

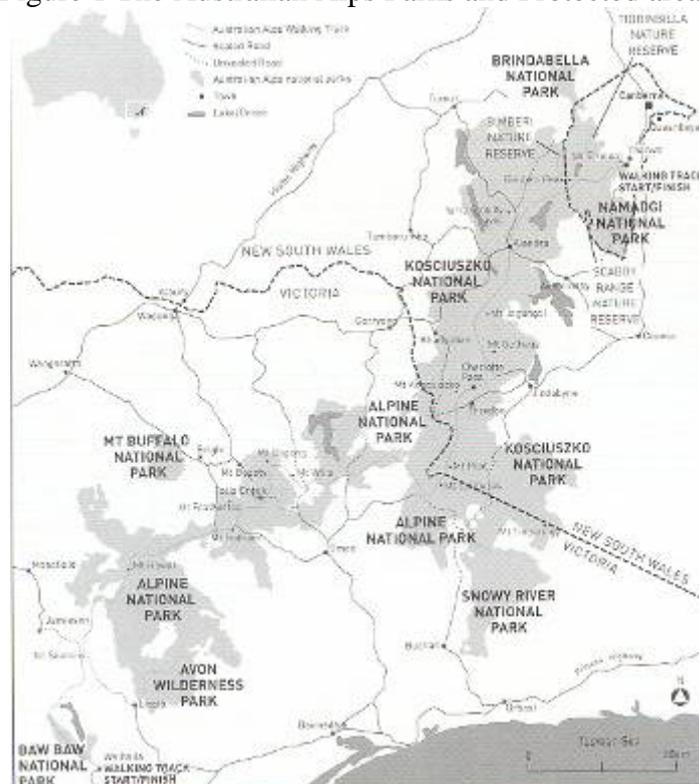


## Restoration of Mires (bogs and fens) in the Australian Alps following domestic stock grazing and the impacts of the 2003 wildfires.

### Background

A number of wildfires have burnt across the Alps in past years, the most extensive being the 1939 and 2003 wildfires. The 2003 fires burnt some 1.5m hectares, the majority of which was within the Alps National Parks in New South Wales (NSW), Victoria and the Australian Capital Territory (ACT) (fig 1).

Figure 1 The Australian Alps Parks and Protected areas



Some 8500ha of alpine mires existed in the Alps at the time of European settlement but approximately half of this area was destroyed by cattle and sheep grazing during the grazing era (1830s to 1960s in NSW; to 2004 in Victoria.).

During the 2003 wildfires almost all the alpine, subalpine and montane mires (bogs and fens) were burnt, with a further loss of about 15 percent of the functional bogs and fens existing at the time. Immediately following the fires it was recognised that many bog and fen areas were at immediate risk due to post-fire runoff and subsequent peat incision, peat drying and erosion, unless some remedial actions were taken.

A program of restoration and revegetation of the burnt bogs and fens has been and continues to be implemented by the managers of the individual national parks within the Alps National Parks Co-operative Management Agreement. This restoration work aims to initiate and enhance the capacity of the bogs and fens to fully recover their functional hydrological role in the mountain catchments; that of storing large quantities of snowmelt and runoff water; regulating and spreading flow regimes in downstream creeks and rivers throughout the year, as well as filtering sediments and other pollutants from the runoff flows. At saturation the bogs and fens can hold up to 300 litres of water per cubic metre of peat, highlighting the significant role of the mire ecosystems (Fig 2).

The alpine and subalpine *Sphagnum* bogs and associated fens were recently listed as a threatened ecological community, recognising both the significance of the ecosystems and the threats to their continued existence.

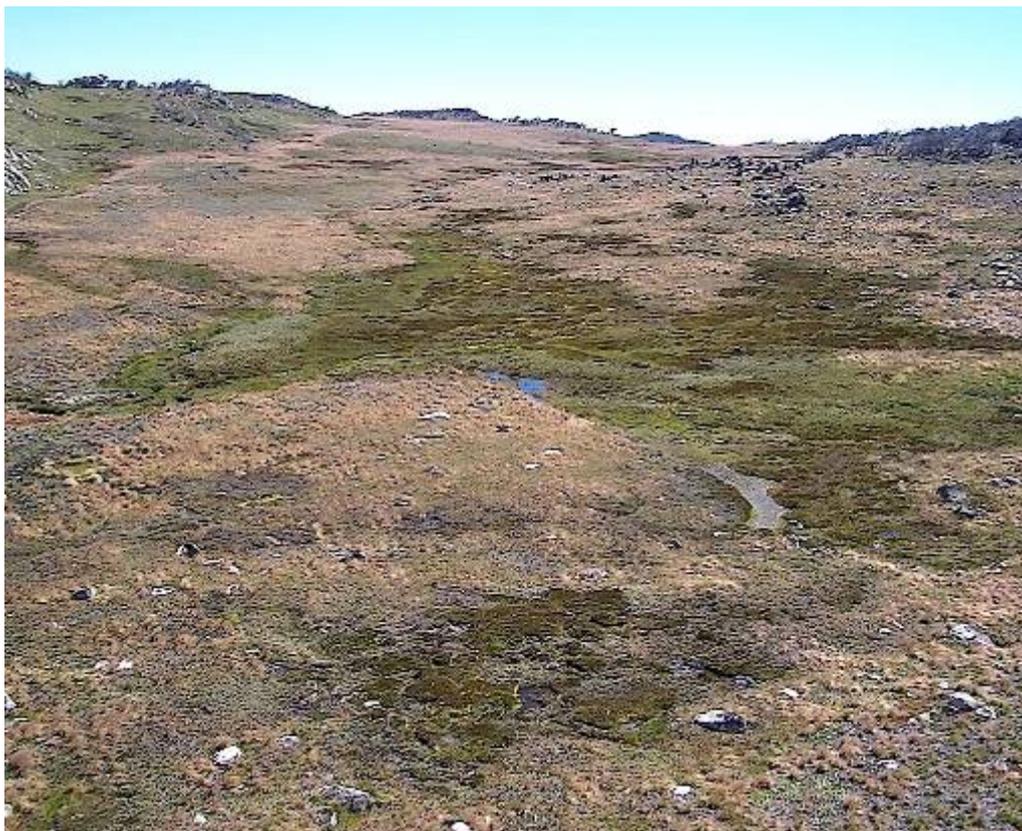


Figure 2 A large valley bog extensively burnt during the 2003 bushfires.

### **Stakeholders and Budget.**

The mire restoration program was commenced in 2003 under the auspices of the Australian Alps Liaison Committee (representatives from the Alps National Parks in NSW, Victoria and the ACT as well as the Commonwealth Government) and carried out through the planning and supervision of the 'Alps Mire Restoration and Research Group'.

The program of restoration was commenced with special post-fire funding from the individual States (NSW and Victoria) and Australian Capital Territory governments, parties to the Alps Agreement. A total amount of approximately \$2.5 million was initially allocated to the program, with subsequent funding and in-kind support being provided by research personnel from the Australian National University (Prof. Geoff Hope), the Tasmanian Department of Primary Industry and Water (Biodiversity Conservation Branch) (Dr Jennie Whinam), and La Trobe University (Vic) (Dr Arn Tolsma). Additional funding has subsequently been provided by individual National Parks and their respective State and Territory government Departments, as well as the Natural Heritage Trust.

### **Ecosystems and Impacts.**

The Alps bogs and fens are only two of the Alps ecosystems severely impacted by the 2003 fires but were recognised as playing a functional role in the storage, flow regulation and filtering of snow-melt and runoff flows, and therefore were identified as the priority ecosystems for post-fire restoration works. It was also recognised that restoration of the fire-damaged communities of the bogs and fens, would involve the enhancement or re-establishment of a stable *Sphagnum* moss and *Empodisma spp.* vegetation cover and most significantly, the restoration of the water holding and filtering capacity of the under-lying peats of the bogs and fens.

At the time of the 2003 fires many of the bog and fen areas were still recovering from the impacts of stock grazing, some 40 to 50 years after the time of removal of the stock from the Alps. Due to the long 2000 to 2003 drought the bogs and fens were also in a dehydrated condition that enabled burning of the vegetative cover and the under-lying peatbeds in a number of significant areas. Following the 2003 wildfires, a number of these bogs and fens were so severely impacted that they were beyond restoration but many suffered less impact and were identified as being in a condition that would benefit from the implementation of specific restoration works. The impacts of the fires varied with the intensities and the rate of spread of the fires at the time the bogs and fens were burnt. The impacts ranged from minor burning of some *Sphagnum spp* (moss) hummocks, to complete destruction of the bog and fen vegetative cover, to partial to complete burning of the underlying peatbeds, the latter resulting in the loss of the functional role of the peatbeds and hence total loss of the ecosystem service the bogs and fens provide to catchment water yields, flow regulation and runoff filtering. The area of bog and fen lost as a result of the fires was approximately 375 ha.

Restoration works were applied to approximately 130 bogs and fens, covering an area of approximately 1100ha of the total bog and fen area burnt by the fires. All the restoration works were underpinned by earlier ecological research and restoration experience accrued from the alpine area post-grazing restoration and revegetation program carried out over a 15 year period between 1960 and 1974.

## Restoration goals and planning.

The first objective of the Mire Restoration and Research Group was to develop a set of criteria from which the priority bog and fen areas for restoration could be determined. These were:

1. *Extent of degradation* – including (a) the amount of vegetation lost during the fires, (b) if peat incision had begun and (c) if the soils had become hydrophobic following the fires.
2. *Recoverability* – some potential for recovery had to be evident. While clearly affected by the fire, some vegetation (including *Sphagnum* and *Carex* species) needed to be present and the peatbeds still intact.
3. *Size and extent of peat beds* – with consideration to catchment value.
4. *Significance in terms of catchment value* – whether the catchment drained into an important river system or was part of a closed system?
5. *Location* – both within the landscape and the catchment. Valley bottom bogs especially targeted due to their deeper peatbeds and upper catchment mires targeted to retain water in the catchment.
6. *Access availability* – ease of access to get materials to the site in terms of time and costs.
7. *Cost benefit of rehabilitation* – restoration activities to be of greatest cost / benefit to catchment protection and values.
8. *Past history of damage* – eg. Extent of damage by earlier grazing periods.
9. *Iconic importance* – some areas have significant iconic importance. eg Pengilly's bog in Kosciuszko National Park had a large Corroboree frog population prior to the fires and retained the potential for supporting reintroduced populations.
10. *Education value* – bogs that could be used to illustrate management issues and functional processes were a priority.
11. *Long term monitoring potential* – Issues such as access, location and importance were considered in selecting long term monitoring sites.

The second objective was to establish the most appropriate techniques for restoration of these sensitive ecosystems within the significant catchments and within the major conservation areas (Alps National Parks). The general strategies for the restoration program were:

1. To assist and promote the regrowth of *Sphagnum*, *Empodisma*, *Carex* and other bog and fen vegetation species;
2. to slow the rate of water movements both into and within the bogs and fens to reduce the potential for peat incision, and channel entrenchment;
3. to restore where possible the functional hydrological role of the bog and fen communities in the catchment,
4. to implement sound ecologically based techniques that would ensure sustainability of the restored sites,
5. To implement a research and monitoring program as an integral part of the rehabilitation works such that the success of the program could be assessed in future years.

The third objective was to develop a program, through the Alps National Parks Cooperative Management Agreement, so that all restoration works would be undertaken concurrently and with the same or similar techniques in the individual national parks of the Alps within each jurisdiction (NSW, Victoria and the ACT).

The fourth objective was to ensure knowledge transfer between the research personnel, restoration specialists, national park staff and non-government organization volunteers involved in the program. To this end a number of workshops and forums were planned and have subsequently been held, with a further major workshop to be held in 2009 to review the success of the program and the wider consequences to other ecological restoration programs in other biomes and environments.

### **Project implementation**

Research and experience from earlier alpine area rehabilitation work undertaken in the 1960s and 1970s following the removal of grazing from the alpine area in NSW, indicated that the recovery of the hydrological functioning of restored bogs and fens would take up to 30 to 40 years to achieve. The restoration works were therefore aimed only at initiating and enhancing the recovery processes.

The basic techniques for the restoration of these ecosystems and entrenched flowlines are relatively simple and involve the shading and protection of the remnant bog and fen plant populations, particularly *Sphagnum* species, from desiccation; the construction of straw-bale dams in flowlines; the construction of subsurface straw-bale dams; and the placement of coir and straw-filled jute mesh 'logs' as surface water-spreaders and sediment traps. The most important step in the rehabilitation program is to slow surface flows to prevent flowline entrenchment and to create pools of surface water where *Sphagnum spp* can regenerate and the pooled water can spread laterally through the peats, subsequently restoring the hydrologic regime of the bogs and fens.

Following the implementation / placement of any straw bales as flow-control structures, sods of *Sphagnum* and *Carex* species were subsequently planted into them to hasten the recovery of the species and to assist the integration of the organic materials into the peat complex. In most pools, silt deposition has occurred and *Carex* sods have been planted into the sediment fans. The rehabilitation techniques and materials used are outlined below but should not be considered as the only techniques and approaches that can be used in such programs.

#### (ii) Spreading and diversion of inflows to the bogs and fens.

The initial works at each site was to identify any entrench flows into the bogs and fens and to plan a system of water spreading works such that flows into the bogs were slowed and spread across the entrant slope. This was done to reduce the potential for flowline incision through the bogs and fens as a result of concentrated and high flows; or to reduce flows through any bogs already heavily incised.

Where water-spreading was required it was achieved through the placement of coir

logs and straw bales across the slopes above the bogs. These structures diverted excess flows while the porous structure of the coir logs and straw bales provided for leakage through them into the bogs and fens (fig 3).



Figure 3. Coir logs placed on the contour to prevent flow-line formation and to act as water-spreaders of surface runoff into bogs and fens.

#### (ii) Ponding and control of peatbed incision

Immediately after the fires heavy rainfall events were expected and did occur resulting in increased run-off flows, this causing flowline incision, deep channel development and destruction and loss of the natural pools within the bogs and fens. The techniques to prevent flowline incision within the bogs and fens involved the placement of straw bales in inflow and outflow channels to recreate surface ponding and slowing of the flows from the sites. The ponding provided the opportunity for regeneration of a fringing water- edge *Sphagnum* community and re-saturation of the underlying peatbeds (figs 4 & 5)



Figures 4 and 5. Hay bales inserted into low rate flow areas, to spread water into the surrounding peatlands and to form stable pools for the re-establishment of fringing *Sphagnum* hummocks.



In areas where high flow rates and substantial vertical incision of the peat had developed, channel depths of a metre or more were evident. It was also found that once incision to bedrock had occurred, lateral erosion of the peat up to two metres either side of the incised flowline was evident, with subsequent peat collapse and loss of the peat from the site if no remedial action was taken.

Reducing flows in these areas was also achieved through the packing of straw bales into the incised flowlines (fig 6), with hessian bags filled with straw being inserted into areas of undermined peatbeds, to provide support for the peat.



Figure 6. Three or four layers of straw bales packed into an incised flowline to prevent lateral undercutting and peat collapse.

#### (iv) Gully-line bank protection

In many sites where deep gullies had developed as a result of peat incision, collapse and erosion, the increased flows in the gullies resulted in rapid undermining of bank edges that required techniques and materials to divert water flows away from the bank edges. Two approaches were taken involving pool creation and barrier insertion. While pools acted to slow high flows into an area being actively eroded, diversion barriers acted to divert the flows away from peat streambanks that were being undermined and, in some places to retain sediment to rebuild the stream banks. Coir

logs (coconut fibre wrapped in a jute mesh) were placed (1 to 4 layers) into the undermined flowline banks and fastened with steel pins (fig 7).



Figure 7. Coir log used as a barrier in a creek to prevent further undercutting of peat flowline banks

(v) Subsurface Straw-filled Dams.

In several large dehydrated and drained bog areas, trenches were cut through the peatbed down to the underlying gravels or bedrock (1 to 2.5 m) and then filled with one to three levels of straw bales (fig 8). This was done to provide a subsurface semi-impervious organic ‘dam’ to assist the wetting of the peats from surface and subsurface inflows. After placement the straw bales were covered with sods of peat and bog vegetation (*Sphagnum*, *Carex* and *Empodisma spp*), the straw bales eventually decomposing, and being incorporated into the peat mass. This was a drastic measure to impose on several bog areas but was deemed essential if the bogs were to regain their water-holding capacity and their hydrological functioning effectively restored. This technique has achieved its goals, with no apparent or obvious detrimental impact on the structure of the mires.



Figure 8. One hundred metre long subsurface ‘straw-bale dam’ (partly exposed for demonstration) to assist the retention of inflows in the peat during resaturation.

(vi). Vegetation Shading

Not all vegetation was destroyed by the burning-over of the bogs and fens and in some bogs *Sphagnum* moss hummocks still existed. In other bogs, the *Sphagnum* exhibited small patches of regeneration from within the core of the *Sphagnum* hummocks, with growth being assisted by some shading from overhanging dead shrub material and other dead herbaceous organic matter.

Initially, in order to further increase the potential for *Sphagnum* recovery, sterilized straw-mulch was spread over remnant *Sphagnum* hummocks that exhibited some post-fire recovery. The straw was spread at a rate of approximately 2 tonnes per hectare, loosely spread to a depth of 3-5cm. This rate of application provided approximately 70% shading for the underlying vegetation; a level of shading previously identified as optimal for initiating and enhancing *Sphagnum* regeneration.

Due to the difficulty of transporting heavy and bulky straw bales to remote sites, commercial shade cloth (fig 8) was trialled and was found to be a suitable alternative, being easier to apply and longer-lasting than the straw shading material. Some 6000 square metres of shade cloth has been placed over *Sphagnum* hummocks in bog and fen sites in Kosciuszko and Namadgi National Parks with noticeable benefits to plant growth and health, evident after only two years.



Figure 8. A 600 square metre shade cloth cover over core *Sphagnum* hummocks in a significant bog site.

### **Progress to date**

A total of approximately \$2.6million has been expended to date with some 130 bogs and fens having had some rehabilitation works implemented in them. Some 300 ha of bog and fen ecosystem have been restored to functional and stable mires, with large areas of adjacent shrub and grassland ecosystems benefiting from the improve soil moisture regime accruing from the mire restoration works. All bogs and fens to which restoration works have been applied / implemented have recovered from a dehydrated state to a saturated state, although the recovery of this condition has taken between 15 months and 5 years to reach, while a complete bog and fen vegetation complex will still take many years to achieve.

The rehabilitation work is nearing completion (2009/10) but the associated mire mapping and monitoring programs will continue for at least a further 5 years and 15 years respectively.

Six workshops for staff of the three agencies involved in the program have been held during the course of the program and four field based workshops held for other interested personnel eg NGO volunteers, local government, and for Catchment Management Authorities to educate and train staff in mire rehabilitation techniques and approaches.

Presentations on the program have been given at six scientific symposiums / conferences and as part of four Australian Network for Plant Conservation rehabilitation workshops.

### **Monitoring and research links.**

The program has been underpinned by research and field trials, which were first, commenced in the 1950s by CSIRO personnel (Dr Alec Costin and Dane Wimbush), and subsequently by Alps research and field restoration staff of the NSW Soil Conservation Service.

More recently the research and monitoring program has been supported by further research and specific field rehabilitation trials by Australian National University (Prof G.Hope and Dr Rachell Nanson), La Trobe University (Drs John Morgan, Arn. Tolsma, and Warwick Papst), Tasmanian Department of Primary Industries and Water (Dr Jennie Whinam) and NSW, ACT and Victorian National Parks staff (Ms Gen Wright, Dave Whitfield, Ms Elaine Thomas, Roger Good and others). The sharing of research and monitoring data has been maintained through the program of workshops and scientific forums coordinated by the Australian Alps Liaison Committee, which oversees the Alps Parks Cooperative Management Program. Several post-graduate bog and fen ecological research programs have also been carried out over the past five years, as part of the overall bog and fen restoration program (Dr Sam Grover and Andrea White).

Eight papers and a number of other presentations have been made at scientific and Alps ecological management conferences over the past six years, including two international conferences.

### **Lessons learned**

Important lessons have been learnt during the program in terms of the techniques implemented to assist the re-saturation of peatlands (peat trenching and damming, peat tunnel blocking, and pooling of incised flowlines through the bogs); recreation and restoration of permanent bog and fen pools and the re-establishment of *Sphagnum* mossbeds (artificial shading), as well as the development of new rehabilitation / restoration materials (now commercially available).

Importantly, several of the techniques developed and implemented have been considered appropriate and have already been implemented in a number of stable undisturbed bogs and fens, as part of an associated program to enhance mire survival capacity and resilience under predicted climate change regimes.

New techniques for the mapping and monitoring of mires have also been developed in association with research personnel from the Australian National University, La Trobe University, Tasmanian DPIW, the ACT water catchment authority (ACTEWAGL) and ACT environment research personnel, and NSW Department of Environment and Climate Change (National Parks).

The techniques and approaches to ecosystem restoration have been taken up by

several other land and wetland management agencies in other bioregions and environments and interest in the program has been expressed by mire management personnel from Austria and the United Kingdom.

### **Further reading**

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