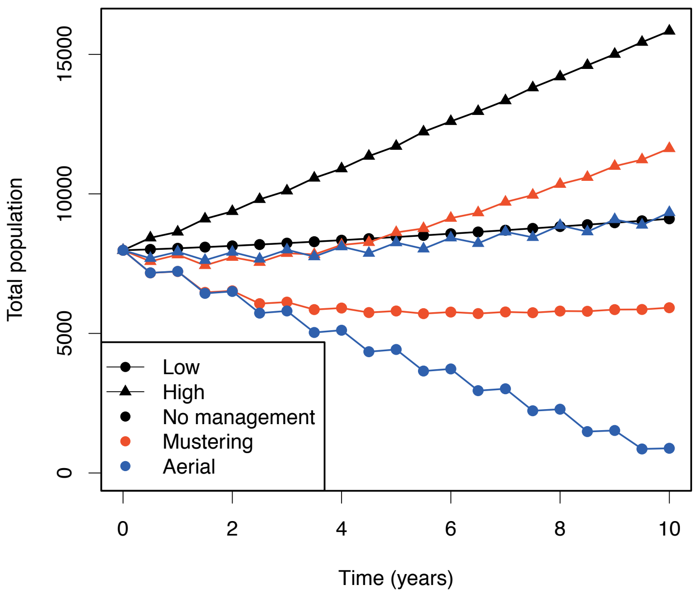

Figure 8. Predicted total horse population during the 10 years of a simulated management program.

None (black); trapping and mustering near Victorian roads (red); and aerial culling across the Australian Alps (blue). Predictions are given for both low (circles) and high (triangles) growth and dispersal rates.

Source: N. Beeton.

Feral horses, Tantangara Reservoir, Kosciuszko National Park.
Source: Martin Schulz.

1.10

GLOBAL IMPACTS

A GLOBAL ASSESSMENT OF FERAL HORSE IMPACTS ON ENVIRONMENTAL QUALITY

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Invasive species have had profound effects on ecological processes worldwide. Invasive herbivores, in particular, can have major effects on ecosystems, both directly—by altering plant community structure and composition—and indirectly—by changing soil processes and ecosystem processes, which feed back to alter ecosystem functions and biotic communities. One invader, the feral horse (*Equus caballus*), has presented considerable problems for land managers worldwide, particularly national park managers, rangeland ecologists, pastoralists and farmers. To our knowledge, there have been few attempts to assemble a global synthesis of their impacts on ecosystems to determine the net effect of increasing horse grazing on environmental quality.

We combined a structured, qualitative search of global literature with a quantitative meta-analysis to explore the net effects of feral horses on ecosystems worldwide. We retrieved 4,150 observations from 159 studies in 72 publications that reported quantitative data on the effects of feral horses on 30 ecosystem response variables ranging from plant community composition and cover, to soil chemistry and soil stability. Most observations (55%) were from North America, followed by Australasia (22%), Europe (11%) and South America (10%). For each observation, we calculated a log response ratio that compared the effect of increasing horse grazing with either no horse grazing or a lower intensity of horse grazing, such that a more positive value represented an improvement in environmental quality due to horses based on the specific attribute (e.g. greater plant cover, more soil carbon, less erosion). When we examined the average effect across all attributes, we found that the log response ratio increased for some attributes but declined for others. Averaged across all 4,150 observations, the average log response ratio (lnRR) was –0.17, which represented a decline in environmental quality of 16±12% (mean ± Standard Error) due to horses. This highlights the average degree of degradation resulting from horse grazing, despite the wide environmental variation in our dataset across different communities, systems, environments and types of land management at the global scale. Despite the significant average effect across all attributes, when we arranged our data into structural (e.g. plant cover, plant height), compositional (e.g. plant richness, plant or animal abundance) and functional (e.g. soil carbon, plant productivity) categories, we found that the lnRR did not differ from zero, largely because of the large confidence intervals (CI) due to wide environmental variability.

We then examined the response to increasing horse grazing for those attributes for which we had >250 observations. These were plant abundance, plant biomass, plant cover, plant richness and soil stability. Plant biomass declined, on average, by 34% (lnRR = –0.41, 95% CI: –0.12 to –0.70), soil stability declined by 32% (lnRR = –0.39, 95% CI: –0.17 to –0.62), and plant abundance declined by 15%

(lnRR = –0.41, 95% CI: –0.07 to –0.25). The average effects of horse grazing on plant cover and plant richness were close to zero (lnRR = –0.01), with broad confidence intervals (0.33 to –0.35), indicating that cover and richness increased under increasing horse grazing in some areas, but declined in others. Overall, our results are consistent with previous regional and local studies of feral horse impacts on plants, soils and biotic communities and indicate that, overall, increases in the intensity of feral horse grazing will lead to reductions in environmental quality.

Campsite, Blue Waterholes, Kosciuszko National Park.

Feral horses have eaten the grass and roots surrounding the fireplace leaving the soil exposed to needle ice and erosion, October 2018.

Source: Di Thompson.

Right: Headwaters of the mighty Snowy River at Charlotte Pass, Kosciuszko National Park.

Source: Mel Schroder.

THEME TWO

AUSTRALIAN ALPS WATER

2.1

IMPACTS TO WATER

FERAL HORSE IMPACTS AND WATER RESOURCES IN SOUTH EASTERN AUSTRALIA

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The Australian Alps national parks are a crucial source of water for South Eastern Australia. Water is fully or over-allocated for human consumption, resulting in the reallocation to improve the health of the Snowy River and the Murray–Darling Basin (MDB) rivers (Commonwealth of Australia, New South Wales and Victoria 2002; Prime Minister of Australia 2012). The value of the water from the Alps can be considered in terms of the critical ecosystem services they provide for Australia (Reid-Piko et al. 2010).

Supporting and Regulating

The small area of the Alps yields a lot of water. Winter low-pressure systems generate snow, which slowly melts in spring and summer. Combined with the water storage and release from alpine Sphagnum moss bogs, this ameliorates seasonal variations to sustain a higher volume and quality of base flow in the rivers. Climate change is projected to further diminish precipitation (CSIRO 2010). Smaller snow packs and sublimation of snow diminishes runoff (Hennessey et al. 2008). Enhancing natural water storage in the Alps, particularly by conserving the bogs (Worboys et al. 2011), could minimise these impacts.

The freshwater ecosystems in the Alps support threatened, endemic flora and fauna of Gondwana origin that is distinctive at a global scale, such as stonefly species (Williams et al. 2014).

Cultural

Five Indigenous nations are custodians of the rivers of the Snowy Mountains region, including Kosciuszko National Park. Their cultural values are linked to the seasonal timing, volume and quality of the river flows—for example, in sustaining populations of native fish species (Connolly and Williams 2014). The rivers rising from the Alps are extensively used for recreation, and tourism provides vital employment and diversification for regional communities, projected to be $7.7 billion per year in non-use value (Morrison and Pickering 2012; CSIRO 2012).

Provisioning

MDB waters support the domestic and commercial needs of over 3 million Australians. The Alps yield on average approximately 9,600 GL of water per year, which is about 29% of the total average surface water yield of the MDB from just 1% of its area of 1 million square km (Figure 9) (Worboys et al. 2011). The value of the 3,980 GL of water flowing from the Victorian Alpine National Park catchments has been estimated as at least $4 billion (Worboys et al. 2011). The Snowy Mountains Hydroelectric Scheme was constructed to generate energy from water in the catchments of the Snowy River and the Murray River. The national electricity market relies in large part on the Snowy Hydro to store energy and provide grid stability with increasing supply from intermittent solar and wind generators (SHL 2018). The Snowy 2.0 pumped storage proposal would increase the generating capacity of the scheme by 50% (SHL 2017).

Water from the Alps supports around a quarter of the MDB's annual average irrigated production of $5.5 billion (MDBA 2010). The water is of national economic importance. Major regional urban areas rely on Murray River waters for domestic consumption, including Albury-Wodonga and (in part) Adelaide. Recreational fishing is important for tourism, with indigenous fish depending on particular water flows, clarity and temperature. Commercial fisheries in the lower lakes of the Murray River and nearshore marine depend on freshwater flows (Zampatti et al. 2010; Auricht et al. 2018).

Horse Impacts

Feral horses, deer and pigs degrade the alpine catchments and water resources. Horses are especially egregious because of their mobility and they impact on the highest altitude drainage lines that are most significant for water yields (Robertson et al. 2015). Feral horse trampling and selective grazing opens gaps in the vegetation that exposes soil to frost heave and erosion (Nimmo and Miller 2007) and also streams to erosion. Sphagnum moss is especially vulnerable to trampling, opening channels through the otherwise raised bogs that speed water flows and dry out the peat, making bogs vulnerable to fire (Williams et al. 2014; Wahren et al. 1994). Loss of bogs diminishes the water-holding capacity of the environment, reducing base flows and increasing pulses of runoff. Horse faeces and dung piles add to the nutrient pollution of alpine streams. More intense and higher energy storms associated with climate change will help accelerate this erosion and diminish water quality (Pittock 2003). Further research is required to ascertain the impacts of these changes in catchment hydrology on water yields. Many aquatic animals in the Alps rely on rocky or cobbled stream substrates to breed, which can be covered by sediment (Boulton et al. 2014). These aquatic species also live within very specific water temperature ranges, and temperatures could be increased by the seasonal diminution of base flows (Pratchett et al. 2011).

Implications

Feral horses in the Australian Alps national park catchments have key negative impacts in addition to biodiversity loss. Degraded wetlands, incised streams and lower water tables allow catchments to shed water quickly rather than a steady, longer term discharge. Erosion and flooding may be further exacerbated by high energy, high water volume storm events of the future. Hydropower generators lose storage to sedimentation and costs increase from wear on equipment. Water is a limited resource in South Eastern Australia, and may be diminished further with climate change. Retaining and restoring water catchments in the Alps is critical for supplying water for Australia's economic future as well as the protection of its high mountain environments. Feral horses degrade these catchments—especially the bogs—changing water-flow regimes and diminishing water quality. Removal of thousands of feral horses in the Alps, and especially Kosciuszko, that are damaging these critical water catchments is required.

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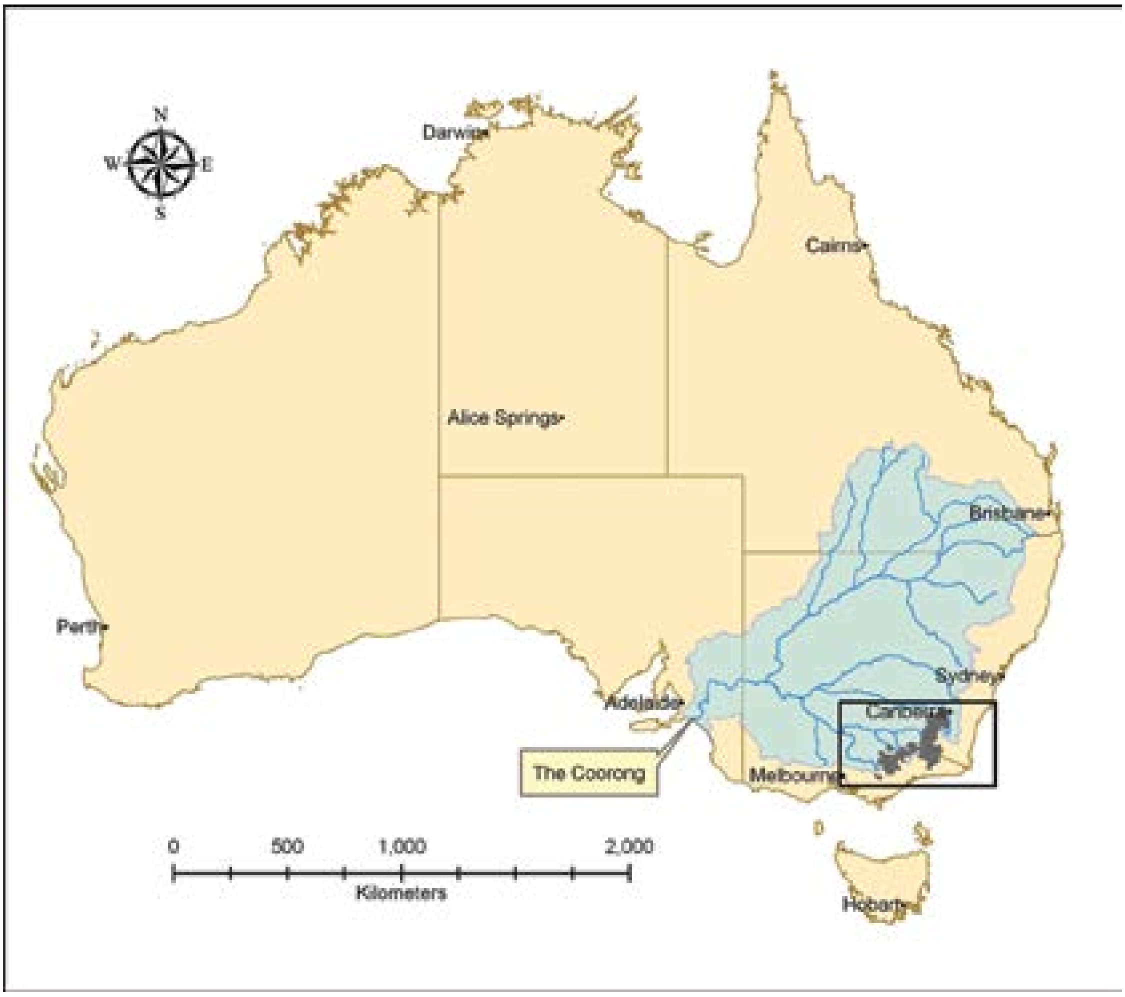

Figure 9. The Murray–Darling Basin (blue) with the Australian Alps national parks (grey).

Source: Doug Mills in Worboys et al. (2011).

Swampy Plains River, near Geehi, Kosciuszko National Park.
Source: Graeme L. Worboys.

2.2

STREAMBANK IMPACTS

USING DRONES TO MONITOR STREAMBANK IMPACTS OF FERAL HORSES IN KOSCIUSZKO NATIONAL PARK

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This project monitors damage to drainage lines caused by feral horses in Kosciuszko National Park. The focus is horse trampling of streambanks and the erosion it causes. The project complements and extends prior field assessments of feral horse impacts in Victoria, NSW and the ACT in 2011 and 2012 (Robertson et al. 2015). Those assessments found that riparian systems of the Australian Alps national parks were being extensively degraded by feral horses, as indicated by loss of streambank stability and 'pugging' damage from hooves, amongst other measures.

Preliminary trials into the use of unmanned aerial vehicles (i.e. drones) for remotely sensing streambanks commenced in Kosciuszko National Park in October 2013. Aerial imagery of treeless, sub-alpine streams was captured in the form of overlapping, near-vertical photographs. Ground control markers placed along the banks of the streams were included in the imagery and their precise locations were surveyed with a Real-Time Kinematic Geographic Positioning System. After fieldwork, a methodology known as structure-from-motion modelling was applied to produce three-dimensional, computer point-cloud representations of the streams, which were geographically referenced based on the ground control information. High-resolution digital elevation models and aerial photo-mosaics having centimetre to sub-centimetre accuracy were then exported to a Geographic Information System where geomorphological metrics were derived.

Stream reaches, each of about 50 m length, are now being monitored in this way over a three-year period (2016/17–2018/19), with funding generously granted by the Australian Alps Liaison Committee and considerable in-kind support from the University of New South Wales. The objective is to measure changes over time to channel cross-sectional profiles and sediment lost from streambanks impacted by feral horses. Between October 2016 and March 2017, 32 baseline monitoring sites were established. Most of these streams were resurveyed in the summer of 2017/18. An initial estimate of sediment lost from the very heavily horse-impacted Ingeegoodbee River in the Pilot Wilderness of Kosciuszko National Park indicates that up to 0.07 tons of sediment per metre of bank length might be lost per year (Figure 10). Additional experiments are now being conducted to survey and model much longer reaches—for example, 400–500 m. The aim here is to eventually up-scale the finer measurements. The summer of 2018/19 will see the final round of surveys of these sites. The watercourses and their associated digital models comprise an important future reference against which the continued impacts of feral horses can be gauged, along with widespread but less obvious damage caused by feral pigs and deer.

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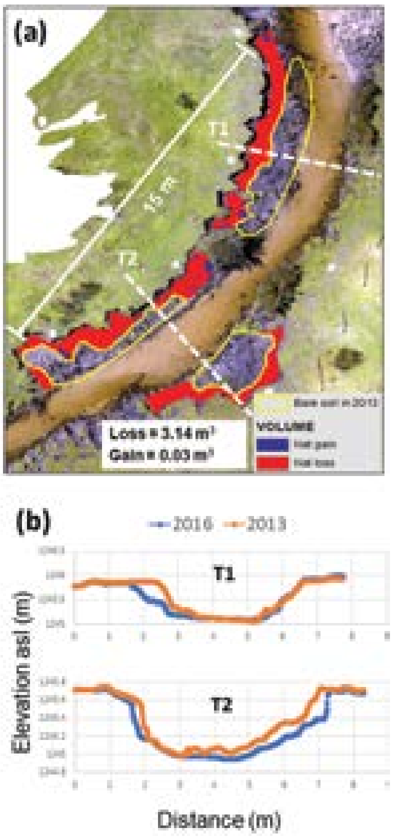

Figure 10. Structure-from-motion model of the Ingeegoodbee River, Kosciuszko National Park.

An assessment of horse impacts between 2013 and 2016 as indicated by (a) volume of sediment lost, and (b) cross-sectional profile changes along T1 and T2.

Source: D. J. Paull, unpublished data.

Streambank damage by feral horses, Ingeegoodbee River, Pilot Wilderness, Kosciuszko National Park, 2013.

Source: Graeme L. Worboys.

Right: Northern Corroboree Frog, *Pseudophryne pengilleyi*.

Source: Murray Evans.

THEME THREE

ALPINE AND SUB-ALPINE NATIVE ANIMALS: AMPHIBIANS

3.1

AMPHIBIAN CONSERVATION: THE NORTHERN CORROBOREE FROG

THE ACT RECOVERY PROGRAM AND AVAILABILITY OF SUITABLE HABITAT FOR ITS REINTRODUCTION

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Northern Corroboree Frogs (*Pseudophryne pengilleyi*) and Southern Corroboree Frogs (*Pseudophryne corroboree*) have restricted distributions in the higher elevation areas of the Australian Alps national parks (Pengilley 1966, 1973; Osborne 1989; ACT Government 2011), where Sphagnum moss bogs and other wet seepage areas provide critical summer breeding habitat (Pengilley 1966; Osborne 1989). In the ACT, suitable habitat for the Northern Corroboree Frog occurs along a disjunct narrow strip that follows the top of the Brindabella/Bimberi Range in Namadgi National Park on the ACT/NSW border.

Prior to the 1980s, both Corroboree Frog species were apparently abundant in suitable habitat within their respective distributions (Pengilley 1966; Osborne 1989; Osborne et al. 1999). However, both species underwent severe population declines during the 1980s, which are continuing (Osborne 1989; Osborne et al. 1999; Hunter et al. 2010). The introduced Amphibian Chytrid Fungus (*Batrachochytrium dendrobatidis*) is the primary cause of these population declines (Berger et al. 1998; Hunter et al. 2010; Scheele et al. 2016).

In 2003, the ACT Government established a captive 'insurance' population of Northern Corroboree Frogs at Tidbinbilla Nature Reserve from eggs collected in Namadgi National Park. This captive breeding population varies between about 500 and 1,000 individuals annually. A second captive population has been established at the Healesville Sanctuary in Victoria. Since 2011, the ACT Government has experimentally released over 2,000 captive-bred Northern Corroboree Frogs back to Sphagnum moss bogs in Namadgi National Park. All individuals have their unique belly patterns photographed to allow for subsequent identification. The aim is to determine whether supplementation by captive-bred juvenile frogs that have been 'headstarted' through the egg, tadpole and metamorphosis stages can counteract increased mortality from Amphibian Chytrid Fungus. Post-release survivorship of these juvenile (one year post-metamorphosis) frogs is low, though sufficient to maintain small breeding aggregations since 2015. Future reintroductions will involve releasing older frogs (two or three years post-metamorphosis) that are closer to breeding age (four years old), which demographic modelling suggests could result in maintaining breeding aggregations that are two to three times the current size.

To protect Corroboree Frog breeding habitat and other areas of Namadgi National Park, feral horses moving across the border into the park from the adjacent Kosciuszko National Park and Bimberi Nature Reserve in NSW are removed by the ACT Parks and Conservation Service under the ACT *Feral Horse Management Plan* (ACT Government 2007), to protect Sphagnum moss bogs and other conservation values in the Park. Increased numbers of feral horses in NSW will undoubtedly result in higher numbers moving across the border into Namadgi National Park, increasing the risk of damage to the near-pristine Sphagnum moss bogs that are critical Corroboree Frog habitat.

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Ginini Swamp, a Ramsar Wetland within the ACT, is an undisturbed (feral horse–free) wetland protected in Namadgi National Park of the ACT.

Note the richness of the Sphagnum and the elevated (perched) water table.

Source: Graeme L. Worboys.

Right: The *Mastacomys fuscus* (Broad-toothed Rat), one of Australia's 'old endemics'. It is listed in NSW as a Vulnerable Species.

Source: Ken Green.

THEME THREE

ALPINE AND SUB-ALPINE NATIVE ANIMALS: MAMMALS

3.2

MAMMAL CONSERVATION: THE MOUNTAIN PYGMY-POSSUM

INDIRECT IMPACTS OF THE FERAL HORSE ON THE MOUNTAIN PYGMY-POSSUM

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The Mountain Pygmy-possum (*Burramys parvus*) is a small, ground-dwelling possum, which occurs in patches of boulder-field habitat in Kosciuszko National Park and the Victorian Alps at elevations above 1,200 m (Broome et al. 2012; Broome, pers. comm., September 2018). It is the only member of its genus and the only Australian mammal limited in its distribution to the alpine/sub-alpine environment. It is the only marsupial that hibernates beneath snow cover during winter, waking in spring to feast on migratory bogong moths, which occupy the boulder-fields soon after snowmelt. Heathland shrubs surrounding the boulder-fields provide additional dietary items, including a variety of arthropods, nectar, fruits and seeds (Gibson et al. 2018). The shrubs also promote a sub-nivean space during winter, which is used by possums during their short arousal periods throughout the hibernation period (Broome and Geiser 1995) and they provide protection from predatory feral cats and foxes after snow melts. Adult weights in spring are around 35–45 g, but body weight may double, reaching over 80 g in autumn (Heinze et al. 2004).

The species is listed as 'Endangered' under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) and the *Biodiversity Conservation Act 2016* (NSW). It is 'Threatened' under the *Flora and Fauna Guarantee Act 1988* (Vic), and 'Critically Endangered' on the 2008 IUCN Red List of Threatened Species. The total population is estimated at around 3,050 adults (1,015 in NSW; 2,035 in Victoria) (Broome et al. 2012; Broome, pers. comm., September 2018).

Two populations of Mountain Pygmy-possums occur in Kosciuszko National Park, scattered in small colonies between Dead Horse Gap and Gungartan Pass in the south and from Snow Ridge to Happy Jacks Valley in the northern region (Broome et al. 2013; Bates and Broome, unpublished data). Major threats include predation from feral cats and foxes, loss of habitat from developments and impacts of feral herbivores, drying and siltation of boulder streams, and loss of snow cover from climate change (Bates 2017).

Feral horses are currently not abundant around areas of Mountain Pygmy-possum habitat. However, they have been seen grazing among boulder-fields and feeding on sedges in lakes on the western fall of Mt Kosciuszko, on the Summit Road habitat site 2 km from Charlotte Pass and at Dead Horse Gap. Horse presence (dung heaps) is evident around the Rough Creek habitat site in Northern Kosciuszko

National Park (Broome, pers. comm., September 2018). Expansion of horse numbers throughout the alpine area and parts of the Jagungal Wilderness Area (e.g. Gungartan) can be expected without effective control, particularly with continuing climate change–induced droughts. Resulting impacts include trampling of alpine shrubs and sedimentation of streams, evident where horses are currently abundant. This is likely to cause loss of food resources and enhancement of feral predator impacts through reduced cover and creation of trails in summer and disruption of the sub-nivean space in winter. Increased sedimentation of streams, which run into boulder-field habitats, is likely to decrease their depth, a key predictor of high-quality habitat (Broome et al. 2013; Broome, pers. comm., September 2018).

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Mountain Pygmy-possum eating Mountain Plum-pine seed.
Source: Linda Broome.

Feral horses grazing near Mountain Pygmy-possum habitat on the western side of Mt Kosciuszko, December 2013.
Source: Linda Broome.

3.3

MAMMALS: IMPACTS OF FERAL HORSES— THE BROAD-TOOTHED RAT

THE BROAD-TOOTHED RAT (*MASTACOMYS FUSCUS*) AND FERAL HORSE IMPACTS

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Feral horse impacts are directly influencing the occurrence of the small native mammal the Broad-toothed Rat (*Mastacomys fuscus*) within parts of its range. Its habitat is being impacted from browsing and trampling associated with the expansion of feral horse populations. This rodent has a fragmented distribution, being mainly endemic to the alpine and sub-alpine regions of South Eastern Australia (Happold 2008). It is sometimes described as an 'old endemic', having had a wider distribution in the Pleistocene than today, and is one of a number of Australian native mice that have no really close relatives anywhere else. It is listed as endangered in Victoria (Department of Sustainability and Environment 2013), vulnerable in NSW (Office of Environment and Heritage 2018) and the mainland population is listed as vulnerable by the Commonwealth (Department of the Environment and Energy 2018). Populations are known from Victoria, the ACT and in NSW at Kosciuszko National Park and adjacent lands on both Crown land and private tenure. There is also a disjunct population (separated by 450 km of unsuitable habitat) in the Barrington Tops National Park (O'Brien et al. 2008). These locations vary in altitude and vegetation, but are similar in having high rainfall, cool summers and cold winters, and a dense ground cover of grasses, sedges and shrubs (Green and Osborne 2003). Its presence is readily ascertained by its distinctive olive-green scats (Happold 1998; Triggs 2004). Individuals produce 200 to 400 pellets each day, which last many months (Happold 1998), thereby confirming the presence or absence of the species at a site (O'Brien et al. 2008; Green and Osborne 2003).

Sites supporting vegetation communities known to provide prime habitat for this native species (Green and Osborne 2003) were investigated for its presence in relation to the impacts of feral horses. There were 180 sites assessed. The study was conducted in the North Eastern Wild Horse Area (Office of Environment and Heritage 2016) in Northern Kosciuszko National Park, as well as some adjacent areas such as Happy Jacks Plain, between November 2016 and April 2017. The distinctive scats of the Broad-toothed Rat were found in 74% of sites investigated. This study found a significant negative relationship between the presence of the Broad-toothed Rat and the increasing impacts of feral horses. Consequently, no native rat scats were located in sites severely impacted by feral horses. As the impacts of feral horses declined, the presence and abundance of the Broad-toothed Rat increased. Locations with no evidence of feral horses, including all Happy Jacks Plain sites, had a high incidence of Broad-toothed Rat presence.

In moderate impact sites there was a high proportion of sites with no evidence of native rats (over 35%), while the remainder of sites only supported low abundances of the species. In contrast, sites with no feral horse or low feral horse impacts had much greater numbers of *Mastacomys*.

In 88% of sites with low impacts and 78% of sites with moderate impacts, greater feral horse impacts were recorded on adjacent slopes or parts of the flats further away from watercourses. Because high-impact levels generally indicate that Broad-toothed Rats will be absent or at low abundance, high feral horse damage adjacent to watercourses suggest that the Broad-toothed Rat is likely restricted to habitat refuges. However, as the feral horse population increases and suitable habitat becomes more widely dispersed in the landscape, populations are likely to become smaller and increasingly isolated. Consequently, the overall range of the species will be expected to contract and become increasingly restricted within Kosciuszko National Park.

Extensive corridors of tussock grassland traverse large sections of the North Eastern Wild Horse Area in valleys heavily impacted by feral horses, notably the Eucumbene and Murrumbidgee Rivers and Tantangara Creek. Such corridors provide important remnant habitat for the Broad-toothed Rat; however, with increasing horse numbers, such remnant habitat is likely to diminish. It is recommended that, where breaks in the dense vegetation along such watercourse systems occur, these are rehabilitated to further increase the importance of such corridors for the long-term persistence of the Broad-toothed Rat in this section of the Park.

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The Broad-toothed Rat captured at Horse Camp, Kosciuszko National Park.
Source: Martin Schulz.

Severe feral horse impacts along Tantangara Creek, North Kosciuszko National Park.
Source: Martin Schulz.

Pugging—severe feral horse impacts, Pigeon Square Creek.
Source: Martin Schulz.

No feral horse impacts along Happy Jacks Creek.
Source: Martin Schulz.

Right: Guthega Skink (*Liopholis guthega*)—An endangered species.
Source: Mel Schroder.

THEME THREE

ALPINE AND SUB-ALPINE NATIVE ANIMALS: REPTILES

3.4

REPTILES: IMPACTS OF FERAL HORSES—THE ALPINE WATER SKINK

FERAL HORSE IMPACTS ON A THREATENED LIZARD AND A NATIONALLY ENDANGERED ECOLOGICAL COMMUNITY IN VICTORIA'S SUB-ALPINE REGION

Rebecca C. Cherubin, Dr Susanna E. Venn, Dr Tim S. Doherty, Professor Don Driscoll and Dr Euan G. Ritchie

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As introduced, large ungulates, horses represent a relatively recent and novel threat to Australian ecosystems (Ashton and Williams 1989; Tolsma and Shannon 2018). Feral horses have a wide distribution across mainland Australia, and arguably have the greatest negative impact on highly sensitive and nationally endangered species, such as the Alpine Sphagnum Bogs and Associated Fens Endangered Ecological Community (Parks Victoria 2017; Roberston et al. 2015). Already highly fragmented with a very restricted geographic extent, Sphagnum bogs are typified by soft, spongy moss, impeded drainage systems and restricted growing seasons (Commonwealth of Australia 2009). The long-term survival of Sphagnum bogs is under threat, particularly from climate change and fire (Commonwealth of Australia 2009; White 2009), and damage by feral horses may compound these threats, exacerbating ecosystem degradation and biodiversity loss (Greene and Osborne 2003).

The Alpine Water Skink (*Eulamprus kosciuskoi*) is a live-bearing, diurnal reptile that is almost exclusively associated with montane and alpine Sphagnum moss beds and associated wet healthlands (Department of Sustainability and Environment 2003). Its highly specialised habitat requirements and dependency on this fragmented ecosystem likely make it vulnerable to grazing and trampling of vegetation by feral horses (Clemann 2002; Department of Environment, Land, Water and Planning 2018; Steane et al. 2005).

We assessed the potential impact of feral horses on bog vegetation and populations of *E. kosciuskoi* at 20 sites in Victoria's north eastern alpine range (between Nunniong and Cobberas). We quantified feral horse impacts as hoof damage to substrate (pugging), the level of defined animal tracks, and grazing disturbance. We also determined an index of feral horse abundance from scat counts. Vegetation structure and cover were quantified using structure pole and line intercept surveys. *E. kosciuskoi* occupancy and abundance were surveyed using repeated 30-minute active searches across suitable habitat.

Sites with increased horse use had lower grass, sedge, rush (graminoids) and shrub structure, and reduced cover of shrubs and mosses. These sites also supported more forbs. *E. kosciuskoi* were more likely to occur at sites with increased areas of Sphagnum bog and wet heathland vegetation, and were less likely to occur and had a lower abundance in areas with more forbs. *E. kosciuskoi* were also more abundant in areas with increased Sphagnum moss structure. We suggest forb-dominated areas may provide less suitable habitat for *E. kosciuskoi*, as these skinks require sufficient Sphagnum cover for thermoregulation, shelter and foraging (Steane et al. 2005). As we detected a positive relationship between feral horses and forbs, it is possible horses are driving vegetation change that indirectly negatively affects Alpine Water Skinks.

Our findings add to a growing body of research that demonstrates feral horses negatively impact endangered Sphagnum bogs and other sensitive montane and alpine vegetation communities, and hence indirectly impact co-occurring and habitat-dependent fauna.

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Alpine Water Skink (*Eulamprus kosciuskoi*).
Source: Rebecca Cherubin.

Right: A large Stocky Galaxias (*Galaxias tantangara*).
Source: Hugh Allan.

THEME THREE

ALPINE AND SUB-ALPINE NATIVE ANIMALS: FISH

3.5

FISH: IMPACTS OF FERAL HORSES—STOCKY GALAXIAS

THE THREAT FROM FERAL HORSES TO A CRITICALLY ENDANGERED FISH

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Stocky Galaxias (*Galaxias tantangara*) is a small native fish found in the headwaters of the Tantangara Creek catchment in Kosciuszko National Park. The species is one of 15 recently described taxa, being formerly included in the Mountain Galaxias complex (Raadik 2014). Stocky Galaxias is listed as critically endangered in NSW (NSW FSC 2016) and nationally by the Australian Society for Fish Biology (Lintermans 2016). Only a single population is known; located above a natural waterfall in the headwaters of the catchment. Now found in about 3 km of a small permanent stream (average about 1 m wide and 10 cm deep), it is predicted to have been formerly much more widely distributed throughout the Tantangara Creek and possibly the upper Murrumbidgee River catchment (Raadik 2014; NSW FSC 2016). The current restricted distribution of Stocky Galaxias is thought to result from the impacts of predatory trout (NSW FSC 2016).

Wild horses are abundant in the Tantangara area and establish/use well-worn trails throughout the Tantangara Creek catchment. These trails commonly cross Tantangara Creek where Stocky Galaxias is found. At such crossings, bankside vegetation is largely absent, bank structure is damaged, the stream is wide and shallow, and fine gravels and silt have filled an otherwise boulder- and cobble-dominated substrate. The population density of horses in Northern Kosciuszko (including Tantangara Creek) is two to three times the density recorded elsewhere in the Australian Alps (Cairns and Robertson 2015).

Observations downstream of horse crossings show accumulations of fine sediment, almost certainly mobilised by horse damage (pugging, trampling, bank slumping, runoff from trails). These sediment accumulations are generally less severe or absent in areas further downstream, or immediately upstream of crossings. The extremely small current distribution of Stocky Galaxias magnifies the importance of instream and riparian habitat degradation from feral horses. The impacts of horses on aquatic habitats in the High Country in Australia have been documented for nearly 30 years (Dyring 1990; Roberston et al. 2015). However, this damage has not been previously considered from a fish perspective.

Like many *Galaxias* species, rocky substrates and clean spaces between stones appear important for Stocky Galaxias spawning (Cowden 1988; Stoessel et al. 2015). Sedimentation reduces available spawning habitat and can smother and kill fish eggs. The long incubation time of Stocky Galaxias eggs means the species is particularly vulnerable to sedimentation. Unlike other Australian upland fishes, such as blackfish *Gadopsis* sp., which exhibit parental care by fanning eggs to remove sediment and promote oxygenation, *Galaxias* species do not have parental care. Direct damage by horse trampling could also impact egg and larvae survival during this time.

Tantangara Creek at a horse crossing.

Note the narrowness of the stream and bankside vegetation in the top left corner and the fine silt and gravel throughout the stream.

Source: Mark Lintermans.

Preliminary ecological research into Stocky Galaxias indicates that it has a small home range, with most individuals found within a 5 m total linear range. Fish generally shelter within the interstitial space between large substrate particles, such as cobbles and boulders, and are not often found in areas with fine particles such as silt and gravel. Localised damage or loss of stream habitat means the entire home range of several fish may be affected.

Feral horses are impacting stream and riparian habitats throughout the entire remaining range of Stocky Galaxias. Although there are other large feral herbivores in the catchment (deer), their observed abundance around streams is an order of magnitude lower than horses, with the overwhelming abundance of signs at stream crossings and on trails from horses. Quantified measures of horse damage to stream and riparian habitats in Tantangara Creek are urgently required.

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Right: Anemone Buttercup (*Ranunculus anemoneus*), Mount Lee, Kosciuszko National Park, 2016.
Source: Brian Slee.

THEME FOUR

THREATENED NATIVE FLORA

4.1

INTRODUCED STOCK IMPACTS ON ALPINE AND SUB-ALPINE FLORA

FLORA: A SHORT REVIEW OF GRAZING EFFECTS

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A Brief History of Stock Grazing in Australian Alpine Areas

From the mid-19th century, large numbers of cattle and sheep with associated stock horses were taken to the Australian Alps each summer, especially during droughts. Stock numbers could be very high, sometimes more than 100,000 head in about 120 km^2 (Carr and Turner 1959). Sheep and cattle grazing occurred in the Kosciuszko high country and, in the latter half of the 20th century in Victoria, only cattle were permitted to graze. In 1944, with the establishment of Kosciuszko State Park, regulatory limits were placed on grazing numbers and duration in the Snow Leases, and grazing was removed altogether from the Kosciuszko summit area (Costin et al. 2000; Bryant 1973; Taylor 1956). Relief grazing during the worst of historical droughts led to excessive grazing pressures, and this was believed to be the tipping point for the soil erosion in the Carruthers area in the Snowy Mountains (Worboys et al. 2010). Monitoring experiments were instigated by the NSW and Victorian governments to investigate the effects of grazing on soils and vegetation (Carr and Turner 1959; Costin et al. 2000). Domestic grazing stock were removed altogether from government-controlled land in Kosciuszko: first in 1957, where Snow Leases above 1,350 m were withdrawn; and then in 1969, when the NSW Liberal Government advised that all stock grazing with Kosciuszko National Park would be terminated indefinitely. In Victoria, grazing ceased in 2005, after severe fires in 2003 and obvious damage from cattle to alpine landscapes.

General Effects on Alpine Vegetation Composition

Stock were selective grazers in the Alps, with a preference for many inter-tussock forbs, as well as grasses and some low, soft, palatable shrubs. Tall and highly flammable shrubs were not consumed (Van Rees 1984; Van Rees and Holmes 1986; Van Rees and Hutson 1983). Selective grazing caused bare-ground patches in amongst the inter-tussock forbs (Williams and Ashton 1987) and subsequent exposure of fragile soils, which lead to erosion (Worboys et al. 2010). Many graziers recognised the unpalatability of many tussock-forming species and resorted to seasonally burning the alpine and sub-alpine landscapes from the 1860s to the 1940s to facilitate the growth of the 'green-pick', the more palatable regrowth stage of the tussock grasses. This practice of burning, especially during dry periods, exposed the soil and lead to soil erosion (Williams and Ashton 1987). In 1897, in an address to the Royal Geographical Society, the naturalist Richard Helms stated:

> Not satisfied with what nature yields, the herdsmen in order to improve the growth of feed and make it sweeter as they say, yearly burn large tracts of the grass and shrub … what right has one section of the community to rob the other of the full enjoyment of an unsullied landscape … The husbandman on the farm by the river, the artist and tourist who seek the picturesque, the botanist and zoologist who come in pursuit of plants and animals, are all interfered with. And why? Because some inconsiderate people are allowed to do as they please (quoted in Stanley 1982: 4).

Many studies have occurred investigating the responses of vegetation to stock grazing. These studies demonstrate decreases in the palatable forbs, grasses and low shrubs, and initial sharp increases in non-palatable shrubs and other woody plants (snow gum). They also demonstrate that grazing in alpine and sub-alpine areas has the potential to change the overall composition of vegetation in different communities by way of the creation of bare-ground patches and subsequent colonisation by various forbs and grasses.

Long-term exclusion plots in Victoria in the 1940s clearly showed that, without grazing, the abundance of many palatable species increases substantially (Carr and Turner 1959; Wahren et al. 1994), the cover of which changed little on grazed plots. In contrast, most shrubs in both open and closed heathland are non-palatable and were not affected by grazing (Wahren et al. 1994; Wahren 1997). Similarly, within stock exclosures in sub-alpine Kosciuszko (Bryant 1969), there was a rapid increase in shrub cover of 15–30% in the first three years (but the cover of these species declined thereafter), and also a rapid increase in the number of tree seedlings establishing and persisting. The transects and photoquadrats established in the Kosciuszko area, after the removal of grazing in 1959, showed an initial increase in the cover of palatable species and a decrease in the cover of bare ground (Wimbush and Costin 1979a, 1979b; Scherrer and Pickering 2005). Experimental sheep grazing trials in Kosciuszko National Park, conducted by Alec Costin and Dane Wimbush from 1959 to 1979, showed similar trends (Wimbush and Costin 1979a).

Grazing Effects on Threatened Plant Species and Communities

The selectivity of domestic grazing animals can push some plant species to near extinction. The highly palatable forb *Ranunculus anemoneus* was once widely distributed in the Kosciuszko area, but by the 1960s was becoming difficult to find and was believed to be a species of rock ledges (Costin et al. 2000). Now, in the long absence of grazing, it is found in a wide range of habitats and is reasonably common. The tall grass *Chionochloa frigida* has made a similar return from obscurity in the Kosciuszko area. Many palatable species are restricted by narrow distributions and specific habitat requirements, and may be listed as rare or vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* (Venn et al. 2017). Selective grazing of alpine bog and wetland species, and subsequent damage to peat soils, lead to the listing of Alpine Sphagnum Bogs and Associated Fens as a nationally threatened ecological community. Recent activity of feral horses has had a serious impact on this community through trampling and subsequent draining of such wetlands.

Grazing by hard-hoofed stock animals, such as cattle and horses, with no effective control strategy, is an immediate threat to the survival of alpine plant communities and the rare species within them. Scientific enquiries over the last 100 years previously led to governments in Victoria and NSW removing stock animals for the sake of the mountain catchments and the downstream environments they support. The alpine vegetation in some places will never fully recover from cattle grazing. Feral horses in alpine and sub-alpine areas will cause the same amount of damage if left unchecked.

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Ribbony Grass (*Chionochloa frigida*) was a favourite food of stock in the high mountains and has become more common since grazing ceased.

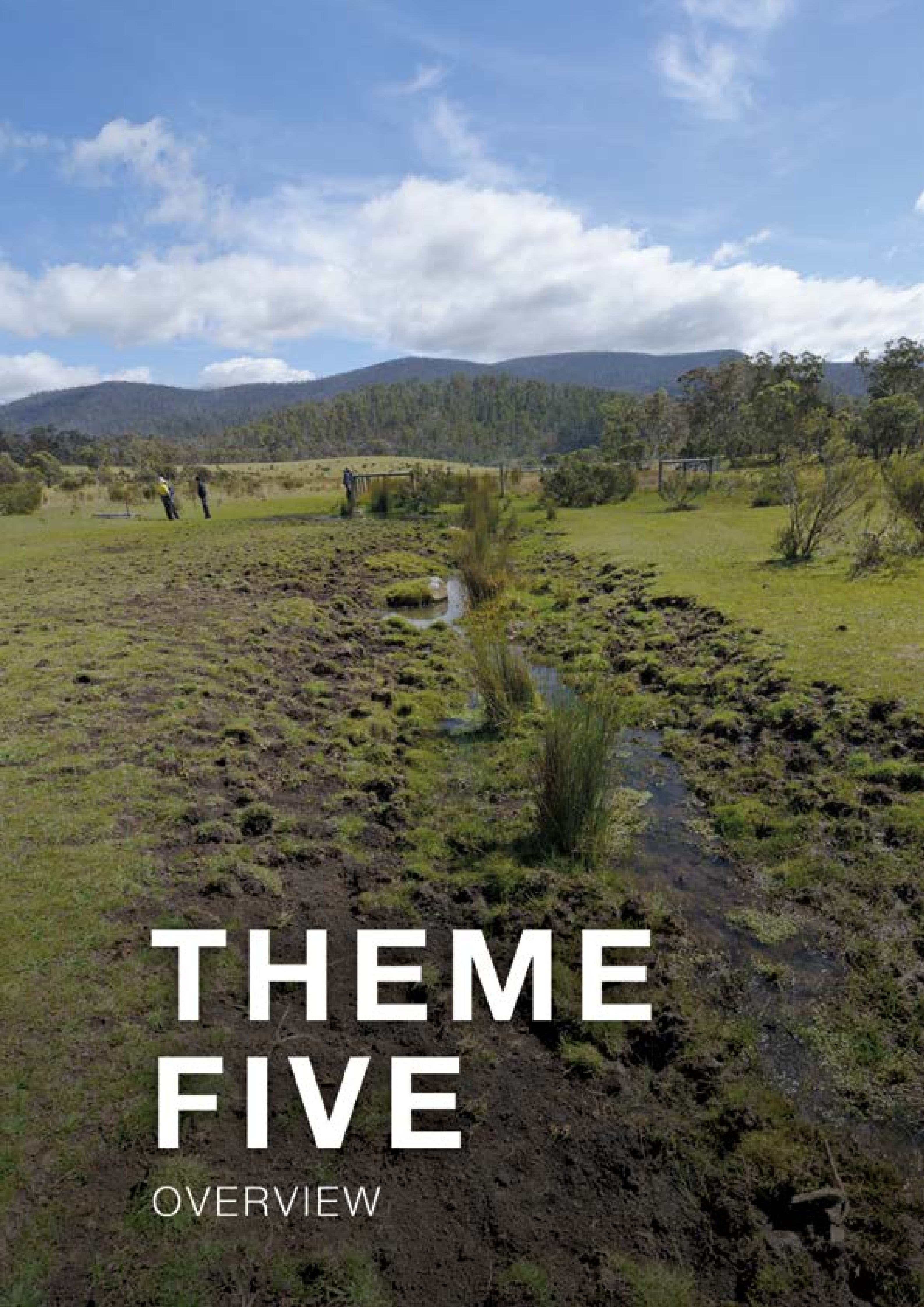
Source: Graeme L. Worboys.

Sphagnum, self-healing, Dicky Cooper Creek tributary, following the removal of stock from Kosciuszko National Park and in the absence of feral horses.

Source: Graeme L. Worboys.

Right: Impacts of feral horses on creek line, Murray River headwaters, Cowombat Flat, Alpine National Park Victoria, 2013.

Source: Graeme L. Worboys.



THEME FIVE

OVERVIEW

5.1

IMPACTS OF FERAL HORSES: AN OVERVIEW

IMPACTS OF FERAL HORSES: KNOWLEDGE, GAPS, DIRECTIONS

Professor Don Driscoll

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The case for urgently removing feral horses from the Australian Alps national parks is now overwhelming. Multiple, large datasets show that feral horses damage vegetation structure, degrade stream morphology and drive declines in threatened alpine bog communities. The damage feral horses cause is widespread, with studies from across the alpine national parks demonstrating degradation and declines of native species, including remote-sensing research (Mackey) and very large field studies, each encompassing more than 150 plots (Wright, Schulz).

There is irrefutable evidence that feral horses eliminate populations of Broad-toothed Rats (Schulz), have reduced invertebrate abundance (Ward-Jones), and are likely driving down Alpine Water Skinks (Cherubin). Further, with expert knowledge of habitat requirements and evidence that horses destroy habitat, there is compelling advice that Corroboree Frogs (Scheele, Evans), Mountain Pygmy-possums (Bates) and the Stocky Galaxias (Lintermans) are at risk without rapid action to remove horses.

We know that, historically, plant species have been dramatically reduced in range when cattle and sheep were the big threat, and horses are likely to have similar impacts across ecosystems (Venn). Finally, damage to bogs and streams will likely increase fluctuations in water flow, and could degrade water quality entering Australia's biggest water catchment (Pittock).

Look Over There! It's the Deer! Not.

Opponents of effective feral horse control often point to feral deer as the bigger threat, but this Conference proves such opinions are wrong. Based on data from more than 100 plots across NSW, the ACT and Victoria, the same amount of stream degradation was evident, whether the dataset included sites with evidence of non-horse damage or not (Wright); that is, deer and pigs made no substantive contribution to the damage. Cumulative damage was recorded from bogs and riparian areas on the Bogong High Plains, using data that only included horse impacts (Brown). Corroboree Frog habitat depth was halved by feral horse impacts, with no evidence of deer or pigs on the study plots (Scheele). Horses were singled out as driving loss of carbon from wetlands across Kosciuszko, not deer (Hope). In evaluating threats to the critically endangered fish, Stocky Galaxias, Mark Lintermans noted that horses are an order of magnitude more abundant than deer and cause the vast majority of stream damage. Evidence that deer could be part of the problem came from the Victorian eastern alps (Cherubin) and the dry woodlands of the lower Snowy Valley, where 84% of the dung was from horses and 13% from deer (Ward-Jones). While deer are probably contributing to the impact in dry lower elevations, horses remain the dominant herbivore. Deer should be on the list of things for management action in the Alps, but the rightful priority for protecting the Alps is to remove horses.

Damage is Cumulative

Critical evidence from the Bogong High Plains suggests that damage accumulates because recovery is very slow. Therefore, even small numbers of horses are causing ongoing degradation (Brown). This was a point supported by literature from New Zealand (Rogers 1991) and the United States of America (Crane et al. 1997), demonstrating that feral horses cause environmental degradation, even at low densities (Scheele). The evidence of impacts, evidence that it is not deer, and evidence that damage is cumulative at low densities provides a powerful, science-based case for removing *all* horses from the Alps.

How Should Feral Horses be Taken Out of the Alps?

Nick Beeton's study examined the consequences of policies that include or exclude aerial culling. His modelling demonstrates that rounding up a few hundred horses from near roads will not protect the alpine parks. Aerial culling is the only way to reduce horse numbers at the scale, and with the speed and cost-efficiency, that is desperately needed.

Priorities

Without aerial culling, the horse problem cannot be solved. Government agencies are forced to use localised trapping in the hope of reducing impacts on some important ecological assets. But which ones should be prioritised? Setting priorities is difficult because the information that is available is not evenly spread across ecosystems (Figure 11) and taxa, and is of varying quality (Figure 12). We know the most about wetlands, but evidence from dry woodland demonstrates that other ecosystems are severely impacted by feral horses. For most ecosystems and many threatened species, data on the nature or extent of impacts of feral horses are not available, making it difficult to evaluate priorities.

To conclude, unequivocal evidence that feral horses are *the* single cause of widespread environmental degradation, even at low densities, and are a threat to many native species justifies their complete removal from the Australian Alps national parks. Trapping or rounding up horses cannot solve the problem, but aerial culling can. The urgent dialogue now has to be how can scientists, non-government organisations, agencies and politicians work together to make culling politically feasible.

References

Crane, K. K., Smith, M. A. and Reynolds, D. (1997) Habitat Selection Patterns of Feral Horses in South Central Wyoming. *Journal of Range Management* 50: 374–380.

Rogers, G. M. (1991) Kaimanawa Feral Horses and Their Environmental Impacts. *New Zealand Journal of Ecology* 15: 49–64.

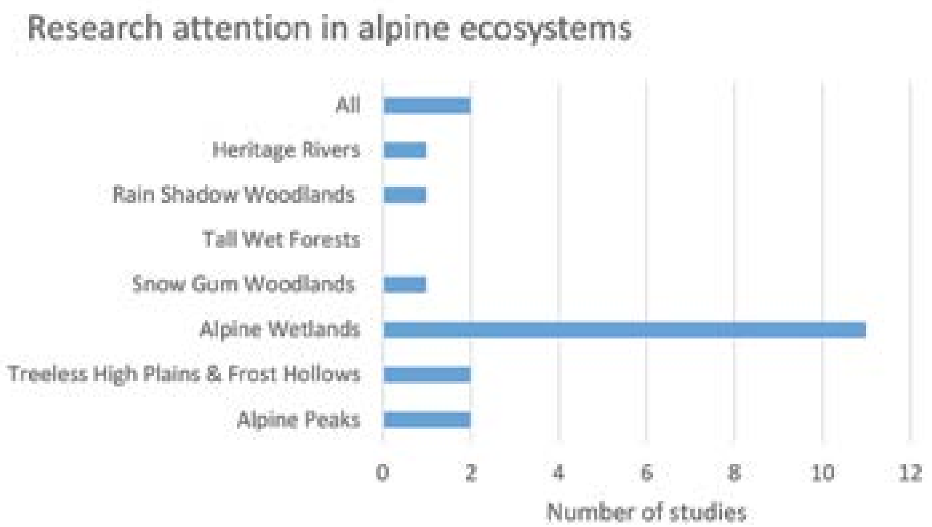

Figure 11. The number of studies presented in this Conference by ecosystem type as defined by Brendan Mackey.

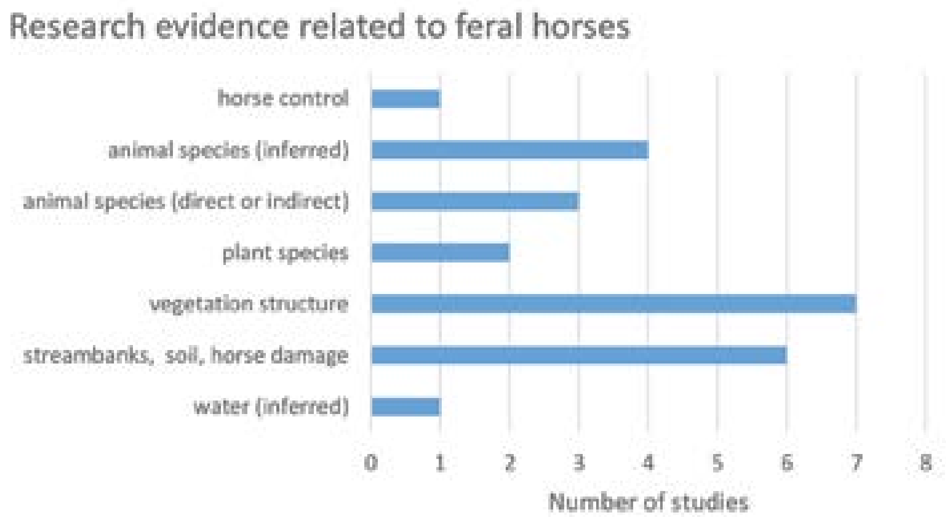

Figure 12. Topics of research and quality of evidence presented in the Conference.

Right: Lower Snowy River, Kosciuszko National Park: Drought, too many feral horses and the elimination of all food near the river leads to starvation and death, October 2018.

The removal of all feed by the feral horses impacts Australian native animal species, removes soil cover and leads to erosion.

Source: Richard Swain.

5.2

CHAMPIONING SCIENCE INFORMATION

MARSHALLING EXPERT OPINION FOR POLICY DEVELOPMENT: PERSONALISED ENGAGEMENT COMPLEMENTS GROUP EFFORTS

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Governments rely on expert opinion to inform policy development, but the manner in which experts are engaged is shifting. As well as contributing to committees and panels, participating in working groups and co-authoring strategic reports, experts are increasingly making it personal—by writing opinion pieces for newspapers, giving interviews to the mainstream media and sharing their reflections on complex issues in real time via social media. Here, I explore how experts engaged with the issue of feral horses, contrasting traditional collective efforts with personal perspectives, and suggest the combination of both is critical for meaningful policy development.

For years, ecologists, conservation scientists and land managers have proactively engaged with the issue of feral horses, especially concerning their impacts in alpine areas. In addition to conducting and communicating empirical research, timely summaries of available information were compiled, informing media releases and summarising a consistent set of talking points. Rather than waiting for an invitation, scientific societies were proactive in communicating the consensus on the issue, explaining uncertainties and contextualising known impacts. By integrating local information on wildlife disease, animal welfare and water quality with international work on the effects of feral horses on wildlife, soil degradation and weed invasion, emotive support of 'brumbies' in the High Country was comprehensively challenged, reframing the debate and demonstrating that feral horses are incompatible with protected area management.

As news of the 'brumby bill' broke, groups of scientists mobilised and responded rapidly—fact-checking statements by politicians and feral horse advocates, countering arguments conflating cultural values with management targets. By sharing information and working cooperatively, the issue remained live and engaged the wider community in the broader issues of protected area management, invasive species impacts and the disproportionate effects of human-induced climate change on alpine biota.

Individual efforts complemented these collaborative contributions, many people sharing their considered views on the Bill, the issue of feral horse impacts and wider concerns about the role of national parks and erosion of trust in the development of public policy. Several individuals dedicated significant efforts to public discourse on the issue, presenting a personal face to the issue and confronting misinformation directly. They pointed out how the Technical Reference Group to the NSW Office of Environment and Heritage (OEH), OEH professionals and the Threatened Species Scientific Committee were all systematically ignored prior to tabling the Bill. Although some view scientific advocacy as an oxymoron, these scientists demonstrated otherwise, illustrating the impact of articulate and informed experts in this age of 24-hour news cycles.

Despite the 2018 Kosciuszko Wild Horse Heritage Bill passing both Houses of the NSW Parliament, there is a continued need for scientific engagement on this issue. Although necessarily slow and variably accessible, peer-reviewed literature on all aspects of feral horse impacts represents the bedrock upon which arguments against the 'brumby bill' and its advocates must be based. Ongoing work by committees and societies integrating this information ensures the currency and relevance of the scientific establishment, providing the impartial knowledge crucial for informed public discourse and policy development.

Finally, it is important to recognise and support those individuals that are the public face of this issue, championing evidence-based policy and transparent governance. Rather than favouring one approach over the other, I suggest this three-way consortium between researchers, scientific organisations and science communicators is our most effective means to boost scientific literacy and promote critical thinking in the era of fake news.