



ACT
Government

ACT High Country Bogs and Associated Fens Ecological Community

Draft Action Plan

Snowy Flats 2009 (Mark Jakobsons)



© Australian Capital Territory, Canberra 2022

This work is copyright. Apart from any use as permitted under the Copyright Act 1968, no part may be reproduced by any process without written permission from:

Director-General, Environment, Planning and Sustainable Development Directorate, ACT Government, GPO Box 158, Canberra ACT 2601.

Telephone: 02 6207 1923 **Website:** www.planning.act.gov.au

Accessibility

The ACT Government is committed to making its information, services, events and venues as accessible as possible.

If you have difficulty reading a standard printed document and would like to receive this publication in an alternative format, such as large print, please phone Access Canberra on 13 22 81 or email the Environment, Planning and Sustainable Development Directorate at EPSDDComms@act.gov.au

If English is not your first language and you require a translating and interpreting service, please phone 13 14 50.

If you are deaf, or have a speech or hearing impairment, and need the teletypewriter service, please phone 13 36 77 and ask for Access Canberra on 13 22 81.

For speak and listen users, please phone 1300 555 727 and ask for Access Canberra on 13 22 81.

For more information on these services visit <http://www.relayservice.com.au>



Cotter Source Bog 2016 (Mark Jakobsons)

Acknowledgement

The EPSDD acknowledges the Ngunnawal people as Canberra’s first inhabitants and Traditional Custodians of Ngunnawal Country. We recognise the special relationship and connection that Ngunnawal people have with Country.

Ngunnawal people are a thriving people whose life and culture are connected unequivocally to this land in a way that only they understand and know, and is core to their physical and spiritual wellbeing. The past disconnection of the Ngunnawal people from culture and Country has had long-lasting, profound and ongoing health and wellbeing effects on their life, cultural practices, families and continuation of their lore.

We acknowledge the historic dispossession of the Ngunnawal people of Canberra and their surrounding regions.

We recognise the significant contribution the Ngunnawal people make in caring for Country as for time immemorial they have maintained and will continue to maintain a tangible and intangible cultural, social, environmental, spiritual and economic connection to these lands and waters.



Little Creamy Flats (Ben Stevenson)

Contents

Acknowledgement of Country	ii
Preamble	1
Purpose	1
Conservation Objectives	1
Conservation Status	2
Links to ACT Biodiversity Planning	3
Description of ACT Bogs and Fens	4
Ecology	5
Connectivity and Critical Habitat	5
Function	6
Flora	8
Fauna.....	8
Cultural Significance.....	12
Distribution	13
Threats	16
Fire	16
Climate Change	19
Pest Species.....	20
Historic Habitat Loss	23
Management.....	24
Fire Management.....	24
Climate Change Adaptation	25
Monitoring and Research	26
Bog extent.....	27
Pest species impacts	27
Fire	27
Threatened and Significant species	27
Other monitoring and research	27
Invasive Species Management.....	28
Goats and cattle	28
Feral deer	28
Feral pigs.....	29
Feral horses.....	29

Rabbits	30
Foxes and Cats	31
European Wasps	31
Weeds	31
Restoration.....	32
Community Engagement	33
Conservation Priorities and Intended Management Actions	34
Protect.....	35
Manage Threats	35
Prevention of fire from entering peat-beds	36
Mitigating climate change impacts.....	36
Control of pest species.....	36
Management of weeds	37
Historic habitat loss	37
Improve	38
Collaborate.....	39
Implementation	41
Objectives, Actions and Indicators.....	42
References	46
Appendix 1 Extract from Cwlth listing.....	57
Appendix 2 'Wet swamp and bog' patches.....	58

Preamble

Purpose

This action plan outlines the conservation requirements for bogs and fens in the Australian Capital Territory (ACT). This is the first action plan for the High Country Bogs and Associated Fens Ecological Community (ACT Bogs and Fens) prepared by the Conservator of Flora and Fauna (the Conservator) as required under section 101 of the [Nature Conservation Act 2014](#) (ACT) (NC Act). The Conservator must identify, protect and ensure the survival of the Ecological Community (as far as practical) and must consider the impact of climate change, threats, connectivity requirements and critical habitat. This plan specifies the objectives, actions, reporting and evaluation requirements for the conservation and management of the ACT Bogs and Fens.

The ACT Bogs and Fens Ecological Community is listed as Endangered on the ACT's [Threatened Ecological Communities List](#) effective 8 February 2019 under section 91 of the NC Act. The ACT Bogs and Fens Ecological Community is consistent with the nationally listed 'Alpine *Sphagnum* Bogs and Associated Fens' Ecological Community, which is listed as 'Endangered' under the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) (EPBC Act). However, the listing in the ACT also includes some bogs and fens at lower elevation.

This Ecological Community is listed under the EPBC Act due to:

- its small geographic distribution coupled with significant demonstrable threats (including climate change and inappropriate fire regimes)
- continued decline of functionally important species
- the severe reduction of its integrity across its range.

The importance of the ACT Bogs and Fens from a national perspective is increasing because of the destruction of similar habitat in NSW and the risk from climate change impacts. The Ramsar-listed Ginini Flats Wetland Complex is also the largest intact *Sphagnum* bog and fen complex in the Australian Alps.

Conservation Objectives

The overall objective of this action plan is to conserve the ACT Bogs and Fens in perpetuity as a viable and well-represented Ecological Community across its natural geographic range in the ACT. This includes the maintenance and improvement of natural ecological and evolutionary processes within the Ecological Community (ACT Scientific Committee 2019). The specific objectives are to ensure that:

1. the ACT Bogs and Fens and its threatened species are protected
2. the ecological values of bogs and fens including ecosystem function, resilience and biodiversity are maintained by managing threats
3. management and conservation of ACT Bogs and Fens is as effective as possible through being informed by relevant research and evaluation
4. stakeholder and community collaboration in the conservation of ACT Bogs and Fens is strengthened.

Conservation Status

Components of the nationally listed 'Alpine *Sphagnum* Bogs and Associated Fens' Ecological Community are listed in the following jurisdictions:

International

Wetland of International Importance – Ginini Flats Wetland Complex – *Ramsar Convention of Wetlands of International Importance 1994*.

National

Endangered – Alpine *Sphagnum* Bogs and Associated Fens – *Environment Protection and Biodiversity Conservation Act 1999*.

Nationally Important Wetlands (ACT) – Ginini and Cheyenne Flats, Nursery Swamp, Rotten Swamp, Cotter Source Bog, Rock Flats, Snowy Flats, Cotter Flats, Scabby Range Lake and Upper Naas Creek – *Directory of Important Wetlands in Australia 2001*.

Australian Capital Territory

Endangered – High Country *Sphagnum* Bogs and Associated Fens – NC Act.

New South Wales

Endangered – Montane peatlands and swamps of the New England Tableland, NSW North Coast, Sydney Basin, South-East Corner, South-Eastern Highlands and Australian Alps Bioregions – *Biodiversity Conservation Act 2016*.

Victoria

Threatened – Alpine Bog Community – *Flora and Fauna Guarantee Act 1998*.

Threatened – Fen (Bog Pool) Community – *Flora and Fauna Guarantee Act 1998*.

Tasmania

Threatened – *Sphagnum* peatland – *Nature Conservation Act 2002*.

Links to ACT Biodiversity Planning

This Action Plan complements existing actions in the following ACT strategies, plans and advice:

- [Nature Conservation Strategy](#)
- [Ginini Flats Wetland Complex Ramsar Site Management Plan](#)
- [High Country Bogs and Associated Fens Conservation Advice](#)
- [Northern Corroboree Frog \(*Pseudophryne pengilleyi*\) Action Plan](#)
- [Northern Corroboree Frog \(*Pseudophryne pengilleyi*\) Conservation Advice](#)
- [Alpine Tree Frog \(*Litoria verreauxii alpina*\) Conservation Advice](#)
- [Broad-toothed Rat \(*Mastacomys fuscus mordicus*\) Conservation Advice](#)
- [Kiandra Greenhood \(*Pterostylis oreophila*\) Conservation Advice](#)
- [ACT Native Grassland Conservation Strategy and Action Plans](#)
- [Namadgi National Park Plan of Management.](#)

Figure 1 shows the connections between these plans and advice in the ACT. Management plans are spatially based and contain a greater degree of detail on management actions at specific sites. Action plans and conservation advice are specific to a species or ecological community across their range within the ACT.

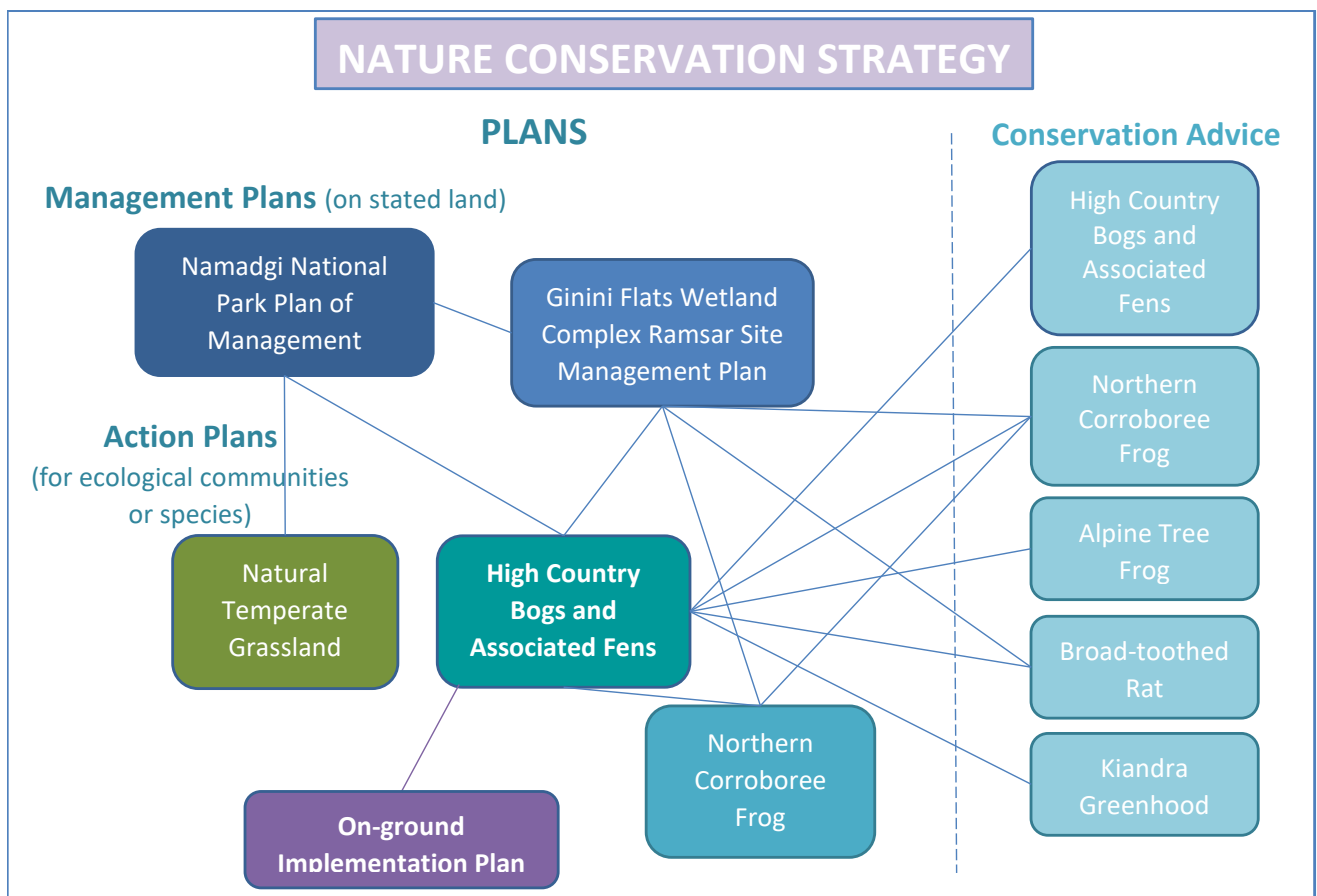


Figure 1–High Country Bogs and Associated Fens Action Plan relationships.

Description of ACT Bogs and Fens

The ACT Bogs and Fens Ecological Community is defined by a peat substratum on which *Sphagnum* species may or may not occur. *Sphagnum* species do not generally occur in fens as conditions do not favour growth. Indeed, *Sphagnum* may not always be a major floristic component of bogs due to disturbance resulting in its depletion or loss. In these cases, the site is still considered part of the ACT Bogs and Fens if other key species are present and a peat substratum is evident.

The Commonwealth EPBC Act listing included a number of definitions of this Ecological Community.

- The ACT Bogs and Fens was initially described in the Commonwealth listing advice as a component of the 'Alpine *Sphagnum* Bogs and Associated Fens' (Department of Environment, Water, Heritage and the Arts (DEWHA) 2009) that can be found across alpine, subalpine and montane environments.
- A more recent classification and mapping of alpine vegetation, undertaken by Mackey et al. (2015 p. 196), describes the Commonwealth-listed Ecological Community as follows:

“Alpine *Sphagnum* Bogs and associated Fens occur in waterlogged and permanently wet treeless areas, such as along streams, drainage lines, valley edges and valley floors generally between 1200 m to 1800 m ASL. They differ from Wet Heathland and Sedgeland in that they contain *Sphagnum* spp. (which is typically underlain by peat), the most common of which is *Sphagnum cristatum*, along with a diversity of sedges, herbs and shrubs. Species commonly include *Empodisma minus*, *Epacris glacialis*, *E. paludosa*, *Baeckea gunniana*, *B. utilis*, *Pratia surrepens* [and] *Richea continentis*. Fens adjoin the bog and are devoid of woody vegetation, [and are] commonly dominated by sedges such as *Carex gaudichaudiana*”.

Some sites of ACT Bogs and Fens differ from this more recent definition as they may not contain *Sphagnum* or they occur at lower altitudes (down to 720 metres). The Commonwealth listing, however, includes sites at lower elevations, where conditions and floristics are within the definition (DEWHA 2009). The Commonwealth listing also includes sites where *Sphagnum* species may not be dominant. Some sites may be dominated by shrubs or Restionaceae spp. (e.g., *Empodisma minus* and *Baloskion australe*), where *Sphagnum* species are only a minor component, and others where *Sphagnum* has been depleted or lost due to disturbance. “In these cases, the site may still be considered to be part of the listed community if other key species are present (Appendix 1) and an underlying layer of peat is evident” (DEWHA 2009 p. 4).

Ecology

Connectivity and Critical Habitat

An evaluation of connectivity requirements is required, especially to be able to enhance the resilience and adaptive capacity of this ecosystem to a changing climate (ACT Government 2016). Identification of activities that tend to weaken or break drainage or ecological connectivity is important. Once this occurs it would be very difficult to improve connectivity in ACT Bogs and Fens.

‘Critical habitat’ is habitat that is critical to the survival of the Ecological Community. There is no ‘critical habitat’ defined for this Ecological Community in the National Recovery Plan (Department of Environment 2015) as it is difficult to identify habitats critical to the survival of the Ecological Community. However, the co-dependency of bogs, fens and the natural drainage lines that connect them is critical to their ecology and function (DEWHA 2009). The Ecological Community is dependent on the maintenance of local hydrological conditions, particularly ground water (Department of Environment 2015).

All bogs and fens are of high conservation value due to the limited distribution and scattered nature of the Ecological Community, and the importance of the Ecological Community to the catchment in which it occurs.

Bogs occur where there is a good supply of groundwater and a water table which is kept at or close to the surface by an obstructed drainage system that prevents the decomposition of organic matter, ultimately forming a peat substrate (DEWHA 2009).

Fens are semi-permanent to permanent pools of surface water occurring in the wettest areas along watercourses or on valley floors and have distinct vegetation (as detailed in Appendix 1) (DEWHA 2009). Fens are considered to be ‘associated’ with surrounding bogs and part of the Ecological Community due to the ecological interdependence with bogs if they are within the same general region or are connected by drainage lines or ecological function and contain typical floristic components (see Box 1 and Appendix 1).

The overall health of local catchments is important to the survival of the Ecological Community, especially the habitat adjacent to bogs and fens (within approximately 200 m) and the remnant native vegetation that surrounds or links several bogs and fens providing habitat for pollinators or allowing them to move between bogs and fens (Department of Environment 2015).

Box 1: ACT Bogs and Fens plant communities (Source: Armstrong et al. 2012)

Key plant communities

- a2: *Baeckea gunniana* – *Epacris paludosa* – *Richea continentis* – *Sphagnum cristatum* Wet Heathland of the Australian Alps Bioregion (Alpine/subalpine Bog)
- a8: *Carex gaudichaudiana* – *Myriophyllum pedunculatum* – *Deschampsia caespitosa* Sedgeland of the Australian Alps Bioregion (Alpine/subalpine Fen)
- a9: *Carex gaudichaudiana* – *Ranunculus amphitrichus* – *Phragmites australis* Aquatic Herbfield of waterways in the Australian Alps and South-eastern Highlands Bioregion (Montane Bogs and Fens)

Associated plant communities:

- a14: *Poa costiniana* – *Carex gaudichaudiana* Subalpine Valley Grassland of the Australian Alps Bioregion (Alpine/subalpine Grasslands/Herbfields)
- e59: *Hakea microcarpa* – *Baeckea utilis* – *Leptospermum myrtifolium* Subalpine Wet Heathland on Escarpment and Eastern Tableland Ranges of the South-eastern Highlands Bioregion
- u193: *Hakea microcarpa* – *Epacris brevifolia* – *Epacris paludosa* Montane Wet Heathland of the Australian Alps and western South-eastern Highlands Bioregions

Note: 'a' are alpine/subalpine communities classified by McDougall and Walsh (2007)
'e' are communities classified by Tozer et al. (2010)
'u' are communities previously unidentified (Armstrong et al. 2012).

Function

The hydrological functions of upland bogs and fens contribute to the overall high quality of water in the Cotter, Gudgenby, Orroral, and Paddys river catchments. Peatlands retain large amounts of water, with peat being more than 95% water by weight, and their slow release of water facilitates steady outflow to the catchments.

Peat is critical to the hydrodynamic functioning of the Ecological Community. Overall, for peatlands to function, there needs to be a net balance of inflow and outflow that maintains waterlogged conditions within the peat. In developed peatlands, the upper levels of the accumulating peat-beds become the predominant substrate for water-flow through the wetland. The living peat plants form an open structure that allows the passage of excess water.

Bogs in general have the effect of reducing the water outflow compared to inflow due to evapotranspiration (Western et al. 2009). Bogs are found in permanently wet areas, such as along streams, valley edges and valley floors where there is a good supply of groundwater and an impeded drainage system that keeps the water-table at or near the surface. They are also situated on slopes where soils are waterlogged (Slattery 1998, Costin et al. 2000). The plentiful groundwater and low-lying topography permit the accumulation of peat. Bogs are relatively isolated, especially when occurring on different drainage lines separated by steep rocky ridges.

These landscapes are dynamic and constantly undergoing change. Fire has also caused further alteration and fragmentation.



Cotter Source Bog 2016 (Mark Jekabsons)

Flora

Helman and Gilmour (1985) produced the first significant biological inventory of montane and subalpine treeless vegetation in the ACT, describing species composition, summarising a range of vegetation types, and including a detailed species list. Small treeless areas are distributed as patches of grasslands and sedgeland in valleys, or grasslands, herbfields, bogs and heaths in montane regions (Helman and Gilmour 1985). The 27 wet swamp and bog ('S') patches selected for survey (Appendix 2) were one of the two main vegetation types surveyed by Helman and Gilmour (1985).

Armstrong et al. (2012) classified the plant communities of the upper Murrumbidgee catchment area and those relevant to the ACT Bogs and Fens as presented in **Error! Reference source not found.** These classifications were used to map the distribution of the Ecological Community in Figure 2.

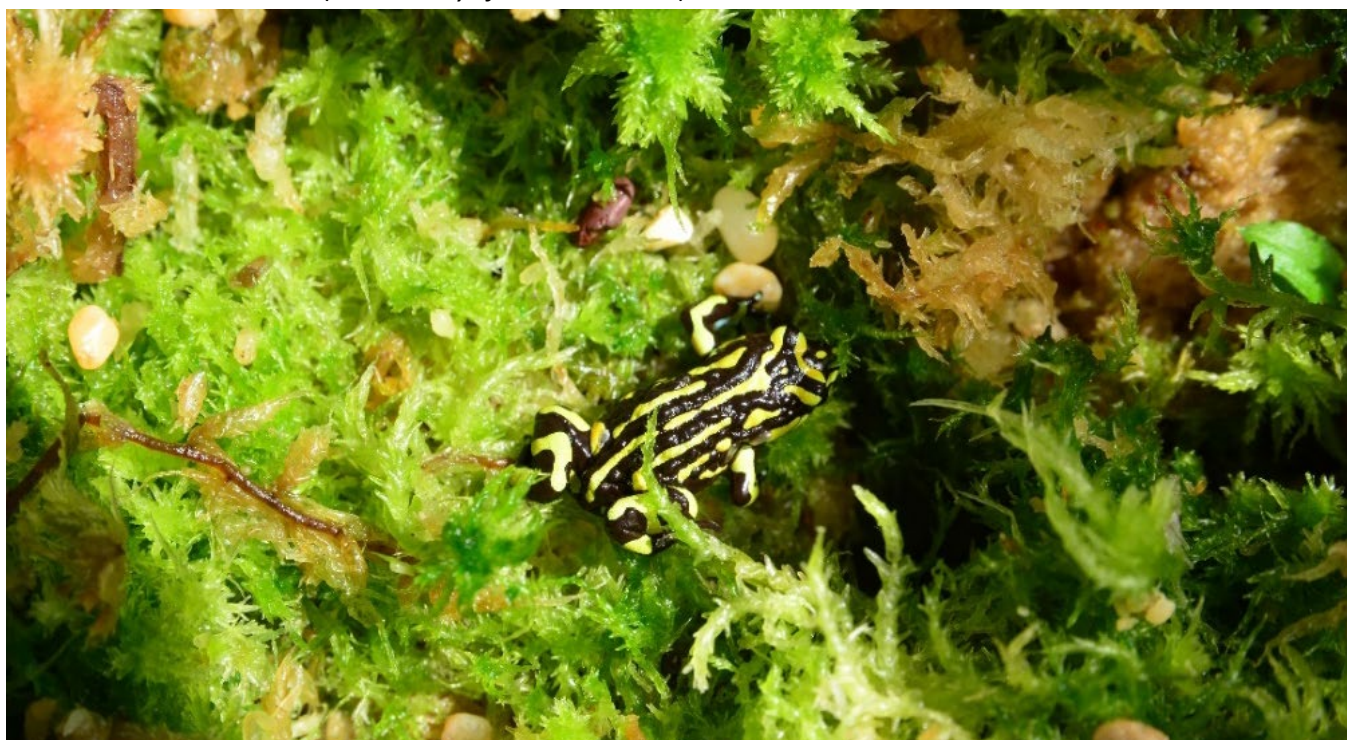
The Critically Endangered Kiandra Greenhood (*Pterostylis oreophila*) orchid occurs in the Ecological Community (but is not restricted to bogs and fens) (Department of Sustainability, Environment, Water, Population and Communities (DSEWPC) 2012).

Fauna

Fauna are an intrinsic part of bog and fen ecological communities and are essential to facilitate ecosystem functions such as pollination, seed dispersal and nutrient recycling. Common bog and fen fauna include frogs, birds, fish, mammals, reptiles and invertebrates (ACT Government 2017a).

Threatened fauna found in the ACT Bogs and Fens and listed under the EPBC Act and the NC Act (with the same conservation status) include the:

- Northern Corroboree Frog (*Pseudophryne pengilleyi*) – Critically Endangered
- Alpine Tree Frog (*Litoria verreauxii alpina*) – Vulnerable
- Broad-toothed Rat (*Mastacomys fuscus mordicus*) – Vulnerable.



Northern Corroboree Frog *Pseudophryne pengilleyi* (Mark Jekabsons)

A species action plan is in place for the Northern Corroboree Frog in the ACT (ACT Government 2011). There is an ex situ breeding program based at Tidbinbilla for the species with eggs collected from the wild in April 2003 and the first release of juvenile frogs into key breeding sites in 2011.

A conservation advice has been prepared for each of the Alpine Tree Frog and the Broad-toothed Rat (ACT Scientific Committee 2019a, 2019b). Actions that will benefit the Alpine Tree Frog and the Broad-toothed Rat through habitat improvement and pest management are included within this action plan.

Other significant species occurring in the ACT Bogs and Fens (ACT Scientific Committee 2019) include:

- Latham's Snipe (*Gallinago hardwickii*) – EPBC listed migratory species (the threat status of this species is being assessed under the EPBC Act)
- Riek's Crayfish (*Euastacus reiki*) – listed as a protected native species in ACT (the threat status of this species is being assessed under the EPBC Act).
- Alpine Spiny Crayfish (*Euastacus crassus*) – listed as threatened in Victoria and as a protected native species in the ACT
- Burrowing Crayfish (*Engaeus cymus*).

Conservation actions relating to Latham's Snipe are described in the Migratory Species Action Plan (ACT Government 2018a). Research is being undertaken on these crayfish in relation to the impacts of the 2020 bushfires (see Monitoring and Research section below).



Riek's Crayfish Euastacus reiki (Mark Jakobsons)



Alpine Spiny Crayfish Euastacus crassus (Mark Jakobsons)

Notable species in this Ecological Community listed in the National Wetlands Database (DAWE 2020) include the:

- Alpine Water Skink (*Eulamprus kosciuskoi*) – Ginini Flats; and in bogs and wet heaths above about 1400 m above sea level at Cotter Source, Jacks Creek, Murrays Gap and Bimberi (Helman et al. 1988). The threat status of this species is being assessed under the EPBC Act.
- Swampland Cool-skink (*Pseudemoia rawlinsoni* synonym *Leiolopisma rawlinsoni* and also known as the Glossy Grass Skink) – Ginini Flats and Snowy Flats; and confined to high altitude bogs and wet heaths in the upper Cotter catchment (Helman et al. 1988, Hutchinson and Donnellan 1988). The threat status of this species is being assessed under the EPBC Act.
- Metallic Bog Cockroach (*Polyzosteria viridissima*) – restricted distribution in the alpine areas of NSW and the ACT (Roach and Rentz 1998).



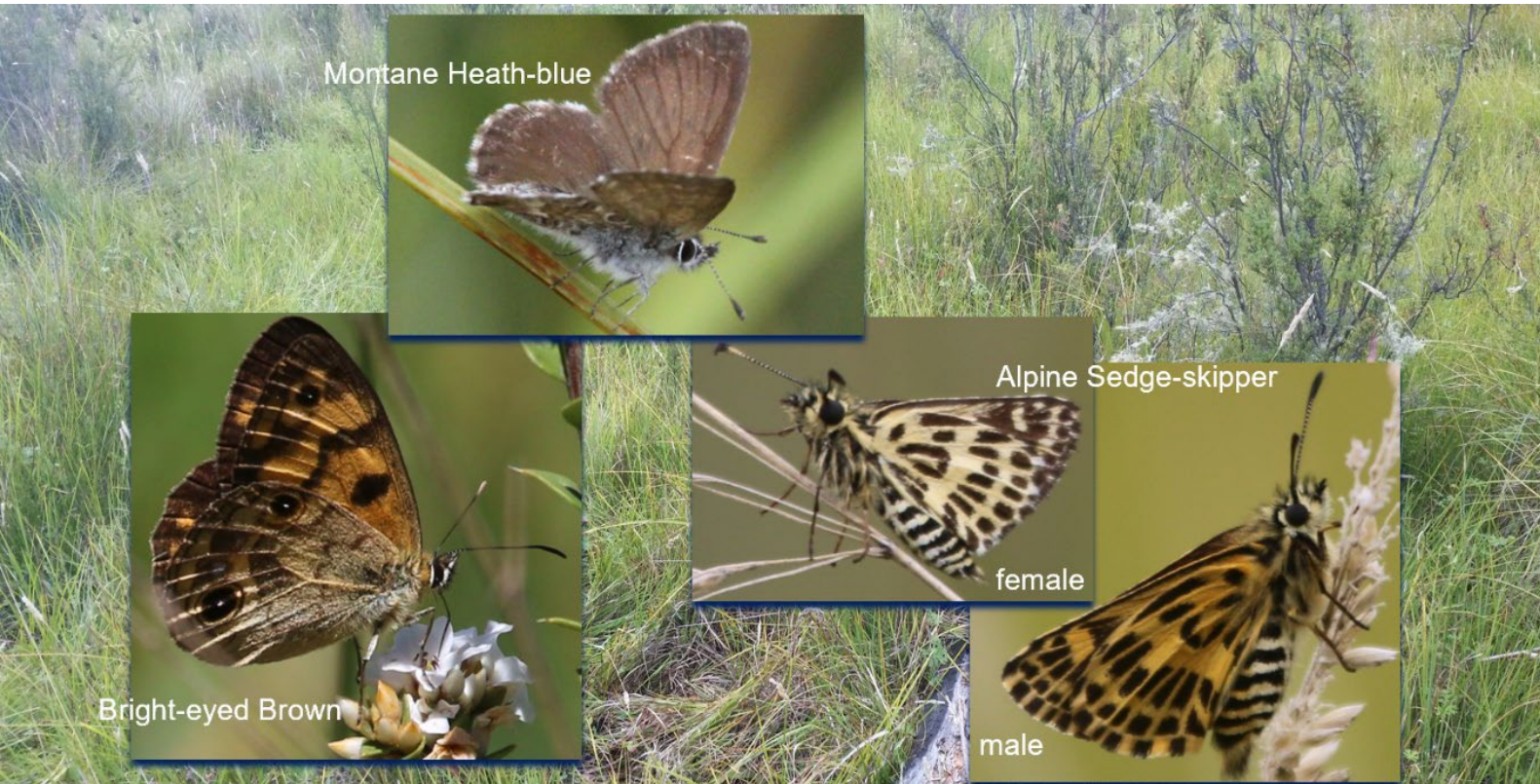
Metallic Bog Cockroach Polyzosteria viridissima (Mark Jakobsons)

Dendy's Toadlet (*Pseudophryne dendyi*) use montane *Sphagnum* bogs and wet heath for breeding sites (Pengilley 1971 in Department of Agriculture, Water and the Environment (DAWE 2021)). It is a species of concern as there have been declines in records of it, particularly since the 2020 bushfires. The species is currently recorded from Smokers Flat and Hospital Creek Flat but it has not been found at other sites where it was recorded in the past, including Nursery Swamp.

Mountain Galaxias (*Galaxias olidus*) is the only known native fish species to occur in the ACT Bogs and Fens. It is not restricted to ACT Bogs and Fens and is not a threatened species but its presence might indicate recovery of bogs and fens after fire. The species can be a good indicator of the lack of alien fish such as trout that are also a threat to frogs and crayfish. Bogs and fens are likely to be important for Mountain Galaxias where streams are present because these locations are often the remains of connection between drainages where they have crossed divides that can lead to genetic isolation. Mountain Galaxias are present at Top Flat, Cotter Source Bog, Cheyenne Flat, close to Ginini Flats and possibly in it. The species is also likely to be in Rotten Swamp, Nass, Orroral, Gudgenby and Upper Cotter bogs and tributaries where trout are absent or minimal.

High country bog specialists in the ACT providing vital pollination services include three butterfly species, the:

- Alpine Sedge-skipper (*Oreisplanus munionga*) – Tasmanian sub-species listed as Endangered in Tasmania
- Bright-eyed Brown (*Heteronympha cordace*)
- Montane Heath-blue (*Neolucia hobartensis*).



Bog butterflies (Suzie Bond)

Cultural Significance

Evidence of traditional Ngunnawal occupation of the mountains and valleys of Namadgi National Park has been found within the ACT Bogs and Fens and the surrounding areas (ACT Government 2017a). Rock shelters dating back 8,000 years have been excavated near large fens (Theden Ringl 2018).

As caretakers of the region, the Ngunnawal people occupied the high country over an extended period in the summer (Argue 1995, Saunders et al. 1996) utilising various resources and engaging in the full range of daily living activities along the edges of bogs and associated streams.

The surrounding country also was important for grazing during the European pastoral period and for providing water sources for stock (ACT Government 2010). The Ngunnawal people and descendants of pastoralists in the mountains continue to have a close association with the region.

Distribution

The ACT Bogs and Fens cover around 740 ha and are mainly located in the mountain and valley landscapes of Namadgi National Park (Figure 2 and on [ACTmapi](#) (ACT Government 2019a)) at elevations from 720 to 1718 m above sea level. There are also small bogs on or very near the summits of Mt Murray and Mt Bimberi at 1800 m and 1870 m above sea level, respectively.

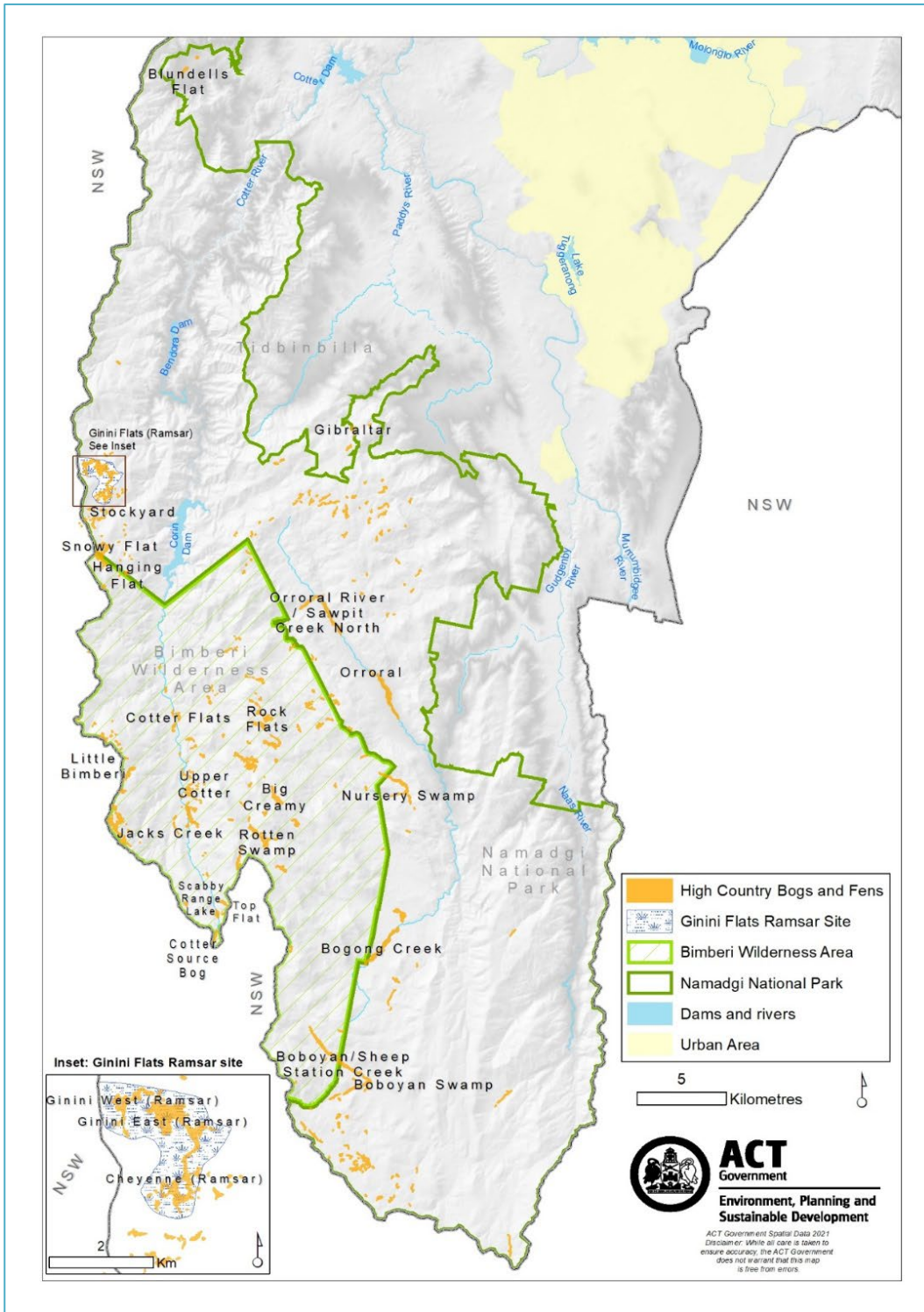


Figure 2–Distribution of ACT Bogs and Fens

Helman and Gilmour (1985) produced the first significant inventory and a record of significant sites of this Ecological Community in Namadgi surveying over 75 plots across 24 wet swamp and bog patches (Appendix 2) which are all included in Figure 2. This work provided a valuable baseline as it was undertaken before the two major, extensive and severe bushfires in 2003 and 2020. Helman and Gilmour (1985) used the following terminology in naming patches/localities:

- Flat – a geographic common name for a natural clearing in a valley or high-altitude basin
- Bog – a community of vegetation with a ground cover of *Sphagnum cristatum*
- Swamp – a valley or community dominated by rushes and sedges, generally along a creekline
- Fen – a swamp dominated by *Carex gaudichaudiana*.

Two sites are located outside Namadgi National Park but are managed by the ACT Parks and Conservation Service (ACT PCS). These are the:

1. small bog on the eastern side of Corin Road in the Gibraltar area, on public unleased land in an area that was formerly pine forest
2. Blundells Flat and Shannons Flat in the Lower Cotter Catchment. These are the lowest sites in the ACT at 700–780 m above sea level (Butz 2004, Butz 2009, Hope et al. 2006, ACT Government 2018b).



Blundells Flat 2018 (Johannes Botha)

Box 2. Directory of important wetlands

The *Directory of Important Wetlands in Australia* (the Directory) identifies nationally important wetlands and provides a substantial knowledge base on what defines wetlands, their variety, and the many flora and fauna species that depend on them. In addition, the Directory contains information about their social and cultural values and some of the ecosystem services and benefits that they provide.

The ACT Bogs and Fens listed in this directory include the following:

Wetland	Area (~ha)	Wetland Type	Criteria*
Ginini and Cheyenne Flats	125	B15	1, 2, 4, 5, 6
Nursery Swamp	53	B9	1, 6
Rotten Swamp	30	B10	1, 6
Cotter Source Bog	5	B15	1, 2, 6
Rock Flats	12	B10	1
Snowy Flats	35	B10, B15	5
Cotter Flats	41	B1, B10	1
Upper Naas Creek (Boboyan)	56	B9	1
Scabby Range Lake	5	B10	2

* The criteria for determining nationally important wetlands in Australia were agreed by the Australian and New Zealand Environment and Conservation Council's Wetlands Network in 1994. A wetland may be considered nationally important if it meets at least one of the following criteria:

1. It is a good example of a wetland type occurring within a biogeographic region in Australia.
2. It is a wetland that plays an important ecological or hydrological role in the natural functioning of a major wetland system/complex.
3. It is a wetland that is important as the habitat for animal taxa at a vulnerable stage in their life cycles or provides a refuge when adverse conditions such as drought prevail.
4. The wetland supports 1% or more of the national populations of any native plant or animal taxa.
5. The wetland supports native plant or animal taxa or communities that are considered endangered or vulnerable at the national level.
6. The wetland is of outstanding historical or cultural significance.

The wetland classification system used in the Directory is based on that used by the Ramsar Convention in describing Wetlands of International Importance but was modified slightly to suit the Australian situation in describing wetlands of national importance. The wetland types relevant to the ACT Bogs and Fens include:

- B1 Permanent rivers and streams; includes waterfalls
- B9 Permanent freshwater ponds (< 8 ha), marshes and swamps on inorganic soils; with emergent vegetation waterlogged for at least most of the growing season
- B10 Seasonal/intermittent freshwater ponds and marshes on inorganic soils; includes sloughs, potholes; seasonally flooded meadows, sedge marshes
- B15 Peatlands; forest, shrub or open bogs.

The online inventory of the Directory is available at the [Australian Wetlands Database](#) and in the [Directory of Important Wetlands in Australia Fact Sheet](#).

Threats

The ACT Bogs and Fens are particularly susceptible to change due to both their fragile nature and their narrow topographical and climatic requirements (Ashton and Williams 1989). The major threats to the ACT Bogs and Fens are ubiquitous and are likely to intensify over the coming decades; they include:

- fire
- climate change
- pest species (including invasive animals, plants and pathogens/disease)
- ongoing effects of historic land use (e.g. fragmentation, human trampling and disturbance).

Together, these groups of threats may have larger effects than when considered individually, as they are part of an interacting and compounding set of circumstances.

Fire

Wildfire occurring within the ACT Bogs and Fens is the greatest threat to its integrity and function, particularly where changes to hydrological or climatic conditions have dried out the underlying peat.

Increased frequency, severity and magnitude of fire may have cumulative impacts on the region's biodiversity through reduced ecosystem condition and structural habitat alteration. This could include changes to species composition and abundance, and increased establishment of invasive species after a fire (Steffen and Hughes 2013). Other significant risks from fire include an increased risk of substrate incision and erosion with consequent changes to water retention, and the loss of shading for *Sphagnum*. Fire is not a process that supports the ecosystem function of the bogs and fens (i.e. the vegetation does not require fire for germination processes or for reduction in fuel loads) (Department of Environment 2015).

Regionally, available peat core records show the presence of fire throughout the development of the ACT Bogs and Fens over the last 14,000 years. They indicate that, if the underlying peat is moist, these wetlands may have been resilient to some level of burning in the long-term past (Hope et al. 2003). However, increased frequency and intensity of post-settlement fire (Banks 1989) has impacted bog and fen integrity. Wildfires that may have had an impact on the ACT Bogs and Fens in post-European times occurred in 1851, 1875, 1899, 1918, 1925, 1939, 1944, 1983, 2003 (Macdonald 2009) and 2020.

In 2003, following ten years of drought, a fire ignited by dry lightning strikes spread from NSW and burnt 90% of Namadgi National Park. Nearly all of the ACT Bogs and Fens (except Boboyan Swamp) were burnt to some degree, ranging in impact from patchily burnt surface vegetation through to areas of severely burnt peat (Carey et al. 2003). In early February 2020, 82% of all the ACT Bogs and Fens (excluding Ginini Flats complex and those further north) were burnt (Figure 3).



Damage to bogs after a 2003 peat fire at Top Flat (Geoff Hope)

Recovery of the bogs will only occur over the medium- to long-term (20 years or more) and some areas may not recover, given the conditions conducive to bog formation are now becoming marginal in south-eastern Australia due to changing climate (Hope 2003, Good et al. 2010).

The greatest immediate risk to the ACT Bogs and Fens is a peat fire. Peat fires usually occur where drainage has incised the peat and low water flows mean that the peat subsequently dries out. Such fires often continue to smoulder for weeks or months as they slowly burn through the dry peat. Such fires release large amounts of carbon dioxide stored in the peat into the atmosphere. Maintaining wet bogs and avoiding peat fires is, therefore, a very high priority both for conserving these areas and for reducing carbon dioxide emissions.

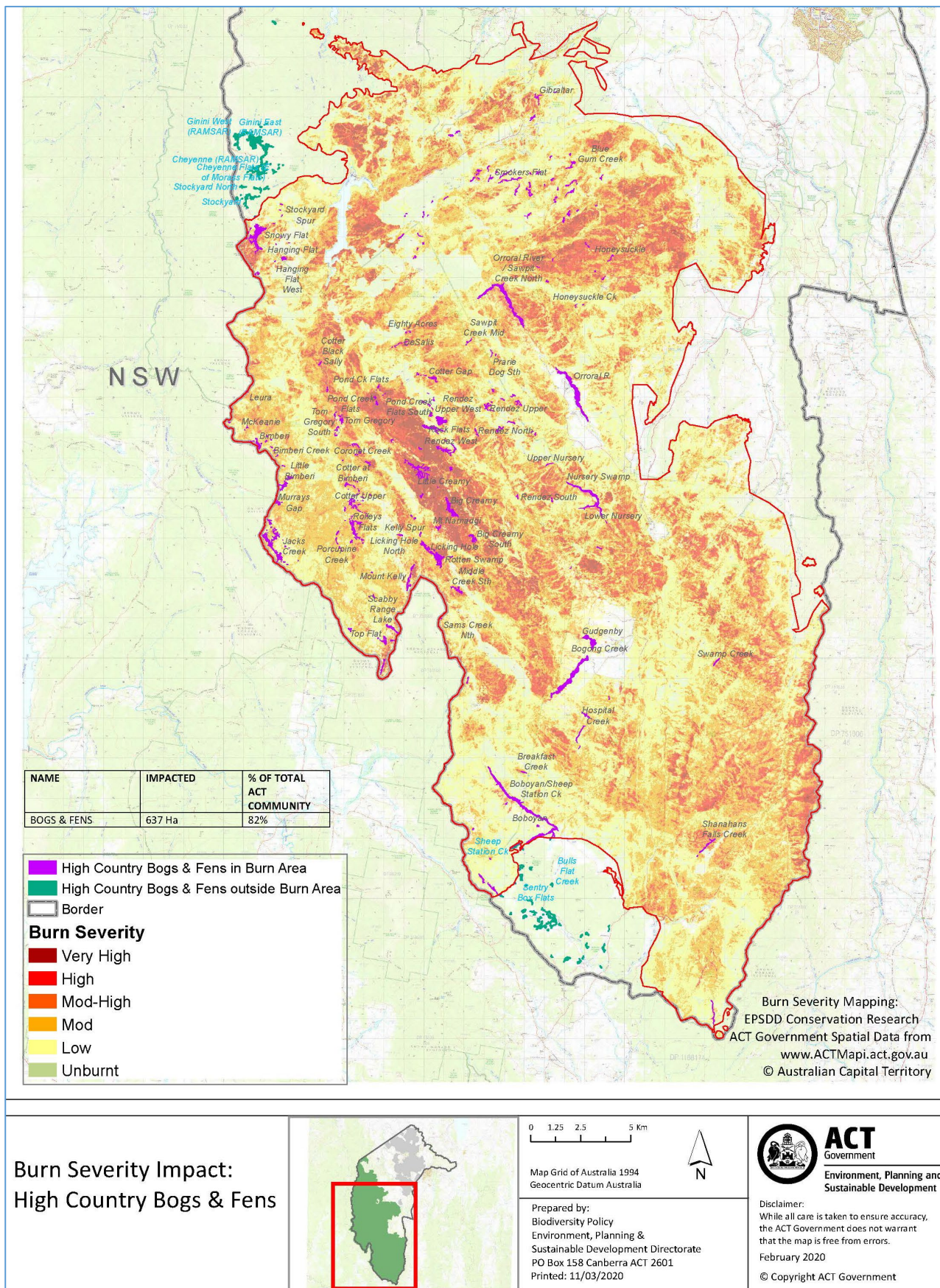


Figure 3–Impact of 2020 Fires on ACT Bogs and Fens

Climate Change

Climate change and its associated processes pose the greatest long-term risk to ACT Bogs and Fens and is likely to increase the risk and impacts of all other threats. Models of climate change impacts predict that bog communities across the Australian Alps will decrease in extent by 2050 (Camac et al. 2021). Alpine and subalpine ecosystems may be stressed by direct factors such as reduced snow cover, and indirectly through reduced water quality and quantity, both in the bogs and fens and downstream. Species within alpine, subalpine and montane areas are predicted to be negatively impacted by climate change but their capacity to adapt remains unclear resulting in a lack of information to inform management of these species (Camac et al. 2021). Increased temperatures, altered rainfall patterns, drought, increased incidence of wildfires, and changes to the distribution and prevalence of invasive species and disease will impact significantly on the functioning of the bogs and fens (Clark 1980, Grover 2001, Pickering et al. 2004, Grover 2006, IPCC 2014).

While similar bogs and fens occur in the Snowy Mountains in NSW, the ACT represents a significant outlier of major biogeographic significance because the ACT Bogs and Fens are near their climatic and environmental limits and are more sensitive to climate change (Hope et al. 2009, 2012). However, even at these limits, it is still scientifically accepted that such bogs can and should be supported for their valuable diversity and dependent organisms (Hope and Keaney 2020).



Desiccated bog pool

Climate change predictions for the ACT region include warmer temperatures, earlier onset of warm days, more frequent and longer heatwaves, and altered rainfall patterns (ACT Government 2016). This is likely to result in the climate being drier overall, which may have significant detrimental effects on the ACT Bogs and Fens.

Projected climate in the subalpine region of the ACT (including all the ACT Bogs and Fens) and NSW, as summarised by Ji (2019), further support these predictions and include:

- the region becoming drier due to a large reduction in spring precipitation and an increase in spring hot days exacerbating the problem of high UV and dry lightning during drought summers
- fewer moderate and heavy rainfall events, with a greater than 60% decrease in seasonal heavy precipitation events projected for some parts in winter
- larger increases in maximum temperature compared to other regions with the greatest projected increase in winter (greater than 3° C increase for 2060-2079 relative to 1990-2009)
- fewer cold nights in winter and spring.

Observed changes in the ACT climate that are likely to affect ACT Bogs and Fens include:

- long-term temperature increases since the 1950s, accelerating since the late 1980s (NSW Office of Environment and Heritage 2014)
- altered precipitation patterns, including extensive and prolonged drought periods (ACT Government 2017a)
- declining snow in the high country of the ACT – 30% reduction since 1954 (Steffen and Hughes 2013)
- extreme conditions of high temperatures and low humidity such as contributed to the 2020 bushfires (Australian Government 2020).

Pest Species

Large vertebrate pests including feral horses (*Equus caballus*), feral pigs (*Sus scrofa*), and Sambar Deer (*Rusa unicolor*) are a significant threat to the hydrological values and function of the Ecological Community (Department of the Environment 2015). These animals cause impacts such as tracking and compaction of peats leading to channelling of water and stream incision. This results in drying of the surrounding peat, draining of pools and death of *Sphagnum* (Whinam and Chilcott 2002, Driscoll et al. 2019). Through grazing and trampling they can also result in the loss of *Epacris* and *Carex* species that are the larval food plants of butterflies delivering vital ecosystem services through their important role as pollinators (S. Bond pers. comm. 2019).

Feral animals cause significant disturbance to breeding pools and egg nests of the Northern Corroboree Frog (Osborne 1991). Feral pig wallowing and rooting in bogs has been observed in Namadgi National Park. The impacts of Sambar Deer are now seen in the ACT with wallowing in the bog system including Cotter Flats and associated drainage lines. Pig rooting and digging by rabbits (*Oryctolagus cuniculus*) in the woodlands and herbfields surrounding bogs is also likely to affect Northern Corroboree Frog habitat and may lead to increased sedimentation of the bogs and fens.



Damage to a bog pool caused by feral pigs (Murray Evans)

One of the most significant impacts of feral horses in the Alps was found by Robertson et al. (2019) to be the damage they cause to the bogs and fens, including their fauna, flora and hydrology. Schultz et al. (2019) found both the presence and abundance of the Broad-toothed Rat declined as feral horse impacts caused the loss of vegetation cover from trampling and grazing. The Broad-toothed Rat cannot then disperse to more suitable habitat and is more vulnerable to predators (Schultz et al. 2019). Water quality is also impacted through horse faeces and urine fouling, as well as sedimentation and turbidity.

Predation on small mammals, Riek's Spiny Crayfish and the Alpine Spiny Crayfish by foxes (*Vulpes vulpes*) and feral cats (*Felis catus*) is likely to have a negative impact on their population size and viability (Carey et al. 2003). Many recent studies have shown that severe losses of native wildlife can be wrought by only a few cats (Legge et al. 2016). Legge et al. (2016) estimated that there are 0.27 feral cats/km² in Australia, corroborating with the 0.2 cats/km² estimate for the ACT Brindabellas by Denny and Dickman (2010).

Introduced vespid wasps including European wasps (*Vespula germanica*) are known to cause damage to ecosystems and they are a likely threat to native biodiversity, especially insects and spiders. They predate on local invertebrates (Potter-Craven et al. 2018). They also compete with local invertebrates for food, influencing the size and morphology of native species or sometimes leading to starvation (Burne et al. 2015). European wasps are a [listed pest animal](#) and are widespread in Namadgi National Park. They have been seen in all monitored bogs and nesting in old, dried out *Sphagnum* hummocks (D. Whitfield pers. comm. 2013). Adult Alpine Sedge-skippers (*Oreisplanus munionga*) are vulnerable to European wasp predation (S. Bond pers. comm. 2019).

The ACT Bogs and Fens has survived in a difficult environment but it is liable to change due to hotter drier conditions and increased drainage causing dry-land plant invasion. It is also subject to changes due to

increases in nutrition from catchment denudation and animal manuring that encourage weed growth of both, weeds of disturbed areas (lower risk) and transformer weeds (high risk) (Hope et al. 2009).

Intact bogs and fens with good vegetation cover are resistant to the establishment of weeds typical of disturbed areas, e.g., Cat's Ear (*Hypochoeris radicata*) and Yorkshire Fog Grass (*Holcus lanatus*), Timothy Grass (*Phleum pratense*) and several clovers (McDougall and Walsh 2007). However, they are not resistant to invasion by transformer species that are of great concern. Invasive plants are weeds that compete with and exclude native plants and the highest impact invasive plants are transformers that can alter hydrological regimes and conditions. Transformers currently impacting some of the ACT Bogs and Fens include Blackberry (*Rubus fruticosus*), Black Willow (*Salix nigra*) and pine wildings (*Pinus* spp.).

Both Chilean Needle Grass (*Nassella neesiana*) and African Lovegrass (*Eragrostis curvula*) are also transformers and have been detected in the early stages of invasion in montane vegetation (including Snow Gum-Alpine Ash, Mountain Gum-Brown Barrel, and Snow Gum-Black Sallee communities) adjacent to ACT Bogs and Fens. Chilean Needle Grass also alters soil conditions and readily outcompetes native groundcover species, while African Lovegrass increases the flammability of the vegetation that it invades.

Some species such as Sweet Vernal Grass (*Anthoxanthum odoratum*) spread rapidly in areas 'opened-up' by feral animal trampling, wallowing, rooting and digging which provides the opportunity for weed species to establish. Sweet Vernal Grass has been detected on the edge of Cotter Source Bog and on the approach to Ginini East.

Some of the well-established weed species of lower altitude areas might show more vigour and be promoted to altitudinally upward migration or range extension in combination with periodic burning under a changing climate (F. Ingwersen pers. comm. 2022). For example, this might occur with Paterson's Curse (*Echium plantagineum*) or St John's Wort (*Hypericum perforatum*). Vigilance should be maintained for these and other invaders, particularly those that are transformers, including Willow (*Salix* spp.), English Broom (*Cytisus scoparius*), Himalayan Honeysuckle (*Leycesteria formosa*), Lupin (*Lupinus angustifolius*), Radiata Pine (*Pinus radiata*), and Yarrow (*Achillea millefolium*) (Hosking et al. 2006, NSW NPWS 2007).

A recent assessment of naturalised plants in the ACT identified over 90 species that have the potential for spread into highland vegetation (Downey and Taylor 2022). Not all of these are likely to become problems in the ACT Bogs and Fens but such an extensive list indicates the high potential for weeds to move with climate change (F. Ingwersen pers. comm. 2022). If any of these weed species established in lower altitude fens, there would be a loss of character, ecological integrity and likely some ecosystem functions. Numerous weed species have invaded the Bogong Creek Swamp, including Willow, Dock and Yorkshire Fog Grass (Hope et al. 2009).

Pathogens pose an additional direct threat to the existence of amphibian species within ACT Bogs and Fens. The Amphibian Chytrid Fungus (*Batrachochytrium dendrobatidis*) was believed to be responsible for a 90% decline in the numbers of Northern Corroboree Frogs in the ACT between the early 1980s and early 1990s and continues to result in very low abundance of the frog in the wild (ACT Government 2017a). This fungus is identified as the primary threat contributing to the moderately high (30–50%) likelihood of extinction of the Northern Corroboree Frog by 2040 (Gillespie et al. 2020, Geyle et al. 2021).

Historic Habitat Loss

Pastoral use of the Namadgi National Park area began in the 1820s and was phased out from 1911 but grazing continued in some areas until the 1980s (ACT Government 2010). The trampling by cattle affected the integrity of ACT Bogs and Fens, causing some patches to contract or disappear. During the transhumant grazing period (i.e., the seasonal movement of livestock, typically to the high country in summer and back to lower areas in the winter) of the mid-nineteenth to mid-twentieth century, high wet areas were severely damaged in the nearby Snowy Mountains. This period of potential and sometimes real damage was truncated in the ACT when its water catchment value in the Cotter valley was recognised. Areas such as Rotten Swamp, Big Creamy Flats, bogs near Cotter Hut and elsewhere were opened to grazing at a much lower intensity than equivalent areas of the Snowy Mountains. However, some residual influence remains in the usually minor introduced weed species encountered in wet areas and there may be ongoing effects of historic land use due to fragmentation, human trampling and disturbance of habitat, catchment sources and old track constructions.

The establishment of arboreta (such as those at Mt Ginini, Cotter Hut, Stockyard Creek and Pryor's Hut) and the Boboyan pines plantation also impacted nearby bogs and fens through the increased spread of exotic species and altered water and sediment inflow. These impacts may be ongoing, even after most of these arboreta and plantations have been removed.

Historic scientific research also unfortunately has played a role in loss of integrity at some sites. In 1938, a two metre-deep, 50-metre-long trench was cut into Ginini West Flat by the Australian Forestry School (a cooperative venture between the Commonwealth and the states) for a study of peat profiles. Also, during World War II, *Sphagnum* from West Ginini was cut for use in filters in vehicle gas production (ACT Government 2017a). During the 2003 fires, these areas were burnt to a greater degree than surrounding untouched areas and recovery has been slower (Wild et al. 2010).



Rotten Swamp immediately after the 2020 fires (Nathan Kay)

Management

Management strategies to reduce the impact of these threats are important in conserving and restoring the ACT Bogs and Fens. While there are several plans that apply to various components of the ACT Bogs and Fens, this action plan is important to bring all these together for the benefit of the whole Ecological Community and to ensure that there is a consolidated management plan for the ACT Bogs and Fens.

The [Namadgi National Park Plan of Management](#) (ACT Government 2010) applies to most of the areas in which ACT Bogs and Fens occur. Namadgi National Park is managed for biodiversity conservation, water supply, appropriate recreation, natural and cultural heritage conservation, visual character, research and education. The objectives and actions listed in section 5.9 (p. 67) of the Namadgi National Park Plan of Management relate to this Ecological Community. Although, within Namadgi National Park, the Ginini Flats Ramsar Wetland site is managed under the [Ginini Flats Wetland Complex Ramsar Site Management Plan](#) (ACT Government 2017a).

Most ACT Bogs and Fens occur in Zone 1 (Remote Zone) of the Namadgi Plan of Management (ACT Government 2010). This is the core conservation and catchment area which includes the Bimberi Wilderness, the middle Cotter Catchment, and adjacent areas. The larger fens and several bogs occur in Zone 2 (the Semi-remote Zone) which is managed for both conservation and recreation.

Fire Management

The importance of not allowing any fire to enter the ACT Bogs and Fens must be a clear objective in all relevant fire management plans. This includes fire management (ecological burns or fuel management burns) of neighbouring areas to prevent fire entering the ACT Bogs and Fens. The main ecological communities that adjoin the ACT Bogs and Fens at lower elevations include *Eucalyptus pauciflora* Montane Woodland (fire threshold of 12–50 years) and Montane Dry Tussock Grassland (fire threshold of 4–10 years).

For the past 15 years, under the *Emergencies Act 2004* (ACT), the ACT Emergency Services Agency (ESA) has delivered three Strategic Bushfire Management Plans (SBMPs), each spanning five years. The [ACT Strategic Bushfire Management Plan: 2019-2024](#) (ACT Government 2019b) is the overarching strategy document currently directing bushfire management across the Australian Capital Territory.

The 2014-19 SBMP (ACT Government 2014) recognised that bogs and fens should be protected from inappropriate fire regimes and not subject to planned burning, as far as practicable. However, the 2019-2024 SBMP only generally identifies some vegetation as having intrinsic values that can be regarded as an asset to be protected from bushfires, including vegetation underpinning local ecosystems and Namadgi National Park. In contrast, the *Namadgi Plan of Management* recognised the importance of excluding fire from the ACT Bogs and Fens (ACT Government 2010).

Various other guidelines also support the protection of bogs and fens from fire. The *Fuel and Fire Suppression Guidelines for ACT Declared Threatened Species and Endangered Ecological Communities* (ACT Government 2008) and the *Ecological Guidelines for Fire, Fuel and Access Management Operations* (EPSDD 2019) inform the development of *Regional Fire Management Plans* and annual *Bushfire Operations Plans* (BOPs) that factor ecological spatial layers including the specific bogs and fens layer. These guidelines recognise that bogs and fens are highly fire sensitive and should be excluded from planned burns, and that

every practical measure is to be undertaken to protect the ACT Bogs and Fens from burning, including during wildfires. The previous *Regional Fire Management Plans* (2014-2019) met these guidelines and the [Regional Fire Management Plan 2019-2028](#) (ACT Government 2021) considers important ecological assets such as threatened, rare or fire-sensitive species and ecological communities such as the ACT High Country Bogs and Fens in the mix of resources that require protection.

Conservation outcomes of proposed fuel reduction burns were assessed using ecological measures including tolerable fire intervals, post-fire age class diversity and growth stage status across the ACT conservation estate. Particular attention was directed to ecosystems that had been extensively impacted in the 2020 Orroral Valley Fire and/or the 2003 Canberra bushfires and that are currently at an early post-fire recovery stage. The remaining unburnt areas of these otherwise heavily impacted ecosystems were also considered to have high conservation value and were identified as areas to minimise impacts of prescribed burning at least during the life of the 2019–23 RFMP (ACT Government 2021, Risk Reduction Tab).

Fire suppression operations may also impact negatively on bogs and fens. In particular, it is important to keep the Cotter Catchment free from the Epizootic Haematopoietic Necrosis Virus (EHNv) which may spread through fire suppression operations in the ACT Bogs and Fens. While the EHNv is not a direct threat to the ACT Bogs and Fens or component species, there is the possibility that it could enter the Cotter River, Bendora or Corin dams. The virus is a risk to the threatened fish species Macquarie Perch and possibly to Two-spined Blackfish in the Cotter River. The EHNv exclusion zone and EHNv hygiene protocols are detailed in ecological guidelines (EPSDD 2019). Water for fire operations in the Cotter Catchment, including the bogs and fens in this catchment, should be sourced only from this catchment above Cotter Dam, or from mains water to reduce the risk of the virus entering the Cotter Catchment and impacting threatened species.

Climate Change Adaptation

Interest in the impacts of climate change on the ACT Bogs and Fens has increased recently with the recognition of the threat that climate change poses, and the potential for change in the ecosystem services provided by bogs (Macdonald 2009). An assessment of climate change impacts on wetlands in the ACT was undertaken for management areas within the ACT hydrogeological landscapes (HGL) project to determine their climate change vulnerability (Cowood et al. 2017). The HGL project included wetland mapping, classification and assignment of wetland condition for all of the ACT Bogs and Fens (Muller et al. 2017). The ACT Bogs and Fens fall in the Pp3 – Peat bogs and fen marshes – wetland type and is the highest vulnerability cluster in this report.

The [ACT Climate Change Adaptation Strategy](#) (ACT Government 2016) provides the following actions for the natural resources and ecosystems sector that this action plan can be evaluated against to deal with climate change.

1. Biodiversity conservation – at a landscape scale, promote better collaboration to:
 - enhance the resilience and adaptive capacity of our ecosystems including through improved habitat condition and connectivity
 - identify, protect and manage potential climate refugia across the region.
2. Safeguarding species – undertake and facilitate targeted interventions to safeguard species under climate change.
3. Caring for land and water to improve:
 - knowledge and understanding of land managers about climate impacts and adaptation actions

- coordination of pest animal and plant control to contribute towards increased landscape resilience under climate change
- monitoring of climate impacts on ecosystems in our bioregion (ACT Government 2016, p. 14).

Monitoring and Research

Research on the ecology of the ACT Bogs and Fens has occurred since the 1930s. More recent research since the 1980s has focused on the palaeo-environment and fire history, fire impacts and rehabilitation, and on species reliant on the ACT Bogs and Fens as part of their habitat (e.g. Northern Corroboree Frog and Broad-toothed Rat).



Releasing Northern Corroboree Frogs back into the wild (Mark Jekabsons)

It is important to note that research activities also have the potential to damage the ACT Bogs and Fens through trampling, spread of weed seeds and pathogens and, depending on the activity, to physically alter components of the bogs and peat functionality. Researchers must consider their potential impacts on the ACT Bogs and Fens and how to avoid or minimise detrimental impacts. Nature Conservation Licences may be required under the NC Act for any activities that may impact the ACT Bogs and Fens and its species (excluding for ACT Government Conservation Officers exercising functions under the NC Act or other management plans (s. 153 NC Act)).

Although there has been some preliminary research into Ngunnawal history relevant to the ACT bogs and fens (Argue 1995, Saunders et al. 1996, Theden Ringl 2018), there is a need for research on Ngunnawal cultural connections to learn how the Traditional Custodians cared for the ACT Bogs and Fens in the past and to ensure culturally appropriate management and ongoing connections of Ngunnawal people to the ACT Bogs and Fens.

Other research and monitoring relevant to the ACT Bogs and Fens includes:

Bog extent

- Mapping of ACT Bogs and Fens to establish baseline data on location and extent.

Pest species impacts

- Pig damage in Namadgi started being monitored by Jim Hone in the mid-1980s once they became overly abundant (Hone 2002). This has led to the following work.
- Pig damage impact surveys are carried out annually in Spring across six sites in Namadgi National Park by the Parks and Conservation Service at Ginini East, Nursery Swamp, Boboyan Valley, Naas Valley, Upper Cotter and Bluegum. Although only one site is surveyed within a bog, many others are within 5 km (the average home range of feral pigs in Namadgi National Park) of bog and fen communities.
- Monitoring/mapping and control of Sambar Deer and impacts in the upper Cotter River catchment was undertaken during 2019-2022 with [Exclusion plots to determine impacts of Sambar Deer](#) (Mulvaney et al. 2017)
- Pest species impacts are being monitored, including impacts from feral horses, rabbits and deer species.

Fire

- Assessment and rehabilitation of bogs was undertaken following the 2003 fire (Whinam et al. 2010).
- Restoration of bogs is occurring after the 2020 fires with research on the effectiveness of leaky weirs and shading techniques, and how to improve them in the future (Macdonald and McLean in prep).

Threatened and Significant species

- Long-term monitoring and captive breeding is occurring of Northern Corroboree Frogs for [adaptive reintroduction strategies](#) to improve understanding of how the chytrid fungus impacts populations and the characteristics of refuges that may protect threatened frogs from chytrid fungus.
- [Population extent monitoring of the Broad-toothed Rat](#) (Milner et al. 2016).
- Genetics of Broad-toothed Rat populations and recolonisation of burnt areas post-fire.
- Surveys of montane *Euastacus* (crayfish) species were conducted after the 2020 fires to collect genetic samples to understand the impact of the fires on genetic viability. However, the study had very low captures of crayfish in the burnt bogs.

Other monitoring and research

- Ecological drivers of seed germination for bog and fen plants and conservation seed banking (Guja and Huttner-Koros 2013 in Australian National Botanic Gardens 2014).
- Palaeo-environment, carbon pool and fire history through peat core analysis.

- Climate change impact research by the Australian Mountain Research Facility (ANU) in collaboration with stakeholders including the ACT Government to predict which species may have greatest adaptive capacity and to consider how to incorporate these results into management practice and policy.
- Listing of ACT high altitude wetlands of significance in the Directory of Important Wetlands in Australia (Lintermans 2001) with updates occurring with the establishment of a new National Wetlands Inventory in 2022.
- [Conservation Effectiveness Monitoring Program](#) (CEMP) (Brawata et al. 2017).

Invasive Species Management

Invasive species management is a core activity within Namadgi National Park and is essential to maintain bog and fen biodiversity, protect water quality, and protect nearby landscapes from disturbance and degradation.

Invasive species management in the ACT is guided by the [ACT Pest Animal Strategy 2012- 2022](#) (ACT Government 2012) and the [ACT Weeds Strategy 2009-2019](#) (ACT Government 2009), which is being revised and updated.

Goats and cattle

Feral goats (*Capra hircus*) and cattle (*Bos taurus*) were successfully eradicated from Namadgi National Park around 2007. However, staff remain vigilant for incursions of these and other hard-hooved animals from surrounding properties.

Feral deer

The ACT Government undertook Sambar Deer presence/absence surveys as part of the vertebrate pest impact survey at bogs for three years commencing in the autumn of 2017 (Mulvaney et al. 2017). These surveys identified impacts of Sambar Deer at bog sites from wallowing, trampling and grazing. A trial control program was undertaken in 2019 in the upper Cotter River catchment and a new project was undertaken in 2019-2022 with Commonwealth funding to investigate Sambar Deer in Namadgi National Park. This project aimed to maintain the ecological integrity of the Ramsar Listed Ginini Flats Wetland Complex (Ginini Flats) by reducing the impact of Sambar Deer. It developed and implemented monitoring of Sambar Deer abundance and impact across Ginini Flats and the upper Cotter River catchment and implemented further controls. Collaboration with NSW NPWS, Vic Parks and NSW DPI was a significant component to ensure best-practice management. The project provided:

- a baseline dataset of bog condition including Ginini Flats through:
 - trialling use of high-resolution aerial imagery to map wallows and general condition
 - an index of deer abundance in the upper Cotter River catchment
- a control program over two years, which trialled the effectiveness of different control methods including thermally assisted ground shooting and thermally assisted aerial shooting
- an indication of further requirements for ongoing control and management of Sambar Deer.

Feral pigs

The ACT Parks and Conservation Service has implemented a successful feral pig control program in Namadgi National Park for over 25 years (ACT Government 2010). Annual pig control using baits has been occurring for many years across large parts of the park, including the upper Cotter River catchment.

The Fire-trail Annual Baiting Program is a proactive management program in Namadgi National Park and Googong that aims to reduce damage from pigs to native plants, animals and ecosystems (ACT Government 2012). The program takes place in the lower regions of Namadgi National Park every autumn or early winter. Pigs are found at higher elevations during summer (December – February) and move to lower elevations in winter (June – August) (Hone 2002). The program involves free-feeding at 500 m intervals for 14 days along identified trails that range across the park. After pig presence is confirmed with cameras, the number of feeding sites is reduced to attract the maximum number of pigs. Baits are added as appropriate to reduce other species ingesting the poison. Information is recorded on the number and location of free-feed stations, uptake at free-feed stations, number of pigs seen on camera and the number of pigs seen taking the bait on camera. The number of assumed kills is determined by the number of pigs seen eating the poison that do not return (although in some cases, confirmation is achieved when their bodies are found).

Targeted cage trapping is a reactive management technique that also is used to remove pigs causing damage to specific sensitive or public areas, or where poisoned baiting is not possible. In addition to the Fire-trail Annual Baiting Program, an aerial survey is undertaken in the higher altitude bogs and fens in summer, with a targeted control program when required.

Additional pig control was undertaken in 2021 and 2022 as part of the Sambar Deer Project. Thermally assisted aerial shooting, targeting both deer and pigs, was trialled, successfully in the areas around Ginini (the only unburnt bog after the 2020 Orroral fire) and Snowy Flat bogs.

Feral pig control to maintain low pig numbers must be continued near the ACT Bogs and Fens and the surrounding woodlands to limit damage from pigs.

Feral horses

Historically, feral horses have caused damage to the ACT Bogs and Fens in Namadgi National Park. Horses were removed from the park in the 1980s but, since the late 1990s, small numbers have entered from neighbouring Kosciuszko National Park and impacted areas of bog in the western part of the upper Cotter River catchment and the south-eastern section of the park in the Naas River catchment.

Between 2014 and 2019, estimates of feral horses across the Australian Alps increased from 9,187 to over 25,318, including increases from 3,255 to 15,687 feral horses in the northern area of Kosciuszko National Park which neighbours Namadgi National Park (Cairns 2019). A more recent survey estimated the population at 14,380 individuals, with a 95% confidence interval of 8,798–22,555 individuals (Cairns 2020). Unmitigated threats in Kosciuszko National Park could increase the pressure for feral horses to move into the suitable habitat of Namadgi National Park. However, trapping and removal of feral horses commenced in 2022 in Kosciuszko near the ACT border.

Provisions within the previous ACT *Feral Horse Management Plan* to quickly detect and manage incursions are implemented by the ACT Parks and Conservation Service (PCS). The ACT PCS undertakes bi-annual aerial surveys to detect the presence and impact of feral horses in bogs along the western border of the ACT. The

ACT PCS also works with NSW Land Services on the south-eastern border of the ACT to manage any occasional incursions of semi-feral/domestic horses.

Changes to the classification of feral horses under NSW legislation ([Kosciuszko Wild Horse Heritage Act 2018](#) (NSW)) could increase the rate of entry of horses into the ACT and the risk and severity of their impacts. While the recently finalised [2021 Kosciuszko National Park Wild Horse Heritage Management Plan](#) aims to reduce the horse population from ~14,000 to 3,000 over five years, this may not adequately protect areas of Namadgi National Park. Escalating numbers of feral horses in the neighbouring northern area of Kosciuszko National Park (Cairns and Robertson 2015) led the ACT Minister for the Environment to commission a revision of the ACT *Feral Horse Management Plan*.

The 2020 ACT [Feral Horse Management Plan](#) aligns with the latest scientific research that feral horses are reversing decades of alpine recovery in the Australian Alps. The plan maintains a strict policy of removing feral horses from Namadgi National Park.



Bimberi Bog during the Feral Horse Survey 2018 (Ben Stevensen)

Rabbits

Rabbits inhabit surrounding grasslands and woodlands of the ACT Bogs and Fens. Extensive rabbit management was carried out in the Nursery Swamp valley in the early 1980s to reduce the severe impact that large numbers were having on the ecosystem (Lintermans 1991). In the 1990s, rabbit control was also carried out in the grasslands surrounding bogs at Rotten Swamp, Cotter Source and Big Creamy flats using explosives to destroy warrens (T. Macdonald pers. comm. 2020).

Ideal environmental conditions after the end of the Millennium Drought resulted in explosive growth in the rabbit population in many areas of Namadgi National Park around 2012–13. Significant damage was caused by rabbits and required substantial resources to bring populations under effective control.

Regular monitoring and analysis of data is essential to quickly respond to increases in rabbit populations. A formal rabbit impact monitoring program in bogs in Namadgi National Park commenced in 2017 as part of the Vertebrate Pest Impact Surveys.

Foxes and Cats

Currently, there is no management of foxes and cats in the ACT Bogs and Fens. Foxes are indirectly impacted by dingo baiting programs in some parts of Namadgi National Park and nearby rural areas. Foxes seem to be maintaining low but stable densities across much of Namadgi National Park, whereas there is evidence that feral cat densities may be increasing (Brawata et al. 2019).

European Wasps

Targeted, asset-based control for European Wasps has been successful at campgrounds and picnic areas in Namadgi National Park. A targeted baiting program at identified bog sites could be introduced to reduce predation on native invertebrates essential for bog flora pollination.

Weeds

The weeds of highest priority are those likely to affect hydrological function and vegetation flammability in the ACT Bogs and Fens. Monitoring and removal/control are undertaken for many weeds including Willow (*Salix* spp.), Scots Pine (*Pinus sylvestris*), Blackberry (*Rubus fruticosus*) and Sweet Vernal Grass (*Anthoxanthum odoratum*).

The incursion of Grey Sallow (*Salix cinerea* ssp. *cinerea*) – mainly in Victoria and also naturalised in NSW, ACT and Tasmania – has been the most widespread because invasion has not been confined to the rivers but has extended to several other habitats, including alpine *Sphagnum* bogs (Carr 1996). Willow seeds are primarily wind dispersed (Cremer 1999). Seed could be transported also by vehicles and footwear. Vigilance and awareness should be increased, especially during recovery periods after wet areas have burnt and are open to seed invasion (F. Ingwersen pers. comm. 2022).

Loss and degradation of native plant and animal habitat by invasion of escaped garden plants is a listed key threatening process under the EPBC Act. Weedy garden plant species, including Soft Rush (*Juncus effusus*) and Musk Monkey Flower (*Mimulus moschatus*), are identified as a great threat to the Alpine Sphagnum Bogs and Associated Fens Ecological Community (Invasive Species Council 2009). Other potential invaders include Hawkweed–Orange Hawkweed (*Hieracium aurantiacum* syn. *Pilosella aurantiaca*) and Mouse-ear Hawkweed (*Hieracium pilosella* syn. *Pilosella officinarum*) which has been recorded from the Brindabella Range in the ACT (Thompson and Wilson 2015). Hawkweed has become a problem in Victoria and is subject to eradication programs in NSW and Victoria. They are highly invasive plants listed as [pest plants](#) in the ACT and pose a very high risk to subalpine regions of Namadgi National Park.

In contemplating any control measure against exotic plant species, the creation of additional and potentially more damaging hazards must be avoided. In aquatic and marginal situations, extreme caution must be exercised as per ecological guidelines (EPSDD 2019), especially with any chemical use when advice on chemical labels may not be adequate in sensitive environments (F. Ingwersen pers. comm. 2022).

Restoration

Active rehabilitation occurred in the ACT Bogs and Fens following fires in 1983, 2003 and 2020. The fire in 1983 severely burnt parts of Rotten Swamp and Top Flat Bog in the upper Cotter River catchment. After noting significant stream incision and drying of the peat-beds, work began in the summer of 1985–86 to attempt the repair of the damage and re-wet the peat-beds to allow natural regeneration of the bog vegetation. At Top Flat, a visual assessment showed that the rehabilitation work was successful after several years. Stream incision halted and in-filled, peats were re-wetted and revegetated and the bog hydrologic function was maintained (G. Hope pers. comm. 2004). In contrast, the work at Rotten Swamp reduced any further stream incision but did not significantly re-wet the peat-beds. The vegetative cover returned but the bog hydrological function was not re-established.

The difference between the recovery of the two bogs was highlighted during the 2003 fire when the peat-beds at Rotten Swamp re-burnt, whereas the Top Flat peats remained wet and did not burn. The rehabilitation success at these two sites is likely due to differences in the degree of valley floor slope and the speed of hydraulic conductivity. Top Flat is almost flat with higher water retention while Rotten Swamp is steeper with faster hydraulic movement.

The 2003 fire burnt almost all the ACT Bogs and Fens, with individual mires ranging in burnt area from 55–100% (Carey et al. 2003). The large fens recovered quickly, resprouting six weeks after the fire. Following assessment of the impact of the fire, a program of bog rehabilitation, including shade cloth and leaky weirs commenced (Whinam et al. 2010). The removal of shrubs and graminoid cover by wildfire reduces the ability of *Sphagnum* to recover rapidly. Consequently, after the 2003 bushfires, a program trialled artificial shading to enhance recovery in bogs across Kosciuszko National Park and Namadgi National Park (Hope et al. 2016, Macdonald and McLean in prep).

The success of the shading techniques was monitored up to twice a year for five years between 2003-2009 and bi-annually thereafter. Plant cover, floristic diversity, peat accumulation/depth and pH values were monitored. Although the total percentage vegetation cover for all native species was significantly different from unshaded areas, Whinam et al. (2010) found there was insufficient data to quantitatively analyse the benefits of the restoration techniques on the recovery of *Sphagnum* moss.

However, a recent assessment of the photo monitoring since 2006 found that the images often were not of the exact areas and, when they were, little information could be extracted (Pulsford 2019).

The only major *Sphagnum* bog that did not burn in the 2020 Orroral fire was the Ginini Flat Complex at the northern end of the range for the ecosystem (Macdonald and McLean in prep). The intensity of the burn varied between and within bogs. The burning of bog vegetation was more complete than in 2003, with very little vegetation (less than 3%) being unburnt across all the bogs (excluding Ginini). As a result, surviving patches for regeneration of *Sphagnum* were less common than in 2003. While most of the peat-bed did not burn, some organic soils on the margins of the peatlands burnt down to a mineral layer. Early assessments indicated the peatlands were in better structural condition than following the 2003 fires, with little evidence of stream incision or erosion, pool drainage or drying of peat. Informal observations suggested that some remaining weirs from previous restoration efforts may have lessened the impact of the 2020 fire (Macdonald and McLean in prep).

In the 12 months following the 2020 fire, 122 weirs and 237 shade cloths were installed across 10 priority sites, including: Snowy Flats, Jack's Flats, Little Bimberi, Rotten Swamp (Upper and Lower), Cotter Source,

Hanging Flat, Top Flat, Mt Kelly Runway and Big Creamy. Installation of shade cloth aims to increase the survival and growth of *Sphagnum* moss (Macdonald and McLean in prep). More broadly, the addition of coir logs into peatlands was carried out to meet three key objectives:

1. prevent, halt and reduce erosion/incision of peat
2. increase the wetness of the peat
3. increase vegetation cover and recovery speeds.

Alongside the restoration actions, a research program was established to facilitate adaptive management of the program over the next 10 years to quantitatively assess how well leaky weirs (coir logs) and shade cloth meet their objectives, and the reasons for varying success rates (Macdonald and McLean, in prep).

Experimental trials of rehabilitation techniques are also underway with ANU for two small low altitude *Sphagnum* bogs at Back Flats (Tidbinbilla Nature Reserve) and Smokers Flat (Namadgi National Park).

Little is known of the impacts of rehabilitation on fauna.

Community Engagement

Off-site interpretation is provided in a display at the Namadgi National Park Visitor Centre, and on interpretation/information signs at the Mt Ginini car park and Nursery Swamp. The captive breeding program at Tidbinbilla Nature Reserve for the Northern Corroboree Frog also aims to raise public awareness (ACT Government 2017a).

The focus of public awareness-raising and engagement is undertaken through off-site means to avoid impacts on the ACT Bogs and Fens. There has been some volunteer assistance in monitoring weeds such as willows in the bogs; however, given its sensitivity to visitor impacts, such as trampling, and introduction of pathogens, community involvement has been limited and will remain so.



Candle Heath – *Richea continentis* at Murrays Gap 2009

Conservation Priorities and Intended Management Actions

The overall aim for conservation of ACT Bogs and Fens is to ensure:

1. the ACT Bogs and Fens Ecological Community and its threatened species are protected
2. the ecological values of bogs and fens including ecosystem function, resilience and biodiversity are maintained by managing threats
3. management and conservation of ACT Bogs and Fens are as effective as possible through support by relevant research and evaluation
4. stakeholder and community collaboration in the conservation of ACT Bogs and Fens are strengthened.

Management actions are outlined in this section against objectives to achieve the above outcomes. Further details of actions and indicators for each objective are provided in the next section.



Monitoring of rehabilitation techniques (Geoff Hope)

Protect

1. To ensure the ACT Bogs and Fens Ecological Community and its threatened species are protected.

Long-term conservation and management efforts are crucial for the persistence of the ACT Bogs and Fens and its native flora and fauna, structural features and hydrology. ACT Bogs and Fens sites are protected in the ACT as they occur on land that is either reserved or managed by the ACT Government through the ACT PCS.

Both the bog and fen biodiversity and the ecological processes within the Ecological Community require protection. This needs to encompass interactions between flora and fauna, hydrological function, peat formation, nutrient cycling, pollination, seed dispersal, and evolutionary processes.

Management recommendation:

- Evaluate annually the status, condition and trajectories of the ACT Bogs and Fens and its threatened and endemic species.
- Protect and report the Ramsar values of Ginini Flats Wetland Complex as required in the [Ginini Flats Wetland Complex Ramsar Site Management Plan](#) (ACT Government 2017a).

Recent mapping has identified additional locations of potential bogs and fens.

Management recommendation:

- On-ground surveys are needed to confirm whether patches meet the definition of the Ecological Community and are appropriately incorporated into conservation planning.

The extent and general condition of deer wallows was mapped through the Namadgi National Park Sambar Deer Project 2019-2022. This provided a baseline data set of bogs through high resolution aerial imagery (2cm resolution) and high-resolution Digital Elevation Model.

Management recommendation:

- This data set should be analysed for reporting on the impacts of feral deer.
- The data set should be incorporated into other end-uses such as vegetation mapping and evaluation of and reporting on sedimentation loss and stream incision.

Manage Threats

2. To ensure the ecological values of bogs and fens including ecosystem function, resilience and biodiversity are maintained by managing threats.

Maintaining and improving integrity of bog and fen patches and associated ecological functioning is needed to increase their resilience to threats.

While the ACT Bogs and Fens sites are some of the most pristine remaining in mainland Australia, size contraction and loss of their ecological integrity has occurred. Management actions should therefore be best practice and focused on increasing patch resilience through maintenance and improvement of existing condition, while minimising the impacts of stressors.

Management recommendation:

- Ensure best practice restoration principles and on-ground management are being utilised to improve conservation effectiveness and monitor the impact of threats and threat management.

Prevention of fire from entering peat-beds

The ACT Bogs and fens Ecological Community is extremely sensitive to fire. Maintaining wet bogs and avoiding peat fires is a very high priority to guarantee against peatland loss and allow rapid recovery from rhizomes impacted by previous fires.

Management recommendation:

- Wherever possible, sites should be protected from both planned and unplanned fire.
- Investigate other methods of vegetation management around bogs to decrease potential burn severity on bog patches.

Mitigating climate change impacts

Climatic predictions for the ACT indicate a drier overall climate, which is predicted to have a significant detrimental effect on the ACT Bogs and Fens. These impacts may include reduced snow cover and reduced water quality and quantity, both in the bogs and fens and downstream. Changes to bog integrity are expected to manifest in above-ground attributes (size and vegetation characteristics), as well as below-ground hydrology and function.

Monitoring of hydrological function combined with periodical monitoring of water chemistry, carbon balance, vegetation characteristics, fauna, bog surface profile and peat depth profile would provide essential data to develop an understanding of how bogs will be affected by climate now and into the future.

Management recommendation:

- To maintain resilience, ensure to the extent feasible that hydrological functioning of inflows to the bogs and fens is maintained and that damage from pest animals and weeds is minimised.
- Monitoring of both above- and below-ground components is necessary to assess impacts of climate change on bog ecosystems.
- Establish ex situ breeding programs for species unable to be maintained in the wild or to supplement wild populations.
- Promote education programs that communicate the impacts of climate change on native species and ecosystems and our efforts to mitigate the impacts.

Control of pest species

The primary pest species impacting ACT Bogs and Fens include deer, feral horses, feral pigs, rabbits and potentially feral cats, foxes and European Wasps.

Management recommendation:

- The priority for control of pest species should be at sites with threatened species habitat.
- Sites with threatened species habitat are monitored to ensure that management of pest animals is effective, and trajectories of threatened species populations are stable or increasing.
- Pest animal management should be guided by the [ACT Pest Animal Management Strategy](#) (ACT Government 2012).

Management of weeds

The primary weeds include woody weeds, [Weeds of National Significance](#), and weeds which have the potential to alter hydrological function or flammability of the Ecological Community – Willow, Scots Pine, Blackberry and Sweet Vernal Grass.

Management recommendation:

- The priority for control of weeds should be at sites with threatened species habitat.
- Sites with threatened species habitat are monitored to ensure that management of weeds is effective, and trajectories of threatened species populations are stable or increasing.
- Weed management in ACT Bogs and Fens should be guided by the new *ACT Invasive Species Management Plan* (ACT Government in prep.) and specifically included in [Invasive Plants Operation Plans](#). Explicit warnings and recommendations should be included for weed control using chemicals in ACT Bogs and Fens with follow-up monitoring required to determine effects.

Historic habitat loss

Following the 2020 bushfires, an assessment of all the major bogs was undertaken and they were prioritised for rehabilitation based on a range of factors. The bogs in the central Namadgi Ranges (around Mt Namadgi, including Cotter Source) were in significantly poorer condition after the 2020 bushfires than those on the Brindabella/Bimberi Ranges. Restoration techniques include a combination of stream barriers, transplants of keystone species, shade and restoration of catchment lines, and possibly large fauna exclusion fencing at some sites (Hope and Keaney 2020).

Management recommendation:

- Continue to restore damaged bogs impacted by historic habitat loss to enhance the long-term integrity and resilience of the Ecological Community.
- Continue to monitor post-fire restoration being undertaken in at least ten of the burnt bogs to ensure that restoration is effective.
- Works should be considered only if there is a commitment to maintain and monitor them for a minimum of ten years with some introduced structures ideally absorbed into the bog fabric and temporary structures removed when no longer required.
- Promote education programs that communicate the impacts of past grazing and fire on native species and ecosystems and our efforts to mitigate the impacts.

Improve

3. To ensure management and conservation of ACT Bogs and Fens are as effective as possible through support by relevant research and evaluation.

Long-term and regular monitoring of priority bog and fen sites is required to determine whether management actions are effective. This is particularly important at sites where the monitoring of threatened species is being undertaken.

Regular monitoring of hydrological function, biodiversity and condition assessments is essential to ensure long-term conservation especially in light of managing climate change impacts and other threats. An increased monitoring effort (i.e. in frequency and across more sites) is also likely to be required during future droughts or after fire. This is particularly important to monitor whether sites are remaining resilient to environmental and climatic change or whether restoration activities are necessary to maintain or improve bog and fen condition and connectivity.

Management recommendation:

- Priority sites for monitoring include sites:
 - with threatened species present
 - where specific management actions are being trialled and carried out, such as restoration activities (Good et al. 2010) or invasive species control
 - identified as requiring management intervention to improve condition and functionality
 - where changes to hydrological function could affect crucial water systems.
- Improve understanding of bog and fen ecology in relation to impacts of climate change.

Monitoring actions will be included in the High Country Bogs and Associated Fens Ecosystem Condition Monitoring Plan: Conservation Effectiveness Monitoring Program (CEMP). The ACT PCS undertook basic photographic monitoring at marked key points in each of the following bogs, every 1-3 years: Ginini West, Cotter Source, Rotten Swamp, Big and Little Creamy Flats, Rock Flats, Top Flats, Upper Top Flats, Jacks Flat, Murrays Gap, Little Bimberi and Bimberi bogs. The analysis of these data (Pulsford 2019) shows an overall recovery in the bogs since the 2003 fires. However, the method was not implemented in a way that could inform management actions for the future.

Management recommendation:

- Ensure consistent and best practice monitoring methods are being utilised to enable appropriate integration of data and reporting to improve understanding of the status, condition and trajectories of the Ecological Community and its threatened species.
- The CEMP will include a set of standardised monitoring indicators relating to ecosystem condition and stressors that can inform management effectiveness.

Collaborate

4. To ensure stakeholder and community collaboration in the conservation of bogs and fens are strengthened.

Consultation and engagement with the public is an essential part of enhancing public awareness and acceptance of the importance of conserving the ACT Bogs and Fens and people's appropriate interactions with bog and fens sites and species. This includes with key stakeholders and relevant national and state governments.

Management recommendation:

- Develop an implementation plan with relevant expert stakeholders to determine on-ground actions and responsibilities for management, monitoring and research.
- Engage with the Australian Alps National Parks Environment Reference Group to ensure regionally consistent approach to the management and monitoring of ACT Bogs and Fens.
- Liaise with the NSW Government about conservation issues and management requirements for bogs and fens that occur on the ACT–NSW border.
- Collaborate with universities, the CSIRO, the Australian National Botanic Gardens and other research institutions to undertake research relevant to the recommendations of this action plan.
- Engage with the community to raise awareness of conservation and management issues and why visitation to ACT Bogs and Fens is not encouraged.

The deep connections of the Ngunnawal people with the lands and waters in the high country of this region are recognised in their ancestral and ongoing legacy to 'Care for Country'. The area covered by Namadgi National Park contains a rich cultural landscape, with the Ngunnawal history of the region dating back over 25,000 years. As caretakers of the region, the Ngunnawal people occupied the high country over an extended period in the summer (Argue 1995, Saunders et al. 1996) utilising various resources and engaging in the full range of daily living activities along the edges of bogs and associated streams.

Management recommendation:

- Engage with the Ngunnawal Community to facilitate their active participation in management of the biodiversity, environmental and cultural values of the ACT Bogs and Fens.
- The EPSDD facilitates, through agreed consultative and on-ground approaches, the maintenance of Ngunnawal people's connection to Country and traditional custodianship of the ACT Bogs and Fens.
- Work with Ngunnawal Traditional Custodians to ensure that any cultural resource use plan or on-ground management activities align with the conservation of the ACT Bogs and Fens and its species in culturally appropriate ways.



Snowy Flat 2009 (Mark Jekabsons)

Implementation

Implementation of this action plan will require:

- an implementation plan to determine on-ground actions and responsibilities for monitoring, research and management that align with this action plan
- allocation of adequate resources to undertake the specified actions
- reporting progress at five-yearly intervals by the Conservator to the Minister for the Environment on delivery of the action plan and its effectiveness
- review of effectiveness of this action plan by the Scientific Committee every 10 years or as requested by the Conservator to assess the need for the modification of this action plan in light of new information or changed circumstances
- annual internal reporting to the Scientific Committee and Conservator on delivery of the action plan to enable evaluation of the status, condition and trajectories of the ACT Bogs and Fens and the ongoing conservation requirements for its threatened and endemic species
- evaluation as appropriate by the Scientific Committee and Conservator of the Ecological Character Description and management needs of the Ginini Flats Ramsar Site.



Snowy Flat February 2020 (Nathan Kay)

Objectives, Actions and Indicators

The actions and indicators for the four key objectives, to be included and further developed in a more detailed implementation plan to determine the on-ground actions and responsibilities for monitoring, research and management, are detailed below.

Objective 1 – Ensure the ACT Bogs and Fens Ecological Community and its threatened species are protected

Action	Indicator
1a. Extend reserve protections to relevant ACT Bogs and Fens sites outside Namadgi National Park	1a. All relevant sites are protected by appropriate formal measures
1b. Evaluate annually the delivery of the action plan and the status, condition and trajectories of the ACT Bogs and Fens Ecological Community and its threatened and endemic species	1b. Internal annual reporting informs current status
1c. The Ramsar values of Ginini Flats Wetland Complex are being protected and reported as required in the Ginini Flats Wetland Complex Ramsar Site Management Plan	1c. Compliance with Ramsar requirements occurs
1d. On-ground surveys to confirm new patches meet the definition of the Ecological Community and are appropriately incorporated into conservation planning	1d. Relevant new patches are included in conservation planning

Objective 2 – Ensure the ecological values of bogs and fens including ecosystem function, resilience and biodiversity are maintained by managing threats

Action	Indicator
2a. Apply best practice restoration principles to on-ground management of damaged sites (post-fire and due to historic habitat loss) to improve conservation effectiveness and monitor the impact of threats and threat management	2a. Various management techniques are appropriately undertaken based on the best available evidence and monitored over time to properly facilitate assessment of success and lead to improved condition (e.g. reduced incision and erosion) – implementation of the <i>ACT Sphagnum Bog Rehabilitation and Monitoring Plan 2020–2031</i>
2b. Ensure ACT Bogs and Fens are considered in fire planning to maintain protection from planned fires with any fire management works and activities in neighbouring ecosystems carried out in accordance with the <i>Ecological Guidelines for Fire, Fuel and Access Management Operations</i> and investigate the need to ban retardant use near wet areas to minimise harm to the ecosystem	2b. No ACT Bogs or Fens are adversely affected by fire management works and activities, and high value habitat, including mature <i>Sphagnum</i> moss-shrub bogs, be prioritised for protection as major Park assets during emergencies

Action	Indicator
2c. Investigate other methods of vegetation management and fire mitigation around bogs to decrease potential burn severity on bog patches (including research into sprinkler systems and potential for slashing/mulching surrounding areas)	2c. Other fire mitigation techniques are investigated and employed where appropriate
2d. Monitor abundance, distribution and impacts of vertebrate pests (e.g. deer, horses, pigs, rabbits, domestic stock, foxes and cats) within and around ACT Bogs and Fens, to determine the level of intervention required and carry out appropriate management in accordance with the <i>ACT Pest Animal Management Strategy 2012</i> , the <i>Namadgi National Park Plan of Management 2010</i> and the <i>Namadgi National Park Feral Horse Management Plan 2020</i>	2d. The intervention level is determined and the impacts of deer and other introduced pest species on ACT Bogs and Fens are mitigated Pest management is effective in reducing impacts of vertebrate pests without indirect damage to ACT Bogs and Fens
2e. Monitor presence of and appropriately treat invasive plants and dry-land species encroachment as guided by the <i>ACT Weeds Strategy</i> and included in Invasive Plants Operation Plans	2e. Invasive plants are identified, removed and recorded
2f. Investigate the level of European Wasp infestation and predation on native pollinators essential for bog flora pollination and where necessary introduce a targeted baiting program at identified bog sites	2f. Decreased populations of European Wasps at identified sites
2g. Develop a 'Protocol for work in ACT Bogs and Fens' that minimises human disturbance and reduces the possibility of spreading pathogens and weeds between sites	2g. Protocol is developed, followed and required by all people entering the ACT Bogs and Fens

Objective 3 – Ensure management and conservation of ACT Bogs and Fens are as effective as possible through support by relevant research and evaluation

Action	Indicator
3a. Support research on bog and fen ecology, restoration principles and best-practice management	3a. Research undertaken, disseminated and applied to the conservation management of the ACT Bogs and Fens
3b. Develop and implement a long-term monitoring program for ACT Bogs and Fens to establish baseline conditions, and track condition and function over time to inform management requirements and evaluate management effectiveness	3b. Development: Threats to and values of bogs and fens are identified from the Bogs and Fens CEMP and inform the implementation of a feasible long-term monitoring program Implementation: A long-term monitoring program is established, enhancing knowledge of condition in Bogs and Fens and effectiveness of management interventions, to inform restoration projects and increased resilience to threats

Action	Indicator
3c. Undertake climate change monitoring and support research projects that improve our understanding of the impacts of climate change on ACT Bogs and Fens and threatened species	3c. Monitoring and research on the impacts of climate change informs and improves restoration projects
3d. Determine connectivity requirements in ACT Bogs and Fens	3d. Connectivity requirements in ACT Bogs and Fens are evaluated and activities that are identified to weaken connectivity cease
3e. Monitor threatened and important fauna and flora populations, especially Broad-toothed Rat, Kiandra Greenhood Orchid and Spiny Crayfish populations in Bogs and Fens to ensure local extinctions do not occur	3e. Monitoring informs our understanding of presence and abundances of key fauna and flora species
3f. Determine and implement site-specific management actions to maintain or improve required habitat for threatened and significant species in ACT Bogs and Fens if monitoring determines as necessary	3f. Research is conducted to determine species' habitat requirements Corresponding site-specific actions are appropriately undertaken Species' required habitat is monitored and maintained or improved
3g. Maintain a captive insurance population of Northern Corroboree Frogs and carry out reintroductions into the wild – as per the <i>Northern Corroboree Frog Action Plan</i>	3g. Number, health and genetic diversity of animals in captivity enables successful captive breeding to ensure production of adequate individuals for release programs Releases conducted, monitored and outcomes reported as part of an approved translocation plan
3h. Increase monitoring effort, in frequency and across more sites, during future droughts or after fire	3h. Information is used to alert need for early intervention or restoration activities are implemented
3i. Develop partnerships to undertake trial propagation of keystone species e.g. <i>Sphagnum</i> , <i>Empodisma</i> , <i>Carex</i> , <i>Epacris</i> , and <i>Richea</i> to provide sterile transplant materials and an effective methodology for potential restoration activities	3i. Trial propagation evaluated to determine effectiveness and appropriateness for future restoration projects

Objective 4 – Ensure stakeholder and community collaboration in the conservation of bogs and fens are strengthened

Action	Indicator
4a. Develop an implementation plan to determine on-ground actions and responsibilities for management, monitoring and research	4a. An Implementation Plan is developed, implemented and regularly (at least annually) evaluated for effectiveness
4b. Engage with the Australian Alps National Parks Environment Reference Group to ensure a regionally	4b. Continued active involvement by EPSDD officers in the Australian Alps

Action	Indicator
consistent approach to the management and monitoring of ACT Bogs and Fens and their threatened species	National Parks Environment Reference Group
4c. Liaise with the NSW Government on bogs and fens that occur on the ACT–NSW border about conservation and management issues	4c. Direct involvement with NSW officers occurs to work towards beneficial outcomes
4d. Collaborate with universities, the CSIRO, the Australian National Botanic Gardens and other research institutions to undertake research relevant to the recommendations of this action plan	4d. Collaboration and consultation with stakeholders is effective
4e. Engage with the community to raise awareness of conservation issues and why visitation to the ACT Bogs and Fens is not encouraged (e.g. interpretative signage/boardwalks)	4e. Activities that increase awareness of the sensitive nature of the ACT Bogs and Fens are undertaken
4f. Engage with the Ngunnawal Community to facilitate their active participation in management of the biodiversity, environmental and cultural values of the ACT Bogs and Fens	4f. Ngunnawal people actively participate in management activities to conserve the ACT Bogs and Fens
4g. The EPSDD facilitates, through agreed consultative and on-ground approaches, the maintenance of Ngunnawal people’s connection to Country and traditional custodianship of the ACT Bogs and Fens	4g. The significance of the Ngunnawal people’s connection to the ACT Bogs and Fens is explored and reinforced
4h. Work with Ngunnawal Traditional Custodians to ensure that any cultural resource use plan or on-ground management activities align with the conservation of the ACT Bogs and Fens Ecological Community and its species in culturally appropriate ways	4h. Plans work together for beneficial outcomes for the ACT Bogs and Fens



Rotten Swamp looking towards Mount Burbidge 2018 (Ben Stevenson)

References

ACT Government 2007. *Namadgi National Park Feral Horse Management Plan*. Territory and Municipal Services, Canberra.

ACT Government 2008. Fuel and fire suppression guidelines for ACT declared threatened species and endangered ecological communities. Unpublished report to Conservation Planning and Research Section, Canberra.

ACT Government 2009. *ACT Weeds Strategy 2009-2019*. Department of Environment, Climate Change, Energy and Water, Canberra.

ACT Government 2010. *Namadgi National Park Plan of Management*. Department of Territory and Municipal Services, Canberra. <https://www.legislation.act.gov.au/di/2010-192/>

ACT Government 2011. Northern Corroboree Frog (*Pseudophryne pengilleyi*) Action Plan No. 6. Second Edition. ACT Government, Canberra. <https://www.legislation.act.gov.au/View/di/2013-277/current/PDF/2013-277.PDF>

ACT Government 2012. *ACT Pest Animal Management Strategy*. Environment and Sustainable Development Directorate, Canberra. <https://www.environment.act.gov.au/cpr/conservation-strategies/pams2>

ACT Government 2014. *The ACT Strategic Bushfire Management Plan 2014-2019*. Emergency Services Agency, Canberra.

ACT Government 2016. *ACT Climate Change Adaptation Strategy: Living with a Warming Climate*. Environment and Planning Directorate, Canberra.

ACT Government 2017a. *Ginini Flats Wetland Complex Ramsar Site Management Plan*. Environment, Planning and Sustainable Development Directorate, Canberra. <https://www.legislation.act.gov.au/di/2017-36/>

ACT Government 2017b. *ACT Native Grassland Conservation Strategy and Action Plans*. Environment, Planning and Sustainable Development Directorate, Canberra. <https://www.legislation.act.gov.au/di/2017-288/>

ACT Government 2018a. *Action Plan for Listed Migratory Species*. Environment, Planning and Sustainable Development Directorate, Canberra. <https://www.legislation.act.gov.au/di/2018-27/>

ACT Government 2018b. *Lower Cotter Catchment Reserve Management Plan 2018*. Environment, Planning and Sustainable Development Directorate, Canberra. https://www.parliament.act.gov.au/data/assets/pdf_file/0015/1185000/Lower-Cotter-Catchment-Reserve-Management-Plan-2018.pdf

ACT Government 2018c. *Two-spined Blackfish *Gadopsis bispinosus* Action Plan*. Environment, Planning and Sustainable Development Directorate, Canberra. https://www.environment.act.gov.au/data/assets/pdf_file/0007/576547/Two-Spined-Blackfish-Action-Plan.pdf

ACT Government 2019a. ACTmapi EPD – ACT Government Online Maps and Apps – High Country Bogs and Fens, ACT Government. <https://actmapi-actgov.opendata.arcgis.com/datasets/ACTGOV::high-country-bogs-and-fens/explore?location=-35.545853%2C148.927538%2C10.02>

- ACT Government 2019b. *The ACT Strategic Bushfire Management Plan 2019-2024*. Emergency Services Agency, Canberra. https://esa.act.gov.au/sites/default/files/2019-09/ESA%20Strategic%20Bushfire%20Management%20Plan2019-2024_ACCESSIBLE.pdf
- ACT Government 2020. *Namadgi National Park Feral Horse Management Plan*. Environment Planning and Sustainable Development, Canberra https://www.environment.act.gov.au/data/assets/pdf_file/0007/1624930/namadgi-national-park-feral-horse-management-plan-2020.pdf
- ACT Government 2021. *Regional Fire Management Plan 2019-2028 – Draft*. Parks and Conservation Service, Environment Planning and Sustainable Development Directorate, Canberra. <https://storymaps.arcgis.com/stories/550220a9bd8343de8ba15d56fadb526>
- ACT/NSW Rapid Risk Assessment Team 2020. Orroral Valley fire Rapid Risk Assessment Namadgi National Park. Unpublished report, Environment, Planning and Sustainable Development Directorate. ACT Government, Canberra. https://www.environment.act.gov.au/data/assets/pdf_file/0003/1495236/orroral-valley-fire-rapid-risk-assessment-namadgi-national-park.pdf
- ACT Scientific Committee 2019a. *Conservation Advice – Alpine Tree Frog (*Litoria verreauxii alpina*)*. ACT Government, Canberra. <https://www.legislation.act.gov.au/ni/2019-242/>
- ACT Scientific Committee 2019b. *Conservation Advice – Broad-toothed Rat (*Mastacomys fuscus mordicus*)*. ACT Government, Canberra. <https://www.legislation.act.gov.au/ni/2019-233/>
- ACT Scientific Committee 2019c. *Conservation Advice – High Country Bogs and Fens Ecological Community*. ACT Government, Canberra. <https://www.legislation.act.gov.au/ni/2019-66/>
- ACT Scientific Committee 2019d. *Conservation Advice – Kiandra Greenhood (*Pterostylis oreophila*)*. ACT Government, Canberra. <https://www.legislation.act.gov.au/ni/2019-236/>
- ACT Scientific Committee 2019e. *Conservation Advice – Northern Corroboree Frog (*Pseudophryne pengilleyi*)*. ACT Government, Canberra. <https://www.legislation.act.gov.au/ni/2019-240/>
- Argue D 1995. Aboriginal occupation of the Southern Highlands: was it really seasonal? *Australian Archaeology* 41(1): 30–36. https://www.researchgate.net/publication/267582120_Aboriginal_Occupation_of_the_Southern_Highlands_Was_it_Really_Seasonal
- Armstrong RC, Turner KD, McDougall KL, Rehwinkel R and Crooks JI 2012. Plant communities of the upper Murrumbidgee catchment in New South Wales and the Australian Capital Territory. *Cunninghamia* 13(1): 125–266. <https://www.rbg Syd.nsw.gov.au/getmedia/75eafe61-81cc-400a-b074-99fa2b6e1ef8/Cun131arm125.pdf.aspx>
- Ashton DH and Williams RJ 1989. Dynamics of the sub-alpine vegetation in the Victorian region. In Good R (ed.) *The Scientific Significance of the Australian Alps: The Proceedings of the First Fenner Conference on the Environment, Canberra, September 1988* pp. 143-168. Australian Alps National Parks Liaison Committee.
- Australian Government 2020. Royal Commission into National Natural Disaster Arrangements Report, Commonwealth of Australia, Canberra. <https://naturaldisaster.royalcommission.gov.au/publications/royal-commission-national-natural-disaster-arrangements-report>
- Australian National Botanic Gardens 2014. *Australian Alpine Plant Research, Conservation and Management*. Report of a symposium on Australian alpine plant research, conservation and management, Australian National Botanic Gardens, June 2014, Canberra. <https://www.anbg.gov.au/gardens/living/seedbank/2014-alpine-symposium-report.pdf>

Banks JC 1989. A history of forest fire in the Australian Alps. In Good R (ed.) *The Scientific Significance of the Australian Alps: The Proceedings of the First Fenner Conference on the Environment, Canberra, September 1988* pp. 265–280. Australian Alps National Parks Liaison Committee.

Beeton NJ and Johnson CN 2019. Modelling horse management in the Australian Alps. *Ecological Management and Restoration – Special Issue: Feral horses in the Australian Alps* 20(1): 57–62. <https://onlinelibrary.wiley.com/doi/full/10.1111/emr.12350>

Brawata R, Stevenson B, and Seddon J 2017. *Conservation Effectiveness Monitoring Program: an overview*. Technical Report. Environment, Planning and Sustainable Development Directorate, ACT Government, Canberra. https://www.environment.act.gov.au/_data/assets/pdf_file/0004/1059241/Conservation-effectiveness-monitoring-program.pdf

Brawata R, Larson E, Stevenson B and Seddon J 2019. *Conservation Effectiveness Monitoring Plan: Upland Native Grasslands Ecosystem Condition Monitoring Plan*. Technical Report. Environment, Planning and Sustainable Development Directorate, ACT Government, Canberra. https://www.environment.act.gov.au/_data/assets/pdf_file/0007/1537432/upland-native-grassland-ecosystem-monitoring-plan.pdf

Burne AR, Haywood J, Lester PJ (2015) Density-dependent effects of an invasive wasp on the morphology of an endemic New Zealand ant. *Biological Invasions* 17(1): 327–335. <https://doi.org/10.1007/s10530-014-0731-0>

Butz M 2004. Blundells Flat area ACT: Management of natural and cultural heritage values. Unpublished background study for the Friends of ACT Arboreta, Canberra. http://www.markbutz.com/Butz%202004%20Blundells%20Flat%20management%20study_FACTA.pdf

Butz M 2008. Conservation Management Plan: Blundells Flat and Shannons Flat, ACT. Heritage Grants Program, ACT Government, Canberra. <http://www.markbutz.com/Butz%202009%20Blundells%20Flat%20Conservation%20Management%20Plan%2006%20Mar%2009.pdf>

Cairns S 2019. Feral Horses in the Australian Alps: The Analysis of Aerial Surveys Conducted in April-May 2014 and April-May 2019. A report to the Australian Alps Liaison Committee. <https://theaustralianalps.files.wordpress.com/2019/12/feral-horses-in-the-australian-alps-the-analysis-of-aerial-surveys-conducted-in-2014-and-2019-cairns-s-2019.pdf>

Cairns S 2020. The results of the survey of the wild horse populations in the Kosciuszko National Park October-November 2020. A report to the NSW Department of Planning, Industry and Environment. GE & SC Cairns Consulting Pty. Ltd., Armidale.

Cairns S and Robertson G 2015. 2014 Survey of Feral Horses (*Equus ferus caballus*) in the Australian Alps. Report prepared for the Australian Alps Liaison Committee. Australian Alps National Parks. <https://theaustralianalps.files.wordpress.com/2016/05/2014-aerial-survey-feral-horses.pdf>

Camac JS, Umbers KDL, Morgan JW, Geange SR, Hanea A, Slatyer RA, McDougall KL, Venn SE, Vesik PA, Hoffmann AA and Nicotra AB 2021. Predicting species and community responses to global change using structured expert judgement: An Australian mountain ecosystems case study. *Global Change Biology* 27(18): 4420–4434. <https://onlinelibrary.wiley.com/doi/epdf/10.1111/gcb.15750>

Carey A, Evans M, Hann P, Lintermans M, MacDonald T, Ormay P, Sharp S, Shorthouse D and Webb N. 2003. *Technical Report 17 – Wildfires in the ACT 2003: Report on initial impacts on natural ecosystems*. Environment ACT, Canberra. https://www.environment.act.gov.au/_data/assets/pdf_file/0006/576816/wildfiresintheact.pdf

Carr GW 1996. *Salix*. In Walsh NG and Entwisle TJ (eds.) *Flora of Victoria Vol. 3, Dicotyledons Winteraceae to Myrtaceae*. Inkata Press, Melbourne. Also available at:

<https://vicflora.rbg.vic.gov.au/flora/taxon/88dead51-3a0e-45de-8114-ee1fea5e0df2>

Clark RL 1980. *Sphagnum* growth on Ginini Flats ACT. Unpublished report to NSW National Parks and Wildlife Service.

EPSDD 2019. *Ecological Guidelines for Fire, Fuel and Access Management Operations*. Conservation Research Branch and Fire Forests and Roads Branch, Environment, Planning and Sustainable Development Directorate. ACT Government, Canberra.

https://www.environment.act.gov.au/_data/assets/pdf_file/0009/1483830/Ecological-Guidelines-2019-ver-1.3.pdf

Costin AB, Gray M, Totterdell CJ and Wimbush DJ 2000. *Kosciusko Alpine Flora, Second Edition*. CSIRO Publishing, Melbourne. <https://www.publish.csiro.au/book/2540>

Cowood A, Nicholson A, Wooldridge A, Muller R and Moore L 2017. Wetland Vulnerability to Climate Change in the ACT. Report to ACT Environment, Planning and Sustainable Development Directorate, Canberra. https://www.environment.act.gov.au/_data/assets/pdf_file/0009/1093887/Wetland-Vulnerability-to-Climate-Change-in-the-ACT.pdf

Cremer K 1999. *Willow Management for Australian Rivers*. CSIRO Forestry and Forest Products, Kingston ACT.

<http://www.hoadley.net/cremer/willows/docs/WMFAR.pdf?msclid=4a353fa9a97111ecb4ef6cb9f3c77abe>

Denny EA and Dickman CR 2010. *Review of Cat Ecology and Management Strategies in Australia*. Invasive Animals Cooperative Research Centre, Canberra. http://www.pestsmart.org.au/wp-content/uploads/2010/03/CatReport_web.pdf

Department of the Environment 2015. *National Recovery Plan for the Alpine Sphagnum Bogs and Associated Fens Ecological Community*. Department of the Environment, Canberra.

<http://www.environment.gov.au/biodiversity/threatened/publications/recovery/alpine-sphagnum-bogs-associated-fens>

Department of Agriculture, Water and the Environment (DAWE) 2020. Directory of Important Wetlands in Australia. Australian Wetlands Database. Available online at: <http://www.environment.gov.au/cgi-bin/wetlands/search.pl?smode=DOIW>

Department of Agriculture, Water and the Environment (DAWE) 2021. *Listing Advice for Pseudophryne dendyi (Dendy's Toadlet)*. Department of Agriculture, Water and the Environment, Canberra.

<http://www.environment.gov.au/biodiversity/threatened/species/pubs/1916-listing-advice-19102021.pdf>

Department of Environment, Water, Heritage and the Arts (DEWHA) 2009. *Alpine Sphagnum Bogs and Associated Fens: a Nationally Threatened Ecological Community*. EPBC Act 1999 Policy Statement 3.16.

Australian Government, Canberra. <http://www.environment.gov.au/system/files/resources/b08acec6-6a27-4e71-8636-498719b253b4/files/alpine-sphagnum-bogs.pdf>

Department of Sustainability, Environment, Water, Population and Communities (DSEWPC) 2012. *Approved Conservation Advice for Pterostylis oreophila (Kiandra Greenhood)*. Australian Government, Canberra.

https://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=22903

Downey PO and Taylor S 2022. List of Alien Plants Naturalised in the ACT. A report prepared for the ACT Government. Invasive Species Technical Report Series No. 1, ACT Government, Canberra.

<https://docs.google.com/spreadsheets/d/1uBNiQctly2APabsa7bP1o8v2-DJmrVix/edit#gid=1592411139>

Driscoll DA, Worboys GL, Allan H, Banks SC, Beeton NJ, Cherubin RC, Doherty TS, Finlayson CM, Green K, Hartley R, Hope G, Johnson CN, Lintermans M, Mackey B, Paull DJ, Pittock J, Porfirio LL, Ritchie EG, Sato CF, Scheele BC, Slattery DA, Venn S, Watson D, Watson M and Williams RM 2109. Impacts of feral horses in the Australian Alps and evidence-based solutions. *Ecological Management and Restoration – Special Issue: Feral horses in the Australian Alps* 20(1): 63–72.

<https://onlinelibrary.wiley.com/doi/full/10.1111/emr.12357>

Environment Planning and Sustainable Development Directorate (EPSDD) 2019. *Ecological Guidelines for Fire, Fuel and Access Management Operations*. Conservation Research Branch and Fire, Forests and Roads Branch, ACT Government, Canberra.

https://www.environment.act.gov.au/_data/assets/pdf_file/0009/1483830/Ecological-Guidelines-2019-ver-1.3.pdf

Geyle HM, Hoskin CJ, Bower DS, Catullo R, Clulow S, Driessen M, Daniels K, Garnett ST, Gilbert D, Heard GW, Hero J-M, Hines HB, Hoffmann EP, Hollis G, Hunter DA, Lemckert F, Mahony M, Marantelli G, McDonald KR, Mitchell NJ, Newell D, Roberts JD, Scheele BC, Scroggie M, Vanderduys E, Wassens S, West M, Woinarski JCZ and Gillespie GR. 2021. Red hot frogs: identifying the Australian frogs most at risk of extinction. *Pacific Conservation Biology* 2021 Aug 20. <https://doi.org/10.1071/PC21019>

Gill AM, Good R, Kirkpatrick J, Lennon J, Mansergh I and Norris R 2004. *Beyond the Bushfires 2003: Environmental Issues in the Australian Alps*. Australian Alps Liaison Committee, Canberra.

<https://theaustralionalps.files.wordpress.com/2013/12/beyond-bushfires.pdf>

Gillespie GR, Roberts JD, Hunter D, Hoskin CJ, Alford RA, Heard GW, Hines H, Lemckert F, Newell D and Scheele BC 2020. Status and priority conservation actions for Australian frog species. *Biological Conservation* 247: 108543.

<https://www.sciencedirect.com/science/article/abs/pii/S0006320719314430?via%3Dihub>.

Good R, Wright G, Whinam J and Hope G 2010. Restoration of mires of the Australian Alps following the 2003 wildfires. In Haberle S, Stevenson J and Prebble M (eds.) *Altered Ecologies: Fire, climate and human influence on terrestrial landscapes*. *Terra Australis* 32: 353-362. <http://press-files.anu.edu.au/downloads/press/p18701/pdf/ch193.pdf>

Grover SP 2001. The hydrology and characteristics of peat soils in the Victorian Alps. Honours thesis, La Trobe University, Melbourne.

Grover SP 2006. Carbon and water dynamics of peat soils in the Australian Alps. Unpublished PhD thesis, La Trobe University, Melbourne.

Guja L and Huttner-Koros B 2013. Ecological drivers of seed germination in endangered alpine bog and fen communities in Australia. In Liu Z, Liu B, Zhu J and Yan Q (eds.) *Seed Ecology IV, Seeds and the Future, Conference Proceedings, International Society for Seed Science*, Shenyang, China, p.120.

Harris S and Kitchener A 2005. *From Forest to Fjaeldmark: Descriptions of Tasmania's Vegetation*. Department of Primary Industries, Water and Environment, Hobart.

Helman CE and Gilmour PM 1985. Treeless vegetation above 1000 metres altitude in the ACT. Report to the Conservation Council of the South-east Region and Canberra, Canberra.

Helman CE, Gilmour PM, Osborne WS and Green K 1988. An ecological survey of the upper Cotter catchment wilderness area, Namadgi National Park, ACT. An unpublished report to the Conservation Council of the South-east Region and Canberra, National Estate Grant, Canberra.

Hone J 2002. Feral pigs in Namadgi National Park, Australia: dynamics, impacts and management. *Biological Conservation* 105(2): 231–242.

<https://www.sciencedirect.com/science/article/abs/pii/S0006320701001859?via%3Dihub>

Hope G, Nanson R and Flett I 2009. Technical Report 19. *The peat-forming mires of the Australian Capital Territory*. Territory and Municipal Services, Canberra.

https://www.researchgate.net/profile/Rachel_Nanson/publication/228503048_The_Peat-Forming_Mires_of_the_Australian_Capital_Territory/links/00b4952df31ab41257000000.pdf

Hope GS, Nanson R and Jones P 2012. *Peat-forming bogs and fens of the Snowy Mountains of NSW*. NSW Office of Environment and Heritage Technical Report, Sydney. www.environment.nsw.gov.au/research-and-publications/publications-search/peat-forming-bogs-and-fens-of-the-snowy-mountains-of-nsw-technical-report

Hope G and Keaney B 2020. An assessment of the ACT peatlands following the February 2020 fire. Unpublished report, Archaeology and Natural History, Australian National University, Canberra.

Hope GS 2003. The mountain mires of southern New South Wales and the Australian Capital Territory: their history and future. In Mackay and Associates (eds.) *Celebrating Mountains: Proceedings of an International Year of Mountains Conference*, Jindabyne, November 2002 pp. 67–80. Australian Alps Liaison Committee. <https://theaustralialps.files.wordpress.com/2013/12/iym-part-1.pdf>

Hope GS, Stevenson J and Haberle S 2006. Palaeoecology of Blundells Flat, ACT. Unpublished report to Ecowise Services and ACT Forests, Canberra.

Hope GS, Wade A and Whinam J 2003. A report on the state of the mountain mires of the Australian Capital Territory after the fires 14-22 January 2003. Report to the ACT Recovery Group: Natural Resources and Wildlife Programs, Environment ACT, Canberra.

Hosking J, Sainty GR and Jacobs SWL 2006. *Alps Invaders: Weeds of the Australian High Country*. Australian Alps Liaison Committee.

Hutchinson MN and Donnellan SC 1988. A new species of scincid lizard related to *Leiopisma entrecasteauxii*, from South-eastern Australia. *Transactions of the Royal Society of South Australia* 112: 143–151. <https://www.biodiversitylibrary.org/page/41129009#page/156/mode/1up>

Intergovernmental Panel on Climate Change (IPCC) 2014. *Climate Change 2014: Impacts, Adaptation, and Vulnerability*. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Barros VR, Field CB, Dokken DJ, Mach KJ, Mastrandrea MD, Bilir TE, Chatterjee M, Ebi KL, Estrada YO, Genova RC, Girma B, Kissel ES, Levy AN, MacCracken S, Mastrandrea PR and White LL (eds.) Cambridge University Press, Cambridge. <https://www.ipcc.ch/report/ar5/wg2/>
https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-PartA_FINAL.pdf
https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-PartB_FINAL.pdf

Invasive Species Council 2009. *Escaped Garden Plants as a Key Threatening Process*. A submission in response to the nomination 'Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including cultivated and aquatic plants'. Invasive Species Council Australia, Fairfield. https://invasives.org.au/wp-content/uploads/2014/02/sub-escaped_garden_KTP_april09B.pdf

Ji F 2019. *Climate Change Impacts in the NSW and ACT Alpine Region: Projected climate*. NSW Department of Planning, Industry and Environment, Sydney. <https://climatechange.environment.nsw.gov.au/-/media/NARCLim/Files/Climate-Change-Impact-Reports/Alpine-impacts/Climate-change-impacts-Alpine---Projected-climate.pdf?la=en&hash=D91FAC555ACFDB5BD6D8FD910D997FEE4E8D45C4>

Kirkpatrick JB 1989. The comparative ecology of mainland Australia and Tasmania alpine vegetation. In Good R (ed.) *The Scientific Significance of the Australian Alps. Proceedings of the First Fenner Conference on the Environment, Canberra, September 1988* pp. 127–142. Australian Alps National Parks Liaison Committee.

- Legge S, Murphy B and Woinarski J 2016. How many cats? Threatened Native Species Hub. Accessed 10 April 2019 from: <http://www.nespthreatenedspecies.edu.au/news/how-many-cats>
- Lintermans M 1991. Long-term rabbit control using explosives. *Ninth Australian Vertebrate Pest Control Conference: Handbook of Working Papers* pp. 350–351.
- Lintermans M 1998. The Ecology of the Two-spined Blackfish *Gadopsis bispinosus* (Pisces: Gadopsidae). Unpublished M.Sc. thesis, Division of Botany and Zoology, Australian National University, Canberra.
- Lintermans M 2001. Chapter 5 – Australian Capital Territory. In Environment Australia (ed.) *A Directory of Important Wetlands in Australia, Third Edition* pp.29–32. Environment Australia, Canberra. <https://www.environment.gov.au/system/files/resources/18f0bb21-b67c-4e99-a155-cb5255398568/files/directory.pdf>
- Love J, Thapa R, Drielsma M and Robb J 2019. *Climate Change Impacts in the NSW and ACT Alpine Region: Impacts on biodiversity*. NSW Department of Planning, Industry and Environment, Sydney.
- Macdonald T 2009. *Technical Report 20 – Sphagnum Bog Mapping and Recovery Plan*. ACT Climate Change Strategy Action Plan 2007–2011, Action 35 Project Report. Territory and Municipal Services, Canberra. https://www.environment.act.gov.au/_data/assets/pdf_file/0009/576819/Technical_Report_20_Sphagnum_Bog_Mapping_and_Recovery_Plan.pdf
- Macdonald T and McLean N (in prep). *ACT Sphagnum Bog Rehabilitation and Monitoring Plan 2020–2031*. Environment Planning and Sustainable Development, Canberra.
- Mackey B, Jacobs P and Hugh S 2015. Classifying and mapping the Australian Alps native vegetation. *Cunninghamia* 15: 185–199. <https://theaustralionalps.files.wordpress.com/2016/05/cunninghamia-classifying-and-mapping-the-australian-alps-native-vegetation1.pdf>
- McDougall KL and Walsh NG 2007. Treeless vegetation of the Australian Alps. *Cunninghamia* 10(1): 1–57. <https://www.rbg Syd.nsw.gov.au/getmedia/5229dc9a-18b9-4c48-b02b-235f0d430ad0/Cun101001McD.pdf.aspx>
- Milner R, Starrs D, Hayes G and Evans M 2016. *Distribution and the Ecology of the Broad-toothed Rat in the ACT*. Conservation Research Technical Report 35. Environment and Planning Directorate, ACT Government, Canberra. https://www.environment.act.gov.au/_data/assets/pdf_file/0006/995532/Technical-Report-35-BT-Rat-survey.pdf
- Morgan G 1997. Freshwater crayfish of the genus *Euastacus* Clark (Decapoda: Parastacidae) from New South Wales, with a key to all species of the genus. *Records of the Australian Museum* 23: 1–110. https://media.australianmuseum.net.au/media/Uploads/Journals/17835/429_complete.pdf
- Muller R, Nicholson A, Wooldridge A, Cowood A, Cook W, Jenkins B and Grant S 2017. *Hydrogeological Landscapes of the Australian Capital Territory*, Third Edition. Office of Environment and Heritage, Wagga Wagga. <https://researchdata.edu.au/hydrogeological-landscapes-hgl-third-edition/1460693>
- Mulvaney J, Seddon J and Orgill O 2017. *Monitoring Impacts of Sambar Deer (*Rusa unicolor*) on Forests in the Cotter Catchment, ACT: Monitoring design and initial findings*. Technical Report. Environment, Planning and Sustainable Development Directorate, ACT Government, Canberra. https://www.environment.act.gov.au/_data/assets/pdf_file/0003/1149015/Technical-report-MONITORING-IMPACTS-OF-SAMBAR-DEER-October-2017.pdf
- NSW NPWS 2007. Appendix 12 Weeds of the Kosciuszko region in *Rehabilitation Guidelines for the Resort Areas of Kosciuszko National Park*. NSW Department of Environment and Climate Change, Sydney. <https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Parks-reserves-and->

[protected-areas/Alpine-resorts/rehabilitation-guidelines-resort-areas-kosciuszko-national-park-appendix-12-070596.pdf?la=en&hash=CDAD8E8FB98520E55A12EC4F64B43A37D4C918C3](https://www.environment.act.gov.au/data/assets/pdf_file/0009/671274/ACTsnapshot_WEB.pdf)

NSW Office of Environment and Heritage 2014. *Australian Capital Territory: Climate Change Snapshot*. Office of Environment and Heritage, NSW Government, Sydney.

https://www.environment.act.gov.au/data/assets/pdf_file/0009/671274/ACTsnapshot_WEB.pdf

Osborne W 1991. *The biology and management of the Corroboree Frog (Pseudophryne corroboree) in NSW*. Species Management Report No. 8. National Parks and Wildlife Service, Hurstville.

Pickering C, Good R and Green K 2004. *Potential Effects of Global Warming on the Biota of the Australian Alps*. Australian Greenhouse Office, Australian Government, Canberra.

https://www.researchgate.net/publication/29458514_Potential_Effects_of_Global_Warming_on_the_Biota_of_the_Australian_Alps

Potter-Craven J, Kirkpatrick JB, McQuillan PB and Bell P 2018. The effects of introduced vespid wasps (*Vespula germanica* and *V. vulgaris*) on threatened native butterfly (*Oreixenica ptunarra*) populations in Tasmania. *Journal of Insect Conservation* 22: 521–532. <https://doi.org/10.1007/s10841-018-0081-9>

Pulsford S 2019. Evaluation of the photo monitoring of bog restoration after the 2003 fires. Unpublished report. ACT Government, Canberra.

Riek EF 1951. The freshwater crayfish (Family Parastacidae) of Queensland. *Records of the Australian Museum* 22(4): 368–388.

Robertson G, Wright J, Brown D, Yuen K and Tongway D 2019. An assessment of feral horse impacts on treeless drainage lines in the Australian Alps. *Ecological Management and Restoration – Special Issue: Feral horses in the Australian Alps* 20(1): 21–30. <https://onlinelibrary.wiley.com/doi/10.1111/emr.12359>

Saunders P, Buckle D, Hope G and Spooner N 1996. Namadgi National Park mountain occupation project: A multi-disciplinary investigation of an Aboriginal site complex in the Scabby Range, ACT. Report to Namadgi National Park, ACT Government, Canberra.

Schulz M, Schroder M and Green K 2019. The occurrence of the Broad-toothed Rat *Mastacomys fuscus* in relation to feral horse impacts. *Ecological Management and Restoration – Special Issue: Feral horses in the Australian Alps* 20(1): 31–36. <https://onlinelibrary.wiley.com/doi/10.1111/emr.12360>

Slattery D 1998. *The Australian Alps: Kosciuszko, Alpine and Namadgi National Parks*. UNSW Press Ltd., Sydney.

Steffen W and Hughes L 2013. *The Critical Decade 2013: Climate change science, risks and response*. Climate Commission, Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education, Canberra.

<http://www.climatecouncil.org.au/uploads/b7e53b20a7d6573e1ab269d36bb9b07c.pdf>

Theden Ringl F 2018. Common cores in the high country – the archaeology and environmental history of the Namadgi Ranges. A thesis submitted for the degree of Doctor of Philosophy. Australian National University, Canberra. <https://openresearch-repository.anu.edu.au/bitstream/1885/149482/1/Theden%20Ringl%20F%20Thesis%202018.pdf>

Thompson IR 2015. Hieracium. In Wilson A (ed.) *Flora of Australia 37 Asteraceae 1*. p128. Australian Biological Resources Study, Canberra and CSIRO Publishing, Melbourne. <https://www.awe.gov.au/sites/default/files/env/resources/ad128eeb-5a72-4129-9302-4d619cdca312/files/flora-australia-37-asteraceae-1.pdf>

Tozer MG, Turner K, Keith DA, Tindall D, Pennay C, Simpson C, MacKenzie B, Beukers P and Cox S 2010. Native vegetation of southeast NSW: a revised classification and map for the coast and eastern tablelands.

Cunninghamia 11(3): 359–406. [https://www.rbg Syd.nsw.gov.au/getmedia/b4f021cf-86e9-4eca-8f2e-058a7e574a3a/Volume-11\(3\)-2010-Cun113Toz359-406.pdf.aspx](https://www.rbg Syd.nsw.gov.au/getmedia/b4f021cf-86e9-4eca-8f2e-058a7e574a3a/Volume-11(3)-2010-Cun113Toz359-406.pdf.aspx)

Victorian Department of Sustainability and Environment (VDSE) (2005). *EVC/Bioregion Benchmark for Wetland Vegetation Assessment*. (EVCs 44, 171, 210, 221, 288-61, 288-62, 917 and 1011) Victorian Government Department of Sustainability and Environment, Melbourne.

Western A, Rutherford I, Sirawardena L, Lawrence R, Ghadirian P, Coates F and White M 2009. *The Geography and Hydrology of High Country Peatlands in Victoria Part 2*. The Influence of Peatlands on Catchment Hydrology. Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment, Melbourne.

Wahren C-HA, Williams RJ and Papst WA 1999. Alpine and subalpine wetland vegetation on the Bogong High Plains, South-eastern Australia. *Australian Journal of Botany* 47: 165–188. <http://www.publish.csiro.au/bt/pdf/BT97106>

Whinam J, Barmuta L and Chilcott A 2001. Floristic description and environmental relationships of Tasmanian *Sphagnum* communities and their conservation management. *Australian Journal of Botany* 49(6): 673–685. <https://www.publish.csiro.au/BT/BT00095>

Whinam J and Chilcott N 2002. Floristic description and environmental relationships of *Sphagnum* communities in NSW and the ACT and their conservation management. *Cunninghamia* 7(3): 463–500. [https://www.rbg Syd.nsw.gov.au/getmedia/d97e01ab-b040-47a7-971f-c73018b9ba94/Volume-7\(3\)-2002-Cun7Whi463-500-\(1\).pdf.aspx](https://www.rbg Syd.nsw.gov.au/getmedia/d97e01ab-b040-47a7-971f-c73018b9ba94/Volume-7(3)-2002-Cun7Whi463-500-(1).pdf.aspx)

Whinam J, Hope G, Good R and Wright G 2010. Post-fire experimental trials of vegetation restoration techniques in the peatlands of Namadgi (ACT) and Kosciuszko National Parks (NSW), Australia. In Haberle S, Stevenson J and Prebble M (eds.) *Altered Ecologies: Fire, climate and human influence on terrestrial landscapes*. *Terra Australis* 32: 363–379. <http://press-files.anu.edu.au/downloads/press/p18701/pdf/ch201.pdf>

Wild A, Roberts S, Smith B, Noble D and Brereton R 2010. Ecological Character Description: Ginini Flats Wetland Complex. Unpublished report to the Australian Government Department of Sustainability, Environment, Water, Population and Communities, prepared by Entura, Hobart.

Personal Communications

- S. Bond – Australian Bureau of Statistics
- G. Hope – Australian National University (deceased)
- F. Ingwersen – ACT Scientific Committee
- T. Macdonald – Parks and Conservation Service, ACT Government (past)
- B. Stevensen – Parks and Conservation Service, ACT Government (past)
- D. Whitfield – Parks and Conservation Service, ACT Government (past)

Other Acknowledgments

Many people have been involved in the restoration and monitoring of the ACT Bogs and Fens since the 2003 fires and by informing various versions of this Action Plan. Thanks is extended to the following contributors:

Greg Baines
Matt Beitzel
Mark Butz
Trish Bootes
Suzi Bond
Johannes Botha
Renee Brawata
Amanda Carey
Linden Chalmers
Rosie Cooney
Peter Cotsell
Col Depageter
Kelly Dobson
Mark Elford
Lisa Evans
Murray Evans

Roger Good
Geoff Hope (late)
Frank Ingwersen
Mark Jekabsons
Ben Kearney
Nathan Kay
Eliza Larson
Mark Lintermans
Rachael Loneragan
Jasmyn Lynch
Trish Macdonald
Alison McInnes
Clare McInnes
Nina McLean
John McRae
Bradley Mapiva

Antonio Mozqueira
Mary Mudford
Penny Olsen
Stephanie Pulsford
Louisa Roberts
Julian Seddon
Ben Stevensen
Steve Taylor
Brian Terrill
Heather Tomlinson
Kathryn Tracy
Wade Young
Jenny Whinam
Dave Whitfield
Genevieve Wright
Hannah Zurcher

Appendices



Releasing Corroboree Frogs in 2016 (Mark Jekabsons)

Appendix 1 (Extract from Commonwealth Listing (DEWHA 2009))

Typical native plant species found in Mainland Alpine *Sphagnum* Bogs and Associated Fens Ecological Community

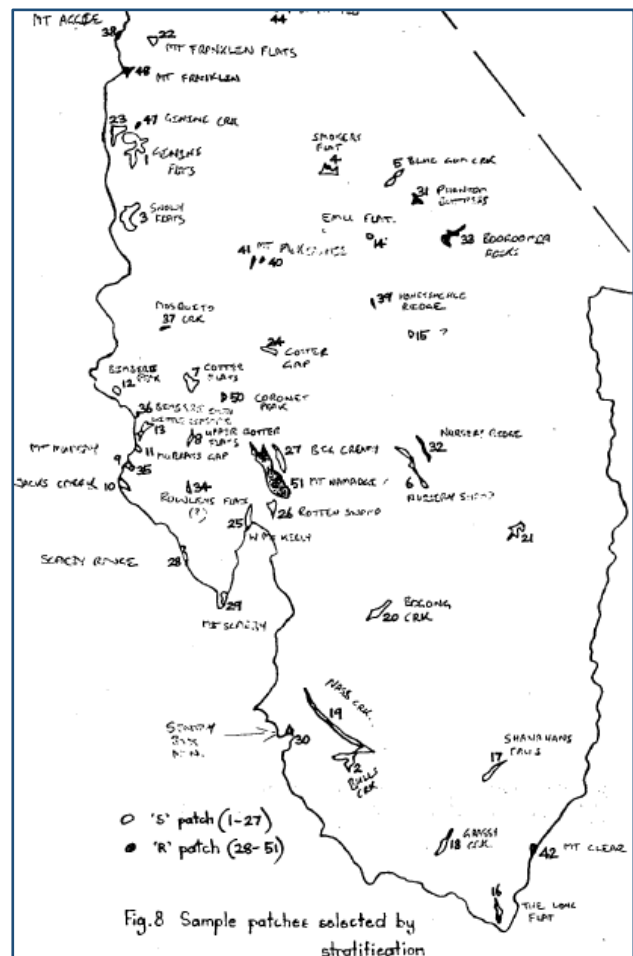
This list is indicative of plant species common to mainland alpine bogs and fens. It is neither comprehensive nor exhaustive and these species may not occur in every alpine bog, and other species may also be present (Ashton and Williams 1989, Kirkpatrick 1989, Whinam et al. 2001, Harris and Kitchener 2005, VDSE 2005, McDougall and Walsh 2007).

Bog	Fen
Mosses	Mosses
<i>Sphagnum cristatum</i>	<i>Sphagnum cristatum</i>
<i>Sphagnum novozelandicum</i>	<i>Sphagnum novozelandicum</i>
Herbs	Herbs
<i>Asperula gunnii</i>	<i>Brachyscome obovata</i>
<i>Brachyscome</i> spp.	<i>Deschampsia caespitosa</i>
<i>Caltha introloba</i>	<i>Epilobium gunnianum</i>
<i>Celmisia</i> spp.	<i>Lobelia surrepens</i>
<i>Epilobium gunnianum</i>	<i>Myriophyllum pedunculatum</i>
<i>Erigeron paludicola</i>	<i>Oreomyrrhis ciliata</i>
<i>Gentianella</i> spp.	
<i>Gonocarpus micranthus</i>	
<i>Nertera granadensis</i>	
<i>Oreomyrrhis ciliata</i>	
<i>Ranunculus</i> spp.	
Grasses, Sedges, Rushes	Grasses, Sedges, Rushes
<i>Astelia alpina</i>	<i>Carex echinata</i>
<i>Baloskion australe</i>	<i>Carex gaudichaudiana</i>
<i>Carex appressa</i>	<i>Carpha nivicola</i>
<i>Carex gaudichaudiana</i>	<i>Empodisma minus</i>
<i>Carex</i> spp.	<i>Isolepis crassiuscula</i>
<i>Carpha nivicola</i>	<i>Juncus falcatus</i>
<i>Empodisma minus</i>	
<i>Isolepis</i> spp.	
<i>Luzula modesta</i>	
<i>Oreobolus distichus</i>	
<i>Poa costiniana</i>	
<i>Poa</i> spp.	
<i>Restionaceae</i> spp.	
Ferns	
<i>Blechnum penna-marina</i>	
Shrubs	
<i>Baeckea gunniana</i>	
<i>Baeckea utilis</i>	
<i>Callistemon pityoides</i>	
<i>Epacris</i> spp.	
<i>Olearia algida</i>	
<i>Oxylobium ellipticum</i>	
<i>Richea continentis</i>	

Appendix 2 (Appendix 3 and 4 from 'Treeless vegetation above 1000m altitude in the ACT' (Helman and Gilmour 1985))

'Wet swamp and bog' patches

- 1 Cheyenne Flat
- 2 Sheep Station Creek
- 3 Snowy Flat
- 4 Smokers Flat
- 5 Blue Gum Creek
- 6 Nursery Swamp
- 7 Cotter Flat
- 8 Upper Cotter
- 9 Mt Murray Top Swamp
- 10 Mt Murray – Jacks Creek
- 11 Murray Gap
- 12 Mt Bimberi Top Swamp
- 13 Mt Bimberi South Swamp
- 14 Emu Flat
- 15 Orroral
- 16 Long Flat
- 17 Shanahans Falls Swamp
- 18 Grassy Creek
- 19 Upper Naas Creek
- 20 Boboyan Swamp
- 21 Booths Hill
- 22 Franklin Flat
- 23 Ginini Flat
- 24 Cotter Gap
- 25* Mt Kelly
- 26* Rotten Swamp
- 27* Big Creamy



'S' – wet swamp and bog patches

'R' – dry rocky patches

* These patches were not able to be surveyed in this study