Department of Sustainability and Environment

Arthur Rylah Institute Technical Report Series No. 152

Recovery of montane swamp complex after bushfires in north east Victoria 2003

Maria Taranto, Judy Downe, Fiona Coates and Alison Oates

Arthur Rylah Institute for Environmental Research

Victoria The Place To Be

Arthur Rylah Institute for Environmental Research
Technical Report Series No. 152

Recovery of montane swamp complex after bushfires in north east Victoria 2003

Maria Taranto, Judy Downe, Fiona Coates and Alison Oates

December 2004

Published by the Victorian Government Department of Sustainability and Environment
Melbourne, December 2004

Authorised by the Victorian Government, 8 Nicholson Street, East Melbourne.

For more information contact the DSE Customer Service Centre 136 186

ISBN 1 74152 085 1
ISSN 0810-5774

Citation
Taranto, M., Downe, J., Coates, F. and Oates, A. (2004) Recovery of Montane Swamp Complex after bushfires in north east Victoria 2003. Arthur Rylah Institute for Environmental Research Technical Report Series No. 152. Department of Sustainability and Environment, Heidelberg

Cover photo. The T1 site of Montane Swamp Complex surrounded by Montane Sclerophyll Woodland. The wall of the Tailings Dam can be seen in the background on the left side.

Contents

List of Figures and Tables

Figures

Tables

Executive summary

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 of the Wilga-Currawong mining project (referred to here as the T1 site). 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.

Introduction

Montane Swamp Complex (Figure 1) is one of six listed threatened communities, burnt during the 2003 bushfires in north-eastern Victoria and identified as having priority for risk management (Parks Victoria and Department of Sustainability and Environment 2003).

Montane Swamp Complex has been listed under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 and the Victorian Flora and Fauna Guarantee Act 1988. Evidence presented for FFG listing supported two major criteria: 1) the community is significantly prone to future threats, which are likely to result in extinction, and 2) the community is very rare in terms of the total area it covers, has a very restricted distribution or has been recorded from only a few localities.

The only known occurrences of Montane Swamp Complex are on a few tributaries of the upper Tambo River near Benambra in East Gippsland. The area has been thoroughly surveyed as part of investigations following the initial Environmental Effects Statement (EES) (Carr *et al.* 1987; Kinhill Engineers Pty. Ltd and Macquarie Resources Ltd. 1987, Gullan and Westaway 1988) resulting from an application to mine copper, zinc and lead by Macquarie Resources Limited. McMahon and Carr (1988) identified seven localities of Montane Swamp vegetation ranging in size from 0.5 to 21 hectares (totalling 44 hectares) plus a few additional sites occupying less than 0.5 hectares. The largest area, known as the T1 site, was the proposed location of the tailings dam for the Wilga-Currawong mining project.

Figure 1. Aerial view of Montane Swamp Complex

Carr and McMahon (1988) identified three sub-communities of Montane Swamp Complex from aerial survey of Montane Swamp vegetation in the Benambra project region. Gullan and Westaway (1988) surveyed five of the six remaining sites greater than 0.5 ha to determine if the vegetation was similar to that at the T1 site. They concluded that the T1 site was a distinct variant of the Montane Swamp Complex that did not occur at any other localities. In a later study, Earl (1990) collected quadrat data from nine additional sites thought to contain Montane Swamp Complex, as identified by McMahon (1988) and Gullan and Westaway (1988), in the Tambo State Forest. These small catchments were all within a seven km radius of the T1 site. A comparison between the additional quadrat data with data from four other studies, including Carr and McMahon's quadrats from the T1 site found that the quadrats from the T1 site classified into a distinct group "distinguished by a number of character species not shared by any other groups" (Earl 1990). It was concluded that the T1 site had greater diversity and habitat specialisation than any of the other swamp or riparian sites that were examined (Earl 1990).

The tailings dam proposed for the T1 site was to be a permanent dump for toxic sludge, containing cyanide, copper, zinc and lead, from the extraction plant of the mine (Sunday Observer 1989). There were major concerns at the time about the destruction of rare or threatened plants, the rare Giant Burrowing Frog, the vulnerable grayling fish as well as the negative consequences for species diversity, water quality and habitat. The development proceeded and 90% of the T1 site was destroyed, reducing its area from 21 ha to 2 ha (Cousins 1994) (Figure 2). The total area of Montane Swamp Complex was reduced to almost half.

Figure 2. Aerial view of Benambra Mine

Montane Swamp Complex is a mosaic of treeless, cold air drainage-line vegetation, with a large number of herbaceous species (Carr and McMahon 1988). Generally, this community is dominated by *Baeckea utilis* (Mountain Baeckea) and *Leptospermum myrtifolium* (Myrtle Tea-tree). An understorey of heathy shrubs is dominated by *Epacris microphylla* (Coral Heath), *E. breviflora* (Drumstick Heath) and *Hakea microcarpa* (Small-fruit Hakea). The field layer contains a diversity of sedges, grasses, forbs and ferns including *Schoenus apogon* (Common Bog-sedge), *Empodisma minus* (Spreading Rope-rush), *Baloskion australe* (Slender Twig-sedge), *Baumea gunnii* (Slender Twig-rush), *Carex gaudichaudiana* (Fen Sedge), *Carex appressa* (Tall Sedge), *Isolepis subtilissima* (Mountain Club-sedge), *Juncus* spp. (Rush), *Festuca asperula* (Graceful Fescue), *Poa costiniana* (Bog Snow-grass), *Blechnum penna-marina* (Alpine Water-fern), *Asperula gunnii* (Mountain Woodruff) and *Sphagnum cristatum* (Peat Moss).

The occurrence of pest plants at the T1 site in the original survey by Carr and McMahon (1988) was low, as might be expected from such an isolated location. They recorded eight weed species, with only two considered to have potential as serious weeds - Blackberry (*Rubus* sp.) and Spear Thistle (*Cirsium vulgare*). Cousins (1994) recorded five species of weeds at the T1 site, four of which were also recorded previously by Carr and McMahon (1988), but were not considered as serious weed species. He did not record Blackberry or Spear Thistle. The other introduced species recorded by Cousins was Jointed Rush (*Juncus articulatus*) a serious weed that has infested large areas of riparian and swampy environments across the state. This species was not recorded in the Straight Creek system prior to the mining development. Cousins (1997) reports that the cover/abundance of three weed species (Jointed Rush, Flatweed and Common Centaury) had increased since the initial monitoring of Montane Swamp Complex. He also recorded Spear Thistle and Dandelion (*Taraxacum officinale* spp. agg.) in the buffer zone between the disturbed areas and the Montane Swamp Complex, but did not record Blackberry at the T1 site.

In the wake of the 2003 bushfires, the objectives of this project were to:

- determine the current condition status of Montane Swamp Complex;
- identify threats to post-fire recovery of Montane Swamp Complex;
- identify management requirements for Montane Swamp Complex;
- provide a baseline against which post-fire recovery of Montane Swamp Complex can be evaluated;
- develop a protocol for ongoing monitoring of key species.

Methods

Site description

The site is located at the Currawong-Wilga Mine, approximately 40 km north-east of Omeo (55H 581827E 5904772N).

The study was confined to the largest area occupied by Montane Swamp Complex vegetation in the headwaters of Straight Creek, between Currawong Road and Tailings Dam Road, southwest of Tailings Dam No.1 (Figure 3a). It was restricted to this site mainly due to the inaccessibility of other sites greater than 0.5 hectares within the time available. Throughout this report, the study site will be referred to as the T1 site.

The T1 site was stratified into three zones:

1) wet depressions (saturated by ground-fed water)
2) vegetation along Straight Creek
3) drier areas that include scattered eucalyptus species

Along Straight Creek and in the wet depressions the soils are silty and highly organic. In contrast, soils supporting the drier woodland areas are clay loams.

Vascular plant species and vegetation condition

Site survey and assessment

Two randomly placed quadrats (10 x 10 m) were placed within each of the three zones (Figures 3a & b).

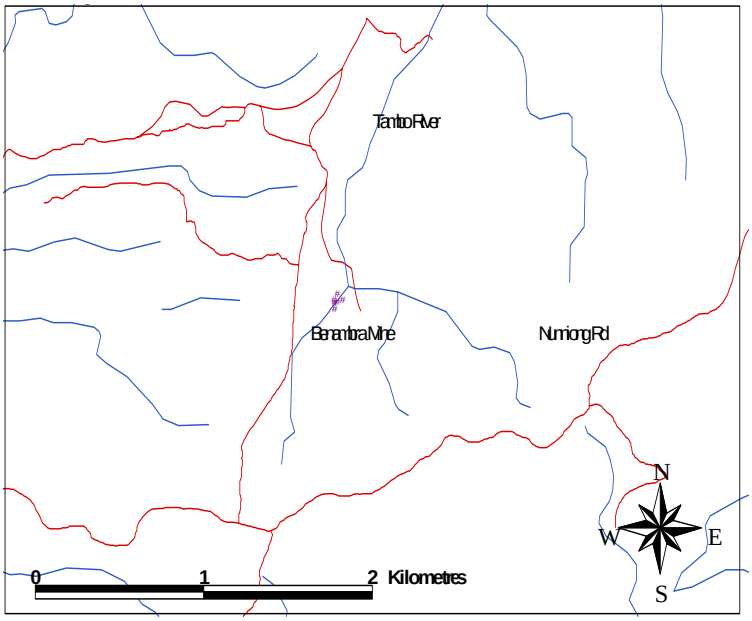
All vascular plant species were recorded in each quadrat and assigned a cover/abundance value according to a modified Braun-Blanquet system[1] (Gullan 1978). Additional data included stage of regeneration (vegetative only, flowering or producing seed), and mean resprout height of dominant species. Percentage cover of moss, bare ground, standing surface water and leaf litter were recorded for each quadrat. GPS readings were recorded at the north-east corner for all quadrats and marked with aluminium posts for ongoing monitoring.

All quadrat data was submitted for inclusion in the Flora Information System (Flora and Fauna Information Management Group, Department of Sustainability and Environment).

[1] + = cover <1%; 1 = cover 1-5%; 2 = cover 5-25%; 3 = cover 25-50%; 4 = cover 50-75%; 5 = cover 75-100%.

The structure of the Montane Swamp community was assessed visually by comparing the descriptions of the three sub-communities described at the T1 site by Carr and McMahon (1988) with the post-fire condition of the vegetation.

Fieldwork was carried out in January and mid-February 2004. Botanical nomenclature follows Ross and Walsh (2003).



(a)

(b)

Figure 3. (a) Location of quadrats, Tailings dam 1 site; (b) Quadrat survey of a wet depression in Montane Swamp Complex.

Threatened species

A list of threatened plant species was compiled from previous surveys (Carr and McMahon (1988, Cousins 1994, 1997) and taxa were searched for within the study area.

Post fire recovery and regeneration

The recovery of Montane Swamp Complex was determined by comparing species richness and regeneration prior to and after the fires at the T1 site. For both data sets, each species was allocated to a life form class. These were: woody perennial, perennial grass or graminoid, herbaceous perennial, fern or moss. To estimate post-fire species richness, the mean number of species recorded before and after the fires was compared for each life form class and for weeds. To estimate regeneration, we compared the number of individuals in each class pre- and post-fire.

Pre-fire species composition was obtained from five of the six quadrats recorded by Carr and McMahon (1988) at the T1 site - F10106, F10110, F10112, F10114 and F10116. Quadrat F10117 was not included in the species list because this site was destroyed by the construction of the tailings dam. Data were obtained from the Flora Information System (DSE). Unfortunately there were no more recent floristic data available.

It should be noted that the taxonomy of some species recorded by Carr and McMahon (1988) has changed since their survey (Ross and Walsh 2003). Consequently, the pre-fire species lists were updated with the current taxonomy where possible, for example *Festuca hookeriana* to *Austrofestuca hookeriana* and *Stylidium* sp. aff. *graminifolium* to *Stylidium montanum*.

Condition of *Sphagnum cristatum* peat bogs

Within the Montane Swamp Complex T1 site, the location, size and general condition of the main *Sphagnum cristatum* bogs were recorded. Exact locations were recorded using GPS. The length and width of bogs was measured and general condition was assessed in relation to percentage of living *Sphagnum cristatum* and regeneration of other species within the predominantly dead *Sphagnum cristatum* bogs.

Fire response characteristics

Vital attributes

Dominant or frequently observed indigenous taxa were assigned a set of "vital attributes" (Noble & Slatyer 1980) required for fire management databases currently being compiled by DSE and Parks Victoria (Fire Ecology Working Group 2004). This information is intended to assist with fire management of specific sites by predicting post-fire vegetation succession based on three attributes: method of persistence, conditions for establishment and longevity (Table 1).

Method of Persistence	
	Seedling establishment
D	seed: dispersed long distances
S	seed: stored, maintains viability for long period, partial germination per disturbance
G	seed: stored, maintains viability for long period, single germination per disturbance
C	seed: short-lived, exhausted after single germination
	Vegetative mechanisms
V	sprouters: all ages survive, all become juvenile
U	sprouters: mature remain mature, juveniles remain juvenile
W	sprouters: mature remain mature, juveniles die
	Dual mechanisms
Δ	dispersed seed + mature remain mature + juvenile may or may not resprout (D+ U or W)
Σ	seed store + mature remain mature + juvenile may or may not resprout (S+U or W)
Γ	seed store with one germination + mature remain mature + juveniles die (G+W)
Conditions for Establishment	
T	tolerant, will establish in presence of adult competition (multi-aged population)
I	intolerant, needs disturbed site with competition removed (single aged population)
R	requires some precondition to be met before establishment, delayed establishment
Longevity	
Juv	Number of years plant remains reproductively immature
Mat	Number of years plant remains mature and alive
Ext	Number of years any source of regenerative material (seeds, rhizomes etc.) remains on site

Table 1. Vital attributes and their codes (Noble & Slatyer 1980). A taxon was considered mature if more than 50% of the population was fertile in the season during which the survey was conducted.

Results

Vascular plant species and vegetation condition

The intensity of the fire was severe at all sites of Montane Swamp Complex that were inspected. The shrubland structure was totally destroyed and approximately 90% of the sphagnum moss beds burnt. Sixty-nine species were recorded in quadrats, including 4 weed species (Appendix 2). Thirty-six indigenous species and 1 weed species (*Trifolium repens* var. *repens*) were flowering or had set seed.

Comparison between the three vegetation zones sampled in the post-fire survey and the sub-communities described by Carr and McMahon (1988) proved difficult, as the post-fire quadrats did not clearly fit into the sub-communities previously described. There were too few quadrats in either survey to conduct a more sophisticated multivariate statistical analysis. Further, the structural descriptions of the sub-communities provided no assistance because the fire had destroyed the structure of the vegetation. It seems that the wet soaks (Quadrats 1 and 2) and the creek sites (Quadrats 3 and 4) best fitted into sub-communities 1.1 and 1.3. Both these vegetation zones contained characteristic species but when these species were compared to the list of character species for the sub-communities some species occurred in sub-community 1.1 and others in sub-community 1.3. In addition some species were recorded from all three vegetation zones but were characteristic of only one sub-community.

Whilst several species are common to all three vegetation zones there are major differences in species composition (Appendix 1). Along Straight Creek and on the periphery of wet depressions *Xerochrysum subundulatum* and *Empodisma minus* dominated. *Xerochrysum subundulatum* was in flower at the time of the study and was particularly obvious in these zones. *Carex gaudichaudiana, Utricularia dichotoma, Gratiola peruviana, Ranunculus collinus, Ranunculus pimpinellifolius, Goodenia elongata* and *Sphagnum cristatum* were also common (Figure 4).

Figure 4. A wet depression in foreground, dominated by *Xerochrysum subundulatum* and drier areas in background dominated by grass species.

Grass species were few in the wetter areas. In the drier zone, *Utricularia dichotoma* was absent, *Arthropodium milleflorum*, *Stylidium montanum* and *Velleia montana* were more dominant and grass species prevalent. Some eucalypt species occurred as well as a few shrubby species typical of Montane Sclerophyll Woodland.

Regeneration was vigorous, particularly in wetter areas, where dense vegetation growth had resulted in total ground cover (Figure 5). Shrubs were mostly regenerating by shoots similar in height to the graminoids at the site. The mean height of all regenerating woody perennials was variable, and large differences existed between quadrats for the same species (Table 2).

Areas of bare ground were high in the drier zones (Figure 6, Appendix 2) whereas leaf litter cover and moss cover were generally low overall (<5%). As was expected, standing water was high in wetter areas (Appendix 2)

Species	**Number of quadrats recorded**	**Mean height (cm) ± SE**
Baeckea gunniana	1	15
Baeckea utilis	5	28 ± 3.4

Comesperma retusum	3	22.3 ± 11
Epacris breviflora	6	15 ± 2.9
Eucalyptus rubida	2	45 ± 25
Eucalyptus stellulata	2	45 ± 25
Hakea microphylla	3	60 ± 5.8
Leptospermum myrtifolium	2	40 ± 20
Lomandra longifolia subsp. *exilis*	1	40
Olearia erubescens	2	32.5 ± 17.5

Table 2. Mean height ± SE of dominant or frequently recorded woody perennials.

Figure 5. Graminoid and herbaceous species regenerating in the wet depressions. The mound of *Sphagnum* moss has been fire-killed and *Ranunculus*, *Empodisma* and other species are growing over and through it.

Figure 6. Grass and shrub species regenerating in the drier vegetation zone. Patches of bare ground occur between the grass tussocks.

Rare or threatened species

Three species of conservation significance were recorded in transects or were observed within the study site. Seven significant species which were known from the T1 site prior to the fires were not re-located (Table 3).

Species (threat status[#])	**Source**			
	Carr and McMahon (1988)	Cousins (1994)	Cousins (1997)	This study
Deyeuxia gunniana	Yes	Yes	Yes	No
Goodenia elongata	Yes	Yes	Yes	Yes
Juncus sp. I – Assume *J. falcatus*	Yes	No	No	Yes
Leptospermum sp. aff. *juniperinum*	Yes	No	Yes	No
Myriophyllum alpinum (r)	Yes	Yes	Yes	No

Ophioglossum petiolatum (r)	Yes	No	No	No
Pterostylis dubia – now *P. oreophila* (e)	Yes	No	No	No
Stylidium sp. aff. *graminifolium* – assume *S. montanum*	Yes	No	No	Yes
Viola hederacea subsp. *fuscoviolacea*	Yes	No	No	No
Carex capillacea (r)	Yes	Yes	Yes	No

Table 3. Significant plant species recorded in Montane Swamp Complex at the T1 Site. e= endangered in Victoria, v = vulnerable in Victoria, r = rare in Victoria, k = poorly known in Victoria (Ross and Walsh 2003).

Post-fire recovery and regeneration

Species richness

Species richness was higher fifteeen years prior to the fires than 1 year post-fire in all life form classes, with the exception of geophytes and annuals and weeds (Figure 7). Species richness of woody perennials, herbaceous grasses and graminoids and herbaceous perennials were roughly half that of 1988 levels. However, due to the lack of more recent pre-fire data this comparison may not accurately reflect post-fire floristic changes. Weeds recorded during the post-fire survey were *Holcus lanatus* and *Trifolium repens*, although only the latter was present in pre-fire data. No annual species were recorded in pre-fire quadrats, and two annuals were seen in 2004. There were no ferns or mosses recorded in 2004 although these were observed elsewhere within the study area.

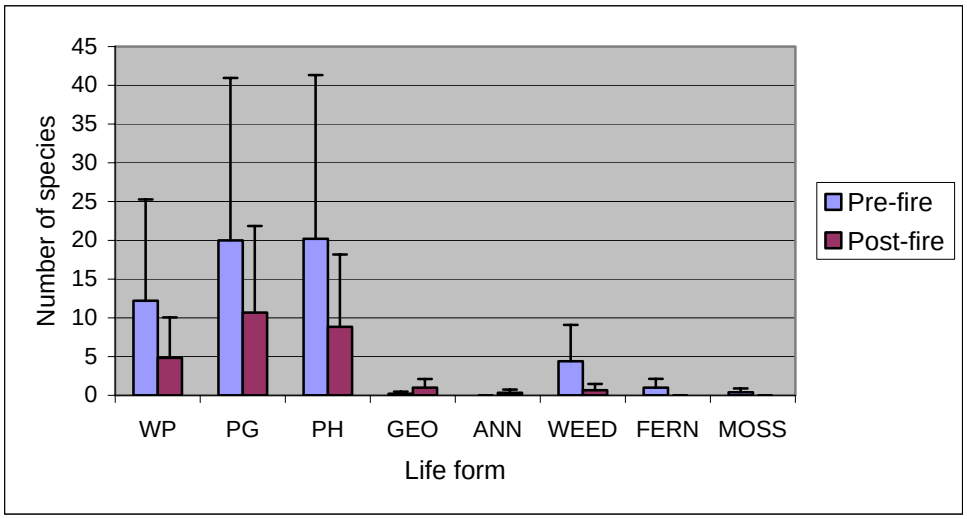


Figure 7. Mean total species richness for each life form class before and after the 2003 bushfires. Pre-fire quadrat data from Carr and McMahon (1988). WP = woody perennials, PG = perennial grasses and graminoids, PH = herbaceous perennials, GEO = geophytes, ANN =annuals, WEED = weeds, FERN = ferns, MOSS = non-vascular species.

Regeneration

There was a high number of species in cover class category "+" (<1%) for the three major life forms, woody perennials, perennial grasses, graminoids and herbs overall post-fire (Figure 8). As was expected after the fire, numbers were highest in this cover class and decreased in cover classes "1" and "2". Regeneration had not yet exceeded 25% cover for any life form category.

A higher number of geophytes was recorded in early stages of regeneration in 2004, although these were a relatively insignificant component of post-fire recovery. However, weed regeneration was noticeably low post-fire, with fewer species recorded and the distribution of species within cover classes suggesting that post-fire growth of weeds may be slow.

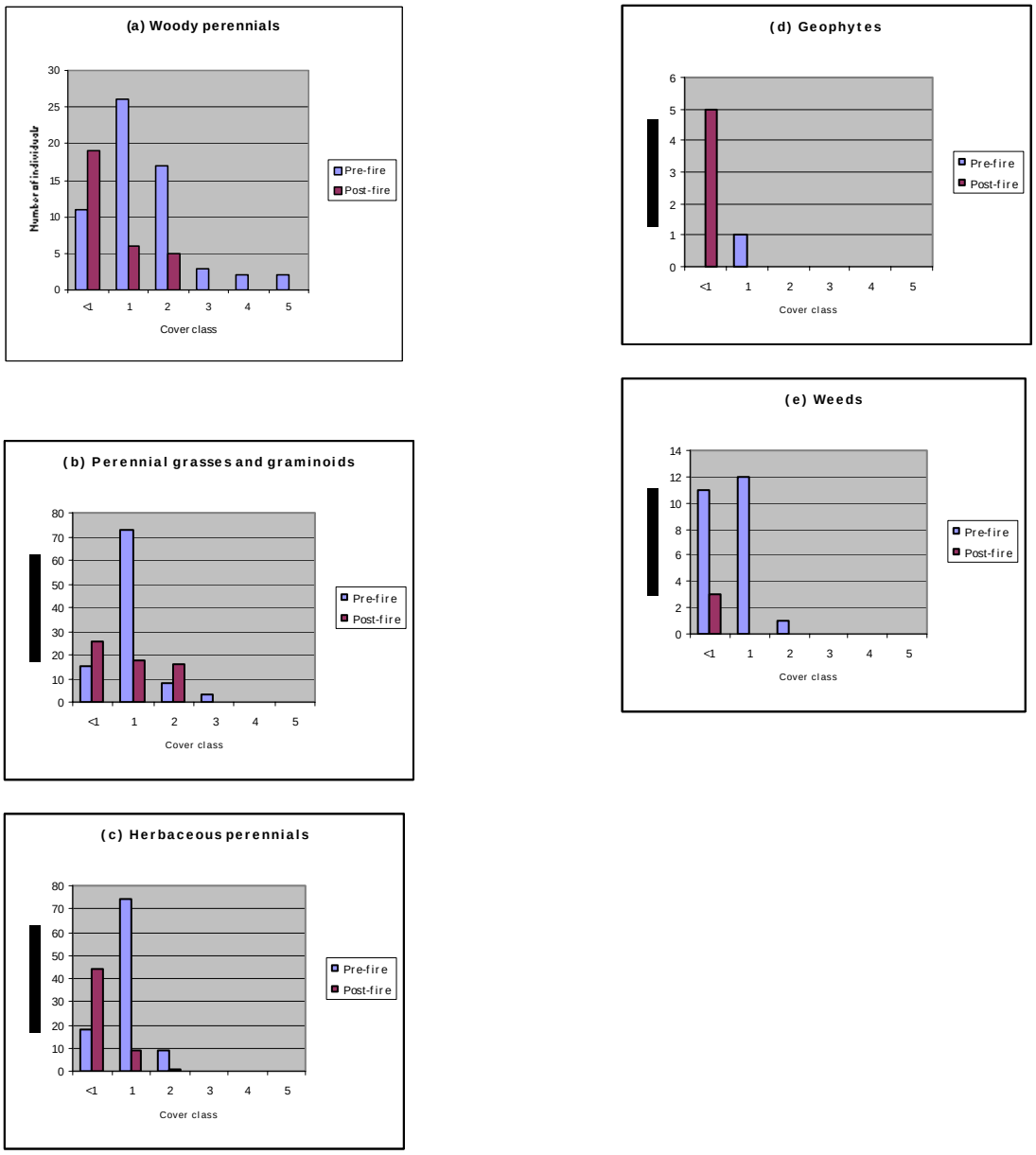


Figure 8. Number of species in each cover/abundance class for plant life forms before and after the 2003 bushfires. Pre-fire data are from quadrats at the T1 site recorded by Carr and McMahon (1988). See methods for an explanation of cover class codes.

Condition of *Sphagnum cristatum* bogs

Three main populations of *Sphagnum cristatum* occurred within the study site (Table 4). In each of these populations, tall shrubs (>2m) that were growing out of the moss beds had been burnt, leaving dead stems and sometimes resprouts (Figures 9 and 10). However, whilst most of the *Sphagnum* was dead, leaving 1-5% living, much still remains on site. Sphagnum beds had not been totally incinerated by the wildfire nor had it subsequently been removed by wind or water. Presumably, the moisture content of *Sphagnum* moss

prevented it from being completely killed even though most of the aboveground biomass of shrubs growing within the moss beds was destroyed. However, in one area on the western side of site 3, patches of *Sphagnum* were totally removed leaving the ground surface severely scorched and mineralized. It appeared that the fire had entered the swamp area at this point and had been extremely intense. The high moisture content of the swamp vegetation had obviously reduced the intensity of the fire so that other areas of the Montane Swamp Complex were not burnt as severely.

Site	Easting	Northing	Altitude	Aspect	Length	Width	Area of occupancy (m^2)	% cover
1	581776	5904762	1179	EW	10	6	60	5
2	581751	5904722	1155	NE-SW	30	14	420	1-5
3	581731	5904739	1163	NE-SW	50	36	1800	<1

Table 4: Location, altitude, aspect, size and percentage cover of living *Sphagnum cristatum* for each *Sphagnum* site at the T1 site of Montane Swamp Complex.

Figure 9. *Baeckea utilis* resprouting in burnt *Sphagnum* moss bed.

Figure 10. Severely burnt western side of *Sphagnum* site 3.

Sphagnum cristatum site 1

This site was several metres east of Straight Creek, supported by an underlying wet sink. The *Sphagnum* mounds at this location were up to approximately 60cm deep and were the site of mass regeneration of numerous plant species. These included: *Baeckea utilis*, *Hakea microcarpa*, *Epacris breviflora*, *Ranunculus collinus*, *Hydrocotyle algida*, *Xerochrysum subundulatum*, *Lagenophora* sp., *Asperula gunnii*, *Stylidium montanum*, *Wahlenbergia ceracea*, *Oreomyrrhis ciliata* and eucalypt seedlings. Graminoid species present were *Empodisma minus*, *Arthropodium milleflorum*, *Eleocharis gracilis*, *Poa* sp., *Deyeuxia* sp., *Juncus* sp. and *Carex* sp. Weed species identified in the surrounding area included *Cirsium vulgare* and *Hypochoeris radicata*.

Sphagnum cristatum site 2

The *Sphagnum* at this site occurred along Straight Creek and extended into the area east of the watercourse. The range of species regenerating within the *Sphagnum* at site 2 were similar to that listed for site 1 (see above). However, in addition to these species there was a population of approximately 200 Sun Orchids *(Thelymitra* sp.) growing within and around site 2 (Figure 11).

Several small mounds of *Sphagnum* (1-2 m in diameter) had been burnt down to ground level in the centre by the burning stems of shrubs that grew in the moss (Figure 12). Presumably, at the time of the bushfires, these mounds were dry enough to burn.

Figure 11. *Thelymitra* sp. growing in *Sphagnum* site 2 - seed pods are shown.

Figure 12. Craters (almost 50 cm deep) burnt into the *Sphagnum* moss around the base of burnt shrubs.

Sphagnum cristatum site 3

This site was situated on the boundary of Montane Swamp Complex and the adjacent Montane Sclerophyll Woodland and extended into the woodland. It is the most extensive area of *Sphagnum* within the Montane Swamp Complex site. This was clearly the site of Closed Shrubland as the remaining burnt stems of *Baeckea* and *Leptospermum* shrubs, up to 3-4 m tall, indicate high cover abundance throughout the area prior to the bushfires. These shrubs were established within the extensive *Sphagnum* mounds that had blanketed the site. The intensity of the bushfire in this area was also high, with patches of bare ground and burnt stems scattered across the site. Less then 1% of the *Sphagnum* remained alive and fewer species were regenerating here than in Sites 1 and 2. Among these were *Baeckea utilis* and *Leptospermum myrtifolium* (resprouting), eucalypt seedlings (1-3cm), *Geranium* sp. and *Carex* sp. Along the creek near *Sphagnum* site 3 other species found included *Blechnum penna-marina*, *Epilobium billardierianum* subsp. *cinereum*, *Geranium potentilloides*, *Wahlenbergia gloriosa* and *Wahlenbergia graniticola*.

Weed species in and around this area included *Rubus fruticosus* spp. agg., *Cirsium vulgare* and *Hypochoeris radicata*.

Fire response characteristics

Vital attributes were recorded for 76 regenerating indigenous species (Appendix 2). Seedling recruitment occurred for 19% of species assessed overall. The remaining species regenerated mainly by vegetative resprouting or by a combination of vegetative and sexual strategies.

Woody perennials regenerated almost entirely by combined seeding and resprouting mechanisms. Perennial grasses and graminoids showed a similar response, with only 16% regenerating primarily by seed. Approximately 25% of herbaceous perennials were obligate seeders, although vegetative reproduction was still strongly represented in this life form group.

Discussion

Post-fire recovery and current status

Flora

There were some differences in the species composition occurring before and after the fire, particularly in the genera *Austrofestuca (Festuca), Isolepis* and *Wahlenbergia*. *Festuca asperula* occurred at the T1 site for a number of years, having been recorded by both Carr and McMahon (1988) and Cousins (1994, 1997) in reasonable abundance. This species was not found in the post-fire survey. However *Austrofestuca hookeriana* was found growing extensively in the T1 site after the fire, whereas Carr and McMahon (1988) recorded it only once at the southern end of T1. Cousins (1994, 1997) did not record this species in his surveys.

Four species of *Isolepis* were recorded from the pre-fire surveys but only two species were found after the fire. Of these two species only *Isolepis subtilissima* was recorded at the T1 site before the fire. Carr and McMahon (1988) and Cousins (1994, 1997) found *I. crassiuscula* in their surveys whereas this species was not found post-fire, however *I. inundata* was recorded. The additional *Isolepis* spp. found by Carr and McMahon (1988) were *I. fluitans* and *I. habra*.

Cousins (1994, 1997) recorded four species of *Carex* including the rare *C. capillacea;* Carr and McMahon (1988) recorded an additional three *Carex* species not found by Cousins (1994, 1997).. In this study four species of *Carex* were recorded

Two of the three *Deyeuxia* spp. recorded prior to the fire were found – *D. gunniana* was not recorded post-fire.

Senecio glomeratus and *Senecio tenuiflorus* were recorded in the pre-fire survey by McMahon and Carr (1988), but not by Cousins (1994, 1997). The taxonomy of the *Senecio* genus has changed since 1988 and the species *Senecio* sp. 1 and *Senecio* sp. 2 have been recognised and separated from *Senecio glomeratus* and *Senecio tenuiflorus* respectively. *Senecio* sp. 1 and *Senecio* sp. 2 were recorded in the post-fire survey. These species have recently been given specific epithets are now known as *Senecio extensus* and *Senecio lageniformis* respectively (Thompson 2004).

In the post-fire survey four species of *Wahlenbergia* were found whereas only one species, *Wahlenbergia ceracea,* was recorded prior to the fires.

Vegetation

This study compared the number of species present 15 years before the 2003 bushfires with the number of species present 12 months afterwards. Although the pre-fire data available was not ideal, some comparisons can be made.

The number of species in three major life form categories, representing almost all species present at the site, was approximately half of that recorded pre-fire. The results are atypical of post fire regeneration, where species richness tends to be highest in the year or two immediately following fire, at least in lowland dry sclerophyll ecosystems (Russell and Parsons 1978, Posamentier et al. 1981, Hobbs et al. 1990, Yates et al 2003), although this is not well understood at high altitudes.

The results may reflect the sampling strategy used, the small number of quadrats used or seasonal variation reflected at the time of sampling. However, the results also suggest that some species may not have regenerated since the fire. Lower species diversity may be a result of competition from vigorous grass growth, particularly *Poa*, *Austrofestuca* and *Empodisma* that respond rapidly to fire and appropriate space otherwise available for seedling recruitment. Other causes may include deterioration or loss of seed banks after long fire-free intervals, drought stress, or the intensity of the fire was unsuitable for broadscale regeneration. Insufficient time may also have elapsed for species to invade from elsewhere, or external propagules may also be limited due to the widespread extent of the fires.

A shift in structural and floristic composition in plant communities is commonly observed after fires (Hobbs 2002). The results of this survey demonstrated that the highest number of perennial plants occupied an area of <1% after the fires. In 1988, most perennial plants had cover values of between 1 and 5%, and up to 25%. The difference between the two studies partially reflects the differences in species richness, but otherwise the results indicate that post-fire regrowth will approach pre-fire levels over time.

Further work is required to investigate post-fire effects on community composition and structure, with additional data collection required over the next few years. The conservation status of Montane Swamp Complex may have been compromised by the 2003 bushfires, as indicated by a reduction in species richness and failure to re-locate the majority of threatened plant species known to have been present.

Potential threats to post-fire recovery

The site had not been disturbed by any fire management activities (e.g. fire breaks, vehicular access etc.). Although most other sites of Montane Swamp Complex were not assessed during this study, aerial photographs taken of this region in May 2003 showed no evidence of such disturbance elsewhere within the Benambra mine area and surrounds.

Weeds are currently not of major concern at the T1 site, with the exception of part of *Sphagnum* site 3. Where the regeneration of the herb layer is dense there is very little bare ground available for invasive weed species to establish. The areas of the community where bare ground has been exposed as a result of the fire are in the drier vegetation zones and where the *Sphagnum* moss was burnt down to ground level. This occurs especially around

the base of shrubs that grew in the moss beds. Although many of these shrub species are regenerating there are many patches of bare ground available for invasive weed species to establish. The conditions of moisture and fertility within the burnt *Sphagnum* mounds would be particularly favourable to weed growth. The area of the *Sphagnum* site 3 that was particularly badly burnt is of concern because there are large patches of bare ground and the serious weeds *Rubus fruticosa* spp. agg., *Hypochaeris radicata* and *Cirsium vulgare* are already present.

Further invasion of other weed species is quite likely given the degree of soil disturbance surrounding the tailings dam and the network of roads throughout the mining area.

Weeds currently pose a low threat to the Montane Swamp complex. *Holcus lanatus* and *Trifolium repens* were the only weed species recorded within quadrats surveyed. Each of these species had cover abundance of less than 1%. *Rubus fruticosa* spp. agg., *Hypochaeris radicata* and *Cirsium vulgare* occurred in the most severely burnt section of the T1 site. Cousins (1994) recorded a low presence of weed species from this site with *Trifolium repens*, *Prunella vulgaris*, *Hypochoeris radicata*, *Juncus articulatus* and *Centaurium erythraea* being present. In the ensuing survey Cousins (1997) reported that the cover/abundance of *Hypochoeris radicata*, *Juncus articulatus* and *Centaurium erythraea* had increased but still remained at a low value. *Juncus articulatus* and *Centaurium erythraea* were not recorded during this survey.

The main threat to the conservation of the Montane Swamp Complex at the tailings dam No.1 site is the potential of acidic water (with high metal concentrations) overflowing and leaking from tailings dam No.1 into the Montane Swamp Complex. Whilst the threat posed by leakage from the dam is not linked with the alpine fires it is currently the greatest threat to the conservation and indeed future of this site.

Management recommendations

1. The site should be re-surveyed within two years to monitor species regeneration and structural recovery of the community.
2. The other sites of Montane Swamp Complex identified in the previous studies need to be assessed for their recovery after the fire. The assessment should incorporate species diversity and rarity, vegetation structure and condition and status of the threats (pest plant and animal) to future conservation.
3. Ongoing monitoring of Montane Swamp Complex is required to manage current and future threats to this endangered community:

   - Maintenance of permanent quadrats to assess changes in species composition and regeneration at two year intervals for ten years. The *Sphagnum cristatum* areas need to be separately monitored.

   - A survey to establish the location of rare and threatened plant populations, to be continued with ongoing monitoring of permanently marked populations.

   - Ongoing, regular sampling and analysis of groundwater and streamwater from the site adjacent to the main tailings dam (T1) and from surrounding locations to monitor the threat posed by acid water overflowing and leaking from the tailings dam.
4. Control weeds to maintain the current low level of infestation and prevent further spread at *Sphagnum* site 3.
5. Exclude cattle from the mine area in future.

Acknowledgements

The authors are grateful to the following people for their contributions during this study:

- David Adams, Forest Resource Inventory, Dept. of Sustainability and Environment.
- David Foster, Ranger in Charge, Parks Victoria, Eastern Alps Unit, Alpine Nat. Park.
- Glenn Digby, Forest Management, Dept. of Sustainability and Environment, Swift Creek.
- Rob Stewart, Forest Management, Dept. of Sustainability and Environment, Bairnsdale.
- Ron Thumerer, Caretaker, Benambra Mine, Benambra.
- Dale Tonkinson proof read the report.

The project was funded under the Victorian Bushfire Recovery Program (DSE and Parks Victoria).

References

Carr, G.W., McMahon, A.R.G. and Bedgood, S.A. (1987) *Environmental effects statement – Vegetation of the proposed copper mine development at Benambra, North-east Victoria*. Report to Kinhill Engineers P/L.

Carr, G.W. and McMahon, A.R.G. (1988). *The Benambra Project, Wilga and Currawong Modified Project Description. Vegetation data and assessment of significance*. Report to Kinhill Engineers P/L. May 1988.

Cousins, G.B. (1994) Vegetation Monitoring – Montane Swamp Complex: An initial report. Report to Benambra Mine P/L. April 1994.

Cousins, G.B. (1997) Vegetation Monitoring – Montane Swamp Complex: Continuity Report – Survey #2. Report to Benambra Mine P/L. January 1997.

Earl, G. (1990). *Investigation of four small catchments in the Tambo State Forest*. Unpub. report to the Bairnsdale Region, Department of Conservation and Environment, November 1990.

Fire Ecology Working Group (2004) *Guidelines and Procedures for Ecological Burning on Public land in Victoria 2004*. Department of Sustainability and Environment, Melbourne.

Gullan, P.K. (1978). Vegetation of the royal botanic gardens annexe at Cranbourne, Victoria. *Proceedings of the Royal Society of Victoria* **70**, 225-240.

Gullan, P.K. and Westaway, J. (1988). *Proposal for Tailings Dam for the Benambra Project. Investigation of additional sites in Montane Swamp Vegetation*. Unpub. report, Flora Survey Group, Department of Conservation, Forests and Lands. August 1988

Hobbs, R. (2002) Fire regimes and their effects in Australian temperate woodlands. In: *Flammable Australia: the Fire Regimes and Biodiversity of a Continent* (eds: R. Bradstock, J. Williams & M. Gill). pp. 305-328. Cambridge University Press.

Hobbs, R. and Atkins, L. (1990) Fire-related dynamics of a banksia woodland in south-western Western Australia. *Australian Journal of Botany* **38**, 97-100.

Kinhill Engineers Pty. Ltd and Macquarie Resources Lt. (1987). *The Benambra Project Wilga and Currawong. Environment Effects Statement*. Kinhill Engineers P/L. and Macquarie Resources, Melbourne, November 1987.

McMahon, A.R.G. (1988). *Aerial Survey of Montane Swamp Vegetation in the Benambra Project Region, North-east Victoria*. Report to Kinhill Engineers P/L.

McMahon, A.R.G. and Carr, G.W. (1988). *The Benambra Project, Wilga and Currawong Modified Project Description. Vegetation data and assessment of significance*. Additional Flora Survey. Report to Kinhill Engineers P/L. June 1988.

Parks Victoria and Department of Sustainability and Environment (2003) *Statewide Public Land Ecological and Cultural Fire Recovery Plan*. Parks Victoria and Department of Sustainability and Environment, Melbourne, Victoria, Australia.

Posamentier, H. G., Clarke, S. S., Hain, D. L. and Recher, H. F. (1981) Succession following wildfire in coastal heathland (Nadgee Nature Reserve NSW). *Australian Journal of Ecology* **6**, 165-175.

Ross, J. H. & Walsh, N. G. (2003) *A census of the vascular plants of Victoria 7th Edition*, Royal Botanic Gardens, Melbourne.

Russell, R. P. and Parsons, R. F. (1978) Effects of time since fire on heath floristics at Wilson's Promontory, southern Australia. *Australian Journal of Botany* **26**, 53-61.

Thompson, I. R. (2004) Taxonomic Studies of Australian *Senecio* (Asteraceae): the disciform species. *Muelleria* **19**,101-214.

Yates, C. J., Hopper, S. D., Brown, A. and van Leeuwen, S. (2003) Impact of two wildfires on endemic granite outcrop vegetation in Western Australia. Journal of Vegetation Science **14**, 185-194.

Appendix 1

Details of Quadrats Surveyed in Montane Swamp Complex, 2004.

Quadrat No.	Size	AMG (AUS 66) NE peg	Altitude	Date
FR 01	5m x 2m	581827E	1159m	18/02/2004
		5904772N		
FR 02	10m x 1m	581796E	1175m	18/02/2004
		5904764N		
FR 03	5m x 2m	581773E	1160m	18/02/2004
		5904774N		
FR 04	5m x 2m	581796E	1164m	18/02/2004
		5904813N		
FR 05	5m x 2m	581781E	1167m	18/02/2004
		5904762N		
FR 06	5m x 2m	581779E	1166m	18/02/2004
		5904719N		

Appendix 2.

Species and sample variables recorded at T1 site post-fire, 2004.

Cover/abundance, average height, flower/seed production and mode of regeneration.

Scientific Name	Cover/Abundance						Average Height (cm)						Flowers						Seed					
	Wet soak		Creek line		Wood land																			
	Q1	Q2	Q3	Q4	Q5	Q6	Q1	Q2	Q3	Q4	Q5	Q6	Q1	Q2	Q3	Q4	Q5	Q6	Q1	Q2	Q3	Q4	Q5	Q6
Agrostis spp. agg. aff. *hiemalis*		+	+											y	y					y	y			
Arthropodium milleflorum s.l.	1	+			+	+							y	n			n	n	y	y			y	y
Arthropodium minus				+												y						y		
Asperula gunnii	+	+	+	+	+	+							y	y	y	y	y	n	y	y	y	y	n	n
Austrodanthonia penicillata					+												n						y	
Austrofestuca hookeriana	2	+	2	2		1							n	n	n	n		n	y	y	y	y		y
Baeckea gunniana			+						15						n						n			
Baeckea utilis	2	1		1	1	+	30	25		40	25	20	n	n		n	n	n	n	n		n	n	n
Baloskion australe	2	+	+			+							y	n	n			n	n	n	n			n
Brachyscome decipiens		+												n						n				
Carex gaudichaudiana			2	2											y	y					y	y		
Carex sp.					+												n						n	
**Cirsium vulgare*	+												n						n					
Comesperma retusum	+	+	+			+		25	40			2	n	n	n			n	n	n	n			n
Craspedia spp. (previously *C. glauca* spp. agg.)	+												n						n					
Deyeuxia brachyathera	+		+	+									n		n	n			y		y	y		
Deyeuxia carinata					1	+											n	n					y	y
Deyeuxia monticola var. *monticola*					1	+											n	n					y	y
Drosera peltata	+				+	+							y				n	n	y				y	n
Eleocharis gracilis		3	+											y	y					y	y			
Empodisma minus	3	2	2	2	+								n	n	n	n	n		n	n	n	n	n	
Epacris breviflora	2	1	+	+	+	+	15	20	25	15	10	5	n	n	n	n	n	n	n	n	n	n	n	n
Eriochilus cucullata					+												y						y	
Eucalyptus rubida					2	+					70	20					n	n					n	n
Eucalyptus stellulata				+	2	1					70	20				n	n	n				n	n	n
Euchiton involucratus s.s.			+	+											n	n					n	n		
Gonocarpus micranthus	1	1	+	+	+	+							y	n	n	n	y	n	*	n	n	n	n	n
Goodenia elongata			+	+											y	n					n	n		
Gratiola peruviana			+	+											y	n					y	n		
Hakea microcarpa	+	+			+		70	60			50		n	n			n		n	n			n	
**Holcus lanatus*	+												n						n					
Hydrocotyle algida				+												n						n		
Hypericum japonicum					+												y						y	
Hypoxis hygrometrica					+	+											y	y					n	
Isolepis inundata	1	2	+	+									y	y	y	y			y	y	y	y		
Isolepis subtilissima	1		2	1									y		y	y			y		y	y		
Juncus gregiflorus			+	1											n	y					n	y		
Juncus planifolius			+												y						y			
Juncus A or B	+	1	1	1									n	n	n	n			n	n	n	n		
Leptospermum myrtifolium					2	1					60	20					n	n					n	n
Lomandra longifolia subsp. *exilis*					1	1					40						n	n					n	n
Luzula modesta		1	+	+										y	n	y				y	y	y		
Mentha laxiflora			+												y						y			
Microlaena stipoides var. *stipoides*					+												y						y	
Microtis unifolia	+	+	+	+	+								y	n	y	y	n		y	n	y	y	y	
Myriophyllum pedunculatum			+												n						n			

Scientific Name	Cover/Abundance						Average Height (cms)						Flowers						Seed					
	Q1	Q2	Q3	Q4	Q5	Q6	Q1	Q2	Q3	Q4	Q5	Q6	Q1	Q2	Q3	Q4	Q5	Q6	Q1	Q2	Q3	Q4	Q5	Q6
Olearia erubescens					1	+					50	15					n	n					n	n
Oreomyrrhis ciliata		+												n						y				
Oreomyrrhis eriopoda			+	+											n	n					n	n		
Persoonia chamaepeuce					+												n						n	
Poa costiniana			1												n						y			
Poa clivicola	2												n						y					
Poa sieberiana var. *sieberiana*		1	1	2	2	2								n	n	n	n	n		y	y	y	y	y
Pratia pedunculata		+	+											n	n					n	n			
Ranunculus collinus (r)			1	1											n	n					n	n		
Ranunculus pimpinellifolius			+	+											n	n					n	n		
Schoenus apogon	+	+		+	2	1							n	y		y	y	n	y	y		y	y	n
*Senecio lageniformis (*previously *Senecio* sp.2)(k)					+												n						y	
Stylidium montanum (k)					1	1											y	y					y	y
Tetratheca bauerifolia					+												n						n	
Themeda triandra					+												y						y	
**Trifolium repens* var. *repens*			+												y						n			
Utricularia dichotoma s.l.	+		+	+									y		y	y			y		y	y		
Velleia montana					1	+											n	n					y	n
Veronica gracilis			+	+											y	n					y	n		
Wahlenbergia multicaulis					+												y						y	
Xerochrysum subundulatum			1	2	+										y	y	y				n	y	y	
Sample variables																								
Moss cover	2	2	1	1	-	0																		
Bare ground cover	1	1	2	2	3	4																		
Water cover	3	2	1	2	-	0																		
Litter cover	1	+	+	1	2	1																		

Appendix 3

Species recorded at the T1 site pre and post-fire.

Pre-fire data from Carr and McMahon (1988); Flora Information System (DSE) and Cousins (1994, 1997).

Vital Attributes codes – see methods.

Conservation status: E = endangered nationally; e= endangered in Victoria, V = vulnerable nationally; v = vulnerable in Victoria, R = rare nationally; r = rare in Victoria, k = poorly known in Victoria (Ross and Walsh 2003).

Family	**Scientific Name**	**Presence** **# = pre - fire** **O = post-fire**	**Vital Attributes**		
BRYPOHYTA					
SPHAGNACEAE			***Persistence***	***Conditions for Establishment***	***Juv.***
	Sphagnum cristatum	# O	ND	ND	ND
POLYPODIOPHYTA					
BLECHNACEAE					
	Blechnum nudum	#			
	Blechnum penna-marina subsp. *alpina*	# O	ND	ND	ND
DRYOPTERIDACEAE					
	Polystichum proliferum	#?			
OPHIOGLOSSACEAE					
	Ophioglossum reticulatum	O	ND	ND	ND
MONOCOTYLEDONS					
CYPERACEAE					
	Baumea gunnii	#			
	Carex appressa	#			
	Carex blakei	O	ND	ND	ND
	Carex breviculmis	#			
	Carex capillacea (Rr)	#			
	Carex gaudichaudiana	# O	V	T	1
	Carex gunniana	#			
	Carex hebes	#			
	Carex incomitata	#			
	Carex inversa	#			
	Carex sp.	O	ND	ND	ND

Family	Scientific Name	Presence # = pre - fire O = post-fire	Vital Attributes		
	Eleocharis gracilis	# O	V	T	1
	Isolepis crassiuscula	#			
	Isolepis fluitans	O	ND	ND	ND
	Isolepis habra	#			
	Isolepis inundata	O	C?	T	1
	Isolepis spp.	#			
	Isolepis subtilissima	# O	C?	T	1
	Lepidosperma lineare	O	ND	ND	ND
	Oreobolus distichus	#?			
	Oreobolus oxycarpus	O	ND	ND	ND
	Schoenus apogon	# O	S	T	1
	Schoenus maschalinus	#			
HYPOXIDACEAE					
	Hypoxis hygrometrica	# O	ND	T	1
JUNCACEAE					
	Juncus alexandri subsp. *alexandri*	O	ND	ND	ND
	**Juncus articulatus*				
	Juncus falcatus	O	ND	ND	ND
	Juncus gregiflorus				
	Juncus phaeanthus	O	ND	ND	ND
	Juncus planifolius	O	V?	T	1
	Juncus sarophorus				
	Juncus sp.	O	ND	ND	ND
	Juncus usitatus				
	Luzula modesta	# O	?	T	1
	Luzula novae-cambriae	O	?	T	1
	Luzula spp.				
LILIACEAE					
	Arthropodium milleflorum	# O	Γ	T	1
	Arthropodium minus	O	Γ	T	1
	Dianella tasmanica	#?			

Family	Scientific Name	Presence # = pre - fire O = post-fire	Vital Attributes		
ORCHIDACEAE					
	Eriochilus cucullata	O	U	T	1
	Microtis unifolia	O	U	T	1
	Pterostylis furcata	O	U	T	1
	Pterostylis longifolia				
	Pterostylis oreophila (e)	O	U	T	1
PHORMIACEAE					
	Caesia alpina	O	ND	ND	ND
POACEAE					
	Agrostis aff. *hiemalis*	# O	C	T	1
	Agrostis aff. *hiemalis (now A. bettyae & A. propinqua)*	#			
	Agrostis spp.	#			
	Austrodanthonia laevis	O	Γ	T	1
	Austrodanthonia penicillata	O	Γ	T	1
	Austrodanthonia pilosa	O	Γ	T	1
	Austrodanthonia racemosa var. *racemosa*	#			
	Austrofestuca hookeriana (previously *Festuca hookeriana*)	# O	Γ	T	1
	Deyeuxia brachyathera	# O	Γ	T	1
	Deyeuxia carinata	O	Γ	T	1
	Deyeuxia crassiuscula	O	Γ	T	1
	Deyeuxia gunniana	#			
	Deyeuxia innominata	O	Γ	T	1

Family	Scientific Name	Presence # = pre - fire O = post-fire	Vital Attributes		
	Deyeuxia monticola var. *monticola*	# O	Γ	T	1
	Deyeuxia spp.	#			
	Dichelachne inaequiglumis	O	Γ	T	1
	Dichelachne micrantha	#?			
	Elymus scaber var. *scaber*	#?			
	Festuca asperula	#			
	**Holcus lanatus*	O			
	Joycea pallida	#			
	Microlaena stipoides	O	Γ	T	1
	Poa clivicola	O	Γ	T	1
	Poa costiniana	# O	Γ	T	1
	Poa ensiformis	#			
	Poa fawcettiiae	?			
	Poa helmsii	#			
	Poa hiemata	?			
	Poa sieberiana var. *cyanophylla*	# O	Γ	T	1
	Poa sieberiana var. *hirtella*	#?			
	Poa sieberiana var. *sieberiana*	O	Γ	T	1
	Poa tenera	#			
	Themeda triandra	O	V	T	1
RESTIONACEAE					
	Baloskion australe (ex *Restio australis*)	# O	V	T	1
	Empodisma minus	# O	V	T	1
XANTHORROEACEAE					
	Lomandra longifolia subsp. *exilis*	# O	V	T	ND
DICOTYLEDONS					
APIACEAE					
	Hydrocotyle algida	# O	C	T	1
	Hydrocotyle hirta	#?			
	Hydrocotyle laxiflora	#?			

Family	Scientific Name	Presence # = pre - fire O = post-fire	Vital Attributes		
	Oreomyrrhis ciliata	?			
	Oreomyrrhis eriopoda	# O	S	T	1
	Aciphylla simplicifolia	O	V	T	1
ARALIACEAE					
	Polyscias sambucifolia	#			
ASTERACEAE					
	Brachyscome aculeata	O	S	T	1
	Brachyscome decipiens				
	Brachyscome obovata	O	ND	ND	ND
	Brachyscome scapigera	O	ND	ND	ND
	Brachyscome spathulata	# O	ND	ND	ND
	Cassinia aculeata	# O	C	T	ND
	**Cirsium vulgare*	# O			
	Cotula alpina	O	ND	ND	ND
	Craspedia coolaminica	O	V	T	1
	Craspedia spp.	#			
	Craspedia spp. (previously *C. glauca* spp. agg.)	#			
	Euchiton gymnocephalus				
	Euchiton involucratus s.s.	# O	D	T	ND
	Helichrysum rutidolepis	# O	ND	ND	ND
	**Hypochoeris radicata*	# O			
	Lagenophora gracilis	# O	ND	ND	ND
	Lagenophora montana	#			
	Lagenophora stipitata	# O	ND	ND	ND
	Leptinella filicula	# O	ND	ND	ND
	Leptorhynchos squamatus	?			

Family	Scientific Name	Presence # = pre - fire O = post-fire	Vital Attributes		
	Olearia alpicola	#			
	Olearia erubescens	# O	Γ	T	2
	Olearia myrsinoides	#	Γ	T	2
	Senecio biserratus	#	ND	ND	ND
	Senecio extensus (previously sp.1)	O	ND	ND	ND
	Senecio glomeratus	#	ND	ND	ND
	Senecio lageniformis (previously sp. 2)		D	T	1
	Senecio tenuiflorus	#	ND	ND	ND
	Xerochrysum subundulatum (ex *Bracteantha subundulata* & *Helichrysum acuminatum*)		D	T	1
CAMPANULACEAE					
	Pratia pedunculata (ex *Lobelia pedunculata)*	# O	Γ	T	1
	Pratia surrepens	O	Γ	T	1
	Wahlenbergia ceracea	# O	ND	ND	ND
	Wahlenbergia gloriosa	O	ND	ND	ND
	Wahlenbergia graniticola	O	ND	ND	ND
	Wahlenbergia multicaulis	O	ND	ND	ND
	Wahlenbergia spp.	#	ND	ND	ND
CARYOPHYLLACEAE					
	**Cerastium glomeratum*	O			
	Scleranthus biflorus	#?			
	Solenogyne gunnii	?			
	Stellaria palustris	#			

Family	Scientific Name	Presence # = pre - fire O = post-fire	Vital Attributes		
	Stellaria pungens	# O	V	T	1
CLUSIACEAE					
	Hypericum japonicum	# O	V?	T	1
CONVOLVULACEAE					
	Dichondra repens	# O	V	T	1
DILLENIACEAE					
	Hibbertia obtusifolia	# O	V	T	ND
DROSERACEAE					
	Drosera peltata subsp. *peltata*	O	V?	T	1
EPACRIDACEAE					
	Epacris breviflora	# O	V	T	ND
	Epacris microphylla var. *microphylla*	#			
	Epacris spp.	#			
	Leucopogon pilifer	?			
FABACEAE					
	Bossiaea foliosa	# O	V	T	ND
	Hovea spp.	#?			
	Pultenaea juniperina s.s. (r)	#			
	Pultenaea tenella	?			
	**Trifolium dubium*	?			
	**Trifolium repens* var. *repens*	# O			
GENTIANACEAE					
	**Centaurium erythraea*	#			
GERANEACEAE					
	Geranium antrorsum	O	ND	ND	ND
	Geranium potentilloides	O	ND	ND	ND
GOODENIACEAE					
	Goodenia elongata	# O	Γ	T	ND
	Velleia montana	# O	V?	T	1
HALORAGACEAE					

Family	Scientific Name	Presence # = pre - fire O = post-fire	Vital Attributes		
	Gonocarpus micranthus	# O	Γ	T	1
	Gonocarpus montanus	#?			
	Gonocarpus tetragynus	O	Γ	T	1
	Myriophyllum alpinum (r)	#			
	Myriophyllum pedunculatum subsp. *pedunculatum*	# O	V	T	1
LAMIACEAE					
	Mentha laxiflora	O	ND	T	1
	**Prunella vulgaris*	#?			
LENTIBULARIACEAE					
	Utricularia dichotoma	# O	ND	T	1
MYRTACEAE					
	Baeckea gunniana	O	V	T	ND
	Baeckea utilis var. *utilis*	# O	V	T	1
	Eucalyptus pauciflora	# O	Σ	T	ND
	Eucalyptus rubida	# O	Σ	T	ND
	Eucalyptus stellulata	# O	Σ	T	ND
	Leptospermum continentale	# O	Σ	T	
	Leptospermum grandifolium	?			
	Leptospermum myrtifolium	# O	Γ	T	ND
ONAGRACEAE					
	Epilobium billardierianum subsp. *cinerea*	O	ND	ND	ND
	Epilobium curtisiae	O	ND	ND	ND
	Epilobium gunnianum	#			
PLANTAGINACEAE					
	Plantago euryphylla	O	ND	ND	ND
	Plantago varia	?			

Family	Scientific Name	Presence # = pre - fire O = post-fire	Vital Attributes		
POLYGALACEAE					
	Comesperma retusum	# O	V	T	1
PROTEACEAE					
	Banksia canei	#			
	Hakea microcarpa	# O	Γ	T	ND
	Persoonia chamaepeuce	O	Γ	T	2
RANUNCULACEAE					
	Ranunculus amphitrichus (ex *R. rivularis*)	#			
	Ranunculus collinus	# O	S	T	1
	Ranunculus pimpinellifolius	# O	S	T	1
ROSACEAE					
	Acaena novae-zelandiae	# O	ND	ND	ND
	**Rubus fruticosus* spp. agg.	# O			
RUBIACEAE					
	Asperula gunnii	# O	Γ	T	1
	Coprosma hirtella	O	ND	ND	ND
	Galium spp.	# O			
SCROPHULARIACEAE					
	Euphrasia collina	O	V	I	1
	Euphrasia scabra	O	C	I	1
	Gratiola peruviana	# O	ND	ND	ND
	Veronica gracilis	O	V	T	1
	Veronica sp. 2 (ex aff. *gracilis*)	#			
STYLIDIACEAE					
	Stylidium graminifolium s.s.	#			
	Stylidium montanum (ex S. sp. aff. *graminifolium*)	# O	?	T	2
TREMANDRACEAE					
	Tetratheca bauerifolia	# O	Γ	T	2

Family	Scientific Name	Presence # = pre - fire O = post-fire	Vital Attributes		
VIOLACEAE					
	Viola betonicifolia subsp. *betonicifolia*	# O	V	T	1
	Viola hederacea	# O	V	T	1