Fire Biodiversity
in the
Australian Alps National Parks

Workshop Proceedings
Albury NSW 2005

AUSTRALIAN ALPS NATIONAL PARKS

State Government Victoria Department of Sustainability and Environment

Parks Victoria

Report compiled by Trish Macdonald for the Australian Alps Cooperative Management Program

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INTRODUCTION

The fires of January and February 2003 burnt a total of nearly 2 million hectares across the Australian Alps, including 68% of the Australian Alps national parks. This event posed significant challenges to each of the Alps management agencies. Initially agencies were focused on dealing with their specific challenges in their own regions.

In 2004 the Australian Alps Ministerial Council, through the Australian Alps Liaison Committee, appointed an Expert Scientific Panel to review the environmental-recovery operations of the relevant State agencies following the fires and to make recommendations on policy matters and on potential projects.
The Panel recommended that:
On policy matters:

- The Parks Agencies explicitly declare themselves 'learning organisations', thereby embodying the principle of continuous assessment of practices and outcomes whether these concern rehabilitation works, achievement of the aims of management generally or increasing the skill and knowledge of staff.

- The Parks Agencies facilitate the provision of on-going workshops, lectures and field studies, possibly with external organisations, which enhance the knowledge of staff and the public about the ecological effects of fire regimes on explicit natural and cultural assets.

- The Parks Agencies collectively determine cross-agency fire mapping standards for comprehensiveness, accuracy, precision, storage, retrieval and validation, for both prescribed and unplanned ('wild') fires.

- The Parks Agencies review their protocols for the exchange of information, ideas and expertise in relation to the effects of unplanned and prescribed fires between agencies and with external stakeholders.

- The AALC review policy structures within agencies to ensure that unplanned Alps fires automatically become subject to protocols for co-operation in terms of suppression and any rehabilitation action.

- The AALC review the opportunities and protocols for post-fire collaboration on issues where inconsistencies in current management exist or potentially exist.

- The Park Agencies continue to use their publicly approved management plans in the immediate post-fire period as a matter of course.

- The Park Agencies consider further cooperative funding of projects outside the AALC process, to maximise the benefits of a combined Agency approach.

The Panel recommended a series of **Projects** in the following themes:

- Assessment of the impacts of firefighting methods on the environment: where and when are these methods ecologically and economically appropriate?
- Fuel mapping and strategic fuel measurement.
- Strategic prescribed burning.
- Which between-fire interval when, and where?
- Effects of fire regimes on the natural environment.

- Weather assessment in the Alps.
- Documentation and analysis of fire histories.
- Bibliography of Fire in the Alps: Ecology, Behaviour, and Management.
- Identifying sensitive sites in relation to erosion-degradation potential.
- Standards and criteria for post-fire rehabilitation.

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.

Following on from the publication of this report the Australian Alps Cooperative Management Program along with Parks Victoria and the Department of Sustainability and Environment hosted a 2-day workshop for researchers and managers in Fire Recovery Biodiversity, to facilitate cross agency cooperation

WORKSHOP OBJECTIVES

The aims of the workshop were to:

- Bring together key people that are planning and implementing on-ground flora & fauna research, monitoring and restoration following fire in the Alps
- Provide an opportunity for researchers to share information, results & techniques
- Identify actions that need addressing and further opportunities for working collaboratively across the Alps
- Inform a small representative group of land managers about results that affect public land management.

WORKSHOP RECOMMENDATIONS

Workshop sessions reviewed the work completed by the Alps agencies following the 2003 fires and made the following recommendations for future research, education, co-ordination, and incorporation of research findings into fire management .

Research and Monitoring

*An integrated, long-term approach to research, monitoring and management is required, with a commitment at senior levels to the long time scales involved.
*Similarly, funding needs to be long-term to allow a full assessment of research.
*There is a need to invest in expertise and maintain information expertise in corporate knowledge.

Monitoring *'If you burn, learn'*

*There needs to be ongoing pro-active monitoring–not just after disaster. Many answers to management questions are just not known. Baseline monitoring provides a strategic and efficient way of obtaining better information to address broader management needs.
*There was a general call for increased permanent monitoring. Some of the best information that we have been able to learn from this fire event has been because there was pre-fire data from long term monitoring programs.

Data

*Effective data management is an imperative in any research field.
*Central information/data sharing/coordination across the Alps needs significant improvement (what is being done, what can be done?).

Research

The following areas of research were seen as integral to effective management of the Alps' natural resources following the Alpine fires:
*analysis of research and monitoring gaps (eg invertebrates, reptiles/ aquatic vertebrates/smoky mouse etc.)
*Analysis of Alps fire regimes
*Weed invasion issue
*Archive data base – an Alps wide opportunity
*Restoration - ensure restoration resources are used on realistic sites
    -Trial rehabilitation and assess results
    - focus on peat in bogs
*Map extent of bogs and fens across Alps
*Integrated pest management (cats/fox/rabbit)following fires is an imperative
*Analysis of what is the minimum data set, and when and for how long? These are questions that need to be addressed in any research if it is to be meaningful and testable.

Coordination across Alps

*Strengthen cross-border Agency research projects and develop a more coordinated data collection/storage/documentation system with effective data sharing.
* Find better ways to collaborate between states – especially with regard to funds and people: financial planning/projections
*Develop an alpine management plan that is cross jurisdictional, ongoing - a Strategic Plan for the whole of the Alps parks that is informed by questions such as:
    What would we do differently? Outcomes of research and monitoring? Gaps? with clear objectives and clear funding requirements.

Education/communication

There was a strong view from the workshop participants that the public needed to have a view of fires other than as disasters.
    'Wild fire is a natural event and will occur again'
    'Don't use D words – destroy, disaster, devastation, destruction. Do use R words – Robust, resilient' Use burnt, not destroyed.

In order to get the message out – need a well structured communication plan and delivery.
    Summarise key messages from research for presentation to a broader community – eg education packs specifically for primary/secondary students - communication –good news, results

Some of the messages that it was felt important to impart included:

- Recovery 'better than expected'
- Intensity varied > response varied. Ecological response is complex.
- Fires are not all bad news – there are some benefits/opportunities
- Drought – fire impact is difficult to separate.
- Recognition of the importance/value of Alps for water catchment

Fire Management

*Ecology before expediency - ecological knowledge should drive fire management plans – good science
*Natural fire regimes to be used in future fire planning – better fire regimes for a better future.
*Fire ecology needs to be part of fire training – part of the education of bushfire fighters
*Fire Action Plans – during the fires resources were not available to protect key iconic species and locations
*Ensure there is comprehensive information on biodiversity assets negatively impacted by fire
*Inherent patchiness of burns – is an advantage. Need to capture the scale of patchiness (mapping) and feed into fire burning plans - Plan for patchiness in HRs
*Map fire intensity/patchiness for all types of fires including HR (Hazard Reduction Burns) - pick important forest/communities
* Managing/protecting unburnt areas, and ‘managing the margins’ – fire planning
* Prescribed burning didn’t affect the impact of the bushfire –frequency, intensity and timing of prescribed fires is important
*Caution against protecting areas from unplanned burns – not cognisant of previous fire history.

Fire planning objectives from an ecological standpoint.
*Simplicity – **seek to avoid extinction**
*Population declines – How low can you go? What is the minimum population size from which a species can recover?
*Paradox of shrubs – primary habitat + highly flammable.

Does alpine grazing reduce blazing?
A landscape test of a widely-held hypothesis

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Abstract
"Alpine grazing reduces blazing" is a widely and strongly held view, in both rural and urban settings, concerning the effects of livestock grazing on fuels, and therefore fire behaviour and impact, in Australia's high country landscapes. As a test of this hypothesis, we examined the patterns of burning across the alpine (treeless) landscapes of the Bogong High Plains in Victoria, following the extensive fires of January 2003. Data were collected from multiple transects, each 3-5 km long, with survey points located randomly at either 50, 200 or 500 m intervals along each transect. The transects traversed the major regions of the Bogong High Plains, both grazed and ungrazed. At each point, we recorded whether the point was burnt or unburnt, the vegetation type (closed-heath, open-heath, grassland or herbfield), the estimated pre-fire shrub cover, slope, aspect, and a GPS location. At burnt heathland sites, we recorded the minimum twig diameter (an aposteriori measure of fire severity) in a sample of common shrubs. In total, there were 108 km of transect lines, 419 survey points and 4050 twig measurements, with sample points equally distributed across grazed and ungrazed country. The occurrence of fire (i.e. burnt or unburnt) in grazed and ungrazed areas was analysed by logistic regression; the variation in twig diameters by ANOVA. Approximately half of all points were burnt.

There was no statistically significant difference between grazed and ungrazed areas in the proportion of points burnt. Fire occurrence was determined primarily by vegetation type. The deceasing order of flammability of plant communities, as measured by the proportion burnt, was closed-heath (proportion of points burnt = 0.87) open-heath (0.59 burnt), grassland (0.13 burnt) and snow patch herbfield (all points unburnt). In both closed-heath and open-heath, grazing did not significantly lower the severity of fire, as measured by the diameter of burnt twigs.

That grazing did not reduce occurrence or severity of fire is consistent with previous research on shrub dynamics (little or no grazing effect on long-term abundance of taller shrubs), diet and behaviour of cattle (herbs and dwarf shrubs eaten; tall shrubs not eaten and closed-heath vegetation generally avoided), and fuel flammability (shrubs more flammable than grass). Whatever effects livestock grazing may have on vegetation cover, and therefore fuels in alpine landscapes, they are likely to be highly localised, with such effects unlikely to translate into landscape-scale modifications of fire behaviour. The use of livestock grazing in Australian alpine environments as a fire mitigation practice is not justified on scientific grounds.

Nature, Extent and Effects of the 2002/2003 High Country fires in NSW - A Digital Database and Archive

Dr Elizabeth Tasker
Department of Environment and Conservation (NSW)

Background
The massive fires that swept through the Australian Alps in summer 2003 were the largest bushfires in the region for more than 60 years, burning an estimated 1.73 million hectares. These events were of national and international ecological and cultural significance.

The high country of mainland Australia is unique and profoundly affected by fire, and the alpine region contains many plants and animals found nowhere else in the world, including many that are threatened with extinction. Occupying just 0.06 per cent of the Australian continent and being restricted to high elevations, the alpine and subalpine environments of mainland Australia are also particularly vulnerable to climate change.

The previous major bushfires in the high country, the "Black Friday" fires of 1939, burnt an enormous area, yet we know little of where they burnt and what their effects were because they were so poorly documented, particularly in New South Wales. In contrast, the fires of 2003 have been mapped, photographed and documented in considerable detail, and almost immediately following the fires surveys and monitoring of the survival of various plants and animals began, and various projects are ongoing. However, this material is currently scattered throughout various government offices, universities and other locations, and much of it is unpublished reports, internal documents or maps that are not publicly available.

The 2003 fires provide a unique and important opportunity to understand the impacts of bushfires in structuring alpine and subalpine plant and animal communities, and the nature of where the fires burnt and why.

The digital archive and database
To ensure that the documentation of the 2003 high country fires in NSW is safely captured as a valuable resource for the future, the Department of Environment and Conservation is compiling a digital archive and searchable database of this material.

The NSW Alpine Fires Digital Database/Archive is being constructed in Microsoft Access with a user-interface consisting of an interactive map and drop-down menus, and is searchable by topic, document type (e.g. photograph, map, thesis, unpublished report), fire name, topographic feature, park, state forest, map sheet, LGA, CMA, DEC region and area. The database can also be searched spatially via the interactive map.

Materials entered in the archive include maps of the areas burnt, maps of fire spread, fire severity mapping, submissions and results of official inquiries, photographs, unpublished reports on fuel-loads, climatic data, immediate fire impacts on plants and animals, and survey results documenting longer term impacts on vegetation and fauna. The database will also include a list of research projects that are currently in progress.

The archive will include originals of all documents (other than books) in digital format, e.g. pdf, jpeg, so that the user can not only search for items on particular subjects or places, but also open, read and print them. Because the database is primarily intended as a scientific resource, value-added digital formats will be used wherever possible. For example, maps are being included both as jpegs for easy viewing and printing, and as original Arcview themes wherever possible, to allow further analysis and use of these layers for GIS projects in the future.

Availability

The archive is due for release in September 2005 on DVD. This will be distributed free of charge to research institutions, libraries and relevant land managers. It will also be available to the public for a nominal fee from the Dept of Environment and Conservation (NSW). Subject to further funding we hope to make it available on-line so that it is accessible to a wider audience.

Inquiries and submission of material

The archive is being compiled by the Fire Ecology Unit (Policy & Science Division, Hurstville) in conjunction with the Conservation Planning Unit (Environment Protection & Regulation Division, Queanbeyan).

If you have material that you think would be relevant for inclusion, or would like to find out more about the project, please contact the project coordinator:

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Post-fire Flora Work - Impacts on Flora

Keith McDougall *et al*.
Biodiversity Conservation Section,
NSW Department of Environment & Conservation

Walsh NG & McDougall KL (2004) **Progress in the recovery of the flora of treeless subalpine vegetation in Kosciuszko National Park after the 2003 fires.** *Cunninghamia* 8, 439-452.

Sixty quadrats first sampled in late 2002 were re-sampled in late 2003 to assess the mode and extent of regeneration in a range of treeless plant communities in KNP. There was no significant difference in mean number of species / quadrat between pre-fire and post-fire quadrats (although there were more weeds post-fire). One species, *Chenopodium erosum*, had not previously been recorded and is believed to be the only native chenopod in alpine vegetation in Australia. Of the 290 species recorded, 38% regenerated from seed, 68% regenerated from resprouting organs (roots, tubers and/or basal stems), 17% regenerated from both seed and resprouts and 8% hadn't regenerated 12 months after the fire. Based on the regeneration observed, most plant communities will return naturally to their pre-fire species composition and cover over a period between a few years and a few decades. Major exceptions are bog communities that incorporated significant biomass of *Sphagnum cristatum* pre-fire, *Podocarpus lawrencei* shrublands and *Celmisia costiniana* closed herbfields.

McDougall KL & Summerell BA (in review) **Unusual 'outbreaks' of a diatom (*Tabellaria flocullosa*) in the Australian Alps.** *The Victorian Naturalist*

Large quantities of the remains of a diatom (*Tabellaria flocullosa*) were observed smothering vegetation beside waterways on the Bogong High Plains and Kosciuszko National Park in the two summers following the 2003 fires. Whilst there does appear to have been localised deaths caused by the smothering, the impact is very localised. A direct link between diatoms and terrestrial plants does not appear to have been reported previously. Increases in diatom populations have similarly been reported (overseas) following fires.

Fire ecology of *Podocarpus lawrencei* at Blue Cow
Keith McDougall, Linda Broome & Genevieve Wright

Plants (in KNP at least) are killed when all of their foliage is consumed by fire (oddly those in the ACT and some in Victoria resprouted from the base after the fire). Resprouts on partly burnt stems are weak and many died between 12 and 24 months after the fire. The only seed germination 12 months after the fire was in burnt areas (and often under or close to rocks) - i.e. most recruitment occurs after fire. Based on estimates of stem diameter growth there was negligible recruitment over the last 90 years at Blue Cow, suggesting that the 1926 and 1939 fires burnt little *Podocarpus*. Dendro-chronological work is continuing on *Podocarpus* from Blue Cow. Preliminary data indicate that there have been two to three broad scale fires per century over the past 300 (and perhaps 400) years, the last inter-fire interval being the greatest over that period based on the consistency of preliminary ring counts on Podocarpus at Blue Cow and ring counts from snow gum in other parts of Kosciuszko and the ACT .

Maisie's Bog, 1979 - 2004
Keith McDougall
A Sphagnum bog on the Bogong High Plains was fenced in 1946 by Fawcett and Turner. An adjoining bog was to act as a control in long-term monitoring. No measurements were made until 1979 when both bogs were mapped in their entirety at a fine scale. In a subset of 125 contiguous 4 x 4 m quadrats Sphagnum and pools were mapped, and the cover of major species estimated in 1979, 1999, 2004. About half of each site burnt in January 2003.

Changes between 1946 – 1977 were described by Maisie Carr: "most of the (fenced) mossbed was firm underfoot and there were numerous patches of bare peat. The surface had a dense cover of Big Horny Grass (*Poa costiniana*). On the downhill side of each hillock was a steep concave eroded face with, in front of it, a flat apron of bare peaty soil ……. There is no doubt that the (fenced) mossbed has increased in size…… One lunch place which we used in the early days of our work (and incidentally were tormented by small black ants) is now so wet that neither we nor the ants would find it comfortable. The comparable mossbed to the east of the plot has shown little, if any, change".

Between 1979 and 1999 there were significant changes in Sphagnum cover (unchanged in grazed, increased in ungrazed), pools (increased in grazed, decreased in ungrazed), *Baeckea gunniana* (decreased in grazed, increased in ungrazed), and *Empodisma minus* (increased in grazed, increased in ungrazed). *Richea continentis* was unchanged in both bogs. Monitoring will continue.

The 2003 fire burnt some peat to depth exposing mineralised soil. *Richea* was often killed even when there was no obvious sign of burning. Small green Sphagnum tips were visible even on severely burnt mounds

Treeless Vegetation Recovery on the Bogong High Plains

Arn Tolsma, James Shannon, Henrik Wahren, Liz MacPhee & Warwick Papst

The Bogong High Plains comprise the largest area of treeless high mountain vegetation in Victoria. They contain a mosaic of vegetation types, including grasslands, heathlands, mossbeds and snowpatch herbfields.

A large proportion of the treeless vegetation was burnt in 2003, including ¾ of the closed heathland, ½ of the mossbed area and less than ¼ of the grasslands. Snowpatch herbfields were not burnt. The aims of the research were to measure the condition of heathland, grassland and mossbed vegetation, and to measure the post-fire recovery of burnt vegetation types.

In grasslands and heathlands, vegetation data were collected from new, burnt plots established in 2003, and from established burnt and unburnt long-term plots dating back as far as 1944. Cover data were obtained using the point quadrat technique along permanent replicate transects, and biomass was collected from within random replicate ¼ m^2 quadrats. The results show that recovery to pre-fire condition will vary substantially between vegetation types:

- Grasslands – around 5 years for high quality cover and biomass, and greater than 5 years for high quality litter.
- Heathlands – 7 or more years for shrub cover, more than 10 years for shrub biomass, and longer again for litter.

In mossbeds, attributes known to be important for condition were assessed using aerial photographs, supplemented by field data and observations. These attributes were *Sphagnum* cover, channels and pools, tracks, exposed peat and gravel pavements, and area burnt. 73 mossbed systems on the Bogong High Plains were graded into 6 condition classes, using a long-undisturbed mossbed system as a reference. The results showed that most mossbeds assessed were in poor condition prior to the 2003 fires, with nearly 2/3 of mossbeds in the lowest two condition classes. All burnt systems were in worse condition post-fire. It is expected that recovery of burnt mossbed vegetation to its pre-fire state will require longer than 20-30 years. Active restoration may also be required, as will be the removal of willow seedlings.

Post-fire Catchment Rehabilitation Works

Groundwater Communities – Bogs and Fens

Roger Good, Senior Project Manager, Mountain Catchments (retired)
Genevieve Wright, Project Officer (Catchment Rehabilitation Kosciuszko National Park)
Amanda Carey, Project Officer (Rehabilitation – Namadgi National Park)

Following the removal of domestic stock grazing from the upper catchments of the Murray, Murrumbidgee and Snowy Rivers in the 1950s and 1960s, only 50 percent of the bog and fen communities along the Main Range (Snowy Mountains) in Kosciuszko National Park remained as functional groundwater communities (approximately 2200ha of some 5500ha.)
During the 2003 bushfires that burnt across kosciusko national park and namadgi national park in the act the remaining areas of functioning bog ecosystem were further impacted upon. in kosciuszko national park approximately 15% of remaining bogs were damaged such that they were considered beyond physical rehabilitation to a functional state. in the act all bog areas were impacted by the fires, although few sites were considered to be damaged beyond a capacity to restore their hydrological role in the catchments.
A collaborative rehabilitation program between nsw and act staff was commenced in march 2004 and continues to the present time. a set of criteria were defined and used to determine the priority sites. these criteria 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 peat soils had become hydrophobic following the fires.

2. **Recoverability** – some potential for recovery needed to be evident. While clearly affected by the fire, some vegetation (including *Sphagnum* and *Carex* species) needed to have remained at the site, while peat incision was still manageable.

3. **Size and extent of peat beds** – with consideration to catchment value.

4. **Significance in terms of catchment value** – did the catchment drain into an important river system or was it part of a closed system?

5. **Location** – both within the landscape and the catchment. Valley bottom bogs were targeted because of their deeper peat soils and the greater amount of drainage that may / would occur through them.

6. **Access availability** – with consideration to the efforts required to get to the location in terms of both time and money.

7. **Cost benefit of rehabilitation** – with limited funds and subsequent time constraints on the rehabilitation works, activities were to be undertaken that would be of greatest benefit to catchment protection.

8. **Past history of damage** – Some areas were affected by compounding damage with earlier grazing periods having caused significant damage. While recovery in these areas may have been occurring since the cessation of grazing, the fires were found to have “reopened” some of the previous degradation.

9. **Iconic importance** – some areas have significant iconic importance and are as such of value for protection. Pengilley's bog for example, has previously had a large Corroboree frog population and still retains the potential for reintroduced populations. In other examples, Guthrie's Creek has previously represented the largest bog area outside of the Main Range area, while within the Prussian Creek area, an important research history has evolved. (Wimbush 1970).

10. **Education value** – bogs that could be used to illustrate management issues and functional processes were identified as important for recovery works.

11. **Long term monitoring potential** – essential to undertaking such a program is the potential for measuring the success of the works. Issues such as access, location and importance were considered in selecting long term monitoring sites.

The rehabilitation program

The rehabilitation work commenced in the most significant sites (Pengilley's, Prussian Creek, Guthrie's and the Wragge's Creek bogs in Kosciuszko NP and Ginini, Rotten Swamp and Cotter Source bogs in Namadgi NP. A number of other sites in the vicinity of Mt Tate, the Cup and Saucer, and the Mt.Jagungal area (KNP) were subsequently worked on when the highest priority areas were completed.

The full recovery of bogs and fens when highly degraded, such as occurred in many bog areas, takes up to 30 years and hence it was recognised that any rehabilitation work would only be to initiate and enhance the natural processes of recovery. The works were therefore only to stabilise the sites, slow the rate of runoff, spread surface flows, re-saturate the peat profile, and to enhance the rate of recovery of a *Sphagnum, Empodisma* and other bog plant species.

Coir log diversion banks were initially placed across the slope in the bogs and adjacent sites as water spreaders, silt traps and water filters to slow surface flow rates and to divert the maximum amount of surface flow to the core area of the bogs

Hay bales were subsequently placed in eroded and incised peat areas, to slow the flows in eroded trenches and to create pools of surface water around which *Sphagnum* could readily recover. To further enhance the *Sphagnum* recovery, sods of *Sphagnum* were planted around the edges of some pools and shaded with a light layer of hay mulch (3 to 5 tonnes per hectare). It had previously been found that *Sphagnum* regrowth and recovery benefits from a 70-75% shade cover. Trials by the bog and fen recovery team (Hope, Good, Carey, Whinam & Wright) indicated that shade-cloth is an easy and practical way of providing this shade and it was subsequently used in a number of bog sites in Kosciuszko and Namadgi National Parks.

Following trials to ascertain the most appropriate technique(s) to enhance re-saturation of the many dried-out or drying peatbeds, trenches were cut with a small backhoe down to the underlying gravels (1-2metres) into which hay bales were packed (1 to 3 bales in height). These bale-lined trenches slowed and filtered the sub-surface flows through the peatbeds providing for the complete saturation of the peatbeds behind them. This was considered a drastic action to take but was based on an understanding of how water moves naturally through peatbeds. It was also based on the recognition that the hay bales would eventually decompose and be integrated into the organic material of the peatbeds.

Two years on from the initial rehabilitation works the priority bogs had recovered their vegetative cover of *Carex, Empodisma, Sphagnum, Ranunculus* and other groundwater dependent species. The peatbeds recovered their saturated peat state in 12 to 24 weeks at which time outflows started to exceed the inflows and the initial phases of the restoration of bog ecosystem functioning was considered to have been achieved.

Summary

The successful rehabilitation of damaged and highly disturbed bogs and fens requires an understanding of how a bog ecosystem functions and the role of bogs and fens in catchment hydrology. It also requires an understanding of the ecological requirements of the significant plant species eg *Sphagnum,* and an appreciation of the level or degree of degradation. At the extremes of degradation, rehabilitation to the pre-fire community condition was recognised as not possible and restoration to another stable ecological community, such as a sod-tussock grassland was pursued.

Where rehabilitation was identified as possible, the techniques to restore the communities to their pre-fire functional role were relatively simple and readily implemented, although the restoration of full functionality and a stable vegetation complex was recognised as not likely to be attained for several decades.

Controlling Weed Invasion Post-fire

Implications for Restoration of the Native Vegetation

Lynise Wearne[1&2] and Cathy Allan[1]

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Successful control of invasive plants depends to a large degree on the regeneration potential of the target species and the impact of the removal effort on other species.

A variety of techniques can be used to remove exotic species, however monitoring and maintenance after invasive species removal and subsequent restoration is essential but often overlooked. In numerous areas throughout Australia, the invasive legume, *Cytisus scoparius* (L.) Link (Broom) forms both dense stands above-ground and abundant seed banks below ground. A number of factors make *C.scoparius* a threat to native biodiversity and a challenge to restoration practitioners, including its ability to resprout after cutting, a long-live seed bank and the associated decline of native species. Despite efforts to eradicate *C.scoparius*, a fully interegrated protocol for the control of this species and subsequent recovery of native vegetation has not been produced.

The specific goals of this study were: (1) to understand the regenerative potential of native vegetation in the subalpine and montane regions (2) to compare eradication methods of *C.scoparius* and (3) compare regeneration of native vegetation between treatments.

Plots were established prior to the 2003 Alpine Bushfires and consisted of; (1) areas removed of *C.scoparius* manually (2) areas invaded by *C.scoparius* (no control) (3) uninvaded native areas (4) previously sprayed (herbicide treatment) areas. All vegetation was initially monitored and subsequently removed within each plot and recovery monitored over one year. Following the 2003 alpine wildfire, all plots were burnt and remonitored. In addition large infestations of *C.scoparius* were killed in other areas and resulted in massive regeneration of the soil seed bank. Parks Victoria has subsequently developed an experimental management program (AEM) to assess the effectiveness of different herbicides on the control of *C.scoparius* and the impact on other vegetation.

This program will run over 5 years. Initial findings of this project and pre-and-post–fire regeneration of both *C.scoparius* and the native vegetation will be discussed.

Recovery of Threatened Flora and Vegetation in North-Eastern Victoria after the 2003 bushfires

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Post-fire recovery of priority populations of threatened flora in north-east Victoria after the 2003 bushfires

Forty-four species of threatened plants were identified as 'possibly at risk' following the bushfires that burnt 1.1 million hectares of public and private land in 2003 (Parks Victoria 2003). The post-fire response of most of these species had not been previously documented. Surveys were conducted for 43 of these species to relocate at least some of their populations within the boundary of the fire-affected area and to assess whether -

- the target species were burnt and regenerating,
- were burnt and not yet regenerating but were likely to do so,
- were burnt and unlikely to regenerate or
- had not been burnt.

Existing population records were prioritised for survey and fieldwork, which was conducted from January to April 2004. Information recorded during the surveys included population size, habitat variables, an estimate of the local fire severity, fire response traits, threats present at the site and management requirements. Information was collected only at burnt sites. By the close of the survey period, 181 populations had been found, including populations that had not been previously recorded. 126 of these populations had been burnt. 17 additional rare or threatened species were found.

Twenty-two vascular plant species showed good regeneration at all sites inspected. Seven species were not, or mostly not, burnt across their range within the fire-affected area. Four vascular species and two non-vascular species showed poor regeneration or had not regenerated where burnt. An additional four species were not relocated, but all except one are highly likely to be extant, with no records found for the remaining species. Two species were subject to recovery plan implementation and were not surveyed. Two species are considered to have become extinct pre-fire. Seven species with known locations require further survey to clarify their status.
Fire response characters were recorded for 28 species. The majority (14) of species with burnt populations were resprouters with no persistent seed bank. Eight species had the ability to resprout and regenerate from a persistent seed bank. Four species were obligate seed recruiters from a persistent seed bank with no ability to resprout. Two species were short-lived annuals.

Threats were recorded in 24% of populations, however most of these threats were relatively minor. Pest plant (environmental weed) management should be given the highest priority. Strategies for pest animal management should be implemented.
Rapid monitoring methods were devised to determine the rate of post-fire recovery over time and tested for nine species. These represented the range of functional traits present within the range of species surveyed.

Most populations of most species are recovering successfully after the fires, with many having benefited from the stimulus to regeneration. Nevertheless, fire management planning that considers rare and threatened species will be required in the future. At present, little is known of the life histories or regenerative strategies of any of the species targeted during this survey. The fires have presented a unique opportunity to acquire information on the population biology and dynamics of threatened flora and their responses to fire. Species monitoring should continue over the next three to five years.

Recovery of Mountain Plum-Pine Shrubland After Wildfire (Cobberas)

Populations of Mountain Plum-Pine (*Podocarpus lawrencei*), ranging in size from around 10 m^2 to 3000 m^2, were assessed at five peaks on the Cobberas Range, eastern Victoria in March 2004 under the Victorian Bushfire Recovery Program. The aims were to determine the extent of damage to the populations from the 2003 alpine fires, the mode and success of regeneration, any threats that might act upon that regeneration, and to identify urgent management actions.

The proportion of each population killed varied substantially, ranging from zero to 95%. The total proportion killed at each of the five peaks ranged from 2% to 63%, with an overall average of 28%. *Podocarpus* did not carry fire with the same intensity as adjacent shrubby vegetation, but it was sufficiently sensitive to fire that burning of the bark at the base of the trunk caused plant death.

Regeneration of scorched plants was occurring, albeit at low levels, through resprouts on the trunks and branches, and occasional root resprouts. Sprout location was directly related to the intensity with which individual plants were burnt or scorched. Small numbers of seedlings were present, ranging in size from around 2 to 6 cm.
Fire management plans to protect the remaining populations are recommended, along with continued rabbit control. Weeds do not currently pose a threat. However, periodical monitoring of weeds and other factors that might affect on-going regeneration success is recommended.

Recovery of Silurian Limestone *Pomaderris* Shrubland after the 2003 bushfires in north-east Victoria.

The status and post-fire recovery of the nationally threatened community Silurian Limestone *Pomaderris* Shrubland was assessed after the 2003 bushfires under the Victorian Bushfire Recovery Program. Prior to 2003 there had been no records of fire at Marble Gully for at least one hundred years. The community is restricted to limestone geology, occurring only at Marble Gully near Omeo in East Gippsland.
Species fire response characteristics, threats to recovery and management requirements for the vegetation community were identified. Permanent transects

were established to monitor post-fire recovery of key common species, minor species and five rare or threatened species.

The influence of fire on species composition was determined by comparing the species list from pre-fire studies with a list compiled from this study. Community structure was severely affected with the canopy virtually totally destroyed. All lifeforms were regenerating but it will take many years, with the absence of fire, to determine if the community will return to its original structure. 213 vascular species, including 38 weeds, were recorded pre- and post-fire. 85 of these were recorded in 2003 plus 34 species that were previously unknown. Response to fire and/or vital attribute data were collected for 115 indigenous species.

Nine rare or threatened species were re-located during the 2004 survey: *Olearia astroloba* (Vv), *Ozothamnus adnatus* (v), *Arthropodium* sp.1 (r), *Pimelea flava* subsp. *dichotoma* (r), *P*. *pauciflora* (r), *Pomaderris oraria* subsp. *calcicola* (r), *Pultenaea densifolia* (r), *Vittadinia tenuissima* (r) and *Senna aciphylla* (r). Two rare species previously recorded were not found - *Asplenium trichomanes* subsp. *quadrivalens* (r) and *Desmodium varians* (k). Two of three additional species known to be significant at Marble Gully due to their disjunct geographical distribution, were also found (*Austostipa scabra* subsp*. falcata* and *Ptilotus spathulatus)*. One other disjunct species previously recorded at the site, *Isoetopsis graminifolia,* was not re-located.
The study showed that most rare or threatened species regenerated by a combined mechanism of sexual and vegetative means. Seedlings were more numerous and generally smaller than the resprouting individuals. One species, *Pimelea flava* subsp. *dichotoma* was an obligate seed recruiter and one species, *Arthropodium* sp.1, was an obligate resprouter.

Fire suppression activities did not impact directly on the community. It is recommended that the community be protected from fire until a fire management plan is prepared. There is a low level threat from weeds and grazing by livestock, which may impact on post-fire recovery. Ongoing monitoring is proposed for at least five years.

Recovery of Montane Swamp Complex after Bushfires in North East Victoria 2003.

The status and post-fire recovery of the threatened community, Montane Swamp Complex was investigated 12 months after the 2003 bushfires as part of the Victorian Bushfire Recovery Program. This community has been listed under the Commonwealth EPBC Act 1999 and the Victorian FFG Act 1988. It is restricted to a few tributaries of the upper reaches of the Tambo River, near Benambra in East Gippsland. This study was confined to the largest area of Montane Swamp Complex, adjacent to the Tailings Dam No. 1 site (T1) of the Wilga-Currawong mining project. The T1 site was stratified into three zones consisting of wet soaks, creekline vegetation and woodland. Each zone was sampled using two randomly placed quadrats and recording the presence and cover/abundance of all the species present, as well as stage of development, mode of regeneration, vital attributes and environmental variables.

Recovery of Montane Swamp Complex was determined by comparing species composition, richness and cover/abundance recorded in this study with the results of earlier surveys. Approximately half the number of woody, graminoid and herbaceous perennials were regenerating in quadrats since the fire compared to pre-fire numbers, indicating that the community is now less floristically diverse than previously. However, structural recovery appeared steady, with a relatively high number of plants in the early stages of regeneration and indications of growth for all three of these life form classes. In areas containing peat bogs most *Sphagnum* was dead with only 1%-5% living, although much of the burnt *Sphagnum* remained on site. Species were regenerating mainly by vegetative or combined strategies, and to a lesser extent by sexual means. A number of herbs and graminoids had flowered or set seed since the fire, although tree and shrub species matured more slowly.

Only three out of ten known rare or threatened species were relocated after the fire. There are few threats to post-fire recovery from pest plants and animals and weed species richness is lower since the fire. The conservation status of Montane Swamp Complex may have been compromised by the 2003 bushfires, although this can only be determined with additional survey and monitoring. It is recommended that quadrats are re-visited within two years and that post-fire monitoring continue for ten years. Some minor weed control measures should also be implemented.

Has previous fire history influenced post-fire recovery of treeless subalpine vegetation at Mt Buffalo National Park?

There have been six major fires at Mt Buffalo since the early twentieth century, with three of these occurring since 1972. The frequency of burning is now a concern for the Parks Victoria who need to know how to prioritise fire management. Post-fire monitoring of treeless alpine and subalpine vegetation and litter at Mt Buffalo between 1985 and 1999 showed that recovery of treeless vegetation and ground cover to pre-fire levels takes 10-15 years (Wahren et al. 1999; Wahren & Walsh 2000), although there has been long-standing concern for the declining condition of bog vegetation because of stream incisement and lowering of the water table in the high valley plains as a result of fire (Rowe 1970).

In this study, we investigated the effect of different fire histories on community composition, community function and plant performance in three vegetation types: subalpine bogs, alpine heath dominated by herbaceous species and alpine heath dominated by woody species. We hypothesised that vegetation that was moderately disturbed (i.e. burnt by two of the three fires since 1972: 1972+2003, 1985+2003) would be more diverse than either frequently (1972+1985+2003) or infrequently (2003 only) disturbed communities (intermediate disturbance hypothesis, Connell 1978). The null hypothesis was that fire history would make no difference to post-fire recovery because there had been sufficient time between fires for vegetation and habitat to recover (13 years and 20 years), as postulated by Wahren et al. (1999) and Wahren & Walsh (2000). We examined three aspects of vegetation diversity/recovery after the 2003 fire: (a) species richness/diversity and floristic composition, (b) functional response (life form richness and regenerative response), (c) rate of recovery/plant performance (measured as heights of dominant regenerating species), and (d) general habitat recovery (bare ground and litter cover). We intend to use the results to determine whether specific vegetation management actions should be prescribed according to fire history. Analyses are currently underway.

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Response of Sequestrate Fungi and Mycophagous Mammals to Disturbance by Fire

Honours thesis, submitted November 2004

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Abstract

In early 2003 a naturally lit bushfire burned through Alpine National Park and surrounding areas, including the Upper Ovens and Kiewa Valleys. In anticipation of such fire events some prescription burning had been conducted in these areas, and during the fire, further prescription burning was conducted in an attempt to control the spread of the fire. This study looked at specific ecosystem responses under four different burning regimes including an area long unburned, an area burned in the natural fire, a prescribed burn area, and an area that had been burned by both prescribed burning and the natural fire.

Ecosystem responses were measured in winter and spring of 2004, approximately 18 months after the bushfire. The primary responses measured were those of sequestrate fungi species diversity and abundance, and mycophagous (fungus eating) mammal species diversity and abundance. Vegetation characteristics were also measured to document responses in the primary biota.

The area that had been prescribed burned prior to the natural fire burned at a significantly higher intensity than the other sites, a result that is counter to the accepted rationale for the use of prescribed burning in fire mitigation. The area was also depauperate of sequestrate fungi, yet had a higher number of mammals present, predominately introduced species. There was a broad similarity between the areas burned by the natural fire and prescribed burned during the fire event. These areas had a greater species diversity and abundance of sequestrate fungi than the unburned area, yet fewer species of native mammals. The area prescribed burned only had a significantly greater number of plant species in the understory than the other areas sampled.

The interaction between the vegetation, sequestrate fungi and mycophagous mammals was disrupted in the burned areas by removal of the major mycophagous species of the area. The effect is most severe in the combination burn treatments where sequestrate fungi are lacking and mycophagous mammals will be required to disperse spores into the area. Disruptions of the interactions between these taxa may have serious implications for the long-term health of this forest ecosystem.

Monitoring Vegetation Recovery after the 2003 Fires in the 'Northern Extremities' of the Australian Alps

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The unplanned fires (wildfires) of January 2003 have provided a unique opportunity to assess the impacts on and recovery of vegetation in alpine and sub-alpine environments. These environments only experience relatively infrequent fire and many of the areas burnt in 2003 had last been burnt by unplanned fire in 1939 or in some cases, even prior to that. Hence, the effects of the fires on many plant species were unknown although some of the more widespread species occur in other environments which are prone to more frequent and intense fire. Much of the post-fire work undertaken by State agencies and Universities has been concentrated in the true alpine and higher sub-alpine areas of New South Wales and Victoria, but the fires extended from the Victoria to the most northerly extent of the Australian Alps and it is this northern area that forms the basis of our study area.

In the late 1990's, a series of 163 permanent stratified 20m x 20m plots were established in Bimberi Nature Reserve, Brindabella National Park and Burrinjuck Nature Reserve in the northern part of the Australian Alps as part of a vegetation survey that was undertaken to inform the management of these reserves. In recognition of the potential of long term monitoring plots in reserve management, all of the plots were permanently marked and photographed when surveyed. All of these plots were burnt by a range of fire intensities during January 2003 with the exception of one plot only. The opportunity presented for a before-and-after study has led to an opportunistic post fire re-sampling regime being instituted by NPWS and CSIRO. So far, sampling has been undertaken in Spring-Summer 2003-2004 and Spring-Summer 2004-2005. Each plot has been documented via recording full floristics with cover abundance, structural attributes, animal habitat complexity and site photographs. The original plot photos were re-recorded and additional post fire data including recovery mechanism, scorch height, fire patchiness and additional site photos were recorded post-fire. In the 2003-2004 season, we attempted to sample all plots and of the 163 original plots, 156 were found and re-sampled. In the 2004-2005 season, a sub-set of 55 plots was sampled and these plots were stratified to cover all 3 reserves and high and low fire intensities within each vegetation type.

The initial post fire survey work has concentrated on documenting fire recovery mechanisms and some 350 species have so far been documented. Of these, approximately 80% are re-sprouters and the remaining 20% are obligate seeders – this latte category covers a mixture of exotic annuals and serotinous and other fire-killed native species. Effects of the fires on structure are varied but three primary response types can be discerned in relation to canopy recovery: primarily epicormic response (e.g. *Eucalyptus dalrympleana*, *Eucalyptus robertsonii*, *Eucalyptus fastigata*); primarily basal response (e.g. intensely burnt *Eucalyptus mannifera* and *Eucalyptus dives*) and primarily fire-killed response requiring seedling re-establishment (e.g. *Leptospermum micromyrtus* and *Eucalyptus delegatensis).* Additionally, all species are being monitored to ascertain primary and secondary juvenile periods. Preliminary results on floristic and structural changes, recovery mechanisms and rates were presented at Bushfire 2004 in Adelaide (Doherty and

Wright 2004) and two interim reports have been prepared (Doherty and Wright 2004, Doherty and Wright 2005).

We intend to continue post-fire sampling for at least 5 years post-fire and the floristic data will be analysed using multivariate methods to determine if there are distinct ‘trajectories’ of plots post fire i.e. the following questions will be investigated:

- *Does the floristic composition of plots change significantly after fire?*
- *If so, is it a short, medium or long term effect?*
- *Is the floristic composition changed permanently in some cases?*
- *What is the nature of the response of exotic species and the interaction between exotic and native species richness and composition?*
- *How long does vegetation structure take to recover in different vegetation types with differing or similar fire intensities?*

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ACT Long-term Vegetation Monitoring

Margaret Kitchin
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ACT has established a long-term vegetation monitoring program primarily based on sites that were initially surveyed in the 1970s and 1980s.

A stratification of over 200 of these sites, vegetation communities and environmental attributes identified 38 sites for on-going monitoring. In autumn 2004, all sites were initially surveyed. In autumn 2005 a subset of 14 sites were surveyed. A subset will be surveyed until 2008 when it is proposed all are surveyed again. The sites are being assessed for post-fire regenerative response, primary juvenile period and composition and structural change. Preliminary results have indicated that species are recovering well. Some fire sensitive species such as *Callitris endlicheri* and *Eucalyptus delegatensis* are regenerating at sites where they were previously recorded but in reduced numbers.

The data gathered in this study is being compiled into the ACT Fire Response Database. This program will provide research to support the understanding of the responses of different terrestrial vegetation types to fire regimes and collect data for the development of ecologically appropriate fire thresholds for future fire management.

Australian Alps Fire Response Monitoring System
(Alps Fire Ecology Plots)

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Background

Various fire management regimes have been imposed on the constituent parks of the Australian Alps national parks based on a mixture of economic and environmental considerations. However little is known about the suitability of such regimes in terms of long-term management of the Alps biodiversity.

In October 1993, the Australian Alps Liaison Committee funded a workshop to discuss the issue of the effect of fire on Australian Alps vegetation. The workshop developed a series of research proposals and priorities for investigation into the fire ecology of the Alps.

The Australian Alps Fire Response Monitoring System, the first of these proposed projects, commenced in 1996.

Objective

To establish a series of permanent sites and a monitoring system to enable long-term monitoring of the effects of fire on vascular plant species and communities in the Alps parks. Data from this monitoring system will enable more informed management decisions regarding the timing and effect of various fire regimes, particularly with respect to the conservation of rare, threatened and fire-sensitive floral species and communities, and the promotion of biodiversity.

Established a set of 40 plots in the Alps - 4 areas of the Alps were chosen.
Kosciuszko National Park – The Merambego and Nungar areas chosen as they have a diverse history of wildfires and hazard reduction burns, and were likely to continue to be burnt as part of the ongoing protection of neighbouring properties and assets
Alpine National Park – Buchan Headwaters Wilderness and immediately adjacent areas were selected as there were extensive documented fire histories for the areas and long-term plans for periodic rotational fuel reduction burns.
Namadgi National Park – by comparison didn't have a history of frequent fires though hazard reduction fires had occurred in the past along with periodic wildfires. No extensive fuel reduction burns were planned in the immediate future.

In all the above areas sites were selected across the major vegetation provinces. Cold air drainage shrub and herbfields were not considered fire-prone and were not sampled. Sites were also selected in a variety of fire histories, and areas known to contain endangered, threatened or rare species were also sought.

Sites were established (30mX30m quadrat) with permanent photo points. At each site various physical parameters were recorded (landform, slope, aspect, strew size etc). All vascular plant species present were recorded, with growth form and height class noted, and cover/abundance estimated. The vegetation association at each quadrat was described in terms of the dominant overstorey species, structure and dominant understorey species.
Standardised data sheets and tables were designed, and a relational database *(Microsoft Access)* designed to form the basis of the monitoring system database.

A total of 313 species were recorded across the sites, of which 146 (47%) were species unique to the area. Of the total species listed 116 species were included in the national fire response system (Gill) but no records were from any of the Alps national parks. Only 67 of the 116 species have records from the ACT, eastern NSW or eastern Victoria. Of these 67 species only 27 had records from more than one ACT/NSW/VIC location and many showed variable fire responses. It was considered that species data from only one or two nearby locations is not sufficient on which to base alps fire management decisions.

The fires of 2003 provided the greatest single opportunity to gather ecological information on the natural vegetation communities of the Alps since the project's establishment. After the initial assessment and monitoring of the plots following the 2003 fires, there was a review of the adequacy of the recording data sheets and rationalisation of the amount of data to be collected in the monitoring system.

Preliminary results

Species Regeneration Mechanisms

The regeneration mechanisms displayed by species affected by the 2002/2003 bushfires were examined. One hundred and forty-seven species (48% of the total number of species recorded) were observed regenerating.

Examination of the data revealed that:

- The majority of species (98%) were most frequently observed regenerating vegetatively, with 75% re-sprouting from root suckers or rhizomes, 18% re-sprouting from basal stem buds and 5% re-sprouting from epicormic shoots.
- Only 2% of species were most frequently observed regenerating from seed (in all instances from canopy–stored seeds).
- Only one species had equal instances of responding vegetatively (by root suckers or rhizomes) and by seed (from soil-stored seeds).

Time to fruiting or flowering - Gill and Nicholls (1987) refer to the time from fire to first flowering of a seeder population as the 'Primary Juvenile Period'. They propose that the time after a fire at which a population will be secure (ie the species is likely to be able to regenerate adequately if burnt again) is either when 50% or more of the plants present have become reproductive or when twice the primary juvenile period has passed.

Initial data found that 197 species in the plots had fruited or flowered in the period between the 2003 fire and Autumn 2005. 92 species and 8 genera had not been observed flowering/fruiting.

The study provides an opportunity to track vegetation changes in structure and species composition. This study is unusual in having pre-fire baseline data for this. It is more common to begin such studies after fires and the pre-fire condition is often implied or derived from related areas.

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Post Fire recovery of Mountain Pygmy-possums and Smoky Mice in Kosciuszko National Park.

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Mountain Pygmy-Possum

Introduction

The endangered Mountain Pygmy-possum *Burramys parvus* occurs only in alpine areas above the winter snowline in the alps of the Australian mainland. Total population size is currently estimated to be about 2255 adult individuals (1760 in Victoria, 495 in NSW) (Heinze *et al.* 2004, Broome *et al*. 2005, unpubl. data). The NSW population occurs within Kosciuszko National Park, in an area of approximately 30 X 8 km extending from Thredbo to Gungartan Pass. Within this area local populations are distributed in small patches of rocky, boulderfield habitat with associated shrubby heath. Broome *et al.* (2005) identified 21 habitat clusters as Mountain Pygmy-possum habitat (Fig1.). The altitudinal distribution extends from approximately 1600 m to the peak of Mt Kosciuszko (2228m). The total area of boulderfield habitat is less than 2 square km. During the January 2003 bushfires approximately 58,140 ha (77 %) of the alpine area in Kosciuszko National Park above 1600m elevation was burnt. In this study we assess the extent of fire damage to Mountain Pygmy-possum habitat and outline the recovery actions that are being implemented.

Mapping of fire severity and impact on habitat

Fire impact modelling for the 2003 ACT & Southern NSW fires using multitemporal Landsat ETM imagery was carried out by Tom Barrett & Shawn Capararo Conservation Information Officers, DEC South Branch, Queanbeyan. A fire severity map (Fig. 1) was generated from the resulting GIS layer. Assessment of the percentage of each Mountain Pygmy-possum habitat cluster that was affected by the fires was assessed visually on GIS by digitally overlaying the mapped habitat on orthorectified digital air photos captured after the fire. NSW Land and Property Information, at the request of NSW NPWS, captured aerial photography of the fire-affected areas. A total of 57 runs were flown over the area between 24 February and 21 April 2003 capturing more than 1500 overlapping photo frames. Frames were scanned and rectified to produce digital orthophotos for the area (Barrett and Capararo 2005).

Results

Approximately 40 ha of the 185 ha (22%) of mapped possum habitat was burnt to some extent, including eleven of the twenty boulderfield habitat clusters, (Fig. 1) (Table 1).

Table 1. Boulderfield clusters (cluster # shown on Fig. 1), the numbers of adult *Burramys parvus* trapped (1996-2001) by Broome *et al*. (2005), and percentage of each cluster burnt in the January 2003 fires.

Cluster #	Boulderfield cluster name	No adult *B. parvus* trapped	% of total population	No ha	% burnt
1	Gungartan-Schlinks	11	3.3	10.6	30
2	Whites River	3	0.9	5.1	10
3	Dicky Cooper	0	0.0	3.5	80
4	Windy Creek	3	0.9	3.9	80
5	Anton-Anderson	0	0.0	3.3	90
6	Blue Lake-Headley Tarn	2	0.6	9.3	5
7	Townsend-Byatts Camp	**41**	**12.1**	44.8	15
8	Wilkinsons Creek	0	0.0	11.0	50
9	Muellers Peak	14	4.1	3.8	0
10	Mt Kosciuszko	**36**	**10.7**	25.9	0
11	Cootapatamba-Swampy Plain	8	2.4	6.2	20
12	Central-South Ramshead	4	1.2	9.4	10
13	Thredbo-North Ramshead	2	0.6	7.9	0
14	Etheridge	7	2.1	3.5	0
15	Snowy-Merrits	0	0.0	2.4	0
16	Summit Road	21	6.2	3.6	0
17	Charlotte Pass	**62**	**18.3**	4.8	0
18	Spencers Creek	23	6.8	3.2	0
19	Paralyser	31	9.2	7.1	0
20	Blue Cow-Guthega	**70**	**20.7**	15.6	80
21	Disappointment Ridge	1	0.3	0.4	80
	TOTAL	**339**	**613***	**184.8**	**22**

* total population size in 1996-2001 estimated by Broome *et al.* (2005).

The most severely affected sites were those at the northern and western extent of the distribution (sites1, 3, 4, 5, 8, 20). However, most of these sites carried very low number of possums with the exception of site 20, Blue Cow-Guthega. Historically, Blue Cow-Guthega was one of only four sites that supported more than 25 females and up until recently supported the largest possum population in Kosciuszko National Park (Table 1). Approximately 80% of the habitat on Mt Blue Cow was severely burned during the January 2003 bushfires. However, the three other large populations (sites 7, 10, 17) were only lightly (Mt Townsend) or not affected (Mt Kosciuszko and Charlotte Pass) by the fires.

The major boulderfields at Mt Blue Cow, and three other sites (The Paralyser, Charlotte Pass and Summit Road), have been monitored annually since 1986. Monitoring results from Mt Blue Cow (Fig 2) show a substantial decline in the population size since 1997. The largest decline occurred between 1999 – 2000 but the decline has continued to 2004. There was no equivalent decline at Paralyser or Summit Road (monitored sites away from ski resort areas), but there has been a declining trend at Charlotte Pass. Up until 1997 there was an average of 30 females and 15 males at Mt Blue Cow, the population declined to 12 females and 2 males in 2000 and by December 2002, just before the January 2003 bushfires only 8 females and 2 males were captured. The area was trapped in February 2003, just after the fires, when only 2 of the 8 females were recaptured, as well as one new male. In December 2003, one of these females, 4 new females and 2 new males were captured. In December 2004 the population was at its lowest point seen since monitoring began in 1986, with only 2 females and 1 male captured on the monitoring sites, and 2 additional females in the broader area (one at Guthega, one at the 'Saddle' trapping site, at the top end of Blue Cow Creek).

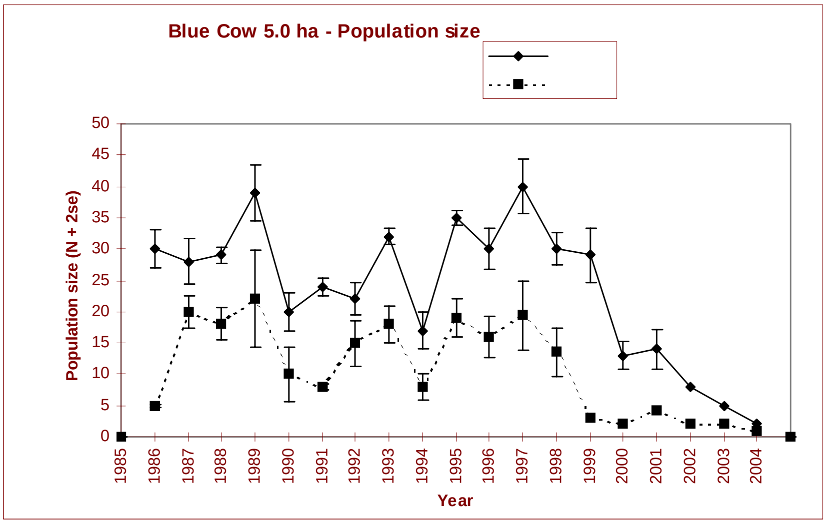

Fig. 2. Mountain Pygmy-possum population size estimates on monitored sites at Mt Blue Cow, 1986-2004.

The reasons for the population decline at Mt Blue Cow are not known with any certainty. However an interaction of increasing predation from feral cats and several years of low snow cover, that may also exacerbate any impacts from resort activities is possible. Numbers of feral cats appear to have been increasing in the area, and in 1999 a litter of kittens was found in one of the main boulderfields on Mt Blue Cow. The habitat at Mt Blue Cow is the closest of the monitored sites to the forest / low winter snow cover interface, which is likely to allow feral cats to survive through winter, or to easily reinvade in spring.

In addition to direct habitat loss, the January 2003 fire has left the small patches of remaining habitat isolated, increasing the predation risk for the remaining Mountain Pygmy-possums when they move between patches.

Recovery actions

1. Trapping and monitoring of feral cats in the Perisher Range, Charlotte Pass and Thredbo ski resorts.

A trapping program for feral cats around the ski resort areas was initiated by David Woods, Resorts Liaison Officer, Resorts Section, DEC, Jindabyne, in winter 2002. This was continued after the advent of the fires. The numbers of cats trapped has declined each year since the program began (Table 2). It is speculated that this decline reflects a decline in the numbers of cats present. However, to verify this, sandpads were established across tracks around BlueCow-Guthega in October 2004 and April 2005. Monitoring was limited to one night in October and 2 nights in April due to rain, but the program will continue.

Table 2. Numbers of feral cats trapped around the Kosciuszko ski resorts 2002-2005.

Year	2002	2003	2004	2005@
Perisher Blue	30	20	7*	3

Thredbo	10	6	6	2
Charlotte Pass	#	#	1	1

not trapped
* six radiocollared and released
@ to September

2. Radiotracking study of feral cats in the Perisher Range.
During winter 2004 a Masters student through the University of Sydney (Ms Karen Watson) commenced a study of the movements of feral cats around Perisher Blue ski resort. The aim of this study was to find out where cats are denning during winter and summer, how far they move and how much time they spend in Pygmy-possum habitat. This information will enable more efficient design of trapping programs or other control strategies to minimise the number of feral cats in the ski resorts. Six cats were collared and radiotracked during winter 2004. Three did not survive the winter, but the other 3 continued to be tracked throughout summer 2005. They will be retrapped and removed during winter 2005.

Assessment of Fire Damage and Rehabilitation of Mountain Pygmy-Possum Habitat at Mt Blue Cow.

A study was commenced in 2003 to assess the fire response and recovery of the Mountain Plum-pine *Podocarpus lawrencei* at Mt Blue Cow following the bushfires. A student initially commenced this study but it has been continued internally by DEC (Keith McDougall, Gene Wright and Linda Broome).

The Mountain Plum-pine is an important part of the habitat of the Mountain Pygmy-possum, and like the possum, is restricted to the alpine area, primarily on the rocky boulderfields. The seeds and fruits of the Plum-pine are eaten by the possum, and the sprawling branches that cover the rocks provide shelter and protection from predators for the possum, as well as habitat for caterpillars, beetles, spiders and other invertebrates that are included in the possum’s diet (Smith and Broome 1992). Plum-pines are very slow growing and it was speculated that many of the large plants may be hundreds of years old (Mansergh and Broome 1994).

The fires provided the opportunity to age the Plum-pines because many of the plants at Mt Blue Cow were killed. The aim of this study was to assess the severity of fire damage, assess the potential for recovery of the Plum-pines and determine the age of dead plants from ring counts. Other aspects of population dynamics including seedling recruitment and survival and growth rates will also be determined. Preliminary data indicate ages ranging from 52 - 383 years and suggest that fires have occurred at Mt Blue Cow on average every 44 years since 1620.

During autumn 2004 cuttings were collected from some of the surviving Plum-pines on Mt Blue Cow. One thousand cuttings were propogated by Liz McPhee (Department of Primary Industries, at Ovens in Victoria, now DEC, Tumut). Approximately 600 plants were replanted into the burnt areas at Mt Blue Cow in mid-March 2005. The remainder will be planted in spring 2005.

Smoky Mouse

Post-fire Survey of the Smoky Mouse (*Pseudomys fumeus*) in the Yarrangobilly Area of Kosciuszko National Park.

Introduction

In 1998 the endangered smoky mouse (*Pseudomys fumeus*) was found at Yarrangobilly Caves in Kosciuszko National Park (Ford 1998). The species occurs in Victoria, but has only been recorded from a handful of locations in the ACT and New South Wales, making the population in the Yarrangobilly region potentially important for survival of the species in New South Wales. Sites from which the species has been recorded tend to contain vegetation communities that develop during mid-late stages of recovery following fire (10-15 years +). These are characterised by heaths (family Epacridaceae) and legumes (families Fabaceae and Mimosaceae) which dominated the Yarrangobilly site. However, the entire Yarrangobilly region was burnt by the January 2003 bushfires. Fieldwork was conducted in the region between the 18th of September and 10th of October 2003 to ascertain the probable effects of the January fire on smoky mice. Smoky mice are difficult to locate and monitor as they exist in small, scattered, ephemeral populations. However, their apparent preference for habitats that contain a shrub community dominated by heath and legume species allows the extent of potential habitat to be assessed in the absence of capture records. Accordingly, specific aims of the work conducted in 2003 were to; 1) assess the extent of unburnt habitat suitable for the smoky mouse, 2) conduct trapping for smoky mice, 3) establish long-term vegetation monitoring plots, 4) determine whether post-fire blackberry control would potentially affect smoky mice in the Yarrangobilly area.

Results

The main sites of interest were the river walk at Yarrangobilly (easting 634080, northing 6044880 AGD 66, 8526 Yarrangobilly 1:100,000 topographic map), where three dead mice were found in 1998 (Ford 1998), and Stable Walls at Ravine (easting 62880, northing 6036900 AGD 66), where smoky mouse hairs were recovered from a quoll scat. Both these sites, and significant areas around them, were intensively burnt. No shrub layer was present in the Ravine area, and a small remnant patch (~30m x 5m) of vegetation remained at the collection locality at Yarrangobilly. Two bush rats (*Rattus fuscipes*) inhabited the small remnant at Yarrangobilly. Trapping in small areas of unburnt habitat adjacent to Caves House and above the Glory Hole cave system yielded several bush rats, a sugar glider (*Petaurus breviceps*) and one agile antechinus *Antechinus agilis*. Dog and fox scats were collected from a number of localities to supplement trapping results (Table 3) but no remains of smoky mice were found. Nor did quoll scats collected from Black Perry in March 2004 contain rodent remains (Table 3) but further collections will be made from these areas. An interesting adjunct to the survey has been the excavation of subfossil owl pellets deposits from some of the caves around the Yarrangobilly area. These deposits contain numerous remains of smoky mouse and broad-toothed rat *Mastacomys fuscus*, species that are now uncommon in the local area as well as the swamp rat *Rattus lutreolus*, which is extant in south east NSW but not known recently from the Yarrangobilly area. Additionally, three *Pseudomys* species presumed to be locally extinct, the Hastings River mouse *P. oralis* (known from northern NSW), New Holland mouse *P. novaehollandiae* (northern NSW and Victoria) and Long-tailed mouse *P. higginsii*, known only from Tasmania also occur.

The bones of some of these species are being radiocarbon dated to ascertain their age.

Table 3. Results from analysis of predator scats collected in the Yarrangobilly area*.

No	Date	Location	Scat	Definite
1	Sept 03	Thermal pool track	fox	Rabbit *Oryctolagus cuniculus*
2	Sept 03	Thermal pool track	dog	Brush-tailed possum *Trichosurus* sp.
3	Sept 03	Thermal pool track	fox	Black rat *Rattus rattus*
4	15/3/04	Castle track	fox	Sugar glider *Petaurus breviceps*
5	Sept 03	Bluff lookout	?dog	Brush-tailed possum *Trichosurus* sp.
6	Sept 03	Pinnacles	fox	Black rat Rattus rattus
7	Sept 03	Column	fox	Rabbit *O. cuniculus*
8	15/3/04	Old Mountain Rd	fox	-(feathers)
9	Sept 03	Talbingo Mt	?dog	Swamp wallaby *Wallabia bicolor*; *O cuniculus*
10	15/3/04	Black Perry Mountain	quoll	*Trichosurus* sp
11	15/3/04	Black Perry Mountain	?quoll	*Trichosurus* sp.;*F. catus* (gr)
12	15/3/04	Black Perry Mountain	quoll	*Trichosurus* sp.

* Scats analysed by Barbara Triggs.

The Yarrangobilly region was burnt so extensively that no habitat resembling known smoky mouse habitat remained. Potential unburnt habitat was located on Talbingo Mountain, which lies in the unburnt region to the north of the Snowy Mountains Highway. Two trapping grids were located on the mountain, but no captures of any species were made. Many signs of animal activity were evident at the site, particularly digs in the soil, and abundant discarded shells from hard-cased truffles, a favored food of smoky mice and bush rats. Further indications of suitable habitat were provided by herbarium collections from Black Perry Mountain, located 5 km to the east of Talbingo Mountain. This area and the Bogong Peaks-Blowering Cliffs area to the north are unburnt, and may harbor populations of smoky mice based on the characteristics of habitat in those areas. Trapping of smoky mice in Bondo State Forest to the north of Kosciuszko National Park in 2001 also suggests that lower altitude habitats on north-western edge of the park, such as Talbingo mountain, may provide suitable habitat for the species.

Long-term vegetation monitoring plots were established at Yarrangobilly and Ravine. Twenty-five plots per site were marked with metal pegs that will survive future fires. All plant species within a 5m radius were recorded, including details of cover and number. These plots will be monitored at least every three years to trace recovery of vegetation, and hopefully to establish at what stage smoky mice will re-colonise an area. However, the erratic nature of captures of smoky mice indicates that monitoring the presence of mice will be a very difficult task.

Local folklore at Yarrangobilly has established that blackberries were providing protection for smoky mice, and therefore control of blackberries was not conducted in the area of the River Walk and thermal pool. There is no justification for not controlling blackberries in the Yarrangobilly area, either pre- or post-fire. The native vegetation in which the species was found was denser than the blackberry thickets, and provided excellent cover for small mammals. Post-fire, smoky mice are unlikely to be present in the area, and re-colonisation will probably not occur until denser heaths return to the site.

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Small Mammals Post-Fire
in
Kosciuszko National Park

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The small mammal fauna of the Australian Alps does not only consist of the iconic Mountain Pygmy-possum *Burramys parvus*, but several other species that remain active throughout the year including winter during which they spend most of their time in the space that forms between the ground and the base of the snow-pack, the subnivean space.

The most common of these above the snowline include the bush rat, *Rattus fuscipes*, dusky antechinus, *Antechinus swainsonii* and the threatened broad-toothed rat, *Mastacomys fuscus*. Of these species *R. fuscipes* and *A. swainsonii* are the most commonly occurring small mammals in the Alps. Research and monitoring of these species, (especially *M. fuscus*) has been undertaken for some time in Kosciuszko National Park, the Smiggin Holes trapping grid being monitored since 1978. Prior to the fires, eight grids were being monitored during December, February and April each year. Augmenting this, a landscape scale transect had been established in the subalpine zone to investigate and monitor the distribution of small mammals in relation to snow cover and the development of the subnivean space.

Recent research in particular, demonstrated the importance of habitat structure in the development and maintenance of the subnivean space; in particular shrub structural complexity and microtopographic relief.

The 2003 fire had a number of effects on small mammals. In the first instance there was a significant reduction in the population of each species at burnt grids. A second reduction occurred following the next winter when small mammal numbers on highly burnt grids fell to zero. A similar effect was also observed at the landscape scale with small mammals absent from burnt sites on the subalpine transect. We attributed this to the loss of the subnivean space which was almost non-existent at burnt sites.

Two years after the fire small mammals are being detecting in small numbers on burnt trapping grids and at pre-fire levels on unburnt grids. At the landscape scale small mammals are still not being detected at burnt sites. We expect that small mammal recovery will be closely linked to the recovery of the subnivean space which is coupled to the regeneration of heathlands. The fire has provided numerous opportunities to expand our understanding of alpine and subalpine ecosystems. A commitment to long-term monitoring and research will expand our understanding of the small mammal fauna and its relationship to snow cover and the subnivean space. It will also add to the knowledge base that is crucial if long term conservation and management objectives are to be addressed effectively.

Post-fire monitoring of terrestrial invertebrates on the Bogong High Plains, Victoria

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Soil and surface active invertebrates were monitored on the Bogong High Plains following the fires in January 2003. Six grassland sites and six heathland sites in the vicinity of Rocky Valley Storage were surveyed, half of each being burnt and half unburnt. Invertebrate surveys were conducted in March and December 2003 and in April 2004, and three sampling methods were used: 1) sweeping, which involved 2 x 100 sweeps per site with a standard insect net; 2) pitfall trapping, with 9 test tube traps per site left out for one week on each occasion; and 3) soil sampling and extraction, with two cores of approximately 500 cm^2 being collected from each site on each occasion. Sweeping was abandoned after the first collecting date due to the absence of any insects over the burnt sites.

Soil moisture content was measured for the soil cores, and there was little difference between the burnt and unburnt sites. Preliminary results suggest there is also little difference in the invertebrate diversity between the burnt and unburnt soil samples, although identification below ordinal level has not yet been carried out. Pitfall samples in March 2003 were heavily contaminated with soil and ash in the burnt areas, but again preliminary results from subsequent samples indicate little difference in diversity between the burnt and unburnt areas. The most notable difference appears to be fewer large species (such as cockroaches and beetles) in the burnt areas, particularly in the heathland samples.

Post-Fire Recovery of Small Mammals in the ACT

Murray Evans, Senior Wildlife Ecologist, Environment ACT
Nicola Webb, Wildlife Ecologist, Environment ACT

The 2003 wildfires in the ACT were extremely hot (almost all areas burnt were classed as moderate to very high severity) and widespread (90% of Namadgi National Park affected). Such conditions have the potential to severely affect populations of small mammals and even cause localised extinction.

Environment ACT began monitoring of a range of fauna, including small ground mammals, within 6 weeks post-fire. Small mammal trapping was conducted in a range fire severity classes and vegetation communities, including Montane (Snow Gum) Woodland, Montane Tall Moist Forest (Alpine Ash), Montane Moist Forest, Dry Woodland and Riparian Forest. Between 75 and 100 Elliot traps were placed at nine sites in autumn 2003, with retrapping conducted in autumn during 2004 and 2005. Where possible trapping was conducted at locations where previous (pre-fire) trapping surveys had been undertaken.

Three small ground-dwelling mammal species are known to occur in Namadgi NP, the Agile Antechinus *Antechinus agilis*, Dusky Antechinus *Antechinus swainsonii* and Bush Rat *Rattus fuscepes*. All three species were still present in the burnt areas six weeks post-fire, including the most severely burnt sites. Agile Antechinus were present at all sites trapped, whereas the other two species were present at all sites except those in Alpine Ash and dry woodland. Generally, trapping rates were surprisingly high for these species so soon after the fires. At sites where trapping occurred pre-fire, post-fire trapping rates were lower, though not significantly so.

During the subsequent two years post-fire (2004 and 2005) trapping rates for both Antechinus species declined markedly (significant statistically) during the next two years post-fire, with Dusky Antechinus apparently becoming locally extinct at all trapping sites one year post-fire. Trapping rates for Bush Rats over the two-year post-fire monitoring period did not vary significantly.

Post-fire habitats were invaded by House Mice *Mus musculus*, which had not been recorded in any pre-fire surveys and was not known to occur in Namadgi NP. No House Mice were caught in the first trapping period six weeks post fire, one mouse was trapped in the first year following the fire and by the second year trapping rates of House Mice had increased seven-fold to become the most trapped species at any time following the fires. Such post-fire invasions of house mice have been seen in other studies of fire and effects on small mammals.

Summary

- There was surprisingly high survival of all three native small ground mammal species within the first 2 months following fire.
- During two years following fire, trapping rates of both Antechinus species severely declined with one species apparently becoming locally extinct.
- Numbers of House Mice exploded in post-fire habitats in the second year.

’Fried Fish’: The Impacts of the 2003 Canberra Bushfires on Fish Communities and Threatened Fish Species in Small Streams

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Background
The January 2003 wildfires burnt 70% of the ACT, burning 90% of Namadgi National Park including the entire Cotter River catchment, Canberra’s main water supply. The Cotter catchment also contains four of the five threatened fish in the ACT. Localised rainfall events following the fire resulted in significant erosion in the Cotter catchment, with a 2-day event in the upper Cotter in February 2003 having a rainfall intensity with a 1 in 75 year probability of occurrence. It is estimated that these rain events resulted in the deposition of 1800 tonne of sediment in Corin Reservoir in the first few months post-fire, with a further 7000 tonne deposited in the stream channels upstream and likely to reach to the reservoir during future flow events (Wasson *et al*. 2003)

Fish kills were recorded immediately after the fire.

There has been very little published on the impacts of fire on fish, so it was decided to investigate how the general fish community and in particular, two threatened fish species had been affected.

Methods
A general fish survey was conducted in April-May each year from 2003-2005. In this general survey 23 sites were sampled by backpack electrofishing encompassing a:

- range of altitudes, catchments
- Burnt and unburnt sites

Two specific fish monitoring programs were also undertaken in Feb-March each year from 2003-2005, sampling both burnt and unburnt sites. For Two-spined Blackfish (*Gadopsis bispinosus*), in 2003 nine sites were sampled, with 12 sites sampled in 2004 and 2005. For Macquarie Perch (*Macquaria australasica*) a total of five sites were sampled each year, using a combination of gill nets, fyke nets, boat and backpack electrofishing and bait traps.

Results

- High ash and sediment loads were delivered to streams following high-intensity rainfall events immediately post fire. Large amounts of sediment are stored in streams, and this continues to be reworked with every rainfall event.
- Fish abundance in the general stream survey in 2003, 2004 and 2005 was markedly reduced across all species (Brown Trout *Salmo trutta*, Rainbow Trout *Oncorhynchus mykiss*, Mountain Galaxias *Galaxias olidus*), but results need to be interpreted with care as different sampling techniques were used post-fire (electrofishing) than pre-fire (mix of rotenone and electrofishing), with electrofishing normally expected to return fewer fish. Another caveat is that some of the pre-fire data was collected up to 15 years before the fire, so population changes may have occurred for reasons other than fire. However, even with these caveats, the reduction was striking.

- Declines in the abundance of the Two-spined Blackfish in 2003 were pronounced, with declines of up to 99% at some sites. This is compared to a baseline collected in 2001, using identical sampling methods.
- Macquarie Perch numbers were down slightly immediately following the fire, and in two sites were at or below detection limits of the sampling gear, but this is thought to be unrelated to the fire.
- There was some recovery in fish numbers in the general fish survey and the blackfish monitoring in 2004, although drought impacts are still evident at some sites.
- In 2005 there was a trend to lower fish abundance across all sites in the general fish survey (burnt & unburnt), and also in the blackfish monitoring with low blackfish recruitment evident.
- Environmental flow releases were adequate for recruitment of Macquarie Perch in 2004 and 2005

What are the impacts of drought?

- In small-stream lowland environments, trout abundance was severely impacted by drought
- In lowland environments, the trout decline (pre-fire) has allowed an increase in small species (western carp gudgeon, and mountain galaxias) but few sites were sampled (because of a lack of scarcity of small lowland streams with water present and a lack of unburnt sites!)
- In 2005 there was a trend to lower fish abundance across all sites (both burnt & unburnt)

Take Home Messages

- You can't ignore the confounding effects of the prolonged drought
- There has been much discussion about the benefits to fauna of patchy burns. Patchy burns don't help fish who live in linear environments
- We should recognise events like fire and drought can be used to advantage for feral fish control (e.g. trout)
- Sediment is going to stay in streams for decades. There is no quick fix
- Pools are worse affected than riffles by sediment, so pool dependant species will be hardest hit
- Don't forget the charismatic semi-aquatic megafauna (crayfish) in post-fire monitoring programs. Anecdotal evidence indicates that post-fire fox predation on bog-dwelling crayfish (*Euastacus rieki*) was enormous

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The effects of fire on skinks in Chiltern-Mt Pilot National park, Victoria

Honours thesis, submitted May 2005

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Abstract

Fire effects on habitat structure and terrestrial invertebrates were assessed following the 2003 Victorian alpine bushfires to determine if these affected the abundance and diversity of ground-dwelling skinks in Chiltern-Mt Pilot National park, Victoria. Twenty sites were established in two treatment groups (unburnt/burnt) of two areas (rocky/non-rocky). The area that had been burnt at high intensities was dominated by flammable tree species and had significantly reduced amounts of ground fuel (litter) two years post-fire.

Habitat variables differed considerably between treatment areas, with a high number of regenerating shrubs and young trees in the burnt treatment. Skink abundance and diversity were measured using three survey techniques: pitfall trapping, active searching and artificial refuges. Pitfall trapping was effective in capturing several reptile species, however, active searching yielded the highest number of individuals. The majority of skinks were found by active searching in various microhabitats. *Hemiergis decresiensis* was the most common ground-dwelling species detected in the study area, particularly under logs. They preferred large, highly decayed logs, which were less available in the burnt treatment. Skinks were correlated with ground cover attributes including litter, grass and coarse woody debris. *Morethia boulengeri* were abundant in leaf litter, while *Lampropholis guichenoti* were not frequently detected.

Skink abundance was significantly reduced in fire-affected areas where ground cover was sparse. Likewise, invertebrate diversity and abundance were significantly lower in sites lacking sufficient ground cover. The unavailability of invertebrates as prey items may have contributed to the reduced number of skinks in the burnt treatment.

The associations between fire intensity, vegetation and ground cover variables with the abundance and diversity of skinks and terrestrial invertebrates were apparent. The removal of coarse woody debris may greatly affect skink distribution and it should therefore be protected. Further research regarding these relationships is necessary to clarify the effects of wildfire and prescribed burning on skinks to aid in quality long-term conservation and management.

Lessons from the Burning Bush
The Influence of Live Fuels on Fire Behaviour

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Introduction

This study examines the role of the shrub *Daviesia mimosoides* in low to moderate intensity experimental fires and uses a rudimentary semi-physical model to predict the contribution of the species to fire intensity with changing weather conditions, terrain, leaf moisture, plant size and plant density.

Methods

Data was collected from video and other records of 8 experimental burns carried out in the Kosciuszko National Park and Macanally Nature Reserve in the Southern Tablelands of NSW. This was used to find broad changes in flammability of the species, specifically maximum flame length and duration relating to combustibility and sustainability (see Anderson 1970, Gill & Zylstra in press re. flammability), and these changes were examined as functions of leaf moisture and plant height.

The semi-physical model used empirical data (Table 1) collected from the burns coupled with existing theory on:

1. the relationship between ignition delay time and leaf moisture / leaf thickness (Gill & Moore 1996)
2. Flame merging or Cluster-burning theory (Gill 1990), and
3. Plume angle (Alexander 1998)

Table 1: Field Data used in the Model

Live Fuel Descriptors
Plant height, plant base height, plant diameter, leaf thickness, leaf moisture, plant spacing, & cover of plants.

Other Factors
Change in flame height & duration with moisture content & plant height, mean surface flame height away from burning plants, surface fuel moisture & quantity, mean 30 second wind speed, slope

Flame geometry was reduced to a single line with given length, duration at any length, and angle. The temperature gradient in the plume was not considered, but calculations were made on the assumption that the point of flame contact was the necessary temperature at which to consider ignition delay time, and only convective heat transfer was considered. These latter two simplifications were necessitated as sufficient data has not yet been collected to build these models.

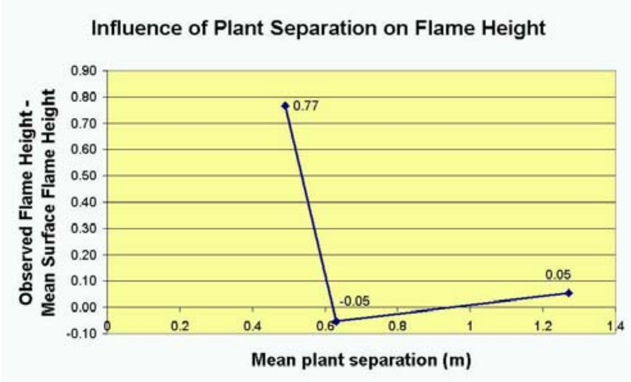

Figure 1. The Influence of plant separation on flame height

Predicted results were compared with those of an existing empirical model that does not consider differences in live fuels (McArthur 1962) using a conversion of the tables and figures into equations (Zylstra & Weber. Unpub.). Results were tested against 37 flame height measurements taken during one of the experimental burns:

a) When only surface fuels and isolated plants were burning, and
b) When groups of plants were burning and flame merging occurred

Results

D. mimosoides plants had a negligible effect on mean flame height when the separation between plants was 0.63m or greater, but when the mean separation was 0.49m or less, the effect was to multiply the flame height by a factor of 3.57 (figure 1).

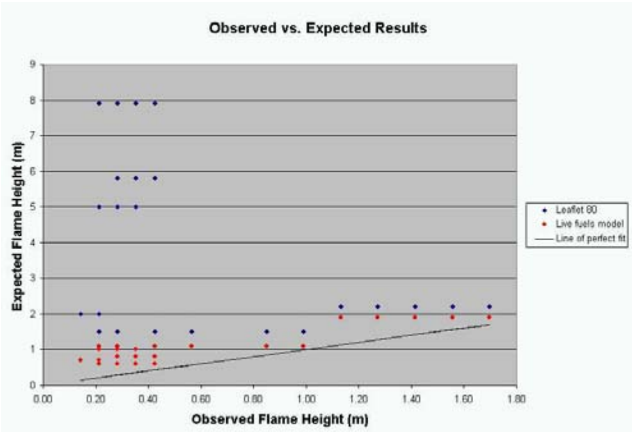

Figure 2. Observed vs. expected results for both models.

Flame height in the study was poorly represented by the empirical approach of Leaflet 80 (figure 2), which significantly over-predicted when surface fuels were 15t/Ha and live fuels sparse, but only slightly over-predicted when surface fuels were 9t/Ha and live fuels were dense.

The semi-physical model was able to more closely follow the change in flame height, giving a consistent slight over-prediction but with a correlation coefficient of 0.87.

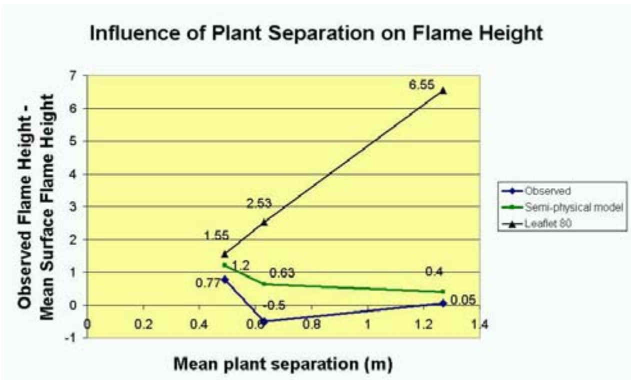

Figure 3. Sensitivity of the models to plant spacing

Discussion
Although only in its early stages, this study suggests that the contribution to flame height by burning live fuels can be significant and beyond the capacity of a generic empirical model to encapsulate. Models such as McArthur's Leaflet 80 use only surface litter as fuel input, however the gross over-prediction noted in the heavier surface fuels would suggest that increased elevated fuels are implied to the model by higher surface fuels.

As given in figure 1, flame height was greatly affected by plant spacing. A comparison of the 2 models with this observation (figure 3) reveals that while the empirical model was unable to recognise the impact of plant spacing, the semi-physical model correctly identified the point at which flame height increased due to flame merging.

A reasonable conclusion is that the variability in plant flammability and density of cover from one forest type to another requires some physical data to accurately represent fire behaviour.

Acknowledgments
Much valuable advice has been provided for this work by Professor Rodney Weber, Dr Malcolm Gill, Dr Matt Plucinski and Mr Brendan Pippin. All burns were carried out with the generous assistance of the NSW NPWS staff at Jindabyne and the rocky Plains Fire Brigade.

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Appendix 1

Australian Alps Cooperative Program

and

Parks Victoria and the Department of Sustainability and Environment (Vic)

Fire Biodiversity Workshop

June 15-16, 2005
Lake Hume, Albury

AGENDA

Wednesday

12.00	Lunch	
1.00	Welcome	Gill Anderson
1:10	Keynote address –***Beyond the Bushfires 2003 – Environmental Issues in the Australian Alps.***	Dr Malcolm Gill
1:50	Post-fire regeneration of plants at Kosciousko and fire in a *Podocarpus* shrubland at Blue Cow	Keith McDougall
2.15	Patterns of fire occurrence and severity of the 2003 fires on the Bogong High Plains	Dick Williams
2:40	Treeless vegetation recovery	Arn Tolsma
3:05	Sphagnum Bog recovery – NSW and ACT	Roger Good
3:30	Nature, extent and effects of the 2002/03 high country fires in NSW – an archive/database	Elizabeth Tasker
3:35	Afternoon tea – 25 minutes	
4:00	Broom recovery in the subalpine and montane areas, Victoria	Lynise Wearne and Cathy Allen
4:25	Victorian Threatened flora research	Fiona Coates
4:00	Mountain Pygmy Possum recovery following fire in the Victorian alps	Dean Heinz
4:25	Post-fire recovery of Mountain Pygmy Possum and Smoky Mouse in NSW	Linda Broome
4:50	Post fire recovery of small mammals in NSW	Glen Sanecki
5:15	Post-fire monitoring of terrestrial invertebrates on the Bogong High Plains	Dennis Black
5:40	Afternoon Session Conclusion – 15 minutes to draw out the key messages to managers, and the gaps in research at an overall ecological level, with respect to fire. Collaboration opportunities?	Dave Darlington

7:30	DINNER	
	After-dinner speaker - **Roger Good – Grazing in the Australian Alps**	

Thursday

8:30	The impact of wildfire on the spotted-tailed quoll in Kosciuszko National Park	Andrew Claridge
8:55	Post-fire recovery of small mammals in the ACT	Murray Evans
9:20	Post-fire monitoring in the dry rain-shadow woodlands of the Snowy River valley.	Kevin Thiele
9:45	"Fire and the Black Cypress-pines at Mt Pilot North East Victoria" reporting research with Ian Lunt	Christine Watson
9:45	Corroboree Frog	Dave Hunter and Rob Pietsch
10:15	Aquatic species post-fire recovery	Mark Lintermans
10:40	Morning tea (30 mins)	
11:10	Brindabella Vegetation Monitoring	Michael Doherty
11:35	ACT Vegetation Monitoring	Margaret Kitchen
11:50	Alps Fire Ecology plots	Trish Macdonald
12:00	Workshop session What have we achieved, What have we missed, and What are the potential collaborative projects?"	
12:45	Final wrap up:	
1:00	Lunch	

Post-fire Biodiversity Workshop - PARTICIPANTS

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PowerPoint Presentations from Workshop

Fire Biodiversity in the Australian Alps National Parks

Note –PowerPoint presentations in italics do not have a corresponding Workshop Paper.

1. ***Beyond the Bushfires of 2003: Environmental Issues in the Alps***Malcolm Gill

2. **Alpine grazing and blazing: A landscape test of a widely-held view**
   Dick Williams, Henrik Wahren, Ross Bradstock and Warren Muller

3. **Post-fire flora work – NSW and Victoria**
   Keith McDougall et al.,

4. **Treeless Vegetation Recovery on the Bogong High Plains**Arn Tolsma, James Shannon, Henrik Wahren, Liz MacPhee & Warwick Papst

5. **Post-fire Bog and Fen Revegetation and Restoration in Kosciuszko and Namadgi National Parks.**
   Roger Good, Amanda Carey, Genevieve Wright

6. **Controlling weed invasion post-fire – implications for restoration of the native vegetation.**
   Lynise Wearne and Cathy Allen

7. **Recovery of threatened flora and vegetation after the 2003 bushfires**Fiona Coates, Maria Taranto, Arn Tolsma

8. **Monitoring Vegetation Recovery after the 2003 Fires in the 'Northern Extremities' of the Australian Alps**Michael Doherty and Genevieve Wright

9. **ACT Long-term Vegetation Monitoring Plots**
   Margaret Kitchin

10. ***Post-fire monitoring in the dry rainshadow woodlands of the Snowy River valley***Suzanne Prober, Kevin Thiele and Mick Bramwell

11. **Small mammals post-fire in Kosciuszko National Park**Glenn Sanecki and Ken Green

12. **Post-fire Monitoring of Terrestrial Invertebrates on the Bogong High Plains, Victoria**Dennis Black

13. **Post-fire small mammal monitoring, ACT**
    Murray Evans and Nicola Webb

14. **Fried Fish: The impacts of the 2003 Canberra fires on fish communities in small streams**Mark Lintermans

15. **Post Fire recovery of Mountain Pygmy-possums and Smoky Mice in Kosciuszko National Park**Linda Broome

16. ***Post-fire assessment of the habitat and populations of the Mountain Pygmy-possum Burramys parvus in Victoria****Dean Heinze*

17. ***Implications of the 2003 Wildfires to the Conservation of the Southern Corroboree Frog, Pseudophryne corroboree.***
David Hunter and Rod Pietsch ***Spotted-tailed Quoll Research Program, Kosciuszko National Park, 2002-2005***
Andrew Claridge and James Dawson

19. **Lessons From the Burning Bush – The Influence of Live Fuels on Fire Behaviour**
Philip Zylstra