Conservation actions for Australian alpine and sub-alpine peatlands

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A good practice guide for conserving and restoring alpine and sub-alpine peatlands across Australia

Alpine peatlands

Australian Alpine *Sphagnum* Bogs and Associated Fens (alpine peatlands for short) are wetlands with layers of partially decomposed organic matter (peat) that form when plant matter builds up in low nutrient, low oxygen, and often acidic waterlogged conditions. This ecosystem is made up of a complex of bogs (communities dominated by *Sphagnum* moss, rushes or shrubs with the peat surface above the water table) and fens (small pools dominated by sedges).

Alpine peatlands are listed as threatened under the EPBC Act 1999[1] and under legislation in each state they are found in. These unique ecosystems have a small and highly scattered distribution across the Australian Alps and Tasmania. They are imperiled due to damage from human activity, introduced hoofed animals, weeds, wildfire and climate change.

A healthy alpine peatland (photo: Joslin Moore)

The alpine water skink (Eulamprus kosciuskoi) in an alpine peatland in Bogong High Plains (photo: James Kidman).

About this guide

A national recovery plan[2] identified a wide range of management strategies and broad actions aimed at conserving this important ecosystem. Numerous conservation efforts are already underway, yet knowledge regarding best practice implementation and the effectiveness of management interventions is limited. This makes it challenging to identify effective strategies for conservation and filling this gap is an important priority for practitioners and researchers working in alpine peatland[3].

This guide is designed for those working to restore alpine peatlands that have been degraded. It is based on information gathered during a workshop series and individual pre-workshop interview on the experiences of 31 experts and practitioners working around Australia to conserve and restore alpine peatlands. During the interviews, experts evaluated the effectiveness of the management interventions they had experiences using in alpine peatlands. This information was expanded during the workshops by participants and synthesised to form the key recommendations and conclusions presented in this guide, an associated paper[4] and on the Atlas of Living Australia's BioCollect platform.

Importance of peatlands

Alpine peatlands provide habitat for endemic and threatened species, such as the critically endangered Southern Corroboree Frog, Alpine Bog Skink, and Brandy Mary's Leek Orchid[2]. These systems provide essential ecosystem services[1]. For example, peatlands are important for regulating the climate by storing carbon as peat. They also form the headwaters for many rivers that provide freshwater for cities and agriculture. Many peatlands are significant sites for Australia's First peoples.

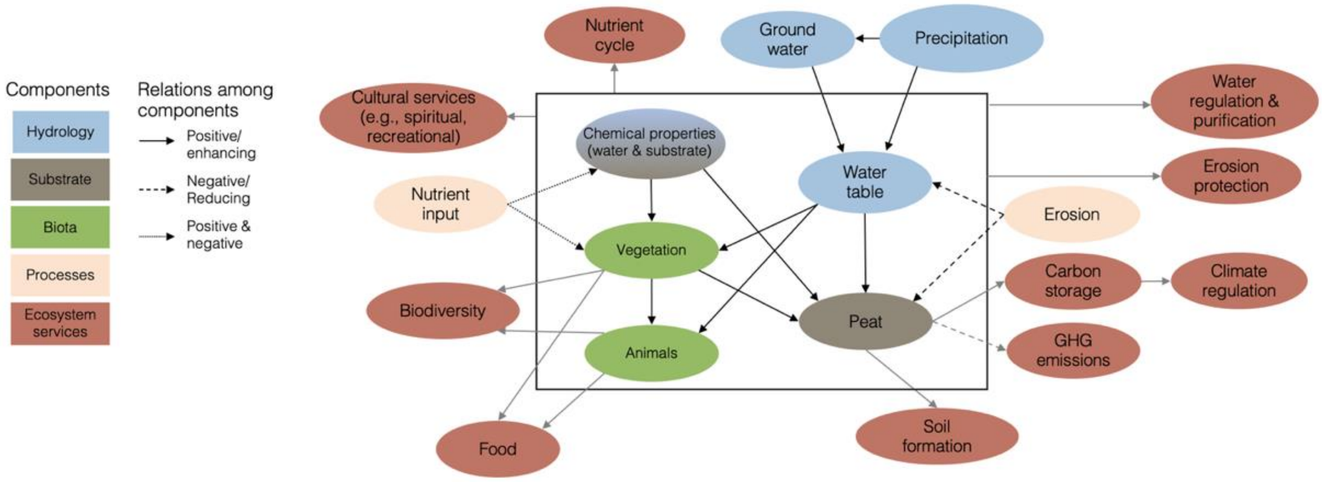
Key features to restore

Alpine peatlands are complex ecosystems with three core, highly interconnected components[5] that need to be repaired for restoration to be successful[6] (Figure 1):

- **Hydrology**: Alpine peatlands have waterlogged soils as precipitation and groundwater inputs exceed water loss, resulting in a high water table.
- **Chemical properties**: The characteristic high water table creates low oxygen (anoxic) conditions. Fens are nutrient rich and have slightly alkaline or acidic environments, while bogs are nutrient poor and acidic.
- **Key species**: Fens are dominated by water-tolerant grasses, sedges, and forbs, whereas bogs are dominated by water-loving mosses (notably *Sphagnum*), grasses, rushes and shrubs. Alpine peatlands are also home to a wide range of animals, from birds to invertebrates.

The waterlogged soils together with the characteristic chemical properties slow decomposition and allows organic matter to gather and form peat[5]. These conditions also support the distinctive vegetation, particularly *Sphagnum* moss and *Empodisma*.

Figure 1. Conceptual model of the peatland features, processes and the ecosystem services provided by peatlands. GHG = greenhouse gas. Modified from Rowland et al.[6]



Australian expert's insights

The management actions used in alpine peatlands can be divided into three board categories: actions to manage threats, actions to restore the structure and function, and policies and regulations. Managing and reducing the threats affecting these ecosystems is important if restoration is to be successful[7]. We show that there are many effective approaches to mitigating threats and restoring peatlands and highlight actions that were not recommended for use in Australia (Figure 2).

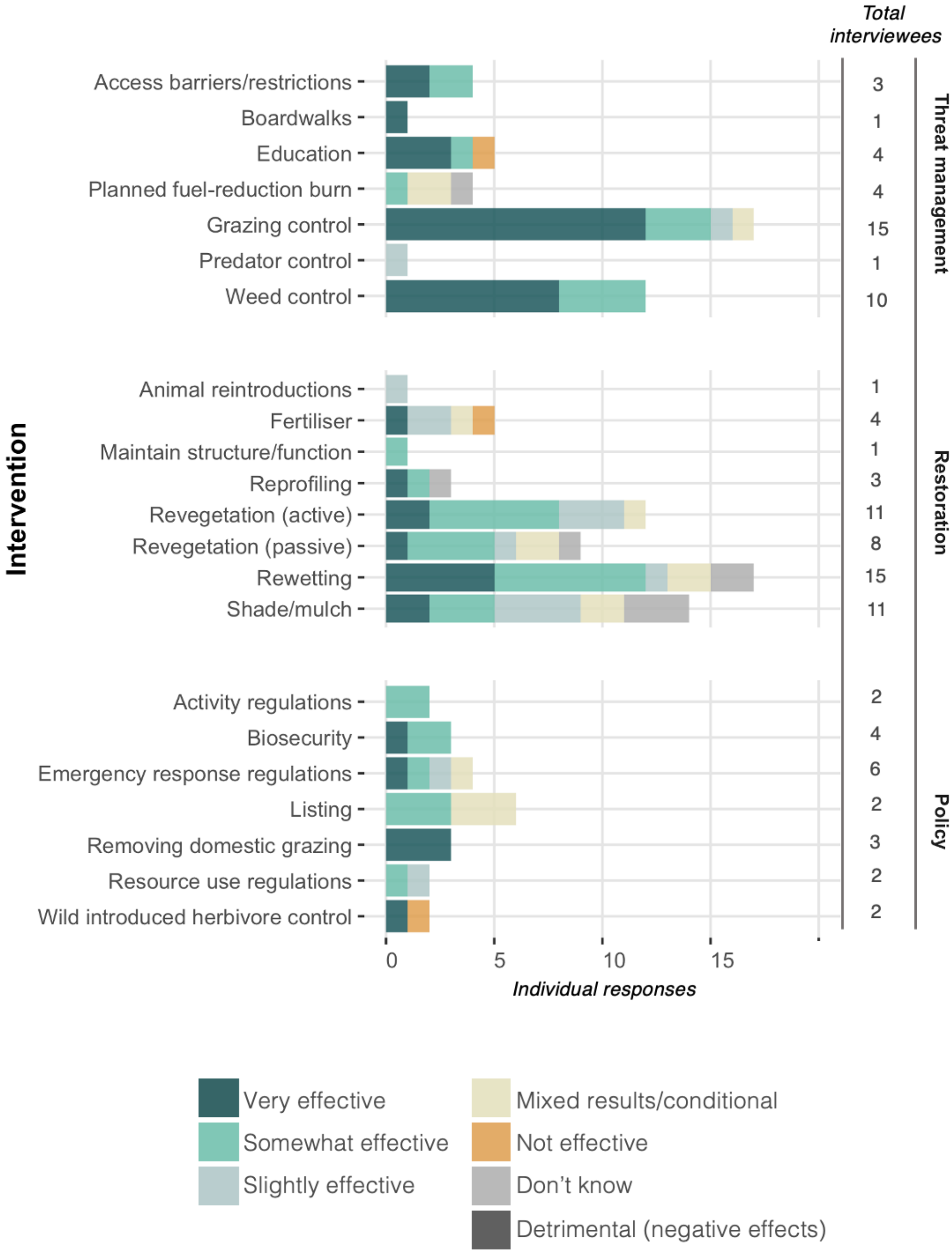


Figure 2. The effectiveness of management interventions, based on the number of responses from interview participants who had experience with each intervention. No interventions were reported as "Detrimental (negative effects)".

Threat management

Before restoration interventions can be used, it is essential that threats are removed or substantially reduced. Several interventions have been used to reduce threats in alpine peatlands, with varying degrees of success (Figure 2).

Alpine peatlands are greatly damaged by hard-hoofed livestock and feral animals, such as horses, deer, pigs, cows and sheep[2]. These species cause physical damage to the vegetation and soils[8], increases erosion and water drainage [8,9] and spread weeds and pathogens. **Excluding or reducing density of introduced herbivores**, particularly cattle, has led to the rapid recovery of native vegetation and hydrology. The rate of recovery varies with level of damage and relies on these animals remaining absent (e.g., by maintaining fences) and the

Willow seedling in an alpine peatland (photo: Joslin Moore).

absence of fire. Reducing deer and horse abundance via shooting or trapping and removal has been more challenging and less successfully implemented than cattle exclusion[8,10] due to being more cryptic (deer) or controversial (horses) to manage. The effectiveness of population reduction programs varied depending on whether there was sustained control to keep populations low. There are no/few studies examining how impact varies with density.

Introduced plant species have increased in abundance due to fire, past land use and human activities[2], particularly grey sallow willow (*Salix cinerea*) and soft rush (*Juncus effusus*)[2]. These species outcompete and replace the peatland vegetation[11,12] and alter the hydrology[13]. **Herbicides and physical removal** of weeds has effectively reduced the presence/abundance of weeds in many sites. The effectiveness of these programs can vary among species (e.g., due to detectability), invasion extent and site accessibility, and requires ongoing management. No information exists on the benefit of weed control for native plants, ecosystem processes or function (including hydrology).

Introduced predators such as foxes and cats can kill native species, such as the broad-toothed rat and crayfish[2,14]. Trapping of feral cats and foxes across the alpine zone has been slightly effective at controlling feral predator populations, although this program did not specifically target alpine peatlands.

Fire frequency is expected to increase under climate change, posing a big threat to alpine peatland persistence. Fire can cause soils to become dry and hydrophobic[15] and facilitate weed invasion[16]. Fire itself is challenging to manage once it enters a peatland. Management has focused on reducing the chance of fires spreading into peatlands by doing **planned fuel-reduction burns** of surrounding ecosystems. However, there is a lack of evidence of whether this reduced the risk of burning during a fire as it is difficult to establish causality.

Human activities have increased in alpine areas over the past few decades; Bushwalking and bike tracks have been constructed, and there has been an increase in off-track walking, horse riding, and four-wheel-drive use[2]. This can physically damage the vegetation and soils as well as alter the hydrology and spread weeds and pathogens[17]. **Installing boardwalks** for hikers has stopped human trampling as walkers like using them. However, the impact of installing the boardwalk and the construction materials must be considered as timber boardwalks (unlike steel) are susceptible to burning during wildfire, damaging surrounding vegetation. Positioning **road barriers** to block access by vehicles has been effective at removing vehicle impacts and allowing the vegetation and peat to recover, but only if the barriers remain in place.

A key factor limiting effective conservation of alpine peatlands is the lack of appreciation by the public and decision makers of their value for biodiversity and society, and the huge impacts of various threatening processes[10]. **Educating** the public on weed control and local landowners on the value of alpine peatlands and the actions they can take to minimise damage from sheep, fires and harvesting on their land has been an effective for improving public

Alpine peatland degraded from trampling by introduced hard-hooved herbivores (photo: Khorloo Batpurev).

Dry alpine peatland (photo: James Kidman).

knowledge and changing their behaviours. But detailing the results of modelling of potential timing and impacts of climate change in the Australian Alps had less success in changing policy and on-ground management.

Restoring alpine peatlands

Restoring degraded alpine peatlands is important for addressing climate change, conserving biodiversity and supporting human wellbeing[18,19]. There are several methods that span the three core parts of peatlands – hydrology, chemical properties, and biota.

Rewetting and shading/mulching were often effective at improving the hydrological conditions and vegetation, reducing erosion, and associated with the presence of crayfish. **Rewetting** has been used to rehydrate soils where they have been drained. Rewetting is most effective when drainage points are blocked with coir logs or hessian bags with wood chips, the peatland is in better initial condition, water level is high, water moves slowly through the system, the gradient is not steep, and where rewetting occurs alongside permanent removal of introduced herbivores. Rewetting may not protect peatlands from wildfires occurring nor degradation from drought. Peatlands can recover naturally over time, so rewetting may not always be necessary.

In degraded peatlands, **shading** the surface with shade cloth that are not too dense (30% shade cloth better than 50% shade) and placed horizontally can be a useful approach to prevent drying of surfaces and vegetation to support recovery of vegetation after a disturbance. This is particularly effective when done alongside active planting of *Sphagnum*, and where there is slow flowing water at the site to be effective at supporting vegetation regrowth. Although, the positive effects only last a few years, shading may not be needed to support revegetation in the long term, and this may not be a cost-effective intervention to use across large areas. **Mulch** (e.g., hay) has been less effective as it lacks longevity in the environment by breaking down or blowing away.

Reprofiling and applying fertilisers successfully helped restore the characteristic water and substrate chemistry after degradation caused by wildfires, introduced herbivores and land-use change (Figure 2). Removing degraded topsoils or altering the landform of peatlands to change water flow (**reprofiling**) at small scales can lead to wetter soils and in some cases revegetation. However, it can be very difficult to re-establish wetland vegetation once soil is disturbed. **Fertiliser** (e.g., Osmocote native vegetation pellets) has been trialed to alter the site chemistry post-fire and grazing to support regrowth of vegetation and reinstate peat formation. It can effectively reduce alkaline conditions and increase native vegetation regrowth within years of application but has smaller long-term benefits due to natural recovery and potential changes in vegetation composition. Fertilisers need to be carefully applied to avoid over-fertilisation and weed invasions; apply on bare surfaces and do not use along edges of peatlands to avoid encouraging weed invasion.

Researchers taking water quality measurements at a peatland in the Bogong High Plains (photo: Joslin Moore).

Recovering the native vegetation is an important step in alpine peatland restoration. **Planting native vegetation** or allowing plants to **naturally regrow** (passive revegetation) are commonly used and effective approaches to support recovery of vegetation after disturbances such as fire and grazing, provided the threatening processes have stopped. The ceasing of threats, planting technique, level of shade, wetness and extent of planting are the main factors affecting the success; Wetter, shadier sites tend to show the most recovery, and using *Sphagnum* plugs alongside peat was more successful than *Sphagnum* plugs alone on a small scale. Natural regeneration of vegetation after a disturbance has been very effective, with most bogs recovering, but at different rates.

Animal reintroduction programs have been used to conserve threatened animals, with minor success. Amphibian Chytrid Fungus Disease is an infectious disease that has led to large declines in the Northern Corroboree Frog[20]. Captive bred frogs have been reintroduced into alpine peatlands, but the population is not self-sustaining as chytrid fungus persists in the environment.

Policy and regulations

Policy is a useful approach to protecting alpine peatlands but had highly variable effects among types of policy. **Nationally listing** the ecosystem as threatened has highlighted their significance, increased awareness of threats, directed funding toward peatland management, and ensured that proposed developments trigger an impact assessment to avoid or minimise impacts. Although overall it had varied impact because listing, and individual policies in general, rely on other co-occurring policies and management to be effective at addressing persistent threats (especially horses and climate change).

Regulations to remove domestic grazing substantially reduced/eliminated cattle populations on peatlands and thus reduced trampling pressure (Figure 2). **Regulating populations of wild introduced herbivores** (horses, deer) was more effective at reducing the abundance of horses and thus trampling pressure in the ACT than in NSW, likely due to differences between policies.

Physical damage can occur during fire response activities, such as damage from trucks and fire retardants. Implementing **emergency response regulations** is effective at minimising damage and burn risk, where the guidelines are followed during an emergency. This is enhanced when there is support from the incident management team and there is collaboration between fire teams and land managers during a fire. Effectiveness depends on the nature of the fire itself; protecting human life and property are the priority in large, fast-moving fires.

To limit the spread of weeds and pathogens, **biosecurity protocols** such as cleaning vehicles and tools before and after visiting a peatland are effective at changing human behaviours and limiting the spread of pathogens, when there is strong compliance. **Regulating use of resources** (water, *Sphagnum*, peat) and **regulating recreational activities** in national parks (e.g., campfires, horse riding) were also effective at reducing degradation from human activities.

An alpine peatland in the Bogong High Plains (photo: Abbey Camaclang).

Actions not recommended

Cutting, mowing, or grazing (using introduced hard-hoofed animals) are methods used overseas to manage the vegetation by maintaining a disturbance regime. These are not recommended by experts in Australian peatlands because they do not have a history of disturbance regimes.

While **planned ecological burns** have been used overseas to control problem plant species[6], the experts do not recommend this in Australia as it is more likely to degrade peatlands than benefit them.

Conclusions

Managers and practitioners have been actively working at restoring and conserving alpine peatlands across Australia. This factsheet provides recommendations for which interventions are effective and under which conditions, which interventions are ineffective and those needing more information to support researchers, managers, and decision makers to effectively conserve peatlands. There is evidence that not intervening in some circumstances can have positive outcomes for alpine peatlands, if threats are eliminated.

These recommendations are a broad overview of the experiences and perspectives of experts working in this space. Importantly, the effectiveness of each intervention will depend on the specific context of each peatland. To make our findings accessible, we have developed a website outlining the experts' management experiences alongside evidence from published scientific papers and reports (see *Cited material*).

Further information

This guide was prepared by Jessica Rowland, Joslin Moore, and Jessica Walsh with input from participants at an expert workshop hosted by NESP Threatened Species Recovery Hub in February 2021 (see Acknowledgments).

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This fact sheet summarises key findings of Rowland et al.[4]

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