Protecting the Natural Treasures of the Australian Alps

Alpine National Park
Avon Wilderness Park
Bimberi Nature Reserve
Brindabella National Park
Kosciuszko National Park
Mount Buffalo National Park
Namadgi National Park
Scabby Range Nature Reserve
Snowy River National Park

Peter Coyne

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A report to the Natural Heritage Working Group of the Australian Alps Liaison Committee

About the author

Peter Coyne has had an interest in the Australian Alps from early childhood and a long history of interest and involvement in protected area issues. This began with preparation of a management plan as an honours project when such a document was a real novelty. He had the rare opportunity to create national parks, working with the Land Conservation Council in Victoria where he defined the boundaries and gave names to proposed new national parks, including Croajingalong, Snowy River and Tingaringy, which the Government adopted.

Dr Coyne joined the Australian National Parks and Wildlife Service in its early days and spent four years establishing the Service's office and operations on Norfolk Island, and introducing the concept of environmental management to the island's community and government (which led to the creation of the Norfolk Island National Park). He then headed the ANPWS Park Planning Section, personally preparing the management plan for Kakadu National Park and having responsibility for preparation of other plans ranging from central Australia (Uluru–Kata Tjuta) to marine national nature reserves in the Coral and Timor Seas, and park plans for Australia's remote Indian Ocean Territories. During this time he also developed the legislation and lease to enable transfer of Uluru to its traditional Aboriginal owners and its lease back to the Director of National Parks and Wildlife for continuing use as a national park. The legislation and lease arrangements became models used elsewhere to enable Aboriginal ownership of existing national parks.

Dr Coyne subsequently led the Marine Conservation Unit and the National Reserve System team in ANPWS/ANCA, working on development of strategic national systems of terrestrial and marine protected areas to protect representative samples of Australia's biodiversity. In this capacity he had active roles in two conferences in the USA.

In 1997 he was thrilled to be invited to become a member of the World Commission on Protected Areas.

In late 1999 he was delighted to be invited to undertake this project

Preface

Stretching from Canberra through the Brindabella Range in the ACT, the Snowy Mountains of New South Wales and along the Great Dividing Range through Victoria, the Australian Alps national parks form a 1.6 million hectare chain of protected areas crossing State and Territory borders across the roof of southern Australia.

To look after these protected areas the national park agencies in New South Wales, Victoria and the ACT and the Commonwealth agreed in 1986 to a system of cooperative management under an intergovernmental Memorandum of Understanding (MOU). The MOU was signed to protect the landscape, water catchments, plants, animals and cultural heritage of the Australian Alps as a whole ecosystem while providing opportunities for public appreciation and sustainable enjoyment of the resource.

The area encompassed by this report is generally the Australian Alps "national parks" (listed on the title page), which are considerably broader than the alpine zone. The Australian Alps national parks include parts of three biogeographic regions: Australian Alps, South Eastern Highlands and South East Corner. Some of the discussion, where appropriate, extends beyond the boundaries of the Australian Alps national parks, for example to include significant species from Baw Baw National Park.

This report is the outcome of a six-month project funded under the MOU by the Natural Heritage Working Group under the Australian Alps Liaison Committee. Only five months was available from commencement of this project until submission of the draft final report. Time was inadequate to fully cover the source materials collected during the project, or to collect a comprehensive suite of source material. Readers should recognise this significant constraint and not assume that this report is more complete than it actually is. Many features which deserve inclusion are missing, either because they were not identified during the project or even because they remain unknown. A second stage of the project in early 2001 developed the report and database as an interactive electronic version for distribution on CD.

This report deals with some contentious issues on which opinion in the community is divided. As a scientific report the focus is on the scientific evidence and viewpoint, but it is important that other views are recognised. As a concise and accurate means of portraying those other views, some direct quotations have been used. That they are inconsistent with the main thrust of the report is a consequence of the nature of the report. No disrespect is intended towards those who have been quoted. Their viewpoints are the result of long experience and are respected, even if not endorsed.

We hope this project will stimulate further study of the natural features of the Australian Alps and their threats, and that the information presented here will quickly be augmented by new contributions. Information may be sent via the Australian Alps national parks website:

http://www.australianalps.environment.gov.au/

Acknowledgments

Many people enthusiastically helped with this project. Their assistance was vital and greatly appreciated.

At the risk of accidentally leaving out some names, which I would deeply regret, I wish to acknowledge the valuable contributions of the following people who helped in the initial stages of the project and/or commented on the draft database:

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The following participated in the two-day workshop, and put a lot of effort into checking the database and allocating priorities to the natural features and their threats:

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I greatly appreciate the willing provision by many people of draft or pre-publication papers and other documents, an important contribution to this report.

I also wish to record my appreciation of:

- workshop facilitator David Bailey for his considerable effort in preparing for, running and documenting the workshop;
- Keith McDougall for scoring 260 flora taxa following the workshop;
- AALC staff Brett McNamara and Cath Renwick for their support and encouragement;
- Environment Australia Library staff for a big effort compiling a bibliography on natural heritage of the Australian Alps national parks;
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Summary

The Australian Alps are a treasure-trove of remarkable features, some of which occur only there — the only marsupial species which stores food; an insect which changes colour to reflect or absorb heat as a way of regulating its body temperature; a beautiful, cliff-bound, lake created by the grinding action of a glacier. The catalogue is long and diverse, yet the great natural value of the Australian Alps is rarely fully recognised. This report identifies more than one thousand significant natural features of the Australian Alps, and the threats to their continued survival, and assesses the priorities for resourcing for research and management. The recommendations are designed to improve the long-term security of precious national and international assets by encouraging collection of more and better information and by striving for the best possible management approaches right across the Australian Alps.

The wonderful natural features of the Australian Alps national parks have great value, both internationally and nationally. Biological, geological, geophysical, and other physical features are all immensely significant. Their conservation is a responsibility which we recognise but tend to under-rate. There are many reasons for looking after our natural treasures, outlined in the first chapter of this report, but perhaps the most pressing is that our welfare, and our successors' welfare, depend on it, even if indirectly.

We must conserve the natural features of the Australian Alps national parks for our own good, but in case that is not enough we have created legal obligations to ensure that short-term economy does not jeopardise long-term security. The Commonwealth, as party to international conventions and agreements, has obligations which are expressed more generally but apply to the Australian Alps national parks specifically. National agreements and strategies identify the reponsibilities of the Commonwealth and the States and Territories. Again, they are written generally but apply to the Australian Alps. The pertinent parts of the relevant instruments are highlighted in Chapter 1.

For the Australian Alps national parks specifically, the Commonwealth, New South Wales, Australian Capital Territory and Victorian governments have joined in signing a Memorandum of Understanding which aims to "pursue the growth and enhancement of inter-governmental co-operative management to protect the nationally important values of the Australian Alps national parks". The MoU and its implementation are internationally acclaimed as a leading example of cross-border cooperation in national park management.

Finally, the legislation of the two States and the ACT applies to the parks of each jurisdiction separately.

The environment of the Australian Alps national parks changes constantly. Chapter 2 describes some of the changes, particularly in the last 100,000 years. Glaciers in the Kosciuszko area during the last ice age, 20,000 years ago, created new landforms and periglacial conditions were more extensive through the Australian Alps. Since then the climate has changed gradually, but now we are faced with expected climatic change far more rapid than has occurred naturally.

Aboriginal people began to change the landscape long before the arrival of Europeans, but the extent of environmental change since the early 1800s has been considerable. Until the mid-1900s environmental change in the Alps was almost always detrimental, but since then management has been directed towards restoration of a damaged environment. Never-the-less, new impacts on natural features and systems continue to develop.

So much change makes it difficult to identify what is “natural”. The “natural” condition could be defined as preceding human intervention or preceding white settlement, but in either case climatic conditions are now different. Furthermore, protecting an endangered species could require specific management which varies from what was natural. Yet the legislation governing the management of the Australian Alps national parks generally requires protecting, preserving or conserving the **natural** environment, features and communities. Clearer objectives are necessary for unambiguous management.

The only marsupial to hibernate; a beautiful flowering species almost exterminated by grazing stock; a marsupial so rare it was discovered less than forty years ago and formally described only twenty years ago; a bird about 30 cm long which flies from Japan to Australia in a few days to spend the summer in south-eastern Australia before flying back to Japan for the breeding season; and a cave in rock 400 million years old, superbly decorated with natural limestone formations. These are just five of approximately 1300 “significant natural features” identified by this project. Not all of them might command the same emotional appeal, but they all have their own value. Many of them are endangered or rare; twenty-six are considered at real risk of extinction within 100 years from known threats. If 1300 sounds a lot, there are many more. The list is not exhaustive because it was compiled from documents such as park management plans and legislative lists which focus largely on rare and threatened species and communities. Other reasons for significance, such as ecological, biogeographical or scientific importance, are not so prominent but that does not diminish their importance. Added to that, there must be many which have yet to be identified, or which are known but whose significance remains unidentified.

Chapters on Fauna and Flora list the most significant (ie endangered, vulnerable or rare) taxa, generally species and subspecies, and provide information on:

© their legal status nationally and in New South Wales, Victoria and the ACT;
© the documentation available (eg action plans);
© their distribution in the Australian Alps national parks (and for some flora their distribution and reservation outside the Australian Alps); and
© the threats to each, where known.

The status of faunal taxa recorded in the IUCN Red List of Threatened Animals of the World is also listed. For Flora the IUCN relies on the national listing already included, so was not repeated. These chapters also provide textual information on the listed taxa when it was available.

Other features are briefly described and discussed in Chapter 6. Categories include communities and ecosystems; scientific sites; caves; and other geophysical features. Though the discussion is brief, the importance of these features is great. Individual communities can be home to multiple threatened plants and animals, as well as to the other plants and animals essential to their survival. Long-term scientific sites are of special value for the duration of their records, and some in the Australian Alps are very notable by international comparisons. Caves can be spectacular to visit, but for many their value is less obvious. Cave fauna is especially significant, and caves often provide a record of pre-history which aids our understanding of our present environment. The other geophysical features are diverse and many are rare examples of phenomena, giving them great scientific value.

The threats to the natural treasures are described and discussed in Chapter 7. Almost all, if not all, the threats are of our making. Some we created accidently, a few might be necessary, but a substantial number are threats of choice. They arise from activities we find profitable or pleasurable. For example, northern hemisphere species of trout are bred and released into our streams for the benefit of anglers, yet they threaten the continued existence of some native fish, frogs and probably invertebrates. Foxes are possibly the most destructive predators of small native mammals; they were brought to Australia and released for the fun of catching them.

Probably the most pervasive threat to the natural treasures of the Australian Alps is global climate change. Mountain systems are among the most vulnerable to global warming. Snow is a crucial environmental factor in the alpine and sub-alpine environments. Many species which live there depend on snow for protection from the extreme cold and wind exposure in winter. Although considerable uncertainty remains about global warming, scientific agreement that it is happening is overwhelming. The estimated change of snow cover in the Australian Alps under the **best case** scenario is an 18% decline by 2030 and 39% by 2070. The estimated decline in snow cover under the **worst case** scenario is 66% by 2030 and 96% by 2070.

A separate issue, depletion of the ozone layer and increased incidence of ultra-violet radiation, is another global threat which may have contributed to biological decline in the Australian Alps.

Although the list of threats is extensive it should not cause despondency. Much can be done to alleviate the effects. Some threats can even be eliminated. Identifying the threats is the first step towards managing them. Of course, the threats to the Alps were identified long ago and are well known to park managers, but this report provides the most comprehensive and current description of the the threats across the jurisdictional boundaries in the Alps.

A major objective of this project was to prioritise the significant natural features and threats across the whole of the Australian Alps national parks. Chapter 8 discusses the development and application of a system to do that. There appear to be few precedents for such an exercise, so the system was developed for this project. It was applied in a workshop of about 35 experts drawn from park managers, park scientific staff, university scientists and a few others with relevant expertise. The final outcome, after further work, is a ranked list of almost all the rare and significant fauna and flora features, other features and threats. The ranking system also provides much more information than just the relative priority of each feature. Scoring of the five criteria which combine to provide each final score enables the status of each feature to be examined for each criterion (if necessary) and for combinations of two or more of the criteria. For example, using the scores for degree of threat and recovery potential is interesting.

Because this system was an untested prototype when it was used at the workshop some bugs became evident. They did not prevent achievement of the ranking but they do place some constraints on the use of the results. In any event, such a system is incapable of absolute precision and accuracy because it depends on the subjective assessments of the people applying it and complete consistency between different groups of people is impossible to achieve. The system worked very well in the circumstances, and periodically repeating the exercise using a system enhanced on the basis of experience would be worthwhile to ensure the rankings are current. Scoring can be undertaken at any time if warranted by changed circumstances or new information.

The report contains a substantial bibliography of almost 400 references. Additionally, bibliographies compiled for this project by the Environment Australia library and the librarian at the New South Wales National Parks and Wildlife Service office in Jindabyne are included in the Appendices. The three bibliographies together provide many useful leads to useful and sometimes obscure information on the natural features of the Australian Alps and their threats.

A great deal of information was collected for this project. Much of it is included in the text and tables of the report. Appendices contain additional information, as well as presenting in different form information used in the report. After completion of this project with submission of the report, so far as possible in a two week period all the information will be incorporated in an electronic database to optimise its availability and utility.

Recommendations

The final output of the project is a series of recommendations which are listed below. Each of the recommendations should be read in conjunction with the text which accompanies it in Chapter 9, and preferably in conjunction with relevant content in the body of the report. Isolated from its background, a recommendation might not be so clearly appropriate.

1. That the best scientific information on the ecological situation of the Australian Alps national parks and management needs be documented in a readily assimilated form and promulgated to the public and especially to politicians.
2. That this report be made available to park staff, universities and university students, non-government organisations and any other groups who can contribute to the essential task of learning more about the natural features of the Australian Alps and their threats. Wider distribution of the report might be worthwhile to foster support for necessary conservation activities in the Australian Alps.
3. That all possible means to improve the biological and ecological knowledge of the Australian Alps national parks be investigated and encouraged. To the greatest possible extent, the input by managing agencies should be supplemented from outside sources. Universities and voluntary groups could be valuable partners with the park managing agencies.
4. That natural features of significance which have not been identified in this project, especially cryptogammic plants and invertebrates, be identified and documented.
5. That study of poorly known taxa, especially those with the potential to affect ecosystem function, be strongly encouraged.
6. That pending development of a more sophisticated database, the database developed during this project be distributed as widely as practicable and updated regularly. It should be updated centrally, perhaps every six months, and redistributed to ensure current information is used by park staff and researchers.
7. That a systematic approach be further developed to allocate priorities for resourcing across the Australian Alps.
8. That the managing agencies cooperate to develop and document a series of trans-alps procedures manuals dealing with specific generic management issues (such as fire management, pig control or ecological monitoring), and that ongoing improvements be sought and introduced.
9. That priority be given to developing and using a trans-alps database for the storage and provision of information on the natural resources of the Australian Alps and the threats to them.
10. That an Australian Alps ecological community classification and map be developed, and that the individual species listed in this report then be linked to the communities.
11. That all known threats be systematically assessed for their potential long-term affects, and management effort be directed accordingly. Pending more comprehensive assessment, the priority rankings of this project should be used.
12. That greater emphasis be given to managing the Australian Alps national parks as a single ecological entity rather than as discrete functional units. Greater integration could be assisted by:

- Consistent, meaningful, management objectives for all the parks (see **Recommendation 13**);
- Greater cooperation between parks and agencies to develop and consistently apply the best possible management techniques for specific issues (see **Recommendation 8** and discussion preceding **Recommendation 14**);
- Consistent management plans (see **Recommendation 14**);
- Endangered species recovery plans written for each species across its range rather than separately State-by-State (or better still, plans be developed for ecological communities or for several species which could be managed together) (see **Recommendation 15**;
- A single database for all the Australian Alps national parks (see **Recommendation 9**); and
- A single vegetation communities classification scheme and map (see **Recommendation 10**).

13. That the agencies cooperate to develop management objectives for the Australian Alps national parks that are consistent, clear and meaningful.
14. That management planning so far as possible be consistent across the Australian Alps national parks.
15. That where possible the management needs for individual species be accommodated within community-based management, but if a species must be managed individually, management be under a single plan across its range. (See also **Recommendation 17**.)
16. That a process be developed to consider the appropriate emphasis on management for individual species compared with management of broader communities or ecosystems.
17. That so far as possible, consistently with the outcome of **Recommendation 16**, management be directed at ecological communities or ecosystems rather than individual species.
18. That park management agencies continue to encourage study by universities and university students of the ecology of threats and threatening processes, and provide all reasonable assistance to maximise the efficiency of information acquisition.
19. That where threats arise from choice, the facts of the conflict be documented and made public so the choice is informed.
20. That a simple trans-alps ecological monitoring program be developed, based on a few key indicators. This might be undertaken efficiently by the parks agencies jointly with a university.

Recommended Action Plan

AALC to:

- Establish a task force to develop consistent, clear and meaningful management objectives (immediately).
- Establish a task force to standardise the approach to management of the Australian Alps national parks (immediately).

A single task force might be appropriate to undertake both the above functions.

- Develop and issue documentation proposed in Recommendation 1 (progressively).

NHWG to establish task forces to develop:

- a resource description document, building on the outputs of this project (immediately);
- a database, building on the outputs of this project (immediately);
- vegetation communities classification and map (within one year);
- management approaches for individual issues (progressively); and
- an ecological health monitoring program (within two years).

NHWG to initiate strategic studies into high priority threats and features identified in this plan (within one year).

NHWG to review and enhance or replace the priority setting system and repeat the priority setting exercise every two–three years (within two years).

NHWG and agencies to encourage partnerships with universities and volunteer groups for research, survey and monitoring activities (immediately).

Agencies, perhaps through an ANZECC committee, review the emphasis on managing individual species.

Implementing these recommendations and building on the information in this report, the agencies of New South Wales, Australian Capital Territory, Victoria and the Commonwealth can:

- **restore environmental damage already sustained;**
- **minimise future damage;**
- **protect the many natural treasures of the Australian Alps;**
- **fulfill international obligations; and**
- **earn the respect and gratitude of present and future generations of Australians.**

1 Importance of conservation

1.1 The significance of the Australian Alps

International Significance

The Australian Alps national parks are more than a national treasure — they have considerable international significance. Natural values of international importance include biological, geological and geomorphological, and international scientific interest extends to particular sites where research and monitoring has been undertaken.

Although occupying less than 0.3 percent of the continent, the Australian Alps present to the world a large and irreplaceable sample of Australian natural history with the prospect that it can be preserved for a very long time (NSW NPWS 1988b).

It would be reasonable to claim that any large, relatively undisturbed area of land, such as eastern Victoria, or the Australian Alps national parks, where the fundamental ecological processes are still intact and where the vast majority of species originally present still occur, is of national, even international significance, almost regardless of the nature of the component attributes. Natural areas which contain a high degree of habitat diversity are especially significant (Good 1992a).

Wardle (1989) considers the Australian Alps have outstanding scientific significance in their own right. He points out their significance is enhanced through comparison with the other high mountain systems of Australasia which are, indeed, worlds apart in many respects, yet share underlying biological similarities.

Kosciuszko National Park was declared a World Biosphere Reserve in 1977 under the UNESCO Man and the Biosphere program. Thus, UNESCO subscribed to the proposition that "the lands within the Park were an outstanding example of alpine environments which contain unique communities and areas with unusual natural features of exceptional interest." (IUCN 1979). The 1977 declaration of Kosciuszko National Park as a Biosphere Reserve can reasonably be taken to testify to an international acceptance of this part of the Australian Alps as an outstanding example of alpine environments, and of the significance of the park for its unique communities and unusual natural features (Kirkpatrick 1994 #)[#]

Geology and Geomorphology

Several writers have testified to the international significance of the geomorphology of the Australian Alps (Kirkpatrick 1994 #). Particularly significant features include the uplifted plateaus within the alpine and subalpine zone, which are relatively rare on a world scale, the periglacial and (to a lesser extent) glacial landforms, features of the karst areas, especially at Cooleman Plain, the migrating feldmark, snowpatch dynamics, aeolian-enriched solifluction lobes and stepped ponds (Kirkpatrick 1994 #).

The Australian Alps have a highly complex geological and geomorphological history of outstanding universal scientific interest. They are highly unusual on a world scale because of the combination of an intraplate location and an extremely narrow continental shelf. The nature and timing of their origin in the context of their intraplate location has generated intense international scientific interest (Kirkpatrick 1994 #).

The diversity of land form associated with the long history of uplift and dissection is enhanced by the wide range of rock types dating back to Cambrian time, almost 600 million

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[#] AALC publication or report

years ago. Some minerals within these rocks are as old as 3000 million years, providing evidence of rock recycling at least on a continental scale. There is a complex record of marine sedimentation, igneous intrusions, lava flows and fresh-water deposition. The marine limestones of the Yarrangobilly and Cooleman areas are renowned: not only for the beauty and variety of their cave formations, but also for the international scientific significance of other karst features and related processes (Spate and Houshold, 1989, cited by Costin 1989 #).

The various uplift processes which created the Australian Alps may have started up to 90 million years ago. By contrast, the highlands of New Zealand and New Guinea and many other mountain ranges of other countries are thought to have originated within the last few million years (Costin 1989 #).

The Australian Alps are well-worn by long geological erosion and are gently rounded compared with the younger, angular, alpine areas of Europe, Asia, North and South America, and New Zealand.

The Victorian highlands are of national and perhaps international geological significance. This significance lies in the diversity of Palaeozoic sedimentary and volcanic lithology exposed by the elevated chain of The Great Divide. The Victorian highlands also contain rock outcrops that are not well represented in other areas (Busby 1990).

The highlands are also of national and perhaps international geomorphological significance. Although not significant as ‘alpine’ terrain, the absence of intensive Pleistocene ice modification of an elevated landscape is very unusual on a world scale. The Pleistocene periglacial features, although neither unusual nor substantial on a world scale, are nevertheless of major importance in establishing climatic and process gradients along eastern Australia during cooler phases of the Pleistocene. The sub-basaltic relief preserved beneath the Tertiary lava flows is also of major importance in determining the chronology of highlands evolution. (Busby 1990)

The very restricted glaciation on the Australian mainland invites comparison with other small glaciated areas elsewhere and gives the Kosciuszko features both national and international significance (Good 1992a).

Because of the mildness of the glaciation and the current climatic mildness of the alpine zone as a whole, the Australian Alps have a great range of active and fossil periglacial features of great international scientific interest (Kirkpatrick 1994 #).

The alpine humus soils of the Australian Alps are relatively deep, reflecting the prior existence of a soil mantle, whereas the much steeper, heavily glaciated, mountains elsewhere are relatively soil free (Costin 1989 #).

The significance of the karst areas in Kosciuszko National Park can be recognised both nationally and internationally; for the karst processes taking place, the unique karst features exhibited and for the recreational and economic values of the cave systems (Good 1992a). Several surface features of the Cooleman karst have attracted international scientific interest, particularly the ‘A-tent’ structures (Good 1992a). Spate and Houshold (1989, quoted in Good 1992a) consider that these karst areas have been subjected to prolonged erosion and hence are of special interest as they exhibit multiple episodes of karstification. Some of these episodes are of antiquities unknown or unrecognised elsewhere and so give the karst international significance.

Biology

World interest in the natural history of the Southern Hemisphere starts with the fact that this hemisphere contains relatively little land especially in the temperate latitudes of approximately 30°–60°. Mountains extending from the lowlands to snow country are even more restricted and isolated, in contrast to those of the Northern Hemisphere boreal zone (Costin 1989 #).

Kosciuszko National Park has been recognised by the World Conservation Union (IUCN) as one of six Australian sites of plant biodiversity and one of 167 throughout the world (Good 1992a). At the species level the Australian Alps contain a significant proportion of the biological diversity of Australia, and thus of the world (Kirkpatrick 1994 #). The Australian Alps is one of eleven major centres of plant diversity and endemism on mainland Australia identified in (Boden 1995), based on the collective knowledge of members of the IUCN Australasian Plant Specialist Group and others with intimate knowledge of the Australian flora and vegetation, and supplemented by reference to published and unpublished work.

Global interest in the ecology of the Australian Alps is centred on two main groups of features: those which have counterparts in the more extensive mountains elsewhere in the world and those which are uniquely Australian (Costin 1989 #).

The significance of the Australian alpine flora lies not only in its diversity and high degree of endemism but also in its phytogeographical relationships and differences with other alpine Australasian and Southern Hemisphere continental and subantarctic island floras. The flora is, therefore, a major resource for further phytogeographical studies, particularly focusing on differences with New Guinea and subantarctic island alpine floras (Good 1995). Australian mountain flora have a key role in world phytogeography including significance regarding earlier contiguities of continents now separated (Costin 1989 #).

Costin (1989 #) regards the outstanding scientific attribute of the Australian Alps to be the extent and scale of continuous and interrelated environmental diversity as expressed in their ecosystems. Whilst in a country as large and as different from north to south and east to west as is Australia, it is impossible to find a single representative sample of the total ecology effectively conserved, the ecosystems of the Australian Alps largely do this for the southeast of the continent.

Mainland alpine vegetation, though not as highly significant as the Tasmanian alpine vegetation, should still be ranked as being of international significance (Busby 1990).

The Australian Alps have the most outstanding development of open treeless subalpine valleys, or ‘parks’, in the world, an attribute related to their generally gentle topography and relatively deep soils. The dynamics of the sharp inverted treeline are the focus of considerable international scientific interest (Kirkpatrick 1994 #).

Alpine plant communities are of international significance (Busby 1990). The significance of the present alpine flora lies in the many commonalities of the floristic groups, and the affinities and differences between genera and species, compared with those of other alpine Australasian areas and with the other Southern Hemisphere continents and subantarctic islands (Good 1992a).

Eucalyptus pauciflora and the Tasmanian *Eucalyptus coccifera* form the only upper slope treelines in the world dominated by open-crowned, evergreen angiosperms (Kirkpatrick 1994 #).

The Australian Alps are the best example in the world of an area covered by a wide variety of sclerophyll vegetation communities. Most are eucalypt dominated forest types including stands of tall sclerophyll forest. They occur in a setting which is highly diverse in landforms and climate and have no counterpart anywhere else in the world. The relatively unmodified forests extend in an unbroken arc south-west to north-east for several hundred kilometres. All of the plant communities in the area and most of their characteristic fauna are intact and in a state of dynamic evolution (Mosley 1992 #).

The high diversity of eucalypt species in south-eastern Australia is of international significance (Busby 1990). Large areas of forest dominated by sclerophyllous evergreen angiosperms are very unusual in the world, and the Australian eucalypt forests are thus of major significance. South-eastern Australia has the highest richness of eucalypt taxa, and also of endemic taxa, of any comparable region of the country (Busby 1990). The major radiation of eucalypts to occupy such a wide variety of habitats is a feature which is virtually unparalleled in the world and is thus of very high international significance (Busby 1990).

The significance of the evolution of the eucalypts lies in the dominance the genus exhibits in the majority of sclerophyllous forests and woodlands. No other continent is so completely characterised by a single genus of tree and in the Alps the genus occurs over the full altitudinal range of climatic regimes from the driest areas of the eastern rainshadow to the treeline at about 1800 metres (Good 1992a).

Kirkpatrick (1994) considers the universally most outstanding feature of the Australian Alps is the catena of eucalypt-dominated woodland and forest communities, extending from 100 m above sea level to the tree line. Their dynamics are highly unusual on a global scale, as almost all of the forest and woodland is dominated by species dependent on the exogenous disturbance of fire for their regeneration, because of the apparent ecological independence between overstorey and understorey and because of the relatively high degree of hybridisation and intergradation between the dominants of the eucalypt forest which covers almost all of the area. (Kirkpatrick 1994 #)

In a global sense, the most remarkable communities are those of sclerophylls, and the most remarkable species of these communities are of the genus *Eucalyptus.* In contrast to most other mountains where species of several diverse genera dominate different components of the vegetation, the Australian Alps are largely dominated by species of a single genus. At least 36 species of eucalypt have been recorded in the Alps with many additional subspecies, varieties, ecotypes and geographic races. Their growth forms range from mallee scrub to tall forest trees. They have adapted to water stress, high and low temperatures, nutrient deficiencies and other limiting soil conditions, wind, snow cover, mechanical damage, and fire. Different responses to the same influence have also evolved. For example, some species exhibit extreme sensitivity to fire, with abundant seeding the only effective means of regeneration (eg. *E. regnans);* others regenerate from a lignotuber (eg. *E. glaucescens);* and still others regenerate from epicormic shoots along the trunk and branches in which the cambium is protected by thick bark (eg. the peppermints, *E. dives* and *E. radiata).* The snow gum *(E. pauciflora ssp niphophila),* a broadleaved evergreen, has adapted to the same treeline conditions (associated with a mean temperature of about 10°C for the warmest month) as the deciduous and coniferous treeline species of the Northern Hemisphere (Good 1992a).

As Costin (1989) notes, there can be few other examples within a single genus of such wide and rapid radiation, adaptation and continuing evolution as in the eucalypts. The Australian Alps, particularly the Alps National Parks, maintain and protect much of this unique genetic diversity and resource. This role is very significant as some 200 species of *Eucalyptus* are now planted in foreign countries and all the species occurring in the Alps are grown overseas for hardwood supplies, firewood and land reclamation programs. The finely tuned genetic adaptation of the eucalypts to nearly all edaphic and climatic conditions and the continuous variation of populations over their range is therefore a genetic resource of world-wide importance (Blakers 1987, cited in Good 1992a)

Possibly the most significant feature of the fauna is its parallel evolutionary radiation from common ancestral sites and the evolution of similar cold climate adaptations, in total isolation from other species elsewhere in the world. This adaptation also parallels in time similar evolutionary radiation and adaptation in the alpine flora following dispersal from their sites of common origin and together the flora and fauna comprise a unique Australian component of the world biota (Good 1992a).

The significance of the mountain pygmy-possum (*Burramys parvus*) is its scientific (specialised dentition, status as alpine-subalpine species, ability to hibernate, only marsupial to store food), and conservation status. It and its habitat are rated as being of international significance (Busby 1990).

Documentation over many years of the condition and trend of ecosystems is essential to understanding them but such studies are rare. The long-term measurements of vegetation change on the Bogong High Plains initiated by Mrs Maisie Carr and continued by Drs David Ashton and Dick Williams, and those in the Snowy Mountains carried out by Dane Wimbush and Alec Costin, cover periods of up to 40 years. This work provides guidelines essential for scientific ecosystem management, particularly for nature conservation and catchment water yield. It also attracts world interest for its contribution to the understanding of vegetation dynamics and successional theory, particularly in relation to competition between woody and herbaceous species (Good 1992a). This work has revealed long term natural processes of outstanding international scientific interest (Kirkpatrick 1994 #).

National Significance

All the natural features which have international significance are, of course, important nationally. Additional natural features have national significance.

The Alps assemblages of habitats and communities are among the richest on the mainland, and probably the richest with national park or equivalent protection (Costin 1989 #).

Costin (1989 #) regards the extent and scale of continuous and interrelated environmental diversity as expressed in their ecosystems to be the outstanding scientific attribute of the Australian Alps.

The Victorian highlands are of high national biological significance, with individual features of international significance (Busby 1990).

Alpine treelines, wherever they occur, are regarded as being of considerable scientific and conservation significance. This is because the often abrupt change in vegetation structure in a harsh environment has profound ecological implications for the other flora and fauna. The presence of an alpine treeline comprised of *Eucalyptus pauciflora* is rated as being of national significance (Busby 1990).

The Australian Alps have great national significance as a source of water — for town and city supply, for irrigation and for hydro-electricity. Provision of water is a major function of each of these national parks. Much of Namadgi National Park is the catchment for Canberra’s water supply, Kosciuszko National Park provides the water for the Snowy Mountains Hydro-electric Scheme which then is diverted westward into the Murray and Murrumbidgee catchments for irrigation, while the Alpine National Park provides the water for the Kiewa Hydro-electric Scheme and irrigation storages such as Lake Dartmouth and Lake Buffalo.

Parts of the Lake Hume, Ovens River (Bright), Upper Kiewa and Mitchell proclaimed water supply catchments are located within the Bogong unit of the Alpine National Park. These catchments make nationally significant contributions to domestic and irrigation water supplies (DCE 1992a). There are several proclaimed water supply catchments covering parts of the Wonnangatta-Moroka unit of the Alpine National Park, viz. Glenmaggie, Upper Goulburn, King River (Lake William Hovell), Buffalo River (Lake Buffalo), Buckland River and Mitchell River. These catchments are important for domestic and irrigation water supplies (DCE 1992d). The Dartmouth unit of the Alpine National Park surrounds, but does not include, Lake Dartmouth. The unit comprises part of the Lake Hume proclaimed water supply catchment, which makes a substantial contribution to domestic and irrigation water supplied from the Murray River to users in three States (DCE 1992c).

Kosciuszko National Park includes the headwaters of the Murray, Murrumbidgee and Snowy Rivers systems, which together constitute one of the most important protected water catchment areas in Australia. Water supplies for many towns and cities, for irrigation in the Murray Valley (in three states) and in the Murrumbidgee Irrigation Area, and for peak-load power for the cities and industries of New South Wales, Victoria and the ACT are substantially dependent on the protection of the water catchments and snowfields within Kosciuszko (NSW NPWS 1988b).

Australia is the earths' driest continent or large island. The average annual flow of Australia's rivers, if spread evenly over the continent, would give a depth of water of about 3.5 centimetres. By contrast the water from the USA's ten major rivers would cover the USA to a depth of some 15.5 centimetres. In such a drought prone country, the existence of even a small area of mountain catchments subject to winter snowfalls is a matter of great national significance. So the Snowy Mountains covering only 0.3 % of Australia's land area in the south-east of the continent, are of supreme importance to the nation (Gare 1992 #).

The alpine regions of mainland Australia contain the headwaters of the Murray and Murrumbidgee rivers, key parts of the major river system in Australia. The alpine areas have much more reliable precipitation than other parts of Australia, and so these rivers are regulated to provide water for hydroelectric power generation and for irrigated agriculture. Extensive snowfields cover the alpine areas for about four months each year and support a significant ski industry with consequential demand for recreation facilities. Many of the rivers in the Alps National Parks are considered valuable for their conservation recreational, and aesthetic values. The Management Plan for the Kosciuszko National Park, for example, emphasises the wild and scenic nature of these rivers and stresses that these values must be protected along with native aquatic flora and fauna (Cullen 1992 #).

1.2 Why conserve rare species?

> To protect an environment for future generations, we have to build a society on a foundation of clean air, water, soil and energy and rich biodiversity to fulfil our biological needs — David Suzuki, 22 February 2000.

When scientists speak of biological diversity they simply mean variety of life: variety of species and their genetic variation, and variety of communities of plants and animals. The extinction of a species irretrievably diminishes biodiversity. It is not just the rare species that have been affected in Australia. Species that were widespread and abundant only a few decades ago are now extinct, endangered or vulnerable. The decline of these species is a symptom of the underlying environmental degradation that has occurred over the last 200 years (Endangered Species Advisory Committee 1992).

Almost unnoticed, the earth's living wealth is slipping away. As human populations expand and intensify their use of the land, species of wild things and their habitats disappear. With them go not only the beauty and variety of life created over millions of years but also environmental stability and untold potential for supplying human needs. Wild plants and animals are the basis of our food, many of our medicines, and countless industrial products. As wildlife vanishes, our own life is impoverished, if not imperilled (US National Park Service 1999).

Over billions of years, the earth has been enriched with an abundance of life forms. As different forms of life evolved, others became extinct. Sometimes cataclysmic events like asteroid strikes, abrupt climate changes, or the advance of ice sheets caused mass extinctions. When this happened, new species evolved that were adapted to the changed environment (US National Park Service 1999).

Today we are witnessing another extinction of unprecedented proportions, this one caused by humans. People are rapidly altering and destroying environments that have fostered a wondrous diversity of organisms. Soon, at present rates of loss, a quarter of the world's existing plant and animal species (estimated at five million but possibly several times that number) may have vanished forever, many before they are identified and described. Some experts think that species are dying out at the rate of 100 a day. Overharvesting or direct human exploitation is only partly to blame (US National Park Service 1999).

Even if a species is not extinguished but only drastically reduced in numbers, there is still cause for concern, because it will have lost much of its natural genetic variation. Because of this loss, it will be less able to adapt to environmental change through the mechanism of natural selection. Numerous and diverse populations thus make it more likely that a species will have the genetic variety needed to escape extinction from slow environmental change, and the numbers to recover from natural catastrophes or human impacts. Conserving biodiversity is not, therefore, a matter of saving a few remnants. Many large populations of each species are essential — and to preserve large populations, we must preserve sufficient habitat. National parks and other protected areas help provide that habitat (US National Park Service 1999).

Nearly all the food in the supermarket was originally derived from wild sources. Of an estimated 80,000 types of plants know to be edible, only about 150 are extensively cultivated. A mere three crops—corn, wheat, and rice, all of wild origin—supply two-thirds of the world's total grain harvest (US National Park Service 1999).

Wild species are necessary to ensure the continued productivity of our cultivated foods. The potato blight in Ireland during the 1840s led to the starvation of two million people and prompted mass emigration to the United States. Eventually, the potato was crossbred with several of its wild, disease-resistant relatives, producing the many reliable varieties in use today (US National Park Service 1999).

Among other things, nature resembles a giant drug store. Almost one-quarter of all prescription drugs sold in the United States (an $8 billion-a-year market) contain natural substances. Alkaloids, plant substances especially common in tropical plants, are used in cancer-fighting drugs, painkillers, blood-pressure boosters, anti-malarial drugs, and muscle-relaxants. Probably the best known natural drug is penicillin, derived from *Penicillium* mould, a close relative of common bread moulds. Aspirin also had a natural origin. Even when synthetic versions of drugs are developed, giving us substitutes for penicillin or aspirin, they are usually created by following the "blueprints" of natural chemical compounds. Yet of earth's hundreds of thousands of species or higher plants (estimates range between 250,000 and 750,000) only a relative handful have been exhaustively studied for their medicinal value. The world's flora surely holds many more cures for human ills (US National Park Service 1999).

Life in a technical age is unimaginable without many other products that come from natural sources. Trees supply wood, paper, pulp, chemicals, and other products worth well over $100 billion annually worldwide. Rayon, derived from wood chemicals, is important to making cloth. Ethanol, derived from fermenting corn, sorghum, or sugar cane, may well become an important source of fuel in a world short of petroleum. Industrial oils and waxes can be obtained from many plants and some animal species (US National Park Service 1999).

Nature is our security. By sustaining natural diversity through the establishment of national parks and other reserves, we protect potential genetic sources of economic wealth for the future (US National Park Service 1999).

There are four main reasons for the conservation of species (Endangered Species Advisory Committee 1992).

The first reason is that species are vital components of ecosystems that provide us with indispensable services as the life support systems of our planet. They provide the oxygen we breathe, maintain the quality of the atmosphere, control and ameliorate the climate, regulate fresh water supplies, generate and maintain the topsoil, dispose of wastes, generate and recycle nutrients, control pests and diseases, pollinate crops and provide a genetic store from which we can benefit in the future. The accelerated loss of species indicates fundamental problems with our life support systems.

The contribution of the rarer species to the provision of life-support systems is poorly understood. The vulnerable cassowary could be regarded as a keystone species as it disperses the seeds of two hundred species of rainforest trees and vines. Some rarer species may be important in the recovery processes following ecosystem disturbance or may play a larger role in changed climatic circumstances. Change in the future is inevitable and likely to be rapid. Today's rare plant and animal species may become tomorrow's keystone species as conditions change.

The second reason is based on the economic benefits of biodiversity. Plants, animals and micro organisms provide all our food, and many of our medicines and drugs, as well as renewable resources such as fuel, building materials, clothing, paper and leather. They are an essential resource for developing biological control of pests and diseases. The unique Australian flora and fauna, and the scenery they help create, also attract tourists.

So far only a minute proportion of the economic potential of Australian plants and animals has been realised. Examples are the eucalypts now planted as cash crops throughout the subtropics of the world and the macadamia nut which has been widely cultivated for food. Many other biological resources, including species considered 'useless' today, will be found to have new values in the future. Clearly, extinctions reduce our future options. For example if the attractive wildflowers of Western Australia had been lost during settlement, the present wildflower industry worth more than $12 million/year would not exist.

The third reason is based on aesthetic and cultural values. Species should be preserved because of their beauty, symbolic value or intrinsic interest. Kangaroos and other large mammals, wildflowers of striking beauty and butterflies of iridescent hue appeal automatically to most members of our society and we would feel a loss if they and the wild places they live in disappeared. Many Australians wish to conserve the plants and animals of their country because of pride in their natural heritage. The extinction of species reduces the richness of potential human experience.

The fourth reason is that compassion demands their conservation. Compassion develops from the view that other species have a right to exist; the needs and desires of humans should not be the only basis for ethical decisions (Endangered Species Advisory Committee 1992).

It is also important to maintain the range of genetic diversity within individual species. Small populations generally lose genetic diversity over time. With limited genetic variability a species may be unable to evolve in changing environments, and it is vulnerable to new conditions such as climatic change or new diseases. The rapidly developing techniques of the new science of biotechnology also depend on genetic diversity to improve, for example, crop species resistance to disease (Endangered Species Advisory Committee 1992).

Our planet's essential goods and services depend on the variety and variability of genes, species, populations and ecosystems. Biological resources feed and clothe us and provide housing, medicines and spiritual nourishment. The natural ecosystems of forests, savannas, pastures and rangelands, deserts, tundras, rivers, lakes and seas contain most of the Earth's biodiversity (UNCED 1992).

Our urban and rural lifestyles impose considerable environmental pressures on the natural environment. There are, however, natural heritage assets and values that provide substantial and fundamental societal benefits. They need to be recognised and protected from further damage (ACT Government 1998a).

Biological resources. The world's plants and animals provide us with all our food, many medicines and industrial products.

Loss of species diversity means options for future exploitation are foregone. Who would have foreseen, even one generation ago, the horticultural and cut flower business generated by our native plants. Medicinal and food products continue to offer considerable potential. Australian trees and timbers are valued world-wide.

If the wild genetic material that forms the basis of many of our existing biological products is no longer accessible, opportunities for increased productivity or coping with environmental change are removed. Breeding for disease resistance often means resorting to wild stock.

Ecological processes. Benefits arising from conservation of Australia's biodiversity include the provision of a wide array of ecological services (natural processes that play an essential part in maintaining ecosystem integrity). They are fundamental to our way of life and our economy, but are often grossly undervalued.

Examples include water catchment protection, maintenance of soil production and fertility, protection from soil erosion, nutrient storage and recycling, and pollution breakdown and absorption. Consider the alternatives in terms of water quality and siltation management if water supplies were not protected by vegetated catchments. Healthy and diverse ecosystems are self-sustaining.

Social benefits. The natural environment provides for many of the spiritual, educational, aesthetic and recreational needs of our community. There are direct economic benefits to be obtained by assisting others to appreciate environmental experiences for example, in the tourism and recreation industries.

Cultural heritage values are often linked to our natural environment. Landscapes and other features may grow in significance because of their uniqueness, connection with people or events, or simply because of their intrinsic characteristics such as age or complexity.

A respect for nature ethos. There is a widely held ethical basis for conserving our biodiversity. It is expressed in the National Strategy for the Conservation of Australia's Biological Diversity in the following terms: 'We share the earth with many other life forms that warrant our respect, whether or not they are of benefit to us. Earth belongs to the future as well as the present; no single species or generation can claim it as its own'.

Benefits of timely action. There is little scope to restore natural ecosystems and rehabilitation costs can accumulate alarmingly if degrading influences are not identified and managed adequately. The inevitable consequence of inaction is increasing loss of productivity and general decline in the quality and value of our natural assets through loss of biodiversity and heritage values.

While preferred lifestyles and economic and political priorities may be the immediate realities that determine our environmental standards, in the long term our basic welfare and survival depend on them being ecologically sustainable (ACT Government 1998a).

> A system of protected areas is the core of any program that seeks to maintain the diversity of ecosystems, species and wild genetic resources. [IUCN, UNEP & WWF, 1992. Caring for the earth: A strategy for sustainable living. IUCN, Gland.]

1.3 International obligations

Convention on Biological Diversity (1992)

There is no doubt that the Australian Alps national parks exhibit components of biological diversity that would be identified as important under this convention, and that they would be appropriately selected as protected areas as the best way of maintaining these components. There would seem to be a case that the Convention, through its integrity recommendations, should impel greater efforts in excluding or controlling threatening introduced species, and preventing or mitigating threatening processes, such as stock grazing and logging. (Kirkpatrick 1994 #)

Article 7. Identification and Monitoring

Each Contracting Party shall, as far as possible and as appropriate, in particular for the purposes of Articles 8 to 10:

(a) **Identify components of biological diversity important for its conservation** and sustainable use having regard to the indicative list of categories set down in Annex I;

(b) **Monitor**, through sampling and other techniques, the **components of biological diversity** identified pursuant to subparagraph (a) above, paying particular attention to those requiring urgent conservation measures and those which offer the greatest potential for sustainable use;

(c) **Identify processes and categories of activities** which have or are **likely to have significant adverse impacts on the conservation and sustainable use of biological diversity**, and monitor their effects through sampling and other techniques; and

(d) **Maintain and organise**, by any mechanism **data, derived from identification and monitoring** activities pursuant to subparagraphs (a), (b) and (c) above.

Article 8. In-situ Conservation

Each Contracting Party shall, as far as possible and as appropriate:

(a) **Establish a system of protected areas** or areas where special measures need to be taken to conserve biological diversity;

(b) **Develop**, where necessary, **guidelines for the selection, establishment and management of protected areas** or areas where special measures need to be taken to conserve biological diversity;

(c) Regulate or **manage biological resources important for the conservation of biological diversity** whether within or outside protected areas, with a view to ensuring their conservation and sustainable use;

(d) **Promote the protection of ecosystems, natural habitats and the maintenance of viable populations of species in natural surroundings**;

(e) Promote environmentally sound and sustainable development in areas adjacent to protected areas with a view to furthering protection of these areas;

(f) **Rehabilitate and restore degraded ecosystems and promote the recovery of threatened species**, inter alia, through the development and implementation of plans or other management strategies; …

(h) **Prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species**;

(i) Endeavour to provide the conditions needed for compatibility between present uses and the conservation of biological diversity and the sustainable use of its components;

(j) Subject to its national legislation, respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity and

> promote their wider application with the approval and involvement of the holders of such knowledge, innovations and practices and encourage the equitable sharing of the benefits arising from the utilisation of such knowledge, innovations and practices;
>
> (k) Develop or maintain necessary legislation and/or other regulatory provisions for the protection of threatened species and populations; and
>
> (l) Where a significant adverse effect on biological diversity has been determined pursuant to Article 7, regulate or manage the relevant processes and categories of activities; …(UNEP 1996)

Agenda 21

In 1992, more than 100 heads of state met in Rio de Janeiro, Brazil, for the United Nations Conference on Environment and Development (UNCED). The Earth Summit was convened to address urgent problems of environmental protection and socio-economic development. The assembled leaders signed the Framework Convention on Climate Change and the Convention on Biological Diversity; endorsed the Rio Declaration and the Forest Principles; and adopted **Agenda 21**, a 300-page plan for achieving sustainable development in the 21st century.

Agenda 21 (UNCED 1992) is a comprehensive plan of action to be taken globally, nationally and locally by organisations of the United Nations System, Governments, and Major Groups in every area in which human impacts on the environment.

Agenda 21, the Rio Declaration on Environment and Development, and the Statement of principles for the Sustainable Management of Forests were adopted by more than 178 Governments at the United Nations Conference on Environment and Development (UNCED).

Agenda 21 places particular importance on mountains, with Chapter 13 specifically on mountains:

> MANAGING FRAGILE ECOSYSTEMS: SUSTAINABLE MOUNTAIN DEVELOPMENT
>
> 13.1. Mountains are an important source of water, energy and biological diversity. Furthermore, they are a source of such key resources as minerals, forest products and agricultural products and of recreation. As a major ecosystem representing the complex and interrelated ecology of our planet, **mountain environments are essential to the survival of the global ecosystem. Mountain ecosystems are**, however, **rapidly changing**. They are susceptible to accelerated soil erosion, landslides and rapid loss of habitat and genetic diversity. On the human side, there is widespread poverty among mountain inhabitants and loss of indigenous knowledge. As a result, **most global mountain areas are experiencing environmental degradation**. Hence, the proper management of mountain resources and socio-economic development of the people deserves immediate action.
>
> 13.4. Mountains are highly vulnerable to human and natural ecological imbalance. **Mountains are the areas most sensitive to all climatic changes** in the atmosphere. Specific information on ecology, natural resource potential and socio-economic activities is essential. **Mountain and hillside areas hold a rich variety of ecological systems. Because of their vertical dimensions, mountains create gradients of temperature, precipitation and insolation**. A given mountain slope may include several climatic systems - such as tropical, subtropical, temperate and alpine - each of which represents a microcosm of a larger habitat diversity. There is, however, a lack of knowledge of mountain ecosystems. The creation of a global mountain database is therefore vital for launching programs that contribute to the sustainable development of mountain ecosystems.

The Australian Alps and the Biosphere Reserve concept

The Man and the Biosphere (MAB) Program (UNESCO 2000) is a model based around reference areas of the global biosphere used to develop more sustainable landuse practices around the core functions of conservation (of genetic resourses, species, ecosystems and landscapes), development (to foster sustainable human and economic development), and logistic support (to foster demonstration projects, environmental education and training, and research and monitoring related to local, national and global issues of conservation and sustainable development).

Biosphere Reserves are areas of terrestrial and coastal ecosystems which are internationally recognised within the framework of UNESCO’s Man and the Biosphere (MAB) Program. Collectively, they constitute a World Network. They are nominated by national governments and must meet a minimal set of criteria and adhere to a minimal set of conditions before being admitted into the World Network. Each Biosphere Reserve is intended to fulfil three basic functions, which are complementary and mutually reinforcing:

- a conservation function - to contribute to the conservation of landscapes, ecosystems, species and genetic variation;
- a development function - to foster economic and human development which is socio-culturally and ecologically sustainable;
- a logistic function - to provide support for research, monitoring, education and information exchange related to local, national and global issues of conservation and development.

Kosciuszko National Park was declared a World Biosphere Reserve in 1977, but there would seem to be no criterion-based barrier to extending Biosphere Reserve status to all of the Australian Alps national parks. If the Australian Alps national parks were treated as the core nature conservation area, the Biosphere Reserve could be extended to encompass those parts of the Australian Alps that are not conservation reserves, but which have conservation qualities that could be maintained through appropriate integrated management (Kirkpatrick 1994 #).

Convention Concerning the Protection of the World Cultural and Natural Heritage

The Australian Alps have outstanding international significance on the criteria used in the World Heritage Convention in a variety of areas, most notably their outstanding representation of a highly diverse and unusual assemblage of communities dominated by eucalypts, their evidence of geomorphological, edaphic and ecological processes in the alpine and treeless subalpine zones, and their character as a globally unusual intraplate mountain range (Kirkpatrick 1994 #).

By signing the Convention, **each country pledges to conserve the sites situated on its territory, some of which may be recognised as World Heritage (UNESCO 1998).**

> Article 2
>
> For the purposes of this Convention, **the following shall be considered as “natural heritage”:**
>
> **natural features consisting of physical and biological formations or groups of such formations, which are of outstanding universal value from the aesthetic or scientific point of view;**
>
> **geological and physiographical formations and precisely delineated areas which constitute the habitat of threatened species of animals and plants of outstanding universal value from the point of view of science or conservation;**
>
> **natural sites or precisely delineated natural areas of outstanding universal value from the point of view of science, conservation or natural beauty.**

Article 4

Each State Party to this Convention recognises that the **duty of ensuring the identification, protection, conservation, presentation and transmission to future generations of the cultural and natural heritage** referred to in Articles 1 and 2 and situated on its territory, belongs primarily to that State. **It will do all it can to this end, to the utmost of its own resources** and, where appropriate, with any international assistance and co-operation, in particular, financial, artistic, scientific and technical, which it may be able to obtain.

Article 5

To ensure that effective and active measures are taken for the protection, conservation and presentation of the cultural and natural heritage situated on its territory, each State Party to this Convention shall endeavour, in so far as possible, and as appropriate for each country:

a. to adopt a general policy which aims to give the cultural and natural heritage a function in the life of the community and to integrate the protection of that heritage into comprehensive planning programs;

b. to set up within its territories, where such services do not exist, one or more services for the protection, conservation and presentation of the cultural and natural heritage with an appropriate staff and possessing the means to discharge their functions;

c**. to develop scientific and technical studies and research and to work out such operating methods as will make the State capable of counteracting the dangers that threaten its cultural or natural heritage;**

d. to take the appropriate legal, scientific, technical, administrative and financial measures necessary for the identification, protection, conservation, presentation and rehabilitation of this heritage; and

e. to foster the establishment or development of national or regional centres for training in the protection, conservation and presentation of the cultural and natural heritage and to encourage scientific research in this field.

Convention on Wetlands (Ramsar, Iran, 1971)

The Australian Alps national parks contain two identified Ramsar sites. One includes Blue Lake, Hedley Tarn and the majority of their catchments in Kosciuszko National Park, and the other covers the Ginini Flats Wetland Complex in Namadgi National Park. More broadly, under the Convention there is a general obligation for the Contracting Parties to include wetland conservation considerations in their national land-use planning (the Ramsar Convention Bureau 2000). They have undertaken to formulate and implement this planning so as to promote, as far as possible, “the wise use of wetlands in their territory” (Article 3.1 of the treaty).

Convention on the Conservation of Migratory Species of Wild Animals

An important group of summer residents of the alpine zone is the transequatorial birds which migrate from the northern hemisphere. Of this group only four are regular visitors (to Kosciuszko National Park) and six occasionally utilise the alpine lakes and rivers when drifting from the main migration route along the coast. The annual southerly migration of the transequatorial species is total and in drought years great losses can occur as the birds traverse Australia towards the end of a very long flight from the Northern Hemisphere. The Park therefore also plays a significant role in meeting management obligations under the International Migratory Birds Agreement (Good 1992a).

Article II

Fundamental Principles

1. The Parties acknowledge the importance of migratory species being conserved and of Range States agreeing to take action to this end whenever possible and appropriate, paying special attention to migratory species the conservation status of which is unfavourable, and taking individually or in co-operation appropriate and necessary steps to conserve such species and their habitat.

2. The Parties acknowledge the need to take action to avoid any migratory species becoming endangered.

3. In particular, the Parties:

should promote, co-operate in and support research relating to migratory species;

shall endeavour to provide immediate protection for migratory species included in Appendix I; and

shall endeavour to conclude Agreements covering the conservation and management of migratory species included in Appendix II (UNEP/CMS Secretariat).

JAMBA and CAMBA

Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment

Article III

1. Each Government shall take special protective measures, as appropriate, for the preservation of species or subspecies of birds which are in danger of extinction.

2. Whenever either Government has determined the species or subspecies of birds which are in danger of extinction and taken special protective measures therefor, the Government shall inform the other Government of such determination and of any cancellation thereafter of such determination.

3. Each Government shall control the exportation or importation of such species or subspecies of birds as are determined in accordance with paragraph 2 of this Article, and of the products thereof.

Article IV

1. The two Governments shall exchange data and publications regarding research on migratory birds and birds in danger of extinction.

2. Each Governments shall encourage the formulation of joint research programs on migratory birds and birds in danger of extinction.

3. Each Government shall encourage the conservation of migratory birds and birds in danger of extinction.

Article V

Each Government shall endeavour to establish sanctuaries and other facilities for the management and protection of migratory birds and birds in danger of extinction and also of their environment.

Article VI

Each Government shall endeavour to take appropriate measures to preserve and enhance the environment of birds protected under the provisions of this Agreement. In particular, it shall:

(a) seek means to prevent damage to such birds and their environment;… (Anon 1981)

Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment (CAMBA)

> Article IV
>
> Each Contracting Party shall endeavour, in accordance with its laws and regulations in force, to:
>
> (a) establish sanctuaries and other facilities for the management and protection of migratory birds and also of their environment;
>
> and
>
> (b) take appropriate measures to preserve and enhance the environment of migratory birds. In particular, each Contracting Party shall:
>
> (i) seek means to prevent damage to migratory birds and their environment, and
>
> (ii) endeavour to take such measures as may be necessary to restrict or prevent the importation and introduction of animals and plants which are hazardous to the preservation of migratory birds and their environment. (Anon 1988)

1.4 National obligations

Intergovernmental Agreement on the Environment

> Schedule 9
>
> 1 The parties agree that protection of flora and fauna and should use their best endeavours to ensure the , both terrestrial and aquatic, that make up Australia's biota. The parties recognise that the protection and sound management of natural habitats is of fundamental importance to this aim and that all levels of Government should use their best endeavours to conserve areas critical to the protection of Australia's flora and fauna and the maintenance of ecological processes that ensure biological productivity and stability.
>
> 2 The parties recognise that **area of nature conservation**.
>
> 6 **The Commonwealth and the States agree to cooperate in the conservation, protection and management of native species and habitats that occur in more than one jurisdiction**. In addition to participating in such cooperative activities, the Commonwealth and the States may take whatever action they deem appropriate within their respective jurisdictions to protect any native species and habitats which they consider requires specific action.
>
> 10 **The parties agree to co-operate in fulfilling Australia's commitments under international nature conservation treaties** and recognise the Commonwealth's responsibilities in ensuring that those commitments are met (CoAG 1992).

National Strategy for Ecologically Sustainable Development

> Objective 10. 1
>
> To establish across the nation a comprehensive system of protected areas which includes representative samples of all major ecosystems, both terrestrial and aquatic; manage the overall impacts of human use on protected areas; and restore habitats and ameliorate existing impacts such that nature conservation values are maintained and enhanced.

> Governments will …encourage enhanced public involvement and awareness in the planning, management, monitoring and review of Australia's conservation values and protected areas (Anon 1992).

National Strategy for the Conservation of Australia's Biological Diversity

1 - Conservation of biological diversity across Australia

In the face of significant and continuing reductions to our biological diversity, there is a pressing need to strengthen conservation activities across Australia.

Objective 1.1

Identify important biological diversity components and threatening processes.

Objective 1.2

Manage biological diversity on a regional basis, using natural boundaries to facilitate the integration of conservation and production-oriented management.

Objective 1.3

Improve the standards of management and protection of Australia's biological diversity by encouraging the implementation of integrated management techniques.

Objective 1.4

Establish and manage a comprehensive, adequate and representative system of protected areas covering Australia's biological diversity.

Objective 1.7

Enable Australia's species and ecological communities threatened with extinction to survive and thrive in their natural habitats and to retain their genetic diversity and potential for evolutionary development, **and prevent additional species and ecological communities from becoming threatened.**

Objective 1.8

Recognise and ensure the continuity of the contribution of the ethnobiological knowledge of Australia's indigenous peoples to the conservation of Australia's biological diversity.

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Recognise and ensure the continuity of the contribution of the ethnobiological knowledge of Australia's indigenous peoples to the conservation of Australia's biological diversity.

1.3.1 Integrated techniques

Develop and improve integrated land management techniques, extending across protected and other areas. Emphasis should be given to research into practical, cost-effective methods for the conservation of natural habitat, including remnants and corridors, and techniques for management at catchment and regional levels.

1.3.2 Consistent management approaches

Ensure consistency between Commonwealth, State and Territory and local governments' management approaches affecting the conservation of biological diversity; for example, fire management and weed and pest management.

1.3.4 Option analysis

Develop effective methods for the economic analysis of management and protection options, with particular reference to the allocation of external costs and benefits (Anon 1996).

Australian National Strategy for the Conservation of Australian Species and Communities Threatened with Extinction

The overall aim of this national strategy for the conservation of endangered and vulnerable species and ecological communities is:

> **To ensure that endangered and vulnerable species and ecological communities can survive and flourish, and retain their genetic diversity and potential for evolutionary development in their natural habitats, and to prevent further species and ecological communities from becoming endangered** (Endangered Species Advisory Committee 1992)**.**

While the primary focus is on species, attention also needs to be directed to the conservation of subspecies or distinct populations that may be endangered although the species itself may be secure. Maintenance of sub-species and distinct populations is essential if the range of genetic diversity within a species is to be retained.

There are considerable cost savings in ameliorating threatening processes before species become endangered and vulnerable or before endangered species reach critically low levels. The longer we wait, the more expensive and more difficult recovery becomes.

Because most Australian species are found nowhere else, Australians have a special responsibility to conserve them. In addition, Australia has a responsibility to conserve the many species that are shared with other countries. The best known examples of shared species are probably the migratory wading birds that breed in Siberia and other places in the northern hemisphere and spend the northern winter in Australia.

The conservation of endangered and vulnerable species is the responsibility of all levels of government and all Australians.

The States and Territories, through their constitutional responsibility for land use and management, are the major participants. States and Territories have legislation relating to wildlife conservation and have conservation agencies involved in management of native species and ecological communities. National coordination is through the Australian and New Zealand Environment Council (ANZECC).

Objective 2. **To ensure that the conservation agencies managing endangered and vulnerable species and ecological communities are professionally staffed and adequately funded**

To be achieved by:

2.1 The Commonwealth Government making funds available to States and Territories for research into and management of endangered and vulnerable species and ecological communities based on a systematic and scientific assessment of national priorities:

Primary responsibility - Commonwealth Government through the ESP and other relevant programs.

2.2 State, Territory and Commonwealth **agencies increasing resources, as part of a balanced wildlife conservation program, for management of endangered and vulnerable species and ecological communities with particular emphasis on the implementation of recovery plans and threatening process prevention plans**:

Primary responsibility - State Governments, Territory Governments, and Commonwealth Government and government conservation agencies.

2.3 Increasing funding from the corporate sector, NGOs and individuals for research into and management of endangered and vulnerable species and ecological communities:

Primary responsibility - Corporate sector, appropriate NGOs and individuals,

2.4 All government conservation agencies with responsibility for endangered and vulnerable species and ecological communities employing permanent staff, including expertise in at least the following areas - marine ecology, freshwater ecology, terrestrial flora including non-vascular plants, terrestrial vertebrates, terrestrial invertebrates and terrestrial community ecology.

Primary responsibility - Government conservation agencies.

2.5 Establishing Chairs of Conservation Biology in Universities to enhance the range of skilled personnel available to agencies, industry and the community.

Primary responsibility - Department of Employment, Education and Training and the Universities.

Objective 3. **To refine the identification of those species and ecological communities considered endangered or likely to become endangered and to identify threatening processes.**

To be achieved by:

3.1 **Providing funding for projects to improve knowledge of the conservation and reservation status of endangered and vulnerable species and ecological communities**. Included within the scope of this action are species whose present classification is unclear but which are suspected to be endangered or vulnerable.

Primary responsibility - State Governments, Territory Governments and Commonwealth Government, government conservation agencies, other relevant government agencies, corporate sector, appropriate NGOs and individuals

3.2 Preparing and regularly revising lists of nationally endangered and vulnerable species and ecological communities and threatening processes:

Primary responsibility - Australian and New Zealand Environment and Conservation Council (ANZECC) with assistance from ESP.

3.3 **Assisting the coordination of the various databases with endangered and vulnerable species and ecological communities information** and developing protocols for exchange of information. Assist exchange of information between such databases and those relating to resource development such as the National Resource Information Centre (NRIC):

Primary responsibility - Australian National Parks and Wildlife Service.

3.4 The Australian Biological Resources Survey (ABRS), Herbaria, Museums, Universities and other research agencies describing and classifying, as a matter of high priority, undescribed species that may be endangered or vulnerable:

Primary responsibility - ABRS Steering Committee.

3.5 Preparing and regularly reviewing standard terminology and criteria for use in endangered and vulnerable species and ecological communities projects:

Primary responsibility - ANZECC with assistance from ESP.

Objective 4. **To increase research aimed at understanding threatening processes and develop measures to eliminate or mitigate their effects. to increase research aimed at preventing the extinction of specific endangered and vulnerable species and ecological communities.**

To be achieved by:

4.1 Increasing research into the conservation biology of endangered and vulnerable species and ecological communities:

Primary responsibility - Commonwealth Government through the ESP, State Government and Territory Governments, government conservation agencies, other relevant government agencies, the Universities, corporate sector, appropriate NGOs and individuals.

4.2 Making conservation of biodiversity a national priority research area for the Australian Research Council (ARC) and Commonwealth Scientific and Industrial Research Organisation (CSIRO):

Primary responsibility - Australian Research Council and CSIRO.

4.3 Establishing Chairs of Conservation Biology to increase the academic research emphasis on endangered and vulnerable species and ecological communities:

Primary responsibility - Department of Employment, Education and Training and the Universities [See also 2.5].

4.4 **Preparing and regularly revising overviews of the significance of various threatening processes for endangered and vulnerable species and ecological communities.**

Primary responsibility - ESP.

4.5 Following recognition by the National Fox Control Workshop that foxes are playing a critical role in threatening mammals and some ground dwelling birds, **expanding the recently commenced national program on fox control:**

Primary responsibility - ESP, CSIRO, government conservation agencies, other relevant government agencies and other research organisations.

4.6 Setting up an environmental weeds research program.

Primary responsibility - Government conservation agencies, other relevant government agencies and research institutions.

4.7 Conducting research into the impacts of the rootrot disease caused by Phytophthora species on endangered and vulnerable species and ecological communities and conducting research into its control:

Primary responsibility - Government conservation agencies, other relevant government agencies and research institutions.

4.8 **Conducting research into other key threatening processes** identified in overviews:

Primary responsibility - Government conservation agencies, other relevant government agencies and research institutions.

4.9 Ensuring that State and Commonwealth programs concerned with threats such as climatic change address endangered and vulnerable species and ecological communities considerations:

Primary responsibility - ANZECC.

Objective 5. **To develop and implement plans for mitigating the effects of threatening processes.**

To be achieved by:

5.1 **Preparing and implementing plans to mitigate the effects of environmental weeds** on endangered and vulnerable species and ecological communities where adequate research, techniques and data are available (eg. bitou bush and blackberries):

Primary responsibility - Government conservation agencies and other relevant government agencies, ESP and local government.

5.2 **Preparing and implementing plans to mitigate the effects of exotic animals** on endangered and vulnerable species and ecological communities or on critical habitats of endangered and vulnerable species where adequate research data and techniques are available (eg. rabbits, feral cattle, feral donkeys, foxes). The most humane methods possible to be followed for control of exotic animals.

Primary responsibility - Government conservation agencies and other relevant government agencies, ESP, local government.

5.3 Maintaining and where necessary improving quarantine measures to ensure that potentially damaging species and diseases are not introduced to Australia:

Primary responsibility - Australian Quarantine and Inspection Service.

5.4 Noting the importance to conservation of endangered and vulnerable species of islands free of certain pests and ensuring that such islands remain free of those pests:

Primary responsibility - State Governments, Territory Governments and Commonwealth Government, government conservation agencies.

5.5 Preventing clearance or degradation of critical habitats of endangered and vulnerable species on public lands (see also 8.3) and in the aquatic environment.

Primary responsibility - State Governments, Territory Governments and Commonwealth Government, government conservation agencies, local governments.

Objective 6. **To prepare and implement recovery plans for all endangered species and ecological communities and selected vulnerable species and communities**.

To be achieved by:

6.1 **Identifying those species and ecological communities that are most likely to benefit from the immediate preparation and implementation of recovery plans** and listing those plans to be prepared within 10 years, in general giving preference to the critically threatened species and ecological communities:

Primary responsibility - Government conservation agencies, ESP.

6.2 Preparing recovery plans for identified priority species and ecological communities where information is available and implementing those plans as resources become available (see 2.2).

Primary responsibility - Government conservation agencies, ESP.

6.3 Where appropriate, reserving for conservation purposes endangered and vulnerable ecological communities and critical habitats of endangered and vulnerable species that are threatened by inadequate representation in reserve systems:

Primary responsibility - State Governments, Territory Governments and Commonwealth Government, government conservation agencies.

6.4 Coordinating efforts by zoos, botanic gardens, gene banks and related organisations to assist in ex situ breeding or propagation programs for those endangered and vulnerable species that would benefit from such measures, re-establishment in the wild being the ultimate objective:

Primary responsibility - Government conservation agencies, ESP.

6.5 Utilising Aboriginal knowledge and management skills in recovery plans for endangered and vulnerable species and ecological communities:

Primary responsibility - Government conservation agencies, Aboriginal and Torres Strait Islander Commission, Aboriginal communities and land councils, ESP.

6.6 Ensuring that landholders, individuals and volunteers as well as organisations have opportunities to carry out tasks recommended in recovery plans:

Primary responsibility - Government conservation agencies, ESP, NTSN and NGOs.

Objective 7. **To ensure that local, state and territory governments, the Commonwealth and public authorities manage all lands and waters under their control so as not to endanger species or ecological communities.**

To be achieved by:

7.1 All governments identifying areas under their control that are critical to the persistence of endangered and vulnerable species or which contain endangered and vulnerable ecological communities:

Primary responsibility - Local government and government conservation agencies.

7.2 **Integrating recovery plans for endangered and vulnerable species and ecological communities, and plans for controlling threatening processes into management of identified areas**, preferably in the form of management plans:

Primary responsibility - Government conservation agencies, ESP and other relevant government and management agencies including local government.

National Weeds Strategy

In 1991 the Commonwealth, State and Territory ministers responsible for agriculture, forestry and the environment agreed to develop a National Weeds Strategy to reduce the impact of weeds on the sustainability of Australia's productive capacity and natural ecosystems (Anon 1999a).

The Strategy (Anon 1999a) addresses weed problems of national significance, in

particular:

- weed problems which threaten the profitability or sustainability of Australia's principal primary industries;
- weeds problems which threaten conservation areas or environmental resources of national significance;
- weed problems where remedial action may be required across several States and Territories;
- weed problems which constitute major threats to Australia's biodiversity.

Goal 2 – To reduce the impact of existing weed problems of national significance
Establish procedures to assist in identifying, assessing and ranking weed problems of potential national significance.
Establish procedures for the development of management plans to ensure integrated and coordinated action against weed problems of national significance, with the involvement and participation of all relevant stakeholders.
Objective 2.2
To deal with established weed problems of national significance through integrated and cost effective weed management.

Register of the National Estate

The Australian Heritage Commission has a statutory obligation under the *Australian Heritage Commission Act 1975* to identify the National Estate. The Register of the National Estate is Australia's national inventory of natural and cultural heritage places which are worth keeping for the future(Australian Heritage Commission 2000a).

Entry in the Register of the National Estate is not a land management decision. The way in which private, State and local government owners manage their national estate properties is not directly affected by listing. The Commission does not manage places in the Register and entry in the Register does not give the Commonwealth Government any rights to acquire, manage, or enter places which are private property (Australian Heritage Commission 2000a). The Commonwealth has an obligation to take into account the effect of its actions on the National Estate and is the only body whose actions are constrained as a result of listings in the Register (Australian Heritage Commission 2000a).

National Trust Registers

The National Trust identifies and records places of national and local significance. Classification by the National Trust gives recognition to the heritage value of a particular place. If a place or object is threatened, the National Trust takes action (Australian Council of National Trusts 2000).

The Kosciuszko Alpine Landscape Conservation Area, the high country above the 1600m contour which extends approximately 100km north from the Victorian border with a maximum width of 20km, is on the National Trust Register (The National Trust of Australia (New South Wales)).

1.5 State obligations

Victoria

Under the Parks Victoria Act (1998) Parks Victoria must meet its obligation “not to act in a manner which is not environmentally sound.” For any given area of land or water under its management, Parks Victoria is also required to conduct its management to achieve the conservation objectives outlined in an extensive range of treaties, conventions, Acts, regulations and policies (see Figure 1). For each park or reserve, Parks Victoria must develop an integrated environmental management program which meets these objectives. (Parks Victoria 1998)

Examples of Parks Victoria’s conservation obligations include:

- the Ramsar convention on wetlands of international importance (1971);
- the Japan Australia Migratory Bird Agreement (JAMBA), (1974);
- the China Australia Migratory Bird Agreement (CAMBA), (1986);
- the *National Parks* Act (1975);
- the *Reference Areas* Act (1978);
- the Flora *and Fauna* Guarantee Act (1988);
- the Wildlife Act (1975);
- the Strategy for the Conservation of Biodiversity in Victoria (1997).

Victoria is signatory to several national agreements and strategies including: Intergovernmental Agreement on the Environment (IGAE); National Strategy for Ecologically Sustainable Development; National Strategy for the Conservation of Australia’s Biological Diversity; and the National Strategy for the Conservation of Threatened Species and Communities in Danger of Extinction.

Flora and Fauna Guarantee Act

The Flora and Fauna Guarantee Act, proclaimed in 1988, provides the main legal framework for the protection of Victoria’s biodiversity, native plants and animals and ecological communities on land and in water, and for a major program of State Government and community action. The aim is to ensure that Victoria’s native flora and fauna survive, flourish and retain their potential for evolutionary development in the wild.

At present, 141 plant species, 128 animal species and 23 ecological communities are listed on Schedules as threatened under the Act, and 22 processes are listed as potentially threatening. When a listing occurs an action statement must be prepared. Action Statements identify actions that have been or will be taken to conserve the species, or community, or manage the potentially threatening process. These statements consider social and economic issues and include community input.

Biodiversity strategy

Victoria recently released its Biodiversity Strategy which complements the National Strategy and the Flora and Fauna Guarantee Act 1988. This Strategy demonstrates how conserving biodiversity is a part of everyday life and how many of our actions can affect biodiversity. It provides the overarching direction for biodiversity conservation and management in Victoria. The Biodiversity Strategy is coordinated with other natural resources management mechanisms such as Regional Catchment Strategies, Regional Forest Agreements, and National Parks and Reserve planning. The Strategy forms a key step in the Flora and Fauna Guarantee program. It shows how to achieve the Flora and Fauna Guarantee Act’s objectives of conserving native species, communities and gene pools, preventing threats and encouraging community involvement.

Catchment strategies

The Catchment and Land Protection Act 1994 establishes an administrative framework for advising Government on the integrated management and protection of catchments on all land tenures across the State. It establishes processes to encourage and support community participation in the management of land and water resources through the establishment of a State-wide Catchment and Land Protection Board, ten regional Catchment and Land Protection Boards, and a Pest Animal Advisory Committee.

During 1997, 10 Regional Catchment Strategies (RCSs) were prepared by the Catchment and Land Protection (CaLP) Boards and approved by government. Catchment Management Authorities have now replaced the previous CaLP Boards and Waterway Management Authorities in nine of the 10 CaLP regions. RCSs applying to the Australian Alps national parks are those for the North East, West Gippsland and East Gippsland Regions. Although these strategies relate primarily to private land, they also apply to national parks (eighty percent of the East Gippsland Region is public land). The RCSs cover issues such as pest plants and animals, fire, biodiversity conservation, erosion and water quality.

Park management plans

Alpine National Park Bogong Unit Management Plan 1992;

Alpine National Park Cobberas–Tingaringy Unit Management Plan 1992;

Alpine National Park Dartmouth Unit Management Plan 1992;

Alpine National Park Wonangatta–Moroka Unit Management Plan 1992 (also covers the Avon Wilderness Park);

Mount Buffalo National Park Management Plan 1996; and

Snowy River National Park Management Plan 1995.

New South Wales

National Parks and Wildlife Act

The *National Parks and Wildlife Act 1974* is the main legislation that defines the powers, duties and functions of the NSW National Parks and Wildlife Service relating to all areas reserved as national parks, historic sites, nature reserves, Aboriginal areas, state recreation areas and regional parks.

Wilderness Act 1987

The Wilderness Act 1987 governs management of wilderness areas in NSW

Threatened Species Conservation Act, 1995

The *Threatened Species Conservation Act, 1995* came into effect on 1 January, 1996 and provides for the protection of all threatened plants and animals native to New South Wales (with the exception of fish and marine plants). The Act amended the *National Parks and Wildlife Act,1974* and the *Environmental Planning and Assessment Act, 1979* and integrates the consideration of threatened species into the planning process. The Threatened Species Conservation Act provides for the conservation and recovery of threatened species and makes provision for the management of threats to species under the Act. The Act also introduces extensive community input into management strategies for threatened species conservation.

The Threatened Species Conservation Act contains the lists of species which have been classified as threatened. Threatened species are listed under two categories:

Schedule 1	**Schedule 2**
Endangered Species	Vulnerable Species
endangered species	
endangered populations	
endangered ecological communities	
species presumed extinct	

The Threatened Species Conservation Act provides for the preparation of recovery plans which are designed to promote the recovery of a threatened species, population or ecological community with the aim of returning the species, population or ecological community to a position of viability in nature. A recovery plan must be prepared for each threatened species listed under the Act

Schedule 3 of the Threatened Species Conservation Act provides for the listing of key threatening processes. For each key threatening process that is listed the National Parks and Wildlife Service is required to prepare a threat abatement plan.

The Threatened Species Conservation Act makes provision for the declaration of critical habitat by the Minister for the Environment. Critical habitat is defined as the whole or any part or parts of the area or areas of land comprising the habitat of an endangered species, population or ecological community that is critical to the survival of the species, population or ecological community.

Park management plans

Kosciuszko National Park Plan of Management 1988;

Bimberi Nature Reserve Plan of Management 1997; and

Cooleman Plain Karst Area Management Plan 1987

The Australian Capital Territory (ACT)

The ACT is party to a number of key national strategies for the conservation of Australia's natural biological values.

Nature Conservation Act

Together with the Land (Planning and Environment) Act 1991 (which, via the Territory Plan, provides for reservation of Public Land for conservation of the natural environment) the Nature Conservation Act 1980 (through the authority of the Conservator of Flora and Fauna, and the ACT Parks and Conservation Service) comprises the statutory core for nature conservation in the ACT.

The ACT Nature Conservation Strategy

The ACT Nature Conservation Strategy provides a framework for a coordinated and strategic approach to protection of our biological diversity and the maintenance of underpinning ecological processes.

The strategic goal for the ACT Nature Conservation Strategy is adopted from The National Strategy for the Conservation of Australia's Biological Diversity *to protect our biological diversity and maintain ecological processes and systems*.

Park management plans

Namadgi National Park Management Plan 1986

1.6 The Alps MOU

On 28 November 1996 Commonwealth, State and Territory environment ministers reaffirmed their commitment to cooperative management in the Australian Alps national parks by re-signing an internationally acclaimed agreement.

The decade-old Australian Alps national parks Memorandum of Understanding (MOU) was re-signed by the Federal Minister for the Environment, Senator Robert Hill, New South Wales Minister for the Environment, Ms Pam Allan, Victorian Minister for Conservation and Land Management, Mrs Marie Tehan and ACT Minister for the Environment, Land and Planning, Mr Gary Humphries.

The Ministers said the MOU, which unites five national parks, a wilderness park and three nature reserves covering 1.6 million hectares across the ACT, New South Wales and Victorian borders, was the only one of its kind in Australia.

The agreement aimed to share resources and information among park managers and national parks services to protect the region’s plants, animals, water catchments and cultural heritage, while providing sustainable recreation opportunities for all Australians.

“This agreement has been recognised by the World Conservation Union (IUCN), as a world class example of protecting areas of national significance through cross-border cooperation, the Ministers said.

“The program is all about cooperation to ensure the unique environment of the eight areas within the Australian Alps are protected for all to enjoy.”

“The new agreement and strategic plan aim to achieve the highest possible level of cross-border cooperation in conservation management. We are reaffirming our commitment to protecting the Alps and looking to the future.”

The re-signed MOU includes New South Wales’ new 12,000 hectare Brindabella National Park, which is the northern most park in the Alps and contains a significant population of the endangered corroboree frog.

The protected areas covered under the MOU include Victoria’s Alpine, Mt Buffalo and Snowy River national parks and Avon Wilderness, New South Wales’ Brindabella and Kosciuszko national parks and Bimberi and Scabby Range Nature Reserves and the ACT’s Namadgi National Park.

The parks contain plants and animals found nowhere else in the world, Australia’s highest peaks, spectacular scenery, a rich Aboriginal and European heritage and the headwaters of some of our most famous rivers.

The MOU is overseen by the Australian Alps Liaison Committee (AALC), made up of a senior representative from the ACT Parks and Conservation Service, the New South Wales National Parks and Wildlife Service, the Victorian Department of Natural Resources and the Environment and the Biodiversity Group of Environment Australia.

2 Ecological history of the Australian Alps national parks — constant change

2.1 The ice ages and before — prehistoric climate change

The Australian Alps have not always been as they are today. They have a long history of change extending over hundreds of millions of years. Some 450 million years ago Mt Kosciuszko was covered by a large sea which extended over most of what is now eastern Australia. During that period (the Ordovician), extensive sediments were deposited. Remnants of those sediments (now much altered) are still to be seen as the slates, phyllites, quartzites and schists forming part of the Kosciuszko area between Rawson Pass and Watson's Crags. Periods of folding, uplift and sedimentation continued for millions of years during the Ordovician into the Silurian and early Devonian periods when intrusion of granites and folding and uplift of the area above sea level occurred. The oldest of those granites, the most abundant rocks in the Kosciuszko alpine area, are about 390 million years old. Many millions of years of relative stability of the Earth's crust followed, during which the uplifted areas were weathered and slowly worn down to a fairly even peneplain surface with only a few of the most resistant parts, including some of the Kosciuszko peaks, remaining above the general level. This long period of crustal stability and erosion tended through most of the Carboniferous, Permian, Triassic, Jurassic and Cretaceous periods until the beginning of the Tertiary period about 60 million years ago (Costin et al 1979).

The Tertiary period commenced an era of major uplift of eastern Australia during which the Kosciuszko alpine area, reached approximately its present elevation. The uplifting, which continued spasmodically until several million and perhaps as recently as about one million years ago, also caused extensive fracturing and faulting of the rocks and gave the rivers new erosive power. The major fracture patterns in the rocks provided zones of weakness along which many of the streams were able to cut down more rapidly to establish the stream pattern of long straight parallel courses which we see in the Kosciuszko area today: the upper Snowy, Crackenback, Guthega and Munyang Rivers provide good examples. From fossil evidence we know that the climate during much of the Tertiary was warmer and wetter than it is now (Costin et al 1979).

Although the south-eastern highlands have probably been in existence since early Tertiary times, high global temperatures effectively inhibited the development of alpine conditions until the late Tertiary or early Quaternary. There is evidence of altitudinal variation within the predominant rainforest vegetation of the middle Tertiary of south-eastern Australia and some taxa that were prevalent at high altitudes are now established in present day alpine and sub-alpine communities (Kershaw & Strickland 1989 #).

The Quaternary, the period of Ice Ages, represents an extraordinary episode in earth history. Not since the Permian did the earth experience such an onset of cold climates as those which occurred during this period. Over the past two million years, the Quaternary, there have been some 19 Ice Ages, culminating in the most recent which finished some 12,000 years ago (Busby 1990).

This was a time of generally colder climates throughout the world. At higher latitudes and altitudes glacial conditions developed, interspersed with warmer interglacials when the snow and ice cover largely or completely disappeared again. The Kosciuszko area was likewise glaciated, although apparently weakly. The cirques, lakes, moraines, erratics and polished pavements seen at Kosciuszko are products of these glacial conditions (Costin et al 1979).

Some of the landscape features of the highest parts of the Main Range, such as Lake Albina, Cootapatamba, Club and Blue Lakes, and Hedley Tarn, are attributable to minor glacial activity during a period of cold climate some 30,000–10,000 years ago. The processes associated with this cold climate also produced a number of unusual landforms, such as boulder streams, on lower slopes (NSW NPWS 1988b).

Where the ice cover was thin or absent, low temperatures also produced shattering of rocks, differential freezing and thawing of the soil with movement and accumulation of debris downslope, and other so-called ‘periglacial’ effects both within and below the glaciated area itself. For the last few thousand years (in the so-called Recent period) Kosciuszko has been virtually ice-free, although some of the late-lasting snow patches sometimes persist for more than a year at a time (Costin et al 1979).

Glacial action at Kosciuszko in the past was accompanied and followed by extensive periglacial activity due to the effect of deep freezing and seasonal thawing of exposed soil and rock surfaces not insulated by a permanent cover of ice and snow. Thus, many exposed peaks underwent severe shattering, and boulders and other frost debris accumulated around them. This debris was also affected by deep freezing and seasonal thawing which, on sloping ground, resulted in its slow downslope movement. The periglacial blockstream between Mt Stilwell and the Snowy River was formed by these processes. Water from subsequent snow-melt and rains has washed out much of the finer soil material which originally formed part of the blockstream, leaving only the larger boulders (Costin et al 1979).

The well-developed periglacial screes or blockstreams must have required low temperatures to produce the extensive shattering and downslope movement of rocks which have occurred. On the Toolong Range to the north of Kosciuszko, a blockstream has overrun a stump of a temperate-climate southern beech resembling *Nothofagus cunninghamii,* still common in Tasmania but restricted in Victoria and now absent from New South Wales. The stump has been dated at about 35,000 years old and therefore gives a maximum age for the onset of the colder conditions. The maximum age of related periglacial slope deposits — as dated at Geehi, Munyang and Island Bend — is broadly similar at about 32,000 years. The development of these slope deposits, like the blockstreams, requires frozen subsoils over which topsoil material, saturated from melting snow and ice, can move. The development of these conditions on an extensive scale in the Kosciuszko area implies a lowering in mean annual temperature of about 9–10°C compared with present temperatures. The depth of the slope deposits indicates that the cold climate continued for a long time (Costin et al 1979).

With some fluctuations, conditions deteriorated, becoming most severe around 23,000–18,000 years ago, when snow lines descended as much as 1000 m below present elevations and glaciers developed on the Snowy Mountains and in Tasmania. The alpine treeline in the south-eastern highlands at that time was no higher than 900–1000 m above sea level, compared to 1500–1800 m today. These conditions had a major impact on the flora and fauna. The enhanced seasonality with cold winters and windier, drier summers, associated with low sea-levels and exposed continental shelves, produced environments inimical to many plants. The eucalypt woodlands of the south, poorly adapted to frost and strong winds, were forced into protected pockets of the landscape. These pockets, known as refugia, are of particular significance to conservation (Busby 1990).

Wherever conditions favoured the accumulation and persistence of snow and ice, glaciers also developed, as on parts of the Main Range. For example, lake deposits approximately 20,000 years old in the north-eastern cirque of Mt Twynam indicate that at least cirque glaciers or large semi-permanent snow patches were in existence then (Costin et al 1979).

The first evidence of general improvement of the climate is in the form of old peats overlying glacial or periglacial rubble in the upper Snowy Valley and the Carruthers Creek area. These peats are about 15,000 years old and show that these and similar parts of the Kosciuszko area were by then becoming sufficiently ice-free to permit plant growth. However, in leeward sites favourable for the accumulation and persistence of snow, small cirque glaciers may well have persisted for several thousand years longer since peats in these sites are not more than 9000–10,000 years old (Costin et al 1979).

Temperatures then increased to at least present-day levels to promote extensive plant growth with peat formation and soil development, except for a brief period between about 3000 and 1500 years ago when there was a return to slightly colder conditions. During this so-called ‘little ice age’ mean annual temperatures were apparently at least 3°C lower than at present, sufficient to cause local subsoil freezing and slope instability, and an increase in snow-patch activity, at least at the highest levels. Many of the soil terraces which are such a conspicuous feature of the areas of altered sedimentary rocks between Mt Northcote and Mt Twynam were formed at this time. From the fact that a fall in mean annual temperature of only 3°C would be sufficient to induce such landscape instability, it can be appreciated that parts of the high country are now on a knife edge between stability and erosion (Costin et al 1979).

Alternate freezing and thawing of soil and rock materials result in their downslope movement by processes termed solifluction. Kosciuszko has many solifluction features. Some of these terraces are between 1500 and 2500 years old, on the evidence of the carbon-14 ages of the fossil shrubs and other vegetation material that are buried beneath them; a lowering in mean annual temperature of about 2–3°C compared with present conditions could have caused terrace formation. Although well-preserved terraces are, now restricted to a few peaks at Kosciuszko, they apparently developed on a much wider scale in the past as can be appreciated by the extensive ‘rippled’ appearance of much of the alpine country (Costin et al 1979).

Glaciation during the Pleistocene modified the landscape at the highest elevations but as only a single glacial event occurred between 100,000 and 10,000 years ago, and over an area of only 30 to 40 square kilometres, the effect on the wider Alps landscapes was minimal (Good 1992b #).

During the height of the glacial period, present alpine and sub-alpine areas were characterised by glacial and periglacial activity and probably had a very sparse and restricted vegetation cover. Many alpine taxa would have been associated with a relatively homogeneous cool steppe vegetation, with no modern analogue, that covered much of south-eastern Australia under precipitation levels substantially lower than those of today. Those taxa requiring high moisture levels may have been restricted to stream valleys particularly in the better watered areas of the lower slopes of the eastern highlands. Tree taxa would have been similarly restricted to locally moist and sheltered areas but there is some evidence for more extensive survival within East Gippsland (Kershaw & Strickland 1989 #).

The flora now inhabiting the Australian Alps arrived in the region after the earlier flora had been displaced by Plio–Pleistocene climate changes (about 2 million years ago), land surface uplift and subsequent erosion to landscapes similar to those existing today. The Plio–-Pleistocene period of change had great significance not only for the Australian flora but also for the biota of the whole world (Good 1992a).

The contiguities of the southern land masses in the early Tertiary have left their broad impress on the character of what is now the Kosciuszko alpine flora. However, it is the more recent events of the Pleistocene and its associated cold periods which have been most important in the development of the present landscape with its many modifications which constitute the habitats for present-day species (Costin et al 1979).

The basic elements of the alpine flora are likely to have been present for at least the last few hundred thousand years, but extreme climatic fluctuations during that time combined with changing fire regimes would have resulted in major changes in distribution and community relationships of the flora. Evidence from Lake George demonstrates vegetation changes in southern New South Wales within the last 700,000 years. Through much of that period ‘fire sensitive’ *Casuarina* dominated forests and rainforest taxa characterised the warm and generally wetter interglacial periods, while open herbaceous communities were prevalent during the cool and drier glacials. Within the last 130,000 years or so, eucalypt forests and woodlands became much more important, particularly during the last interglacial and Holocene periods. These largely replaced *Casuarina* and the rainforest taxa, many of which became regionally extinct. This change is associated with higher and more sustained levels of charcoal particles that indicate increased burning, considered to be a result of bush-firing by Aboriginal people (Kershaw & Strickland 1989 #).

Climatic amelioration after the height of the glacial period is marked in the south-eastern highlands by organic sedimentation beginning about 15000 years ago (Kershaw & Strickland 1989 #). It may have taken place in a number of stages, and occurred between 15000 and 8700 years ago. This resulted in the establishment of various alpine herbaceous and shrubby communities. Many wet sclerophyll forest taxa were more widely distributed during the 'climatic optimum' period of higher temperatures and precipitation that lasted from about 8700 to at least 6400 and possibly to 4500 BP and were common at present subalpine altitudes (Kershaw & Strickland 1989 #).

Table 2.1 Climatic Changes During the Last 347,000 Years (Ride et al. 1989)

Period (thousands of years [Ka] ago)	Event
347–297 Ka	interglacial.
297–251 Ka	glacial with one interstadial.
251–195 Ka	interglacial.
195–128 Ka	glacial
128–75 Ka	last interglacial. Dramatic increased evidence of burning.
75–64 Ka	cold interval at the beginning of the last glacial period.
64–22 Ka	cool temperate interstadial. From 40 to 30 Ka it was cooler and moister than now. There was high run-off and mantle instability. *Nothofagus* flourished. Glaciers developed between 30 and 25 Ka and temperatures on the summit and the tablelands (including the Monaro) may have been 10 degrees colder than at present.
22–18 Ka	includes last glacial maximum. Periglacial conditions would have extended down to at least 1000 m.
18–6 Ka	Holocene warming. Between 16 and 13 Ka, alpine herbfields occurred. At about 9 Ka there was a surge in vegetation, with wet sclerophyll to 1750 m by 8.6 Ka (ie., at its modern level). Between 7 and 6.5 Ka moisture-loving taxa reached their maximum altitudinal extent. Precipitation then was probably much as at present but temperatures were higher.
6–2 Ka	interval of increasing dryness. From 3–1.7 Ka hygrophilous pollens reached their minimum.
2 Ka–present	present climatic conditions were achieved between 1.7 Ka and the present (ie, they returned to the values of 6.5 Ka).

The early to middle Holocene is marked by maximum representation of trees and shrubs that indicate wet as well as warm conditions. *Pomaderris* is the most consistent indicator of the performance of wet sclerophyll forests that expanded throughout south-eastern Australia and most likely reached higher altitudes than today. *Leptospermum lanigerum, Tasmannia* and ferns were also more widespread and formed a larger component of vegetation at sub-alpine altitudes than they do at present. The phase lasted from at least 8700 to about 6500 BP but may have extended to 4500 BP (Kershaw & Strickland 1989 #).

Subsequent lower temperatures and precipitation between about 4000 and 3000–2500 years BP were probably responsible for the development of cold air drainage in sub-alpine plateau regions resulting in the initiation of inverted treelines and grassy plains. Despite cooler temperatures, the treeline may have continued to rise perhaps with the development of distinctive *Eucalyptus pauciflora* woodlands. An increase in effective precipitation within the last 2500 years or so resulted in a marked increase in growth rates of bog sediments and the expansion of raised bog communities. Evidence from recent fine resolution pollen studies on the Baw Baw Plateau indicates a number of vegetation changes resulting from the activities of European people. These include a reduction in the *Notbofagus* component of montane and sub-alpine vegetation and increases in sub-alpine grassland most likely due to regular burning of the vegetation, and some destruction of bog vegetation as a result of cattle trampling and ski slope development (Kershaw & Strickland 1989 #).

About 2500–3000 years ago organic sediment accumulation at many sites increased sharply, resulting in the extensive development of raised bogs. This development is attributed to an increase in effective precipitation that could have resulted from a further decrease in temperatures, an actual increase in precipitation or greater cloud cover. As the feature is marked over a broad altitudinal range, it is considered unlikely that a temperature decrease alone could have resulted in such changes within all sites (Kershaw & Strickland 1989 #).

2.2 Aboriginal history

Within the last 130,000 years or so, eucalypt forests and woodlands became much more important, particularly during the last interglacial and Holocene periods. These largely replaced *Casuarina* and the rainforest taxa, many of which became regionally extinct. This change is associated with higher and more sustained levels of charcoal particles that indicate increased burning, possibly a result of bush-firing by Aboriginal people. It is likely that a large proportion of Australian vegetation was similarly affected, as fire induced changes from more ‘fire sensitive’ to ‘fire-promoting’ vegetation have been recorded elsewhere on the continent — notably north-eastern Queensland and the western plains of Victoria (Kershaw & Strickland 1989 #).

Human association with the Kosciuszko alpine flora begins with the Aborigines. Carbon-14 dates of charcoals, associated with sites of Aboriginal occupation show that in many inland and coastal parts of Australia Aborigines had been present for at least 20,000–30,000 years before the arrival of white settlers (Costin et al 1979). The Barrage rock shelter in the ACT provides evidence of Aboriginal occupation about 21,000 years ago (A. Carey pers. comm.).

Although the records of explorers and early settlers indicate that the alpine areas and their environs were not permanently occupied by the Aborigines (Costin et al 1979), in historic times Aborigines stayed in the mountains of the ACT, at the lower elevations, even during the cold winter months. Whether this was the case during the last ices age is unknown (A. Carey pers comm.). The Australian Alps provided a wide variety of food for the indigenous peoples, and the Bogong moth may have been only one of many types of food available in the Alps during the warmer months. According to Eddie Kneebone, tribal elder of one of Victoria’s alpine tribes, indigenous peoples went to the Alps for a spiritual experience — a view supported by others (A. Carey pers. comm.).

Costin et al (1979) concluded that prehistoric man and wild herbivores appear to have had no effect on the evolution of the Kosciuszko alpine flora, so the flora was in no sense pre-adapted to the pastoral practices of Europeans.

One of the best documented records of Aboriginal fire management is from Gippsland from the 1860s to the 1890s, when Alfred Howitt was police magistrate there. Howitt knew the Aborigines of Gippsland personally and made an outstanding contribution to the scientific study of their society. He also knew the country and its vegetation, almost as well as he knew the people. In 1890 he published an important botanical paper, *The Eucalypts of Gippsland.* In this paper he made two firm statements: first, that the Aborigines had burnt the country every year and thereby kept it open and grassy; second, that the white settlers protected their property against fire and thereby encouraged the return of trees and scrub. In support of the second statement, he cited his own observations throughout three decades in seven representative districts. He then continued:

> I might go on giving many instances of the growth of Eucalyptus forests within the last quarter of a century, but those I have given will serve to show how widespread the re-foresting of the country has been since the time when the white man appeared in Gippsland, and, dispossessed the Aboriginal occupiers, to whom we owe more than is generally surmised for having unintentionally prepared it, by their burnings, for our occupation (Alfred Howitt 1890 — quote from Hancock 1972).

Howitt's evidence might seem conclusive, so far as Gippsland is concerned, but the situation is less clear. In a 1970 paper on 'Bushfire Frequency and Vegetational Change in South-eastern Australian Forests', Norman Wakefield argued that the white people caused the return of the scrub, not by stopping fires, but by starting them. Wakefield is a well qualified inquirer, for he was trained as a biologist and thereafter made himself an expert in the history of exploration and settlement in East Gippsland, where he was continuously resident from the 1920s to the early 1950s. His paper opens with the quotation of a long statement by a grazier, K. C. Rogers, whose direct acquaintance with East Gippsland stretches back from the late 1860s to the early 1900s, when his father acquired a large property on the Wulgulmerang plateau.

> Over a period of years before we came to the district, it had been the accepted practice to burn the bush, to provide a new growth of shorter sweet food for the cattle.
>
> The practice was to burn the country as often as possible, which would be every three or four years according to conditions. One went burning in the hottest and driest weather in January and February, so that the fire would be as fierce as possible and thus make a clean burn ... We would light along the rivers and creeks, so that the fire would roar up the steep slopes on either side, making a terrific inferno and sweeping all before it. The hotter the fire, the sweeter and better the food for the cattle after the new growth came. The tablelands received special attention ... (K. C. Rogers — quote from Hancock 1972).

Rogers goes on to say that the sweet grass grew coarse again after a season or two and that scrubby growths proliferated (Hancock 1972).

Although it seems Aboriginal peoples used fire quite extensively in the foothills and lower tablelands, burning of the high country appears to have been more limited. Hancock (1972) concluded that the first white stockmen saw little man-made change when they drove their cattle into the high country. Since white settlement began, fires have increased in number until at the present time severe fires occur every five to ten years. In 1932 Baldur Byles was convinced that 99% of fires in the mountains were lit by human agency (Hancock 1972).

Banks (1989) presented dendrochronological evidence which supported that conclusion. From examination of old fire scars in trees he found fire frequency in the Brindabella Range and the upper Tooma catchment increased considerably after 1830.

2.3 Post 1800

Exploration

In 1834 John Lhotsky, a Polish zoologist, set out on a three-months expedition to the Snowy Mountains with four convict servants and a horse and cart (Lennon 1992 #). It is possible that Lhotsky reached the summit of Mt Kosciuszko as early as 1834 but more recent research on Lhotsky's diaries, maps and most likely route suggests rather that Lhotsky reached an alpine peak (known as Mt William IV or Mt Terrible) well to the south of the Kosciuszko Plateau, at the headwaters of the Mowamba, Jacobs and Thredbo Rivers (Costin et al 1979).

In 1835 George McKillop and party explored south-westerly from Monaro to Omeo. McKillop's name is preserved in the Snowy River gorge. Following this exploration, cattle were sent to the new district by James MacFarlane. By 1837 there were men in the vicinity of

Omeo named Pendergast and Livingstone. In 1838 James MacFarlane's nephew, Walter Mitchell, found a route through to the Tambo (Lennon 1992 #).

Precisely when the Kosciuszko area was first visited by white men is not certain, but the Polish-born explorer, Paul Strzelecki, is usually credited with the first ascent of Mt Kosciuszko. In 1840 he approached the area from the Murray side and climbed up what is now known as Hannels Spur. Perhaps both Lhotsky and Strzelecki were preceded by local stockmen since, by the 1830s, all of the main pastoral runs on either side of the mountains had been occupied (Hancock 1972*)* and the squatters were always on the lookout for new pastures. James Spencer, the well-known squatter at Waste Point near Jindabyne, apparently was the first to use the Kosciuszko Plateau (known as his Excelsior Run) for grazing livestock. He came to know the area so well that he acted as guide to many expeditions (Costin et al 1979).

The highest mountains around Mt Bogong were first explored by white men in 1852, when two cattlemen from Cobungra, Jim Brown and Jack Wells, following information given by Larnie, an Aborigine, first found a route to the high plains (Turner 1960).

Botanists and naturalists were also eager to explore and to collect specimens of the flora. Outstanding among these was Ferdinand Mueller (later Baron von Mueller). Mueller was undoubtedly the greatest of all Australian botanists and ranks among the great botanists of all time. Immediately after his appointment as Government Botanist in Victoria in 1853, he threw himself into the task of botanical collecting. This involved absences of weeks and months at a time usually with no other company than a pack-horse for his supplies and botanical collections, and a saddle-horse for himself. Mueller's first expedition in Victoria was to the Buffalo Plateau and Mt Buller where he made his initial acquaintance with Australian alpine plants. His second expedition, in 1853–54, also included visits to the high country near the Victoria–New South Wales border. On the third expedition, in 1854–55, he explored and collected on Mt Bogong and Mt Feathertop, two of Victoria's highest peaks. By January 1855 he was collecting on the Main Range around Kosciuszko; Mueller's Peak, between Mt Kosciuszko and Mt Townsend, commemorates this achievement. By then Mueller felt justified in writing to Sir William Hooker, "After having traversed now the main chains of the Snowy Mountains in so many directions I am led to believe that the plants mentioned in this and the two previous letters, and those mentioned in my reports, comprehend almost completely the Alps flora of this continent. . .". Although experience has shown this to be somewhat of an over-statement, Mueller's contribution to the knowledge of the alpine flora was of great importance (Costin et al 1979).

Grazing

In 1840, when Stewart Ryrie went exploring with his compass, sextant and sketch book, he praised the good pasture under the snow gums and above the tree line; but he reported no cattle or sheep grazing on it (Hancock 1972).

Sir John Robertson's land legislation was closely coincidental in time with the Kiandra gold rush. One of its consequences was a steep rise in the number of animals grazing on properties cut down to size. By the mid 1860s, graziers were looking to the high country to save them from disaster in years of drought. Such a year was 1865, when William Bradley's sheep manager for the northern runs drove 48,000 sheep and 2,000 cattle into the mountains (Hancock 1972).

By the late 1880s, H. T. Edwards had lifted Bibbenluke to a carrying capacity of one sheep to the acre; but he would have been unable to do so had he not lightened the pressure on his paddocks by sending 10,000 to 20,000 sheep every summer into the Kiandra country. The Litchfields were making similar use of the alpine pastures dominated by the Brassies and Kerries ranges, due west of Cooma (Hancock 1972).

Summer grazing in the mountains thus became for the Litchfields an integral part of flock management. In years of extreme drought they might send cattle as well as sheep; if so, they would follow the Monaro custom of confining the cattle to the steeper, rougher country, where dingos were still numerous, whereas the alpine pastures in Victoria remained predominantly cattle country (Hancock 1972).

Up to the last decade of the nineteenth century there was not even the pretence of official control over grazing in the high country. Control began when the Lands Department, hungry as ever for revenue, made provision for snow leases and some related tenancies in the Crown Lands (Amendment) Act of 1889. Four years later, Richard Helms reported that 81,000 acres of summer pasture adjacent to Mt Kosciuszko had been divided into twenty-two snow leases. Until then, Helms said, the mountains had been ‘free country’ for anybody’s cattle and sheep — and, of course, for the brumbies (Hancock 1972).

> A common, and, in my opinion, very improvident practice, will probably be continued as hitherto, viz., the constant burning of the forest and scrubs ... This procedure has only a temporarily beneficial effect in regard to the improvement of the pasture by the springing up of young grass . . . I have seen some very detrimental effects from this practice here, because the heavy rains wash the soil away from the steep declivities . . . The more or less constant diminution of humus in the soil of the slopes is a danger not generally recognised. (Helms 1893)

In an address a few years later to the Royal Geographical Society of Australia, Helms returned to that theme. The graziers, he said, would be doing no damage to ‘the dense carpet’ of alpine pasture if they were not also fire raisers (Hancock 1972).

> Not satisfied with what nature yields, the herdsmen in order to improve the growth of the feed and make it sweeter, as they say, yearly burn large tracts of the grass and scrub. This procedure gives the otherwise fresh and cheerful-looking country here and there a desert-like appearance which is perhaps the least evil done. The greater evil is undoubtedly that it interferes with the regular absorption, retention and distribution of moisture . . . Where the natural growth covers the ground, numberless minute water-courses may be observed even in the height of summer and on considerably sloping ground, when at the same time the burned patches are void of all moisture ... That ignorance and maybe greed should be allowed to interfere so drastically in the economy of nature is pernicious, and should not be tolerated. Even from an aesthetic point of view it ought not to be allowed, for what right has one section of the community to rob the other of the full enjoyment of an unsullied alpine landscape, and to replace a fresh and fragrant growth by dead and half-burned sticks, making a desert of what was once a garden? The “husbandman on the farm by the river, the artist and tourist who seek the picturesque, the botanist and zoologist who come in pursuit of plants and animals, are all interfered with. And why? Because some inconsiderate people are allowed to do as they please”. (Helms 1893)

By the end of the 1800s summer grazing of sheep and cattle with burning of the vegetation to promote fresh regrowth had become a well-established practice at Kosciuszko, having been formalised by the NSW Department of Lands in 1889 with the introduction of the snow lease system of land tenure. As early as 1893 Helms warned against the effects of burning off in reducing the plant cover and thereby promoting soil erosion. In 1898 Maiden, then Government Botanist in New South Wales and interested in the Kosciuszko flora, commented on the adverse effects of burning on the scenery and vegetation. But these warnings were lost in the clamour for high-country grazing areas during the disastrous drought of 1890–1901. In those earlier years stockmen remained with their sheep and cattle during much of the snow-free season, depending on pack-horses and bullock teams for the transport of their own rations and of rock-salt for their livestock (Costin et al 1979).

In the summer of the severe drought of 1902–1903, an estimated 40,000 sheep and large mobs of cattle and horses grazed the Bogong High Plains (Bennett 1995).

We know with some precision how the Litchfields used the country which rises from the Snowy valley to the headwaters of the Whites and Finn Rivers beneath Gungartan, the Kerries and the Brassies. Around 1910, their combined flocks in the high country totalled approximately 10,000 sheep; but, possessing such ample pasture, they were able to graze it lightly (Hancock 1972).

In the records of the New South Wales Lands Department up to about the 1930s, concern for the preservation of the water catchments is conspicuous by its absence (Hancock 1972). Not until the late 1920s did leasehold agreements contain any prohibitions against over-stocking or burning. In practice, such prohibitions were ineffective because the Lands Department made no serious attempt to police them. Not until the 1940s did it appoint two rangers — a ridiculously inadequate patrol for so large a territory (Hancock 1972).

In 1932 a report by Baldur Byles to the Commonwealth Forestry Bureau described widespread damage to the vegetation and soils in parts of the Upper Murray catchment on the western slopes of Kosciuszko. The Soil Conservation Service of New South Wales, set up in 1938, formed the same conclusion and realised that catchment protection measures were urgently needed. Private individuals and societies — notably the National Parks and Primitive Area Council of New South Wales — also pressed for the protection and better management of the Kosciuszko environment. These and similar pressures led to the passing of the Kosciusko State Park Act of 1944, under which an area of about one and a quarter million acres (approx. 5000 sq km) of mountainous country centred on Kosciuszko was proclaimed a Park under the control of a specially appointed Trust. At the same time, the Kosciuszko alpine area itself was withdrawn from grazing in the interests of minimising further damage to this part of the catchment area. The Act also provided for the setting aside of a Primitive Area, although none was designated at the time. Concern for the condition of the mountain catchments increased with the development of the Snowy Mountains Scheme, leading to further withdrawals of snow leases and improved fire protection. By 1958, all areas in the Park above approximately 4500 ft (1370 m) had been withdrawn from grazing (Costin et al 1979).

Byles identified nine separate zones, which he defined by the types of vegetation that had adapted themselves to the various conditions of altitude, rainfall, temperature, soil and underlying rock. Above the tree line, where low woody shrubs gave cover to alpine grasses and herbs, the fire-sensitive species had been severely damaged and the soil eroded in some places down to the bare rock. Although the area of total destruction was not as yet very great, the destructive processes could be observed almost everywhere. Unless these processes were checked, Byles warned, the consequences would be catastrophic (Hancock 1972).

In the snow gum zone (1500–1800 m) he found only one stand of trees untouched or nearly untouched by fire. In the country running north from the summit area, very many trees had been destroyed and succeeded by woody shrubs, sometimes with a growth of grass beneath them. What troubled Byles most was the drying out of this country (Hancock 1972).

> The most notable example of this is the block covered by Snow Lease No. 29157 ... I am told by men who worked on this block over 30 years ago, that their first job was to burn and keep on burning the woody shrubs and snow gum; at that time it required a very experienced horse to cross the swamps; once a horse put his hoof off a tussock of grass it would sink up to its belly in the swamp; now in an average summer a bullock dray can be taken across the former swamps and not sink more than a few inches ...
>
> Not only on this block, but throughout the Murray Plateau, the country is, on the testimony of men who have mustered cattle there all their lives, definitely drier now than it was 30 years ago. They point out again and again swamps and creeks which were formerly impassable but where now a man can ride without any danger of sinking. Consequent upon the drying of the swamps, the creeks are getting lower, and I can foresee the time when some of them will not last through the summer months. (Byles 1932, quoted in Hancock 1972)

Byles did not rule out the possibility of the drying up of this top country having been caused in part by a drier climatic cycle. However, rainfall records in the lower country — in the mountains there were none — did not support that explanation. Whatever the facts of the climatic cycle might prove to be, the destruction by burning of soil cover on the catchments was an established fact. Byles believed that he was safe in saying that it had had a very great effect on the steady drying process (Hancock 1972).

In the alpine ash zone (approximately 900–1200 m in the high rainfall area of the western and south-western slopes) fires recurring at intervals of five to ten years had devastated steeply sloping areas where the erosion risk was extreme. Byles saw many scoured gullies up to 27 m wide and 6 m deep; they were bound, he said, to extend further up the mountain side with each winter's rain. He reported a landslide close to Geehi which had carried 2 ha of earth into the river, damming it back with a wall of earth 6 m high (Hancock 1972).

Byles did not believe that grazing by itself was doing any serious damage to the watersheds: fires were doing the damage. Yet he had made it quite clear in his report that in ninety cases out of a hundred those fires were started by graziers (Hancock 1972).

Sheep in the high country graze selectively on the small plants between the tussocks of snow grass; consequently what may appear to be a prudent stocking rate represents a grazing pressure many times heavier (Hancock 1972).

> In 1967 E S Clayton put on record his carefully formulated conclusions on catchment policy in the Snowy Mountains (quoted in Hancock 1972) —
>
> "It is essential to preserve, or indeed improve if possible, the vegetation cover to conserve snow, increase fog and cloud drip, improve penetration, reduce evaporation, improve continuity of flow and raise rather than lower the groundwater table. This requires a type of vegetation which allows the rain to enter the soil cover before reaching the stream. In this way erosion is kept to a minimum and flash flood runoff reduced. All informed authorities agree that any reduction of the ground cover in the Snowy watershed reduces water infiltration and catchment efficiency ... and unless the deterioration is arrested the damage to the source of useable water would reach devastating proportions.

Most of the ecological investigations into the effects of grazing and associated practices (mainly regular 'burning-off`) were at first oriented towards soil erosion and the performance of the Snowy Mountains as a major water catchment, although interest in recreation, nature conservation and wilderness values had also been growing for a long time. Thus, the actual establishment of the Kosciusko State (now National) Park in 1944 was as much a political response to and compromise of opposing State departmental views on the grazing question as it was recognition of the value of the Snowy Mountains as a national park (Wimbush & Costin 1979a).

The first extensive area to be withdrawn from grazing was the Kosciuszko Summit Area of some 4000 ha in 1944, on account of the locally very serious erosion there and the increasing erosion hazard. Near Mawson's Hut, other areas (8000 ha) which showed serious erosion were withdrawn in 1950. Following the establishment of the Hume/Snowy Bush Fire Prevention Scheme in 1951, burning-off was prohibited except under permit; this reduced the number of autumn-lit fires above about 1220 m (formerly 100–200 each year) by at least tenfold (Costin 1971). In 1957 the Government of New South Wales decided to exclude grazing from most of the high country (above about 1370 m) from June 1958. In 1961, grazing was discontinued in the few remaining snow leases and the permissive occupancies in lower forest country, although some livestock were re-admitted to restricted areas in the summer of 1967–68 as a drought relief measure. Both cattle and sheep have been grazed in the Kosciuszko area, the latter predominating especially during the later years of snow lease grazing (Wimbush & Costin 1979a).

Trends and associated plant successions reflect the effects of protection from burning off and livestock grazing and the occasional periods of unfavourable weather including drought, prolonged snow cover and low temperatures. The vegetation trends, which are continuing, are generally beneficial to water catchment and nature conservation values. Grazing potential has suffered through the replacement of minor herbs by less palatable grasses and shrubs, and although palatable major herbs have increased these could not sustain grazing at the previous stocking rates. Unless grossly disturbed, some of the associated plant successions are likely to continue to a total of at least 50 years before near-climax stages are reached, and on severely disturbed sites subclimax conditions may persist indefinitely (Wimbush & Costin 1979b).

Throughout the subalpine tract, formerly slightly entrenched small drainage lines below emergent springs are becoming filled with sedges and silt. As a result, some of the drainage water is now being spread laterally, thus reversing in the headwater situations the processes of stream-cutting that are still active in the valley bottoms. On the Bogong High Plains, similar changes were noted by Carr in an experimental exclosure at Rocky Valley, and by Costin in parts of the Mt Loch area excluded from grazing since the early 1960s. They are also evident in Costin's and Wimbush's measurements on alpine vegetation in the Kosciuszko area. There are, however, many steeper, severely disturbed hillside sites where more or less complete erosion of the residual peat will probably occur. These sites will then be colonised by snow-patch species and various hygrophilous minor herbs, followed by rushes, sedges and shrubs. But the full recovery of *Sphagnum* with its associated peat may take several hundred years (Wimbush & Costin 1979b).

In Cesjacks Hut area, where Kosciuszko National Park adjoins freehold land on top of the Divide, a marked contrast between the condition of the woodlands on either side of the boundary fence was apparent by 1971. Snowgum regeneration around old trees and the flowering of major herbs were evident on the Park side of the fence but were absent on the freehold side. In the near-drought summer of 1977–78 large mobs of sheep entered the Park across the boundary fence. The immediate effect of the grazing was a drastic reduction of the major and intermediate herbs from within the snowgrass (Wimbush & Costin 1979b).

Fires are a particularly severe event in the alpine environment, removing much of the vegetation and exposing the underlying soil to frost, wind and water erosion. At subalpine and lower alpine levels shrubs are often more successful colonisers than herbs (Wimbush and Costin 1979b), but at middle to high alpine elevations where shrub growth is more restricted herbs usually play a greater role in recolonisation. Selective over-grazing of these herbs may arrest the secondary succession, thereby prolonging the period of accelerated soil erosion and finally producing a stone-erosion pavement, as on parts of the Kosciuszko Main Range. The stones provide some protection from frost-heave and erosion, thus enabling sparse colonisation by feldmark species. These induced feldmark communities, like the disclimax heaths of severely eroded subalpine areas, may persist almost indefinitely (Wimbush & Costin 1979c).

Many alpine species which became rare during the period of grazing and burning are now making a spectacular recovery, with a massed flowering in summer which is surpassed in few other parts of the world (Costin et al 1979).

Mining

In the Victorian mountains, gold was discovered at Omeo in 1851, Mitta Mitta in 1852–53, Cobungra River and Gibbo River in 1852, Harrietville in 1853, Dargo River in 1854, Crooked River and Big River in 1860 and Wombat Creek in 1861 (Supple 1992 #).

Prospectors learnt to use fire to expose the mineral soil and parent material. To the prospector fire was indispensable as it was cheap and easy to use. So the greatly increased fire incidence between about 1860 and 1940 was due to the combined onslaught on the forest by pastoralists and prospectors alike (Banks 1989 #).

Seen in the field, the intense local activity at a pit head or a working open-cut mine is unmistakable, but at a more general scale the impact of mining on landforms and vegetation can be difficult to recognise, particularly after the mine has ceased operation. The mining activity is often more extensive than may be realised even within a single mining lease, and there may be many leases, both spatial and sequential, in a given area (Winston-Gregston 1992 #).

Shaft mining is static on the surface and traverses underground. Although the mine opening may be only a few metres in diameter, the impact on the landscape can be extensive — and more subtle than the associated mullock heaps. For example, a dip in a fence and mature trees leaning into the prevailing wind indicate a subsidence line, the roof of a subterranean mine (Winston-Gregston 1992 #).

Reef copper was mined at Lobbs Hole on the Yarrangobilly River from 1874 to 1917. The main shaft was about four metres across, but this little opening supported a community of up to 300 people and a need for fuel and engineering supplies, food and civic services (Winston-Gregston 1992 #).

Hydro schemes

Concern for the area as a water catchment can be said to have commenced in the 1920s during the construction of the Hume Dam, collecting waters from the western slopes of Kosciuszko for subsequent use in irrigation areas in New South Wales, Victoria and South Australia. This use was to culminate with the Snowy Mountains Scheme, commencing in 1948 and not completed until 1972 (Costin et al 1979).

Skiing/Tourism

Commercialised winter sports are such big business nowadays that it is interesting to explore their humble origins in Kiandra, as recorded in a news item of 29 July 1861 in the *Monaro Mercury*(Hancock 1972) —

> Kiandra is a rather dreary place in the winter, but yet the people are not without their amusements. The heaven-pointing snow-clad mountains afford them some pleasure. Scores of young people are frequently engaged climbing the lofty summits with snow-shoes and then sliding down with a volancy that would do credit to some of our railway trains. *Monaro Mercury* 29 July 1861

Tourist and recreational interest rapidly increased after the completion of the Kosciusko Hotel and the 53 km road from Jindabyne to Mt Kosciuszko in 1909 (Costin et al 1979).

2.4 What are we trying to protect?

The objects of the Victorian *National Parks Act 1975* are:

> To make provision, in respect of national and state parks
>
> (i) For the preservation and protection of **the natural environment** including wilderness areas in those parks
>
> (ii) For the **protection and preservation** of indigenous flora and fauna and of features of scenic or archaeological, ecological, geological,, historic or other scientific interest in those parks
>
> (iii) For the **study** of ecology, geology, botany, zoology and other sciences relating to the conservation of the natural environment of those parks
>
> For the **responsible management** of the land in those parks.

The Government has accepted Land Conservation Council (1983) recommendations that the Alpine National Park be used to:

(a) Provide opportunities for recreation and education associated with the enjoyment and understanding of **natural environments**
(b) Conserve and protect **natural ecosystems**
(c) Supply water and protect catchments and streams.

The management objectives for Kosciuszko National Park, set out in the plan of management (NSW NPWS 1988b), include:

- to preserve and protect the outstanding scenery and **natural features**
- to protect the mountain catchments
- to **conserve wildlife**
- to protect the **natural features, communities**, landmarks and special scientific sites
- to maintain the **natural environmental processes** as far as possible…

"Management emphasis for Namadgi [will] be directed primarily at conserving existing **natural** and cultural values." (ACT P&CS 1986)

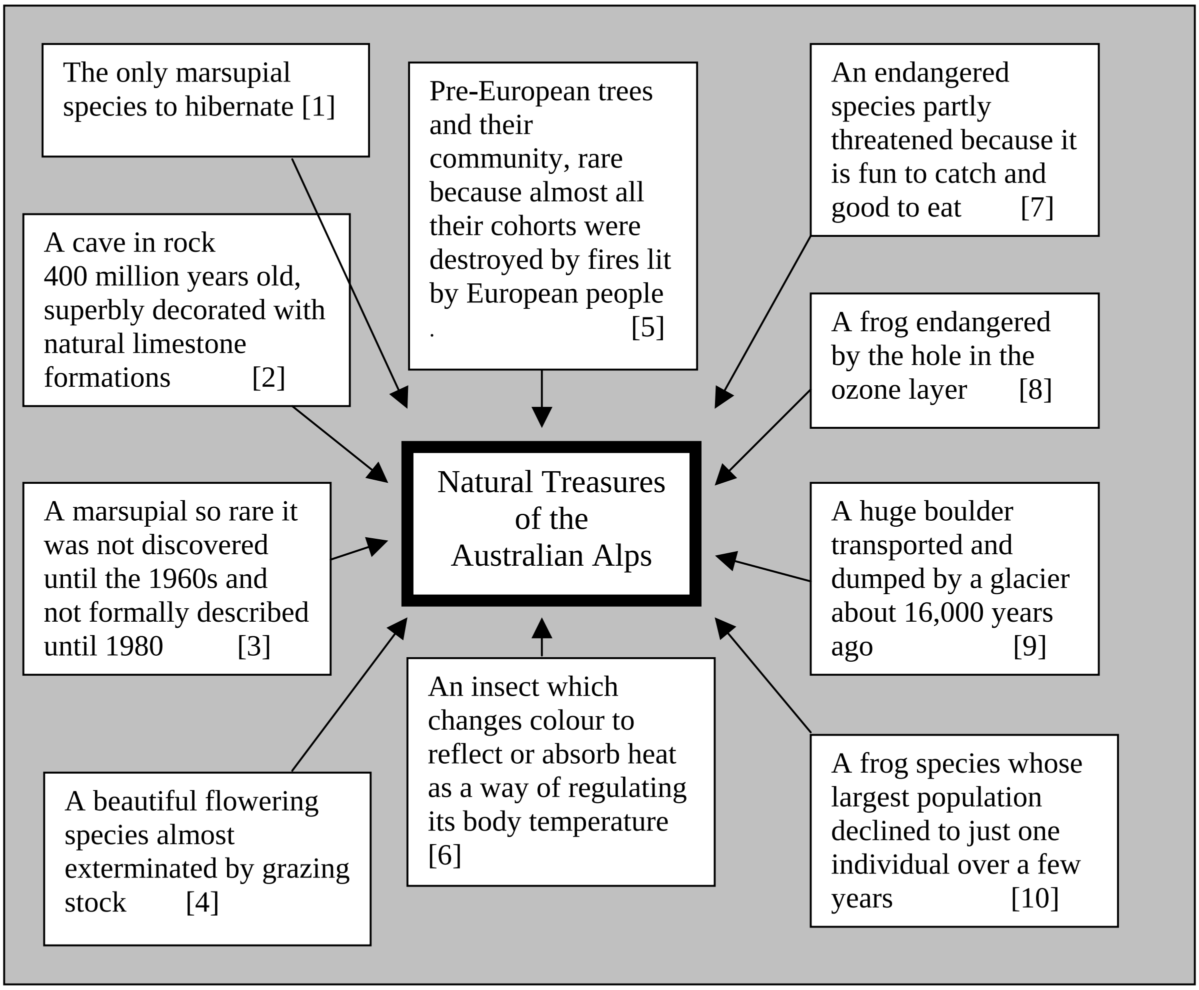
The US National Park Service is required by law to keep the parks as unaltered by human activities as possible (US National Park Service 1996).

As the preceding discussion clearly shows, the environment has been changing constantly. Aborigines arrived in Australia tens of thousands of years ago, and so began the human impacts on the natural environment which have continued and increased ever since. Superimposed on those changes are the natural climatic changes, perhaps most dramatic during the last ice age, about 20,000 to 16,000 years ago, but ongoing ever since, with changes in temperature and degree of water availability. The environment we see today is the result of all these changes and impacts, and we cannot point to a particular site and say that is "natural". From the inconsistent views on the extent and effect of pre-European burning by Aborigines, we evidently find impossible the necessary step of defining what is natural. Yet the Australian Alps national parks are required to be managed to preserve, protect, conserve or maintain "natural" values. They also are required to do things which could be inconsistent with that first requirement, in that they must conserve, protect or preserve wildlife and natural features. Extinctions and loss of other natural features are part of the natural process, though they are now happening at a rate much greater than is natural. To preserve all wildlife species and other natural features might require active management to intervene in natural processes, and is likely to involve environmental manipulation.

The management objectives for the Australian Alps national parks should be clear, which requires spelling out more precisely what is intended. The simplest approach to this would be to substitute "pre-European" for "natural" but that still leaves the difficulty of defining what that means in ecological terms. Perhaps the US National Park Service requirement to keep the parks as unaltered by human activities as possible is more easily interpreted, but do we really want to return to pre-Aboriginal conditions? And if we want to, is it possible?

Resolving this issue is beyond the scope of this project, but recognising the issue is the necessary first step.

3 Identifying significant natural features



1	Mountain pygmy-possum	6	Alpine thermocolour grasshopper
2	Jillabenan Cave, Yarrangobilly	7	Macquarie perch
3	Long-footed potoroo	8	Alpine tree frog
4	Anemone buttercup	9	Glacial erratic, Kosciuszko NP
5	Snow gum	10	Spotted tree frog

Those are just a small sample of the natural treasures of the Australian Alps. This project identified approximately 1300 “significant natural features”, drawing on lists in:

- legislation;
- management plans;
- subsidiary park documents;
- government reports and databases; and
- scientific papers.

Many, especially biological features, are listed because they are rare or threatened. Some occur in the Australian Alps national parks but live predominantly elsewhere. Many of the area features were listed because they are habitat for one or several rare or threatened species. Few features were listed for their scientific, biogeographic or other reasons.

The listed features include:

- plant and animal species and subspecies;
- ecological communities;
- areas of special significance (eg nationally important wetlands);
- geological and geomorphological features (many reflecting past climates).

An electronic database containing the information assembled about those features (approximately 120 pages when printed) was distributed early in the project to about 70 experts for checking, enhancing and updating. Relatively few responses were received but their information and taxonomic changes were incorporated in the database and lists.

A major part of the project was a workshop of park managers, park service scientists and scientists from other organisations, which was partly to enhance and validate the database and lists of features. The features thus identified included too many to be considered by the workshop, so some were removed. Many plant species listed in Victorian management plans are so listed because they are rare in Victoria, even if they are common outside Victoria. Any of those species not considered significant for any other reason (eg rare nationally, or significant in another State) were deleted from the list. The various park management plans also identified sites of significance for the species occurring there — sometimes for a single species, sometimes for several. Since the “significant” species were to be considered anyway, the associated sites were also deleted from the list.

The resulting lists as considered in detail by the workshop included:

- 18 mammals
- 16 birds
- 12 reptiles
- 10 frogs
- 11 fish
- 31 insects
- 35 other invertebrates
- 197 plants and
- 115 other features.

It is crucial to recognise that these are not the only significant natural features of the Australian Alps.

Other reasons for significance, such as biogeographical or scientific importance, were not the focus of the source documents and consequently were largely excluded from this listing process — which neither recognises nor diminishes their importance. Hopefully the list of significant natural features will be further developed after this project.

Many significant natural features are poorly known or even unknown. The invertebrate fauna, especially the soil fauna, and their plant equivalents are very incompletely documented, yet they may be important at an ecosystem level and well justify being considered significant natural features. For example, arbuscular mycorrhizal fungi form symbiotic relationships with the majority of herbaceous plant species. The fungi colonise the roots of host plants and enhance uptake of nutrients, particularly phosphorus, influence plant water relations and protect against root pathogens. The external hyphae of arbuscular mycorrhizal fungi may contribute towards maintenance of soil structure. Thus arbuscular mycorrhizal fungi may influence significantly host plant growth and be an important link in ecosystem-level processes, such as nutrient cycling, which determine plant community structure and ecosystem stability (Johnston & Ryan in press).

All components of an ecosystem have their essential place by adaptation and/or behavioural adjustment over thousands and sometimes millions of years. The whole ecosystem, or group of ecosystems, is significant — at the State level, nationally and internationally. To pick out a few individual components of the ecosystem is rather like looking at a wonderful tapestry and saying the red stiches are significant — they are, but so are all the others. The full value of the tapestry is in the combination of all the stiches and the red stiches alone would have their value diminished.

The Great Barrier Reef is often referred to as the largest living thing in the world (ie a single living entity). Although the Australian Alps are not as extensive as the Great Barrier Reef, the Australian Alps and the Australian Alps national parks are analogous to the Reef. The areas of alpine zone, on the separated highest parts, could represent the islands; the subalpine zone, the reefs; and the extensive eucalypt forest, the open sea; other specialised ecosystems make up the whole. Recognising the interconnectivity of the components of the ecosystems of the Australian Alps, and seeing the whole as an integral living thing, is fundamental to effective management.

The Australian Alps national parks contain significant geomorphological features. Granitic terrain has particular aesthetic appeal, with sometimes huge tors intriguingly arranged. Granite and related rocks are important in Mt Buffalo, Kosciuszko and Namadgi National Parks.

4 Fauna

The vertebrate fauna of the Australian Alps national parks are generally species with more extensive ranges which are not dependent on, or strongly adapted to, the environmental conditions of the Australian Alps. The exceptions are two mammal species, a few reptiles and four frog species. Many more invertebrate species are restricted to the alpine and subalpine zones, but the invertebrate fauna remain poorly known.

4.1 Mammals

Table 4.1 Mammal species of the Australian Alps national parks considered significant as rare, vulnerable or threatened

Common name	Scientific name	IUCN	EPBC Act	ANZECC list	NSW TSC Act	Vic FFG Act	VROTS	ACT NC Act
Mountain pygmy-possum	*Burramys parvus*	E	EO	E	v	2A	v	
Leadbeater's Possum	*Gymnobelideus leadbeateri*	E	EP	E		2A	e	
Long-footed potoroo	*Potorous longipes*	E	E	E	eP	2A	e	
Smoky mouse	*Pseudomys fumeus*	V	EO	E	eP		r	eA
Spot-tailed quoll/Tiger quoll	*Dasyurus maculatus*	V	VO	V	v	2A	v	
Brush-tailed rock wallaby	*Petrogale penicillata*	V	VO	V	v	2A	e	eA
Yellow-bellied glider	*Petaurus australis*	L	S		v			
Squirrel glider	*Petaurus norfolcensis*	L	S		v			
Brush-tailed phascogale	*Phascogale tapoatafa*	L	S		vP	2A		
Koala	*Phascolarctos cinereus*	L	S		v			
Great Pipistrelle	*Falsistrellus tasmaniensis*				v			
Broad-toothed Rat	*Mastacomys fuscus*				v			
Common Bent-wing Bat	*Miniopterus schreibersii*	L			v	2	c	
Greater long-eared bat	*Nyctophilus timoriensis*	V			v			
Eastern horseshoe bat	*Rhinolophus megaphyllus*					2	c	
Dingo	*Canis familiaris dingo*						ins	
Eastern broad-nosed bat	*Scotorepens orion*						ins	

IUCN	E = Endangered; V = Vulnerable; L = Lower risk, near threatened
Commonwealth Environment Protection and Biodiversity Conservation Act	E = Endangered; V = Vulnerable; P = Recovery Plan completed; O = Recovery Outline completed; S = Taxon summary completed
ANZECC list	Cr = critically endangered; E = endangered; V = vulnerable
NSW Threatened Species Protection Act	e = Endangered; v = Vulnerable; P = Threatened Species Profile completed
Victorian Flora and Fauna Guarantee Act	2 = listed on Schedule 2 as Threatened; A = Action Statement completed
Victorian Rare or Threatened Species list	e = Endangered; v = Vulnerable; r = rare
	c = Restricted colonial breeding or roosting sites
	ins = Insufficiently known (suspected of being End, Vul or R)
ACT Nature Conservation Act	e = Endangered; v = Vulnerable; A = Action Plan completed

Mountain pygmy-possum *Burramys parvus*

The mountain pygmy-possum is one of the rarest, yet best-known, animals of the Australian Alps national parks and the only mammal endemic to the Alps. Because of its high profile and dependence on snow cover, it is now widely regarded as an icon species for the Australian snow country.

It was first described in 1896 from mandible and other skull fragments found in a fossil deposit at Wombeyan Caves, New South Wales. Further fossils were found at Buchan Caves, Victoria, in the early 1960s and later, at Jenolan Caves, New South Wales. It was regarded as extinct until 1966, when the first live animal was found in a ski lodge at Mt Hotham, in Victoria. However, it was then assumed that the animal had been brought to the lodge in a load of firewood, and the Mt Hotham area was not trapped. It was not until 1970 that it was first trapped in Kosciuszko National Park and subsequently at Mt Hotham and other areas in Victoria (NSW NPWS 2000c). Surveys in the early 1970's and 1980's indicated the presence of three disjunct populations in Victoria and one in New South Wales, within Kosciuszko National Park. All of these populations occur above the level of the winter snowline and are widely separated by low lying valleys. A fifth population of up to 300 adults was discovered at Mt Buller in 1995 (Good 1995).

Since the late 1970s a large amount of survey and research has been focused on the mountain pygmy-possum. The species has also received a lot of attention because of its occurrence within ski resorts at Mt. Hotham, Falls Creek and Mt Buller in Victoria, and at Mt Blue Cow and Charlotte Pass in New South Wales (NSW NPWS 2000c).

The dilemma for this species is that its survival is not only dependant on its immediate environment, but also on regional migratory patterns of its major food source, the Bogong Moth, and global influences of human activity on the alpine climate. Alpine environments world wide are increasingly being recognised as under threat from invasive species, escalating visitor impact and global climate change, which are major threats to the continued survival of the mountain pygmy-possum (NSW NPWS 2000c).

Broome and Mansergh (1989) stated that most types of habitat degradation that affect the mountain pygmy-possum have been recorded in the Mt Hotham alpine resort, and definitely increased in this area between 1978 and 1984. They also noted that significant mountain pygmy-possum habitat lies in areas of potential ski development in Kosciuszko National Park. Degradation of vegetation due to past stock grazing is also recognised as a problem for mountain pygmy-possum, although many areas are now recovering (Kirkpatrick 1994 #).

The mountain pygmy-possum is the only marsupial which is confined to the alpine environment. It has international scientific significance on the basis of its archaic premolar teeth, its status as an alpine-subalpine marsupial species, its ability to hibernate, and its singular characteristic as a marsupial of being able to store food (Kirkpatrick 1994 #).

It is the only marsupial known to store food; the longest living small terrestrial mammal (<200g) known in Australia; the only marsupial known to hibernate; and it has evolved a breeding strategy that involves segregation of the sexes during the non breeding season (Mansergh, Kelly & Scotts 1989). It is the only mammal restricted to alpine-subalpine habitats in Australia. It feeds mainly on fruits and seeds, but will also take Bogong moths and other invertebrates (Busby 1990).

The total adult population is fewer than 3000 (DNRE 1997c). It is considered endangered nationally, and vulnerable in New South Wales and Victoria.

Population boundaries have been contracting up the mountains since the last ice age, and isolated remnant populations are now small. The total area of habitat available in Victoria is about 2 sq km (Mansergh, Kelly & Johnston 1991). In Victoria the most important area for the conservation and scientific study of the species is the area between Mt Loch and Mt Higginbotham. About 70% of that area is within the former Bogong National Park (now part of the Alpine National Park, which is managed by Parks Victoria, and about 30% is within the Mt Hotham Alpine Resort, which is managed by the Mt Hotham Resort Management Board (Mansergh, Kelly & Johnston 1991). Population estimates for Kosciuszko National Park have ranged from 500 adults in 8 sq km of habitat (in the early 1980s) to 1312 adults (in 1989). A revised estimate of the area of suitable habitat is being prepared (Good 1995) which is likely to reduce the area and the estimated population in Kosciuszko National Park.

The mountain pygmy-possum habitat often coincides with ski resort areas. In 1991 the main threat to the species was habitat destruction and fragmentation from human activities associated with skiing and alpine resort development. These include absolute destruction, weed invasion, erosion, soil deposition, and interruption of the breeding cycle and hibernation. Fire can destroy the Mountain Plum Pine heathland, and in the alps it would take many decades to recover. There is a high risk of inappropriate fires being lit by humans near important habitat areas (Mansergh, Kelly & Johnston 1991).

Premature death is probably due to the operation of various factors over time, for example: predation by foxes, dogs and cats, kestrels and owls during the non breeding season, presumed to be of predominantly juvenile *Burramys*; animals die when forced out of habitat during dispersal periods (January-April); and animals that do not have sufficient fat reserves may be unable to survive the extended (and repeated) periods of torpor necessary for survival over winter (Mansergh, Kelly & Scotts 1989).

Because Bogong Moths are a major component of its diet in summer, any factors which severely reduce Bogong Moth populations are likely to impact on the mountain pygmy-possum (NSW NPWS 2000c).

The greatest current threat to the continued viability of the mountain pygmy-possum is habitat loss and marginalisation, which is expected to increase with the predicted effects of climate change. A change in climate would most likely increase winter mortality of the mountain pygmy-possum because of decreased insulation and frequent changes in hibernacula temperatures, as well as reducing the amount of available habitat particularly at lower elevations and on westerly aspects. It may also lead to increased competition from other species in the habitat (NSW NPWS 2000c).

If current populations do begin to decline because of global warming, a possible management consideration would be to provide additional habitat on south-easterly aspects and to consider increasing the amount of winter insulation by snow-making over habitat within ski resort areas (NSW NPWS 2000c).

Leadbeater's Possum *Gymnobelideus leadbeateri*

Until 1961 Leadbeater's Possum was known from only five specimens which had been collected prior to 1910. In 1960 Leadbeater's Possum was listed as 'probably extinct' by the International Union for the Conservation of Nature. Leadbeater's Possum now appears to be mainly confined to the montane ash forests of the Central Highlands of Victoria (Macfarlane, Lowe & Smith 1995).

The Leadbeater's Possum is endangered nationally and in Victoria It is listed as occurring in the Alpine National Park (DCE 1992c), but is not listed for the Alpine National Park in the Resource Manual for Environmental Management Program Development 2000/2001.

It has been predicted that the availability of nest trees will decline, precipitating a massive decline of Leadbeater's Possum over the next 30 years followed by a population 'bottleneck' lasting until about 2075 (Macfarlane, Lowe & Smith 1995).

Long-footed Potoroo *Potorous longipes*

The Long-footed potoroo (Potorous longipes) is one of the rarest mammals in Australia (Thomas, Henry & Baker-Gabb 1994). It is listed as endangered nationally, in New South Wales and in Victoria. Occurring in the forests of East Gippsland, north-eastern Victoria south of Mount Buffalo, and south-eastern New South Wales, the long-footed potoroo is so rare and so shy that it was unknown to biologists before the 1960s. It has been recorded in the Alpine National Park (Parks Victoria 2000).

The long-term survival of the Long-footed Potoroo is uncertain. The influence of introduced predators is thought to be an important factor limiting the distribution and abundance of the Long-footed Potoroo (Thomas, Henry & Baker-Gabb 1994). Predation by wild dogs and foxes may be restricting populations to areas of dense understorey. Management activities such as road-building, fuel-reduction burning and harvesting in State Forest may affect potoroo food supply, change forest structure and improve access for predators. The effects of these activities are not well understood (DNRE 2000b).

Smoky Mouse *Pseudomys fumeus*

Since European settlement the range of the smoky mouse has declined and it is currently limited to a small number of sites scattered throughout western, southern and eastern Victoria, south-east New South Wales and the ACT (NSW NPWS 1999i). It is listed as endangered nationally, in New South Wales and the ACT, and rare in Victoria. It is a Category 1 (Highly Significant) natural feature in Kosciuszko National Park (NSW NPWS 1999e), recently recorded within the Yarrangobilly Caves Management Unit (NSW NPWS 2000b). Two animals have been trapped in the ACT, in Namadgi National Park (ACT Government 1999g). In Victoria the Howqua Heritage River is important habitat (DNRE 1997a), and it has been recorded in upper Wonnangatta catchment/heritage river (DNRE 1997b). It is considered likely to be in the Avon, Turton, and Dolodrook Rivers and Ben Cruachan Creek Natural Catchment Area (DNRE 1997b).

Threats to the smoky mouse include vegetation clearance, resulting in loss of habitat and likely contraction of range; inappropriate fire regimes (too frequent fires), resulting in changes to the floristic composition of ground and shrub vegetation, which may have deleterious effects on food sources; and predation by the introduced dog, fox and cat - may be significant for small isolated populations; fragmentation of many of the remaining forest habitats, the effects of wildfires, inappropriate fire regimes and predation are all likely to exacerbate serious problems resulting from reduced dispersal, recolonisation ability and gene flow (ACT Government 1999g), (NSW NPWS 1999i). Also cattle and rabbit grazing resulting in reduction in food resources and the depletion of shrub cover (NSW NPWS 1999i).

Spot-tailed or Tiger Quoll *Dasyurus maculatus*

The spot-tailed quoll is the largest carnivorous marsupial surviving on mainland Australia and the only surviving species of *Dasyurus* in the Australian Alps national parks (Murray 1998 #).

The spot-tailed quoll is listed as vulnerable on national lists, a threatened taxon in Schedule 2 of the Flora and Fauna Guarantee Act 1988, vulnerable under Schedule 2 of the NSW Threatened Species Conservation Act and is a Category 2 (Very Significant) natural feature in Kosciuszko National Park. Records on the Australian mainland are few and are concentrated in very few localities. Within the Victorian range of the species over 30 flora and fauna surveys of forestry blocks (each about 10,000 ha in area) collected predator scats as part of the general wildlife survey. Of 2484 scats collected, only eight (0.3%) were from the Tiger Quoll (Mansergh & Belcher 1992).

Within most of its current range, native forests are cleared, timber harvested and trapping and baiting is carried out to control wild dogs and foxes (Mansergh & Belcher 1992). Poisoning to control dogs and particularly foxes could be highly beneficial to spot-tailed quolls, but the quolls could also be put at risk if poisoning programs are carried out which employ methods which allow quolls access to the baits. Burying the baits at depths greater than 10 cm significantly reduces the risk to quolls (Murray 1998 #). Major threats to quolls include timber harvesting and pest control; moderate threats are clearing, managed fires, wildfires, introduced species and vandalism (JCVRFASC 1998b).

Brush-tailed rock wallaby *Petrogale penicillata*

Brush-tailed rock-wallabies were once widespread within the catchment of the Snowy River south to the Murrindal River near Buchan, at Tintaldra in the upper Murray, and near Omeo and Mt. Tambo. K Rogers reported that 1200 were shot on the Suggan Buggan River in northeastern Victoria during a single winter around 1903 (Hill & Baker-Gabb 1994).

Vulnerable nationally and in New South Wales, endangered in Victoria and the ACT. Considered as Critically Endangered by the Victorian Government, being found in Victoria only in the rocky cliffs of the upper Snowy River and in the Grampians (Bunbury 1992) although it is suspected to occur among rocky outcrops along the Mitta Mitta Heritage River (DNRE 1997a). It is a Category 1 (Highly Significant) natural feature in Kosciuszko National Park (NSW NPWS 1999e).

Populations in the southern part of the range of the brush-tailed rock wallaby are small, fragmented and isolated. This reduces the likelihood of successful migration between colonies, making them vulnerable to extinction from inbreeding and catastrophes such as wildfires. Introduced predators such as the fox, feral cat and wild dog also threaten rock-wallabies. Feral goats and rabbits are competitors for shelter sites and food (DNRE 2000a).

Interestingly, brush-tailed rock wallabies occur wild on the Hawaiian island of Oahu, where they coexist with feral cats but do not have to contend with foxes. Probably there are more on Oahu than in the Australian Alps national parks. Other feral mammals on Oahu include goats, pigs, axis deer and mongooses (The Coordinating Group on Alien Pest Species 2000). In an e-mail on 26 May 2000 Dick Veitch reported that New Zealand has successfully eradicated brush-tailed rock wallabies from Rangitoto and Motutapu Islands, where they had no predators. They continue to thrive on Kawau Island along with other wallaby species.

Yellow-bellied glider *Petaurus australis*

Listed as Vulnerable under Schedule 2 of the NSW Threatened Species Conservation Act, and a Category 2 (Very Significant) natural feature in Kosciuszko National Park (NSW NPWS 1999e). It also occurs in Brindabella National Park.

Threats are habitat reduction and alteration through land clearing for agriculture and timber harvesting. Will suffer declines in density with the removal of old growth elements from unlogged forests or from previously lightly-logged forests. Requirement for variety of feed trees in mixed forest over large home range and need for hollows in which to nest mean that effective conservation can only be achieved through reservation of forest. Pair for life, so extensive areas required. Isolated populations such as those in far western Victoria and south-eastern South Australia may not be viable in the long term (Maxwell, Burbidge & Morris (eds) 1996d).

Squirrel glider *Petaurus norfolcensis*

Population fragmented and probably in steady decline in areas with predominantly pastoral or agricultural land use. Also has suffered loss of habitat in New South Wales north of Sydney due to coastal development (Maxwell, Burbidge & Morris (eds) 1996c). Listed as Vulnerable under Schedule 2 of the NSW Threatened Species Conservation Act. It has been recorded in Kosciuszko National Park and probably occurs in Brindabella National Park.

Threats are steady attrition of quality and extent of habitat remnants due to removal of timber for both sawn products and firewood; lack of suitable hollows in most habitat remnants on the inland slopes; lack of regeneration of trees and shrubs due to grazing by stock, rabbits and macropods and inappropriate fire regimes; removal of habitat during prospecting and mining for gold; tree decline in rural lands and outbreaks of leaf-skeletonising caterpillars in riverine forests; and further coastal development in New South Wales and south-east Queensland (Maxwell, Burbidge & Morris (eds) 1996c).

Brush-tailed Phascogale *Phascogale tapoatafa*

The brush-tailed phascogale, vulnerable in both New South Wales and Victoria, is a Category 2 (Very Significant) natural feature in Kosciuszko National Park (NSW NPWS 1999e). In Victoria the Brush-tailed Phascogale's distribution is fragmented. The species occurs in the foothills to the east and north-east of Melbourne. There have been no records from Gippsland for over 25 years despite many fauna surveys, but in 1994 brush-tailed phascogale hair was found in the scats of Spot-tailed Quoll at Mt Stradbroke, west of Suggan Buggan (Humphries & Seebeck 1997).

The greatest current threat is the increasing decline in the availability of hollow-bearing trees. Predation by foxes and cats. Male die-off makes this taxon particularly vulnerable to stochastic events. Reproductively viable populations are unlikely to persist in suitable habitat areas smaller than thousands of hectares (Maxwell, Burbidge & Morris (eds) 1996a).

Koala *Phascolarctos cinereus*

The koala’s geographic range on the mainland has contracted significantly due to loss of large areas of habitat since European settlement. While remaining populations are widely distributed throughout the remaining range, habitat fragmentation and modification has resulted in an increased prevalence of predation, in addition to geographic and genetic isolation (Maxwell, Burbidge & Morris (eds) 1996b).

In the early decades of this century, Koala populations declined greatly, due to disease, commercial hunting and widespread habitat destruction. Commercial hunting ceased many decades ago and koala populations recovered in many areas (Maxwell, Burbidge & Morris (eds) 1996b).

Listed as Vulnerable under Schedule 2 of the NSW Threatened Species Conservation Act, and a Category 2 (Very Significant) natural feature in Kosciuszko National Park (NSW NPWS 1999e). It also occurs in Namadgi National Park and is likely to occur Brindabella National Park.

Current threats are continued habitat destruction, fragmentation and modification, bushfires and disease, as well as drought associated mortality in habitat fragments. There are management problems with many populations, with remnant populations living at high densities in isolates of habitat being at greatest risk. Predation, especially by domestic dogs, and mortality due to motor vehicles are of concern in some areas. Public concern for the species is high (Maxwell, Burbidge & Morris (eds) 1996b).

Great Pipistrelle *Falsistrellus tasmaniensis*

The Great Pipistrelle is a Category 2 (Very Significant) natural feature in Kosciuszko National Park (NSW NPWS 1999e). It is a large bat (14–26 g in weight) which feeds on moths and beetles and roosts in hollow trees (Green & Osborne 1994).

Broad-toothed Rat *Mastacomys fuscus*

In New South Wales, where it is found in the Barrington Tops region and the Bimberi Range/Snowy Mountains region (Green, Mansergh & Osborne 1992 #), the broad-toothed rat is confined to the high country, mainly above the level of the winter snowline. In the ACT it has been found as low as 1000m (Green & Osborne 1994). In Victoria it is found at lower elevations than in New South Wales (Green, Mansergh & Osborne 1992 #), and it also occurs in Tasmania. This species was much more widespread in the Pleistocene, and its decline was probably due to long term climatic and subsequent environmental changes (Green & Osborne 1994). The broad-toothed rat is a Category 2 (Very Significant) natural feature in Kosciuszko National Park (NSW NPWS 1999e).

Foxes selectively feed on broad-toothed rats, possibly due to palatability or ease of capture (Green & Osborne 1994).

Common Bent-wing Bat *Miniopterus schreibersii*

Listed as Vulnerable under Schedule 2 of the NSW Threatened Species Conservation Act, and listed as a threatened taxon on Schedule 2 of the Flora and Fauna Guarantee Act. It is a Category 2 (Very Significant) natural feature in Kosciuszko National Park (NSW NPWS 1999e), and it occurs in Brindabella National Park. The caves along the upper Victorian section of the Snowy River are key components of the habitat of this species (Land Conservation Council 1991a). Occurs from Australia through Asia to Europe and Africa (IUCN 2000)

Greater long-eared bat *Nyctophilus timoriensis*

Listed as Vulnerable under Schedule 2 of the NSW Threatened Species Conservation Act. Occurs within the Yarrangobilly Caves Management Unit of Kosciuszko National Park (NSW NPWS 2000b), and in Brindabella National Park. Occurs in Australia, Papua New Guinea and Indonesia (IUCN 2000)

Eastern horseshoe bat *Rhinolophus megaphyllus*

Listed as a threatened taxon on Schedule 2 of the Flora and Fauna Guarantee Act. The caves along the upper Victorian section of the Snowy River are key components of the habitat of this species (Land Conservation Council 1991a).

Dingo *Canis familiaris dingo*

The dingo is considered insufficiently known (in Victoria), but is suspected of being Endangered, Vulnerable or Rare (Management plans for Mount Buffalo National Park and Alpine NP). Dingoes were brought to Australia by people, so might be considered exotic, but they have been here for at least several thousand years and the present native fauna has developed in and adapted to the presence of dingoes (National Parks Service 1995). Consequently dingoes are treated as native fauna by the Australian Alps national parks agencies, but they interbreed with feral dogs and are collectively referred to as “wild dogs”. Dingoes are at risk by the genetic mixing of crossbreeding, but the great majority of wild dogs in the Eastern Highlands of Victoria are considered dingo-like wild canids with the gene pool predominantly dingo in composition (DCE 1992d). Wild dogs are considered pests (declared noxious in New South Wales and established pest animals in Victoria) and land owners are obliged to control them. Park managers control wild dogs around park boundaries (the good neighbour program) but in doing so cannot practically distinguish between feral dogs and dingoes. See also “Dogs” in Chapter 7, where wild dogs are discussed as threats.

Moderate - timber harvesting, wildfires, introduced species, pest control; minor - clearing, managed fires, grazing/trampling, vandalism, dams/impoundments (JCVRFASC 1998b)

Eastern broad-nosed bat *Scotorepens orion*

Occurring in the Snowy River National Park, the eastern broad-nosed bat is insufficiently known but is suspected to be endangered, vulnerable or rare in Victoria (DNRE 1995).

4.2 Birds

No bird species is confined to the Australian Alps, but a number of rare or threatened species occur in the Australian Alps national parks. Another consideration is the international migrant species, which receive special protection through international conventions and agreements (see Chapter 1). Although the Australian Alps are not the prime habitat of the migratory species, some pass through the Australian Alps national parks and the Japanese snipe frequents Kosciuszko National Park in small numbers each year (Good 1992a).

Table 4.2 Bird species of the Australian Alps national parks considered significant as rare, vulnerable or threatened, or as migratory species:

Common name	Scientific name	IUCN	EPBC Act	ANZECC list	NSW TSC Act	Vic FFG Act	VROTS	ACT NC Act
Regent honeyeater	*Xanthomyza phrygia*	E	E	E	e	2A	e	eA
Swift parrot	*Lathamus discolor*	V	E	V	v	2	e	vA
Glossy black cockatoo	*Calyptorhynchus lathami*	V			v	2	v	
Grey falcon	*Falco hypoleucus*	V			v	2A		
Square-tailed kite	*Lophoictinia isura*	V			v		v	
Barking owl	*Ninox connivens*				v	2		
Powerful owl	*Ninox strenua*	V			v	2	r	
Olive whistler	*Pachycephala olivacea*				v			
Pink robin	*Petroica rodinogaster*				v			
Masked owl	*Tyto novaehollandiae*				v	2	r	
Sooty owl	*Tyto tenebricosa*				v	2	r	
White-bellied sea eagle	*Haliaeetus leucogaster*					2A	r	
Turquoise parrot	*Neophema pulchella*					2	r	
Peregrine falcon	*Falco peregrinus*							
Latham's snipe	*Gallinago hardwickii*							

IUCN	E = Endangered; V = Vulnerable
Commonwealth Environment Protection and Biodiversity Conservation Act	E = Endangered; V = Vulnerable; P = Recovery Plan completed; O = Recovery Outline completed; S = Taxon summary completed
ANZECC list	Cr = critically endangered; E = endangered; V = vulnerable
NSW Threatened Species Protection Act	e = Endangered; v = Vulnerable; P = Threatened Species Profile completed
Victorian Flora and Fauna Guarantee Act	2 = listed on Schedule 2 as Threatened; A = Action Statement completed
Victorian Rare or Threatened Species list	e = Endangered; v = Vulnerable; r = rare
	c = Restricted colonial breeding or roosting sites
	ins = Insufficiently known (suspected of being End, Vul or R)
ACT Nature Conservation Act	e = Endangered; v = Vulnerable; A = Action Plan completed

Regent honeyeater and swift parrot

The regent honeyeater *Xanthomyza phrygia* and swift parrot *Lathamus discolor* are endangered nationally. Although recorded from the Australian Alps national parks, these parks are not particularly important for these species. For example, the Alpine National Park accounts for 0.24% of recent (30 years) Victorian records of the swift parrot and 0.37% of the regent honeyeater records (Parks Victoria 2000).

Glossy black cockatoo *Calyptorhynchus lathami*

Vulnerable in New South Wales and Victoria, the glossy black cockatoo is a Category 2 (Very Significant) natural feature in Kosciuszko National Park (NSW NPWS 1999e), while the Alpine National Park is considered important for it (Parks Victoria 2000).

Grey falcon, square-tailed kite, barking owl and masked owl

The grey falcon *Falco hypoleucus, s*quare-tailed kite *Lophoictinia isura*, barking owl *Ninox connivens* and masked owl *Tyto novaehollandiae* are considered vulnerable in New South Wales and threatened or vulnerable in Victoria. Although recorded from, or expected to occur in, the Australian Alps national parks, these species are not particularly dependent on these parks.

Clearing and grazing of arid zone habitat, the destruction of raptors because they were thought to prey on domestic poultry, and the use of pesticides have all had an adverse effect on the species (Venn 1997)

Powerful Owl *Ninox strenua*

The powerful owl, vulnerable in New South Wales and threatened in Victoria, occurs in many of the Australian Alps national parks, but its range is much more extensive and these parks are relatively unimportant for its survival. For example, only 1.39% of recent Victorian records are from the Alpine National Park, and 0.06% from Mount Buffalo National Park (Parks Victoria 2000). Nevertheless, the powerful owl is a Category 2 (Very Significant) natural feature in Kosciuszko National Park (NSW NPWS 1999e).

Olive whistler and pink robin

The olive whistler *Pachycephala olivacea* and pink robin *Petroica rodinogaster* are considered vulnerable in New South Wales. They are both listed as a Category 2 (Very Significant) natural feature in Kosciuszko National Park (NSW NPWS 1999e) and also occur in Brindabella National Park.

Sooty Owl *Tyto tenebricosa*

The sooty owl is considered vulnerable in New South Wales and threatened in Victoria. It is a Category 2 (Very Significant) natural feature in Kosciuszko National Park (NSW NPWS 1999e) and 3% of Victorian records are from the Alpine National Park (Parks Victoria 2000).

White-bellied sea eagle *Haliaeetus leucogaster*

The white-bellied sea eagle, considered threatened in Victoria, has been recorded from the Alpine National Park and the Snowy River National Park. Again these parks are relatively unimportant for its survival. The Alpine National Park accounts for 0.28% of recent Victorian records (Parks Victoria 2000).

Threats include increased human presence, direct poisoning during dog and fox control programs, secondary poisoning during rabbit control programs, deliberate shooting, eggshell thinning because of the past use of DDT, and food chain contamination by heavy metals (Clunie 1994).

Turquoise parrot *Neophema pulchella*

The turquoise parrot inhabits the foothills of the Great Divide, from south-eastern Queensland to northern Victoria, in eucalypt woodlands and open forests with ground cover of grasses and sometimes low understorey of shrubs. It often breeds in the ecotone between farmland and forest: most breeding in forests in north-eastern Victoria occurs within 100m of cleared land, and breeding in either forests or pasture rarely occurs more than one kilometre from the edge of the forest (Higgins 1999).

Peregrine Falcon *Falco peregrinus*

The Peregrine Falcon is a cosmopolitan bird, occurring throughout Europe and northern Asia to Japan, India to southern China, north-west Africa and south of the Sahara, Alaska and northern Canada to Mexico and Central America, Southern Chile and Argentina, Indonesia, New Guinea, Australia and the south-west Pacific. In Australia it occurs over wooded and forested lands, open country and wetlands of tropical and temperate areas, extending into the arid zone though not treeless or waterless deserts. It extends from sea level to alpine regions, though the maximum recorded altitude of nesting is 900m (Marchant and Higgins 1993) — but Tony Stubbs has observed nesting at around 1300m in Kosciuszko National Park (pers. comm.). Australia has one of the few secure continental populations, but nesting in some areas is threatened by habitat change (Marchant and Higgins 1993). Kosciuszko National Park has a stable population of about 30 pairs of peregrine falcons (NSW NPWS 1999a).

Latham's Snipe *Gallinago hardwickii*

Latham's Snipe breeds in northern Japan and the eastern Asian mainland. Records suggest these birds (which are about 29–33 cm long) fly directly between Japan and Australia, stopping at few staging areas and moving from Japan to Australia in a few days. It is a non-breeding visitor to south-eastern Australia, arriving late August to December –January, where it occurs in a wide variety of permanent and ephemeral wetlands. In Victoria and New South Wales it leaves the high country during the season to move to feeding grounds near the coast, before flying back to the northern hemisphere. Creation of artificial wetlands (eg hydro-electric impoundments) usually decreases the amount of suitable habitat. Most leave south-east Australia by the end of February (Higgins & Davies 1996). Latham's snipe is listed on the Convention on Migratory Species and on Australia's migratory birds agreements with China (CAMBA) and Japan (JAMBA). About 1.4% of Victorian records are from the Alpine National Park and Mt Buffalo National Park (Parks Victoria 2000).

Approximately 10,000–30,000 occur in Australia during the non-breeding period (Lane & Parish 1991).

Other migratory birds listed on JAMBA and CAMBA recorded in Victoria's Australian Alps national parks include the white-throated needletail (2.8% of Victorian records), rainbow bee-eater, fork-tailed swift and great egret (Parks Victoria 2000).

4.3 Reptiles

Table 4.3 Reptile species of the Australian Alps national parks considered significant as rare, vulnerable or threatened:

Common name	Scientific name	EPBC Act	ANZECC list	NSW TSC Act	Vic FFG Act	VROTS	ACT NC Act
Alpine she-oak skink	*Cyclodomorphus praealtus/ Tiliqua casuarinae*				2	v	
Alpine water skink	*Eulamprus kosciuskoi/ Sphenomorphus kosciuskoi*				2	v	
High Plains/ alpine bog skink	*Pseudemoia cryodroma*				2		
Mountain dragon	*Amphibolurus diemensis/ Tympanocryptus diemensis*					ins	
Glossy grass skink	*Pseudemoia rawlinsoni*					ins	
Tree goanna	*Varanus varius*					ins	
Snowy Mountains skink	*Egernia sp*						
Skink	*Egernia sp. 1*						
Skink	*Egernia sp. 2*						

Commonwealth Environment Protection and Biodiversity Conservation Act	E = Endangered; V = Vulnerable; P = Recovery Plan completed; O = Recovery Outline completed; S = Taxon summary completed
ANZECC list	Cr = critically endangered; E = endangered; V = vulnerable
NSW Threatened Species Protection Act	e = Endangered; v = Vulnerable; P = Threatened Species Profile completed
Victorian Flora and Fauna Guarantee Act	2 = listed on Schedule 2 as Threatened; A = Action Statement completed
Victorian Rare or Threatened Species list	e = Endangered; v = Vulnerable; r = rare
	c = Restricted colonial breeding or roosting sites
	ins = Insufficiently known (suspected of being End, Vul or R)
ACT Nature Conservation Act	e = Endangered; v = Vulnerable; A = Action Plan completed

Alpine She-oak Skink, Alpine water skink and High Plains skink

The alpine she-oak skink *Cyclodomorphus praealtus/ Tiliqua casuarinae*, alpine water skink *Eulamprus kosciuskoi/ Sphenomorphus kosciuskoi*, and High Plains (or alpine bog) skink *Pseudemoia cryodroma* are substantially alpine in occurrence. Of all recent Victorian records, 60%, 96% and 12% respectively were from the Alpine National Park (Parks Victoria 2000). The alpine she-oak skink is a Category 1 (Highly Significant) natural feature in Kosciuszko National Park, and the alpine water skink is a Category 3 (Significant) natural feature (NSW NPWS 1999e).

Mountain Dragon *Amphibolurus diemensis/ Tympanocryptus diemensis*

The mountain dragon *Tympanocryptus diemensis/Amphibolurus diemensis* is the only agamid lizard that occurs above the winter snowline in Australia. It is found up to about 1750 m in open woodland, open heath and on rocky north- or west-facing slopes of the mainland mountains. It does not occur at high altitudes in Tasmania (Green (ed) 1998).

Undescribed skinks *Egernia spp*

Two undescribed skinks are listed as Category 2 (Very Significant) natural features. One of these, the Snowy Mountains (rock) skink, is confined to the Snowy Mountains, where it occurs between 1600 m and 2000 m (Green (ed) 1998).

4.4 Frogs

Table 4.4 Amphibian species of the Australian Alps national parks considered significant as rare, vulnerable or threatened:

Common name	Scientific name	IIUCN	EPBC Act	ANZECC list	NSW TSC Act	Vic FFG Act	VROTS	ACT NC Act
Spotted tree frog	*Litoria spenceri*	V	E	Cr	e	2	e	
Baw Baw frog	*Philoria frosti*	E	E	Cr		2A		
Southern corroboree frog	*Pseudophryne corroboree*	E	E	Cr	e			
Giant burrowing frog	*Helioporus australiacus*		V	V	v	2A	r	
Alpine tree frog	*Litoria verreauxii alpina*	V	V	V				
Northern corroboree frog	*Pseudophryne pengilleyi*		V	V	v			vA
Booroolong frog	*Litoria booroolongensis*				e			
Blue Mountains tree frog	*Litoria citropa*						r	
Eastern banjo frog (montane form)	*Limnodynastes dumereli fryii*							

IUCN	E = Endangered; V = Vulnerable
Commonwealth Environment Protection and Biodiversity Conservation Act	E = Endangered; V = Vulnerable; P = Recovery Plan completed; O = Recovery Outline completed; S = Taxon summary completed
ANZECC list	Cr = critically endangered; E = endangered; V = vulnerable
NSW Threatened Species Protection Act	e = Endangered; v = Vulnerable; P = Threatened Species Profile completed
Victorian Flora and Fauna Guarantee Act	2 = listed on Schedule 2 as Threatened; A = Action Statement completed
Victorian Rare or Threatened Species list	e = Endangered; v = Vulnerable; r = rare
	c = Restricted colonial breeding or roosting sites
	ins = Insufficiently known (suspected of being End, Vul or R)
ACT Nature Conservation Act	e = Endangered; v = Vulnerable; A = Action Plan completed

Spotted tree frog *Litoria spenceri*

The spotted tree frog is mainly confined to the north-west side of the Great Dividing Range between the Central Highlands in Victoria and Mount Kosciuszko. Across this narrow geographic range 17 discrete populations have been identified, four of which are presumed extinct (NSW NPWS 1999d). The spotted tree frog is considered critically endangered (ANZECC 1999). Most of the population was confined to a 1.6 km section of Bogong Creek in Kosciuszko National Park above a substantial waterfall, with consistently more than several hundred individuals recorded during the summers from 1993 to 1996. The population underwent a steep decline, with only two individuals recorded there in the summer of 1997-98, and only one since then (NSW NPWS 1999a; NSW NPWS 1999d).

The spotted tree frog is considered critically endangered by ANZECC, and endangered in New South Wales and Victoria.

The sole surviving spotted tree frog in Kosciuszko National Park has recently been taken into a captive breeding program, so none remains in the park.

Facilities have been developed at the Amphibian Research Centre in Melbourne, Victoria, for captive husbandry of Victorian populations of *L. spenceri*. This program has allowed for successful breeding and rearing of progeny from wild founder stock. The existing captive colony is currently being used for various research activities, but over the longer-term is being viewed as a potential source of animals for re-introduction purposes (NSW NPWS 1999d).

One of the greatest threats to the spotted tree frog is from trout predation on tadpoles, and grazing poses a significant threat to the protection of spotted tree frog habitat, by disturbing soil and vegetation on river banks and surrounding areas (DNRE 1997a), but these are unlikely to be the cause of the population decline at Bogong Creek (NSW NPWS 1999d). Disease is a possible cause, although that remains unproven. Spotted tree frogs have been found to be infected with *Batrachochytrium* (Berger, Speare & Hyatt 1999).

See also the box in Section 7.2 (page 142).

Baw Baw frog *Philoria frosti*

Although not occurring within the Australian Alps national parks, the Baw Baw frog merits special consideration as it is considered critically endangered (ANZECC 1999).

The Baw Baw Frog is restricted to the highest, subalpine areas of the Baw Baw Plateau, 130 km east of Melbourne. Surveys have shown the population to be confined within the Baw Baw National Park and the Mount Baw Baw Alpine Resort. The Baw Baw Frog's most important breeding areas are on the western side of the plateau where recreational pressure is the greatest. An estimated 10% of the population occurs within the Mt Baw Baw Alpine Resort. Increasing recreational use is expected to exacerbate threats to the frog and its habitat. Expansion of the resort could both damage and remove habitat and pollute streams and the wetter drainage areas favoured by the frog. the taxon is significantly threatened by disturbance at breeding sites from construction of ski slopes, ski trails, roads and walking tracks. (James & Morey 1993).

Corroboree Frogs *Pseudophryne corroboree* and *P pengilleyi*

The southern and northern corroboree frogs are found only in the Snowy Mountains and nearby Fiery Range and the Brindabella Range, throughout the mountain areas between about 1200m and 1700 m. They have not been found on Bogong High Plains despite similar habitat (Green, Mansergh & Osborne 1992 #). Before 1970 the two forms were abundant. By 1984 they had declined considerably at many sites in the alps.

The southern corroboree frog appears to have suffered the greatest recent population decline. It was once common in at least three resort areas, but has now disappeared from all resort areas in the Snowy Mountains (Green, Mansergh & Osborne 1992 #). It seems to have retreated from high altitude but also from the drier part of its range to the wetter part. The decline apparently is due to high winter mortality due to lack of water in ponds and lack of insulating snow (NSW NPWS 1999a).

The southern corroboree frog is listed as Endangered under Schedule 1of the NSW Threatened Species Conservation Act and is a Category 1 (Highly Significant) natural feature in Kosciuszko National Park (NSW NPWS 1999e).

The northern corroboree frog is confined to the high country of the ACT and adjacent New South Wales, along the Brindabella and Bimberi Ranges and throughout the Fiery Range and Bogong Mountains. The ACT population is located almost entirely in the subalpine areas of Namadgi National Park, with an important stronghold being the internationally recognised Ginini Flats wetland complex (ACT Government 1998c).

The northern corroboree frog has also suffered a substantial decline in the last 10 years or so. Long-term disturbance or loss of habitat due to drought, feral animals (especially pigs and horses), weed invasion and wildfire are implicated. The possible affects of increased ultra-violet radiation associated with depletion of atmospheric ozone and global warming as a result of climate change are issues of particular concern for this high-altitude, cool-adapted species. The northern corroboree frog is faced with considerable risk from disturbance to breeding sites or drought. Its relatively low breeding capability reduces the ability of the species to recover quickly during favourable conditions (ACT Government 1998c).

It is listed as Vulnerable under Schedule 2 of the NSW Threatened Species Conservation Act and vulnerable in the ACT. It is a Category 2 (Very Significant) natural feature in Kosciuszko National Park (NSW NPWS 1999e).

Giant Burrowing Frog *Helioporus australiacus*

Records of the giant burrowing frog are confined to the coastal slopes of the Great Dividing Range below 1000 m altitude, between Gosford in New South Wales and Walhalla in central Gippsland. No records are known between Jervis Bay and Eden, indicating that the species may be composed of two disjunct populations. Within Victoria by 1993, only 26 adult frogs, one juvenile frog and three groups of tadpoles had been recorded at 24 localities scattered over a large area of central and eastern Gippsland. At the majority of sites only a single adult has been found.

It is considered vulnerable nationally and in New South Wales, and threatened in Victoria. It has been found in Snowy River National Park (DNRE 1995) and in the Mitchell–Wonnangatta Heritage River (DNRE 1997b).

Given the lack of knowledge of the species' habitat requirements it is inappropriate to re-evaluate the effects of disturbance, particularly fuel reduction burning, at this stage. Consequently a conservative management strategy has been adopted (Mazzer 1994).

Alpine Tree Frog *Litoria verreauxii alpina*

The alpine tree frog appears to have undergone an extensive and apparently catastrophic decline (Hunter, Osborne & Smith 1997)

The rapid and widespread nature of population declines in a diverse array of amphibian species at high altitudes, in apparently undisturbed environments, has indicated a ubiquitous causal agent common to all areas of the globe, one perhaps particularly manifest at higher altitudes. Recent studies at high altitudes in North America have suggested a link between declining frog populations and increases in UV-B radiation (Broomhall 1998a #).

The alpine tree frog is found only in the Australian Alps (Green, Mansergh & Osborne 1992 #). Numerous historical records show that the alpine tree frog was widespread and abundant throughout much of the high country of south-eastern Australia (Osborne, Hunter & Hollis 1999). It is now regarded as nationally vulnerable. In Kosciuszko National Park it previously occurred in all likely habitats at altitudes between 1500m and 2100m. Above 1500m, it is now confined to two man-made ponds and one natural pond with 2 calling males at about 1800m (NSW NPWS 1999a). It has disappeared entirely from the alpine zone (above 1850 m) (Hunter, Osborne & Smith 1997; Broomhall 1998a).

Recent (1993–1998) searches for the alpine tree frog were made at 49 locations in the Alpine National Park, 92 locations in Kosciuszko National Park and Bimberi Nature Reserve (each location generally included a number of water-bodies that provided potential breeding sites), and nine in Namadgi National Park (Osborne, Hunter & Hollis 1999).

Of the seven locations where extant populations of the alpine tree frog were located in Kosciuszko National Park, four were associated with artificial water bodies. No alpine tree frog were found during surveys at Baw Baw Plateau, Davies Plain, and Bogong High Plains in Victoria, but several small populations were located to the south-east of Mt Hotham near

Dinner Plain (altitudinal range 1300 to 1600 m), and a more extensive population on the Dargo High Plains (1400 to 1600 m). No frogs or tadpoles of the alpine tree frog were observed at any of the sites surveyed in Namadgi National Park (Osborne, Hunter & Hollis 1999).

These surveys indicated that in the highlands of south-eastern Australia four species of frogs have experienced pronounced population declines. These frogs are the alpine tree frog, southern and northern corroboree frogs and the Baw Baw frog. The northern corroboree frog is still widespread and abundant at lower altitudes, but there are few remaining substantial populations of the other three species, which are faced with the likelihood of extinction in the short term if the current trends continue. There appears to be an altitudinal influence on the extent of the declines, with the most serious declines all occurring at higher altitudes, particularly in the subalpine and alpine zones. This apparent relationship between altitude and the extent of the population decline has been observed in other frog species in Australia and in other countries (Osborne, Hunter & Hollis 1999)

Experimentally blocking UV-B radiation significantly enhanced survival for the alpine tree frog. The species may have been on the periphery of its adaptive tolerance for UV-B, such that even small increases in radiation were sufficient to cause elevated mortality. This research has determined that existing levels of UV-B in the south-eastern alpine region of Australia are likely to be a significant causative factor in the decline of populations of the alpine tree frog (Broomhall 1998a #).

Booroolong Frog *Litoria booroolongensis*

The Booroolong frog is restricted to New South Wales and north-eastern Victoria, predominantly along the western-flowing streams of the Great Dividing Range, from 200 m to above 1300 m above sea level. It was formerly abundant above 800 m along streams draining the Northern Tablelands but has not been recorded from the Northern Tablelands during the past 15 years despite extensive surveys. There have been very few records of the Booroolong frog in the past 5 years, contrasting markedly with the 1980's when the species was perceived to be abundant in northern New South Wales. The Booroolong frog has disappeared from the Northern Tablelands and is now rare throughout most of the remainder of its range (Gillespie 1999).

In New South Wales the Booroolong frog is listed as Endangered under the *Threatened Species Conservation Act 1995,* indicating that it is likely to become extinct unless the circumstances and factors threatening its survival or evolutionary development cease. In Victoria the species is considered to be Critically Endangered, but has not yet been listed under the Flora and Fauna Guarantee Act. It is a Category 1 (Highly Significant) natural feature in Kosciuszko National Park (NSW NPWS 1999e).

Several potentially threatening processes have operated, or are operating, in various parts of the range of the Booroolong frog. However, in most cases, the impact of these processes upon populations of the species have not been examined, and the primary cause(s) of its apparent decline are unknown (Gillespie 1999).

Blue Mountains tree frog *Litoria citropa*

The Blue Mountains tree frog is confined to the coast and ranges of NSW and eastern Victoria, where it primarily inhabits heaths and wet and dry sclerophyll forests (Cogger 1994).

Eastern banjo frog (montane form) *Limnodynastes dumereli fryii*

The eastern banjo frog (montane form) is found only in the Australian Alps (Green, Mansergh & Osborne 1992 #).

4.5 Fish

Table 4.5 Fish species of the Australian Alps national parks considered significant as rare, vulnerable or threatened:

Common name	Scientific name	IUCN	EPBC Act	ANZECC list	NSW FM Act	Vic FFG Act	VROTS	ACT NC Act
Trout Cod	*Maccullochella macquariensis*	E	EO	Cr	e	2A	e/v	eA
Macquarie perch	*Macquaria australasica*	D	EO	E	v	2	v	eA
Australian grayling	*Prototroctes maraena*	V	VO	V		2	v	
Murray Cod	*Maccullochella peeli*	Cr				2	v	
Two-spined blackfish	*Gadopsis bispinosus*							vA
Australian bass	*Macquaria novemaculeata*						r	
Climbing Galaxias	*Galaxias brevipinnis*						r	
Flat-headed Galaxias	*Galaxias rostratus*	V					r	
Freshwater Blackfish	*Gadopsis marmoratus*						ind	
Mountain Galaxiid	*Galaxias olidus*						ins	
Dwarf flat-headed gudgeon	*Philypnodon sp. nov.*						ins	

IUCN	Cr = critically endangered; E = Endangered; V = Vulnerable; D = data deficient
Commonwealth Environment Protection and Biodiversity Conservation Act	E = Endangered; V = Vulnerable; P = Recovery Plan completed; O = Recovery Outline completed; S = Taxon summary completed
ANZECC list	Cr = critically endangered; E = endangered; V = vulnerable
NSW Fisheries Management Act	e = Endangered; v = Vulnerable
Victorian Flora and Fauna Guarantee Act	2 = listed on Schedule 2 as Threatened; A = Action Statement completed
Victorian Rare or Threatened Species list	e = Endangered; v = Vulnerable; r = rare
	c = Restricted colonial breeding or roosting sites
	Ind = Indeterminate (known to be End, Vul or R)
	ins = Insufficiently known (suspected of being End, Vul or R)
ACT Nature Conservation Act	e = Endangered; v = Vulnerable; A = Action Plan completed

Trout Cod *Maccullochella macquariensis*

The trout cod (or bluenose cod) was once widespread in the Murray-Darling system, mostly in the upper reaches (eg. Mitta Mitta, Ovens, King and Goulburn Rivers), though recorded as far downstream as Mannum in South Australia (Reed 1993). Trout cod occupy a wide range of habitats from alpine regions to inland lowland areas. They are considered critically endangered nationally (ANZECC list and endangered under the EPBC Act), Endangered in the ACT, and in Victoria it is listed as a threatened taxon under Schedule2 of the Flora and Fauna Guarantee Act. Only two self-sustaining populations are known (Harris 1999).

In Victoria the only known viable population occurs in Seven Creeks, and originates from fish translocated from the Goulburn River in 1921 and 1922 (Reed 1993)

In New South Wales, trout cod occur naturally in the Murray River from below Yarrawonga Weir down to the Barmah Forest. They have been released into the upper Murray River near Jingellic and Tintaldra, the Murrumbidgee River near Cooma and Narrandera, and into

Talbingo and Cataract Dams. Trout cod have also been released into Bendora Dam in the ACT (Reed 1993).

Mitta Mitta Heritage River is important habitat. Although considered to be no longer present, Trout Cod are indigenous to the area and were recorded in the River prior to its inundation by Lake Dartmouth. (DNRE 1997a).

The trout cod is listed in the Mount Buffalo National Park management plan as significant fauna, with 4.6% of Victorian records being from Mount Buffalo National Park. The Alpine National Park has 2.3% of Victorian records (Parks Victoria 2000).

Macquarie perch *Macquaria australasica*

The Macquarie perch is considered endangered nationally, in Victoria and in the ACT, and in Victoria it is listed as a threatened taxon under Schedule2 of the Flora and Fauna Guarantee Act, but it may still be caught for fun or food in Victoria.

Occurs naturally north of the Great Dividing Range in tributaries of the Murray-Darling system. Introduced to a number of waters south the Divide, but now persisting as self-supporting populations only in the Yarra River and Wannon River (Barnham 1998).

Macquarie perch is typically found in the cooler, upper reaches of the Murray-Darling river system in Victoria, New South Wales and the Australian Capital Territory. The species was introduced into some coastal drainages in the late 1800s and early 1900s. There are also some natural coastal populations in New South Wales, notably the Nepean, Hawkesbury and Shoalhaven rivers (ACT Government 1999d).

Naturally a riverine fish, preferring deep holes in the cool, upper reaches of Victorian tributaries of the Murray-Darling system. Does well in impoundments with suitable spawning streams (Victoria's best population is in Lake Dartmouth where this large lake is fed by suitable shallow spawning streams including the Mitta Mitta River (Barnham 1998). Some 15 of the 206 Victorian records are from the Alpine National Park (Parks Victoria 2000).

The Mitta Mitta Heritage River is important habitat. The lower section of the river, and the long narrow inlets at the southern end of the Dartmouth Reservoir, contain the largest remaining natural population in the Murray-darling Basin (DNRE 1997a).

The major threats to the continued survival of native fish species in freshwater habitats are habitat alteration, overfishing, and introduced fish species. All three threats are considered to have had an impact on populations of Macquarie perch nationally and in the ACT (ACT Government 1999d).

Habitat modifications occur in many forms but the major classes are:
- barriers to fish passage,
- reduction in floodplain habitat,
- alteration to flow regimes below impoundments,
- reduction of instream habitat, and
- reduction in water quality (ACT Government 1999d).

Macquarie perch provides good angling and excellent eating (Barnham 1998). Overfishing is cited as one of the contributing factors in the decline of Macquarie perch and has been shown to be important in the decline of other native fish species such as Trout Cod. In Victoria in 1959 and 1960, it was estimated that between two and three tonnes of Macquarie perch were removed from the rivers flowing into Lake Eildon by recreational anglers **in the first week** of the fishing season (ACT Government 1999d). The taking of Macquarie perch from Victorian waters by rod and line in accordance with the provisions of the Fisheries Act and the Fishing Regulations is still permitted under the powers of a Governor-in-Council Order of August 1991(Barnham 1998).

Abundance and distribution reduced by construction of dams on streams, changes to river flow and temperature regimes, siltation of spawning streams and impact of introduced species including trout and redfin. (Barnham 1998).

The most serious threat from introduced fish species to Macquarie perch may lie in the impacts of an exotic disease Epizootic Haematopoietic Necrosis Virus (EHNV). This virus, unique to Australia, was first isolated in 1985 on the introduced fish species redfin perch *Perca fluviatilis.* Macquarie perch is one of several species found to be extremely susceptible to the disease (ACT Government 1999d).

Australian grayling *Prototroctes maraena*

Considered vulnerable nationally and in Victoria, the Australian grayling is one of only two species of its family. The other, in New Zealand, is considered extinct, although the reason for its extinction has never been satisfactorily understood or explained (McDowall 1996a).

The Australian grayling is known in streams draining to the sea along the south-eastern Australian coast between the Grose River in central New South Wales and the Hopkins River in western Victoria. It probably extends inland to elevations of about 1000 m, having been recorded in tributaries of the Snowy River draining the slopes of Mt Kosciuszko. It also occurs in Tasmania (McDowall 1996a).

For some time the Australian grayling was considered one of Australia's rarest and most vulnerable fish species, but in the last two decades it has been found to be more common and widespread than previously believed. Its need to migrate to and from the sea to complete its life cycle makes it vulnerable to depletion as a result of barriers to upstream and downstream migration (McDowall 1996a).

Murray Cod *Maccullochella peeli*

The Murray cod is considered vulnerable in Victoria and is listed as a threatened taxon under Schedule2 of the Flora and Fauna Guarantee Act.

It was once very abundant throughout most of the Murray–Darling system except for upper reaches of some southern tributaries, but has declined dramatically in range and abundance. It is now relatively uncommon in most areas and rare in most Victorian tributaries of the Murray (Harris & Rowland 1996a).

The decline of the Murray cod has been caused by environmental changes in the Murray–Darling system, particularly altered flow and temperature regimes and reduced frequency, magnitude and duration of floods. Other contributing factors include recreational fishing, competition with or predation by introduced redfin perch, siltation, desnagging and pollution (Harris & Rowland 1996a).

About 500,000 Murray cod fry are produced annually by hatcheries for stocking (Harris & Rowland 1996a).

Two-spined blackfish *Gadopsis bispinosus*

Considered vulnerable in the ACT, but very abundant in many streams across its range. It is widespread and often abundant in north-eastern Victoria at altitudes of 200–700 m, and its range extends into south-eastern New South Wales and the ACT (Jackson et al 1996).

There has been little published on the behaviour or biology of two-spined blackfish (ACT Government 1999j).

The reasons for the apparent decline in G. bispinosus populations in the ACT region are not known, although the major threats to the continued survival of native fish species generally in freshwater habitats are overfishing, habitat alteration and introduced fish species (ACT Government 1999j).

Australian bass *Macquaria novemaculeata*

Considered rare in Victoria, but occurring in Snowy River National Park. Its range is coastal rivers from the Mary River and Fraser Island in Queensland to tributaries of the Gippsland Lakes. It has declined severely as access to about half of the potentially available habitat has been obstructed by dams and weirs. Recruitment is also adversely affected by changes to stream flows and water quality (Harris & Rowland 1996a).

Climbing, or Broad-finned, Galaxias *Galaxias brevipinnis*

Considered rare in Victoria, but occurring in the Alpine National Park. Occurs in New South Wales, Victoria, Tasmania and South Australia, and also in New Zealand. There is evidence of high vulnerability to predation by rainbow trout in lakes and displacement by brown trout in streams (McDowall & Fulton 1996). The distribution of this species has probably been fragmented by habitat deterioration over much of its range. It prefers clear, tumbling waters in the headwaters of streams flowing through forested land. The common name comes from the Climbing Galaxias' ability to climb damp rock faces and waterfalls tens of metres high. The fish achieves this by facing up the incline, spreading the large pectoral and pelvic fins against the substrate, and wriggling the body with lizard-like movements (Australian Museum 2000).

Flat-headed Galaxias *Galaxias rostratus*

Considered rare in Victoria.

Known only from the Murray–Darling system, where it is widespread but intermittent and locally abundant at low elevations (McDowall & Fulton 1996).

Freshwater Blackfish *Gadopsis marmoratus*

The freshwater blackfish is considered "indeterminate" in Victoria, which means although its status is not more precisely known, it is known to be endangered, vulnerable or rare.

Its range is apparently considerably reduced. A decline in abundance is also evident in areas where habitat degradation has occurred, but it remains common in many areas (Jackson et al 1996).

Mountain Galaxiid *Galaxias olidus*

Considered insufficiently known in Victoria (suspected of being Endangered, Vulnerable or Rare). 3.2% of Victorian records are from the Alpine National Park (Parks Victoria 2000).

It remains very widespread and locally abundant through its extensive range, but is sensitive to the introduction of trout to its habitat and may disappear in the presence of trout (McDowall & Fulton 1996).

Dwarf flat-headed gudgeon *Philypnodon sp. nov.*

Considered insufficiently known in Victoria (suspected of being Endangered, Vulnerable or Rare). Recorded from Snowy River National Park.

Occurs in coastal streams of southern Queensland and New South Wales, Victoria and South Australia; also known from Bathurst and a few localities in the Murray River in New South Wales and South Australia (Larson & Hoese 1996).

4.6 Insects

Table 4.6 Insect species of the Australian Alps national parks considered significant:

Common name	Scientific name	IUCN	EPBC Act	ANZECC list	NSW TSC Act	Vic FFG Act	VROTS	ACT NC Act
Alpine stonefly	*Thaumatoperla flaveola*					2		
Bogong Moth	*Agrotis infusa*							
Alpine mayflies	*Ameletoides lacusalbinae*							
Stonefly	*Austrocerella hynesi*							
Stonefly	*Austrocerella verna*							
Caddisfly	*Austropsyche bifurcata*							
Rayed Blue Butterfly	*Candalides heathi alpinus*							
Caddisfly	*Chimarra monticola*							
Mayfly	*Coloburiscoides munionga*							
Reduced-wing Stonefly	*Eusthenia venosa*							
Caddisfly	*Helicopsyche tillyardi*							
Kosciuszko Mtn Grasshopper	*Kosciuscola tristis tristis*							
Stonefly	*Leptoperla cacuminis*	V						
Stonefly	*Leptoperla rieki*							
Stonefly	*Leptoperla sp. nr. tasmanica*							
Spotted grasshopper	*Monistria concinna*							
Ground beetle	*Notonomus carteri*							
Ground beetle	*Notonomus kosciuskianus*							
Moth	*Oenochroma alpina*							
Alpine Silver Xenica	*Oreixenica latialis theddora*							
Caddisfly	*Polyplectropus lacusalbinae*							
Metallic Cockroach	*Polyzosteria viridissima*							
Stonefly	*Riekoperia intermedia*					2		
Ground beetle	*Scopodes splendens*							
Moth	*Synemon sp.*							
Caddisfly	*Tasimia atra*							
Mayfly	*Tasmanophlebia lacuscoerulei*							
Mayfly	*Tasmanophlebia nigrescens*							
Ground beetle	*Teraphis crenulata*							
Hairy cicada	*Tettigarcta crinita*							

IUCN	V = Vulnerable
Commonwealth Environment Protection and Biodiversity Conservation Act	E = Endangered; V = Vulnerable; P = Recovery Plan completed; O = Recovery Outline completed; S = Taxon summary completed
ANZECC list	Cr = critically endangered; E = endangered; V = vulnerable
NSW Threatened Species Protection Act	e = Endangered; v = Vulnerable; P = Threatened Species Profile completed
Victorian Flora and Fauna Guarantee Act	2 = listed on Schedule 2 as Threatened; A = Action Statement completed
Victorian Rare or Threatened Species list	e = Endangered; v = Vulnerable; r = rare
	c = Restricted colonial breeding or roosting sites
	Ind = Indeterminate (known to be End, Vul or R)
	ins = Insufficiently known (suspected of being End, Vul or R)
ACT Nature Conservation Act	e = Endangered; v = Vulnerable; A = Action Plan completed

4.7 Other invertebrates

Table 4.7 Invertebrate species of the Australian Alps national parks, other than insects and cave fauna, considered significant:

Common name	Scientific name	IUCN	EPBC Act	ANZECC list	NSW TSC Act	Vic FFG Act	VROTS	ACT NC Act
Murray River crayfish	*Euastacus armatus*	V						vA
Freshwater crayfish	*Euastacus crassus*	E						
Freshwater crayfish	*Euastacus woiwuru*							
Spider	*Sternodes castaneous*							
Mountain Earthworm	*Graliophilus montkosciuskoi*							
Mountain Earthworm	*Graliophilus woodi*							
Kosciuszko Funnel Web Spider	*Hadronyche sp*							
Wolf Spider	*Lycosa kosciuskoensis*							
Wolf Spider	*Lycosa musgravei*							
Wolf Spider	*Lycosa summa*							
Peripatus, Velvet worms	Onychopohora - *Peripatoides leuckartii*							

IUCN	E = Endangered; V = Vulnerable; L = Lower risk, near threatened
Commonwealth Environment Protection and Biodiversity Conservation Act	E = Endangered; V = Vulnerable; P = Recovery Plan completed; O = Recovery Outline completed; S = Taxon summary completed
ANZECC list	Cr = critically endangered; E = endangered; V = vulnerable
NSW Threatened Species Protection Act	e = Endangered; v = Vulnerable; P = Threatened Species Profile completed
Victorian Flora and Fauna Guarantee Act	2 = listed on Schedule 2 as Threatened; A = Action Statement completed
Victorian Rare or Threatened Species list	e = Endangered; v = Vulnerable; r = rare
	c = Restricted colonial breeding or roosting sites
	ins = Insufficiently known (suspected of being End, Vul or R)
ACT Nature Conservation Act	e = Endangered; v = Vulnerable; A = Action Plan completed

4.8 Cave fauna

Cave invertebrates are often confined to one or a few caves, because movement in the open is difficult or impossible.

Many troglobites (species which can live only in caves) are relicts of some antiquity and only distantly related to surface forms. They may be phylogenetic relicts, with no close living relatives, or they are distributional relicts, having survived in a geographic region in subterranean refugia. They provide valuable insights into the zoogeographic and evolutionary history of our faunas (Eberhard & Spate 1995).

Table 4.8 Fauna confined to the caves of Kosciuszko National Park, or there and very few other localities.

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1 Eberhard, S and Spate A, 1995, Cave Invertebrate Survey: Toward an Atlas of NSW Cave Fauna, Copyright Dept Urban Affairs and Planning and the Australian Heritage Commission

2 NSW NPWS, 2000b, Yarrangobilly Management Unit Kosciuszko National Park Karst Area Management Plan (draft), NSW NPWS

JI Jo Ingarfield pers.comm.

4.9 Fauna — Status, Distribution and Threats

See following table

Table 4.9 Fauna - Conservation Status, Distribution and Threats

Species	Cw	ANZ	TSC	FFG	VRT	NCA	ANP	Buff	SR	KNP	Brin	Bimb	Sc	NNP	Threats
Note: codes are explained at the end of this Table (page 74).	Cwlth EPBC Act	ANZECC list	NSW TSC Act	Victorian FFG Act	VROTS	ACT NC Act	Alpine NP	Mt Buffalo NP	Snowy River NP	Kosciuszko NP	Brindabella NP	Bimberi NR	Scabby Range NR	Namadgi NP	Threats (Note: some of these threats apply only outside the Australian Alps national parks. Their operation outside the parks underlines the importance of the parks in the conservation of these species.)
MAMMALS															
Burramys parvus	EO	E	v	2A	v		+			1					The main threat to the species is habitat destruction and fragmentation from human activities associated with skiing and alpine resort development. These include absolute destruction, weed invasion, erosion, soil deposition, and interruption of the breeding cycle and hibernation (Mansergh, Kelly & Johnston 1991); habitat loss and degradation, disruption of movement corridors, skiing and associated activities, predation (mainly by foxes), possibly competition from rabbits, rats and house mice, fire, global warming (NSW NPWS 2000c). Major - clearing, recreation; moderate - wildfires, introduced species, grazing/trampling, road construction and maintenance; minor - pest control (JCVRFASC 1998b); weeds (Adair & Groves 1998).
Canis familiaris dingo					ins		+	+	+	+	L	L	L	L	Moderate - timber harvesting, wildfires, introduced species, pest control; minor - clearing, managed fires, grazing/trampling, vandalism, dams/impoundments (JCVRFASC 1998b); interbreeding with wild domestic dogs.
Dasyurus maculatus	VO	V	v	2A	v		+	+	+	2	+	L	L	1	Within most of its current range, native forests are cleared, timber harvested and trapping and baiting is carried out to control wild dogs and foxes (Mansergh & Belcher 1992). Major - timber harvesting, pest (feral predator) control by inappropriate methods; moderate - clearing, managed fires, wildfires, introduced species, vandalism; minor - grazing/trampling, road construction and maintenance, tree dieback, recreation, dams/impoundments (JCVRFASC 1998b)
Falsistrellus tasmaniensis			v				+	+	+	2	L	+	+	+	Clearing/fragmentation of preferred foraging habitat, changes to forest ooverstorey structure leading to loss of hollow-bearing trees (W/shop)
Gymnobelideus leadbeateri	EP	E		2A	e		+								availability of nest trees will decline (Macfarlane, Lowe & Smith 1995)
Macropus robustus					r		+		+					+	
Mastacomys fuscus			v				+	+		2	+	+	+	7	moderate - managed fires, wildfires, introduced species, grazing/trampling, minor - clearing, timber harvesting, recreation,

Species	Cw	ANZ	TSC	FFG	VRT	NCA	ANP	Buff	SR	KNP	Brin	Bimb	Sc	NNP	Threats
															dams/impoundments (JCVRFASC 1998b); global warming leading to lack of snow base through winter, predation by feral foxes, dogs and cats (W/shop)
Miniopterus schreibersii			v	2	c		+	L	L	2	L	L	L	+	Major - vandalism; moderate - introduced species, pest control; minor - clearing (JCVRFASC 1998b)
Nyctophilus timoriensis			v							+	+				Clearing/fragmentation of preferred foraging habitat, changes to forest ooverstorey structure leading to loss of hollow-bearing trees (W/shop)
Petaurus australis	S		v				+			2	+			4	Threats are habitat reduction and alteration through land clearing for agriculture and timber harvesting. Will suffer declines in density with the removal of old growth elements from unlogged forests or from previously lightly-logged forests. Requirement for variety of feed trees in mixed forest over large home range and need for hollows in which to nest mean that effective conservation can only be achieved through reservation of forest. Pair for life, so extensive areas required. Isolated populations such as those in far western Victoria and south-eastern SA may not be viable in the long term (Maxwell, Burbidge & Morris (eds) 1996d). Major - timber harvesting; moderate - clearing, wildfires; minor - managed fires, introduced species, grazing/trampling, road construction and maintenance, dams/impoundments (JCVRFASC 1998b)
Petaurus norfolcensis	S		v							+	L				Threats are steady attrition of quality and extent of habitat remnants due to removal of timber for both sawn products and firewood; lack of suitable hollows in most habitat remnants on the inland slopes; lack of regeneration of trees and shrubs due to grazing by stock, rabbits and macropods and inappropriate fire regimes; removal of habitat during prospecting and mining for gold; tree decline in rural lands and outbreaks of leaf-skeletonising caterpillars in riverine forests; and further coastal development in NSW and south-east Queensland (Maxwell, Burbidge & Morris (eds) 1996c). Major - clearing; moderate - timber harvesting, managed fires, wildfires, grazing/trampling, road construction and maintenance, tree dieback; minor - introduced species, pest control, recreation (JCVRFASC 1998b)
Petrogale penicillata	VO	V	v	2A	e	eA	+		+	1				1	Predation by the fox, cat , dingo and/or wild dog; competition with goats, rabbits and sheep; management of land between populations incompatible with the species' survival; hunting; disease; climatic change; wildfire; and drought (ACT Government 1999b); the main threat to this species appears to be the successive extinction of the remaining small, isolated populations following a natural catastrophe such as a wildfire or drought. Predation, in particular by the Red Fox (Vulpes vulpes) and possibly feral Cats (Felis catus), has reduced the likelihood of successfully recolonising areas where populations have become extinct. In addition, the carrying capacity and thus the size of each population may now be smaller because of competition with goats or rabbits (Hill & Baker-Gabb 1994)

Species	Cw	ANZ	TSC	FFG	VRT	NCA	ANP	Buff	SR	KNP	Brin	Bimb	Sc	NNP	Threats
Phascogale tapoatafa	S		vP	2A						2				1	Fragmentation of remnant habitat, loss of nest hollows and inappropriate fire regimes affect habitat quality and are thought to be contributing factors in their decline, as is predation by the introduced fox and cat (Humphries & Seebeck 1997), (NSW NPWS 1999g). Also competition for nest hollows with the introduced honeybee, and natural or other hazards acting on populations fragmented by habitat loss (NSW NPWS 1999g). Major - clearing; moderate - timber harvesting, wildfires, introduced species; minor - managed fires, grazing/trampling, pest control, road construction and maintenance, tree dieback (JCVRFASC 1998b). Major - predation; moderate natural disasters (fire, drought) (JCVRFASC 1996)
Phascolarctos cinereus	S		v							2	L			4	Current threats are continued habitat destruction, fragmentation and modification, bushfires and disease, as well as drought associated mortality in habitat fragments. There are management problems with many populations, with remnant populations living at high densities in isolates of habitat being at greatest risk. Predation, especially by domestic dogs, and mortality due to motor vehicles are of concern in some areas. Public concern for the species is high (Maxwell, Burbidge & Morris (eds) 1996b).
Potorous longipes	E	E	eP	2A	e		+								The influence of introduced predators is thought to be an important factor limiting the distribution and abundance of the Long-footed Potoroo. Much of the known distribution of the species is in forest subject to fuel-reduction burning, and most is in State forest and is thus available for timber harvesting. All of its distribution is in areas vulnerable to periodic wildfires (Thomas, Henry & Baker-Gabb 1994). Disturbance of food sources by fire or logging, habitat fragmentation, and predation by dogs, foxes and possibly cats (NSW NPWS 1999h). Major - timber harvesting; moderate - managed fires, wildfires, introduced species, road construction and maintenance; minor - clearing, grazing/trampling, pest control, dams/impoundments (JCVRFASC 1998b). Major - predation (JCVRFASC 1996)
Pseudomys fumeus	EO	E	eP		r	eA	+			1	L			1	vegetation clearance, resulting in loss of habitat and likely contraction of range; inappropriate fire regimes, resulting in changes to the floristic composition of ground and shrub vegetation - may have deleterious effects on food sources; and predation by the introduced dog, fox and cat - may be significant for small isolated populations; fragmentation of many of the remaining forest habitats, the effects of wildfires, inappropriate fire regimes and predation are all likely to exacerbate serious problems resulting from reduced dispersal, recolonisation ability and gene flow (ACT Government 1999g), (NSW NPWS 1999i). Also cattle and rabbit grazing resulting in reduction in food resources and the depletion of shrub cover (NSW NPWS 1999i). Major - managed fires; moderate - timber harvesting, wildfires, introduced species; minor - clearing, grazing/trampling, road construction

Species	Cw	ANZ	TSC	FFG	VRT	NCA	ANP	Buff	SR	KNP	Brin	Bimb	Sc	NNP	Threats
															and maintenance, recreation, dams/impoundments (JCVRFASC 1998b)
Rhinolophus megaphyllus				2	c		+		+						Major - vandalism; moderate - introduced species, pest control (JCVRFASC 1998b)
Scotorepens orion					ins										
BIRDS															
Calyptorhynchus lathami			v	2	v				+	2			+	+	Minor - clearing, managed fires, grazing/trampling (JCVRFASC 1998b)
Falco hypoleucus (apparently wrong identification)			v	2A						2					Clearing and grazing of arid zone habitat, the destruction of raptors because they were thought to prey on domestic poultry, and the use of pesticides have all had an adverse effect on the species (Venn 1997)
Falco peregrinus							+	+	+	+	+			+	
Gallinago hardwickii										2				+	
Haliaeetus leucogaster				2A	r		+		+						Increased human presence, direct poisoning during dog and fox control programs, secondary poisoning during rabbit control programs, deliberate shooting, eggshell thinning because of the past use of DDT, and food chain contamination by heavy metals (Clunie 1994). Moderate - clearing, timber harvesting, road construction and maintenance, recreation; minor - pest control, tree dieback, vandalism (JCVRFASC 1998b)
Lathamus discolor	E	V	v	2	e	vA	+		+						clearing for agriculture, urban development and forestry operations (ACT Government 1999h). Major - clearing; moderate - timber harvesting, grazing/trampling, tree dieback; minor - introduced species, road construction and maintenance (JCVRFASC 1998b)
Lophoictinia isura			v		v				+						Moderate - clearing, timber harvesting, managed fires, wildfires, vandalism; minor - grazing/trampling, road construction and maintenance, tree dieback (JCVRFASC 1998b)
Neophema pulchella				2	r		+		+						
Ninox connivens			v								L			+	

Species	Cw	ANZ	TSC	FFG	VRT	NCA	ANP	Buff	SR	KNP	Brin	Bimb	Sc	NNP	Threats
Ninox strenua			v	2	r		+	+	+	2	+	+	+	+	Major - timber harvesting, wildfires; moderate - clearing, managed fires; minor - pest control, road construction and maintenance, tree dieback (JCVRFASC 1998b)
Pachycephala olivacea			v							2	+	+	+	+	
Petroica rodinogaster/ phoenicea			v							2	+			+	Moderate - timber harvesting, tree dieback, climate change; minor - clearing, managed fires, wildfires, grazing/trampling (JCVRFASC 1999)
Tyto novaehollandiae			v	2	r		+				L				Major - clearing, pest control; moderate - timber harvesting, managed fires, wildfires, grazing/trampling, tree dieback; minor - introduced species, road construction and maintenance (JCVRFASC 1998b)
Tyto tenebricosa			v	2	r		+		+	2	L				Major - timber harvesting, wildfires; moderate - clearing, managed fires; minor - pest control, road construction and maintenance, tree dieback (JCVRFASC 1998b)
Xanthomyza phrygia	E	E	e	2A	e	eA	+		+						loss of its box woodland habitat (ACT Government 1999f); The Regent Honeyeater has a low population level based on the 1988-1990 survey - between 500 and 1500 is considered a reasonable estimate - and low population densities throughout its range. It has specialised habitat requirements with an apparent reliance on a small number of favoured sites. There have been significant reductions in the extent and quality of habitat (Menckhorst 1993). Major - clearing, tree dieback; moderate - timber harvesting, wildfires, grazing/trampling; minor - introduced species, road construction and maintenance (JCVRFASC 1998b)
REPTILES															
Amphibolurus (Tympanocryptis) diemensis					ins		+	L		+	+	+	+	+	(Listed in Victoria for Grampians form/sub-species.)
Cyclodomorphus praealtus				2	v		+	+		1					Major - clearing, grazing/trampling, recreation; moderate - managed fires, wildfires; minor - introduced species, road construction and maintenance, dams/impoundments (JCVRFASC 1998b)
Egernia sp															
Egernia sp. 1										2					
Egernia sp. 2										2					
Eulamprus kosciuskoi							+			3	+			+	
Pseudemoia cryodroma				2	v										
Pseudemoia rawlinsoni					ins		+							+	
Sphenomorphus kosciuskoi				2	v		+			+				+	
Tiliqua casuarinae					v		+								
Varanus varius					ins		+		+						Timber removal, feral predators (W/shop)

Species	Cw	ANZ	TSC	FFG	VRT	NCA	ANP	Buff	SR	KNP	Brin	Bimb	Sc	NNP	Threats
FROGS															
Helioporus australiacus	V	V	v	2A	r		+		+						Fluctuations of stream conditions caused by human activities such as timber harvesting and roading may not be within the tolerance ranges of these tadpoles resulting in reduced recruitment to the adult population (Mazzer 1994). Major - timber harvesting; moderate - clearing, managed fires, wildfires, introduced species, grazing/trampling, road construction and maintenance, mining/quarrying (JCVRFASC 1999).
Limnodynastes dumereli fryii															Found only in the Australian Alps (Green & Osborne 1994)
Litoria booroolongensis			e							1					Cause of decline unknown - future threats include habitat modification, hydrological change, introduced fish (trout, carp, goldfish, redfin and gambusia), terrestrial predators (foxes and cats) (Gillespie 1999)
Litoria citropa					r		L		+						Predation of eggs and tadpoles by trout
Litoria* sp. affin. *phyllochroa														+	New species found in 1993. Occurs only upstream of Bendora Dam.
Litoria spenceri	E	Cr	e	2	e		+	+		1					Predation of eggs and tadpoles by introduced fish species (ie. trout); habitat destruction and/or modification leading to increased sedimentation of streams; alteration of natural flow regimes of streams through man-made diversions, impoundment's etc; atypical climatic events (ie. extremes of temperature and/or rainfall and associated flooding); invasion of weed plant species (ie. blackberry) into riverine habitats and the use of herbicides to control them; and disease (NSW NPWS 1999d). Major - introduced species, mining/quarrying; moderate - timber harvesting, grazing/trampling, pest control, road construction and maintenance, recreation, dams/impoundments; minor - clearing (JCVRFASC 1998b)
Litoria verreauxii alpina	V	V					+			1				+	UV-B radiation, and possibly drought (Hunter, Osborne & Smith 1997). Major - grazing/trampling; moderate - recreation; minor - pest control, road construction and maintenance (JCVRFASC 1998b)
Philoria frosti	E	Cr		2A											Threats include broad environmental factors such as prolonged drought, wildfire, and the enhanced greenhouse effect. Vulnerability is increased by the pressures of recreational activities within its range, including: destruction of habitat due to clearing or modification of vegetation for ski-slope and ski-trail development; destruction and degradation of habitat and impacts on breeding due to the off-site effects of development from within the Mount Baw Baw Alpine Resort, associated roads and carparks; and disturbance to breeding due to changes in water quality and flows resulting from waste disposal from the resort and altered hydrology from impacts of

Species	Cw	ANZ	TSC	FFG	VRT	NCA	ANP	Buff	SR	KNP	Brin	Bimb	Sc	NNP	Threats
															visitors (James & Morey 1993).
Pseudophryne corroboree	E	Cr	e							1					Cause of decline unknown - future threats include climate change, UV-B radiation, disease, fires (especially in autumn), site disturbance (especially in ski resorts), specimen collection, feral animals (pigs), and ongoing effects of grazing, construction activities, and fertilisers used in rehabilitation (NSW NPWS 1999c).
Pseudophryne pengilleyi	V	V	v			vA				2	+			+	pigs, fire, weeds, global warming, habitat disturbance, drought (ACT Government 1998c); Cause of decline unknown; future threats include global warming, UV-B, disease, fires (wild and managed), weeds, feral animals, hydrological changes from tracks and roads, specimen collection (NSW NPWS 1999b)
FISH															
Gadopsis bispinosus						vA	+	+		+	+			+	overfishing, habitat alteration and introduced fish species (ACT Government 1999j); sedimentation (W/shop)
Gadopsis marmoratus					ind		+	+	+						Moderate - predation, altered hydrology (JCVRFASC 1996) ; sedimentation (W/shop)
Galaxias brevipinnis					r		+								Considered a threat as its range is expanding (W/shop)
Galaxias olidus					ins		+	+	+	2	+			+	Moderate - predation, competition; minor - altered hydrology (JCVRFASC 1996)
Galaxias rostratus					r			+							
Maccullochella macquariensis	EO	Cr	e*	2A	e/v	eA	+?	+						?	overfishing, habitat alteration and introduced fish species (ACT Government 1999i); angling, introduction of trout, and activities that damage rivers, including sedimentation, dams, and river improvement works (eg. desnagging and channel modification) (Reed 1993); widespread degradation of aquatic ecosystems caused by river regulation, riparian and catchment damage, siltation and establishment of alien species; alterations to flow regimes and habitat conditions (including flow variability, substrate condition, temperature extremes, nutrient transport and fish passage at barriers) below impoundments; diseases associated with alien species and aquaculture (eg EHN disease of redfin perch, BLPV, tapeworm *Bothriocephalus*, and anchor-worm *Lernaea* infestation) Harris 1999
Maccullochella peeli				2	v		+								
Macquaria australasica	EO	E	v*	2	v	eA	+				+			?	overfishing, habitat alteration and introduced fish species (ACT Government 1999d); widespread degradation of aquatic ecosystems caused by river regulation, riparian and catchment damage, siltation and establishment of alien species; alterations to flow regimes and habitat conditions (including flow variability, substrate condition, temperature extremes, nutrient transport and fish passage at barriers) below

Species	Cw	ANZ	TSC	FFG	VRT	NCA	ANP	Buff	SR	KNP	Brin	Bimb	Sc	NNP	Threats
															impoundments; diseases associated with alien species and aquaculture (eg EHN disease of redfin perch, BLPV, tapeworm *Bothriocephalus*, and anchor-worm *Lernaea* infestation) Harris 1999
Macquaria novemaculeata					r				+						Moderate - predation, altered hydrology (JCVRFASC 1996)
Philypnodon sp. nov.					ins				+						
Prototroctes maraena	VO	V		2	v		+		+						Moderate - altered hydrology; minor - predation (JCVRFASC 1996) ; widespread degradation of aquatic ecosystems caused by river regulation, riparian and catchment damage, siltation and establishment of alien species; poor understanding of the Australian grayling's biology and threatening processes inhibit development of sound conservation management Harris 1999
INSECTS															
Agrotis infusa										3				+	
Ameletoides lacusalbinae										3					
***Aphrotenia* sp**														+	Rare un-named species, larvae found in two localities in Namadgi NP
Austrocerella hynesi										2					
Austrocerella verna										2					
Austropsyche bifurcata										2					
Candalides heathi alpinus										3					
Chimarra monticola										2					
Coloburiscoides munionga										2					
Eusthenia venosa										2					
Helicopsyche tillyardi										2					
Kosciuscola tristis tristis										3					
Leptoperla cacuminis										2					
Leptoperla rieki										2					
Leptoperla sp. nr. tasmanica										2					
Monistria concinna										3					
Notonomus carteri										2					
Notonomus kosciuskianus										2					
Oenochroma alpina										2					
Oreixenica latialis theddora								+							

Species	Cw	ANZ	TSC	FFG	VRT	NCA	ANP	Buff	SR	KNP	Brin	Bimb	Sc	NNP	Threats
Polyplectropus lacusalbinae										2					
Polyzosteria viridissima										2				+	
Scopodes splendens										2					
Synemon sp.										2					
Tasimia atra										2					
Tasmanophlebia lacuscoerulei										2					
Tasmanophlebia nigrescens										2					
Teraphis cavicola										2					
Teraphis crenulata										2					
Tettigarcta crinita										3					
Thaumatoperla flaveola				2			+								
OTHER INVERTEBRATES															
Arachnida - Lycisidae										+					
Arachnida - Sternodes castaneous										e					
Euastacus armatus	ind		ind			vA	+	+		+					habitat alteration, overfishing and possibly interactions with introduced fish species (ACT Government 1999e)
Euastacus crassus							+			+				+	
Euastacus woiwuru							+?								
Graliophilus montkosciuskoi										2					
Graliophilus woodi										2					
Hadronyche sp										2					
Icona sp nov										e					
Lycosa kosciuskoensis										2					
Lycosa musgravei										2					
Lycosa summa										2					
Nemertea															
Onychopohora - Peripatoides leuckartii															
Platyhelminthes - Tricladida															

Notes:

EPBC Act	E = Endangered; V = Vulnerable; P = Recovery Plan completed
	O = Recovery Outline completed; S = Taxon summary completed
ANZECC list	Cr = critically endangered; E = endangered; V = vulnerable
TSP Act	e = Endangered; v = Vulnerable; P = Threatened Species Profile completed e*= endangered and v*=vulnerable under the Fisheries Management Act 1994
FFG Act	2 = listed on Schedule 2 as Threatened; A = Action Statement completed
VROTS	e = Endangered; v = Vulnerable; r = rare
	c = Restricted colonial breeding or roosting sites
	ins = Insufficiently known (suspected of being End, Vul or R)
	ind = Indeterminate (known to be End, Vul or R)
NC Act	e = Endangered; v = Vulnerable; A = Action Plan completed
Alpine NP	+ = present
Mt Buffalo NP	+ = present
Snowy River NP	+ = present
Kosciuszko NP	1 = Category 1 (Highly Significant) natural feature
	2 = Category 2 (Very Significant) natural feature
	3 = Category 3 (Significant) natural feature
	+ = present ; e = endemic to Kosciuszko NP
Brindabella NP	+ = present; L = likely to be in park
Bimberi NR	+ = present
Scabby Range NR	+ = present
Namadgi NP	Number = number of significant sites
	+ = present

5. Flora

5.1 Vascular Plants

Perhaps the most distinctive feature of the Australian Alps is the dominance of one genus, *Eucalyptus*, from close to sea level to the treeline, with species replacing each other in altitudinal, topographic and edaphic sequences, rather than there being distinct forest zones dominated by taxa in unrelated genera, as is the typical situation elsewhere in the world. *Eucalyptus* forms globally unique forests and woodlands with its open canopies, consequently diverse understoreys, its dependence upon and resistance to fire and its toleration of nutrient-poor soils. While eucalypt forests are widespread in Australia and some islands to the north, it is only in the Australian Alps that a wide diversity of eucalypt-dominated communities extend uninterrupted from the close to sea level to the treeline. Much of this eucalypt forest has never been logged and has only lightly, if ever, been grazed, with individual plants that were alive when the gathering and hunting societies were destroyed during the British invasion. Relatively few other temperate mountain areas of the world have forest vegetation in such a natural state (Kirkpatrick 1994 #).

Most of the eucalypt species are not rare or threatened, but collectively they comprise an extraordinary ecological phenomenon.

Kirkpatrick (1994) highlighted the apparent ecological independence between overstorey and understorey and the relatively high degree of hybridisation and intergradation between the dominants of the eucalypt forest which covers almost all of the area.

Almost all native species found in the Australian Alps are Australian endemics. Approximately 40% of the higher plant taxa found in the alpine vegetation do not occur in the alpine areas of Tasmania. The Australian Alps represent one extreme in biotic variation in the most biotically distinct of continents (Kirkpatrick 1994 #).

The alpine vegetation is dominated by large herbs to a degree in excess of any other alpine area in the world, although small areas of similar vegetation occur in the Southern Alps of New Zealand (Kirkpatrick 1994 #).

On the limestone soils in the Yarrangobilly and Blue Water Holes area, a flora adapted to the alkaline soil conditions has developed. Several species are now restricted in distribution to these soils and a *Grevillea* from the area still remains to be described. In the cold air drainage valleys of the northern end of Kosciuszko National Park where the nightly inversion of the air mass can produce sub-zero temperatures another specialised flora has also developed. The valleys are treeless and dominated by tussocky snowgrasses, (*Poa* spp.) with a fringing occurrence of *Eucalyptus stellulata* around the valley sides defining the temperature level suitable for tree growth. This valley fringing community of *E. stellulata* is the only area where another tree species replaces the otherwise ubiquitous *E. pauciflora* in the areas of cold temperature extremes (Good 1992a).

Another community of particular interest is the remnant rainforest occurring in small discrete areas in southeastern facing gully lines in the Geehi Valley. These small areas of rainforest are the only direct vegetation links in the Park with the ancient Gondwanan flora. These rainforest gullies support a remnant single tree species forest of *Atherosperma moschatum*. The species has primitive flowers possessing numerous stamens and free carpels but it survives in the Park entirely by vegetative regeneration (Good 1992a).

The retention of these rainforests is very much dependent on the shade and protection afforded by the adjoining tall eucalypt forest, so management must ensure wildfires do not destroy the eucalypt forest canopy or enter the rainforest communities. The communities ' continue to exist in very marginal micro-climate environments and very minor changes in the humidity and temperature regimes would result in their extinction in the Park (Good 1992a).

The dynamics of the *Callitris* forests also have an interesting relationship with fire. Like many tree species in fire-prone environments around the world *Callitris* is fire-sensitive as an individual, but regenerates profusely from seed released from persistent cones. This means that, if two fires are less than the period between germination and seed ripening apart, *Callitris* can be eliminated from a site. Consequently, *Callitris* tends to occur in places protected from the effects of severe fire by low productivity or rockiness (Kirkpatrick 1994 #).

Twenty-four plant species are considered endangered or vulnerable nationally (Table 5.1), seven are too poorly known to classify (Table 5.2), and 78 more are endangered or vulnerable in New South Wales or Victoria (**Table 5.4**). One endangered species, *Gentiana bauerlenii*, is known from Namadgi National Park. Button wrinklewort (*Rutidosis leptorhynchoides*) is the only rare or threatened plant species reported from Brindabella National Park.

Gentiana bauerlenii

Gentiana baeuerlenii is a small annual herb, standing 2-4 cm high. The species is currently known only from one location, which was identified during a remarkable chance rediscovery in the Orroral Valley, Namadgi National Park. It was believed to be extinct, having previously been described from the Quidong area near Bombala NSW, from specimens found there in 1887 (ACT Government 1998b). Now considered endangered (Cross 1990), it was earlier presumed extinct (Newman 1964). Its presumed extinction was believed to be caused by agriculture, domestic and feral grazing, and possibly competition from weeds.

> Species with known populations <1000 plants which are wholly in reserve(s) (Briggs & Leigh 1996)*:*
>
> *Gentiana baeuerlenii*
> *Kelleria laxa*
> *Olearia rhizomatica*

It is very likely that the species was once widespread but has become restricted through activities associated with land clearing and grazing, particularly in times of drought as the wet grassy areas in which it is found would have remained palatable well into the driest seasons. Although the species is likely to be unpalatable to stock because it contains chemicals known to render plants distasteful, it could have been grazed inadvertently, along with other herbage species. Its habitat may have been trampled, especially when adjoining areas dried out (ACT Government 1998b).

There are now only a few plants at the site, less than ten having been counted in 1994. At the time of discovery in 1992, 20 plants were observed.

The main threat to survival of this population and therefore the species is likely to be deliberate or unintended actions associated with park management activities in the local area. It is not clear whether grazing animals such as kangaroos may also pose a threat to survival of remaining plants, or whether such grazing may benefit the species by keeping competing grass tussocks and other plant growth short and open (ACT Government 1998b).

Enigmatic greenhood orchid *Pterostylis aenigma*

Very localised in Victoria, it is known only from near Omeo where it grows on sheltered slopes near streams in tall open-forest (Walsh & Entwhistle (eds) 1994).

Button wrinklewort *Rutidosis leptorrhynchoides*

The vast majority of the range of this species is outside the Australian Alps national parks.

The button wrinklewort appears to have been formerly widespread across the western plains of Victoria, and south-eastern New South Wales. The species has a disjunct distribution and is known from 16 populations in the ACT region (nine within the ACT, six across the border

Table 5.1 Species considered endangered or vulnerable nationally

Common name	Scientific name	EPBC Act	ANZECC list	ROTAP (see Table 5.3)	NSW TSC Act	Vic FFG Act	VROTS	ACT NC Act
	Gentiana baeuerlenii	E	E	2ECit	e			eA
Cotoneaster pomaderris	*Pomaderris cotoneaster*	E	E	3ECi	e	t		
Enigmatic greenhood orchid	*Pterostylis aenigma*	E	E	2KC-			r	
Button wrinklewort	*Rutidosis leptorrhynchoides*	E	E	3ECa	e	tA		eA
River swamp wallaby grass	*Amphibromus fluitans*	V	V		v			
Maidenhair spleenwort	*Asplenium hookerianum*	V	V	3VC-+			e	
Gland burr daisy	*Calotis glandulosa*	V	V	3VC-	v			
? Bent-grass	*Deyeuxia pungens*	V	V	2KC-t			v	
Yellow donkey orchid	*Diuris ochroma*	V	V				v	
Cushion cudweed/ Shining cudweed	*Euchiton nitidulus*	V	V	3VCa+	vR		v	
Thick eyebright	*Euphrasia crassiuscula ssp. glandulifera*	V	V				v	
Bogong eyebright	*Euphrasia eichleri*	V	V	2VC-			v	
Drapetes	*Kelleria laxa*	V	V	2VCit+			e	
Ovate phebalium	*Nematolepis squamea subsp. coriacea*	V	V				v	
	Pomaderris brunnea	V	V				v	
Pale pomaderris	*Pomaderris pallida*	V	V	2VCi	v			
Bent pomaderris	*Pomaderris sericea*	V	V	3VCi		t	v	
Snow pratia	*Pratia gelida*	V	V	2RC-			v	
Leafy greenhood	*Pterostylis cucullata*	V	V	3VCa	v	tA	v	
Anemone buttercup	*Ranunculus anemoneus*	V	V	2VCat	vR			
Monaro golden daisy/Tufted wrinklewort	*Rutidosis leiolepis*	V	V	2VC-	v			
Mountain grass/Small alpine grass/Feldmark grass	*Rytidosperma pumilum*	V	V	2VC-t+	vR			
Austral toadflax	*Thesium australe*	V	V	3VCi+	v	tA	e	
Snowy River westringia	*Westringia cremnophila*	V	V	2VC-			v	

E = endangered nationally; V = vulnerable nationally

e = endangered in NSW, Victoria or ACT; v = vulnerable in NSW, Victoria or ACT; r = rare in Victoria; t = listed under the Victorian Flora and Fauna Guarantee Act as threatened

A = action plan or statement completed; R = draft recovery plan written

near Queanbeyan and one recently discovered near Goulburn) and nine in Victoria. Current populations range in size from five to round 95,000 plants and are often restricted to small, scattered refugia that have escaped grazing, ploughing and the application of fertilisers, for example, road margins, railway easements and cemeteries (ACT Government 1998d).

It is estimated that 95% of Victoria's native lowland grasslands have been substantially altered since European settlement. Historically, the decline of the Button Wrinklewort is linked with the destruction of its grassland habitat. The major grassland type known to contain Button Wrinklewort is the Western (Basalt) Plains Grassland community. This community has been listed as threatened on Schedule 2 of the Flora and Fauna Guarantee Act 1988, since only about 0.16% of the original extent of the community now remains and the decline is continuing (Humphries & Webster 1992).

Maidenhair spleenwort *Asplenium hookerianum*

Maidenhair spleenwort is a cvery rare fern in Australia; known only from a few collections from among rocks or on rock ledges in the Mt Kosciuszko region and eastern Victoria, and on wet rock walls in dark forest in the valleys of the Franklin and Hellyer Rivers, Tasmania; it is also common in New Zealand (Brownsey 1998). In Victoria it is known only from two localities on the Snowy Range, south of Mt Howitt (Walsh & Entwhistle (eds) 1994).

Cushion cudweed/Shining cudweed *Euchiton nitidulus*

Shining cudweed is a low, mat-forming perennial daisy, with crowded stems only a few centimetres tall. There are perhaps only seven records of this species in New South Wales, but it also occurs in Victoria and New Zealand. Searches in Kosciuszko National Park in 1998 and 1999 found 600 plants but only a small portion of the habitat was searched (NSW NPWS 1999f).

There are no obvious threats from humans to the populations observed in Kosciuszko National Park. Shrubs occupy some of the gaps in grasslands in which the Shining cudweed occurs. Invasion of inter-tussock spaces by shrubs is a consequence of cattle grazing and other disturbances. The inter-tussock shrubs observed may be an artefact of grazing in the Kosciuszko area more than 40 years ago (NSW NPWS 1999f).

Species which also occur outside Australia (Briggs & Leigh 1996):

Asplenium hookerianum
Carex capillacea
Carex cephalotes
Chionohebe densifolia
Cystopteris tasmanica
Euchiton nitidulus
Kelleria laxa
Rytidosperma pumilum
Thesium australe

Drapetes *Kelleria laxa*

Kelleria is a genus of about 11 species which is distributed in Borneo, New Guinea, New Zealand and (for two species) south-eastern Australia. The Australian species were previously included in *Drapetes*, a genus confined to southern South America. In Australia *Kelleria laxa* is known only from the Bogong High Plains, but it also occurs in New Zealand (Elliot & Jones 1993). This species is listed in each of the four boxes in this Chapter.

Leafy greenhood *Pterostylis cucullata*

The Leafy Greenhood occurs in South Australia and on islands off the north-east coast of Tasmania. In Victoria the taxon displays two distinct distributions: inland and coastal. Coastal populations occur from Wilsons Promontory in the east to Nelson in the west including Mornington Peninsula (Cape Schanck, Rye and Tootgarook), Cape Otway, and Portland (Bridgewater Lakes and Cape Bridgewater). Inland it is found in the Central Highlands (Lake Eildon, Howqua River and Licola) the Strathbogie Ranges and East Gippsland (Serpentine Creek, Buchan and Benambra), with one small population in a remnant of the lowland Gippsland plains at Moormurng Reserve east of Bairnsdale (Bramwells 1993).

Of the inland populations on public land, only that at Frys Hut on the Howqua River, is thought to have disappeared. Weed invasion in the last 20 years, accelerated by the presence of stock and intensive recreation pressure nearby is believed to be partly responsible. A range of threats face remaining inland and coastal populations: urban development, roadworks, vehicle movement, recreational activities, weed invasion, introduced animals and trampling of habitat and collection by enthusiasts. Many populations are more vulnerable to natural catastrophes and changes in environmental factors over time because of their small size (Bramwells 1993).

Anemone buttercup *Ranunculus anemoneus*

This species occurs in a band about 8 km wide along the Great Dividing Range between South Rams Head and the Schlink Pass–Gungartan area. Most records are in the alpine zone, above 1900 m (NSW NPWS 1999f).

Grazing by domestic animals until the 1950s had a drastic effect on the spatial and temporal distribution of the anemone buttercup. At the time stock grazing ceased in the Kosciuszko area it was close to extinction (NSW NPWS 1999f).

It was recorded from Mt Hotham in Ewart's Flora of Victoria (1930) but it is now considered endemic to Kosciuszko, Victorian records being erroneous (Willis 1972).

Mountain grass/Small alpine grass/Feldmark grass *Rytidosperma pumilum*

This is an inconspicuous tufted grass with leaves only about 3 cm high. All of the Australian collections list the location as one of: Lake Albina area, Mt Lee, Mt Northcote or Northcote Pass — a very narrow distribution. Searches in 1998 found only one population of between 5,000 and 30,000 plants in a narrow (20–60 m wide) belt along the ridge top from Mt Northcote to Mt Lee, a distance of about 1 km. The species is more common in New Zealand (NSW NPWS 1999f).

Threats seem minimal at present, but because it is found in only one population it is likely to be more prone to catastrophic events than species with many populations (NSW NPWS 1999f).

Species with fewer than 1000 plants known to occur in a conservation reserve (Briggs & Leigh 1996):

Galium roddii
Gentiana baeuerlenii
Kelleria laxa
Monotoca rotundifolia
Myoporum floribundum
Olearia rhizomatica
Pomaderris cotoneaster
Pomaderris pallida
Pomaderris sericea
Thesium australe

Austral toadflax *Thesium australe*

The Austral Toad-flax is a member of the Santalaceae (Sandalwood Family) and, like many members of this genus, is hemiparasitic on the roots of other plants, notably Kangaroo Grass *Themeda triandra*. Collections in Australian herbaria indicate that Austral Toad-flax was widespread in eastern Australia, from the Bunya Mountains in Queensland south to eastern Tasmania. It is not currently known from Tasmania, but was collected there by Robert Brown in the early 1800s. The Austral Toad-flax has a wide ecological tolerance having been recorded from subtropical, temperate and sub-alpine climates, and on soils derived from sedimentary, igneous and metamorphic rocks as well as recent alluvium. However, it is largely confined to grasslands, grassy woodlands or sub-alpine grassy heathlands. Despite extensive searches by botanists from La Trobe University, Austral Toad-flax has been found at only five sites in Victoria since 1979, four of which are in the Alpine National Park. All sites are confined to areas between 800 m^2 and 24 ha (Scarlett, Bramwell & Earl 1994).

The contraction in the documented range of Austral Toad-flax is due to heavy grazing and cultivation of grasslands and grassy woodlands in the lowlands of Victoria. Changes in fire regime may also be responsible for the absence of Austral Toad-flax from the native grassland remnants of the lowland plains. The absence of Austral Toad-flax from areas with dense shrub and/or tree cover at known sites suggests that the maintenance of open conditions by frequent firing in the long-term may be as important for the survival of Austral Toad-flax as the apparent stimulation of germination by fire (Scarlett, Bramwell & Earl 1994).

Rough eyebright *Euphrasia scabra*

Rough eyebright was widely collected last century from montane and riparian sites in Victoria, Western Australia, South Australia, New South Wales and Tasmania. It is now considered extinct in New South Wales and South Australia, where it has not been collected since. In Tasmania the species has only been relocated at three sites in the five years to 1992.

Two of these contain very small populations while the third, Dukes Marsh, regularly has thousands of plants. In Western Australia rough eyebright is classified as 'poorly known'. It is probably extinct in the northern part of its range (near Perth) and, despite intensive field

Table 5.2 Poorly known species

Common name	Scientific name	EPBC Act	ANZECC list	ROTAP (see Table 5.3)	NSW TSC Act	Vic FFG Act	VROTS	ACT NC Act
Bog bird orchid	*Chiloglottis turfosa*			2KC-t				
Weeping snow gum	*Eucalyptus lacrimans*			2KC-				
Rough eyebright	*Euphrasia scabra*			3KCa	e	tA	e	
Dwarf eyebright	*Euphrasia* sp. 3			2KC-t				
Bog midge orchid	*Genoplesium turfosum*			2KC-t				
	Genus nov.8 sp.7 subsp. 2			2KC-				
Alpine daisy bush	*Olearia aglossa*			2KC-				

E = endangered nationally; V = vulnerable nationally

e = endangered in NSW, Victoria or ACT; v = vulnerable in NSW, Victoria or ACT; r = rare in Victoria; t = listed under the Victorian Flora and Fauna Guarantee Act as threatened

A = action plan or statement completed; R = draft recovery plan written

Table 5.3 Codes for Rare or Threatened Australian Plants (ROTAP)

Rare or Threatened Australian Plants

J.D. Briggs and J.H. Leigh

1995 Revised Edition

Distribution Category

2 Geographic range in Australia less than 100 km

3 Geographic range in Australia greater than 100 km

Conservation Status

E **Endangered:** taxon in serious risk of disappearing from the wild within 10–20 years if present land use and other threats continue to operate. This category includes taxa with populations possibly too small (usually less than 100 individuals) to ensure survival even if present in proclaimed reserves.

V **Vulnerable:** taxon not presently Endangered, but at risk over a longer period (20–50 years) of disappearing from the wild through continued depletion, or which occurs on land whose future use is likely to change and threaten its survival.

R **Rare:** taxon which is rare in Australia (and hence usually in the world) but which currently does not have any identifiable threat. Such species may be represented by a relatively large population in a very restricted area or by smaller populations spread over a wide range or some intermediate combination of distribution pattern.

K **Poorly Known:** taxon that is suspected, but not definitely known, to belong to one of the above categories. At present, accurate field distribution information is inadequate.

C **Reserved:** indicates taxon has at least one population within a national park, other proclaimed conservation reserve or in an area otherwise dedicated for the protection of flora. The taxon may or may not be considered adequately conserved within the reserve(s), as reflected by the conservation status assigned to it. Where applicable, the 'C' symbol immediately follows the conservation status symbol in the written code, eg. 2RC.

Size-class of all reserved populations (options are a, i or -)

a 1000 plants or more are known to occur within a conservation reserve(s)

i less than 1000 plants are known to occur within a conservation reserve(s)

\- reserved population size is not accurately known

t **Total known population reserved**

\+ **Overseas occurrence** (included if the taxon has a natural occurrence overseas) searches, has not been found in the southern part of its range for many years. Two forms of rough eyebright are recognized: one from lowland and montane environments, and a high mountain form, with characteristics approaching those of *Euphrasia caudata*. Of Victoria's eight known Rough Eyebright populations, four are in the Alpine National Park and only those from Clearwater Creek and McNamara's Hut are the high mountain form. The population near McNamara's Hut has not been seen since 1947 and is possibly extinct (Thompson 1992). Rough eyebright is thought to be extinct in Kosciuszko National Park (McDougall pers. comm.).

> Species for which the total known population in Australia is reserved (Briggs & Leigh 1996):
>
> *Brachyscome stolonifera*
> *Chiloglottis turfosa*
> *Chionochloa frigida*
> *Chionohebe densifolia*
> *Colobanthus nivicola*
> *Colobanthus pulvinatus*
> *Coprosma niphophila*
> *Craspedia leucantha*
> *Deyeuxia pungens*
> *Erigeron setosus*
> *Eucalyptus mitchelliana*
> *Euphrasia alsa*
> *Euphrasia sp. 3*
> *Genoplesium turfosum*
> *Gentiana baeuerlenii*
> *Grevillea diminuta*
> *Kelleria laxa*
> *Leptospermum namadgiensis*
> *Olearia lasiophylla*
> *Olearia rhizomatica*
> *Parantennaria uniceps*
> *Pomaderris oblongifolia*
> *Ranunculus anemoneus*
> *Ranunculus clivicola*
> *Ranunculus dissectifolius*
> *Ranunculus niphophilus*
> *Ranunculus productus*
> *Rytidosperma pumilum*

Rough eyebright has declined severely since European settlement. Likely causes include: gross habitat alteration due to goldmining (e.g. Ovens River); agriculture (e.g. Western Victoria, and southern tablelands of New South Wales); establishment of pine plantations (southern New South Wales); and competition from blackberries and introduced members of the Scrophulariaceae family such as bellardia (*Bellardia trixago*), common bartsia (*Parentucellia latifolia*) and sticky bartsia (*Parentucellia viscosa*). Its decline in less disturbed semi-natural areas is something of a mystery. Increased grazing pressure from domestic and feral animals and altered burning and hydrological regimes may have contributed to its decline in these areas. The remaining populations of rough eyebright are small and subject to considerable annual fluctuation. Loss of any one would be a significant loss of genetic variation and therefore affect the species' potential long term survival (Thompson 1992).

Hairy anchor plant *Discaria pubescens*

The Hairy Anchor Plant usually occurs in grassy open woodlands and forests in the east of Victoria and stream and river valleys to the west of Melbourne. The species formerly had a widespread distribution in all the eastern Australian states. It has not been recorded from Queensland since 1898 (Willis 1955) and is considered endangered in Tasmania. In Victoria, the species is now restricted to small fragmented populations in the eastern highlands and to the west of Melbourne (Humphries 1993).

In Victoria, the Hairy Anchor Plant is extremely rare. There are approximately 1000 adult plants at 25 sites throughout Victoria. In western Victoria it has been recorded from 13 sites but is now presumed locally extinct at four of these sites. At the remaining nine sites the species occurs in critically low numbers (1-10 plants per site except at Birchs Creek near Clunes, where there are approximately 70 widely dispersed plants). Only one of the western Victorian populations is within a public reserve (Turpins Falls Scenic Reserve, where two plants exist). The remaining eight populations are on private land or public water frontages. In eastern Victoria, the species is currently more secure. There are 16 populations; seven in the Alpine National Park, four in other reserves and five on private land (Humphries 1993).

Throughout both Victoria and Australia, all remaining plants are mature to senescent. Natural regeneration from seed has never been observed. Given continuing pressure from grazing and direct accidental destruction, together with lack of management to enhance survival at the remaining sites, the species is in danger of being lost from the wild. Urgent management actions are required (Humphries 1993).

Table 5.4 Species considered endangered or vulnerable in New South Wales, Victoria or ACT and not listed above

Common name	Scientific name	Cw	ANZ	ROTAP	TSC	FFG	VRT	NCA
Common name	**Scientific name**	**EPBC Act**	**ANZECC list**	**ROTAP (see Table 5.3)**	**NSW TSC Act**	**Vic FFG Act**	**VROTS**	**ACT NC Act**
Raleigh sedge	*Carex raleighii*			3RCa	eR		r	
Shining anchor plant	*Discaria nitida*			3RC-	e	t	e	
Suggan Buggan mallee	*Eucalyptus saxatilis*			3RC-	e			
Elusive cress/Branched cress	*Irenepharsus magicus*			2RC-	e			
	Abutilon oxyxarpum ssp. subsagittatum						e	
	Acacia binervia						e	
Water-fern	*Blechnum vulcanicum*						e	
Veined spider-orchid	*Caladenia montana*						e	
Yellow hyacinth orchid	*Dipodium hamiltonianum*						e	
Slender myoporum	*Myoporum floribundum*			3RCi			e	
	Pterostylis oreophila						e	
Bogong cushion	*Abrotanella nivigena*			3RCa			v	
Woolly-bear wattle	*Acacia lucasii*			3RCa			v	
Net veined wattle	*Acacia subtilinervis*			3RCa			v	
Ridge flannel-flower	*Actinotus forsythii*						v	
Winter-cress	*Barbarea grayi*						v	
Lemon-scented boronia	*Boronia citrata*						v	
Showy boronia	*Boronia ledifolia*						v	
Austral moonwort	*Botrychium australe*						v	
Grassy moonwort	*Botrychium lunaria*						v	
Mountain daisy	*Brachyscome sp. 3 (sens. Fl. Victoria 4)*					t	v	
	Caladenia aestiva						v	
Wire-head sedge	*Carex cephalotes*			3RCa+		t	v	
Plump windmill grass	*Chloris ventricosa*						v	
Devious bent-grass	*Deyeuxia decipiens*						v	
Hair-like (or Hill) bent-grass	*Deyeuxia innominata*						v	
	Deyeuxia talariata						v	
Matted (or Prostrate) parrot-pea	*Dillwynia prostrata*						v	
Hairy anchor plant	*Discaria pubescens*			3RCa		tA	v	
Mountain cress	*Drabastrum alpestre*			3RC-		t	v	
Slender bottlewashers	*Enneapogon gracilis*						v	
Daisy (or Coast) fleabane	*Erigeron conyzoides*						v	
	Eucalyptus elaephloia						v	
Thick eyebright	*Euphrasia collina ssp. diversicolor*						v	
	Genoplesium nudiscapum						v	
	Genoplesium nudum						v	

Common name	Scientific name	Cw	ANZ	ROTAP	TSC	FFG	VRT	NCA
Narrow-leaved parsnip	*Gingidia harveyana*						v	
	Glossocardia bidens						v	
	Goodenia macmillanii						v	
Dwarf brooklime	*Gratiola nana*						v	
Spreading holy grass	*Hierochloe submutica*			3RC-			v	
Rush	*Juncus thompsonianus*						v	
Slender woodrush	*Luzula atrata*						v	
Trailing broom-heath	*Monotoca rotundifolia*			3RCi			v	
Silver carraway	*Oreomyrrhis argentea*						v	
Winged everlasting	*Ozothamnus adnatus*						v	
Parantennaria	*Parantennaria uniceps*			3RC-t			v	
	Parsonsia eucalyptophylla						v	
Mountain stork's-bill	*Pelargonium helmsii*						v	
Mountain geebung	*Persoonia asperula*			2RCa			v	
Snow (or Small star) plantain	*Plantago glacialis*						v	
Star plantain	*Plantago muelleri*						v	
Hooker's tussock-grass	*Poa hookeri*						v	
	Poa labillardierei var acris						v	
Rock snow grass	*Poa petrophila*						v	
Rock tussock-grass	*Poa saxicola*					t	v	
	Prasophyllum aff rogersii						v	
	Prasophyllum lindleyanum						v	
	Prasophyllum suttonii						v	
Sparkling mint-bush	*Prostanthera rhombea*						v	
	Pterostylis coccina						v	
Low bush-pea	*Pultenaea subspicata*						v	
Felted buttercup	*Ranunculus muelleri*						v	
Namadgi pearlwort	*Sagina namadgi*						v	
Austral sage	*Salvia plebeia*						v	
Alpine pennywort	*Schizeilema fragoseum*						v	
Wild sorghum	*Sorghum leiocladum*						v	
Pink-bells	*Tetratheca procumbens*						v	
Thyme pink-bells	*Tetratheca thymifolia*						v	
Sun-orchid	*Thelymitra aff erosa*						v	
Bog sun-orchid	*Thelymitra circumsepta*						v	
Rare veined sun orchid	*Thelymitra cyanea*						v	
	Uncinia sulcata						v	
Fairies apron	*Utricularia monanthos*						v	
Dainty bluebell	*Wahlenbergla densifolia*						v	
Westringia	*Westringia lucida*			3RC-			v	
Lemon-scented zieria	*Zieria sp.*						v	

E = endangered nationally; V = vulnerable nationally

e = endangered in NSW, Victoria or ACT; v = vulnerable in NSW, Victoria or ACT; r = rare in Victoria; t = listed under the Victorian Flora and Fauna Guarantee Act as threatened

A = action plan or statement completed; R = draft recovery plan written

5.2 Mosses

Only 4% of species of alpine mosses in Australia are endemic, a low degree of endemism when compared with New Guinea (53 %) or New Zealand (11 %) (Busby 1990).

In 1906 the Reverend W.W. Watts collected mosses in the vicinity of Yarrangobilly Caves. Almost every species collected by Watts was still present in 1993 in the immediate vicinity of Yarrangobilly Caves. However, the current absence of some species collected by Watts appears to be related to environmental changes resulting from land use. The swamp where Watts was "rewarded with many treasures" has disappeared with the construction and improvements to the thermal pool (Downing, Selkirk & Oldfield 1997).

Downing, Selkirk and Oldfield added an additional 36 species to Watt's list, giving a total of 131 species. A significant number of species collected by Downing, Selkirk and Oldfield but not present in Watts' collections have probably been introduced as a result of human activities. Grazing by sheep and cattle appears to contribute to change in moss assemblages on calcareous substrates, often leading to an increase in the number of introduced and cosmopolitan species, and may have influenced the moss assemblages at Yarrangobilly. Fifteen of the additional taxa now present at Yarrangobilly are those of microphytic soil crusts characteristic of calcareous soils of semi-arid and arid areas of western New South Wales, Victoria and South Australia. Severe droughts in south-eastern Australia from the late 1800s until the 1940s were often followed by severe dust storms which may have carried moss propagules to the east coast of Australia (Downing, Selkirk & Oldfield 1997).

Although many undisturbed locations in the vicinity of Yarrangobilly, on both calcareous and non-calcareous substrates, have moss assemblages similar to those collected by Watts in 1906, there are significant differences in areas which have been intensively utilised (Downing, Selkirk & Oldfield 1997).

5.3 Lichens

The lichens of Kosciuszko National Park are of considerable botanical interest with over 50 genera recorded to date. These genera constitute more than 20 percent of the total Australian genera and nine of the world's 10 largest lichen genera are well represented in the Park. The majority of the lichen genera are cosmopolitan or of bipolar distribution and hence all genera occurring in Kosciuszko are to be found throughout the world. It is of interest that this applies not only to the alpine genera but to all genera making the lichens the only flora having all but a few of their total genera represented on every continent except Antarctica (Good 1992a).

Included within the lichen flora of Kosciuszko National Park is a common Austral group of species; those of distribution limited to the Gondwanan continents of Australasia and South America. This group includes the very conspicuous *Cetraria islandica* ssp. *antarctica, Hypogymnia kosciuskoensis*, *H. lugubris*, *Menegazzia platytrema* and *Placopsis perrugosa.* While most lichen species are cosmopolitan Kosciuszko National Park does have one endemic species which grows at or above the treeline, this being *Cetrara australiensis* (Good 1992a).

5.4 Flora — Status, Distribution and Threats

See Table 5.5 on next page.

Table 5.5 Flora - Conservation Status, Distribution and Threats

Species	Cw	ANZ	ROTAP	TSC	FFG	VRT	NCA	ANP	Buff	SR	KNP	Bri	Bim	Sca	NNP	Out	Threats
Note: codes are explained at the end of this Table (page 96).	Cwlth EPBC Act	ANZECC list	ROTAP (see Table 5.3)	NSW TSC Act	Victorian FFG Act	VROTS	ACT NC Act	Alpine NP	Mt Buffalo NP	Snowy River NP	Kosciuszko NP	Brindabella NP	Bimberi NR	Scabby Range NR	Namadgi NP	Outside Alps parks	Threats (Note: some of these threats apply only outside the Australian Alps national parks. Their operation outside the parks underlines the importance of the parks in the conservation of these species.)
Abrotanella nivigena			3RCa			v		+			3					-0	Not threatened (Briggs & Leigh 1996); rare status interpreted to result from grazing by cattle and sheep (Duncan 1997a); horses and pigs (W/shop)
Abutilon oxyxarpum ssp. *subsagittatum*						e				+							
Acacia binervia						e				+							
Acacia boormanii										+	+						
Acacia dallachiana			3RC-			r		+?	+		3					-0	Not threatened (Briggs & Leigh 1996); the one population in Kosciuszko National Park could be threatened by fire (Duncan 1997a); SMA works (W/shop); several populations in Kosciuszko National Park are doubtfully threatened (Briggs pers. comm.)
Acacia lucasii			3RCa			v		+								-1	Not threatened (Briggs & Leigh 1996)
Acacia phlebophylla			2RCa			r			+e?							-0	Not threatened (Briggs & Leigh 1996)
Acacia subtilinervis			3RCa			v				+						A5	Not threatened (Briggs & Leigh 1996)
Aciphylla glacialis											3e						No identified threats (Briggs pers. comm.)
Actinotus forsythii						v		+									
Agrostis meionectes			3RC-					+	+		3				+?	-1	Not threatened (Briggs & Leigh 1996)
Almaleea capitata			3RC-		2	r		+								-0	Not threatened (Briggs & Leigh 1996)
Amphibromus fluitans	V	V		v				+									
Asplenium hookerianum	V	V	3VC-+			e		+								B1	Low numbers is a threat (Briggs pers. comm.)
Astelia psychrocharis											3e						

Species	Cw	ANZ	ROTAP	TSC	FFG	VRT	NCA	ANP	Buff	SR	KNP	Bri	Bim	Sca	NNP	Out	Threats
Astrotricha sp Suggan Buggan											+						
Astrotricha sp. 4 (sens. Flora Victoria, 4: 252)								+?		+?							
Babingtonia crenulata		V	2RCa			r			+e?							-0	Not threatened (Briggs & Leigh 1996)
Baeckea denticulata			3RCa								3					A1	Not threatened (Briggs & Leigh 1996)
Banksia marginata stand											Y						
Barbarea grayi						v		+			+						
Bertya findlayi			3RCa								3					A1	Not threatened (Briggs & Leigh 1996). As some populations grow along roadside, there is a danger it may be eliminated by road works. Populations in the gullies on the western side of Kosciuszko NP are often located in the openings around SMA installations and appear to prefer the open sites so personnel must become aware of their presence (Duncan 1997a).
Blechnum vulcanicum						e		+									
Boronia citrata						v		+									
Boronia ledifolia						v				+							
Botrychium australe						v		+			+				+		
Botrychium lunaria						v		+			+				+		
Brachyscome petrophila			2RC-			r		+?		+					+?	-0	Not threatened (Briggs & Leigh 1996)
Brachyscome riparia			3RC-			r				+						-0	Not threatened (Briggs & Leigh 1996)
Brachyscome sp. 3 (sens. Fl. Victoria 4)					2	v		+									
Brachyscome stolonifera			3RCat								2e					-0	Not threatened (Briggs & Leigh 1996). Prior to the cessation of snow leases the habitats of Creeping Daisy would have been affected by trampling. At present the species does not appear to be under any particular threat (Duncan 1997a).
Brachyscome tadgellii						r		+			3						Not threatened (Briggs pers. comm.)
Caladenia aestiva						v		+									
Caladenia montana						e		+									
Calotis cuneata subsp *pubescens*								[e]			[+]						

Species	Cw	ANZ	ROTAP	TSC	FFG	VRT	NCA	ANP	Buff	SR	KNP	Bri	Bim	Sca	NNP	Out	Threats
Calotis glandulosa	V	V	3VC-	v							2					B1	It appears that grazing may have led to a decline in *C. glandulosa* populations (Duncan 1997b). Recovering after removal of grazing (Briggs pers. comm.).
Carex archeri											+						
Carex capillacea			3RC-+			r		+			3				+	A0	Not threatened (Briggs & Leigh 1996). The distribution of this species in Kosciuszko National Park Is limited and its survival is dependent on the retention of swamp and fen areas there, as elsewhere in its range (Duncan 1997a).
Carex cephalotes			3RCa+		2	v		+			3					-0	Not threatened (Briggs & Leigh 1996)
Carex hypandra								+			3						
Carex raleighii			3RCa	e		r		+			1					C8	Not threatened (Briggs & Leigh 1996); threats unknown (NSW NPWS 1999f).
Celmisia sericophylla			2RCa		2	r		+								-0	Not threatened (Briggs & Leigh 1996)
Chiloglottis turfosa			2KC-t								3e					-0	Pigs are potential threat (Briggs pers. comm.)
Chionochloa frigida			2RCat								2e					-0	Not threatened (Briggs & Leigh 1996). This species was originally distributed throughout the alpine zones, but due to grazing had largely disappeared from the eastern Kosciuszko area, though it is now re-establishing (Duncan 1997a).
Chionogentias sylvicola											3				+		This species is only known from the one locality and should be monitored, though there are no known threats to that area of northern Kosciuszko National Park (Duncan 1997a).
Chionohebe densifolia			2RC-t+								2					-0	Not threatened (Briggs & Leigh 1996). All Australian *C. densifolia* populations are contained within the protection of Kosciuszko National Park. Since the cessation of snow grazing leases this area is no longer subject to trampling and browsing by stock. However, some natural erosion occurs and some migration of plant clumps due to the windiness of the feldmark area (Duncan 1997a).
Chloris ventricosa						v		+									
Colobanthus nivicola			2RC-t								2e					-0	Not threatened (Briggs & Leigh 1996)
Colobanthus pulvinatus			2RC-t								2e					-0	Not threatened (Briggs & Leigh 1996). Certain areas of feldmark communities, especially on the Lakes walk, are subject to some destruction by hikers' boots which, as well as natural forces, can cause erosion and destruction of habitat (Duncan 1997a).
Coprosma niphophila			2RC-t								2e					-0	Not threatened (Briggs & Leigh 1996)

Species	Cw	ANZ	ROTAP	TSC	FFG	VRT	NCA	ANP	Buff	SR	KNP	Bri	Bim	Sca	NNP	Out	Threats
Craspedia alba			3RC-					+			3					-0	Not threatened (Briggs & Leigh 1996). This rare species occurs in very few areas of alpine NSW and Victoria, presumably because of the restricted distribution of appropriate habitats (Duncan 1997a).
Craspedia costiniana											3e						
Craspedia discolor ms								+			+						
Craspedia lamicola											3e						
Craspedia leucantha			2RCat								2e					-0	Not threatened (Briggs & Leigh 1996)
Craspedia maxgrayii								+			3e						
Cystopteris tasmanica			3RCa+			r		+		+	3					B5	Not threatened (Briggs & Leigh 1996)
Danthonia sp. A											3e						
Derwentia nivea			3RC-					+	+		3					B3	Not threatened (Briggs & Leigh 1996)
Deyeuxia affinis			3RC-			r		+			3					-0	Not threatened (Briggs & Leigh 1996)
Deyeuxia decipiens						v		+		+							
Deyeuxia innominata						v		+			+						
Deyeuxia pungens	V	V	2KC-t			v		+e								-0	
Deyeuxia talariata						v		+									
Dichosciadium ranunculaceum var. ranunuculaceum											3e						
Dillwynia prostrata						v				+	+				+		
Dipodium hamiltonianum						e		+		+							
Discaria nitida			3RC-	e	2	e		+?			1					-0	Not threatened (Briggs & Leigh 1996). A few sites appear to be at some risk from invasion by willows (*Salix* spp) and blackberries (*Rubus* spp) but most sites appear reasonably secure and under no immediate threat (Wright & Briggs 1999). Young shoots of *D. pubescens* have been observed to be browsed on by cattle, sheep and rabbits, which is thought to have contributed to the present rarity of that species. Few observations have been published on *D. nitida*, but this species is also subject to stock browsing, often more heavily than *D. pubescens*. However, whether this is the deciding factor in *D. nitida*'s more rare occurrence is unknown (Duncan 1997b).

Species	Cw	ANZ	ROTAP	TSC	FFG	VRT	NCA	ANP	Buff	SR	KNP	Bri	Bim	Sca	NNP	Out	Threats
Discaria pubescens			3RCa		2A	v		+			3			+	+	C5	Broom, gorse, blackberry (Adair & Groves 1998). Continuing pressure from grazing and direct accidental destruction, together with lack of management to enhance survival at the remaining sites (Humphries 1993). Not threatened (Briggs & Leigh 1996). Grazing by domestic stock appear to have been the major threat to this species and could eliminate it (Duncan 1997a).
Diuris ochroma	V	V				v		+			+						
Dodonaea rhombifolia			3RCa			r				+						B7	Not threatened (Briggs & Leigh 1996)
Drabastrum alpestre			3RC-		2	v		+			3					A0	Not threatened (Briggs & Leigh 1996). It is not a competitive species and is susceptible to disturbance and invasion by introduced weed species. In populations in the ACT fruiting inflorescences had been eaten off mainly by rabbits, but also by kangaroos or wallabies (Duncan 1997a).
Enneapogon gracilis						v				+							
Erigeron conyzoides						v		+			+						
Erigeron paludicola											3e						
Erigeron setosus			3RC-t								2e					-0	Not threatened (Briggs & Leigh 1996). Preservation of the short alpine herbfieds below snowpatches is necessary for its survival (Duncan 1997a).
Eucalyptus elaephloia						v		+									
Eucalyptus lacrimans			2KC-								3					-0	
Eucalyptus mitchelliana			2RC-t			r			+e							-0	Not threatened (Briggs & Leigh 1996)
Eucalyptus neglecta			3RC-			r		+								-0	Not threatened (Briggs & Leigh 1996)
Eucalyptus pauciflora (>150 y o)											+						
Eucalyptus saxatilis			3RC-	e				+?		+	1					-0	Not threatened (Briggs & Leigh 1996)
Eucalyptus triplex															+		Occurs only on Blue Gum Hill and near Braidwood
Euchiton nitidulus	V	V	3VCa+	v		v		+			2					-0	No obvious threats (NSW NPWS 1999f)
Euphrasia alsa			2RC-t								2e					-0	Not threatened (Briggs & Leigh 1996)
Euphrasia collina ssp. diversicolor						v		+			+						
Euphrasia collina ssp. glacialis											3e						
Euphrasia collina ssp. lapidosa											3e						

Species	Cw	ANZ	ROTAP	TSC	FFG	VRT	NCA	ANP	Buff	SR	KNP	Bri	Bim	Sca	NNP	Out	Threats
Euphrasia crassiuscula ssp. glandulifera	V	V				v		+									
Euphrasia eichleri	V	V	2VC-			v		+								-0	
Euphrasia scabra			3KCa	e	2A	e		+			1x					C4	Agriculture, domestic grazing, competition (weeds) (Leigh, Boden & Briggs (eds) 1984); blackberry (Adair & Groves 1998); gross habitat alteration due to goldmining (e.g. Ovens River); agriculture (e.g. Western Victoria, and southern tablelands of NSW); establishment of pine plantations (southern NSW); and competition from blackberries and introduced members of the Scrophulariaceae family (Thompson 1992).
Euphrasia sp. 3			2KC-t								2e					-0	
Flammulina velutipes											+						
Galium roddii			2RCi								2e					-0	Not threatened (Briggs & Leigh 1996). Possible threats are from walkers and sighteers to the Cooleman Caves area, but hopefully, since the plants usually grow away from tracks and cave entrances visitation to the area should not cause a problem (Duncan 1997a). Weeds (*Sedum*) are a threat (Briggs pers. comm.).
Gaultheria appressa											3						
Genoplesium nudiscapum						v		+									
Genoplesium nudum						v		+							+		
Genoplesium turfosum			2KC-t								2e					-0	
Gentiana baeuerlenii	E	E	2ECit	e			eA								+e	-0	Agriculture, domestic and feral grazing, possibly competition (Newman 1964); park management activites (ACT Government 1998b)
Genus nov.8 sp.7 subsp. 2			2KC-					+								-1	
Gingidia algens			2RCa								3				+	-0	Not threatened (Briggs & Leigh 1996)
Gingidia harveyana						v		+			+						
Glossocardia bidens						v		+									
Goodenia macmillanii						v		+		+							
Gratiola nana						v		+			+				+		
Grevillea diminuta			2RCat										+		+	-0	
Grevillea willisii			2RC-			r		+		+						-0	Not threatened (Briggs & Leigh 1996)
Grevillea willisii subsp. willisii								+									

Species	Cw	ANZ	ROTAP	TSC	FFG	VRT	NCA	ANP	Buff	SR	KNP	Bri	Bim	Sca	NNP	Out	Threats
Haloragodendron baeuerlenii			3RCa			r		+		+	3					A1	Not threatened (Briggs & Leigh 1996)
Hibbertia spathulata			2RC-			r		+		+?						-0	Not threatened (Briggs & Leigh 1996)
Hierochloe submutica			3RC-			v		+	+?		3					-0	Not threatened (Briggs & Leigh 1996)
Irenepharsus magicus			2RC-	e							1					-0	Not threatened (Briggs & Leigh 1996)
Juncus sp. aff. sceuchzerioides											3e						
Juncus thompsonianus						v		+			+						
Kelleria laxa	V	V	2VCit+			e		+								-0	
Leptospermum namadgiensis			2RCat											+	+	-0	Not threatened (Briggs & Leigh 1996)
Leucopogon riparius			2RCa			r				+						-0	Not threatened (Briggs & Leigh 1996)
Luzula acutifolia subsp. nana											3e						
Luzula atrata						v		+			+						
Monotoca oreophila			3RCa?			r		+								-1	Not threatened (Briggs & Leigh 1996)
Monotoca rotundifolia			3RCi			v		+								-1	Not threatened (Briggs & Leigh 1996)
Myoporum floribundum			3RCi			e		+?		+						A0	Not threatened (Briggs & Leigh 1996); Restricted to a narrow geographic range and in Victoria only occurs in three small isolated populations. The small populations (each less than 50 plants and occupying less than one hectare) are vulnerable to destruction by single events such as:. - roadworks-all known populations are on roadsides and could easily be destroyed by road widening or realignment works, particularly as two of the populations are immediately downslope very steeply from the road; - wildfire-not thought to be fire tolerant, though it may regenerate well after fire (Dickens 1992).
Nematolepis ovatifolia											3e						
Nematolepis squamea subsp. coriacea	V	V				v		+		+							
Olearia aglossa			2KC-								3					-0	
Olearia frostii			2RCa			r		+								-0	Not threatened (Briggs & Leigh 1996)
Olearia lasiophylla			2RC-t								2e					-0	Not threatened (Briggs & Leigh 1996)
Olearia rhizomatica			2RCit								3?			+	+	-1	Not threatened (Briggs & Leigh 1996)
Olearia stenophylla											e						
Oreomyrrhis argentea						v		+			+						

Species	Cw	ANZ	ROTAP	TSC	FFG	VRT	NCA	ANP	Buff	SR	KNP	Bri	Bim	Sca	NNP	Out	Threats
Oreomyrrhis brevipes			3RC-			r		+			3					-0	Not threatened (Briggs & Leigh 1996)
Oschatzia cuneifolia			3RC-			r		+			3					-0	Not threatened (Briggs & Leigh 1996)
Ozothamnus adnatus						v		+									
Parantennaria uniceps			3RC-t			v		+			3				+	-0	Not threatened (Briggs & Leigh 1996)
Parsonsia eucalyptophylla						v				+							
Pelargonium helmsii						v		+			+						
Persoonia asperula			2RCa			v		+?								A1	Not threatened (Briggs & Leigh 1996)
Pimelea bracteata											3e						
Plantago glacialis						v		+			+						
Plantago muelleri						v					+						Mt Baw Baw
Poa hookeri						v				+							
Poa labillardierei var *acris*						v		+									
Poa petrophila						v		+			3						
Poa saxicola					2	v		+			+						
Podocarpus lawrencei (old)											1				+		
Pomaderris brunnea	V	V				v				+							
Pomaderris costata			3RC-			r				+?						A3	Not threatened (Briggs & Leigh 1996)
Pomaderris cotoneaster	E	E	3ECi	e	2						1?					-3	Fire is a threat (Briggs pers. comm.).
Pomaderris oblongifolia			2RCat			r				+e						-0	Not threatened (Briggs & Leigh 1996)
Pomaderris pallida	V	V	2VCi	v							1?				+	-2	This species is considered in danger of disappearing from the wild within 50 years (Duncan 1997b). Presumed extinct in Kosciuszko National Park (Briggs pers. comm.).
Pomaderris pauciflora			3RC-			r				+?						A2	Not threatened (Briggs & Leigh 1996)
Pomaderris sericea	V	V	3VCi		2	v				+?						A1	
Prasophyllum [related to morganii]											2e*						
Prasophyllum aff *rogersii*						v		+									
Prasophyllum lindleyanum						v		+									
Prasophyllum montanum			3RC-					+		+	3				+	-0	Not threatened (Briggs & Leigh 1996)
Prasophyllum suttonii						v			+		+						
Pratia gelida	V	V	2RC-			v		+?	+							-0	Not threatened (Briggs & Leigh 1996)

Species	Cw	ANZ	ROTAP	TSC	FFG	VRT	NCA	ANP	Buff	SR	KNP	Bri	Bim	Sca	NNP	Out	Threats
Prostanthera monticola			3RC-			r			+		3					-0	Not threatened (Briggs & Leigh 1996) This species has several locations in the Geehi Reservoir-Schlink Pass Road area and often borders the road. Any road construction work could pose a threat (Duncan 1997a).
Prostanthera rhombea						v		+									
Prostanthera walteri			3RCa			r				+?						A1	Not threatened (Briggs & Leigh 1996)
Pseudanthus divaricatissimus			3RCa			r				+						B8	Not threatened (Briggs & Leigh 1996)
Pterostylis aenigma	E	E	2KC-			r		+								-0	
Pterostylis coccina						v		+							+		
Pterostylis cucullata	V	V	3VCa	v	2A	v		+								C13	Of the inland populations on public land, only that at Frys Hut on the Howqua River, is thought to have disappeared. Weed invasion in the last 20 years, accelerated by the presence of stock and intensive recreation pressure nearby is believed to be partly responsible. Future threats include: urban development, roadworks, vehicle movement, recreational activities, weed invasion, introduced animals and trampling of habitat and collection by enthusiasts. Populations on the Bass Strait islands are threatened by cattle trampling and grazing by introduced snails (Bramwells 1993).
Pterostylis oreophila						e		+									
Pultenaea subspicata						v		+			+				+		
Ranunculus anemoneus	V	V	2VCat	v							2e					-0	Grazing by domestic animals until the 1950s apparently had a drastic effect on this species. Since grazing ceased it has flourished. It occurs in ski resort areas, and developments mightimpact on populations (NSW NPWS 1999f).
Ranunculus brevicaulis											3e						
Ranunculus clivicola			2RCat								2e					-0	Not threatened (Briggs & Leigh 1996)
Ranunculus dissectifolius			2RCat								2e					-0	Not threatened (Briggs & Leigh 1996)
Ranunculus eichleranus			2RC-			r		+								-0	Domestic grazing, hybridization (Leigh, Boden & Briggs (eds) 1984); Not threatened (Briggs & Leigh 1996)
Ranunculus muelleri						v		+			+						
Ranunculus niphophilus			2RCat								2e					-0	Not threatened (Briggs & Leigh 1996)
Ranunculus productus			3RC-t								2e					-0	Not threatened (Briggs & Leigh 1996)

Species	Cw	ANZ	ROTAP	TSC	FFG	VRT	NCA	ANP	Buff	SR	KNP	Bri	Bim	Sca	NNP	Out	Threats
Rutidosis leiolepis	V	V	2VC-	v							2					-0	Grazing by horses, horse riding, road maintenace and pig activity. Illegal access by 4WD vehicles also may impact on some populations (Wright 2000). It is presumed that during the grazing lease era that this grassland species would have been heavily grazed (Duncan 1997b).
Rutidosis leptorrhynchoides	E	E	3ECa	e	2A		eA					+				C2	The species is at risk from habitat loss throughout its range due to agricultural and urban development, and weed invasion. Competition with other vegetation presents a disadvantage to the species at some sites. In Victoria, "intermittent" burning of some grassland communities is recommended to maintain floristic diversity. Erosion of genetic diversity and increased inbreeding may compromise both short and long-term population viability by reducing individual fitness and limiting the gene pool on which selection can act in the future. This applies to populations of fewer than 200 plants (ACT Government 1999c). Does not occur in the Australian Alps national parks (Briggs pers. comm.).
Rytidosperma pumilum	V	V	2VC-t+	v							1					-0	Trampling by bushwalkers, climate change (NSW NPWS 1999f). This is probably one of the rarest and most restricted grasses in Australia, only known from the area between Mt Northcote and Mt Lee and should be monitored regularly to ensure its survival from human visitation and revegetation work. It has been suggested that even scientific botanical collection should be strictly limited to conserve this species (Duncan 1997b).
Sagina namadgi						v		+			+				+		
Salvia plebeia						v				+							
Schizeilema fragoseum						v		+			+						
Sorghum leiocladum						v		+							+		
Taraxacum aristum			3RC-			r		+		+?	3				+	B2	Not threatened (Briggs & Leigh 1996)
Tetratheca procumbens						v		+									
Tetratheca thymifolia						v			+?		+						
Thelymitra aff *erosa*						v		+									
Thelymitra circumsepta						v				+							
Thelymitra cyanea						v		+			+				+		

Species	Cw	ANZ	ROTAP	TSC	FFG	VRT	NCA	ANP	Buff	SR	KNP	Bri	Bim	Sca	NNP	Out	Threats
Thesium australe	V	V	3VCi+	v	2A	e		+			2				+	C6	Agriculture, domestic grazing (Leigh, Boden & Briggs (eds) 1984); Heavy grazing and cultivation, habitat destruction and fragmentation in the past. The absence of Austral Toad-flax from areas with dense shrub and/or tree cover at known sites suggests that the maintenance of open conditions by frequent firing in the long-term may be as important for the survival of Austral Toad-flax as the apparent stimulation of germination by fire (Scarlett, Bramwell & Earl 1994). Indications are that the species may be declining in NSW. The pattern of decline which occurs in other states suggests that the survival in NSW is likely to become more precarious. This once widespread species is now uncommon or rare, probably due to heavy grazing of its host, *Themeda australis* and its replacement by introduced pasture species and trampling by stock (Duncan 1997b).
Uncinia sulcata						v		+			+						
Utricularia monanthos						v		+	+		+						
Viola improcera			3RC-					+							+	-0	
Wahlenbergla densifolia						v		+			+						
Westringia cremnophila	V	V	2VC-			v				+						-0	
Westringia lucida			3RC-			v		+			3			+	+	-0	Not threatened (Briggs & Leigh 1996). The species does not appear to be under any threat except for road working activities by NPWS and SMA. NPWS field staff have commented on its common occurrence along roadsides (Duncan 1997a).
Zieria sp.						v		+									

See next page for explanation of notes.

Notes:

EPBC Act	E = Endangered; V = Vulnerable; P = Recovery Plan completed
ANZECC list	E = endangered; V = vulnerable
ROTAP	see Table 5.3 Codes for Rare or Threatened Australian Plants (ROTAP)
TSP Act	e = Endangered; v = Vulnerable
FFG Act	2 = listed on Schedule 2 as Threatened; A = Action Statement completed
VROT	e = Endangered; v = Vulnerable; r = rare
	ins = Insufficiently known (suspected of being End, Vul or R)
	ind = Indeterminate (known to be End, Vul or R)
	d = depleted x = presumed extinct
NC Act	e = Endangered; v = Vulnerable; A = Action Plan completed

Any park	? = recorded for this park in park documents, but not in ROTAP, or considered endemic to park in park documents, but not in ROTAP
Alpine NP	+ = present x = presumed extinct in Alpine NP
Mt Buffalo NP	+ = present e = endemic to Mt Buffalo NP
Snowy River NP	+ = present
Kosciuszko NP	1 = Category 1 (Highly Significant) natural feature
	2 = Category 2 (Very Significant) natural feature
	3 = Category 3 (Significant) natural feature
	+ = present; e = endemic to Kosciuszko NP
	x = presumed extinct in Kosciuszko NP; * presumed extinct elsewhere
	Y = the community at Yarrangobilly might be significant, at or near the altitudinal limit of its range.
Brindabella NP	+ = present
Bimberi NR	+ = present
Scabby Range NR	+ = present
Namadgi NP	+ = present e = endemic to Namadgi NP

Outside Alps parks	- = does not occur in any other regions	Number = number of other protected areas in which the species occurs
	A = recorded from one or two other regions	
(from Briggs & Leigh 1996)	B = recorded from three, four or five other regions	
	C = recorded from more than five other regions	

6 Other features

More than 600 other natural features were identified from park management plans and other documents. To help make the workshop expectations realistic, the Steering Committee decided to exclude some types of features from consideration at the workshop, but they have been listed in Appendix 3 for completeness.

These types of features are:

- Reference areas (Victoria)
- Remote and natural areas (Victoria)
- Special Protection Zones (Victoria)
- Heritage Rivers and Representative Rivers (Victoria)
- Special areas under the Catchment and Land Protection Act (Victoria)
- Management areas with special scientific values (Kosciuszko National Park)
- Management areas with outstanding natural resources (Kosciuszko National Park)
- Individual caves (Victoria and New South Wales)
- Significant sites (Namadgi National Park)
- Areas on the Register of the National Estate and on the indicative list for the Register

The remainder of the other features are not all easily classified. For instance caves are a discrete environment which seems to justify a specific group. But a cave could also be a biological community and/or a geomorphological feature. The glacial lakes are significant geomorphological features but they are also important biological communities.

6.1 Communities and ecosystems

This group includes:

- specific communities (eg yellow box-red gum woodland, alpine snowpatch community, *Caltha introloba* herbland community, fen (bog pool) community, montane swamp complex community);
- areas of habitat (eg in Kosciuszko National Park all habitat or context of Category 1 species or features is regarded as a Category 1 (Highly Significant) natural feature);
- important wetlands (listed in *A Directory of Important Wetlands in Australia*, eg Davies Plain, Rennex Gap);
- catchments in Victoria identified by the Land Conservation Council as essentially natural catchment (eg Gattamurgh Creek);
- areas of wilderness (eg the Snowy River and Bowen Wilderness Areas — most of this extensive area of forest is little disturbed. Detailed flora and fauna surveys have recorded a range of species that are known to be particularly sensitive to disturbance.);
- cave communities (caves harbour rich and endemic communities of troglobitic (obligate cave inhabitants) invertebrates that are of major biogeographical and evolutionary importance);
- mountain streams generally (several invertebrate species are known to be restricted to the Australian mainland highlands and these will have their habitats threatened by changes in the catchments); and
- the alpine treeline (Alpine treelines, wherever they occur, are regarded as being of considerable scientific and conservation significance. The often abrupt change in vegetation structure in a harsh environment has profound ecological implications for other flora and fauna.).

Detailed knowledge of the ecology of individual alpine plant species in Australia is in most cases minimal, but good information is available on the main plant communities (Pickering & Armstrong 2000b).

Importantly, communities and ecosystems are the basis for the life of the significant animal and plant species discussed in Chapters 4 and 5 or listed in Appendix 3. Species receive a lot of attention in park management plans and associated documents and lists, and in other literature. None of them could survive alone. They are all part of communities and ecosystems, and the health of these broader units is fundamental to the survival of individual species. The ecological complexity of a community is impossible to describe simply, even if it was adequately known, but as a simple example most plant species rely on insects, sometimes specific insects, for their pollination. If the insects vanish, so must the plants.

Another important characteristic of communities and ecosystems is that one often encompasses several known significant species, and probably other significant species we have not yet recognised. By managing the community or ecosystem, all its component species should benefit, even those we don't know are there. In contrast managing individual species could be detrimental to other species and at the very best will fail to take account of species we know nothing about, regardless of their significance.

Wilderness protects landscapes, plants and animals and allows the natural processes of evolution to continue with minimal interference. This means that the biodiversity, or the total variety of life, of these different environments is conserved as a single functioning natural system (NSW NPWS 1997b).

Wilderness areas protect already rare and threatened plants and animals, and play an important role in helping to ensure that other species are less likely to become endangered. These large natural areas provide clean air and water. They are also a storehouse of genetic material from which future generations may obtain new food crops, drugs, clothing and other valuable natural products. Importantly, and unlike many other land uses, wilderness areas do not close off any land use options for future generations (NSW NPWS 1997b).

As a conservation land use protecting whole ecosystems, wilderness also provides a way of comparing these less modified natural landscape with those areas that have been changed by modern technological land uses and the myriad of other demands placed on the landscape. As such they have significant scientific value. Cultural values are also protected, and wilderness areas can provide a reminder of the Aboriginal landscape of Australia that retains immense cultural significance to the present day (NSW NPWS 1997b).

Two of the important wetlands on the list are artificial waterbodies (Lake Dartmouth and Bendora Reservoir). They have been included because of their significance for native fish species. Lake Dartmouth has the only remaining wild breeding population of the Macquarie Perch *Macquaria australasica* in Victoria. The Trout Cod *Maccullochella macquariensis* inhabits the lake after being introduced to tributary streams in an effort to re-establish wild populations of this species (Environment Australia 2000). Bendora Reservoir has also been stocked (in 1989 and 1990) with Trout Cod as a part of the national recovery program for the species, and it also contains a large population of the Two-spined Blackfish (Environment Australia 2000).

6.2 Scientific sites

A number of highly important scientific study sites are within the Australian Alps national parks. Some have periodic detailed scientific records spanning 50 years or more, which gives them immense value as a scientific resource. The importance of these scientific sites is recognised in Kosciuszko National Park, where scientific sites used for long-term study and established for a period of greater than 20 years are listed as Category 1 (Highly Significant) natural features and scientific sites used for long-term study of natural and cultural processes (other than Category 1 sites) are listed as Category 2 (Very Significant) natural features.

Maisie Carr's grazing-exclusion plots on the Bogong High Plains, maintained and monitored since the 1940s, are one of the world's longest running ecological experiments (Bennett 1995).

The AALC has developed a database of scientific sites, which enhances their value by recording their locations and history of study. This will be greatly beneficial to future studies.

6.3 Caves

The significance of the karst areas in Kosciuszko National Park can be recognised both nationally and internationally; from the karst processes taking place, the unique karst features exhibited and from the recreational and economic values of the cave systems. Karst areas are more than geological and geomorphological entities. They harbour a wealth of geological, climatic and cultural history; they are refugia for a number of relict invertebrates and plants and they are a scientific and educational resource of appeal to the general public (Good 1992a).

Caves also provide a stable environment for a specialised cave invertebrate fauna, much of which is still to be studied in terms of cave ecosystems and invertebrate taxonomy. Bats frequent many caves including Yarrangobilly and Cooleman where very large deposits of undisturbed guano possibly preserve a history of cave development and faunal use. Many bone deposits occur in these caves but to date they have been little studied and much remains to be unravelled as to their age and origins (Good 1992a).

During this project five important caves were identified at New Guinea Ridge in Victoria, three of which have outstanding natural value for bat habitat, geomorphology and archaeology (DNRE 1995). Thirty-eight caves at Cooleman Plain and 33 at Yarrangobilly are listed in Appendix 3 for their special natural values including for cave fauna, speleochronology, hydrology, geomorphology, and outstanding natural decorations (NSW NPWS 2000a).

6.4 Geophysical features

A diversity of geophysical features are considered significant. Glacial features, confined to the Kosciuszko plateau, include the glacial lakes formed by cirque basins or moraine dams, and glacial erratics — boulders transported by a glacier and dumped as the glacier melted. Periglacial features are also of considerable scientific importance and are much more widespread. They include blockstreams at several locations in Victoria and New South Wales, a nivation cirque at Mt Howitt, and solifluction terraces in Kosciuszko National Park.

Other geophysical features include good examples of geological and geomorphological phenomena such as the Campbell Knob/Tulloch Ard gorge which demonstrates morphological variations associated with different rock types, The Razor and The Viking which demonstrate strike ridges, and a young basalt flow at Morass Creek.

The great aesthetic appeal of granite landscapes and individual granite boulders is undeniable. The main portion of Mt Buffalo National Park consists of a granite plateau dominated by tors of diverse shapes and sizes. Roughly half the surface rock of Kosciuszko National Park is granitoid. One of the striking features of Namadgi National Park is Mt Gudgenby, a large granite dome with great tors (Bayly, 1999).

The ranked list of "other features"considered at the workshop are listed in Table 8.8 (page 182).

7 Threats

IBRA

The Interim Biogeographic Regionalisation for Australia (IBRA) (Thackway & Cresswell (eds) 1995) is a biogeographic framework for regional planning of conservation and sustainable resource management. It has been endorsed by the Standing Committee of the Australian and New Zealand Environment and Conservation Council (ANZECC), so has formal national standing. Developed as a tool for setting priorities in the National Reserves System Cooperative Program, IBRA has been used much more widely. Included in IBRA is a list of the limiting factors and constraints to conservation planning and management within each IBRA region. The IBRA regions do not correspond directly to the Australian Alps national parks, but these lists record the formally recognised threats for the three biogeographic regions included in the Australian Alps national parks. Even though some of these factors operate only outside the national parks, it is important to consider them because the national parks are a major (possibly **the** major) means of protecting the biodiversity of these regions and their importance is enhanced by their protection from threats operating outside.

Dominant Limiting Factors and Constraints

Australian Alps region

ACT — Wildfire
New South Wales — Feral animals, feral rabbits, wildfire, forest timber production / harvesting, tourism
Victoria — Forest timber production / harvesting, grazing, pastoral, weeds, tourism

South Eastern Highlands region

ACT — Grazing, pastoral, wildfire, urbanisation
New South Wales — Agriculture, clearing, cropping, extinction of critical weight range mammals occurring, ferals, feral rabbits, wildfire, forest timber production / harvesting, grazing, pastoral, horticulture, mining, salination, weeds
Victoria — Forest timber production / harvesting, weeds

South East Corner region

New South Wales — Agriculture, clearing, cropping, ferals, wildfire, forest timber production / harvesting, grazing, pastoral, tourism, urbanisation
Victoria — Forest timber production / harvesting, weeds

7.1 Fire

> Fire was, is, and will remain inextricably part of ecological Australia — (DCNR 1995b)

Although fire has probably always been a component of many environments since the establishment of land plants, an increase in fire activity about 30 million years ago has been documented, associated with reduced precipitation, increased climatic variability and an increase in abundance of fire tolerant, sclerophyll plants. Fire activity may have peaked as early as 5 million years ago in inland areas but has been increasing in more humid coastal areas over the last few hundred thousand years with variation related mainly to glacial / interglacial climatic oscillations. There is evidence of a peak in fire activity or a change in fire patterns centred on 40,000 years ago which is possibly attributed to Aboriginal burning as it occurs during a period of relative climate stability. Subsequent high levels of fire activity are recorded, but the relative influences of climate and people are difficult to decouple. Many records show marked charcoal peaks associated with early European activities followed by sharp declines to present low burning levels (Kershaw, James & Gill 1999).

Aboriginal peoples used fire for a range of purposes while occupying the lower tablelands and foothills of the Snowy Mountains area. They probably used fire to clear forested areas for easy access, define tribal boundaries and for attracting game. The current understanding of the extent to which Aboriginal peoples used fire as a management tool in elevated areas of the Snowy Mountains is limited, but most evidence suggests that fire frequency in Kosciuszko National Park was considerably less before European settlement (NSW NPWS 1998a).

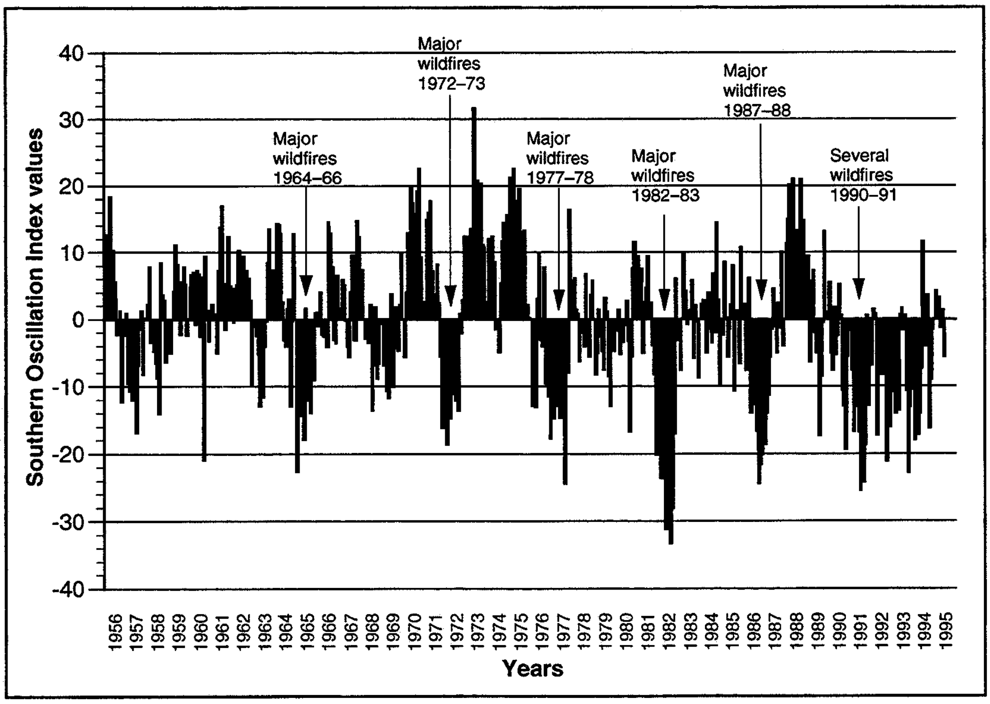
Banks (1988) reported on dendrochronological studies in the Australian Alps national parks, mainly in the Brindabella Range, which established a general pattern of marked increase in fire frequencies with the arrival of European pastoralists and prospectors and recent decline with the ascendancy of the conservationist and recreationist period. The magnitude of the increase is site dependent, and Banks warned against making generalised interpretations.

In the forty-year period 1956–95, about 10% of Kosciuszko National Park burnt four times or more while only 23% was not burnt (NSW NPWS 1998a).

The El Niño Southern Oscillation (ENSO) phenomenon receives a great deal of publicity. The large-scale climatic effects of El Niño Southern Oscillation have important influences on the climate of south-eastern Australia. Increased levels of greenhouse gases in our atmosphere could cause El Niño Southern Oscillation events to occur in Eastern Australia more frequently – as often as every three years, instead of the current average of every five years (Baker et al 2000)

The El Niño Southern Oscillation appears to be one of the major external factors influencing wildfire occurrence in Kosciuszko National Park. Historically, the high proportion of wildfires occurred during summer when there were strong negative values of the Southern Oscillation Index. The 1964–66, 1972–73 and 1982–83 extreme fire seasons appear to correlate with the Southern Oscillation Index, as do major fire seasons in 1977–78, 1987–88 and 1990–91 (NSW NPWS 1998a).

Figure 7.1 The occurrence of major wildfires in Kosciuszko National Park in relation to the Southern Oscillation Index — (NSW NPWS 1998a)



A large number of fire simulation models that considered climate change all concluded that an increase in fire frequency is likely (Baker et al 2000).

Temperature, drought, soil moisture and storm frequency are fundamental to the number of fires each year. Changes to these factors due to the enhanced greenhouse effect will be felt in terms of increased frequency, and possibly intensity, of fires. Additionally, current investigation suggests that seasonal patterns of fire may shift significantly (Baker et al 2000).

Fire is a conservation issue of national significance. Fire is important because of its influence on species and the ecological processes that mediate the persistence of species in communities and ecosystems (Bradstock, Keith & Auld 1995).

The community has a range of views regarding fire. Views on wildfire range from ‘all wildfire is bad and should be suppressed’ to ‘because wildfires are natural let them burn unless they directly threaten life or property’. Regarding the use of prescribed fire, views range from ‘ecosystems are very finely tuned with respect to fire and we do not know enough to interfere with the fire regime’ to ‘ecosystems are adapted to fire so burn them as often as you like’ (DCNR 1995b).

Recently, however, people’s attitudes to fire and the approaches to fire management have started to change. There is no longer a pervading attitude that all fire is bad and should be excluded from natural landscapes, but rather, a recognition that fire has an important role in ecological management and that there needs to be a balance between total fire exclusion and the regular burning of strategic areas primarily for protection purposes. This balance needs to be reached through a better understanding of the role of fire in the ecosystem, the legal requirements to protect life and property, and the resources available for public land management (Fire Ecology Working Group 1999).

The two primary objectives for fire management in Kosciuszko National Park are:

- to protect human life and property within the park; and
- to conserve the natural and cultural features, catchment values and recreational opportunities within the park (NSW NPWS 1998a).

Fire is elemental in the maintenance of many of our native ecosystems and its use as a management tool must recognise that both the application of fire (in all its variety of frequencies and intensities), and its exclusion, will have consequences. On the basis of current knowledge, some of these consequences are predictable, but others are not (DCNR 1995a). However, over the last decade there has been a rapid increase in the knowledge of the impacts of fire behaviour (NSW NPWS 1998a).

Until comparatively recently, most studies into the effects of fire on plants and animals have only considered the impact of a single fire. While a single fire may have a significant impact upon individual plants and animals, the long term survival of species populations is dependent on the frequency, intensity, season and extent of successive fires. Together, these parameters define the fire regime (Kendall, pers. comm.).

The greatest threat to a species population is the occurrence of fire regimes outside the range to which the species is adapted. Both planned and unplanned fires may result in a fire regime outside the range to which a species is adapted. The absence of fire may also result in a fire regime outside the range to which a species is adapted. It is often overlooked that the decision to do nothing is an active management decision that may have equally significant and long lasting consequences as the decision to implement a particular land management activity such as prescribed burning (Kendall, pers. comm.).

Recently, attempts have been made to identify the threshold between the range of fire regimes a species is adapted to and the range of fire regimes under which a species will become extinct. These thresholds are called fire regime thresholds. Often, these fire regime thresholds can be specified for groups of species with similar life-history characteristics (functional groups), rather than for individual species. However, it may be necessary to identify fire regime thresholds for species of particular significance such as rare and threatened species (Kendall, pers. comm.).

Thus managing the threat of inappropriate fire regimes requires the manipulation of fire regimes which takes into account the contribution of both planned and unplanned fires. This requires an adaptive and responsive management approach (Kendall, pers. comm.).

Wild fires

> "The fire which caused the damage around Bright is believed to have started in the Buffalo River area, many miles away, about 8 January [1939]. When the wind changed on 13 January it took the fire in one evening for a distance estimated at up to sixty miles [100 km]. It swept the Buffalo Valley, the Buckland Valley, crossed through the Ovens Valley and joined up with one from the Kiewa Valley side on its way to the high plains." (Noble 1977)

Hopefully wild fires of the intensity and extent of the "'39 fires" will not be seen again, but wild fires occur naturally and even without any human causes, fires will break out and burn uncontrolled in the Australian Alps national parks, as they will elsewhere. With improved detection and suppression technology and infrastructure, faster containment and control is possible now than in 1939, but wildfires will always be a significant threat. Despite our best efforts, some wildfires become uncontrollable, particularly during periods of extreme fire conditions, and pose a significant threat to life, property and other assets (DCNR 1995b). However, because fires are a natural environmental force, they are not just a threat but also a necessary mechanism for ensuring diversity of vegetation stages and even for enabling regeneration of fire-dependent plant species.

Although wildfires occur naturally, and have been part of the environment in which the Australian animals and plants evolved, the present regime of wildfires is far from natural. Of all recorded wildfires in Kosciuszko National Park since 1956, 41% were started by people (22% from illegal ignitions, 11% from campfires, 6% from negligence/accident, and 2% from management), 20% were caused by lightning, and 39% are recorded as starting from other/unknown causes. In other words, people caused two-thirds of the wildfires for which the cause was identified. As identification of the causes of wildfires improves, records show a decreasing proportion of ignitions from other/unknown causes and an increase in illegal ignitions (NSW NPWS 1998a). But while fire ignition is now much more frequent than occurs naturally, substantial effort in fire detection and suppression means many fires, including natural fires, burn much smaller areas than they would otherwise. Fire suppression is a statutory obligation, and it is usually impractical to allow a natural fire to burn unconstrained because of possible risk to human safety and property.

Fires in the high country have been severe in certain areas; the 1939 fires razed most of the montane and subalpine areas across Victoria (Busby 1990).

Fire management activities must be planned and conducted in an environmentally sensitive manner according to the following principles: … fire regimes and fire management activities to be appropriate for maintaining the vigour and diversity in populations of species and communities of the State's indigenous flora and fauna; ... (DCNR 1995a).

A key direction of management in Victoria — "Continue to promote the investigation of natural ecological processes in these landscapes and adjust management regimes in response (e.g. the role of fire and grazing in the long-term ecological health of the natural systems)." (DNRE 1997d).

The Kosciuszko National Park Fire Management Resource Document (NSW NPWS 1997a) examines the strategies required to protect life and property from unplanned fires whilst implementing appropriate fire regimes for managing biodiversity. These two goals are challenging to management but not necessarily mutually exclusive.

There is no doubt that fire suppression is vitally important for the protection of life and property. However, when employing fire suppression techniques, we need to be constantly aware of the possible environmental implications and use techniques that cause minimum environmental damage. The construction of mineral-earth fire-lines leads to severe fragmentation of native habitat and compaction of soil; providing increased avenues for weed and vermin transport, and an increase in 'edge effects’. Fire-line construction in large remote areas may cause little damage in comparison to that in small remnants. The 1998 ‘Caledonia’ fire in the Alpine National Park, Victoria, which burnt 31159ha, had approximately 358 km of fire-line. The percent of bulldozer trail area relative to the total burnt area was 0.5% at the Caledonia fire, but amounted to 8% in the Mount Martha Park, Victoria, where 36 ha was burnt. In the short-term, mineral-earth fire-line construction in the Mount Martha Park led to significant invasion of exotic plant species, with the potential for further longer-term impacts (Caling & Adams 1999). Fire retardants and fire control disturbance were identified as threats at the project workshop.

Managed fires

Target fire regimes are sometimes prescribed for the conservation of single species or small groups of species, including those that are rare, dominant or high in the public profile. There is no single target value of fire frequency or inter-fire interval that is likely to favour all species but rather a range within which conservation of full diversity is possible (Bradstock, Keith & Auld 1995).

In Victoria in 1993–94, most managed (prescribed) fires were for fuel reduction or slash burning. Only 3% of prescribed burns, amounting to about 500 ha, were for ecological purposes (DCNR 1995b).

Prescribed or planned burns in spring and early summer can leave soil exposed to the common summer thunderstorms which can cause erosion and contribute to turbidity loads in streams. Fire also allows for the establishment of weeds which may be less effective in soil protection than native species (Cullen & Norris 1989 #).

Old growth forest is present within the Avon, Turton, and Dolodrook Rivers and Ben Cruachan Creek Natural Catchment Area, but appears restricted to the north-east of the catchment. Other areas are probably burnt too frequently for fuel reduction to be considered old growth (DNRE 1997b).

Hazard reduction burning will not be conducted on karst areas except to strategically reduce fuels around visitor facilities. The use of machinery should be avoided, if possible, on karst areas (Spate 1990).

Post fire rehabilitation works should commence on karst terrains before other environments and should aim to completely halt sediment transport into streams and cave entrances (Spate 1990).

Some of the most complex ecological problems in maintaining the integrity of mountain forests arise from the practices of fuel-reduction burning developed during the last 30 years. The rationale for this practice is the prevention and control of wildfire, but almost any widely applied practice will reduce diversity in the systems to which it is applied. Thus secondary successions in the forest understoreys tend to be arrested at early stages (0–10 years) and some fire-sensitive species are being eliminated. Frequent removal of ground litter can provide potential for recolonisation by alien species, catchment instability and erosion (Busby 1990).

7.2 Pests

> The silent invasion of Hawai'i by insects, disease organisms, snakes, weeds, and other pests is the single greatest threat to Hawaii's economy and natural environment and to the health and lifestyle of Hawaii's people. Pests already cause millions of dollars in crop losses, the extinction of native species, the destruction of native forests, and the spread of disease. But many more harmful pests now threaten to invade Hawai'i and wreak further damage (The Coordinating Group on Alien Pest Species 2000).

Hawaii is far removed from the Australian Alps national parks, but the threat is shared. We must not underestimate the significance of introduced pests, present and future, in the protection of the natural features of the Australian Alps. Curiously, one of Hawaii’s vertebrate pests, or at least alien animals, is the brush-tailed rock wallaby, which is possibly the rarest mammal in the Australian Alps national parks (though there are doubts about its taxonomic status in Hawaii as it appears different from the brush-tailed rock wallaby — Skip Lazell, pers. comm). Although the rock wallabies on Oahu in Hawaii suffer predation from dogs, and cats are numerous, there are no foxes there (Fred Kraus pers. comm.)

A strong consensus emerging from a recent analysis of future biodiversity trends in the major biomes of the world identified the main cause of biodiversity loss in the coming decades as land use change, mainly loss of habitat and landscape fragmentation [which are not really an issue within the Australian Alps national parks]. **The next most important factor identified was invasion by alien species.** Although trends are less certain here, the general conclusion is that alien species will be an increasing problem, given (1) the globalization of economies and, hence, the movement of people and materials; and (2) the susceptibility of disturbed ecosystems to invasions. Changes in atmospheric composition and climate are regarded as longer term factors, increasing in relative importance over time (Walker & Steffen 1997).

More than 70 introduced species of plants and animals have been recorded in the alpine areas of Australia (Busby 1990).

DNRE has identified a key direction of management to "Investigate and implement strategic ways of managing the impacts on biodiversity assets of environmental weeds and introduced predators."

Although it is tempting to control pest species without thorough study of their biology, on the basis that they can be killed easily without such knowledge, experience has shown that such an approach can be very expensive and achieve little. For example, 83,000 donkeys were shot in the Victoria River District of the Northern Territory with no sustained reduction in numbers (Berman 1992 #).

Introduced animals

> Armies of foreign animals are invading Australia…they come in all shapes and sizes, from millipedes and sponges to swans and camels. They also exert an influence on the environment, by preying on native plants and animals, taking over their homes and stealing their foods. Honeybees, for instance, deprive birds of nectar and possums and parrots of nestholes (Tim Low 1999).

Some introduced animals are well-known as pests and recognised as threatening to native wildlife. The effects of many introduced animals, particularly invertebrates, are less well recognised and often poorly known.

Most of our worst vertebrate pests were purposefully set free by foolish men convinced they were doing the right thing. This holds true of our very worst mammals (rabbit, fox, pig), birds (starling, myna, sparrow) and fish (mosquito fish, tilapia, carp, trout) (Low 1999).

> Banjo Patterson's classic poem about stockmen and the brumbies of the mountains, *The Man from Snowy River* "has been inspirational to so many Australians…it has helped so many of us define, in part, that indefinable feeling of Australian-ness". (Hayes 1999)

The emotional and historical significance of many feral animal species increases the difficulty and complexity of their management as pests. They **are** living beings, and many of us have closely related pets in our homes, others are appealing or romantic, but the scientific evidence of the threat they present to whole plant and animal communities is overwhelming. The need for their control, at least, and eradication, if possible, is clear. Management must take account of community attitudes and the need for humane control methods.

The criteria/rationale for determining pest animal priorities in Kosciuszko National Park have been as follows (NSW NPWS 1995):

- those species which compete with, and prey on native animals and plants and degrade natural habitats;
- those species which are capable of spreading disease amongst native animals and domestic livestock which would incur economic loss;
- those species which directly threaten endangered species (ie. both plant and animal);
- those species which cause direct economic hardship to park neighbours.

Interaction between pest species

It is necessary to consider the interaction between pest species when planning action against one.

Increases in feral cat numbers have been reported in some areas after the control of fox populations. Quantification of the ecological interaction between feral cats and foxes is necessary when fox control is planned (Molsher 1998).

> By monitoring changes in the abundance of small mammals in each of three areas at a semi-arid site at Shark Bay, Western Australia, Risbey and Calver (1998) found that:
>
> - small mammal captures increased when both feral cats and foxes were controlled;
> - controlling only foxes led to an increase in the density of feral cats, followed by a dramatic **decline** in small mammal captures; and
> - where feral cats and foxes were not controlled, small mammal captures remained relatively stable.
>
> They concluded that when relieved of competitive and possible predatory pressures following fox control, the density of feral cats can rise to a level which appears to be more detrimental to populations of small native mammals, than the combined density of feral cats and foxes prior to fox control

Feral cats and endemic parrakeets co-existed on Macquarie Island for about seventy years until the introduction of the rabbit in 1879. Rabbits spread quickly over the whole island and provided an abundant year round supply of food for the cats. Supported by this new food source, cat distribution similarly increased to encompass the whole island. In 1984 Hamilton found that cats had become "very numerous and of great size". During winter the absence of seabirds and reduced populations of rabbits forced the now larger number of cats to increase predatory pressure on the parrakeets. By 1890 the parrakeet had become extinct (Cross 1990).

Foxes are a significant vector in spreading blackberry.

Cats

> In South Africa the population of 2,000 cats on Marion Island accounts for 500,000 bird deaths per year while on Kerguelen Island where the cat population is approximately 5,000, 1.2 million birds per year are taken as prey (Cross 1990).

The feral cat is common throughout most environments in Australia, including offshore islands. There is strong evidence that feral cats have caused the decline and extinction of native animals on islands. Feral cats have also been shown to thwart re-introduction programs for native species. Predation by feral cats is thought to have contributed to the extinction of small to medium-sized ground-dwelling mammals and ground-nesting birds in Australia's arid zone, and to threaten the continued survival of native species that currently persist in low numbers (Environment Australia 1999d).

"Predation by feral cats *(Felis catus)"* is listed under the Environment Protection and Biodiversity Conservation Act as a Key threatening Process. "Predation of native wildlife by the cat" is listed on Schedule 3 of the Flora and Fauna Guarantee Act as a potentially threatening process.

Low (1999) and Dickman (1996) discuss the possibility that Macassan fishermen brought cats to Australia, possibly around the fifteenth century. Dickman also refers to the possible arrival of cats on the north-west coast in the seventeenth century from the wrecks of Dutch ships. It is probable that cats were present in Australia long before European settlement, although their distribution and abundance at that time is not known (Seebeck & Clunie 1997). If the dingo is considered a native species, would the cat also be if its arrival preceded the arrival of Europeans? Whether or not cats arrived in northern Australia so long ago, Dickman (1996) states that in eastern Australia, the first cats were probably introduced by European settlers in the late eighteenth century.

An adult feral cat of average weight (about 4 kg) requires about 300 g of flesh daily to survive. Cats do not need drinking water as they can obtain sufficient moisture from their prey. They are the most specialised meat eaters among the carnivores, requiring a much higher proportion of protein in their diet than almost any other mammal. (Seebeck & Clunie 1997).

There is clear evidence that feral cats have caused the decline and extinction of native animals on islands through predation, but sound evidence that feral cats exert a significant effect on native wildlife throughout the mainland is lacking (Environment Australia 1999d).

The impact of processes such as habitat loss, change and fragmentation can be exacerbated by Cat predation on remnant, isolated, populations. When a species exists only as small populations, there is the potential for loss of genetic variation and potentially a decreased resilience to cope with environmental change and stochastic events. Cat predation has the potential to depress local wildlife population sizes and cause local extinctions of species; and in conjunction with other threats, it has a significant impact on the survival of species (Seebeck & Clunie 1997).

Cats can affect native wildlife by predation, by competition, and by transmitting disease, but compelling evidence for competition has not been obtained. Among native mammals, quolls (*Dasyurus* spp) share the greatest similarity in diet with feral cats and coexist with them in forest and woodland habitats. Feral cats could also reduce prey populations for predatory birds such as powerful owls (*Ninox strenua*), masked owls (*Tyto novaehollandiae*) and sooty owls (*T. tenebricosa*) (Dickman 1996).

Cats prey on a large number of native fauna species. The current inventory of species on which the cat is known to feed includes 186 birds, 64 mammals, 87 reptiles, at least 10 amphibians and numerous invertebrates. Cats are known to eat animals up to their own body weight, which includes most endangered and vulnerable mammal species in Australia, but the majority of prey are less than 100g (Seebeck & Clunie 1997). Anecdotal evidence suggests that small mammals and birds are more likely to experience negative impacts from cat predation than other wildlife taxa (Dickman 1996).

Feral cats are widespread in the alpine area, but their numbers and distribution are not known. There is concern that their impact on native fauna is much greater than is currently acknowledged. Some feral cats are caught in snares and some take wild dog baits. Cats are a threat to the Broad-toothed Rat (DCE 1992d).

Species living at low densities in limited areas, or in fragmented habitats, will be particularly susceptible to cat predation (Newsome et al 1997). This is certainly the case with the mountain pygmy-possum.

In Kosciuszko National Park, the most noticeable cat populations are in and around ski resorts and other development areas such as Cabramurra township, Yarrangobilly Caves, Kiandra, Waste Point and the numerous camping areas, picnic areas and lookouts, but feral cat tracks and scats are frequently seen even in the most remote wilderness areas (NSW NPWS 1998b).

Of the fauna of the Australian Alps national parks, cats are a perceived threat to the mountain pygmy-possum, the brush-tailed rock wallaby and the long-footed potoroo. Cats are also a perceived threat to the Baw Baw frog (Environment Australia 1999d). A radiotracked mountain pygmy-possum was taken by a cat in 1996 (NSW NPWS 2000c), and there are records of cats taking other threatened species including brush-tailed phascogale (*Phascogale tapoatafa*) and common bent-wing bat (*Miniopterus schreibersii*). Cats are considered as significant a problem as foxes to colonies of brush-tailed rock wallabies (*Petrogale penicillata*) (Seebeck & Clunie 1997); in contrast, cats are also considered to present no risk of predator impact to brush-tailed rock wallabies (Newsome et al 1997).

Toxoplasmosis is a disease which affects the central nervous system and other organs, and can lead to organ failure, blindness, abortion and death in native wildlife. Cats are an essential part of the life cycle of the disease. It seems likely the decline of some native species may be linked with toxoplasmosis (Seebeck & Clunie 1997). Cats also carry sarcosporidiosis and are potential carriers of rabies (NSW NPWS 1998b).

Dogs

> "With the coming of the national park, the dingo and wild dog problem grew more complicated — and has remained pretty much that way." (Hayes 1999)

Wild dogs are considered to include all animals of the genus *Canis* in the wild, including the dingo (*Canis familiaris dingo)*, dingo hybrids and feral dogs (DCE 1992d). The term wild dog is now often used to collectively describe the present canid population. However, the vast majority of these animals are predominantly dingo in origin and should not be confused with stray or feral domestic dogs (Regan 1994c). Dingoes are a primitive type of dog, introduced into Australia probably between fourteen and three thousand years ago. They became established over much of mainland Australia and because they were introduced prior to European settlement, they are now regarded as a component of our native fauna (Regan 1994c). Without any practical means of distinguishing between feral dogs, dingoes and hybrids, control programs affect all of them.

Recent research indicates that the great majority of the present population of wild dogs in the Eastern Highlands of Victoria can best be described as dingo-like wild canids with the gene pool predominantly dingo in composition. Feral dogs, hybrids and other atypical animals may be present, but few in number (DCE 1992d).

The dingo appeared on mainland Australia about 4000 years ago, probably via northern Australia (Newsome et al 1997). Low (1999) suggests the dingo is exotic because, irrespective of when it arrived, *it was brought here by people*. It is, after all, a domestic dog gone wild. But because it has achieved ecological integration, becoming our top non-human predator, essential to ecosystem functioning, we need to conserve it as if it were a native species.

Wild dogs prey on wildlife, particularly small mammals, birds, reptiles and insects. However, it is assumed that native fauna adapted to predation by dingoes long before European settlement (DCE 1992d). Although the distribution of dingoes and of vulnerable species overlap, such potential prey are rarely taken (Newsome et al 1997). Nevertheless, dingoes, as well as foxes and cats, are considered to present a high risk to the mountain pygmy-possum (Newsome et al 1997).

Within national parks in Victoria, the dingo is considered to be an indigenous species (DCE 1992d), but wild dogs (including dingos) are declared established pest animals under the Catchment and Land Protection Act. The responsibilities of land owners in respect of established pest animals are that the land owner must take all reasonable steps to prevent the spread of, and as far as possible eradicate, established pest animals (DNRE 1999c).

The Victorian National Parks Service Guidelines and Procedures Manual (National Parks Service 1995) states that while native fauna usually constitute a major portion of the dingoes' diet, it can be assumed that wildlife adapted to the presence of dingoes long before European settlement. Therefore, the only reasons that threat to wildlife should be used to justify control programs where dingoes are the likely predators are:

- where the fauna species is rare or threatened (regionally or widespread); or
- where predation is unusually high, perhaps boosted by other wild dogs such as near residential or pastoral areas or in small forest blocks.

The NSW National Parks and Wildlife Service regards the dingo as an integral part of natural systems and will not attempt to eradicate this animal from within any national park. The continued survival of the dingo as a discrete breed of dog is endangered by cross-breeding with feral dogs as well as by eradication by man (NSW NPWS 1988b).

Wild dogs (including dingoes) are also declared noxious animals in New South Wales under the *Pastures Protection Act*, 1972 although the Service is not bound by that *Act*. The Service intends to provide protection for the native dog (dingo) within Service lands wherever this can be achieved while still affording protection to neighbours from predation on stock (NSW NPWS 1988b). Problems with wild dogs generally involve injury to or the loss of stock (chiefly sheep) on neighbouring lands (NSW NPWS 1998b).

The dingo is regarded as a native species within Namadgi National Park, although the status of individual animals may be in doubt as a result of interbreeding with feral dogs. Throughout the core of the park, the animals will be protected like all other native species. However, feral dogs or dingoes can be a problem for sheep graziers in some areas adjoining bushland. The Service accepts that numbers of these animals should be kept at minimal levels within a buffer zone of 1 km inside the park boundaries (ACT P&CS 1986).

There is a high incidence of hydatid tapeworm in wild dogs, but they are rare in domestic dogs. The hydatid worm is important because its intermediate stage, the hydatid, cyst, can be fatal to humans. People can become infected by handling wild dogs and therefore strict hygiene must be practised (DCE 1992d).

Foxes

> Foxes are probably the greatest blight on our smaller mammals (Low 1999).

The European red fox is an adaptable and elusive predator and scavenger which, despite vigorous control efforts, is now common throughout most of the southern half of mainland Australia. There is abundant evidence that predation by foxes is a major threat to the survival of native fauna. Small to medium-sized ground-dwelling mammals and ground-nesting birds, many of which are endangered or vulnerable, are at greatest risk (Environment Australia 1999e).

"Predation by the European Red Fox (*Vulpes vulpes)"* is listed under the Environment Protection and Biodiversity Conservation Act and the NSW Threatened Species Conservation Act as a key threatening Process, and on Schedule 3 of the Flora and Fauna Guarantee Act as a potentially threatening process. The Environment Protection and Biodiversity Conservation Act requires the preparation and implementation of a threat abatement plan to nationally coordinate management of the impact of fox predation on wildlife. The aims of the threat abatement plan (Environment Australia 1999e) are to promote the recovery of endangered or vulnerable native species and communities and prevent further species from becoming endangered by reducing predation by foxes to non-threatening levels.

Because Australian fauna did not evolve with the fox, susceptible prey species have few adaptive strategies to avoid predation. The impact of the fox has probably been exacerbated by habitat fragmentation and modification since European settlement. Subsequent to its establishment, the fox was probably a direct or contributing factor in the extinction of many highly susceptible species (Mansergh & Marks 1993).

There are very few habitats in Australia not already exploited by foxes (Newsome et al 1997).

Species for which foxes are a known or perceived threat include Baw Baw frog (*Philoria frosti*), mountain pygmy possum (*Burramys parvus*), long-footed potoroo (*Potorous longipes)* and brush-tailed rock-wallaby (*Petrogale penicillata*) (Environment Australia 1999e), (Bloomfield (ed) 1999a).

The fox has been implicated in the extinction of six mammal species in the Victorian Mallee. Some native fauna have low population densities and even low levels of fox predation on them may be significant to their continued survival (Horner & Platt 1993).

The diet of the fox may overlap with that of the Tiger Quoll (*Dasyurus maculatus*) in some habitats or seasons. There may be significant competition that affects the distribution and abundance of this native carnivore, which is listed as a threatened taxon under Schedule 2 of the Flora and Fauna Guarantee Act 1988 (Mansergh & Marks 1993)

Foxes may play a role in maintaining reservoirs of diseases harmful to wildlife and domestic animals such as distemper, parvovirus, canine hepatitus and heartworm. Foxes are also carriers of hydatid worms. Foxes with sarcoptic mange (scabies) are thought to be able to spread this disease into Common Wombat populations. Distemper, hepatitis and mange are known to be widespread among foxes (Horner & Platt 1993). They also carry several species of tapeworms and roundworms that parasitise domestic animals (Bloomfield (ed) 1999a).

The fox in Europe is the main vector and reservoir host of rabies and is therefore seen as the main threat for potential spread of this disease should it ever be introduced into Australia. Rabies can seriously affect humans and could have a massive impact on wildlife populations (Mansergh & Marks 1993) (Horner & Platt 1993).

Foxes assist in the dispersal of some environmental weeds, such as blackberries (Horner & Platt 1993) and sweet briar as the seeds remain viable in their dung (NSW NPWS 1995).

Deer

The management plan for Royal National Park says the fallow and Javan rusa deer, introduced to the park in the early 1900s, have had considerable impact on vegetation, regeneration of native species and soil stability.

The main deer species in the Australian Alps national parks are sambar, but red deer and fallow deer are thought to occur in the Cobberas–Tingaringy Unit of the Alpine National Park (DCE 1992b) and fallow deer have been reported in the Dartmouth Unit (DCE 1992c).

All species of deer in Victoria are defined as protected wildlife under the Wildlife Act. Six species: Rusa, Chital, Fallow, Red Deer, Hog Deer and Sambar are further classified as game species, although only the last three (Red Deer, Hog Deer and Sambar) have designated open seasons when they can be legally taken by appropriately licensed hunters (National Parks Service 1995).

The environmental impact of Sambar deer in Kosciuszko National Park is unknown. Sambar are selective feeders, taking no more than a mouthful from different plants as they move through a feeding area (Dunn 1980).

To the hunting fraternity sambar represent the most desirable game animal in Australia (DCE 1992d), (Dunn 1980). Deer hunting is a major recreational activity in the Wonnangatta–Moroka unit of the Alpine National Park. Deer stalking is permitted in the National Park but hunting with dogs is not. Deer hunting with hounds is permitted in the Grant, Mount Murphy and Mount Wills Historic Areas, which adjoin the Alpine NP, and elsewhere in Victoria (DCE 1992b), (DCE 1992d), (DCE 1992c). Hunting of fallow deer is not permitted, as it is a protected species (DCE 1992b).

Deer are known vectors of, or are susceptible to, certain exotic animal diseases. Anecdotal evidence suggests that deer may also be vectors in the spread of some pest plants. This warrants further investigation (National Parks Service 1995).

Under the Victorian National Parks Service Guidelines and Procedures Manual (National Parks Service 1995) control of deer population size **must** be undertaken in parks where deer are found to have an adverse impact on park values. Control **may** also be undertaken where it is considered that populations (if left unchecked) will have an adverse impact on park values.

Illegal deer hunting is a potential management problem, although deer hunters might cause less damage than pig hunters.

Fish

Introduction of live fish into waters outside their natural range within a Victorian river catchment after 1770 is listed on Schedule 3 of the Flora and Fauna Guarantee Act as a potentially threatening process.

<u>Trout</u>

Introduction of salmon and trout to Australia took many attempts over many years, and it was not until 1864 that live eggs were successfully brought from Europe. That success was trumpeted as a mighty achievement (Low 1999).

Only a few of the highest mountain streams and tarns are still trout-free and preserve the original aquatic fauna. Trout have significantly reduced native fish populations. Trout have also apparently changed the structure of the invertebrate benthic communities (Busby 1990). Among the fish species endangered by trout are the barred galaxias (*G. fuscus*) of mountain streams in Victoria and the trout cod (*Maccullochella macquariensis*). Frogs, along with crayfish and other invertebrates, are also disappearing from trout streams (Low 1999).

Notwithstanding the ecological harm they cause, trout are still bred in hatcheries and released into streams for the pleasure of anglers.

<u>Mosquito fish *Gambusia holbrooki*</u>

"Predation by *Gambusia holbrooki*" is listed on Schedule 3 of the NSW Threatened Species Conservation Act as a key threatening process.

Gambusia was released around Brisbane in 1925 for mosquito control, in Sydney in 1926 and in rural New South Wales in 1927. It has proved one of the most successful of all aliens unleashed upon Australia. *Gambusia* displace native fish by eating their eggs, stealing their food and nipping their fins. They also eat small tadpoles (Low 1999).

Gambusia is very widespread throughout New South Wales, South Australia and Victoria in both inland and coastal drainages. It is most abundant in warm and gently flowing or still waters, mostly around the margins and along the edges of aquatic vegetation beds. It tolerates a very wide range of temperatures and other habitat conditions — although it prefers water between 25°C and 38°C it can survive under ice (McDowell 1996b) and apparently occurs in Three-Mile Dam, near Kiandra, which freezes over each winter. It occurs in Kosciuszko National Park but little favourable habitat occurs in the Australian Alps national parks.

<u>Carp</u>

Carp weren’t a problem in Australia until a fish farm imported a vigorous new strain in 1961. Despite massive attempts to defeat them, carp now dominate the Murray–Darling river system. During a recent survey carp comprised a whopping 93 per cent of the 4000 fish sampled (Low 1999).

Olsen (1998) suggests closer examination indicates that carp may not be a major problem to native fish, at least compared to other modifications of the Murray–Murrumbidgee system. She describes extensive environmental changes including water diversion, salinity, nutrient enrichment, pesticides and herbicides, dams and weirs, removal of trees and snags, other introduced fish, and commercial and recreational fishing.

<u>Weatherloach</u>

The oriental weatherloach *Misgurnus anguillicaudatus*, a 20-centimetre burrowing fish that likes cool water, was first recorded in the wild in 1984, is now found around Melbourne, Canberra, Sydney, the Snowy Mountains and elsewhere, and is spreading fast. Its entire distribution results from aquarium releases or pond escapes (Low 1999). It was first recorded in the ACT as a single individual in Lake Burley Griffin in 1980 but no breeding population established. In 1984 an individual was collected from Gininderra Creek and by 1988 the population occupied more than 25 km of streams. In 1992 a population was found in a tributary of Lake Eucumbene (Lintermans 1993b).

The impacts of weatherloach on native fish species are unknown (Lintermans 1993b).

Goats

The feral goat is a generalist herbivore that can survive in many environments. It is found in all States and Territories except the Northern Territory and also survives on many Australian islands. It is most commonly found in the arid and semi-arid rangelands of New South Wales, Queensland, South Australia and Western Australia. There is evidence indicating that competition and land degradation due to feral goats is threatening some native species and ecological communities and for this reason ‘competition and land degradation by feral goats’ is listed as a Key Threatening Process under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (the Act). The Act requires the preparation and implementation of a threat abatement plan (Environment Australia 1999a) to nationally coordinate management of the impact of competition and land degradation by feral goats.

Goats pose a major threat to native vegetation, compete with native animals for food, water and shelter, and contribute to erosion(NSW NPWS 1998b). Feral goats can carry foot-rot which affects sheep and is very difficult to eliminate. They are also potential carriers of foot and mouth disease (NSW NPWS 1995). Feral goat populations are capable of increasing by up to 50 per cent each year under favourable environmental conditions (Environment Australia 1999a).

Goats are uncommon in the Australian Alps national parks.

In Kosciuszko National Park goats are generally confined to the lower Snowy River corridor in the Bryadbo Wilderness Area, but smaller populations occur in the Goobarragandra Valley and escapes from private property are frequent along the Alpine Way and adjacent to the Bryadbo Wilderness Area (NSW NPWS 1998b).

Goats are a perceived threat to the brush-tailed rock wallaby (Environment Australia 1999a).

Horses

> "There have been wild horses in the high country almost since the first days of white settlement and they have become an inseparable part of the folklore of the mountains. To come by chance on a mob of brumbies on a winter's morning before the mist has lifted is an unforgettable experience. Half hidden in the trees, they seem to merge into the shadows, the occasional grey among them ghostly in the mountain fog, barely visible against the still crisp snow." (Hall 1992)

> Dave Pendergast, a member of the original mountain family and the first winner of "The Man from Snowy River Award", with a life-time's experience in the mountains, was quoted by Mike Hayes (Hayes 1999) on the subject of brumbies: *"Brumbies were good dog feed. Some of them was all right — wasn't bad pack horses. You'd get a few good kids' ponies, but as for the rest of them, I never seen much good."* Many other mountain people, though not all, supported Dave's assessment.

Feral horses are likely to promote weed invasion, and disturb or destroy the habitats of rare and threatened species, yet their control or elimination has been largely prevented by public sentiment. It is only in Namadgi National Park that they have been eliminated. In Kosciuszko National Park they are effectively treated as a source of wild horse stock (Kirkpatrick 1994 #).

The impacts of feral horses are well understood but not well documented (Gibbs 1993 #; Dyring 1992 #), but feral horses cause erosion by forming compacted tracks, and thereby drain wet areas. Direct impacts of feral horses include tracks, wallows, streambank crossings and steambank breakdown. Indirect impacts include the proliferation of weed species found in trampled areas and associated with dung piles (Dyring 1992 #). Many recreational riders argue that to restrict recreational horse use from areas with significant feral horse populations is illogical as they claim any damage caused through recreational horse use would be trivial compared to the effects of the feral population (Gibbs 1993 #).

Horse riding is a permitted recreational activity in parts of the Alpine, Kosciuszko, Mount Buffalo, Namadgi and Snowy River National Parks, and the number of people taking part in horse riding is growing considerably. These include commercial tours (about 25 commercial tour operators in the Alpine NP in 1992 (Harris 1992 #)), clubs and individual parties.

The use of horses in a concentrated area, whether along a track or trail system, or around camping or watering points, has the potential to create high levels of impact which are considered unacceptable (Gibbs 1993 #).

The very nature of horse riding activity, using a steel-shod animal weighing about 500 kg, combined with concentrating use along narrow tracks and around facilities such as huts and yards, along with the need to water animals at creek and river edges has led to obvious impact (Gibbs 1993 #). An average of 5.6 cm depth of soil was lost from horse riding tracks in part of the Australian Alps national parks over two seasons (Harris 1992 #). The introduction and spread of weeds and exotic species into areas has been associated with horse riding activity through both horse manure and horse feed as well as soil disturbance (Gibbs 1993 #).

Pigs

> Feral pigs are one of the most serious vertebrate pests in Australia today (Regan 1994b).

Feral pigs are not formally recognised as threatening, but present a significant threatening process in subalpine plains (shortly to be the subject of investigation by NSW NPWS).

The pig's habit of wallowing and rooting around edges of watercourses and swamps destroys vegetation. Feral pigs prey on native animals, nesting birds, reptiles and frogs. They also act as an agent for the dispersal of weeds such as Blackberry, Sweet Briar and Broom. Fence damage with adjoining neighbours is also common (NSW NPWS 1995). A specific concern is pig damage to corroboree frog habitat (NSW NPWS 1998b).

There is a possibility that pigs may at times feed on wildfowl and eggs. In the high plains of Kosciuszko National Park, pigs are known to feed extensively on tuberous plants, which may threaten individual species or plant communities. The result of any such alteration in the make-up of an area's dominant floral species could have adverse effects on those native animals or insects dependent on that environment. In addition, the general result of extensive disturbances by feral pigs is an invasion of weeds and introduced plants that can alter the ecology of an area completely (Regan 1994b).

Feral pigs have been recorded throughout an increasing proportion of the area now within Kosciuszko National Park since 1927, and occur as high as 1800–2000 m during summer (NSW NPWS 1998b). It is known that there have been significant fluctuations in the size of the pig population although the causes of these variations have yet to be established. Control programs have been implemented since 1971 (NSW NPWS 1988b).

Pigs are recognised as a potentially serious animal disease vector as well as causing a detrimental impact on natural environments. Eradication of pigs from Kosciuszko National Park is desirable and may be necessary in the advent of a disease outbreak. Resources well beyond those normally available to the Service would be required to complete an eradication program using current control techniques (NSW NPWS 1988b).

Feral pigs are carriers of a number of serious diseases such as leptospirosis, brucellosis, sparaganosis, tuberculosis and others that are dangerous to humans as well as livestock (Regan 1994b).

The major problem that feral pigs present is the role they could play in the spread of ruinous exotic diseases which have the potential to seriously damage primary industry in Australia, should they ever become established. Feral pigs are susceptible to diseases that include African swine fever, Aujeszky's disease, foot and mouth, rabies and rinderpest. None of these diseases are at present in Australia, however, it is a matter of concern that the widespread distribution of feral pigs, particularly in Northern Australia, would make effective control extremely difficult. Some outbreaks have occurred in the past but fortunately, these have been localized and controllable (Regan 1994b).

Not only pigs, but pig hunters, do a lot of damage in Kosciuszko National Park and Nanadgi National Park and interfere with control programs.

Rabbits and hares

The European rabbit (*Oryctolagus cuniculus*) is one of the most widely spread and numerous of the introduced mammals in Australia. The species has adapted to and survives in a wide range of habitat types and climatic conditions, and rabbits now inhabit some 60 per cent of the country. There is abundant evidence that the impacts of rabbits threaten the continued survival of a wide range of native species and ecological communities. Since its introduction, the rabbit has affected Australia’s flora and fauna profoundly (Environment Australia 1999b).

Rabbits are a known threat to the austral toadflax (*Thesium australe*) and a perceived threat to the Baw Baw frog, mountain pygmy-possum and brush-tailed rock wallaby (Environment Australia 1999b).

'Competition and land degradation by feral rabbits' is listed as a key threatening process under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (the Act). The Act requires the preparation and implementation of a threat abatement plan to coordinate management of the impacts of rabbits on wildlife nationally. The aims of the threat abatement plan (Environment Australia 1999b) are to promote the recovery of endangered or vulnerable native species and communities and prevent further species and communities from becoming endangered by reducing competition and land degradation caused by rabbits to non-threatening levels.

> Of the wild introduced animals, rabbits have caused the most damage to Kosciuszko National Park. They compete with native wildlife for food and shelter. They eat seedlings and therefore prevent regeneration of native plants. They eat plants to below ground level and cause serious soil erosion problems (NSW NPWS 1995).

Rabbits occur throughout Kosciuszko National Park in most habitat types, often in and around formerly cleared or grazed areas. The rabbit is recognised as a major pest species in Kosciuszko National Park for the damage it can cause to soils, vegetation and landscapes in natural areas. It actively contributes to weed control problems (NSW NPWS 1998b).

Generally the area above 1525 m does not provide favourable habitat for rabbits, with no significant numbers of rabbits found in the Kosciuszko Main Range or the sub-alpine woodlands. Disturbed areas like Perisher Valley provide a more suitable habitat, and thus allow rabbits to occur above 1700 m. A small group of rabbits also occurs at Charlotte Pass Village, thus extending this altitude limit to about 1800m (Sanecki 1998).

Hares are widespread in Kosciuszko National Park but their effect on the Park environment is unknown (NSW NPWS 1988b).

Hares are common in the Bogong unit of the Alpine National Park, particularly on the alpine and subalpine plains. Little is known about their impact, although there is concern that their grazing pressure, particularly on young seedlings, could be very significant (DCE 1992a).

Hare populations in the Dartmouth unit of the Alpine National Park are small, scattered and have insignificant environmental effects in the unit (DCE 1992c).

Hares are common in the Wonnangatta-Moroka unit of the Alpine National Park, particularly on the alpine and subalpine plains. Little is known about their impact, although there is concern that their grazing pressure, particularly on young seedlings, could be very significant (DCE 1992d).

Small numbers of hares are present in the Cobberas-Tingaringy unit of the Alpine National Park, particularly on the snow grass plains. Little is known about their impact, although there is concern that their grazing pressure, particularly on young seedlings, could be very significant (DCE 1992b).

Rats and mice

The house mouse is the most widely established introduced mammal in the world. It has become established throughout Australia, particularly in towns and in cereal growing areas (Wilson et al 1992).

Black rats are common in urban environments and have penetrated the bush to some extent. They are capable of transmitting the diseases leptospirosis and salmonellosis to humans (Wilson et al 1992).

The effect of introduced species on *Burramys* may take several forms: direct predation by eg fox, dog, cat; competition from introduced rodents; predators transferring to native prey species after plagues of introduced rodents; non-target poisoning and trapping as a result of controlling introduced rodents eg house mice; as carriers of disease (Mansergh, Kelly & Scotts 1989).

Starlings

Starlings were identified at the project workshop as pests. Starlings often form large flocks, and they are aggressive occupiers of nest hollows in trees, displacing native fauna.

Invertebrates

The lion's share of ecological pest research goes into mammals, leaving us woefully ignorant about smaller invaders such as earthworms, ants, millipedes, bumblebees, molluscs and crabs (Low 1999).

Honeybees (*Apis mellifera*) are one of the planet's most successful animals. From their native homes in Europe, Asia and Africa, honeybees have gone feral across most of the world. They are perhaps Australia's most widespread exotic invader, found in nearly all habitats (Low 1999). Although quantitative data on the density of feral colonies are generally lacking, relatively high densities of feral honey bees are found in national parks containing riparian vegetation habitats, coastal heathland and open eucalypt woodland. The lowest densities occur in protected areas with rainforests, moist temperate montane habitats or arid inland water courses (Spessa 2000).

Bees compete with native species for pollen and nectar, and also for nest hollows. They also interfere with the pollination processes which depend on native species.

Some Australian studies of competitive interactions between honey bees and native fauna have shown that honey bees may alter the demographic performance of native bees and that honey bees compete with birds for access to either flowers or tree hollows, but some other studies have not detected such ecological interactions (Spessa 2000).

Feral honey bee populations in conserved areas with high species endemism should be eradicated, or at the very least controlled (Spessa 2000).

European wasps (*Vespula germanica*) have some potential to become pests in the Australian Alps national parks.

Bumblebees are another potential threat. They are common in New Zealand (where they were introduced more than 100 years ago, and where honeyeater populations have declined sharply) and have been introduced to Tasmania. They are popular with greenhouse produce growers because of their usefulness for pollination, especially of tomatoes. Natural history experts have warned that a recent (perhaps still current) proposal by New South Wales government scientists to introduce bumblebees from Tasmania to the mainland would be an environmental disaster (Roberts 2000).

Two parasites, the nematode *Cyathospirura seurati* and the tapeworm *Echinococcus granulosus*, apparently entered Australia inside dingoes' bellies. The tapeworm now infests kangaroos and wallabies (Low 1999). Since the dingo is considered native, presumably these parasites would also be — but this does illustrate how invertebrate pests can arrive and remain unnoticed.

Another exotic tapeworm (*Bothriocephalus acheilognathi*), introduced with carp, now kills western carp gudgeon (Low 1999).

Populations of the native phasmatid *Didymuria violescens* had built up in the mountain eucalypt forests of southeastern Australia to such a degree that severe defoliation was experienced. Fears were held for the survival of stands of certain eucalypt species (particularly *Eucalyptus delegatensis*), the destruction of which might have affected the stability of the Kiewa catchment. In January, 1961, and again in January, 1963, the State Electricity Commission of Victoria carried out spraying of Malathion over a total of more than 5,000 ha of the forested catchment (Newman 1964).

Table 7.1 Status and Distribution of Pest Animals

			Alpine National Park Cobberas-Tingaringy Unit (DCE 1992b)	Alpine National Park Wonnagatta-Moroka Unit (DCE 1992d)			Kosciuszko National Park (NSW NPWS 1998b)				Namadgi National Park (G Young)				Victorian status
Honey Bees															
Cats	WK	WK	WK	WK	C	C	C	WK	WK	WK	WK				T
Deer [+]					W						R				W
Dogs	P	C	C	C	C	C	C	C	C	C	C				E
Fallow deer [+]			P?				P				R				W
Foxes	C	C	C	C	C	C	C	C	C	C	C				TE
Gambusia							P								
Goats	U	U	U	U/0		U	L			R	L				E
Hares	C	U	U	C							WU				E
Horses	P (150)	U	C	U/0			P				A				
Pigs	0	U	U	0		U	C	P	P	P	P				E
Rabbits	WU	WU	WU	WU	U	L	WU	WU	WU	L	L				E
Red deer [+]			P?				P				R				WH
Sambar [+]	P	U	U	P			P	P			R				WH
Trout								P	P	P					T

P=present L=locally important A= on adjoining land

C=common R = rare

U=uncommon WK=widespread, but numbers and distribution not well known

0=none known WU=widespread, but not numerous

Status

National T=Key threatening process

ACT Pest animals not classified

NSW Pest animals: T=Key threatening process; N=Noxious

Victoria T=Potentially threatening process; W=Protected wildlife; H= Hunting permitted; E=declared as established pest animals [under the *Catchment and Land Protection Act 1994*.

Introduced plants

> More than 2700 weeds have become established in Australia so far, at a cost to the economy of more than $3 billion, and each year another ten take root. Weeds now make up 16 per cent of Australia's wild plant species (Tim Low, 1999).

Plant invasions into natural ecosystems are one of the major threats to the conservation of biological diversity across nearly all biogeographical regions on Earth (Adair & Groves 1998).

Environmental weeds threaten nearly all biological communities in Australia (Adair & Groves 1998).

> Although my study may be focused on Broom invasion and its effects to the native flora, I certainly feel that weed invasion in general is the next biggest threat to the Alps. Especially around the Bogong High Plains, where places such as Falls Creek village and Bogong village are potential weed explosions waiting to happen — Lynise Wearne, pers. comm.

Remarkably few studies have been undertaken to measure the impact of environmental weeds on either biodiversity or ecological functions or even on the processes contributing to invasion, despite the widespread political recognition of environmental weeds as one of the more serious threats to conservation in Australia (Adair & Groves 1998).

Although weeds appear to degrade many natural ecosystems, quantitative measures of their impact on those systems are relatively rare. Information needed to establish priorities for the control of weeds in natural ecosystems include determination of the mechanisms of weed invasion, the ecological impact of the weeds and the threshold points for declines in biodiversity values as weed invasions proceed. Where ecosystem-level functions are altered by weed invasions, habitat conditions or resource availability can be affected adversely for a broad range of species (Adair & Groves 1998).

Introduced plants are an acute and insufficiently appreciated ecological problem. On a national scale, populations of the most invasive species are expanding. Plant species not native to Australia now account for about 15% of our total flora. About half of them invade native vegetation and about one-quarter are regarded as serious environmental weeds or have the potential to be serious weeds. The largest proportion of environmental weeds are horticultural species that have escaped from cultivation. Almost all of Australia's native vegetation has been, or is likely to be, invaded by exotic species that could result in changes to the structure, species composition, fire frequency and abundance of native communities (Australian National Botanic Gardens 2000).

The invasion of native vegetation by environmental weeds is listed on Schedule 3 of the Flora and Fauna Guarantee Act as a potentially threatening process.

Three species of the Australian Alps are considered potentially threatened by weeds (Adair & Groves 1998). Hairy anchor plant (*Discaria pubescens*) is threatened by English broom, gorse and blackberry; rough eyebright (*Euphrasia scabra*) by blackberry; and mountain pygmy-possum by unspecified weeds.

Some 175 alien plant species have been recorded in the sub-alpine and alpine areas of the Australian Alps at elevations above 1500m. They are predominantly associated with disturbance. There are 140 species of alien plants (or 80%) recorded along roadsides and paths; 103 species (59%) have been recorded in and around resort buildings and other infrastructure; and 43 species are associated with grazing. Thirty-five species have become 'naturalised aliens', no longer dependent on human land use to provide suitable habitats (Johnston & Pickering 2000).

More than 80 introduced plants, both exotic and native, have been recorded in Snowy River National Park. While many of these are non-invasive, some have the potential to spread through the park, threatening the integrity of indigenous flora and fauna communities and the survival of particular species (DNRE 1995).

A range of factors influence decisions on weed control, but the extent of infestations combined with the prospects for achieving management objectives seem to be highly influential. In natural ecosystems, a fundamental issue on which management decisions need to be based is the impact (potential or actual) that a particular weed or a group of weeds has on the long-term conservation of biological diversity. In this respect, the questions that need to be answered are:

(1) What impact are weeds having on the population status of native biota?

(2) What impact are weeds having on ecosystem functions within the invaded communities?

(3) What are the threshold levels at which weed invasion has no or minimal impact on conservation objectives?

(4) Are there factors that can be manipulated to reduce the impact and susceptibility of native vegetation to invasion?

Until answers to these questions are considered, let alone found, it is likely that allocation of resources to weed control in natural ecosystems will continue in an ad hoc manner and we run the risk of treating the symptoms of invasion rather than the causes (Adair & Groves 1998).

Determination of priority weed control programs is the foundation of the ACT Weeds Strategy. This recognises the impossibility of effectively dealing with all weeds in all locations at the one time. Determination of priority control programs will ensure strategic and focused allocation of available resources (CCSERC 1996).

Only by monitoring and evaluating weed control programs can their effectiveness be improved. Even a less successful program can provide a learning experience if properly evaluated. Monitoring will also provide a means to demonstrate to the community accountability for the use of government resources (CCSERC 1996).

Non-native plants are invading the national parks, causing tremendous damage to park resources. Called exotics, aliens, non-indigenous species, and weeds, these invasive non-natives get into the parks by various means. Seeds and plant parts are brought into the parks by wildlife, wind, water, and humans. Fast-growing non-native plants encroach from populations established outside park boundaries (US National Park Service 1996).

Weed seeds enter national parks on cars. A vehicle check at Kakadu National Park found that 70% of cars were bringing in weed seeds. Wace germinated more than 18,000 seedlings of 259 species from sludge washed off cars at a Canberra car wash (Low 1999).

Once inside park boundaries, the most aggressive of these non-natives spread like wildfire into undisturbed as well as disturbed areas. These invasive plants often cause irreparable damage to natural resources. The ecological balance of plants, animals, soil, and water achieved over many thousands of years is destroyed. As native plants are displaced, animal populations that rely on the plants for food and shelter also decline. Non-native plants may reduce or deplete water levels, or alter runoff patterns and increase soil erosion, thus diminishing both the land and water quality. Some non-natives release toxic chemicals into the soil or harbor diseases, increasing the stress on native plants. Some nitrogen-fixing non-natives increase soil fertility, allowing other non-natives to outcompete plants that have evolved in the nutrient-poor native soils. Non-natives that interbreed with native species can swamp native gene pools. The growth and spread of non-natives can also change fire patterns and intensities, resulting in an altered ecosystem (US National Park Service 1996).

Estimates indicate that in the USA non-native plants infest 4,600 new acres of federal land each day (US National Park Service 1996).

Managing invasions of this magnitude requires a coordinated strategy based on cooperation among all land managers and on the principles of integrated pest management. Since non-native plants do not recognise political or other jurisdictional boundaries, they can only be managed if all land managers, both private and public, work together. Given the extent of non-native plant infestations and the associated costs for management, all available resources should be shared and used efficiently. This strategy, which emphasises cooperation, education, and science, and is based on integrated pest management techniques, can provide a blueprint for successful management of invasive non-native plants on National Park System lands (US National Park Service 1996).

Most exotic plant species cause minor effects on natural ecosystems. For example, Great Smoky Mountains National Park has approximately 1,500 vascular plant species, 400 of which are exotics, but only 10 species are considered to be threatening to park resources (Hiebert & Stubbendieck 1993).

US policy on exotic species directs park managers to give high priority to controlling and managing exotic species that have substantial impacts on park resources and that are believed to be easily managed. High priority should also be given to managing and monitoring exotic plant species that presently may not cause major impacts to park resources but have life history characteristics associated with colonising or weedy species or are known to cause major impacts in other natural areas. Low priority should be given to species that cause little impact, are virtually impossible to control, or both (Hiebert & Stubbendieck 1993).

For most groups of biota, and certainly for all the cases of native plant species known to Groves and Willis (1999) weed incidence is associated with negative effects on biodiversity. As weed impact increases with time, further losses of native plant species can be expected to occur. Further refinement of systems for weed management has the potential to slow the process of native species loss but only ecological restoration of plant communities has the capacity to turn the process around.

The criteria/rationale for determining priorities for weed control in Kosciuszko National Park have been as follows (NSW NPWS 1995):

- the potential to spread both on and off park;
- legislative responsibilities;
- the effect/impact on natural systems;
- the commercial/agricultural impact;
- to keep all weeds out of the alpine areas above 1800m;
- emphasis on containment along access routes;
- when a new pest species was identified emphasis was on elimination in the first instance, eg. teasel; and
- emphasis given to wilderness areas as opposed to non-wilderness.

A changing scene

The first reasonably detailed survey of the flora of the Kosciuszko region which included observations on the distribution and abundance of introduced species was made in the 1890s by J.H. Maiden, the New South Wales Government Botanist. In two expeditions to the central area of Kosciuszko National Park (between altitudes of approximately 1000m and the Mount Kosciuszko summit at 2228m), Maiden recorded 7 introduced species, four of which had established locally in montane areas (*Vulpia bromoides*, *Hordeum murinum*, *Lotus corniculatus* and *Picris hieracioides*), and the three remaining species- (*Rumex acetosella*, *Hypochoeris radicata* and *Taraxacum officinale*) were "fairly well-established" in the subalpine zone. No introduced species were recorded in the alpine zone, except for *Alchemilla xanthochlora* whose origins are unclear (Mallen-Cooper 1990).

Between 1946 and 1952 Costin recorded 6 introduced species in the alpine zone of Kosciuszko National Park, 44 in the subalpine zone and 67 in the montane zone. Combining the information for the alpine, subalpine and montane zones, introduced species accounted for 11.4% of the vascular plant species in Kosciuszko National Park (Mallen-Cooper 1990).

A 1981 check-list (by Thompson and Gray) of all plant species collected from alpine and subalpine areas of Kosciuszko National Park indicated that introduced species comprised 15.7% of the total number of species. Twenty-seven introduced species were collected in alpine sites and 67 in subalpine sites (Mallen-Cooper 1990).

In 1990 approximately 210 introduced species of non-Australian origin were recorded in Kosciuszko National Park , not including most of the horticultural species planted in and around settlements (Mallen-Cooper 1990).

Trampling and grazing by stock in the Kosciuszko region led to a reduction in the existing vegetation cover and the exposure of bare ground, creating suitable conditions for the establishment of introduced species. Recovery of the native vegetation following the cessation of grazing (and associated burning) in Kosciuszko National Park has resulted in a decreased cover of introduced species away from roads, tracks and other disturbed sites (Mallen-Cooper 1990).

As already noted, weeds can spread fast. It is important to remember that plants which have been present but not weedy, as well as plants which have newly arrived, can quickly become major problems.

Broom was introduced to the Barrington Tops plateau in the 1840s as a garden ornamental but it was apparently not widespread across the plateau up to the 1940s, being restricted to the vicinity of cattle watering points. In the succeeding two decades further spread occurred along logging tracks and fire trails, but only after cessation of cattle grazing and associated burning in 1969 was rapid expansion of the broom population noticed. By 1986 broom grew across an estimated 10,000 ha of plateau, and its spread has continued (Smith 1994).

Yarrow (*Achillea millifolium*) was recorded in Kosciuszko National Park about fifty years ago (F. Johnston & Pickering 2000), but first became a problem about 1995 (S. Johnston, pers. comm.) and has spread rapidly. It has now become naturalised in the park (F. Johnston 2000).

In 1976 the Australian Institute of Agricultural Science published a study of environmental weeds in Victoria. For Mount Buffalo National Park they wrote “Weeds are not a major problem in Mt Buffalo National Park, being localised and on roadsides. They include St John’s wort, twiggy mullein, blackberry and Paterson’s curse.” There was no mention of Himalayan honeysuckle, considered a major weed in the 1996 management plan and occupying an entire valley of 700 ha.

The Australian Institute of Agricultural Science listed important weeds of public land in Victoria, but the list did not include broom. The invasion by broom at “The Lanes”, now the major infestation in subalpine areas in Victoria, was not discovered until the late 1980s (Robertson, Morgan & White 1999).

Soft Rush (*Juncus effusus)*, which is not mentioned in the 1992 park management plan, is now in alpine and sub-alpine communities of the Bogong and Dargo High Plains and is aggressively invading treeless plains below Mt Hotham. It is becoming a serious threat to alpine bog and wetland communities in the Alpine National Park (Robinson & Ecoplan 1996b #).

An ACT Agricultural Bulletin from 1950 describes sweet briar as "the most widely spread and common of the noxious weeds of the ACT". The same Bulletin also demonstrates that the incidence of some weeds has greatly worsened. Blackberry was then found in "odd scattered patches [and] in profusion along Tidbinbilla Creek" (CCSERC 1996). Similarly, the Bulletin described the distribution of St. John's wort in the ACT as found in only scattered patches. The Bulletin went on to comment that St. John's wort is potentially one of our worst weeds. Today, St. John's wort is widespread throughout the ACT, particularly in forest plantations, nature reserves, roadsides, rural lands, and Canberra's urban landscape and has spread fast since 1990 (Busby 1997).

Established weeds

Weeds of national significance in the Australian Alps

Blackberry

All the blackberry naturalised in Australia are of European origin, but it is difficult to establish where in Europe each of them originated (Bruzzese, Mahr & Faithfull 2000). European blackberry comprises a number of closely related plants that are dealt with under the one name. At least 15 taxa, some of which may be hybrids, of blackberry have become naturalized in Australia (Anon 2000a).

Blackberries are a serious weed throughout Australia, and threaten both natural and agricultural ecosystems. Many Australians believe blackberries are the single, biggest plant threat to the country as a whole (Anon 2000a).

Blackberry can quickly dominate land it invades. It threatens most of southern Australia, and thrives in a wide range of habitats due to its variability. It dominates pasture and native ecosystems, as well as invading disturbed sites in urban areas (Anon 2000a). Blackberry can occur at any altitude in Australia, but is restricted to temperate climates with an annual rainfall of at least 700 mm (Bruzzese, Mahr & Faithfull 2000).

In natural ecosystems blackberry infestations affect native plants and animals, and the visual and recreational values of public land, parks and reserves. Substantial displacement of native plants and loss of habitat for animals has been observed in many environments invaded by blackberry but this impact has never been quantified. Blackberry thickets are known to provide harbour for vermin species such as rabbits and foxes which further impact on the native flora and fauna. Blackberry fruit also acts as a seasonal food source for introduced birds and vermin such as starlings, blackbirds and foxes during summer and may help to increase the population of these species (Bruzzese 1997).

Blackberry was introduced with grazing and has invaded most watercourses and catchments in Kosciuszko National Park between 300 m and 1200 m elevation. It provides excellent harbour and seasonal food for vertebrate pests, including wild pigs and rabbits. It is so prolific it can form large areas of monoculture (NSW NPWS 1998b).

Thickets provide shelter and protection for small birds (and probably mammals). Removal of blackberry may displace some species or lead to local extinctions if alternative shelter plants are not available (Bruzzese, Mahr & Faithfull 2000).

The leafy anchor plant (*Discaria nitida*) and rough eyebright (*Euphrasia scabra*) are known to have at least some populations under threat through habitat invasion by blackberry (Adair & Groves 1998).

Fire hazards are exacerbated by the substantial amount of dead material present in blackberry thickets (Anon 2000a), due to its biennial growth habit (Bruzzese, Mahr & Faithfull 2000).

Commonly the most prolific vectors of blackberry are birds, mammals (especially foxes – pests themselves), and water movements (Anon 2000a).

Blackberry will persist indefinitely in an area unless treated. Plants that die are replaced by seedlings or daughter plants produced by adjacent individuals. There may be up to 13,000 seeds per square metre (Bruzzese, Mahr & Faithfull 2000).

Blackberry is declared noxious in New South Wales, Queensland, South Australia, Tasmania, Victoria, and WA. It is not yet declared in the ACT and NT (Anon 2000a).

Serrated Tussock

Serrated tussock, *Nassella trichotom*a, has infested more than 1.1 million hectares of temperate Australia. More than 30 million hectares are threatened. This very invasive wind dispersed weed competes with desirable species and is not eaten by grazing animals. In conservation areas, serrated tussock greatly decreases biodiversity (Anon 2000b).

Serrated Tussock infests only small areas of Kosciuszko National Park at four locations on the eastern boundary (NSW NPWS 1998b).

Willows except Weeping Willows, Pussy Willow and Sterile Pussy Willow

A total of 17 *Salix* taxa are identified as naturalised in Australia. Of these, ten are currently known to occur within or immediately adjacent to the Australian Alps national parks (Ecology Australia 1995 #).

Carr et al (1994) conclude that the biological, physical and visual impacts of *Salix* invasions in Australia and the Australian Alps national parks are disastrous or potentially disastrous, and that the longterm scenario is destruction of riparian and wetland vegetation and associated fauna, from sea-level to high alpine locations. The area currently invaded by willows is expanding rapidly within the Australian Alps national parks and elsewhere (Ecology Australia 1995 #).

Salix cinerea has spread at an alarming rate in Australia. It readily invades wet or moist habitats well beyond open riparian sites and is already entrenched in much of Eastern Victoria. It is spread by airborne distribution of its seed. In New Zealand *S cinerea* has readily spread from seed and has invaded most swamp areas throughout the country. In Australia, it has spread mainly in the lowland and mountain streams of eastern Victoria. In Victoria it occurs along streams or near seasonal or permanent swamps and bogs, from sea level to above the treeline, and is invasive of both disturbed and undisturbed situations. A 1999 survey of the Ovens catchment above Myrtleford estimated that some 130 km of the water courses were infested by *S cinerea.* Regeneration of *S cinerea* from seed in the Ovens area is mainly riparian, or in road ditches and wet seepage areas (Cremer 1999).

S nigra was planted at three poplar plantations near Tumut during 1964–77. By airborne seed it has spread widely around Tumut, apparently to near Cooma, and to near Canberra. The sites invaded by *S nigra* were all essentially riparian, but included spots in remote creeks that are only sometimes wet and were only briefly free of vegetation. *S nigra* has since been planted at Khancoban and in the Ovens Valley (Cremer 1999). *S nigra* is now at several locations in Kosciuszko National Park and is spreading (NSW NPWS 1998b).

The Snowy Genoa Catchment Management Committee is concerned about the spread of willows in the Snowy River below Jindabyne. The potential for spread follows the reduction of stream flow in the river as a result of the Snowy Mountains Scheme. Willows are abundant along the Snowy River in the Bryadbo wilderness (Gooey 1999).

Impacts of willows, predominantly in riparian environments, include:

- the destruction of indigenous vegetation (mostly by shading);
- loss of associated indigenous fauna;
- severe modification to the in-stream environment and massive disruption to food webs and nutrient cycling;
- modifications to stream morphology and flow characteristics; and
- higher water-use than indigenous vegetation.

In addition, willows may have a highly deleterious visual impact as discordant elements in substantially natural landscapes (Ecology Australia 1995 #).

Gorse

Gorse *Ulex europaeus* is a nationally significant weed which occurs in at least some of the Australian Alps national parks, yet it is not mentioned in park management plans or associated documents so apparently is not a significant issue.

<u>Weeds important in the Australian Alps</u>

English broom

Cytisus scoparius (English Broom, Scotch Broom or Spanish Broom) poses a serious threat to the integrity of plant and animal communities in the Australian Alps National Parks. All alpine, subalpine, montane and riparian environments are vulnerable to infestation (Fallavollita & Norris 1992 #).

English broom is a legume and has root nodules that fix nitrogen. It is found mainly in cool temperate areas and grows most successfully on moist, fertile soils. It is common at altitudes of 300 to 800 metres and is a problem weed at higher altitudes in the Alpine National Park. It spreads rapidly down creeks and rivers, and along roads and tracks (Keith Turnbull Research Institute 1998a). Climatic factors would not appear to inhibit the potential for spread of broom in alpine areas in the long-term as some individual plants have already been observed flowering at >1800 m altitude (Robertson, Morgan & White 1999).

Broom forms dense thickets that alter microclimate and exclude most other vegetation. Dense infestations in eucalypt forest prevent regeneration of understorey species and trees. Thickets provide harbour for rabbits, foxes and feral pigs which can modify the disturbance regime to favour the persistence of broom. English broom is highly flammable and burns intensely. Thickets increase fire fuel-loads in native vegetation and agricultural areas. Infestations can impede access along watercourses (Keith Turnbull Research Institute 1998a). It is a prolific seeder with seeds potentially viable for up to 60 years (NSW NPWS 1998b). At Barrington Tops, species richness was reduced by 59% by broom (Adair & Groves 1998).

There are relatively few Australian cases where environmental weeds have been shown to have altered ecosystem functions — broom is one of only eight identified in Adair & Groves 1998.

At Barrington Tops broom is inducing complex ecological changes involving more than simple reduction of ground cover and its later recovery as the broom canopy begins to open. Ecological conditions move towards a more mesic habitat in which some plants become more common than they were before broom invasion. The fauna appears to reflect this change. Reptiles (in particular skinks) which are abundant in uninvaded places, are rare or absent from broom stands between 3 and at least 23 years old (Smith 1994).

Broom has replaced native vegetation in over 200,000 hectares of riparian, grassland, montane, Eucalypt forest and alpine and sub-alpine vegetation communities in Australia with significant infestations occurring within the Australian Alps national parks (McArthur 2000 #).

Broom has the ability to adapt to, and naturalise, almost all alpine vegetation types. It has the potential to out-compete most native understorey species and to restrict the natural regeneration of the forest trees endemic to the area. The dominance of broom in the understorey will result in the loss of biodiversity in alpine vegetation communities (McArthur 2000 #).

Broom spreads only by seed, and most broom seed fails within 1 m of parent plants, although exceptionally explosive release can fling them 4.5 m. Some secondary local dispersal may be achieved by ants. Longer-distance dispersal may occur by movement of seed in mud attached to vehicles, machinery, footwear and animals; by watercourses in flood; and probably internally by animals such as horses and pigs. Humans further assist its spread by deliberate planting for beautification and through soil movement for roadworks in infested areas (Hosking, Sheppard & Smith 2000).

When treating broom in a natural ecosystem, it is essential to consider its management in light of other management issues so that they can be integrated to get the best results. Weeds need to be treated as a symptom of larger land and water management issues (Hosking, Sheppard & Smith 2000).

In many areas of the Australian Alps national parks the invasion is still a manageable problem if resource allocation is well directed and committed for long-term management. The neglect of the broom invasion will invariably lead to broad scale environmental degradation (McArthur 2000 #).

The success of the broom control program in Kosciuszko National Park over the past 20 years indicated that the containment and eradication of broom is a manageable and achievable goal (McArthur 2000 #). In Kosciuszko National Park it occurs at old SMA camps, construction sites and disturbed areas, around some huts and logging coupes, and increasingly along water courses between 800 m and 1600 m elevation (NSW NPWS 1998b).

In 1990 there was about 22 ha of broom present in Kosciuszko National Park. The distribution was patchy, with broom being identified at about 332 "sites". The infestations are thought to have originated mainly from plantings in gardens associated with the construction phase of the Snowy Mountains Scheme; there is some evidence to suggest that broom might have been planted deliberately, with willows and poplars, as an erosion control technique (Fallavollita & Norris 1992 #).

In 1990 there were two main infestations in Namadgi National Park: in the Cotter Valley upstream from Corin Dam; and at the southern end of the Park around Brayshaws Hut and Westermans Hut. Both infestations had been vigorous but were controlled by spraying and in 1990 consisted of small scattered plants covering an area of about 0.3 ha. Both infestations are thought to have originated from garden plantings (Fallavollita & Norris 1992 #).

In Victoria broom distribution is characterised by a pattern of major continuous infestations, in areas where the infestation has been present for a long time, surrounded by a spotted distribution of patches and single plants. These "satellite" occurrences are derived from the original infestation but can be long distances away. The one "major" infestation in the Alpine National Park, in the Mitta Mitta Valley, originated in the abandoned gardens of the gold fields at Glen Wills and Glen Valley and possibly Shannonvale. From there, broom has spread down the Big River and Mitta Mitta River to Eskdale, about 130 km. Downstream. The result is more or less a continuous distribution of broom from Glen Wills to Eskdale except for much of the downstream shores of Lake Dartmouth and most adjoining farmland. About 40 km of the infested river and lake bank is in the Alpine National Park (Fallavollita & Norris 1992 #).

Four other major areas of infestation are, or might be, a threat to the Alpine National Park as sources of seed: Falls Creek alpine resort, Bogong village and Mt Beauty; Omeo and Livingstone Creek; Harrietville and the Ovens Valley; and Gaffneys Creek, Lake Eildon and Mansfield (Fallavollita & Norris 1992 #).

Three biological control agents have been released and have established in Australia: a twig-mining moth, a sap sucking psyllid and a seed-feeding beetle. These insects are still multiplying in the field but it is too early to determine their likely impact (Hosking, Sheppard & Smith 2000). Two of these have been tested for broom control in Kosciuszko National Park (NSW NPWS 1995).

St Johns Wort

St Johns Wort (*Hypericum perforatum*) occurs in Kosciuszko National Park in disturbed areas, along roadsides, powerline easements and watercourses, and in native grasslands and open forest at elevations up to 1800 m. It produces up to 33,000 seeds per plant per season. Seeds are sticky and easily transported in mud, water, on vehicles and by animals. It can cause health problems for native animals (NSW NPWS 1998b). Seeds may remain dormant for at least twenty years (Groves 1996).

It has occurred at Charlotte Pass, an altitude of 1840 m, probably brought into the area by imported gravel or soil (Knutson 1996).

A thorough understanding of the ecology of St. John's wort and the processes that drive the population dynamics of infestations is a key to the management of this weed. However, while some aspects of the weed's biology have been studied in the seventy years of research on its control in Australia, there has been only one study devoted to its ecology; in the Ovens Valley, Victoria, over a two year period (Briese 1997).

The mite *Aculus hyperici*, which has been released to control St Johns Wort but not in Kosciuszko National Park, appears to be the most effective agent found and represents the best prospect so far. The aphid, *Aphiscloris,* was released in 1986–87, including in Kosciuszko National Park (NSW NPWS 1995).

Sweet briar

Sweet briar (*Rosa rubiginosa*) provides food and harbour for pest animals such as feral pigs and foxes, is easily spread by seed and is increasing its range, especially into remote areas (NSW NPWS 1998b).

In Kosciuszko National Park, sweet briar has spread thoughout the karst areas and is abundant on former agricultural areas such as Blowering and Merambego. It occurs up to 1200 m elevation (NSW NPWS 1998b).

<u>Localised weeds</u>

Himalayan honeysuckle

Himalayan honeysuckle (*Leycesteria formosa)* occupies an entire valley of 700ha in Mount Buffalo National Park (Keith Turnbull Research Institute 1998b).

A number of infestations of Himalayan honeysuckle are just outside the Alpine National Park, at Noojee; Buckland Valley; Harrietville; Tawonga Gap Road and Upper Kiewa Catchment adjacent to the Bogong High Plains Road (Robinson & Ecoplan 1996a #).

Soft Rush

Soft Rush (*Juncus effusus),* recorded in alpine and sub-alpine communities of the Bogong and Dargo High Plains over the last decade, is aggressively invading treeless plains below Mt Hotham. Over 13,000 seeds may be produced by a single inflorescence. Apart from its seed persistence in the soil, once established it becomes strongly rhizomatous and may form extensive clonal patches (Robinson & Ecoplan 1996b #).

Of particular concern is the species' invasion of alpine and sub-alpine bogs, wet sub-alpine heathlands and high altitude fens. Anecdotal evidence supported the contention that *J. effusus* is becoming a serious threat to alpine bog and wetland communities in the Alpine National Park (Robinson & Ecoplan 1996b #).

Its potential to invade alpine areas of the Australian Alps national parks is extremely high and this weed should be treated as a matter of urgency (Robinson & Ecoplan 1996b #).

Paterson's curse

Paterson's curse (*Echium plantagineum*) is a prolific seeder which invades disturbed natural areas in Kosciuszko National Park and replaces native vegetation. Within the park it is mainly at five locations (NSW NPWS 1998b).

The leaf-mining moth, *Dialoectica scala7iella* , has shown the most promise for biological control of Paterson's curse. Two weevils, *Ceutorhynchus larvatus* and *Ceutorhynchus geographicus* were released in New South Wales during 1993–94 (NSW NPWS 1995).

Yarrow

Yarrow, or milfoil (*Achillea millifolium*) was recorded in Kosciuszko National Park in 1954 (F. Johnston & Pickering 2000), but it did not become a problem in the park until about 1995 (S Johnston, pers. comm.) and it has spread rapidly since then. In the park yarrow has now achieved the three phases of invasion-introduction, colonisation and naturalisation (Johnston 2000).

Yarrow has become well established in Kosciuszko National Park, prominently along roadways including Kosciuszko Road to Charlotte Pass, Alpine Way and Guthega Road. Other major sites of infestation include Perisher Valley, Smiggin Holes, Guthega Village and along the Shlinks Pass road, with minor infestation along the Disappointment Spur Aqueduct. Populations have been found along the Snowy Mountains Highway, roads that pass through Jugungal Wilderness, and the Cascade Fire Trail to Pilot Wilderness. It has also been found in alpine areas such as along the summit road and the main range walking track, and around Seamans Hut (Johnston 2000).

Although it is predominantly found in areas of disturbance such as around building sites, tracks, roadsides and construction sites, yarrow has been found in areas of undisturbed native vegetation (Johnston 2000).

Potential weeds

> Many of the weeds we see in bushland today are not common and probably not very harmful. But some of them are multiplying fast, and those dismissed as trivial today…may well turn into triffids tomorrow (Low 1999).

<u>Weeds of national significance</u>

Some of the twenty weeds of national significance not yet active in the Australian Alps national parks have potential to invade the Alps. Using potential distribution based on climatic predictions only, these include Alligator weed, Bitou bush/boneseed, Bridal creeper, Cabomba, Chilean needle grass, and Salvinia (Weeds Australia 2000)

<u>Other identified potential weeds</u>

The recent discovery of barberry bush (*Berberis darwinii)* in the lower valley of Rules Creek is of very great concern (Spate 1990).

In April 1999 Orange Hawkweed (*Hieracium aurantiacum*) was identified growing widely in the Falls Creek Resort. This outbreak is the first mainland Australian incursion of this **extremely** invasive weed. A native to the northern hemisphere, Orange Hawkweed has become a major weed of pasture lands in north eastern America, Japan, New Zealand and Patagonia. Although the Australian Quarantine and Inspection Service (AQIS) has listed Orange Hawkweed as a prohibited plant, it has still managed to find its way into Australia, though apparently only to Falls Creek - so far. Throughout New Zealand's montane grasslands this species has displaced and out-competed native vegetation, with a substantial impact to the ecology of mountain areas (Anon 1999b).

Table 7.2 Status and Distribution of Weeds

			A(Ti)	A(WM)	Buff	SR	KNP	Bri	Sca	Bim	NNP				Vic
Note: codes are explained on page 130.				Alpine National Park Wonnagatta-Moroka Unit (DCE 1992d)							Namadgi National Park [G Young]				Victorian status
											L&A				P
Bent grass/Browntop Bent (*Agrostis capillaris*)	L										P				
Blackberry (*Rubus discolor*)	M	M	M	M	L	L	M	L			M				C
Blue periwinkle (*Vinca major*)		G									G				
Buddleia (*Buddleja madagascariensis*)											G				
Cherry plum (*Prunus cerasifera*)		L		L							L				
Cotoneaster (*Cotoneaster glaucophyllus*)		G									G				
English broom (*Cytisus scoparius*)	M,A	M	PU	A							M				C
English ivy (*Hedera helix*)		G									G				
Fennel (*Foeniculum vulgare*)			L			L		L			P				
Flatweed (*Hypochaeris radicata*)	L										P				
Hawthorn (*Crataegus monogyna*)		L		L					L		L				
Hemlock (*Conium maculatum*)			L								L				C
Himalayan Honeysuckle (*Leycesteria formosa*)	A				M						0				
Holly (*Ilex aquifolium*)		G									G				

			A(Ti)	A(WM)	Buff	SR	KNP	Bri	Sca	Bim	NNP				Vic
Horehound (*Marrubium vulgare*)											L				C
Japanese swamp daisy	A										0				
Juniper (*Juniperus communis*)			L								L&G				
(Russell) Lupin (*Lupinus* hybrid)	A										0				
Ox-eyed daisy (*Leucanthemum vulgare*)		G		L							L&U				
Patersons curse (*Echium plantagineum*)	L						L				L				C
Pinus (*Pinus* spp)							M/L	WU			L				
Poplar, White (*Populus alba*)			L								R				
Poplar, Lombardy (*Populus nigra*)															
Pyracantha/Firethorn (*Pyracantha angustifolia*)											LGA				
Rose campion (*Lychnis coronaria*)		G									0				
Serrated Tussock (*Nassella trichotoma*)							L				L&A				P/C
Soft Rush (*Juncus effusus*)	L														
Sorrel (*Acetosella vulgaris*)	L										P				
St Johns wort (*Hypericum perforatum*)	L	L		L	L		L	L			L				C
Sweet briar (*Rosa rubiginosa*)	L	L	L	L			C	L			M				C
Sycamore (*Acer pseudoplatanus*)	L	L		L											
Nodding Thistles (*Carduus nutans*)															
Scotch Thistle (*Onopordum acanthium*)				L							L				C
Spear Thistle (*Cirsium vulgare*)															
Tree lupin (*Lupinus arboreus*)		G				L		L			0				
Tutsan (*Hypericum androsaemum*)					L						0				
Orange hawkweed (*Hieracium aurantiacum*)	L														
White clover (*Trifolium repens*)	L		L								P				
Black Willow (*Salix nigra*)															
Crack Willow (*Salix fragilis*)		L	L	WK		L	L	L			L				
Grey Sallow (*Salix cinerea cinerea*)															
Rusty Sallow (*Salix cinerea oleifolia*)															
Yarrow (*Achillea millefolium*)							L	L							

P=present	M=major weed	G=weed around old gardens
U=uncommon	L=locally important	A=adjoining land
C=common	WK=widespread, but numbers and distribution not well known	
0=none known	WU=widespread, but not numerous	R = rare

Status

National	S=Weed of national significance
ACT	N=Noxious; H=High Priority; M=Medium; L=Low
NSW	Weeds status depends on local government area. Range of status indicated where not consistent.
	1=The presence of the weed on land must be notified to the local control authority and the weed must be fully and continuously suppressed and destroyed.
	2=The weed must be fully and continuously suppressed and destroyed.
	3=The weed must be prevented from spreading and its numbers and distribution reduced.
	4=The weed must not be sold, propagated or knowingly distributed.
	0=not listed for one or more of the shires
Victoria	P=Regionally prohibited weed in Alps regions; C=Regionally controlled weed in Alps regions

<u>Species not yet identified as threats</u>

Plants that appear benign for many years may suddenly spread rapidly following certain natural events such as flood, fire, drought or climate change, or a change in land or water management. Weed scientists call such plants ‘sleepers’. There is a need to recognise and eliminate sleepers during their benign phase or at least identify the events that could turn them into major weeds (Anon 1999a).

It is impossible to predict future weed species whose threat potential remains unidentified, but new weeds are bound to develop. The best protection is eternal vigilance to recognise weedy behaviour early and to eliminate new infestations before they become too extensive.

Populations of invasive species are vulnerable to collapse while in their very early stages of naturalisation. Once firmly established, pest populations usually become very resilient and control costs become enormous. Provided potential pests are detected in their very early stages of establishment, eradication can be successful and inexpensive (Csurhes & Edwards 1998).

It is difficult to predict which plant species will become significant environmental weeds (Csurhes & Edwards 1998). Never-the-less, Csurhes and Edwards (1998) prepared extensive lists of, and information on, potential environmental weeds of Australia. Robinson (1996) provided a list of potentially invasive weeds of the Australian Alps national parks.

Grazing stock

> “Mountain cattlemen of the present generation are aware of the long-term harm of overgrazing. They also know that controlled grazing not only encourages the growth of feed for their stock from year to year but also promotes wildflowers and restricts scrub. Therefore, with their experience and love of the bush and in cooperation with the Soil Conservation Authority, they are not only preserving the condition of their leases, so vital a support to their farms, but also conserving the beauty of the high country for all.” (Holth 1980)

> “Nowhere in the High Country has any appreciable erosion been found due to grazing and the carefully controlled burning off by graziers. But the beneficial results of grazing by sheep and cattle, and particularly by sheep, have been very evident and can still be shown.” Oliver Moriarty 1973

> MCAV strongly disputed that there has been any ‘degradation’ to the licensed grazing areas. In fact … the environment on the Bogong High Plains is stable. Mountain Cattlemen’s Association 1999

“Soil erosion and vegetation damage and disturbance in the alpine regions of Victoria caused by cattle grazing” is listed on Schedule 3 of the Flora and Fauna Guarantee Act as a potentially threatening process.

Concern about the ecological damage caused by grazing stock developed relatively early. In 1887 a naturalist, James Stirling, noted that the anemone buttercup was “fast disappearing from the summits of our Victorian mountains owing to the inroads made into the native vegetation by stock” (Hayes 1999). The anemone buttercup has not been recorded in Victoria since then, and it was close to extinction when grazing stopped in New South Wales.

In 1893 Richard Helms described the damage grazing and the associated burning was doing in the Kosciuszko area (Helms 1893).

Both cattle and sheep have been grazed in the Kosciuszko area, the latter predominating especially during the later years of snow lease grazing. The first extensive area to be withdrawn from grazing was the Kosciuszko Summit Area of some 4000 ha in 1944, on account of the locally very serious erosion there and the increasing erosion hazard. (Wimbush & Costin 1979a).

Fire was used as a management tool to produce fresh green growth from the otherwise unpalatable snow grass. Burning also helped dry out bog and swamp areas to allow better access for bullock drays and pack horses (Irwin & Rogers reprinted 1991).

Most of the ecological investigations into the effects of grazing and associated practices (mainly regular ‘burning-off’) were at first oriented towards soil erosion and the performance of the Snowy Mountains as a major water catchment (Wimbush & Costin 1979a). Scientific investigations over the last half century have demonstrated that stock grazing in the alpine and subalpine zones results in the local elimination of some rare and threatened species, the invasion of exotic plants and changes in structure and dominance within plant communities (Kirkpatrick 1994 #).

After years of grazing and burning much of the grassland and herbfield communities had eroded and the feldmark communities were badly damaged. Once the insulating effect of the vegetation was removed, needle ice attacked the soil, while frost and wind undermined the plant roots. Stock selectively removed the herbs between the snow grass tussocks and in doing so allowed topsoil to be removed. Water and wind erosion further stripped any remaining topsoil, leaving only stony subsoils or erosion pavements (Irwin & Rogers reprinted 1991).

The results of the grazing trials at Dainers Gap and in the Kosciusko Reserve from 1957 to 1971 and of subsequent observations until 1978 show that nature conservation values were very sensitive to livestock grazing in both relatively natural and previously disturbed herbaceous subalpine vegetation. This was because of the selective nature of range-type grazing on certain herbaceous species and on inflorescences and seed heads, and the avoidance of less palatable species (Wimbush & Costin 1979a).

Soil conservation and catchment values were not permanently impaired by several years of livestock grazing in the absence of fires on more or less natural herbaceous vegetation. But these values were sensitive to grazing on sites where the vegetation had been previously disturbed. Where the intertussock communities were large and there was more bare ground, recovery took an indefinite period where grazing continued. Some ungrazed areas of high erosion hazard also continued to erode. A major factor influencing revegetation was the absence of burning-off after 1951, as well as the absence of livestock grazing after 1957 (Wimbush & Costin 1979a).

Grazing will affect both the composition and structure of the vegetation. The introduction of stock into high-country communities has resulted in substantial impact on ecosystems which have evolved over thousands of years in the absence of grazing pressure (Busby 1990).

Approximately 30 plant species in the alpine zone are classified as Rare or Endangered (Leigh, Boden and Briggs 1984). A further 110 Rare or Endangered species occur in the other three floristic zones of the Australian Alps. The relatively large number of Rare or Endangered species reflects both the small area of the various plant communities and recent land use practices, particularly that of grazing domestic stock (Good 1995).

> “Given that a main function of national parks is to preserve and restore outstanding natural environments, grazing is unacceptable. The scientific evidence is incontravertible. The condition of the grazed land is inferior from the national park point of view to that of protected areas.” (Alec Costin, quoted in Bennett 1995

In most areas already dominated by snowgum, the cessation of burning-off and snow lease grazing initiated widespread tree regeneration where there was semi-bare ground beneath the trees. There are also areas where no tree regeneration is occurring — relatively extensive areas of former snowgum woodland where the trees were killed by earlier fires and sheep grazing and where there is no longer any seed supply (Wimbush & Costin 1979b).

Patch dieback of the subalpine snow gum forest is present within Kosciuszko National Park and is threatening the long term existence of the forest. Investigation showed correlation between past points of stock concentration, represented by the old travelling stock routes, travelling stock reserves and overnight stock camps, and the current patches of dieback. Exploratory field investigations showed increased soil erosion, believed to be the result of European grazing and burning practices, at points of dieback. The environmental stresses generating dieback are more likely to be associated with the reduced water holding capacity of the soil than with reduced nutrient supply (Shields 1993).

When cattle are excluded from heath and grassland communities, the shrubs move ahead but only temporarily. As the shrubs age and die they provide a nursery bed for regenerating grasses and herbs. In Maisie Carr's plots on the Bogong High Plains the first measurable downward trend in shrub recorded was recorded more than 40 years after grazing was excluded (Bennett 1995).

In 1979 a botanical survey was made of two mossbeds on the Bogong High Plains. One, ungrazed since 1945, had a large unbroken layer of *Sphagnum* moss, which traps most of the water that flows through the catchment. The other, grazed, mossbed contained four patches of *Sphagnum* and drainage occurred in deep channels between the patches. The ungrazed mossbed should be more efficient at filtering and regulating streamflow, and generally be better for water production (McDougall 1989).

Grazing poses a significant threat to the protection of Spotted Tree Frog habitat, by disturbing soil and vegetation on river banks and surrounding areas. (DNRE 1997a)

Soft Rush (*Juncus effusus*) is one of the first species to colonise damp or wet soil bared by disturbance. Anecdotal reports of rapid expansion of Soft Rush may be partly the result of the plants being more readily observable following withdrawl of grazing from parts of the High Plains. Grazing provides an open sward with patches of disturbed soil suitable for seed germination (Dickins & White).

The association between grazing (physical disturbance "pugging" or "poaching" - particularly on wet sites; and the tendency for grazing to "open up" the vegetation, exposing the soil surface to increased amounts of incident light) and Soft Rush invasion is a recurring theme in the literature (Dickins & White).

Grazing in wet conditions creates ideal micro-habitats and conditions for localised Soft Rush establishment (Dickins & White).

Past land use has adversely affected much of the area now conserved in Kosciuszko National Park. Since 1944 when grazing ceased, conservation and management have led to a recovery of some rare and threatened flora. *Ranunculus anemoneus* was almost grazed to extinction but 40 years on is showing signs of recovery (Rath 1999).

The decline of species can be largely attributed to the impacts of disturbances, both directly on the species and indirectly on essential components of their habitat. For example, predation of Broad-toothed Rats by introduced species such as foxes and feral cats has a direct effect on population numbers, whereas grazing of its habitat by domestic stock can indirectly affect its chances of survival by altering essential components of its habitat such as food and shelter (JCVRFASC 1998a).

"**Mt Buffalo:** research has shown that dryland and wetland plant communities 'recovered' within 15 years - **but** these communities were ungrazed since the fire and for 27 years pre-fire." [bold as in original] (Wahren, Papst & Williams 1999c).

The Mt Fainter data showed that the rate of post-fire regeneration is unquestionably delayed by cattle grazing. Indeed, the grazed sites at Mt Fainter still have unacceptable levels of ground cover after 15 years (Wahren, Papst & Williams 1999a).

In 1957 the Academy of Science published a report proposing that all grazing above 4,500 feet (1350 m) should be discontinued. A potent factor in the adoption of that recommendation by the New South Wales government was the offer by the Snowy Mountains Authority to compensate the Kosciusko State Park for the loss of income consequent on the cancellation of the grazing leases. The amount concerned was about £12,000 per annum. In contrast the estimated power production from the Snowy Scheme was valued at £20–25 million per annum; the value of increased production from irrigation was conservatively estimated at £30 million per annum (Turner 1960).

In 1969 Edgar estimated the value of grazing in Kosciuszko National Park at 10 cents per acre (25 cents per hectare) per year. In contrast he estimated the value of water production from the same area at $80 per acre ($200 per hectare) per year.

See also "Grazing" in Chapter 2 — Ecological History of the Australian Alps national parks.

Diseases and parasites

> Exotic diseases are the most insidious and probably the most underrated of all our invaders. Largely invisible and easily overlooked, they play an ill-defined but probably major role in Australian ecology (Mansergh, Kelly & Johnston 1991).

The transport of soil around the world is very risky. Seeds, eggs, spores, bacteria, mosses, liverworts, worms, mites, snails, and slugs are common passengers in pots. There is little doubt that the dreaded cinnamon fungus (*Phytophthora cinnamomi*) arrived here in soil. A swag of *Phytophthora* species have entered Australia but the cinnamon fungus is the most deadly (Low 1999).

Despite the knowledge of the risks, and the official prohibition of importing soil, soil continues to enter Australia. In 1996 Quarantine inspectors found 14 tonnes of soil on oil rig equipment imported from Texas (Low 1999), but dirty mining and harvesting equipment was recently sometimes unloaded without even a cursory inspection (Mansergh, Kelly & Johnston 1991).

In Kosciuszko National Park compost is made from pine chips, dolomite and dynamic lifter to provide a safe substitute for soil in roadside rehabilitation (Will Allen pers comm).

Phytophthora

Australia's native vegetation and its dependent biota are threatened by an epidemic of root-rot as a result of the introduction of the cryptic microbe Phytophthora cinnamomi. It is thought that the microbe was introduced at some time after European settlement; it is now well established in many of the country's higher rainfall areas—areas with a mean annual rainfall greater than 600 millimetres—in a mosaic of infected and uninfected areas. Its effects range from devastating to inconsequential, depending on environmental factors, which vary both within and between regions. The only biomes that appear to be unthreatened are the wet–dry tropics and the arid and semi-arid regions. Many fungi are known to cause root-rot disease in Australian flora species, but the introduced *Phytophthora cinnamomi* has had the greatest effect and poses the greatest threat. (Environment Australia 1999c).

Dieback caused by the root-rot fungus *Phytophthora cinnamomi* is listed as a Key Threatening Process under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and a potentially threatening process listed on Schedule 3 of the Flora and Fauna Guarantee Act. The EPBC Act requires that a nationally coordinated threat abatement plan be prepared and implemented to manage the impact of phytophthora dieback on Australian ecosystems—see (Environment Australia 1999c).

P. cinnamomi populations are scattered throughout much of Tasmania in areas that are below an altitude of 800m above sea level and which have a mean annual rainfall of at least 600mm (Tasmanian Parks & Wildlife Service 1994). The climatic equivalent in the Australian Alps to 800 m elevation in Tasmania is about 1800m in Victoria and 1900m in New South Wales. (It is considered that the 10°C isotherm for mean summer temperatures is the arbitrary boundary of alpine environments as this is the physiological limit to tree vegetation. This treeline limit occurs at about 1850 m in alpine NSW, 1750 m in Victoria and about 750 m in Tasmania (Rath 1999).)

An infestation of *Phytophthora* has been identified in the south of Snowy River National Park (DNRE 1995).

Many specialists in management and in the science of plant pathological ecology now accept that, unless a novel solution can be found, the epidemic invasion of Australia's native vegetation is likely to continue until *P. cinnamomi* occupies all of the habitats which are suited to its establishment and maintenance (Environment Australia nd).

Only a few attempts have been made to assess the distribution of *P. cinnamomi* in Australia; these are unlikely to give a true picture of its extent, and rapidly become outdated (Environment Australia nd).

P. cinnamomi does not usually cause severe damage to undisturbed vegetation in areas that receive a mean annual rainfall of less than 600 millimetres (Environment Australia nd).

The most serious epidemics of root-rot, which threaten some rare species and communities with extinction and cause major disruption of structure and bioproductivity of native communities over extensive areas, are found in three temperate climatic zones south of latitude 30^{o}S. These include all elevations in areas of Mediterranean climate where mean annual rainfall exceeds 600 millimetres as far east as Wilsons Promontory, and low elevations of the coastal plain and foothills between Wilsons Promontory and the Victoria/New South Wales border (Environment Australia nd).

A fourth climatic zone that is sometimes affected is the montane region above 800m in parts of the southern Great Dividing Range and in the Central Highlands of Tasmania. Although localised minor damage has been recorded on grossly disturbed sites there, no damage has been reported in essentially intact communities. The pathogen seems unable to survive winter cold in those areas (Environment Australia 1999c).

The possible role of several other *Phytophthora* species tolerant of low soil temperatures, as a possible causse of disease in native alpine communities in the Central Highlands of Tasmania, is currently under investigation (Environment Australia nd).

While *P. cinnamomi* is an extremely important cause of root-rot epidemics in certain vulnerable vegetation communities, it can exist in many other Australian terrestrial ecosystems with little, if any, consequence for their health (Environment Australia nd).

The most practical management approaches currently available include reducing the role of humans as vectors to prevent infection of new areas (through quarantine, or through the careful planning of hygienic access to uninfected areas), and the treatment of areas of high conservation value using phosphonate, a chemical which induces resistance to *P. cinnamomi* in native plants (Environment Australia nd).

Phosphonate's effects on fauna have not yet been properly assessed, so the chemical should be used with caution in areas where threatened fauna species are known to occur (Environment Australia 1999c).

There is no comprehensive and up-to-date list of Australian plant species known to be severely affected by *P. cinnamomi* in the wild (Environment Australia nd).

P. cinnamomi does not generally cause severe damage in Australia in undisturbed vegetation in areas of less than 600 mm mean annual rainfall, except where rainfall is supplemented by considerable runoff from impervious catchments such as granite bosses and sealed road pavements (Environment Australia nd).

P. cinnamomi does not tolerate freezing but can persist in cool winter climates undergrouond where freezing does not occur (Environment Australia nd).

Movement of soil during road building and maintenance, timber harvesting, mineral exploration, plant nursery activities and bushwalking are among the most important ways that the infection is spread. Some animals, such as feral pigs, cattle, kangaroos, wombats, bandicoots and sulphur-crested cockatoos, may move infected material (Environment Australia nd).

In Victoria, at altitudes above 800m communities which include species known from experimentation to be highly susceptible remain free of infection, almost certainly because of the low soil temperatures and good drainage coupled with high organic content. They are likely to remain free of infection unless global warming exposes them (Environment Australia nd).

An assessment of 40 plant communities in East Gippsland classed 7 montane communities and 4 subalpine communities as susceptible to *P. cinnamomi* but not vulnerable to damage (Environment Australia nd).

Animal diseases and parasites

A potentially serious impact of introduced fish species is their capacity to introduce or spread foreign diseases and parasites to native fish species. In 1888 a mass die-off of Australian grayling (*Protroctes maraena*) was observed in Tasmania. It was caused by a fungus thought to be introduced with trout or salmon eggs brought from England. The grayling recovered (Low 1999). Carp (*Cyprinus carpio*) or redfin perch (*Perca fluviatilis*) are considered to be the source of the Australian populations of the parasitic copepod *Lernaea cyprinacea* (ACT Government 1999i).

Carp, goldfish or mosquitofish are probably implicated as the source of the introduced tapeworm *Bothriocephalus acheilognathi* which has recently been recorded in native fish species. This tapeworm causes widespread mortality in juvenile fish overseas (ACT Government 1999d).

The Macquarie perch (*Macquaria australasica*) is declining seriously and is considered endangered by ANZECC (Low 1999). The most serious threat from introduced fish species to Macquarie perch may lie in the impacts of an exotic disease Epizootic Haematopoietic Necrosis Virus (EHNV). This virus, unique to Australia, was first isolated in 1985 on the introduced fish species redfin perch. Macquarie perch is one of several species found to be extremely susceptible to the disease (ACT Government 1999d).

Amphibian declines in some regions have been attributed to habitat disturbance but habitat disturbance does not explain the rapid disappearance of high-altitude stream-dwelling rainforest amphibians from many protected areas in Australia and Central America. There was no correlation between frog population declines and changes in ground level solar UV-B radiation in Queensland. Several factors in the declines indicated that a waterborne infectious disease, of high virulence to adults of some species, had entered a population previously unexposed to it. In these two montane rainforest locations — Big Tableland, Australia (1993) and Fortuna, Panama (1997) — sick and dying anurans were collected for pathological examination and found to be infected with chytrid fungi in the skin. This fungus has been placed in a new genus, *Batrachochytrium* (Berger, Speare & Hyatt 1999).

In Australia, *Batrachochytrium* has been found in frogs since 1989 and has been observed in various regions (Berger, Speare & Hyatt 1999). Berger et al (1999) hypothesise that *Batrachochytrium* was introduced to Australia in the 1970s around Brisbane (where the first precipitous declines occurred), although as yet there are no hard data to support this assumption. *Batrachochytrium* has since become established in many areas on the east coast, around Adelaide and in south-west Western Australia.

Spotted tree frog (*Litoria spenceri)*

The spotted tree frog is mainly confined to the north-west side of the Great Dividing Range between the Central Highlands in Victoria and Mount Kosciuszko. Across this narrow geographic range 17 discrete populations have been identified, four of which are presumed extinct (NSW NPWS 1999d). Surveys have indicated that the spotted tree frog has suffered a general decline in distribution and abundance across its entire range (NSW NPWS 1999d). The spotted tree frog is considered critically endangered (ANZECC 1999). Most of the population was confined to a 1.6 km section of Bogong Creek in Kosciuszko National Park above a substantial waterfall, with consistently more than several hundred individuals recorded during the summers from 1993 to 1996. The population underwent a catastrophic decline, with only two individuals recorded there in the summer of 1997-98, and only one since then (NSW NPWS 1999a & d). The sole surviving adult spotted tree frog on the research transect in Kosciuszko National Park has been taken into a captive breeding program.

The general threats to the spotted tree frog are unlikely to be the cause of the population decline at Bogong Creek (NSW NPWS 1999d). Disease is a possible cause, although that remains unproven. Spotted tree frogs have been found to be infected with *Batrachochytrium* (Berger, Speare & Hyatt 1999).

If it becomes established, Newcastle disease could eliminate many bird species (Low 1999).

Toxoplasmosis is a disease which affects the central nervous system and other organs, and can lead to organ failure, blindness, abortion and death in native wildlife; humans and stock may also be similarly affected. It is caused by infection with the sporozoan parasite Toxoplasma gondii. Marsupials are very susceptible to the disease, and a number of species, have been reported to have been affected. Cats are an essential part of the life cycle of the disease. Oocysts are formed in the cat's digestive system and shed in the faeces, to be ingested directly by grazing marsupials or via soil invertebrates or in conjunction with digging for fungal, plant or animal food. It seems likely the decline and even local extinction of some native species may be linked with toxoplasmosis (Seebeck & Clunie 1997).

Foxes would be a prime vector of rabies if this disease was ever introduced to Australia. This could have a massive impact on wildlife populations (Mansergh & Marks 1993).

7.3 Climate change

> The bottom line is that we will probably never be able to predict, with a high degree of certainty, precisely how terrestrial ecosystems will interact with accelerating environmental change. Thus, the analogy that ecosystems can be "managed" in the same way that much simpler human-designed industrial systems can, is misleading and dangerous. In terms of terrestrial ecosystem interactions with global change, we must expect the unexpected (and unpredictable) and keep open as many response options as possible (Walker & Steffen 1997)

Global warming

The term ‘Global warming’ or the ‘Greenhouse effect’ arise from concerns that the natural greenhouse effect that keeps the Earth’s surface at a temperature suitable for life is being exacerbated by increasing levels of greenhouse gases being emitted into the atmosphere from human activities (Baker et al 2000).

Although there are major uncertainties concerning a process as complex as global warming, the general consensus of the scientific community is that global warming is occurring (Baker et al 2000). 99% of scientists agree; global warming is real, it's happening now, and it's getting worse (WWF website).

Analysis of tree rings, corals, ice cores, and lake sediments showed this century's surface temperatures for the Northern Hemisphere to be the warmest since at least 1400 A.D. A newer study of Northern Hemisphere temperatures found it highly likely that the 20th century has been the warmest century of the millennium; the 1990s have been the warmest decade; and 1998 has been the warmest year. A study of temperature data from 600-1,800-foot deep boreholes in North America, Europe, Africa, and Australia found that the Earth's average surface temperature has increased by about 1.8 degrees Fahrenheit (F) over the last five centuries, and that half of this total warming occurred in this century. Of the 120 to 140 years for which thermometer records are sufficiently complete to define a global average temperature, the 11 warmest years have all occurred since 1983. The three warmest years on record were 1998, 1997, and 1995, in that order. In addition, 1998 was also 1.2 degrees F above the long-term average temperature-the 20th consecutive year in which this benchmark has been exceeded (White House Climate Change Task Force 1999).

The globally averaged temperature of the air at the Earth's surface has warmed between 0.3 and 0.6°C (about 0.5 and 1°F) since the late nineteenth century. Data derived from measurements of tree rings, shallow ice cores, and corals, and from other methods of indirectly determining climate trends, suggest that global surface temperatures are now as warm as or warmer than at any time in the past 600 years. (World Meteorological Organization 2000)

Climate change has the potential to alter many of the Earth's natural ecosystems over the next century. Yet, climate change is not a new influence on the biosphere, so why can't ecosystems just adapt without significant effects on their form or productivity? There are three basic reasons.

- First, the rate of global climate change is projected to be more rapid than any to have occurred in the last 10,000 years.
- Second, humans have altered the structure of many of the world's ecosystems. They have cut down forests, plowed soils, used rangelands to graze their domesticated animals, introduced non-native species to many regions, intensively fished lakes, rivers and oceans, and constructed dams. These relatively recent changes in the structure of the world's ecosystems have made them less resilient to further changes.
- Third, pollution, as well as other indirect effects of the utilization of natural resources, has also increased since the beginning of the industrial revolution.

Consequently, it is likely that many ecosystems will not be able to adapt to the additional stress of climate change without losing some of the species they contain or the services they provide, such as supplying sufficient clean water to drink, food to eat, suitable soils in which to grow crops, and wood to use as fuel or in construction (World Meteorological Organization 2000).

During the 20th century, the global climate warmed by about 0.5° C or about 0.05° C per decade. Computer models which simulate the effects on climate of increasing atmospheric greenhouse gas concentrations project that global average surface temperatures will rise by a further 2° C by the end of the 21st century, or 0.2° C per decade. It is currently believed that most ecosystems can withstand at most a 0.1° C global temperature change per decade, before experiencing severe ecological stresses, leading in some cases to species extinction. A warming of 2° C over the next 100 years would shift current climate zones in temperate regions of the world poleward by about 300 km, and vertically by 300m. The composition and geographic distribution of unmanaged ecosystems will change as individual species respond to new conditions. (DEGS, MMU 2000b)

If nothing is done to reduce emissions, current climate models predict a global warming of about 2° C between 1990 and 2100. This projection takes into account the effects of aerosols and the delaying effect of the oceans. This oceanic inertia means that the earth's surface and lower atmosphere would continue to warm by a further 1-2° C even if greenhouse gas concentrations stopped rising in 2100. The range of uncertainty in this projection is 1° C to 3.5° C. Even a 1° C rise would be larger than any century-time-scale trend for the past 10,000 years. Uncertainties about future emissions, climate feedbacks, and the size of the ocean delay all contribute to this uncertainty range (The Secretariat of the United Nations Convention on Climate Change 1999b).

By the end of the 21st century, average world temperatures are likely to be between 0.8°C and 4.5°C higher than now. The mid-range estimate for the year 2100 is a warming of 2°C This may not sound like much, but it could change the Earth’s climate as never before. At the peak of the last ice age (18,000 years ago), the temperature was only 4°C colder than it is today, and glaciers covered much of the temperate land in the Northern Hemisphere (Baker et al 2000).

Biological diversity - the source of enormous environmental, economic, and cultural value - will be threatened by rapid climate change. A warming of 1–3.5° C over the next 100 years would shift current climate zones poleward by approximately 150–550 km - and vertically by 150–550 m - in mid-latitude regions. The composition and geographic distribution of unmanaged ecosystems will change as individual species respond to new conditions. The projected declines in mountain glaciers, permafrost, and snow cover will further affect soil stability and hydrological systems (most major river systems start in the mountains). As species and ecosystems are forced to migrate uphill, those whose climatic ranges are already limited to mountain tops may have nowhere to go and become extinct (The Secretariat of the United Nations Convention on Climate Change 1999a).

Under "business as usual" conditions, global average surface temperature is expected to rise by between 2 and 4° C over the next hundred years. Under a "worst-case" scenario global average surface temperature could rise by 6° C by 2100. Significantly, however, these projections are based solely on changes in greenhouse gases; no account has been taken of the cooling influence of stratospheric ozone loss or sulphate aerosols. When the effects of stratospheric ozone depletion and man-made aerosol emissions are considered, the global average surface temperature is projected to rise by approximately 0.2° C per decade, or 2° C by 2100. This rate of climate change is still faster than at any time during Earth history. (DEGS, MMU 2000a).

The large-scale climatic effects of El Niño Southern Oscillation have important influences on the climate of south-eastern Australia. Increased levels of greenhouse gases in our atmosphere could cause El Niño Southern Oscillation events to occur in Eastern Australia more frequently — as often as every three years, instead of the current average of every five years (Baker et al 2000)

The Bureau of Meteorology's National Climate Centre data showed that Australia's mean annual temperature rose 0.8 degrees between 1910 and 1999, to 28.43 degrees. The National Climate Centre calculated mean temperatures using data from about 130 non-urban observing stations. It found that the three hottest decades last century were the 1990s, 1980s and 1970s, with mean temperatures ranging from 28.1 to 28.43 degrees. It was also revealed that five years in the last decade - 1998, 1996, 1993, 1991 and 1990 - were among the 10 warmest years on record, with 1998 the hottest (Sydney Morning Herald 6/1/2000).

Mountain pygmy-possum (*Burramys parvus)*

Icon species of the Australian Alps national parks

The Mountain Pygmy-possum *Burramys parvus* is a small (35g), terrestrial marsupial confined to

by Robert Broom in 1895, it was first discovered as an extant species at Mt Hotham in Victoria in 1966. Surveys in the early 1970's and 1980's indicated the presence of three disjunct populations in Victoria and one in New South Wales, within Kosciuszko National Park. All of these populations occur above the level of the winter snowline and are widely separated by low lying valleys. A fifth population of up to 300 adults was discovered at Mt Buller in 1995 (Good 1995).

Population boundaries have been contracting up the mountains since the last ice age, and isolated remnant populations are now small. The total area of habitat available in Victoria is about 2 sq km. In Victoria the most important area for the conservation and scientific study of the species is the area between Mt Loch and Mt Higginbotham. About 70% of that area is within the Alpine National Park, which is now managed by Parks Victoria, and about 30% is within the Mt Hotham Alpine Resort, which is now managed by the Mt Hotham Resort Management Board (Mansergh, Kelly & Johnston 1991).

It now appears that the extent of habitat in Kosciuszko National Park has previously been greatly overestimated. Additionally, because many of the patches appear to be of very low quality and support low numbers of mountain pygmy-possum the total population size may be less than the original estimate of 500 adults (Broom & Green 1998 #).

The mountain pygmy-possum is the only marsupial known to store food; the longest living small terrestrial mammal (<200g) known in Australia(12+ years) (Mansergh, Kelly & Johnston 1991); the only marsupial known to hibernate; and it has evolved a breeding strategy that involves segregation of the sexes during the non breeding season (Mansergh, Kelly & Scotts 1989). It is the only mammal restricted to alpine-subalpine habitats in Australia.

In 1991 the main threat to the species was habitat destruction and fragmentation from human activities associated with skiing and alpine resort development (Mansergh, Kelly & Johnston 1991).

Premature death is probably due to the operation of various factors over time, for example: predation by foxes, dogs and cats, kestrels and owls during the non breeding season; animals die when forced out of habitat during dispersal periods (Jan-Apr); and animals that do not have sufficient fat reserves may be unable to survive the extended (and repeated) periods of torpor necessary for survival over winter (Mansergh, Kelly & Scotts 1989).

As little as a 1^{o}C increase in temperature and predicted accompanying rainfall changes would eliminate the bioclimatic range of the mountain pygmy-possum. A 3^{o}C rise, predicted for the next 100 years, would raise the snowline level above the highest peaks in the Alps (Green, Mansergh & Osborne 1992 #).

CSIRO's latest scenarios of regional climate change are likely to be associated with significant, and possibly rather severe, reductions in natural snow-cover in the Australian Alps. The best case scenario anticipates an 18% decline by 2030 in the estimated area with snow cover longer than 30 days, while the worst case anticipates a 66% decline by 2030 (Whetton 1998a #).

Paradoxically, global warming threatens survival of the mountain pygmy-possum by causing death from cold! This is because the mountain pygmy-possum and other alpine animals depend on the insulating blanket of snow to protect them from the severe cold above. With an incomplete snow cover, winter conditions in Australia can be as extreme for small mammals as those encountered in the Arctic (Green 1998)

CSIRO Atmospheric Research has produced a fine resolution climate change scenario for New South Wales (Baker et al 2000). This scenario indicates the following for the ACT region by 2050:

- temperature: a warming of 0.6°C to 2.5°C in south-central and south-east New South Wales.
- number of hot summer days over 35°C (currently the ACT region has up to 10) increases by 5 to 10 days (50 - 100%);
- number of frosty winter days below 0°C (currently Canberra has about 20, and the sub-alps about 40) decreases by about 10 over the entire ACT region;
- number of spring droughts doubles in all regions of New South Wales except the south-east coastal area; and

the present frequency of extremely wet autumns is at least doubled by 2050 in south-central and south-east New South Wales.

The most vulnerable ecosystems will include those habitats where the first impacts are likely to occur, where the most serious adverse effects may arise, or where the least adaptive capacity exists. These include tropical and boreal forests, deserts and semi-deserts, low-lying islands, arctic regions, **mountain systems**, wetlands, peatbogs and coastal marshes, and coral reefs (DEGS, MMU 2000b).

There is no doubt that the impact of climate change due to the intensifying greenhouse effect could be substantial. The fossil record shows clearly that major changes in vegetation, flora and fauna have been correlated with climate changes of similar magnitude to those predicted to occur within the next few decades (Busby 1990).

Climate change scenarios take into account a range of quantifiable uncertainties associated with projecting climate change and thus allow for a range of possible future climates for the region. Simulated impacts using a 'best case scenario' are moderate: the area with simulated snow cover of more than 30 days declines by 18% by 2030 (a reduction of 1000 km^2)and 39% by 2070. Under a 'worst case scenario' the reductions are very marked: 66% reduction by 2030, and 96% reduction by 2070 (Whetton 1998a #).

The presence of snow determines the composition of much of the fauna in the Australian Alps. Snow plays an important role in protecting some animals from winter cold but limits opportunities for other animals. Periods of snow cover, both in winter and in summer, are important determinants of the composition of the fauna, and any changes to either the longevity of the snowpack or its depth is likely to change the ecological conditions under which the present fauna has become adapted (Green & Osborne 1998 #).

Current efforts to study the biological effects of global change have focused on ecological responses, particularly shifts in species ranges. Mostly ignored are microevolutionary changes. Genetic changes may be at least as important as ecological ones in determining species' responses. In addition, such changes may be a sensitive indicator of global changes that will provide different information than that provided by range shifts. Studies of *Drosophila subobscura* suggest that its chromosomal inversion polymorphisms are responding to global warming (Rodriguez-Trelles, Rodriguez and Scheiner 1998).

Climate change will affect natural ecosystems within conservation reserves in the ACT region. Most past climate changes occurred slowly, allowing plants and animals to adapt to the new environment or move somewhere else. However, if future climate changes occur as rapidly as predicted, species and ecosystems may in some cases fail to adapt, placing further selection pressure on species which are already struggling to cope with habitat fragmentation. Weed problems in many ecosystems may increase as weed species are highly adaptable and can rapidly exploit disturbed areas under environmental stress. Pest infestations may also increase, for example, through extensions to the ranges of pests now confined to warmer northern regions (Baker et al 2000).

The high country and alpine areas along the Great Dividing Range have been identified as significant refugia at a sub-continental level under various greenhouse scenarios. However the climatic envelopes of alpine species disappear, suggesting potential extinction of species and a landscape we now recognise as alpine. Examination of the potential distribution of species at lower altitudes suggest that the biota of these landscapes will "march up hill" (Brereton 1998 #).

Snow acts as an insulating blanket, protecting the plants and animals living underneath. For example, at a site in the Snowy Mountains observed by Green (Green 1998) in July 1986 with full snow cover of 66 cm average depth, the ambient temperatures varied between -10°C and +3°C but the temperature below the snow varied only between 0 and -3°C, remaining remarkably steady at just below -2°C.

Many alpine plants have adapted to periods of snow cover and are competitive with other species under these conditions. Shortening the duration of this cover, due to the warming of the environment, could have wide ranging effects on the distribution and possibly survival of these plants. A longer growing season would be expected to favour growth, but this might also allow other species to become more competitive. There are likely to be changes to plant populations and some species may be endangered by a shift in the depth and duration of snow cover. There is the distinct possibility that the loss of the snow blanket would subject plants to more extreme temperature conditions at critical stages of development and increase the water loss associated with cold dry winds (Wardlaw 1998 #). Lack of snow cover may have long term implications for *Ranunculus anemoneus*. Observations during Rath's three year study indicated that the shorter the period of snow cover the less recruitment of flowers the following year (Rath 1999).

Snow is an essential feature of the alpine and sub-alpine zones. For months each year it transforms the environment, creating difficulties for some plants and animals but providing essential protection for others. Under the best case scenario, within 30 years global warming will reduce the area of the Australian Alps covered by snow for longer than 30 days by an estimated 18%, and the reduction by 2070 is expected to be about 39%. The worst case scenario anticipates a 66% decline in 30 years and a 96% decline in seventy years.

Predicted changes in climate may adversely affect as much as 47% of the 190 plant taxa present in the alpine region around Mt. Kosciuszko within the next century. Forty taxa may have their distribution reduced and could be at risk of extinction due to predicted climate change within the next 70 years. A further forty-nine taxa are likely to experience some reduction in distribution (Pickering & Armstrong 2000a).

Under the best case scenario for climate change, Pickering & Armstrong (2000a) consider that about 15 plant taxa could be at risk of extinction: *Abrotanella nivigena, Brachycome tadgelii, Chionohebe densifoia, Colobanthus nivicola, C. pulvinatus, Coprosma niphophila, Deyeuxia affinis, Erigeron setosus, Plantago glacialis, Ranunculus brevicaulis, R. niphophilus, Rytidospermum pumilum, R. australis, Luzula acutifolia* ssp. *nana* and *Schoenus calyptratus*. The last three are not listed elsewhere in this report. But not all alpine species are likely to be negatively affected by climate change. Some species, particularly those that are able to colonise disturbed areas, are likely to increase in abundance and distribution (Pickering & Armstrong 2000a).

Pickering and Armstrong (2000b) have also examined the likely effects of climate change on alpine plant communities. Some communities could benefit while others decline. They conclude that short alpine herbfield and snow bank feldmark communities are likely to be adversely affected by climate change if large snow banks become less common with declining snow cover. Feldmark, however, may become more widespread if snow cover declines, exposing further areas to freezing temperatures and strong winds. Climate change may initially have a beneficial or neutral effect on the tall alpine herbfield, but if snow cover continues to decline as predicted the tall alpine herbfield would eventually decline. Bogs, fens, raised bog and valley bog communities are likely to vary in area as changes in precipitation, runoff, and evaporation alter the competitive ability of plant species belonging to these communities. Heath communities are likely to increase in area as increasing temperatures and declining snow cover favour shrub species over grasses and herbs.

Increasing diversity and abundance of alien species within the alpine zone is likely to continue and may be amplified by climate change.

The influence of global warming on wildfires is discussed in section 7.1 Fire.

Ozone depletion

The ozone layer will slowly recover over the next 50 years. If there is full global compliance with the current provisions of Montreal Protocol and its Amendments and Adjustments up through Montreal, 1997, the stratospheric abundance of ozone-depleting substances is expected to return to its pre-1980 (i.e., "unperturbed") level by about 2050, assuming all other things (for example, global climate) remain equal. Detection of the beginning of the recovery of the ozone layer is achievable only well after the maximum stratospheric abundance of ozone-depleting gases. (Albritton & Kuijpers 1999).

Generally, the shorter the wavelength, the more biologically damaging UV radiation can be if it reaches the Earth in sufficient quantity. UV-A is the least damaging (longest wavelength) form of UV radiation and reaches the Earth in greatest quantity. Most UV-A rays pass right through the ozone layer in the stratosphere. UV-B radiation can be very harmful. Fortunately, most of the sun's UV-B radiation is absorbed by ozone in the stratosphere. UV-C radiation is potentially the most damaging because it is very energetic. Fortunately, all UV-C is absorbed by oxygen and ozone in the stratosphere and never reaches the Earth's surface (DEGS, MMU 2000e).

Decreased quantities of total-column ozone are now observed over large parts of the globe, permitting increased penetration of solar UV-B radiation (280-315 nm) to the Earth´s surface. The Atmospheric Science Panel predicts that the ozone layer will be in its most vulnerable state during the coming two decades. Some of the effects are expected to occur during most of the next century. Increases in surface erythemal (sun-burning) UV radiation relative to the values in the 1970s are estimated to be about 6% at Southern Hemisphere mid-latitudes on a year-round basis (but about 130% in the Antarctic in the spring) (Albritton & Kuijpers 1999).

Increased UV-B can be damaging for terrestrial organisms including plants and microbes, but these organisms also have protective and repair processes. Zooplankton communities as well as other aquatic organisms including sea urchins, corals and amphibians are sensitive to UV-B. There is evidence that for some of these populations even current levels of solar UV-B radiation, acting in conjunction with other environmental stresses, may be a limiting factor (Albritton & Kuijpers 1999).

Alpine tree frog (*Litoria verreauxii alpina*)

The alpine tree frog is found only in the Australian Alps (Green, Mansergh & Osborne 1992 #). Numerous historical records show that the alpine tree frog was widespread and abundant throughout much of the high country of south-eastern Australia (Osborne, Hunter & Hollis 1999). It is now regarded as nationally vulnerable. In Kosciuszko National Park it previously occurred in all likely habitats at altitudes between between 1500m and 2100m. Above 1500m, it is now confined to two man-made ponds and one natural pond with 2 calling males at about 1800m (NSW NPWS 1999a). It has disappeared entirely from the alpine zone (above 1850 m) (Hunter, Osborne & Smith 1997 #; Broomhall 1998a).

The rapid and widespread nature of population declines in a diverse array of amphibian species at high altitudes, in apparently undisturbed environments, has indicated a ubiquitous causal agent common to all areas of the globe, one perhaps particularly manifest at higher altitudes. Recent studies at high altitudes in North America have suggested a link between declining frog populations and increases in UV-B radiation (Broomhall 1998a #).

Of the seven locations where extant populations of the alpine tree frog were located during recent (1993–1998) searches in Kosciuszko National Park, four were associated with artificial water bodies. No alpine tree frog were found during surveys at Baw Baw Plateau, Davies Plain, and Bogong High Plains in Victoria, but several small populations were located to the south-east of Mt Hotham near Dinner Plain (altitudinal range 1300 to 1600 m), and a more extensive population on the Dargo High Plains (1400 to 1600 m). No frogs or tadpoles of the alpine tree frog were observed at any of the sites surveyed in Namadgi National Park (Osborne, Hunter & Hollis 1999).

These surveys indicated that in the highlands of south-eastern Australia four species of frogs have experienced pronounced population declines. These frogs are the alpine tree frog, southern and northern corroboree frogs *Pseudophryne corroboree* and *P. pengilleyi* and the Baw Baw frog *Philoria frosti*. The northern corroboree frog is still widespread and abundant at lower altitudes, but there are few remaining substantial populations of the other three species, which are faced with the likelihood of extinction in the short term if the current trends continue. There appears to be an altitudinal influence on the extent of the declines, with the most serious declines all occurring at higher altitudes, particularly in the subalpine and alpine zones. This apparent relationship between altitude and the extent of the population decline has been observed in other frog species in Australia and in other countries (Osborne, Hunter & Hollis 1999)

Experimentally blocking UV-B radiation significantly enhanced survival for the alpine tree frog. The species may have been on the periphery of its adaptive tolerance for UV-B, such that even small increases in radiation were sufficient to cause elevated mortality. This research has determined that existing levels of UV-B in the south-eastern alpine region of Australia are likely to be a significant causative factor in the decline of populations of the alpine tree frog (Broomhall 1998a #).

Excessive UV-B inhibits the growth processes of almost all green plants. There is concern that ozone depletion may lead to a loss of plant species. However, reliable scientific information on the effects of UV on plants is limited. Only four out of 10 terrestrial plant ecosystems (temperate forest, agricultural, temperate grassland, and tundra and alpine ecosystems) have been studied. The greatest risks connected with the depletion of ozone in the stratosphere are ecological. Exposure tests made in USA and Australia have showed that over one hundred species of land plant could be sensitive to increases in UV-B radiation as a result of stratospheric ozone depletion. (DEGS, MMU 2000d)

Because UV-B radiation is absorbed by only a few layers of cells, large organisms are more protected, whilst smaller ones, such as unicellular organisms in aquatic ecosystems, are among the most severely affected by UV radiation. Solar UV-B radiation has also been found to cause damage to the early developmental stages of fish, shrimp, crab, amphibians and other animals. The most severe effects are decreased reproductive capacity and impaired larval development. Even at current levels, solar UV-B radiation is a limiting factor, and small increases in UV-B exposure could result in a significant reduction in the size of the population of animals that eat these smaller creatures (DEGS, MMU 2000c).

Amphibian populations are in serious decline in many areas of the world, and scientists are seeking explanations for this. Most amphibian population declines are probably due to habitat destruction or habitat alteration. Some declines are probably the result of natural population fluctuations. Other explanations for the population declines, as well as the reductions in range of habitation, include disease, pollution, atmospheric changes and introduced competitors and predators. UV-B radiation is one agent that may act in conjunction with other stresses to adversely affect amphibian populations. Field studies in which embryos of frogs, toads, and salamanders were exposed to natural sunlight or to sunlight with UV-B radiation removed have shown conflicting results. Some studies resulted in increased embryonic mortality after UV-B exposure, whereas others show that current levels of UV-B radiation are not detrimental. Factors such as water depth, water colour, and the dissolved organic content of the water at the sites of egg deposition effectively reduce UV-B penetration through the water and reduce exposure to UV-B radiation at all life history stages. Biotic factors, such as jelly capsules around eggs, melanin pigmentation of eggs, and colour of larvae and metamorphosed forms, further reduce the effects of UV-B exposure (Albritton & Kuijpers 1999).

Higher elevations have less atmosphere overhead, as evidenced by the thinner air and lower atmospheric pressure. The increase in sun-burning UV radiation is typically about 5- 10% for each kilometre of elevation, the exact number depending on the specific wavelength, solar angle, reflections, and other local conditions (Albritton & Kuijpers 1999).

7.4 Tourism

Tourism and Resorts

Although no new grazing, burning and hydroelectric works threaten the Kosciuszko alpine area, new problems are arising. The widening of roads and the construction of parking areas to cope with increased tourist motor traffic involve destruction and disturbance of the vegetation, both directly and from the, accelerated, run-off of rain water and melted snow. Foot traffic along walking tracks is also causing local damage to some of the most restricted and fragile plant communities. Costin et al. (1979) believe these new human pressures not only require further control, but in some cases re-location and restriction of use. They expressed the hope that the public itself will support such management policies as it better understands and appreciates the Kosciuszko environment and its unique alpine flora. (Costin et al 1979)

Approximately 3 million people visit Kosciuszko National Park annually with about 60% arriving in winter. During the peak winter periods as many as 17,000 visitors per day have been recorded. As only 6% of the park receives skiable snow, this results in a very large number of people concentrated into a very small area (Rath 1999).

Kosciuszko National Park is under considerable pressure from human induced activities because of its relatively small size, high accessibility and tourism potential. Costin (1988) states that “tourist pressures are extending well beyond the development zones assigned to them.” Unless there are more stringent controls on winter and summer recreation and the number of daily visitors to the park, the threats to conservation of endemic flora and fauna will remain (Rath 1999).

The development of large resort areas has impacts on water quality both by the urban runoff from buildings and especially roads and carparks, and by the disposal of sewage, which is discharged from treatment plants into streams (Cullen & Norris 1989 #).

Site “disturbance”

Prime areas of mountain pygmy-possum habitat are currently heavily used for skiing and snowboarding at Charlotte Pass and Blue Cow (NSW NPWS 2000c).

The ski resorts of Charlottes Pass, Perisher and Blue Cow all have populations of *Ranunculus anemoneus* growing on the slopes. Damage by skiers, off-road resort vehicles and slope-grooming are threats. As none of these populations is large, the risk of damage must be considered a major hazard (Rath 1999).

<u>Snow making</u>

There are concerns about the ecological impact of extension of the period of snowcover on terrestrial vegetation, but the impact of snow cover on aquatic ecosystems is also of concern. Extraction of waters during low flow winter periods may also put undue stress on stream ecosystems, especially in areas where effluents are discharged (Cullen & Norris 1989 #).

Another concern relates to commercial pressures to add a bacterial substance to the snow making water to facilitate formation of desirable size snowflakes. This imported material is used by the Alpine Resorts Commission in Victoria (Cullen & Norris 1989 #) and at the Perisher Blue and Thredbo resorts in Kosciuszko National Park (NSW NPWS 2000c).

Cullen and Norris (1989) suggest there is no justification for the introduction of microbial material from overseas into our water catchments and believe the Commonwealth Government should require a full assessment for this biological introduction. Suppliers claim it is 98% sterile (Cullen & Norris 1989 #), in which case huge numbers of live bacteria could be present.

Snowmaking has been conducted over mountain pygmy possum habitat at Charlotte Pass since 1993, with large amounts made in the last 3 years (NSW NPWS 2000c).

<u>Snow grooming</u>

Snowgrooming involves the use of snowgraders to smooth the snow surface on ski areas for the use and enjoyment of skiiers. The term snowfarming is used when snowgraders transfer or “harvest” snow from areas of deep accumulation or areas not used for skiing to distribute on ski runs, particularly in problem spots of low natural accumulation and areas of concentrated skier use such as lift access areas. In some areas snowgrooming and snow farming is neccessary for skiier safety, and to maintain snow depths and protect vegetation. Vegetation damage has occurred in the past by snowgrooming when snow depths were too shallow to provide protection, and by snowfarming from areas of mountain pygmy possum habitat (NSW NPWS 2000c).

Compacting snow results in decreased insulation due to an increase in snow density. Even low frequency use by skiiers, snow grooming graders and snow mobiles can compact snow, and where there has been no base formed through snow-melt cycles, decrease or eliminate the subnivean space (NSW NPWS 2000c).

The accumulation of sufficient body fat, minimum expenditure of energy and a well-insulated hibernation site are crucial for over winter survival of hibernating mountain pygmy possum. As a consequence, depletion of energy reserves by excessive arousals, which may be caused by external factors such as noise, vibration or decreased insulation may prove fatal. The degree of disturbance on hibernating mountain pygmy possum in ski areas from noise and vibration from skiing, snow boarding and snow grooming, and the effects of changing depths and compacting snow on the physical characteristics of hibernation sites has not been directly assessed (NSW NPWS 2000c).

Slope grooming, the modification of the vegetation and terrain to create and improve ski slopes, has been found to be significantly degrading the organic soils and destroying soil structure (from Lee, 1998, cited by Rath 1999).

Pest animals

Rabbits are becoming increasingly abundant in the sub-alpine area of Kosciuszko National Park, particularly around the ski resorts. At Charlotte Pass they have been common in the boulderfield near the sewage treatment plant. Rabbits were not noted in any great abundance at Mt Blue Cow until 1995, when they were frequently seen feeding on introduced grasses and clover on the roadside verges and ski runs. Rabbits may damage native vegetation and may attract predators, particularly cats, to the area. (NSW NPWS 2000c).

Feral cats were observed in increasing numbers between 1986–1990 at Mt Blue Cow and a litter of kittens was found in the boulderfields in 1999 (NSW NPWS 2000c).

Mountain pygmy possums are known to enter ski lodges and other buildings within the resort concession areas at Mt Blue Cow, Charlotte Pass and Thredbo. They are susceptible to rat traps and poison which have been used to control rats and mice in these buildings. One male mountain pygmy possum is known to have been killed in a rat trap (NSW NPWS 2000c).

Weed sources

> Places such as Falls Creek village and Bogong village are potential weed explosions waiting to happen. (Lynise Wearne pers comm)

Garden plants introduced to, or maintained in, resorts for decorative purposes present a threat of invasion of adjoining park areas.

Over half the weed species found in the high altitude areas of the Australian Alps were found in resort areas. The establishment and spread of weeds is enhanced by disturbance associated with the construction and operation of tourism facilities. Sites such as roads, paths, ski runs and buildings will act as foci for weed establishment (Johnston & Pickering 2000).

Pollution

The accommodation of large numbers of people in resorts within the national parks, plus the crowds of day visitors, means substantial quantities of sewage are generated and must be disposed of.

Accidental spills (eg fuel, heating oil) are also a risk.

Garbage

Uncovered garbage attracts predators (foxes and cats) to the resort areas and provides a supplementary, winter food supply to predator populations. Rubbish, littering and garbage is a significant issue in areas of mountain pygmy possum habitat, particularly in Resort Lease areas and the summit area of Mt Kosciuszko, which receive heavy use. One mountain pygmy possum, for example, was found drowned in a plastic garbage bin which had been left in the main boulderfield at Charlotte Pass. The boulderfields are also a convenient place to hide rubbish, including drink bottles which could pose a similar hazard to mountain pygmy possums throughout the alpine area (NSW NPWS 2000c).

Non-resort activities

A range of recreational activities cause damage and were identified at the workshop as threats. These include use of 4-wheel drive vehicles in a way that damages tracks or vegetation, deer hunting and pig hunting. Some of the practices of pig hunters are of particular concern. Fishing can also be environmentally detrimental, from several perspectives. Stocking of streams with trout for the benefit of anglers is a major threat to native fish and invertebrates. The lure of trout attracts many people to the streams in areas which would otherwise be relatively undisturbed. Fishing adversely affects rare and endangered native fish species.

7.5 Water Issues

Stream flow

“Alteration to the natural flow regimes of rivers and streams”, “Alteration to the natural temperature regimes of rivers and streams” and “Prevention of passage of aquatic biota as a result of the presence of instream structures” are listed on Schedule 3 of the Flora and Fauna Guarantee Act as potentially threatening processes.

The pattern of flow — the hydrology — drives the ecology of the river system in just about every way imaginable. Given the fact that hydrology has a profound influence on the ecology of river systems, there is no surprise that the construction of impoundments and flow regulation represent the greatest threats to the health of our rivers. Building impoundments and changing the pattern of flow will always have a tremendous impact on the ecology and health of our rivers. (Bunn & Arthington 1997).

By far the greatest and most pervasive impacts occur from changes to the flow regime —not just the amount of water that flows down the river but also, very importantly, the pattern of flow. The shallow, fast flowing part of a stream is its most productive area with high aeration and high production. Keeping systems at low flow so that these areas are unable to function as the “lungs” of the stream can be devastating. Life cycles of animals in the river can be easily disrupted by unnatural patterns of flow in the river. Making variable flows more predictable encourages the spread of exotic species (eg introduced carp and gambusia in the Murray-Darling system, and water hyacinth (Bunn & Arthington 1997).

Fluctuating water levels and an increase in sediment levels, associated with irrigation demands in the lower section of the Mitta Mitta Heritage River cause impacts on the spawning habitat of Macquarie perch (DNRE 1997a).

The potential for spread of willows in the Snowy River has occurred following reduction of stream flow as a result of the Snowy Mountains Scheme. Current flows are insufficient to maintain the natural structure of the river, and pool infilling and exposure of prior riverbed has meant that extensive areas are ideal for establishment of willows (Gooey 1999).

Pollution

Increasing back-country recreation creates a potential problem from the impact of untreated human wastes on the streams and lakes of the parks (Cullen & Norris 1989 #).

The five glacial lakes of the Kosciuszko National Park are under some threat, since they are attractive places for campers, and Timms (1980) suggests that organic pollution from such camp-sites is affecting the benthic fauna of Albina, Blue and Cootapatamba Lakes (Cullen & Norris 1989 #).

Sedimentation

"Increase in sediment input into Victorian rivers and streams due to human activities" is listed on Schedule 3 of the Flora and Fauna Guarantee Act as a potentially threatening process.

Siltation from four-wheel-drive tracks, camping, cattle grazing and horse riding poses a significant threat [to spotted tree frog and *Galaxias*] These activities cause vegetation trampling, siltation of pools and faecal contamination of water (DNRE 1997a).

Fluctuating water levels and an increase in sediment levels, associated with irrigation demands in the lower section of the Mitta Mitta Heritage River cause impacts on the spawning habitat of Macquarie perch (DNRE 1997a).

7.6 Other Land Uses

The hydro schemes

The Snowy Mountains and Kiewa hydroelectric schemes, as major engineering undertakings in the Australian Alps, had diverse environmental effects, both harmful and beneficial.

Prior to the commencement of the Snowy Mountains Scheme mountain access was limited. There was a narrow, gravel-surfaced primitive road terminating at the highest point, Mount Kosciuszko, another similar dead-end road in the south-east corner, and one trans-mountain highway, again narrow and gravel-surfaced, towards the northern end. These roads totalled less than 200 kilometres, and the fact that they dated back to the pre-mechanised equipment construction era meant that minimal earth works and landscape scarring were involved despite the mountain terrain (Gare 1992 #).

Elsewhere access into the mountains was generally on foot (walking or skiing) or on horseback. A number of stock routes traversed the mountains, by which sheep and cattle were taken to and through the mountains each summer, and there were one or two primitive vehicle tracks used by prospectors, miners and timber-getters. So the mountains slept on until the arrival of the Snowy Scheme's bulldozers in 1949 (Gare 1992 #).

The scale and speed of the Scheme's physical assault on the mountains with the enormous excavation and forest-clearing capacity of modern machinery, made immediate impact. Although it has been stated that only two percent of the Kosciuszko National Park is occupied by engineering works, this approach understates the real effect. Even with the revegetation that has largely occurred on cleared areas and earthworks since construction, there are many remaining visual impacts of roads, pipelines, aqueducts and transmission line easements extending over much larger areas than those physically occupied (Gare 1992 #).

Substantial lengths of mountain streams are virtually "dead" for long periods following water diversion by dams, weirs and aqueducts, with associated changes to hydrological and wildlife systems. To the range of pest animals and plants brought to the mountains by pre-Park land use since the early 19th Century was added a further spread of exotic plants such as willows and poplars from cuttings used for erosion control purposes, and sometimes for ornamentation, by the Snowy Mountains Authority. In the wake of temporary construction townships and camps, the surrounding park lands had to absorb a population of abandoned and, in due course feral, dogs and cats, with a resultant adverse impact on native animal populations (Gare 1992 #).

The substantial tunnels of the Scheme, up to 23.5 kilometres long and 8 metres in diameter, produced huge quantities of rock spoil. Where not used for dams, roads and other construction works, considerable quantities of this spoil remain in big ugly dumps in various parts of the Alps (Gare 1992 #).

Logging

Logging has a variety of impacts on native vegetation. Apart from initial disturbance, potential longer -term effects include changes in species composition, including invasion by weeds. Due to changing climate, regeneration may not replace the logged communities (Busby 1990).

Mining

There are several active exploration programs in the Alpine National Park and plans for mining some minerals and materials (Busby 1990). Mining of peat and sphagnum were identified at the project workshop as a threat.

Roads

Roads can have substantial impact in a protected area. Road construction causes considerable diturbance, permanently changing local hydrology. Construction and rehabilitation materials can introduce weeds and disease organisms. Gravel sheeting on roads in Kosciuszko National Park is suspected to have spread the invasive weed, yarrow. The transport of soil as a result of road building and maintenance is a major mechanism for dispersal of the root-rot fungus, *Phytophthora cinnamomi* (Environment Australia 1999c). Perhaps the greatest impact of road construction in protected areas is the provision of new access, leading to increased use and possibly consequential development.

Other deleterious effects include erosion, particularly around streams, provision of invasion routes for weeds and feral animals, and disruption to fauna dispersion routes (Busby 1990). Johnston and Pickering (2000) noted that 80% of alien plant species found in the Australian Alps had been recorded along roadsides and paths.

Cullen & Norris (1989 #) predicted that the use of salt by the Department of Main Roads within Kosciuszko National Park during the snow season may have deleterious impacts. Extensive monitoring of salt impacts on Kosciuszko Road by the NSW NPWS have failed to identify deleterious impacts beyond the immediate road shoulder.

Agricultural Practices Elsewhere

Bogong moths are the major food source for mountain pygmy-possum but their abundance is now a function of agricultural practices in lowland areas in northern New South Wales and southern Queensland where they spend their larval stages (Green, Mansergh & Osborne 1992 #).

7.7 Park Management

Funding for park management is limited and choices must often be made between a number of real needs because resources are inadequate to fulfil all, or even most, requirements. In deciding what will be done and what will not, park managers not only have to assess the ecological implications of their decision but also must address the needs and wishes of park users and political considerations.

Management of ecosystems requires a great deal of information to enable correct identification of need and prediction of the effects of a particular management action. Despite the ecological research and survey which has been undertaken in the Australian Alps, our knowledge of ecosystem function is very incomplete. Furthermore, the accessibility of knowledge is limited.

As an example of how inadequate information can cause less than optimal management, and how difficult it is to predict ecological outcomes, the use decades ago of galvanised wire to rehabilitate sites in Kosciuszko National Park degraded by grazing has caused substantial plant death (Johnston & Ryan in press).

Many threats to the survival of the natural treasures of the Australian Alps are a result of people seeking fun and/or making money. For park managers the scientific evidence might be comprehensive and clear, but the politicians who must make the ultimate decisions must also consider the interests or wishes of the community and then decide where to draw the balance between environmental welfare and the welfare of some of the citizens. Thus it is important that factual information be available to the community and their representatives.

8 Assigning priorities for resourcing

8.1 A system for assigning priorities

The original list of significant natural features of the Australian Alps national parks, prepared during the first two months of this project, contained about 1300 features and nearly 100 threats. The workshop of experts was to allocate priorities to these features and threats, but their number and diversity presented a daunting challenge for the two-day workshop.

The list of features was reduced substantially, largely by deleting the many plant species whose inclusion in the list depended solely on their status as rare in Victoria, and by deleting the sites identified in each National Park as significant because of the one or several significant animal or plant species which occurred there.

The reduced list still included:

- 130 fauna species
- 265 flora species
- 105 other natural features and
- 90 threats.

It was clearly unreasonable to expect the workshop to allocate priorities to some 600 items using a delphic approach (ie relying on a group of experts to reach a consensus on the priority rankings on the basis of their purely qualitative assessment of each item compared to all the others) (Croom & Crosby 1997).

A systematic approach was needed, to make the task possible at all and also to meet a number of logical requirements.

The US National Park Service has released a Handbook for Ranking Exotic Plants for Management and Control (Hiebert & Stubbendieck 1993) which provides a systematic means of allocating priorities to weed species. Croom and Crosby (1997) described a similar scoring approach for allocating priorities to potential marine and coastal protected areas, which they called Dimensionless Analysis.

In an attempt to track down other models, an e-mail request was sent to:

- IUCN Invasive Species Specialist Group (sent to about 550 members);
- Environment Australia Invasive Species Discussion Group (approx 40 members);
- Adrian Phillips (Chair, World Commission on Protected Areas);
- David Sheppard (Secretary, World Commission on Protected Areas);
- Larry Hamilton (World Commission on Protected Areas Vice Chair, Mountains); and
- Jeremy Harrison (World Conservation Monitoring Centre).

Only one model, a Western Australian ranking system for prioritising weeds described in a paper submitted for publication (Randall 2000), came to light from those extensive enquiries.

Parks Victoria (2000) criteria for high priority species or communities are:

- FFG listed, or are critically endangered or endangered VROT;
- are classified as 1A species identified in the NRE bioregional analysis
- occur exclusively or predominantly on Parks Victoria land;
- have greater than 50% of the population on Parks Victoria land;
- the proposed action arises from an Action Statement or Recovery Plan for that species;
- the population comprises the most substantial proportion of the species distribution; and
- there is a threat to long-term security of the population.

Criteria for assessing protection proposals in Southland, New Zealand (Harding 1999) are:

Representativeness (primary criterion)	∧	distinctiveness (secondary criterion);
Sustainability (primary criterion)	∧	condition (secondary criterion); and
Landscape integrity (primary criterion)	∧	amenity (secondary criterion).

No existing system seemed appropriate to the needs of this project. Consequently it was necessary to develop a system which was based loosely on the three referred to above.

The prioritising technique needed to be:

- simple enough to be easily understood and consistently applied;
- comprehensive enough to cover necessary considerations;
- fair enough to be agreeable by all relevant jurisdictions;
- rigorous enough to produce workable **indicative/relative** rankings;
- consistent enough to produce reasonably reproducible results;
- suitable for many features or threats;
- fully transparent;
- easily queried;
- easily revised if information changes;
- easily modified if experience warrants; and
- robust (not much affected by small errors).

8.2 The system

The system developed (Table 8.1 and Table 8.2) relied on scoring each natural feature or threat separately for each of five criteria, and multiplying those scores to derive a single score for each feature. It is simple and quick to use and should be fairly easy for different groups to use consistently — if the definitions for each score are clear and unambiguous.

It was sent as a draft to about twenty people prior to the workshop, and the few comments received were incorporated. It was also discussed at meetings of the project Steering Committee. Because of the very limited time available, it was presented to the workshop as ready to use. Participants were asked to apply it and record concerns for the next version (after this project) unless there was a major problem. Using scores generated by the workshop provided a trans-alps view, but it is important to recognise that the importance of some issues varies across the Alps and an average score could exaggerate the significance of an issue in one park while under-representing its significance in another. The system was really a prototype, and was expected to be refined during and after the project for application again later. It was a beginning rather than an end point. A modified system can be applied at any time and individual items can be reconsidered whenever circumstances change.

One feature of the system for scoring the natural features is the preference for areas, communities or ecosystems over single species. This reflects two considerations:

- areas, communities or ecosystems accommodate many species of animals and plants, and those identified as significant often accommodate at least one endangered species; and
- areas, communities or ecosystems are likely to include micro fauna and flora which remain unknown, or at least unstudied, and would therefore not be protected by a species-based approach.

Some workshop participants suggested that adding the scores for criteria might be better than multiplying them. These alternatives were tested after the workshop using actual scores for 84 threat features. Adding the scores changed the order of the 84 features only slightly, with just nine being a little out of place in the list generated using multiplied scores. The major difference between adding and multiplying was that multiplying is much more sensitive.

Adding the scores for criteria divided the 84 features into 12 classes, whereas multiplying created 25 classes. There is no question of trying to use the results to isolate 25 separate classes, or even 12, but the more sensitive ranking classification might still have advantages.

8.3 Applying the system

The system works best when all items are scored. Before scoring commenced, participants were urged to try to score every item, and to record concerns where appropriate, rather than to leave blanks where a score could not be allocated with confidence. In the end, however, the workshop participants did not have the knowledge to score all items, so the ranking was incomplete. Scores were allocated whenever possible, with the degree of confidence being recorded in each case.

After the workshop participants were sent lists of the unscored features and asked to score, or pass to colleagues to score, as many as possible of those features.

In the workshop predetermined groups were allocated a suite of items to score in order to try to cover all the items during the time available and also to try to achieve some overlap to enable assessment of consistency between groups. For the natural features, the groups were selected to concentrate relevant expertise and also to ensure broad jurisdictional representation in each group. For the threats, groups were selected to achieve broad representation of expertise in each group as well as broad jurisdictional representation.

When the system (Table 8.1) was applied to the natural features (by two groups for fauna, two for flora and one for other features) some ambiguity became apparent. The major issue which arose was the appropriate ranking and scoring of the alternatives under “Recovery potential”. Two other approaches to this criterion were proposed, with logical supporting arguments. It

Table 8.1 Assessment of priority of features

Feature type x Distribution x Rarity x Threat x Recovery potential

Feature type	Score
Species or sub-species or below	1
Area, community or ecosystem without endangered species/attribute	2
Area or community with at least one endangered species/attribute	3
Ecosystem with at least one endangered species	4
Distribution	
Widespread (in [& often beyond] Australian Alps national parks)	1
Restricted distr generally within the Australian Alps national parks only	2
Confined to one or a few sites/populations	3
Rarity	
Common	1
Uncommon or locally rare	2
Endangered or Rare nationally	3
Degree of Threat	
Populations secure from threats	1
One or more threats but possible extinction not an issue	2
Real risk of extinction within 100 years from known threats	3
Recovery potential	
Feature not significantly depleted	1
Survival beyond ca 50 years unlikely	2
Maintenance likely but recovery unlikely	3
Feature likely to recover substantially with management	4

Table 8.2 Initial model for assessment of priority of threats

Threat status x Distribution x Rarity x Impact x Management potential

	Score
Threat status	
Locally significant	1
Regionally significant	2
Of State or Australian Alps significance	3
Distribution	
Confined to one or a few (<5) sites/populations	2
Restricted distribution (5–50 sites within the Alps national parks)	3
Widespread (in the Australian Alps national parks)	4
Rarity	
Few individuals	1
Moderate populations	2
Dense populations or pervasive	3
Impact	
Little detectable impact or likely impact	1
Impact not threatening ecosystems or species	2
Impact on species or ecosystems significant	5
Management potential	
Intensive effort will have little effect	1
Management can reduce threat significantly	2
Management can eliminate threat	3

Table 8.3 Applied model for assessment of priority of threats

Threat status x Distribution x Rarity x Impact x Management potential

	Score
Threat status	
Seen as an issue in one jurisdiction	1
Seen as an issue in two jurisdictions	2
Seen as an issue in three jurisdictions	3
Distribution	
Confined to one or a few (<5) sites/populations in the Australian Alps	2
Restricted distribution (5–50 sites within the Australian Alps)	3
Widespread in the Australian Alps	4
Frequency of occurrence of threat in the Alps	
Few individuals or occurrences	1
Moderate numbers or occurrences	2
Dense populations or pervasive occurrences	3
Impact	
Small current or potential impact	1
Medium current or potential impact	2
Significant current or potential impact	5
Management potential	
Management will have little effect	1
Management can reduce or contain threat	2
Management can eliminate threat	3

was not possible to settle on one of the three approaches in the workshop. Ranking can be undertaken easily using the scores for the first four criteria only, so the system is operational without using recovery potential as a criterion, and recovery potential can be considered later if required.

The three suggested approaches to ranking recovery potential are:

1 Feature not significantly depleted
2 Survival beyond ca 50 years unlikely
3 Maintenance likely but recovery unlikely
4 Feature likely to recover substantially with management

1 Feature not significantly depleted
2 Feature likely to recover substantially with management
3 Maintenance likely but recovery unlikely
4 Survival beyond ca 50 years unlikely

1 Survival beyond ca 50 years unlikely
2 Maintenance likely but recovery unlikely
3 Feature likely to recover substantially with management
4 Feature not significantly depleted

Before applying the system provided for allocating priorities to threats (Table 8.2) the workshop discussed the system and made some modifications (Table 8.3). Five groups then used the revised scoring system to rank the threats.

8.4 The outcome

About 50 fauna taxa and 111 flora taxa could not be scored at the workshop, apparently due to the inability of the participants to allocate scores. That this expert group of field staff and scientists from the agencies and scientists from universities were unable to score these species is important in itself. These species were listed as significant by virtue of their identification in park management plans or associated documents, or in reports or papers. Thus they are of somewhat high profile, even if rare or threatened. This highlights the scope for improvement of our knowledge of the natural resources of the Australian Alps national parks in order to manage them appropriately.

After the workshop, botanist Keith McDougall, who participated in the workshop, offered to score many of the flora features himself. He had suggested at the workshop that the best way to obtain accurate scores for each species was to ask the person who knows most about the species to do it. That is a sensible approach which was unavailable within the scope and timeframe of this project but is worth considering as an enhancement to this system for future application. For many of the plants listed, Dr McDougall was confident that he is in a position to provide reliable scores. For others he used the best available information on their distribution and abundance. Dr McDougall scored virtually all the flora (Table 8. 7), a huge effort which is invaluable to the project for two reasons. Firstly we now have scores for all but eight of the 260 flora features (though by an individual rather than a trans-Alps group), whereas 111 remained unscored after the workshop. Also, and very importantly for the project, an expert assessment is available to compare with the output from the workshop. The workshop remains the basis for priorities identified by the project.

Although not all items were scored, the results are still very useful in recording the views of the workshop participants on the priorities of the natural features and threats. That statement notwithstanding, the results rely on interpretation. The final priority rankings (ie high, medium or low) depend on the approach taken between completion of scoring in the workshop and allocation of rankings.

The system delivers precise numerical scores, which can be deceptive. While listing the items in the order of their numerical scores is possible, it is not necessarily very meaningful.

The scores are the product of individual scores for four or five criteria, and those individual scores are each somewhat subjective. The final scores can indicate a general ranking but should not be used for precise discrimination between items allocated scores which are not greatly different. The final scores form a continuum, and the threshold for the rankings is arbitrary.

Any defined threshold will result in items scoring slightly above and slightly below the threshold, while those items may reasonably have the same or reversed priority ranking in practice.

After different approaches to allocating rankings had been tried, the most workable found was to calculate the average ranking score and then insert the thresholds. This approach is straightforward to apply, and looks very precise, but has some important limitations.

For some items the scores were quite consistent between groups, but for others they varied considerably. Distinguishing between those extremes is necessary, but it is also necessary to recognise that inconsistency might not be limited to occasions where it is obvious. Where only one group scored an item there is no opportunity to assess consistency, but where two groups scored an item similarly the sample might be too small to assume an accurate score has been replicated.

This is illustrated for pest animals in Figure 8.1 and Table 8.4. Note, for example that:

- Foxes were consistently scored highly by the five groups;
- Rabbits were scored highly by two groups but probably a medium score by a third;
- Goats were scored highly by one group, medium by two and low by two;
- Group 1 scored horses much more highly than did Group 5, whereas Group 5 scored rabbits and fallow deer much more highly than Group 1 did; and
- Gambusia were scored very differently by the two groups which tried;

yet considering just the average score (Figure 8.1) gives an apparently clear ranking but does not allow any assessment of the reliability of each score.

Inconsistency between the priority rankings set by different expert groups is not unusual. Three expert groups, working simultaneously with identical information, ranked eighteen potential marine protected areas using both delphic and scoring approaches (Laffoley et al 1997). With only eighteen features (potential marine protected areas) to rank, and with careful preparation to try to achieve consistency in applying the scoring system, between them the three groups ranked twelve areas "high": two areas were ranked high by all three groups, three by two groups, and seven by only one group. Six areas were ranked high by at least one group but also ranked low by at least one group. Inconsistency between the groups when using the delphic approach was similar.

The comparison of the workshop rankings for Flora with those by Dr McDougall is encouraging and provides support for the credibility of the scoring system. It reinforces the importance of scoring all features, because many not scored by the workshop have been ranked highly by Dr McDougall.

Of Dr McDougall's top **twenty** features, 15 were in the workshop's top 25, 16 were in the workshop's top 40 and four had not been scored by the workshop.

Of Dr McDougall's top **thirty** features, 19 were in the workshop's top 25, 21 were in the workshop's top 40 and nine had not been scored by the workshop.

Of Dr McDougall's top **forty** features, 26 were in the workshop's top 40, eleven had not been scored by the workshop, and only three were not ranked highly by the workshop.

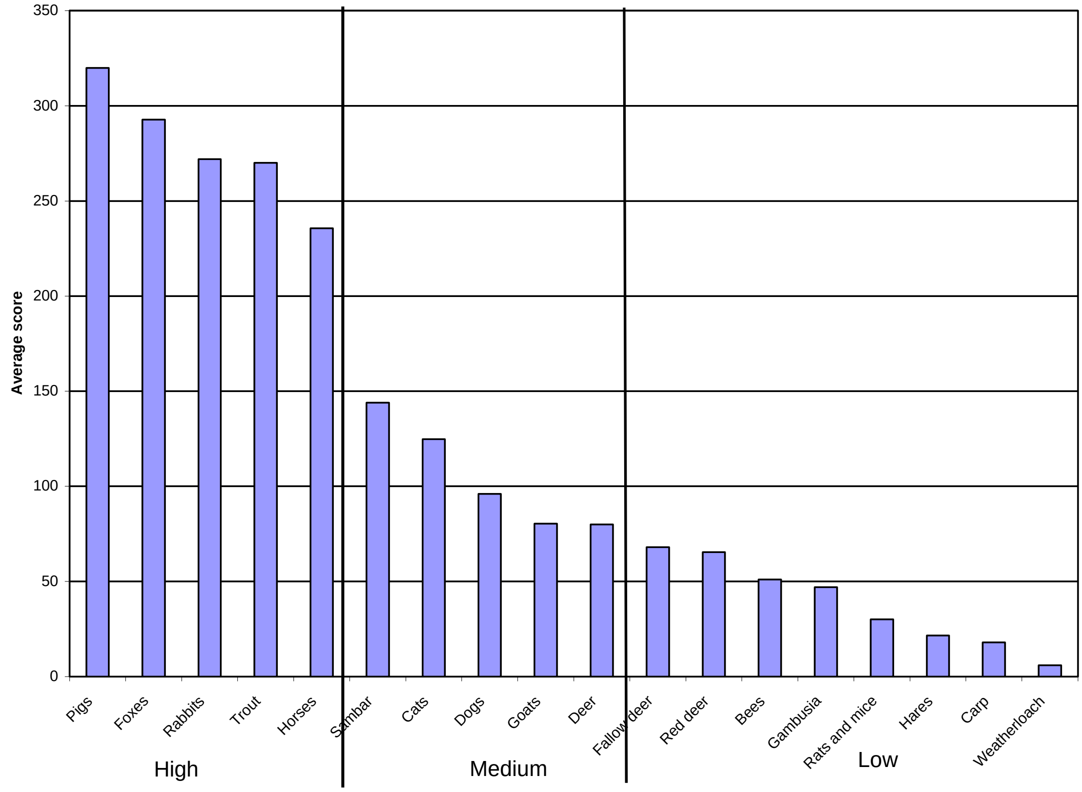


Figure 8.1 Average scores of pest animals in priority ranking

Table 8.4 Priority Scoring - Animal Pests

Pest	Group 1 score	Group 2 score	Group 3 score	Group 4 score	Group 5 score		Ranking
							H
							H
							H
							H
							H
							M
							M
							M
							M
							M
							M
							M
							L
							L
							L
							L
							L
							L

This indicates that the features not scored by the workshop merited more or less pro rata representation in the most highly ranked features, which is interesting in itself. Discounting features which could not be scored would clearly be unwarranted and risky.

The complete scores are recorded in Appendix 4. Access to the scores for individual criteria for each feature is necessary to be able to see the basis for its final score if there is any reason to question it. Scores for the individual criteria are also useful alone or in different combinations. For example, lists in the boxes in this chapter have been derived by using the scores for one or two criteria.

8.5 The priorities

Fauna of High Priority

Burramys parvus	Mountain pygmy-possum;
Potorous longpipes	Long-footed potoroo;
Pseudomys fumeus	Smoky mouse;
Litoria sp. affin. phyllochroa	Cotter River frog;
Litoria verreauxii alpina	Alpine tree frog ;
Philoria frosti	Baw Baw frog;
Pseudophryne corroboree	Southern corroboree frog;
Maccullochella macquariensis	Trout cod;
Macquaria australasica	Macquarie perch; and
Neoniphargus sp.	(a cave invertebrate).

Flora of High Priority

Gentiana baeuerlenii;	
Kelleria laxa	Drapetes

and possibly:

Banksia marginata stand at Yarrangobilly

Pomaderris cotoneaster	Cotoneaster Pommaderris
Calotis cuneata subsp pubescens	
Asplenium hookerianum	Maidenhair Spleenwort
Babingtonia crenulata	Fern-leaf Baeckea
Baeckea denticulata	Thyme Heath Myrtle
Carex raleighii	Raleigh Sedge
Chiloglottis turfosa	Bog Bird Orchid
Chionogentias sylvicola	Late Forest Gentian
Eucalyptus elaephloia	
Eucalyptus mitchelliana	Buffalo Sallee
Eucalyptus neglecta	Omeo Gum
Eucalyptus saxatilis	Suggan Buggan mallee
Eucalyptus triplex	
Genoplesium turfosum	Bog Midge Orchid
Irenepharsus magicus	Elusive Cress/Branched Cress
Monotoca rotundifolia	Trailing Broom-heath
Myoporum floribundum	Slender Myoporum
Olearia aglossa	Alpine Daisy Bush
Pomaderris sericea	Bent Pomaderris
Pratia gelida	Snow Pratia
Rytidosperma pumilum	Mountain Grass/ Feldmark Grass
Westringia cremnophila	Snowy River Westringia

As mentioned previously, there was divergence of opinion at the workshop as to how to rank "recovery potential" for fauna, flora and other features. Should likely recovery with management give a feature high priority for funding (as likely to be a good investment" or should it give the feature low priority in favour of features less likely to survive? Three different approaches have been suggested and this issue remains unresolved. Accordingly the scores and rankings presented here exclude "recovery potential".

Although fauna, flora and other features were scored separately by different workshop groups, they were scored using the same system with the intention that final numerical scores for each of these groups would be roughly equivalent in indicating their priority. In other words, a score of 27, which was the highest possible for a species, was intended to be equivalent to a score of 27 for other features. The result of that approach is that a number of other features were ranked more highly than the highest ranked animal and plant species. This seems appropriate, considering the other features include whole communities considered of high priority.

For ease of consideration, the rankings for fauna (Table 8.5), flora (Table 8.6 and Table 8. 7) and other features (Table 8.8) are presented separately, but the same score thresholds for high, medium and low priority have been used for the three sets of features. Users should remember that this system was not intended to be used to precisely determine ranking order. Instead it is intended to provide useful indicative rankings. Since the thresholds are arbitrary and the scores are not really precise anyway, the thresholds between high and medium priority can be reset according to need. If it is felt too much weight has been given to "other features", the threshold could be lowered for fauna and/or flora (especially flora).

Other Natural Features of High Priority

Rainforest remnant vegetation (e.g. *Atherosperma moschatum*), Kosciuszko NP;
Bog communities associated with the thermal spring area, Yarrangobilly;
Windswept feldmark (*Epacris – Chionohebe*), Kosciuszko NP;
Snowpatch feldmark (*Coprosma – Colobanthus*), Kosciuszko NP;
Short-alpine herbfield, Kosciuszko NP;
Alpine snowpatch community;
Podocarpus lawrencei (Mountain Plum Pine) heathland, Kosciuszko NP;
Yarrangobilly plant species which appear to be restricted to limestone at Yarrangobilly and Wee Jasper;
Important Wetland - Big Creamy Flats - AA001AC;
Important Wetland - Davies Plain - AA005VI;
Important Wetland - Ginini and Cheyenne Flats - AA006AC;
Important Wetland - Mount Buffalo Peatlands - AA008VI;
Important Wetland - Rennex Gap - AA009NS;
Important Wetland - Rotten Swamp - AA011AC;
Important Wetland - Snowgum Flat - AA013NS;
Kosciuszko Alpine Landscape Conservation Area;
Glacial lakes (cirque basins, moraines), Kosciuszko NP;
Non-sorted steps, contour trenches (string bogs - contour banks), Kosciuszko NP;
Nivation cirque, Mount Howitt;
Moraine dumps (kettle lakes), Kosciuszko NP;
Nivation hollows, Kosciuszko National Park ;
Roche moutonnee, Kosciuszko National Park;
Skarn rock outcrops, Kosciuszko National Park;
Solifluction terraces, Kosciuszko National Park; and
Landslide-dammed lake (Tali Karng)

The scoring of threats included "management potential", so the priority assignment for threats is not analogous to the ranking of natural features.

Superimposed on the rankings of natural features are the statutory or other formal obligations to manage endangered or vulnerable species or communities. Assistance for such management might be available by virtue of their status.

Table 8.10 and Table 8.11 compare the rankings from this project and formal status of fauna and flora taxa respectively. As would be expected, nationally endangered and vulnerable fauna make up most of the high fauna rankings, but importantly those rankings also recognise other species which deserve priority — the Cotter River frog *Litoria sp. affin. phyllochroa* and the cave beetle *Teraphis cavicola*. Further down the list, the nationally endangered or vulnerable species are much more scattered, with a mix of less prominent vertebrates and invertebrates out-ranking them.

The rankings and formal status for flora taxa are much less consistent. While the top two species are endangered and vulnerable nationally, fifteen of the top twenty are neither, although seven of them are endangered or vulnerable in at least one State.

The inconsistency between the rankings developed in this project and the formal status of the taxa is probably largely a consequence of the focus of this project on the Australian Alps. Species considered endangered or vulnerable nationally may occur in the Australian Alps incidentally (eg the regent honeyeater *Xanthomyza phrygia*) or threatened species which are confined to the Australian Alps may have been unnoticed at a national scale. Additionally, this project required consistent consideration of taxa, whether they were mammals or birds, beetles or worms, orchids or ferns.

The high ranking of taxa not considered particularly significant nationally demonstrates the importance of undertaking the ranking in this project. When undertaking the scoring, workshop participants had lists providing national and State status and threats (Tables 4.9 and 5.5) and most of the database (Appendix 3), so that information was available to them. Relying on national classifications would have overlooked taxa considered of relatively high priority in this project.

High priority threats

Foxes;
Horses;
Pigs;
Rabbits;
Trout;
Grazing by stock;

English broom (*Cytisus scoparius*);
Blackberry (*Rubus discolor*);
Crack Willow (*Salix fragilis*);
Grey Sallow (*Salix cinerea cinerea*);
Black Willow (*Salix nigra*);
Rusty Sallow (*Salix cinerea oleifolia*);

Introduction/spread of aquatic diseases and parasites;
Alteration to the natural temperature regimes of rivers and streams;
Prevention of passage of aquatic biota as a result of the presence of instream structures;
Water level fluctuation of streams;
Alteration to the natural flow regimes of rivers and streams;
Damming of streams;
Impacts originating elsewhere (eg on Bogong moth larvae in western NSW);
Recreation and tourism; and
Managed fires (artificial fire regime).

The differences between the rankings and the formal status of taxa reinforces the risk of management focused towards species. Clearly species not recognised formally under national or State legislation are significant. This project has identified other significant species but there must be more which have been overlooked due to lack of information. Managing ecosystems or communities, or overarching threats, is the safest way to protect those species which have escaped the attention of scientists so far.

A similar outcome applied to the ranking of threats. English broom was the highest ranked weed, yet it is not a weed of national significance. Pigs and foxes were the highest ranked animal pests; foxes are nationally considered key threats, but pigs are not.

Superimposed on the ranking of threats are the statutory or other formal obligations to control specific threats. For example, blackberry and serrated tussock are among the twenty weeds of national significance. Assistance to address these pests might be available by virtue of their status (eg NHT or similar funding might be available for weeds of national significance).

8.6 Using the scores

The scoring system is designed to enable allocation of priorities by combining the scores for the individual criteria. An important benefit of the system is that, once scores are allocated for each criterion, the scores for criteria can be combined in different ways to alter weightings if experience suggests an improved approach, or if a different approach is to be tested. This allows the scores allocated by the workshop to be used in a different way if necessary.

Discussion during the workshop showed there were several possible ways to rank the scores for Recovery Potential (see section 8.3), and excluding Recovery Potential from the final scores became necessary. The flexibility of the system allowed this change of approach without difficulty, while retaining value from the scores the workshop assigned for Recovery Potential. The scoring system also allows the ranking of individual features to be reviewed if the scores assigned by the workshop are later considered to be incorrect or if circumstances change.

Although not used for priority ranking, and although they cannot be considered hierarchical, the scores for Recovery Potential are still useful and unambiguous,. For instance, a score of 2 indicates the feature was considered unlikely to survive beyond 50 years. Similarly, a score of 4 indicates that the feature was considered likely to recover substantially with management.

Thus the scores from the ranking system can be used individually, or in various combinations, to extract useful information. This can be done most easily using the electronic Excel tables of scores which are available on CD-ROM. Those tables can easily be filtered or sorted on one column or a combination of columns. Text boxes in this section show some results from such exercises.

Animal species whose survival beyond 50 years was considered by a workshop group to be unlikely.

List derived by filtering fauna for a score of 2 for Recovery Potential.

Southern corroboree frog
Northern corroboree frog
Booroolong frog
Alpine tree frog
Trout cod
Dingo

Plant species whose survival beyond 50 years is unlikely.

List derived by filtering flora for a score of 2 for Recovery Potential.

Gentiana baeuerlenii
Irenepharsus magicus
Euphrasia scabra (which is already extinct in Kosciuszko National Park — McDougall pers. comm.)

Fauna species considered at real risk of extinction within 100 years from known threats.

List derived by filtering fauna for a score of 3 for Degree of Threat.

Burramys parvus, mountain pygmy-possum
Canis familiaris dingo, dingo
Dasyurus maculatus, Spot-tailed quoll/Tiger quoll
Gymnobelideus leadbeateri, Leadbeater's possum
Helioporus australiacus, Giant burrowing frog
Litoria booroolongensis, Booroolong frog
Litoria sp. affin. *phyllochroa*, Cotter River frog
Litoria spenceri, Spotted tree frog
Litoria verreauxii alpina, Alpine tree frog
Maccullochella macquariensis, Trout cod
Macquaria australasica, Macquarie perch
Neoniphargus sp., Cave isopod
Petrogale penicillata, brush-tailed rock wallaby
Philoria frosti, Baw Baw frog
Potorous longpipes, Long-footed potoroo
Pseudomys fumeus, smoky mouse
Pseudophryne corroboree, Southern corroboree frog
Xanthomyza phrygia, Regent honeyeater

Plant species considered at real risk of extinction within 100 years from known threats.

List derived by filtering flora for a score of 3 for Degree of Threat.

Gentiana baeuerlenii
Kelleria laxa
Calotis cuneata subsp *pubescens*
Epilobium willisii
Euphrasia scabra
Pomaderris cotoneaster
Pomaderris pallida
Acacia binervia

The information in the text boxes is as reliable as the original scoring, which was done hastily during the workshop the first time the system was used. It is the best such information available now, but with more experience and refinement of the system the reliability of scores might be improved. These lists are valuable for the information they contain and for their demonstration of ways in which the system outputs can be used.

Species considered at real risk of extinction within 100 years from known threats but which are likely to recover substantially with management (as scored by the workshop or by Dr McDougall under Table 8.1 — one such score each except * which have two).

List derived by filtering flora for a score of 3 for Degree of Threat and for a score of 3 for Recovery Potential.

Dasyurus maculatus, Spot-tailed quoll/Tiger quoll
Gymnobelideus leadbeateri, Leadbeater's Possum
Neoniphargus sp., Isopod
Epilobium willisii, Carpet Willow-herb
Kelleria laxa, Drapetes*
Pomaderris cotoneaster, Cotoneaster Pommaderris*
Pomaderris pallida, Pale pomaderris

Threats with significant current or potential impact which management can eliminate (as scored by the workshop under Table 8.3 — the number of scores to that effect is shown in brackets).

List derived by filtering threats for a score of 5 for Impact and for a score of 3 for Management Potential.

Grazing by stock (4)
Horses (2)
Black Willow (*Salix nigra*) (1)
Crack Willow (*Salix fragilis*) (1)
Grey Sallow (*Salix cinerea cinerea*) (1)
Himalayan Honeysuckle (*Leycesteria formosa*) (1)
Poplar, White (*Populus alba*) (1)
Logging (1)
Managed fires (1)

Table 8.5 Priority Ranking — Fauna

Note that rankings are based on scores determined as previously described. The scores, and so the rankings, cannot be exact and should not be treated as rigid. Thresholds have been applied arbitrarily and might be equally appropriate in a different position. Numbers for recovery potential* are not progressive scores but refer to the definitions against 1–4 under “recovery potential” in Table 8.1. As discussed, interpretation of those definitions during the workshop was variable, so recovery potential should be regarded with caution.

Scientific name	Common name	Cat	Rnk	Scr	No	Con	RP
Scientific name	**Common name**	**Category**	**Ranking**	**Overall score**	**Number of scores**	**Confidence in score**	**Recovery potential***
Burramys parvus	mountain pygmy-possum	H	1	27	2	HH	3/3
Litoria sp. affin. phyllochroa	Cotter River frog	H	1	27	2	HM	3/3
Litoria verreauxii alpina	Alpine Tree Frog	H	1	27	2	HM	2/3
Philoria frosti	Baw Baw frog	H	1	27	2	HH	3/3
Pseudophryne corroboree	Southern Corroboree Frog	H	1	27	2	HH	2/3
Potorous longpipes	Long-footed potoroo	H	1	27	1	H	3
Pseudomys fumeus	smoky mouse	H	1	27	1	H	3
Maccullochella macquariensis	Trout Cod	H	1	27	1	H	2
Macquaria australasica	Macquarie perch	H	1	27	1	M	3
Neoniphargus sp.		H	1	27	1	H	4
Threshold score 26							
Litoria spenceri	Spotted tree frog	M	2	23	2	HH	3/3
Petrogale penicillata	brush-tailed rock wallaby	M	3	18	2	MH	3/3
Teraphis cavicola		M	3	18	1		4
Helioporus australiacus	Giant Burrowing Frog	M	4	15	2	ML	3/3
Pseudophryne pengilleyi	Northern Corroboree Frog	M	4	15	2	HH	2/3
Gymnobelideus leadbeateri	Leadbeater's Possum	M	5	14	2	HL	3/4
Cyclodomorphus praealtus/ Tiliqua casuarinae	Alpine She-oak Skink	M	6	13	2	HM	1/3
Calyptorhynchus lathami	Glossy Black Cockatoo	M	7	12	1	L	3
Pachycephala olivacea	Olive whistler	M	7	12	1	L	1
Thaumatoperla flaveola	Alpine stonefly	M	7	12	1	H	3
Graliophilus woodi	Mountain Earthworm	M	7	12	1	H	4
Family Blephariceridae		M	7	12	1		4
Family Ptiliidae	Cave moth	M	7	12	1		4
? *Heterias* sp.		M	7	12	1	H	4
Achaeranea extrilidum	Harvesturan?	M	7	12	1	H	4
Class Symphyla	Silverfish	M	7	12	1	H	4
Engaeus cymus		M	7	12	1	H	4
Genus nov. near *Laetesia* sp. nov.		M	7	12	1	H	4
Glacidorbis hedleyi		M	7	12	1	H	4
Holonuncia recta	Harvesturan?	M	7	12	1	H	4
Icona sp nov		M	7	12	1	H	4
Ixodes sp.		M	7	12	1	H	4
Olois pictus		M	7	12	1	H	4

Scientific name	Common name	Cat	Rnk	Scr	No	Con	RP
Paralaoma sp.		M	7	12	1	H	4
Textricella sp.		M	7	12	1	H	4
Thasyrea lepida		M	7	12	1	H	4
Litoria booroolongensis	Booroolong Frog	M	8	11	2	MM	2/3
Threshold score 10							
Dasyurus maculatus	Spot-tailed quoll/Tiger quoll	L	9	9	2	HM	3/4
Graliophilus montkosciuskoi	Mountain Earthworm	L	9	9	2	LH	1/4
Mastacomys fuscus	Broad-toothed Rat	L	10	8	2	HM	1/3
Rhinolophus megaphyllus	eastern horseshoe bat	L	10	8	2	HH	4/4
Petroica rodinogaster	Pink Robin	L	10	8	1	L	1
Euastacus crassus	Freshwater crayfish	L	10	8	1	H	1
Eulamprus kosciuskoi/ Sphenomorphus kosciuskoi	Alpine water skink	L	11	6	2	HH	1/4
Xanthomyza phrygia	Regent Honeyeater	L	11	6	1	H	3
Varanus rosenbergii	Rosenberg's monitor	L	11	6	1	M	3
Prototroctes maraena	Australian grayling	L	11	6	1	H	3
Euastacus armatus	Murray River crayfish	L	11	6	1	H	4
Cavernotettix montanus	Cave cricket	L	11	6	1		4
Phascogale tapoatafa	Brush-tailed phascogale	L	12	5	2	ML	3/3
Falsistrellus tasmaniensis	Great Pipistrelle	L	13	4	2	ML	1/3
Nyctophilus timoriensis	Greater long-eared bat	L	13	4	2	HL	1/4
Petaurus australis	yellow-bellied glider	L	13	4	2	MM	3/4
Petaurus norfolcensis	squirrel glider	L	13	4	2	LM	3/3
Phascolarctos cinereus	Koala	L	13	4	2	MH	3/4
Litoria citropa	Blue Mountains tree frog	L	13	4	2	ML	1/3
Macropus robustus	Common Wallaroo	L	13	4	1	M	4
Scotorepens orion	eastern broad-nosed bat	L	13	4	1	H	4
Ninox strenua	Powerful Owl	L	13	4	1	M	4
Tyto tenebricosa	Sooty Owl	L	13	4	1	L	1
Limnodynastes dumereli fryii	Eastern banjo frog (montane form)	L	13	4	1	L	1
Gadopsis bispinosus	Two-spined blackfish	L	13	4	1	L	3
Gadopsis marmoratus	Freshwater Blackfish	L	13	4	1	L	3
Galaxias rostratus	Flat-headed Galaxias	L	13	4	1	M	3
Maccullochella peeli	Murray Cod	L	13	4	1	H	1
Euastacus woiwuru	Freshwater crayfish	L	13	4	1	M	1
Canis familiaris dingo	dingo	L	14	3.5	2	MH	2/3
Miniopterus schreibersii	Common Bent-wing Bat	L	15	3	2	HH	4/4
Amphibolurus diemensis/ Tympanocryptus diemensis	Mountain Dragon	L	16	2	2	HH	1/1
Agrotis infusa	Bogong Moth	L	16	2	2	HH	1/1
Falco peregrinus	Peregrine Falcon	L	16	2	1	M	1
Haliaeetus leucogaster	White-bellied sea eagle	L	16	2	1	M	1
Galaxias olidus	Mountain Galaxid	L	16	2	1	H	3
Macquaria novemaculeata	Australian bass	L	16	2	1	H	1
Philypnodon sp. nov.	Dwarf flat-headed gudgeon	L	16	2	1		1
Kosciuscola tristis tristis	Kosciuszko Mountain Grasshopper	L	16	2	1	M	1
Monistria concinna	Spotted grasshopper	L	16	2	1	M	1
Arachnida - Lycisidae	Wolf Spiders	L	16	2	1	H	1
Eusthenia venosa	Reduced-wing Stonefly	L	17	1	1	M	1
Hadronyche sp	Kosciuszko Funnel Web Spider	L	17	1	1	M	1
Not scored							
BIRDS							

Scientific name	Common name	Cat	Rnk	Scr	No	Con	RP
Falco hypoleucus	Grey Falcon						
Gallinago hardwickii	Japanese Snipe						
Lathamus discolor	Swift Parrot						
Lophoictinia isura	Square-tailed kite						
Neophema pulchella	Turquoise parrot						
Tyto novaehollandiae	Masked Owl						
REPTILES							
Egernia sp	Snowy Mountains skink						
Egernia sp. 1	Skink						
Egernia sp. 2	Skink						
Pseudemoia cryodroma	High Plains skink						
Pseudemoia rawlinsoni	Glossy Grass Skink						
Varanus varius	Tree Goanna						
FISH							
Galaxias brevipinnis	Broad-finned Galaxias						
INSECTS							
Ameletoides lacusalbinae	Alpine mayflies						
Aphrotenia sp							
Austrocerella hynesi	Stonefly						
Austrocerella verna	Stonefly						
Austropsyche bifurcata	Caddisfly						
Candalides heathi alpinus	Rayed Blue Butterfly						
Chimarra monticola	Caddisfly						
Coloburiscoides munionga	Mayfly						
Helicopsyche tillyardi	Caddisfly						
Leptoperla cacuminis	Stonefly						
Leptoperla rieki	Stonefly						
Leptoperla sp. nr. *tasmanica*	Stonefly						
Notonomus carteri	Ground beetle						
Notonomus kosciuskianus	Ground beetle						
Oenochroma alpina	Moth						
Oreixenica latialis theddora	Alpine Silver Xenica						
Polyplectropus lacusalbinae	Caddisfly						
Polyzosteria viridissima	Metallic Cockroach						
Scopodes splendens	Ground beetle						
Synemon sp.	Moth						
Tasimia atra	Caddisfly						
Tasmanophlebia lacuscoerulei	Mayfly						
Tasmanophlebia nigrescens	Mayfly						
Teraphis crenulata	Ground beetle						
Tettigarcta crinita	Hairy cicada						
OTHER INVERTEBRATES							
Sternodes castaneous	Spider						
Lycosa kosciuskoensis	Wolf Spider						
Lycosa musgravei	Wolf Spider						
Lycosa summa	Wolf Spider						
Onychopohora - *Peripatoides leuckartii*	Peripatus, Velvet worms						
CAVE FAUNA							
Pseudonemadus sp.							
Teraphis sp. nov.							
Ferrisia sp.							

Table 8.6 Priority Ranking — Flora — as scored by workshop groups

Note that rankings are based on scores determined as previously described. The scores, and so the rankings, cannot be exact and should not be treated as rigid. Thresholds have been applied arbitrarily and might be equally appropriate in a different position. Numbers for recovery potential* are not progressive scores but refer to the definitions against 1–4 under "recovery potential" in Table 8.1. As discussed, interpretation of those definitions during the workshop was variable, so recovery potential should be regarded with caution.

Family	Scientific name	Common name	Cat	Rnk	Scr	No	Con	RP
Family code	Scientific name	Common name	Category	Ranking	Overall score	Number of scores	Confidence in score	Recovery potential*
GENTI	*Gentiana baeuerlenii*		H	1	27	1	H	2
THYMEL	*Kelleria laxa*	Drapetes	H	1	27	1	H	4
Threshold score 26								
PROTE	*Banksia marginata* stand at Yarrangobilly	*Banksia marginata* stand	M	2	24	1	L	4
RHAMN	*Pomaderris cotoneaster*	Cotoneaster Pommaderris	M	3	23	2	-/H	1/4
ASTER	*Calotis cuneata* subsp *pubescens*		M	4	18	2	LH	1/3
PTERIDO	*Asplenium hookerianum*	Maidenhair Spleenwort	M	4	18	1	M	1
MYRTA	*Babingtonia crenulata*	Fern-leaf Baeckea	M	4	18	1	L	1
MYRTA	*Baeckea denticulata*	Thyme Heath Myrtle	M	4	18	1	L	1
CYPER	*Carex raleighii*	Raleigh Sedge	M	4	18	1	M	1
ORCHI	*Chiloglottis turfosa*	Bog Bird Orchid	M	4	18	1	M	1
GENTI	*Chionogentias sylvicola*	Late Forest Gentian	M	4	18	1	M	1
MYRTA	*Eucalyptus elaephloia*		M	4	18	1	M	1
MYRTA	*Eucalyptus mitchelliana*	Buffalo Sallee	M	4	18	1	H	1
MYRTA	*Eucalyptus neglecta*	Omeo Gum	M	4	18	1	H	1
MYRTA	*Eucalyptus saxatilis*	Suggan Buggan mallee	M	4	18	1	H	1
MYRTA	*Eucalyptus triplex*		M	4	18	1	H	1
ORCHID	*Genoplesium turfosum*	Bog Midge Orchid	M	4	18	1	M	1
BRASSI	*Irenepharsus magicus*	Elusive Cress/Branched Cress	M	4	18	1	M	2
EPACR	*Monotoca rotundifolia*	Trailing Broom-heath	M	4	18	1	H	1
MYOPOR	*Myoporum floribundum*	Slender Myoporum	M	4	18	1	M	1
ASTER	*Olearia aglossa*	Alpine Daisy Bush	M	4	18	1	H	1
RHAMN	*Pomaderris sericea*	Bent Pomaderris	M	4	18	1	M	4
LOBELI	*Pratia gelida*	Snow Pratia	M	4	18	1	L	1
POACE	*Rytidosperma pumilum*	Mountain Grass/Small Alpine Grass/Feldmark Grass	M	4	18	1	H	1
LAMIA	*Westringia cremnophila*	Snowy River Westringia	M	4	18	1	M	1
MIMOS	*Acacia dallachiana*	Catkin Wattle	M	5	12	1	H	1
FABAC	*Almaleea capitata*	Slender Parrot-pea	M	5	12	1	M	1
EUPHOR	*Bertya findlayi*	Forest Bertya	M	5	12	1	M	1
CYPER	*Carex capillacea*	Sedge	M	5	12	1	M	1
CYPER	*Carex cephalotes*	Wire-head Sedge	M	5	12	1	M	1
ORCHI	*Diuris ochroma*		M	5	12	1	L	1
BRASSI	*Drabastrum alpestre*	Mountain Cress	M	5	12	1	M	1
BRASSI	*Gingidia algens*	Gingidia	M	5	12	1	M	1
PTERIDO	*Grammitis poeppingiana*	Alpine Finger-fern	M	5	12	1	H	1
RUTAC	*Nematolepis squamea* ssp. *coriacea*	Harsh Phebalium	M	5	12	1	L	4

Family	Scientific name	Common name	Cat	Rnk	Scr	No	Con	RP
ASTER	*Olearia lasiophylla*	Woolly Daisy Bush	M	5	12	1	M	1
ASTER	*Parantennaria uniceps*	Parantennaria	M	5	12	1	M	1
ORCHID	*Prasophyllum montanum*	Mountain Leek Orchid	M	5	12	1	M	1
ORCHID	*Prasophyllum* sp. related to *P. morganii*	Cobungra Leek Orchid	M	5	12	1	H	1
ORCHID	*Prasophyllum suttonii*		M	5	12	1	L	1
LAMIA	*Prostanthera monticola*	Monkey Mint Bush	M	5	12	1	M	1
LAMIA	*Prostanthera walteri*	Monkey Mint-bush	M	5	12	1	M	1
RANUNC	*Ranunculus anemoneus*	Anemone Buttercup	M	5	12	1	H	1
RANUNC	*Ranunculus brevicaulis*	Short-leaved Felted Buttercup	M	5	12	1	H	1
RANUNC	*Ranunculus eichleranus*	Buttercup	M	5	12	1	H	1
RANUNC	*Ranunculus niphophilus*	Kosciuszko Buttercup	M	5	12	1	H	1
CARYO	*Sagina namadgi*		M	5	12	1	L	1
PODOC	*Podocarpus lawrencei*	Old-aged Mountain Plum Pine	M	6	10	2	HH	1/1
Threshold score 10								
ASTER	*Abrotanella nivigena*	Bogong Cushion	L	7	9	2	MH	1/4
SCROPH	*Euphrasia sp. 3*	Dwarf Eyebright	L	7	9	1	H	1
ASTER	*Olearia rhizomatica*	Blue Daisy Bush	L	7	9	1	H	1
APIAC	*Oschatzia cuneifolia*	Wedge Oschatzia	L	8	8	2	HM	1/1
ASTER	*Craspedia discolor* ms	Billy Button	L	8	8	1	H	4
SCROP	*Derwentia nivea*	Mountain Speedwell	L	8	8	1	H	1
MYRTA	*Eucalyptus pauciflora*	Old-aged mature Snow Gums	L	8	8	1	H	1
SCROPH	*Euphrasia crassiuscula ssp. crassiuscula*	Thick Eyebright	L	8	8	1	M	4
SCROPH	*Euphrasia crassiuscula ssp. eglandulosa*	Thick Eyebright	L	8	8	1	M	4
SCROPH	*Euphrasia crassiuscula ssp. glandulifera*	Thick Eyebright	L	8	8	1	M	4
SCROPH	*Euphrasia eichleri*	Bogong Eyebright	L	8	8	1	M	4
SCROPH	*Euphrasia laslanthera*	Hairy Eyebright.	L	8	8	1	M	4
RUBIA	*Galium roddii*	Bedstraw	L	8	8	1	M	4
SCROPH	*Gratiola nana*	Matted Brooklime	L	8	8	1	L	1
PROTEA	*Persoonia subvelutina*	Velvety Geebung	L	8	8	1	L	1
PLANTA	*Plantago glacialis*	Small Star Plantain	L	8	8	1	M	1
PLANTA	*Plantago muelleri*	Star Plantain	L	8	8	1	M	1
RHAMN	*Pomaderris oblongifolia*	Snowy River Pomaderris	L	8	8	1	L	1
RANUNC	*Ranunculus muelleri*		L	8	8	1	H	1
APIAC	*Schizeilema fragoseum*	Alpine Pennywort	L	8	8	1	M	1
POACE	*Sorghum leiocladum*	Wild Sorghum	L	8	8	1	H	1
ASTER	*Calotis glandulosa*	Gland Burr Daisy	L	9	7	2	HH	1/4
ASTER	*Craspedia alba*	Billy Button	L	9	7	2	HH	1/4
ASTER	*Brachyscome tadgellii*	Snow Daisy	L	10	6	2	MM	1/1
APIAC	*Oreomyrrhis brevipes*	Branched Caraway	L	10	6	2	MH	1/4
ARALI	*Astrotricha* sp. 4 (sens. Flora Victoria, 4:252)	Thick-leaf Star-hair	L	10	6	1	M	1
SCROP	*Chionohebe densifolia*	Alpine Speedwell	L	10	6	1	H	1
ASTER	*Craspedia leucantha*	Tall White Billy Button	L	10	6	1	ML	1
PTERIDO	*Cystopteris tasmanica*	Brittle Bladder Fern	L	10	6	1	H	1
ASTER	*Erigeron setosus*	Mountain Fleabane	L	10	6	1	M	1
ASTER	*Euchiton nitidulus*	Cushion Cudweed	L	10	6	1	M	1
SCROPH	*Euphrasia alsa*	Dwarf Eyebright	L	10	6	1	H	1
SCROPH	*Euphrasia collina ssp. lapidosa*	Eyebright	L	10	6	1	H	1
PROTE	*Grevillea diminuta*		L	10	6	1	H	1
HALORA	*Haloragodendron baeuerlenii*	Tree Haloragis	L	10	6	1	M	1
ASTER	*Olearia stenophylla*	Olearia	L	10	6	1	M	1
RHAMN	*Pomaderris brunnea*		L	10	6	1	M	1
LAMIA	*Pseudanthus divaricatissimus*	Tangled Pseudanthus	L	10	6	1	H	1
RANUNC	*Ranunculus clivicola*	Hill Buttercup	L	10	6	1	H	1

Family	Scientific name	Common name	Cat	Rnk	Scr	No	Con	RP
RANUNC	*Ranunculus dissectifolius*	Feather Buttercup	L	10	6	1	H	1
ASTER	*Rutidosis leiolepis*	Monaro golden daisy/Tufted wrinklewort	L	10	6	1	H	1
ASTER	*Taraxacum aristum*	Austral Dandelion	L	10	6	1	M	1
SANTAL	*Thesium australe*	Austral Toadflax	L	10	6	1	H	4
LAMIA	*Westringia lucida*	Westringia	L	10	6	1	H	1
		Billy Button	L	11	4.5	2		1/4
ASTER	*Brachyscome stolonifera*	Creeping Daisy	L	12	4	2	HH	1/1
ASTEL	*Colobanthus nivicola*		L	12	4	2	MH	1/1
ASTEL	*Colobanthus pulvinatus*	Snow Colobanth	L	12	4	2	ML	1/1
PTERIDO	*Asplenium trichomanes*	Common Spleenwort	L	12	4	1	L	1
BRASSI	*Barbarea grayi*	Winter-cress	L	12	4	1	M	1
ASTER	*Brachyscome petrophila*	Rock Daisy	L	12	4	1	M	1
ASTER	*Brachyscome riparia*	Snowy River daisy	L	12	4	1	M	1
RUBIA	*Coprosma moorei*	Turquoise Coprosma	L	12	4	1	L	4
RUBIA	*Coprosma niphophila*	Snow Coprosma	L	12	4	1	H	1
FABAC	*Desmodium brachypodum*	Large Tick-trefoil	L	12	4	1	M	1
BRASSI	*Dichosciadium ranunculaceum var. ranunuculaceum*	Wreath Pennywort	L	12	4	1	L	1
ORCHI	*Dipodium hamiltonianum*	Yellow Hyacinth Orchid	L	12	4	1	M	3
RHAMN	*Discaria pubescens*	Hairy Anchor Plant	L	12	4	1	H	1
SCROPH	*Euphrasia caudata*	Tailed Eyebright	L	12	4	1	M	1
PTERIDO	*Huperzia australiana*	Fir Clubmoss	L	12	4	1	M	1
PTERIDO	*Lycopodium scariosum*	Spreading Clubmoss	L	12	4	1	M	1
APIAC	*Oreomyrrhis argentea*	Silver Carraway	L	12	4	1	H	1
THYMEL	*Pimelea biflora*	Mattedice-flower	L	12	4	1	H	1
POACE	*Poa saxicola*	Rock Tussock-grass	L	12	4	1	M	1
FABAC	*Pultenaea capitellata*	Hard-head Bush-pea	L	12	4	1	L	1
CARYO	*Scleranthus singuliflorus*	Mossy Knawel	L	12	4	1	L	1
RUTAC	*Zieria cytisoides*	Dwarf Zieria	L	12	4	1	L	1
APIAC	*Aciphylla glacialis*	Alpine Celery	L	13	3	2	MH	1/4
ASTEL	*Astelia psychrocharis*	Kosciuszko Pineapple grass	L	13	3	2	HH	1/1
ASTER	*Brachyscome obovata*	Baw Baw Daisy	L	13	3	2	LM	1/1
ASTER	*Craspedia costiniana*	Billy Button	L	13	3	2	HH	1/1
MIMOS	*Acacia lucasii*	Woolly-bear Wattle	L	13	3	1	M	1
MIMOS	*Acacia subtilinervis*	Net veined Wattle	L	13	3	1	H	1
POACE	*Agrostis meionectes*	Bent Grass	L	13	3	1	L	1
EUPHOR	*Dodonaea rhombifolia*	Broad-leaf Hop-bush	L	13	3	1	H	1
MYRTA	*Eucalyptus lacrimans*	Weeping Snow Gum	L	13	3	1	H	1
ASTER	*Craspedia aurantia*	Billy Button	L	14	2.5	2	HH	1/4
MIMOS	*Acacia boormanii*	Snowy River wattle	L	15	2	1	L	1
EUPHOR	*Beyeria lasiocarpa*	Wallaby-bush	L	15	2	1	L	1
ASTER	*Celmisia sericophylla*	Silky Daisy	L	15	2	1	H	1
POACE	*Chionochloa frigida*	Ribbony grass	L	15	2	1	H	1
SCROPH	*Euphrasia collina* ssp. *diversicolor*	Thick Eyebright	L	15	2	1	H	1
SCROPH	*Euphrasia collina ssp. glacialis*	Eyebright	L	15	2	1	H	1
ERICA	*Gaultheria appressa*	Mainland Waxberry	L	15	2	1	M	1
ASTER	*Leptorhynchos elongatus*	Lanky, Buttons,	L	15	2	1	L	1
RUTAC	*Nematolepis ovatifolia*	Ovate Phebalium	L	15	2	1	H	1
RHAMN	*Pomaderris ledifolia*	Sydney Pomaderris	L	15	2	1	-	1
RHAMN	*Pomaderris pauciflora*	Mountain Pomaderris	L	15	2	1	H	1
PTERIDO	*Psilotum nudum*	Skeleton Fork-fern	L	15	2	1	L	1
ORCHID	*Pterostylis coccina*		L	15	2	1	H	1
ORCHID	*Pterostylis fischii*	Fisch's Greenhood	L	15	2	1	M	1
ORCHID	*Pterostylis laxa*	Antelope Greenhood	L	15	2	1	M	1

Family	Scientific name	Common name	Cat	Rnk	Scr	No	Con	RP
VIOLA	*Viola caleyana*	Swamp Violet	L	15	2	1	M	1
MIMOS	*Acacia penninervis*	Hickory Wattle	L	16	1	1	M	1
ORCHI	*Corybas hispidus*	Hispid Helmet-orchid	L	16	1	1	M	1
ASTER	*Craspedia maxgrayii*	Billy Button	L	16	1	1	H	1
ORCHI	*Dendrobium striolatum*	Streaked Rock Orchid	L	16	1	1	H	1
EPACR	*Epacris glacialis*	Reddish Bog Heath	L	16	1	1	H	1
ONAGR	*Epilobium tasmanicum*	Tasman Willow-herb	L	16	1	1	M	1
GOODEN	*Goodenia heterophylla*	Variable Goodenia	L	16	1	1	H	1
EPACR	*Leucopogon montanus*	Snow Beard-heath	L	16	1	1	H	1
TREMAN	*Tetratheca thymifolia*	Thyme Pink-bells	L	16	1	1	M	1
RUTAC	*Zieria smithii*	Sandfly Zieria	L	16	1	1	H	1
ALSEUO	*Wittsteinia vacciniacea*	Baw Baw Berry						
MALVA	*Abutilon oxycarpum* ssp. *subsagittatum*							
MIMOS	*Acacia binervia*							
MIMOS	*Acacia phlebophylla*	Buffalo Sallow Wattle						
APIAC	*Actinotus forsythii*	Ridge Flannel-flower						
PTERIDO	*Adiantum hispidulum*	Rough Maidenhair						
POACE	*Amphibromus fluitans*	River Swamp Wallaby Grass						
POACE	*Australopyrum retrofractum*	Feathery Wheat-grass						
POACE	*Austrostipa setacea*	Corkscrew Spear-grass						
MYRTA	*Baeckea crenatifolia*	Fern-leaf Baeckea						
EUPHOR	*Beyeria viscosa*	Pinkwood						
PTERIDO	*Blechnum vulcanicum*	Water-fern						
RUTAC	*Boronia citrata*	Lemon-scented Boronia						
RUTAC	*Boronia ledifolia*	Showy Boronia						
PTERIDO	*Botrychium australe*	Austral Moonwort						
PTERIDO	*Botrychium lunaria*	Grassy Moonwort						
ASTER	*Brachyscome ptychocarpa*	Tiny Daisy						
ASTER	*Brachyscome* sp. 3 (sens Fl. Victoria 4)	Mountain Daisy						
ORCHI	*Caladenia aestiva*							
ORCHI	*Caladenia montana*	Veined Spider-Orchid						
CYPER	*Carex archeri*	Sedge						
CYPER	*Carex hypandra*	Sedge						
CYPER	*Carex paupera,* actually *C. inversa* which is common?	Dwarf Sedge						
CRYPTOG	*Cetrara australiensis*							
POACE	*Chloris ventricosa*	Plump Windmill Grass						
CUSCU	*Cuscuta victoriana*	Victorian Dodder						
SOLAN	*Cypanthera albicans*	Hoary Ray-flower						
CYPER	*Cyperus concinnus*	Flat Trim-sedge						
GOODE	*Dampiera galbraithiana*	Licola Dampiera						
GOODE	*Dampiera purpurea*	Mountain Dampiera						
GOODE	*Dampiera sp.*	Dampiera						
POACE	*Danthonia sp. A*	Grass						
POACE	*Deyeuxia affinis*	Grass						
POACE	*Deyeuxia decipiens*	Devious Bent-grass						
POACE	*Deyeuxia innominata*	Hair-like Bent-grass						
POACE	*Deyeuxia pungens*	? Bent-grass						
POACE	*Deyeuxia talariata*							
FABAC	*Dillwynia prostrata*	Matted Parrot-pea						
RHAMN	*Discaria nitida*	Shining Anchor Plant						
EUPHOR	*Dodonaea boroniifolia*	Hairy Hop-bush						
POACE	*Enneapogon gracilis*	Slender Bottlewashers						

Family	Scientific name	Common name	Cat	Rnk	Scr	No	Con	RP
ONAGR	*Epilobium brunnescens*							
ONAGR	*Epilobium willisii*	Carpet Willow-herb						
ASTER	*Erigeron conyzoides*	Daisy Fleabane						
ASTER	*Erigeron paludicola*	Swamp Fleabane						
ASTER	*Euchiton umbricolus*	Cliff Cudweed						
SCROPH	*Euphrasia scabra*	Rough Eyebright1						
POACE	*Festuca eriopoda*	Lanky Fescue						
ORCHID	*Genoplesium nudiscapum*							
ORCHID	*Genoplesium nudum*							
BRASSI	*Gingidia harveyana*	Slender Gingidia						
ASTER	*Glossocardia bidens*							
SCROPH	*Glossostigma sp. aff spathulatum*	Spoon Mud Mat						
GOODEN	*Goodenia grandiflora*	Pinnate Goodenia						
GOODEN	*Goodenia macmillanii*							
PROTEA	*Grevillea willisii*	Rock Grevillea						
DILLEN	*Hibbertia spathulata*	rock guinea flower						
POACE	*Hierochloe submutica*	Spreading Holy Grass						
JUNCA	*Juncus antarcticus*	Cushion Rush						
JUNCA	*Juncus sp. aff. sceuchzerioides*	Rush						
JUNCA	*Juncus thompsonianus*	Rush						
POACE	*Koeleria australiensis*	Cat's-tail/Crested Hair-grass						
EPACR	*Leucopogon microphyllus var. pilibundus*	Hairy Beard-heath						
EPACR	*Leucopogon pilifer*	Thready Beard-heath						
EPACR	*Leucopogon riparius*	River beard heath						
PTERIDO	*Lindsaea microphylla*	Lacy Wedge-fern						
CYPER	*Luzula acutifolia*	Sharpleaf Woodrush						
CYPER	*Luzula acutifolia subsp. nana*	Luzula						
CYPER	*Luzula atrata*	Slender Woodrush						
EPACR	*Monotoca oreophila*	Mountain Broom-heath						
POLYGO	*Muehlenbeckia axillaris*	Matted Lignum						
ASTER	*Olearia frostii*	Bogong Daisy-bush						
ASTER	*Ozothamnus adnatus*	Winged Everlasting						
ASTER	*Ozothamnus rogersianus*	Nunniong Everlasting						
APOCYN	*Parsonsia eucalyptophylla*							
GERANI	*Pelargonium helmsii*	Mountain Stork's-bill						
PROTEA	*Persoonia asperula*	Mountain Geebung						
RUTAC	*Phebalium glandulosum*	Glandular Phebalium						
RUTAC	*Phebalium squameum* ssp. *coriaceum*	Harsh Phebalium						
THYMEL	*Pimelea bracteata*	Pimelea						
POACE	*Poa hookeri*	Hooker's Tussock-grass						
POACE	*Poa labillardierei* var *acris*							
POACE	*Poa petrophila*	Rock Snow Grass						
RHAMN	*Pomaderris costata*	Veined Pomaderris						
RHAMN	*Pomaderris pallida*	Pale pomaderris						
ORCHID	*Prasophyllum* aff. *rogersii*							
ORCHID	*Prasophyllum lindleyanum*							
LOBELI	*Pratia gelida*	Snow Pratia						
LAMIA	*Prostanthera decussata*	Dense Mint-bush						
LAMIA	*Prostanthera rhombea*	Sparkling Mint-bush						
ORCHID	*Pterostylis aenigma*	Enigmatic Greenhood Orchid						
ORCHID	*Pterostylis aestiva*	Long-tongue Summer Greenhood						
ORCHID	*Pterostylis cucullata*	Leafy Greenhood						
ORCHID	*Pterostylis oreophila*							
FABAC	*Pultenaea polifolia*	Dusky Bush-pea						

Family	Scientific name	Common name	Cat	Rnk	Scr	No	Con	RP
FABAC	*Pultenaea subspicata*	Low Bush-pea						
RANUNC	*Ranunculus productus*	Rare Buttercup						
POACE	*Rytidosperma australe*	Southern Sheep-Grass						
LAMIA	*Salvia plebeia*	Austral Sage						
LOGAN	*Schizacme montana*	Mountain Mitrewort						
LAMIA	*Scutellaria mollis*	Soft Skullcap						
TREMAN	*Tetratheca procumbens*	Pink-bells						
ORCHID	*Thelymitra* aff. *erosa*	Sun-orchid						
ORCHID	*Thelymitra circumsepta*	Bog Sun-orchid						
ORCHID	*Thelymitra cyanea*	Sun-orchid						
CYPER	*Uncinia compacta*	Compact Hook-sedge						
CYPER	*Uncinia sulcata*							
LENTIB	*Utricularia monanthos*	Tasmanian Bladderwort						
VIOLA	*Viola improcera*							
CAMPAN	*Wahlenbergla densifolia*	Fairy Bluebell						
RUTAC	*Zieria robusta*	Robust Zieria						
RUTAC	*Zieria sp.*	Lemon-scented Zieria						

Table 8. 7 Priority Ranking — Flora — as scored by Keith McDougall

These scores are valuable for comparison with the workshop scores, providing a check on the reliability of the process. In addition, many species not scored at the workshop have been scored here.

Note that rankings are based on scores determined as previously described. The scores, and so the rankings, cannot be exact and should not be treated as rigid. Thresholds have been applied arbitrarily and might be equally appropriate in a different position. Numbers for recovery potential* are not progressive scores but refer to the definitions against 1–4 under "recovery potential" in Table 8.1. As discussed, interpretation of those definitions during the workshop was variable, so recovery potential should be regarded with caution.

Family	**Scientific name**	**Common name**	**Cat**			**RP**
Family code	**Scientific name**	**Common name**	**Category**			**Recovery potential***
GENTI	*Gentiana baeuerlenii*		H			2
THYMEL	*Kelleria laxa*	Drapetes	H			4
Threshold score 26						
ASTER	*Calotis cuneata* subsp *pubescens*		M			3
ORCHID	*Genoplesium turfosum*	Bog Midge Orchid	M			1
RHAMN	*Pomaderris sericea*	Bent Pomaderris	M			4
	Prasophyllum morganii	Cobungra Leek Orchid	M			4
POACE	*Rytidosperma pumilum*	Mountain Grass/Small Alpine Grass/Feldmark Grass	M			1
LAMIA	*Westringia cremnophila*	Snowy River Westringia	M			1
PTERIDO	*Blechnum vulcanicum*	Water-fern	M			3
RUTAC	*Boronia citrata*	Lemon-scented Boronia	M			3
CYPER	*Carex archeri*	Sedge	M			4
ORCHI	*Chiloglottis turfosa*	Bog Bird Orchid	M			1
GENTI	*Chionogentias sylvicola*	Late Forest Gentian	M			1
RHAMN	*Discaria nitida*	Shining Anchor Plant	M			1
MYRTA	*Eucalyptus elaephloia*		M			1
MYRTA	*Eucalyptus mitchelliana*	Buffalo Sallee	M			1
MYRTA	*Eucalyptus neglecta*	Omeo Gum	M			1
MYRTA	*Eucalyptus saxatilis*	Suggan Buggan mallee	M			1
MYRTA	*Eucalyptus triplex*		M			1
BRASSI	*Irenepharsus magicus*	Elusive Cress/Branched Cress	M			2
EPACR	*Monotoca rotundifolia*	Trailing Broom-heath	M			1
ORCHID	*Prasophyllum montanum*	Mountain Leek Orchid	M			1
LOBELI	*Pratia gelida*	Snow Pratia	M			1
VIOLA	*Viola improcera*		M			4
Threshold score 10						
ONAGR	*Epilobium brunnescens subsp. beaugleholei*		L			1
ONAGR	*Epilobium willisii*	Carpet Willow-herb	L			4
SCROPH	*Euphrasia scabra*	Rough Eyebright	L			2
RHAMN	*Pomaderris cotoneaster*	Cotoneaster Pommaderris	L			4
RHAMN	*Pomaderris pallida*	Pale pomaderris	L			4
PTERIDO	*Asplenium hookerianum*	Maidenhair Spleenwort	L			1
PROTE	*Banksia marginata* stand at Yarrangobilly	*Banksia marginata* stand	L			2

Family	Scientific name	Common name	Cat			RP
BRASSI	*Barbarea grayi*	Winter-cress	L			1
EUPHOR	*Bertya findlayi*	Forest Bertya	L			1
PTERIDO	*Botrychium lunaria*	Grassy Moonwort	L			4
ASTER	*Brachyscome* sp. 3 (sens Fl. Victoria 4)	Mountain Daisy	L			4
ASTER	*Brachyscome tadgellii*	Snow Daisy	L			1
CYPER	*Carex capillacea*	Sedge	L			1
CYPER	*Carex cephalotes*	Wire-head Sedge	L			1
CYPER	*Carex raleighii*	Raleigh Sedge	L			1
RUBIA	*Coprosma moorei*	Turquoise Coprosma	L			4
POACE	*Danthonia oreophila*	Grass	L			1
BRASSI	*Drabastrum alpestre*	Mountain Cress	L			1
ASTER	*Erigeron conyzoides*	Daisy Fleabane	L			4
MYRTA	*Eucalyptus pauciflora*	Old-aged mature Snow Gums	L			1
SCROPH	*Euphrasia crassiuscula ssp. crassiuscula*	Thick Eyebright	L			1
SCROPH	*Euphrasia crassiuscula ssp. eglandulosa*	Thick Eyebright	L			1
SCROPH	*Euphrasia crassiuscula ssp. glandulifera*	Thick Eyebright	L			1
SCROPH	*Euphrasia eichleri*	Bogong Eyebright	L			4
SCROPH	*Euphrasia laslanthera*	Hairy Eyebright.	L			4
RUBIA	*Galium roddii*	Bedstraw	L			4
ORCHID	*Genoplesium turfosum*	Bog Midge Orchid	L			4
BRASSI	*Gingidia algens*	Gingidia	L			1
PTERIDO	*Grammitis poeppingiana*	Alpine Finger-fern	L			1
SCROPH	*Gratiola nana*	Matted Brooklime	L			1
POACE	*Hierochloe submutica*	Spreading Holy Grass	L			4
JUNCA	*Juncus antarcticus*	Cushion Rush	L			4
JUNCA	*Juncus thompsonianus*	Rush	L			4
CYPER	*Luzula acutifolia subsp. acutifolia*	Sharpleaf Woodrush	L			1
RUTAC	*Nematolepis squamea* ssp. *coriacea*	Harsh Phebalium	L			1
APIAC	*Oschatzia cuneifolia*	Wedge Oschatzia	L			1
ASTER	*Parantennaria uniceps*	Parantennaria	L			1
GERANI	*Pelargonium helmsii*	Mountain Stork's-bill	L			1
PROTEA	*Persoonia subvelutina*	Velvety Geebung	L			1
THYMEL	*Pimelea bracteata*	Pimelea	L			1
PLANTA	*Plantago glacialis*	Small Star Plantain	L			1
PLANTA	*Plantago muelleri*	Star Plantain	L			1
POACE	*Poa hookeri*	Hooker's Tussock-grass	L			1
RHAMN	*Pomaderris oblongifolia*	Snowy River Pomaderris	L			1
ORCHID	*Prasophyllum* sp. Kiandra (aff. morganii)		L			1
LAMIA	*Prostanthera monticola*	Monkey Mint Bush	L			1
LAMIA	*Prostanthera rhombea*	Sparkling Mint-bush	L			1
RANUNC	*Ranunculus eichleranus*	Buttercup	L			1
RANUNC	*Ranunculus productus*	Rare Buttercup	L			1
CARYO	*Sagina namadgi*		L			1
LOGAN	*Schizacme montana*	Mountain Mitrewort	L			1
APIAC	*Schizeilema fragoseum*	Alpine Pennywort	L			1
POACE	*Sorghum leiocladum*	Wild Sorghum	L			1
TREMAN	*Tetratheca procumbens*	Pink-bells	L			1
CYPER	*Uncinia sulcata*		L			1
LENTIB	*Utricularia monanthos*	Tasmanian Bladderwort	L			4
MIMOS	*Acacia binervia*		L			3
POACE	*Amphibromus fluitans*	River Swamp Wallaby Grass	L			1
ARALI	*Astrotricha* sp. 4 (sens. Flora Victoria, 4:252)	Thick-leaf Star-hair	L			1
SCROP	*Chionohebe densifolia*	Alpine Speedwell	L			1
GOODE	*Dampiera galbraithiana*	Licola Dampiera	L			1

Family	Scientific name	Common name	Cat			RP
POACE	*Deyeuxia pungens*	? Bent-grass	L			1
ORCHI	*Diuris ochroma*		L			1
ASTER	*Euchiton nitidulus*	Cushion Cudweed	L			1
SCROPH	*Euphrasia sp. 3*	Dwarf Eyebright	L			1
RHAMN	*Pomaderris brunnea*		L			1
ORCHID	*Pterostylis cucullata*	Leafy Greenhood	L			1
RANUNC	*Ranunculus anemoneus*	Anemone Buttercup	L			1
ASTER	*Rutidosis leiolepis*	Monaro golden daisy/Tufted wrinklewort	L			1
ASTER	*Taraxacum aristum*	Austral Dandelion	L			1
SANTAL	*Thesium australe*	Austral Toadflax	L			4
LAMIA	*Westringia lucida*	Westringia	L			1
ASTER	*Abrotanella nivigena*	Bogong Cushion	L			1
MIMOS	*Acacia lucasii*	Woolly-bear Wattle	L			1
MIMOS	*Acacia phlebophylla*	Buffalo Sallow Wattle	L			1
APIAC	*Aciphylla glacialis*	Alpine Celery	L			1
POACE	*Agrostis meionectes*	Bent Grass	L			1
POACE	*Australopyrum retrofractum*	Feathery Wheat-grass	L			1
MYRTA	*Babingtonia crenulata*	Fern-leaf Baeckea	L			1
MYRTA	*Baeckea denticulata*	Thyme Heath Myrtle	L			1
ASTER	*Brachyscome obovata*	Baw Baw Daisy	L			1
ASTER	*Brachyscome petrophila*	Rock Daisy	L			1
ASTER	*Brachyscome riparia*	Snowy River daisy	L			1
ASTER	*Calotis glandulosa*	Gland Burr Daisy	L			4
RUBIA	*Coprosma niphophila*	Snow Coprosma	L			1
ASTER	*Craspedia alba*	Billy Button	L			4
ASTER	*Craspedia aurantia*	Billy Button	L			4
ASTER	*Craspedia lamicola*	Billy Button	L			4
ASTER	*Craspedia leucantha*	Tall White Billy Button	L			1
ASTER	*Craspedia maxgrayii*	Billy Button	L			4
PTERIDO	*Cystopteris tasmanica*	Brittle Bladder Fern	L			1
SCROP	*Derwentia nivea*	Mountain Speedwell	L			1
FABAC	*Desmodium brachypodum*	Large Tick-trefoil	L			1
POACE	*Deyeuxia affinis*	Grass	L			1
POACE	*Deyeuxia innominata*	Hair-like Bent-grass	L			1
POACE	*Deyeuxia talariata*		L			1
BRASSI	*Dichosciadium ranunculaceum var. ranunuculaceum*	Wreath Pennywort	L			1
ORCHI	*Dipodium hamiltonianum*	Yellow Hyacinth Orchid	L			3
RHAMN	*Discaria pubescens*	Hairy Anchor Plant	L			1
ASTER	*Erigeron setosus*	Mountain Fleabane	L			1
ASTER	*Euchiton umbricolus*	Cliff Cudweed	L			1
SCROPH	*Euphrasia alsa*	Dwarf Eyebright	L			1
SCROPH	*Euphrasia caudata*	Tailed Eyebright	L			1
SCROPH	*Euphrasia collina ssp. lapidosa*	Eyebright	L			1
POACE	*Festuca eriopoda*	Lanky Fescue	L			1
ORCHID	*Genoplesium nudiscapum*	Dense Midge-orchid	L			4
BRASSI	*Gingidia harveyana*	Slender Gingidia	L			4
GOODEN	*Goodenia macmillanii*		L			1
PROTE	*Grevillea diminuta*		L			1
HALORA	*Haloragodendron baeuerlenii*	Tree Haloragis	L			1
DILLEN	*Hibbertia spathulata*	rock guinea flower	L			1
PTERIDO	*Huperzia australiana*	Fir Clubmoss	L			1
POACE	*Koeleria australiensis*	Cat's-tail/Crested Hair-grass	L			1
EPACR	*Leucopogon riparius*	River beard heath	L			1
CYPER	*Luzula acutifolia subsp. nana*	Luzula	L			1
PTERIDO	*Lycopodium scariosum*	Spreading Clubmoss	L			1
EPACR	*Monotoca oreophila*	Mountain Broom-heath	L			1

Family	Scientific name	Common name	Cat			RP
POLYGO	*Muehlenbeckia axillaris*	Matted Lignum	L			1
MYOPOR	*Myoporum floribundum*	Slender Myoporum	L			1
ASTER	*Olearia aglossa*	Alpine Daisy Bush	L			1
ASTER	*Olearia lasiophylla*	Woolly Daisy Bush	L			1
ASTER	*Olearia rhizomatica*	Blue Daisy Bush	L			1
ASTER	*Olearia stenophylla*	Olearia	L			1
APIAC	*Oreomyrrhis argentea*	Silver Carraway	L			1
APIAC	*Oreomyrrhis brevipes*	Branched Caraway	L			4
ASTER	*Ozothamnus rogersianus*	Nunniong Everlasting	L			1
PROTEA	*Persoonia asperula*	Mountain Geebung	L			1
THYMEL	*Pimelea biflora*	Matted Rice-flower	L			1
POACE	*Poa labillardierei* var *acris*		L			1
POACE	*Poa petrophila*	Rock Snow Grass	L			1
POACE	*Poa saxicola*	Rock Tussock-grass	L			1
PODOC	*Podocarpus lawrencei*	Old-aged Mountain Plum Pine	L			1
ORCHID	*Prasophyllum lindleyanum*		L			1
LAMIA	*Prostanthera walteri*	Monkey Mint-bush	L			1
LAMIA	*Pseudanthus divaricatissimus*	Tangled Pseudanthus	L			1
ORCHID	*Pterostylis aenigma*	Enigmatic Greenhood Orchid	L			1
FABAC	*Pultenaea capitellata*	Hard-head Bush-pea	L			1
RANUNC	*Ranunculus brevicaulis*	Short-leaved Felted Buttercup	L			1
RANUNC	*Ranunculus muelleri*		L			1
POACE	*Rytidosperma australe*	Southern Sheep-Grass	L			1
LAMIA	*Salvia plebeia*	Austral Sage	L			1
ORCHID	*Thelymitra circumsepta*	Bog Sun-orchid	L			1
ORCHID	*Thelymitra cyanea*	Sun-orchid	L			1
CYPER	*Uncinia compacta*	Compact Hook-sedge	L			1
CAMPAN	*Wahlenbergla densifolia*	Fairy Bluebell	L			1
ALSEUO	*Wittsteinia vacciniacea*	Baw Baw Berry	L			1
RUTAC	*Zieria cytisoides*	Dwarf Zieria	L			1
RUTAC	*Zieria citriodora*	Lemon-scented Zieria	L			1
MALVA	*Abutilon oxycarpum* ssp. *subsagittatum*		L			1
MIMOS	*Acacia boormanii*	Snowy River wattle	L			1
MIMOS	*Acacia dallachiana*	Catkin Wattle	L			1
MIMOS	*Acacia penninervis*	Hickory Wattle	L			1
MIMOS	*Acacia subtilinervis*	Net veined Wattle	L			1
APIAC	*Actinotus forsythii*	Ridge Flannel-flower	L			1
FABAC	*Almaleea capitata*	Slender Parrot-pea	L			1
PTERIDO	*Asplenium trichomanes*	Common Spleenwort	L			1
ASTEL	*Astelia psychrocharis*	Kosciusko Pineapple grass	L			1
POACE	*Austrostipa setacea*	Corkscrew Spear-grass	L			1
EUPHOR	*Beyeria lasiocarpa*	Wallaby-bush	L			1
EUPHOR	*Beyeria viscosa*	Pinkwood	L			1
RUTAC	*Boronia ledifolia*	Showy Boronia	L			1
PTERIDO	*Botrychium australe*	Austral Moonwort	L			1
ASTER	*Brachyscome ptychocarpa*	Tiny Daisy	L			1
ASTER	*Brachyscome stolonifera*	Creeping Daisy	L			1
ORCHI	*Caladenia aestiva*	Summer Spider-orchid	L			1
CYPER	*Carex hypandra*	Sedge	L			1
ASTER	*Celmisia sericophylla*	Silky Daisy	L			1
POACE	*Chionochloa frigida*	Ribbony grass	L			1
POACE	*Chloris ventricosa*	Plump Windmill Grass	L			1
ASTEL	*Colobanthus nivicola*		L			1
ASTEL	*Colobanthus pulvinatus*	Snow Colobanth	L			1
ASTER	*Craspedia costiniana*	Billy Button	L			1
ASTER	*Craspedia sp. B*	Billy Button	L			1

Family	Scientific name	Common name	Cat			RP
CYPER	*Cyperus concinnus*	Flat Trim-sedge	L			1
SOLAN	*Cyphanthera albicans*	Hoary Ray-flower	L			1
GOODE	*Dampiera purpurea*	Mountain Dampiera	L			1
POACE	*Deyeuxia decipiens*	Devious Bent-grass	L			1
FABAC	*Dillwynia prostrata*	Matted Parrot-pea	L			1
EUPHOR	*Dodonaea boroniifolia*	Hairy Hop-bush	L			1
EUPHOR	*Dodonaea rhombifolia*	Broad-leaf Hop-bush	L			1
POACE	*Enneapogon gracilis*	Slender Bottlewashers	L			1
ONAGR	*Epilobium tasmanicum*	Tasman Willow-herb	L			1
ASTER	*Erigeron paludicola*	Swamp Fleabane	L			1
MYRTA	*Eucalyptus lacrimans*	Weeping Snow Gum	L			1
SCROPH	*Euphrasia collina* ssp. *diversicolor*	Thick Eyebright	L			1
SCROPH	*Euphrasia collina ssp. glacialis*	Eyebright	L			1
ERICA	*Gaultheria appressa*	Mainland Waxberry	L			1
ASTER	*Glossocardia bidens*		L			1
PROTEA	*Grevillea willisii*	Rock Grevillea	L			1
ASTER	*Leptorhynchos elongatus*	Lanky, Buttons,	L			1
EPACR	*Leucopogon microphyllus var. pilibundus*	Hairy Beard-heath	L			1
PTERIDO	*Lindsaea microphylla*	Lacy Wedge-fern	L			1
CYPER	*Luzula atrata*	Slender Woodrush	L			1
RUTAC	*Nematolepis ovatifolia*	Ovate Phebalium	L			1
ASTER	*Olearia frostii*	Bogong Daisy-bush	L			1
ASTER	*Ozothamnus adnatus*	Winged Everlasting	L			1
APOCYN	*Parsonsia eucalyptophylla*		L			1
RHAMN	*Pomaderris costata*	Veined Pomaderris	L			1
RHAMN	*Pomaderris ledifolia*	Sydney Pomaderris	L			1
RHAMN	*Pomaderris pauciflora*	Mountain Pomaderris	L			1
ORCHID	*Prasophyllum suttonii*		L			1
PTERIDO	*Psilotum nudum*	Skeleton Fork-fern	L			1
ORCHID	*Pterostylis aestiva*	Long-tongue Summer Greenhood	L			1
ORCHID	*Pterostylis coccina*		L			1
ORCHID	*Pterostylis fischii*	Fisch's Greenhood	L			1
ORCHID	*Pterostylis laxa*	Antelope Greenhood	L			1
ORCHID	*Pterostylis oreophila*		L			1
RANUNC	*Ranunculus clivicola*	Hill Buttercup	L			1
RANUNC	*Ranunculus dissectifolius*	Feather Buttercup	L			1
RANUNC	*Ranunculus niphophilus*	Kosciusko Buttercup	L			1
CARYO	*Scleranthus singuliflorus*	Mossy Knawel	L			1
VIOLA	*Viola caleyana*	Swamp Violet	L			1
RUTAC	*Zieria robusta*	Robust Zieria	L			1
PTERIDO	*Adiantum hispidulum*	Rough Maidenhair	L			1
ORCHI	*Caladenia montana*	Veined Spider-Orchid	L			1
ORCHI	*Corybas hispidus*	Hispid Helmet-orchid	L			1
ORCHI	*Dendrobium striolatum*	Streaked Rock Orchid	L			1
EPACR	*Epacris glacialis*	Reddish Bog Heath	L			1
ORCHID	*Genoplesium nudum*		L			1
GOODEN	*Goodenia heterophylla*	Variable Goodenia	L			1
EPACR	*Leucopogon montanus*	Snow Beard-heath	L			1
EPACR	*Leucopogon pilifer*	Thready Beard-heath	L			1
RUTAC	*Phebalium glandulosum*	Glandular Phebalium	L			1
LAMIA	*Prostanthera decussata*	Dense Mint-bush	L			1
FABAC	*Pultenaea polifolia*	Dusky Bush-pea	L			1
FABAC	*Pultenaea subspicata*	Low Bush-pea	L			1
TREMAN	*Tetratheca thymifolia*	Thyme Pink-bells	L			1
RUTAC	*Zieria smithii*	Sandfly Zieria	L			1

Family	Scientific name	Common name	Cat			RP
Not scored						
CRYPTOG	*Cetrara australiensis*					
CUSCU	*Cuscuta victoriana*	Victorian Dodder				
SCROPH	*Glossostigma sp. aff spathulatum*	Spoon Mud Mat				
GOODEN	*Goodenia grandiflora*	Pinnate Goodenia				
JUNCA	*Juncus sp. aff. sceuchzerioides*	Rush				
ORCHID	*Prasophyllum* aff. *rogersii*					
LAMIA	*Scutellaria mollis*	Soft Skullcap				
ORCHID	*Thelymitra* aff. *erosa*	Sun-orchid				

Table 8.8 Priority Ranking — Other Features

Note that rankings are based on scores determined as previously described. The scores, and so the rankings, cannot be exact and should not be treated as rigid. Thresholds have been applied arbitrarily and might be equally appropriate in a different position.

Feature	Cat	Rnk	Scr	Con
Feature	**Category**	**Ranking**	**Overall score**	**Confidence in score**
Glacial lakes (cirque basins, moraines), Kosciuszko NP	H	1	72	H
Windswept feldmark (*Epacris – Chionohebe*), Kosciuszko NP	H	1	72	H
Important Wetland - Rennex Gap - AA009NS	H	1	72	H
Landslide-dammed lake (Tali Karng)	H	1	72	H
Rainforest remnant vegetation (e.g. *Atherosperma moschatum*), Kosciuszko NP	H	1	72	H
Bog communities associated with the thermal spring area, Yarrangobilly.	H	2	54	H
Non-sorted steps, contour trenches (string bogs - contour banks), Kosciuszko NP	H	2	54	H
Short-alpine herbfield, Kosciuszko NP	H	2	54	H
Snowpatch feldmark (*Coprosma – Colobanthus*), Kosciuszko NP	H	2	54	H
Alpine snowpatch community	H	2	54	H
Kosciuszko Alpine Landscape Conservation Area	H	2	54	H
Podocarpus lawrencei (Mountain Plum Pine) heathland, Kosciuszko NP	H	3	36	H
Yarrangobilly plant species which appear to be restricted to limestone at Yarrangobilly and Wee Jasper	H	3	36	H
Important Wetland - Ginini and Cheyenne Flats - AA006AC	H	3	36	H
Important Wetland - Mount Buffalo Peatlands - AA008VI	H	3	36	H
Important Wetland - Snowgum Flat - AA013NS	H	3	36	H
Important Wetland - Davies Plain - AA005VI	H	4	32	H
Important Wetland - Big Creamy Flats - AA001AC	H	4	32	H
Nivation cirque, Mount Howitt	H	5	27	H
Moraine dumps (kettle lakes), Kosciuszko NP	H	5	27	H
Nivation hollows, Kosciuszko NP	H	5	27	H
Roche moutonnee, Kosciuszko NP	H	5	27	H
Skarn rock outcrops, Kosciuszko NP	H	5	27	H
Solifluction terraces, Kosciuszko NP	H	5	27	H
Important Wetland - Rotten Swamp - AA011AC	H	5	27	H
Caltha introloba herbland community	M	6	24	H
Fen (Bog pool) community	M	6	24	M
Montane swamp complex community	M	6	24	M
Caves, karst and fossil sites, Limestone Creek	M	6	24	H
Important Wetland - Cotter Source Bog - AA00	M	6	24	H
Important Wetland - Yaouk Swamp - SEH024NS	M	6	24	
Karst features including ‘A-tents’, limestone caves, rillenkaren, solution ripples, Kosciuszko National Park	M	6	24	H
Important Wetland - Caledonia Fen - AA003VI	M	7	18	
Important Wetland - Lake Tali Karng - SEH013VI	M	7	18	
New Guinea Ridge Caves	M	8	16	H
Yellow box-red gum woodland	M	9	12	H

Feature	Cat	Rnk	Scr	Con
Campbell Knob/Tulloch Ard Gorge	M	9	12	H
Stratified deposits, especially fossil soils, peat deposits and former lake deposits, Kosciuszko NP	M	9	12	H
Various Caves, Cooleman Caves	M	9	12	H
Amphitheatre, rock rivers, Mount Cobberas No. 1	M	9	12	H
Basalt plateau, periglacial forms, Howitt High Plains	M	9	12	H
Blockstreams, Cobberas, Big Hill and Mount Wombargo	M	9	12	H
Cambrian inlier, thrust fault, Dolodrook - Wellington Rivers	M	9	12	H
Twin rhyodacite peaks, Cleft Peak	M	9	12	H
Blockstreams and boulderfields (block glacis), Kosciuszko NP	M	9	12	H
Threshold score 10				
Blockstreams, Whisky Flat	L	10	8	H
Glacial erratics, Kosciuszko National Park	L	10	8	H
Important Wetland - Rock Flats - AA010AC	L	10	8	H
Important Wetland - Scabby Range Lake - AA012AC	L	10	8	H
Important Wetland - Snowy Flats - AA014AC	L	10	8	H
Important Wetland - Upper Cotter River - AA015AC	L	10	8	H
Entrenched meander, Upper Buchan River	L	11	4	H
Sub-basaltic sediments, Mayford - Dargo River Valley	L	11	4	H
Highland alluvial valley, boulder fans - Wonnangatta Valley	L	12	3	H
Palaeozoic sediments, folds - Snowy Bluff, Mount Kent, Moroka Gorge	L	12	3	H
Strike ridges, The Razor and The Viking	L	12	3	H
Tertiary volcanics, Mount Tabletop and Precipice Plain	L	12	3	H
Palaeozoic stratigraphy, gorge - Bryce Plain and Bryce Gorge	L	13	2	H
Sandstone plateau, benched slopes - Mount Ligar-Long Hill	L	13	2	H
Young basalt flow, Morass Creek	L	13	2	H
Scree slopes, Kosciuszko NP	L	13	2	H
The dyke of Tertiary basalt near Lake Albina., Kosciuszko NP	L	13	2	H
Not scored				
Alpine Bog Community, Mt Buffalo National Park				
Bogong High Plains, North and South				
Fen (Bog Pool) Community, Mt Buffalo National Park				
Gorge, structures - Reedy Creek Chasm				
Little River Gorge and Boundary Creek Gorge				
All habitat of category 2 species/features, Kosciuszko National Park				
All habitat or context of Category 1 species or features, KNP				
All habitat or immediate context of Category 3 species/features, Kosciuszko NP				
All roosting /nesting /breeding /hibernacula sites used by threatened, KNP endemic, or treaty-protected fauna, Kosciuszko NP				
Alpine/sub-alpine wetland vegetation communities (Fen, Valley bog and Raised bog, Wet heath), Kosciuszko NP				
Fossil and sub-fossil remains, Kosciuszko NP				
Glacial/peri-glacial features (other than Cat 2), Kosciuszko NP				
Historic scientific sites, Kosciuszko NP				
Karst landscape features (other than Cat.1), Kosciuszko NP				
Scientific and management sites established for short-term studies, Kosciuszko NP				
Scientific sites used for long-term study and established for a period of greater than 20 years, Kosciuszko NP				
Scientific sites used for long-term study of natural and cultural processes (Other than Cat 1 sites), Kosciuszko NP				
Sod-tussock grassland, Kosciuszko NP				
Various Caves, Yarrangobilly				
Avon, Turton and Dolodrook Rivers, and Ben Cruachan Creek				

Feature	Cat	Rnk	Scr	Con
Blue Rag Creek				
Gattamurgh Creek				
Important Wetland - Bendora Reservoir - SEH002AC				
Important Wetland - Blue Lake - AA002NS				
Important Wetland - Cotter Flats - AA004AC				
Important Wetland - Kosciuszko Alpine Fens, Bogs and Lakes - AA007NS				
Important Wetland - Lake Dartmouth - SEH011VI				
Important Wetland - Upper Naas Creek - AA016AC				
Important Wetland - Wongungarra River - SEH023VI				
Mitchell and Wonangatta Rivers heritage river corridor				
Mitta Mitta River				
Mount Gelantipy Creek				
Musk Creek				
Pinnacle Creek (East Branch)				
Rodger River and Mountain Creek				
Sentry Box *Olearia* Site				
Snowy River gorge				
Upper Rodger River/Mountain Creek catchment				
Wallaby Creek				
Wilderness areas, Victoria				
Wongungurra River headwaters				
Alpine treeline				
Cave communities				
Mountain streams				

Table 8.9 Priority Ranking — Threats

Note that rankings are based on scores determined as previously described. The scores, and so the rankings, cannot be exact and should not be treated as rigid. Thresholds have been applied arbitrarily and might be equally appropriate in a different position.

Threat	Cat	Rank	Scr	No
Threat	Category	Ranking	Overall score	Number of scores
English broom (*Cytisus scoparius*)	H	1	360	2
Streams - Alteration to the natural temperature regimes of rivers and streams	H	1	360	2
Streams - Prevention of passage of aquatic biota as a result of the presence of instream structures	H	1	360	2
Streams - water level fluctuation	H	1	360	2
Pigs		2	320	3
Foxes	H	3	293	5
Crack Willow (*Salix fragilis*)	H	4	280	3
Grey Sallow (*Salix cinerea cinerea*)	H	4	280	3
Rabbits	H	5	272	3
Streams - Alteration to the natural flow regimes of rivers and streams	H	5	272	3
Trout	H	6	270	2
Black Willow (*Salix nigra*)	H	7	250	3
Rusty Sallow (*Salix cinerea oleifolia*)	H	8	240	2
Impacts originating elsewhere (eg on Bogong moth larvae in western NSW)	H	8	240	1
Grazing by stock	H	9	236	4
Horses	H	9	236	5
Blackberry (*Rubus discolor*)	H	10	216	3
Introduction/spread of aquatic diseases and parasites	H	10	216	2
Recreation and tourism	H	10	216	2
Managed fires (artificial fire regime)	H	10	212	3
Damming of streams	H	11	205	3
Threshold score 200				
Wildfire	M	12	183	4
Greenhouse warming	M	13	180	3
Ozone depletion (UV-B radiation)	M	13	180	2
Roading	M	13	180	2
Sambar	M	14	144	3
Stream siltation	M	14	144	3
Yarrow (*Achillea millefolium*)	M	15	138	4
Cats	M	16	125	5
Dogs	M	17	96	4
Resorts	M	18	95	2
Serrated Tussock (*Nassella trichotoma*)	M	19	92	3
Fire in organic terrain	M	20	90	1
St Johns wort (*Hypericum perforatum*)	M	21	88	3
Sweet briar (*Rosa rubiginosa*)	M	21	88	3
Goats	M	22	80	5
Deer	M	22	80	3
Threshold score 79				
Poplar, White (*Populus alba*)	L	23	73	3
Vipers bugloss (*Echium vulgare*)	L	24	72	1
Fallow deer	L	25	68	3

Threat	Cat	Rank	Scr	No
Red deer	L	26	65	3
Nodding Thistles (*Carduus nutans*)	L	27	64	3
Stream/water Pollution	L	28	60	2
Logging	L	28	60	1
Himalayan Honeysuckle (*Leycesteria formosa*)	L	29	57	2
Phytophthora - Use of *Phytophthora*-infected gravel in construction of roads, bridges and reservoirs	L	29	57	2
African Lovegrass (*Eragrostis curvula*)	L	30	52	3
Bees	L	31	51	4
Pyracantha/Firethorn (*Pyracantha angustifolia*)	L	32	50	3
Wildfire suppression	L	33	48	1
Gambusia	L	34	47	2
SMA hazardous waste dumps	L	35	46	2
Cotoneaster (*Cotoneaster glaucophyllus*)	L	36	45	2
Hawthorn (*Crataegus monogyna*)	L	36	45	2
Horehound (*Marrubium vulgare*)	L	36	45	2
Pinus (*Pinus radiata* and other spp)	L	37	44	3
Sorrel (*Acetosella vulgaris*)	L	38	40	3
Spear Thistle (*Cirsium vulgare*)	L	38	40	3
Phytophthora - Dieback caused by the root-rot fungus (*Phytophthora cinnamomi)*	L	39	39	3
Scotch Thistle (*Onopordum acanthium*)	L	40	38	3
White clover (*Trifolium repens*)	L	41	36	3
Skiing	L	41	36	2
Snow making	L	42	35	3
Poplar, Lombardy (*Populus nigra*)	L	43	31	3
Rats and mice	L	44	30	2
Patersons curse (*Echium plantagineum*)	L	44	30	2
Tutsan (*Hypericum androsaemum*)	L	45	29	3
Fennel (*Foeniculum vulgare*)	L	46	27	2
Orange hawkweed (*Hieracium aurantiacum*)	L	46	27	2
Hares	L	47	22	5
Bent grass/Browntop Bent (*Agrostis capillaris*)	L	48	21	2
Hemlock (*Conium maculatum*)	L	48	21	2
Ox-eyed daisy *(Leucanthemum vulgare*)	L	48	21	2
Carp	L	49	18	2
Blue periwinkle (*Vinca major*)	L	49	18	2
Cherry plum (*Prunus cerasifera*)	L	49	18	2
English ivy (*Hedera helix*)	L	49	18	2
Flatweed (*Hypochaeris radicata*)	L	49	18	2
Juniper (*Juniperus communis*)	L	49	18	2
(Russell) Lupin (*Lupinus* hybrid)	L	49	18	2
Soft Rush *(Juncus effusus*)	L	49	18	2
Sycamore (*Acer pseudoplatanus*)	L	49	18	2
Tree lupin (*Lupinus arboreus*)	L	49	18	1
Holly (*Ilex aquifolium*)	L	50	15	2
Rose campion (*Lychnis coronaria*)	L	51	12	2
Mining	L	52	9	2
Weatherloach	L	53	6	2
Buddleia (*Buddleja madagascariensis*)	L	53	6	1
Rainmaking	L	54	3	1
Fragmentation of genetic diversity				
Hybridization due to habitat alteration due to climate change				

Table 8.10 Fauna — Comparison of ranking and formal status

(Codes as in Table 4.9)

Species	Rank	Cw	ANZ	TSC	FFG	VRT	NCA
Species	Ranking	EPBC Act	ANZECC list	TSC Act	FFG Act	VROTS	NC Act
Burramys parvus	**1**	EO	E	v	2A	v	
Litoria sp. affin. *phyllochroa*	**1**						
Litoria verreauxii alpina	**1**	V	V				
Maccullochella macquariensis	**1**	EO	Cr		2A	e/v	eA
Macquaria australasica	**1**	EO	E		2	v	eA
Philoria frosti	**1**	E	Cr		2A		
Potorous longpipes	**1**	E	E	eP	2A	e	
Pseudomys fumeus	**1**	EO	E			r	eA
Pseudophryne corroboree	**1**	E	Cr				
Litoria spenceri	**2**	E	Cr	e	2	e	
Petrogale penicillata	**3**	VO	V	v	2A	e	eA
Teraphis cavicola	**3**						
Helioporus australiacus	**4**	V	V	v	2A	r	
Pseudophryne pengilleyi	**4**	V	V				vA
Gymnobelideus leadbeateri	**5**	EP	E		2A	e	
Cyclodomorphus praealtus	**6**				2	v	
Calyptorhynchus lathami	**7**			v	2	v	
Graliophilus woodi	**7**						
Icona sp nov	**7**						
Pachycephala olivacea	**7**						
Thaumatoperla flaveola	**7**				2		
Litoria booroolongensis	**8**						
Dasyurus maculatus	**9**	VO	V	v	2A	v	
Graliophilus monikosciuskoi	**9**						
Euastacus crassus	**10**						
Mastacomys fuscus	**10**						
Petroica rodinogaster/ phoenicea	**10**						
Rhinolophus megaphyllus	**10**				2	c	
Euastacus armatus	**11**						vA
Eulamprus kosciuskoi	**11**						
Prototroctes maraena	**11**	VO	V		2	v	
Xanthomyza phrygia	**11**	E	E	e	2A	e	eA
Phascogale tapoatafa	**12**			vP	2A		
Euastacus woiwuru	**13**						
Falsistrellus tasmaniensis	**13**						
Gadopsis bispinosus	**13**						vA
Gadopsis marmoratus	**13**					ind	
Galaxias rostratus	**13**					r	
Limnodynastes dumereli fryii	**13**						
Litoria citropa	**13**					r	
Maccullochella peeli	**13**				2	v	
Macropus robustus	**13**					r	
Ninox strenua	**13**			v	2	r	

Species	Rank	Cw	ANZ	TSC	FFG	VRT	NCA
Nyctophilus timoriensis	**13**						
Petaurus australis	**13**						
Petaurus norfolcensis	**13**						
Phascolarctos cinereus	**13**						
Scotorepens orion	**13**					ins	
Tyto tenebricosa	**13**			v	2	r	
Canis familiaris dingo	**14**					ins	
Miniopterus schreibersii	**15**			v	2	c	
Agrotis infusa	**16**						
Amphibolurus diemensis	**16**					ins	
Arachnida - Lycisidae	**16**						
Falco peregrinus	**16**						
Galaxias olidus	**16**					ins	
Haliaeetus leucogaster	**16**				2A	r	
Kosciuscola tristis tristis	**16**						
Macquaria novemaculeata	**16**					r	
Monistria concinna	**16**						
Philypnodon sp. nov.	**16**					ins	
Eusthenia venosa	**17**						
Hadronyche sp	**17**						

Table 8.11 Flora — Comparison of ranking and formal status

Ranking as scored by the workshop, except taxa scored only by Dr McDougall, marked *

(Codes as in Table 5.5)

Species	Rank	Cw	ANZ	ROTAP	TSC	FFG	VRT	NCA
Species	**Ranking**	**EPBC Act**	**ANZECC list**	**ROTAP**	**TSC Act**	**FFG Act**	**VROTS**	**NC Act**
Gentiana baeuerlenii	1	E	E	2ECit	e			eA
Kelleria laxa	1	V	V				e	
Banksia marginata stand	2							
*Blechnum vulcanicum**	3						e	
*Boronia citrata**	3						v	
*Carex archeri**	3							
*Discaria nitida**	3			3RC-	e	2	e	
Pomaderris cotoneaster	3	E	E	3ECi	e			
Prasophyllum montanum	3							
*Viola improcera**	3							
Asplenium hookerianum	4	V	V				e	
Babingtonia crenulata	4		V				r	
Baeckea denticulata	4							
Calotis cuneata subsp *pubescens*	4							
Carex raleighii	4			3RCa	e		r	
Chiloglottis turfosa	4							
Chionogentias sylvicola	4							
Eucalyptus elaephloia	4						v	
Eucalyptus mitchelliana	4						r	
Eucalyptus neglecta	4						r	
Eucalyptus saxatilis	4			3RC-	e			
Eucalyptus triplex	4							
*Euphrasia scabra**	4			3KCa	e	2A	e	
Genoplesium turfosum	4							
Irenepharsus magicus	4			2RC-	e			
Monotoca rotundifolia	4						v	
Myoporum floribundum	4						e	
Olearia aglossa	4							
*Pomaderris pallida**	4	V	V	2VCi	v			
Pomaderris sericea	4	V	V			2	v	
Pratia gelida	4	V	V				v	
Rytidosperma pumilum	4	V	V	2VC-t+	v			
Westringia cremnophila	4	V	V				v	
Acacia dallachiana	5						r	
Almaleea capitata	5					2	r	
Bertya findlayi	5							
*Botrychium lunaria**	5						v	
Brachyscome sp. 3 (sens. Fl. Victoria 4)*	5					2	v	
Carex capillacea	5						r	
Carex cephalotes	5					2	v	
Drabastrum alpestre	5					2	v	
*Erigeron conyzoides**	5						v	
Gingidia algens	5							
Grammitis poeppingiana	5						r	
*Hierochloe submutica**	5						v	
*Juncus thompsonianus**	5						v	

Species	Rank	Cw	ANZ	ROTAP	TSC	FFG	VRT	NCA
Nematolepis squamea subsp. coriacea	**5**	V	V				v	
Olearia lasiophylla	**5**							
Parantennaria uniceps	**5**						v	
*Pelargonium helmsii**	**5**						v	
*Pimelea bracteata**	**5**							
*Poa hookeri**	**5**						v	
Prasophyllum sp. related to *P. morganii*	**5**			2VCit	v			
Prasophyllum suttonii	**5**						v	
Prostanthera monticola	**5**						r	
*Prostanthera rhombea**	**5**						v	
Prostanthera walteri	**5**						r	
Ranunculus anemoneus	**5**	V	V	2VCat	v			
Ranunculus brevicaulis	**5**							
Ranunculus eichleranus	**5**						r	
Ranunculus niphophilus	**5**							
*Ranunculus productus**	**5**							
Sagina namadgi	**5**						v	
*Tetratheca procumbens**	**5**						v	
*Uncinia sulcata**	**5**						v	
*Utricularia monanthos**	**5**						v	
*Acacia binervia**	**6**						e	
*Amphibromus fluitans**	**6**	V	V		v			
*Deyeuxia pungens**	**6**	V	V				v	
Diuris ochroma	**6**	V	V				v	
Podocarpus lawrencei (old)	**6**							
*Pterostylis cucullata**	**6**	V	V	3VCa	v	2A	v	
Abrotanella nivigena	**7**						v	
*Acacia phlebophylla**	**7**						r	
*Deyeuxia affinis**	**7**						r	
*Deyeuxia innominata**	**7**						v	
*Deyeuxia talariata**	**7**						v	
Euphrasia sp. 3	**7**							
*Genoplesium nudiscapum**	**7**						v	
*Gingidia harveyana**	**7**						v	
*Goodenia macmillanii**	**7**						v	
*Hibbertia spathulata**	**7**						r	
*Leucopogon riparius**	**7**						r	
*Luzula acutifolia subsp. Nana**	**7**							
*Monotoca oreophila**	**7**						r	
Olearia rhizomatica	**7**							
*Persoonia asperula**	**7**						v	
Poa labillardierei var *acris**	**7**						v	
*Poa petrophila**	**7**						v	
*Prasophyllum lindleyanum**	**7**						v	
*Pterostylis aenigma**	**7**	E	E				r	
*Salvia plebeia**	**7**						v	
*Thelymitra circumsepta**	**7**						v	
*Thelymitra cyanea**	**7**						v	
*Wahlenbergla densifolia**	**7**						v	
Craspedia discolor ms	**8**							
Derwentia nivea	**8**							
Eucalyptus pauciflora (>150 years old)	**8**							
Euphrasia crassiuscula ssp. crassiuscula	**8**						r	
Euphrasia crassiuscula ssp. eglandulosa	**8**						r	
Euphrasia crassiuscula ssp. glandulifera	**8**	V	V				v	
Euphrasia eichleri	**8**	V	V				v	

Species	**Rank**	**Cw**	**ANZ**	**ROTAP**	**TSC**	**FFG**	**VRT**	**NCA**
Galium roddii	**8**							
Gratiola nana	**8**						v	
Oschatzia cuneifolia	**8**						r	
Persoonia subvelutina	**8**						r	
Plantago glacialis	**8**						v	
Plantago muelleri	**8**						v	
Pomaderris oblongifolia	**8**						r	
Ranunculus muelleri	**8**						v	
Schizeilema fragoseum	**8**						v	
Sorghum leiocladum	**8**						v	
Calotis glandulosa	**9**	V	V	3VC-	v			
Craspedia alba	**9**							
*Actinotus forsythii**	**10**						v	
Astrotricha sp. 4 (sens. Flora Victoria, 4: 252)	**10**	Conservation status unknown						
*Boronia ledifolia**	**10**						v	
*Botrychium australe**	**10**						v	
Brachyscome tadgellii	**10**						r	
*Caladenia aestiva**	**10**						v	
*Carex hypandra**	**10**							
Chionohebe densifolia	**10**							
*Chloris ventricosa**	**10**						v	
Craspedia leucantha	**10**							
Cystopteris tasmanica	**10**						r	
*Deyeuxia decipiens**	**10**						v	
*Dillwynia prostrata**	**10**						v	
*Enneapogon gracilis**	**10**						v	
*Erigeron paludicola**	**10**							
Erigeron setosus	**10**							
Euchiton nitidulus	**10**	V	V	3VCa+	v		v	
Euphrasia alsa	**10**							
Euphrasia collina ssp. lapidosa	**10**							
*Glossocardia bidens**	**10**						v	
Grevillea diminuta	**10**							
*Grevillea willisii**	**10**						r	
Haloragodendron baeuerlenii	**10**						r	
*Luzula atrata**	**10**						v	
*Olearia frostii**	**10**						r	
Olearia stenophylla	**10**							
Oreomyrrhis brevipes	**10**						r	
*Ozothamnus adnatus**	**10**						v	
*Parsonsia eucalyptophylla**	**10**						v	
Pomaderris brunnea	**10**	V	V				v	
*Pomaderris costata**	**10**						r	
Pseudanthus divaricatissimus	**10**						r	
*Pterostylis oreophila**	**10**						e	
Ranunculus clivicola	**10**							
Ranunculus dissectifolius	**10**							
Rutidosis leiolepis	**10**	V	V	2VC-	v			
Taraxacum aristum	**10**						r	
Thesium australe	**10**	V	V	3VCi+	v	2A	e	
Westringia lucida	**10**						v	
*Caladenia montana**	**11**						e	
Craspedia lamicola	**11**							
*Genoplesium nudum**	**11**						v	
*Pultenaea subspicata**	**11**						v	
Asplenium trichomanes	**12**						r	

Species	Rank	Cw	ANZ	ROTAP	TSC	FFG	VRT	NCA
Barbarea grayi	**12**						v	
Brachyscome petrophila	**12**						r	
Brachyscome riparia	**12**						r	
Brachyscome stolonifera	**12**							
Colobanthus nivicola	**12**							
Colobanthus pulvinatus	**12**							
Coprosma moorei	**12**						r	
Coprosma niphophila	**12**							
Desmodium brachypodum	**12**							
Dichosciadium ranunculaceum var. *ranunuculaceum*	**12**							
Dipodium hamiltonianum	**12**						e	
Discaria pubescens	**12**					2A	v	
Euphrasia caudata	**12**						r	
Huperzia australiana	**12**						r	
Lycopodium scariosum	**12**						r	
Oreomyrrhis argentea	**12**						v	
Pimelea biflora	**12**						r	
Poa saxicola	**12**					2	v	
Pultenaea capitellata	**12**						r	
Scleranthus singuliflorus	**12**						r	
Acacia lucasii	**13**						v	
Acacia subtilinervis	**13**						v	
Aciphylla glacialis	**13**							
Agrostis meionectes	**13**							
Astelia psychrocharis	**13**							
Brachyscome obovata	**13**						r	
Craspedia costiniana	**13**							
Dodonaea rhombifolia	**13**						r	
Eucalyptus lacrimans	**13**							
Craspedia aurantia	**14**							
Acacia boormanii	**15**							
Beyeria lasiocarpa	**15**						r	
Celmisia sericophylla	**15**					2	r	
Chionochloa frigida	**15**							
Euphrasia collina ssp. diversicolor	**15**						v	
Euphrasia collina ssp. glacialis	**15**							
Gaultheria appressa	**15**							
Leptorhynchos elongatus	**15**						r	
Nematolepis ovatifolia	**15**							
Pomaderris ledifolia	**15**						r	
Pomaderris pauciflora	**15**						r	
Psilotum nudum	**15**						r	
Pterostylis coccina	**15**						v	
Pterostylis fischii	**15**						r	
Pterostylis laxa	**15**						r	
Viola caleyana	**15**						r	
Acacia penninervis	**16**						r	
Corybas hispidus	**16**						r	
Craspedia maxgrayii	**16**							
Dendrobium striolatum	**16**							
Epacris glacialis	**16**						r	
Epilobium tasmanicum	**16**						r	
Goodenia heterophylla	**16**						r	
Leucopogon montanus	**16**						r	
Tetratheca thymifolia	**16**						v	
Zieria smithii	**16**						r	

9 Conclusions and Recommendations

Other authors have identified natural features of the Australian Alps national parks of international significance (summarised in Chapter 1 of this report). The natural features of the Australian Alps appear to meet the World Heritage Convention's definition of "natural heritage" (UNESCO 1998). This report makes no recommendation concerning possible nomination(s) for the World Heritage List. That is beyond the scope of the project. In any case, it seems nomination or inscription on the World Heritage List is not the main concern. Under the Convention, each State Party to the Convention recognises that the **duty of ensuring the identification, protection, conservation, presentation and transmission to future generations of the** cultural and **natural heritage** referred to in Articles 1 and 2 and situated on its territory, belongs primarily to that State. By signing the Convention, each country pledges to conserve the sites situated on its territory, **some** of which may be recognised as World Heritage (UNESCO 1998). Consequently, since Australia is a Party to the Convention, the duty appears to apply whether or not a site containing "natural heritage" as defined in Article 2 is nominated or listed.

Other international conventions and instruments also confer duties or responsibilities to conserve the natural features of the Australian Alps. These include the Convention on Biodiversity, Agenda 21, and to a lesser extent the Wetlands convention and Migratory Species Convention, the Japan–Australia Migratory Birds Agreement and China–Australia Migratory Birds Agreement, and UNESCO's Man and the Biosphere Program.

Additional obligations and commitments stem from domestic agreements, including

- the Intergovernmental Agreement on the Environment
- National Strategy for Ecologically Sustainable Development
- National Strategy for the Conservation of Australia's Biological Diversity; and the
- Australian National Strategy for the Conservation of Australian Species and Communities Threatened with Extinction.

Furthermore, Commonwealth, State and Territory legislation requires the conservation of the Australian Alps national parks.

Thus the proper management of the Australian Alps national parks is not just a worthy objective for the benefit of the human community but a legal obligation. Chapter 1 includes relevant quotations from the international and national agreements mentioned above.

This project has also described how the ecological environment of the Australian Alps has been changing for thousands of years, and how Aboriginal peoples and much later European people have superimposed artificial changes on the natural changes. By the mid-1900s the environment of the Australian Alps national parks was degraded. The last 50 years or so have seen substantial recovery with better management, but also the development of new threats causing new degradation. Further environmental change is inevitable but good management will minimise adverse effects. Global issues such as global warming and damage to the ozone layer (ie increased ultraviolet radiation) may require new approaches to land management to minimise their impact. The public should be kept informed of the facts and the needs.

Recommendation 1

That the best scientific information on the ecological situation of the Australian Alps national parks and management needs be documented in a readily assimilated form and promulgated to the public and especially to politicians.

By providing information on what is known about the significant natural features of the Australian Alps and their threats, identifying priorities for further work, providing comprehensive bibliographies, and identifying gaps in the information base, this report might help stimulate external agencies to undertake research and survey work in the Australian Alps national parks. Distributed more widely, it might help foster support for such work.

Recommendation 2

That this report be made available to park staff, universities and university students, non-government organisations and any other groups who can contribute to the essential task of learning more about the natural features of the Australian Alps and their threats. Wider distribution of the report might be worthwhile to foster support for necessary conservation activities in the Australian Alps.

This project has highlighted how much about the natural features of the Australian Alps national parks remains unknown or poorly documented. In general it was difficult to identify features significant for reasons other than that they were species which are rare or threatened (in at least one of the States), or habitat of those species. Features can be significant for other reasons, such as ecological, scientific or biogeographic importance, or their value as environmental indicators. The project did not provide the opportunity to identify the full range of significant features.

Information is lacking on many species, even those known to be rare, endangered or vulnerable. Notably, the project workshop participants, who represented considerable expertise across the Australian Alps, lacked the knowledge to rank many of the features which were before them, even though those features are specifically identified in park documents. This is not a criticism of the participants but a reflection of the state of knowledge of the biology and ecology of the Australian Alps. The invertebrate animals, micro fauna and flora, and especially soil organisms are poorly known. Some are probably important in ecosystem function and in that respect are probably more significant than some of the more obvious species we know so much better. Further study of somewhat neglected taxa is needed, focussing on those with the potential to affect ecosystem function.

To effectively preserve the environmental values of parks and reserves it is essential that these values are known, their ecology understood and taken into account, and any threatening processes recognised and acted upon.

Recommendation 3

That all possible means to improve the biological and ecological knowledge of the Australian Alps national parks be investigated and encouraged. To the greatest possible extent, the input by managing agencies should be supplemented from outside sources. Universities and voluntary groups could be valuable partners with the park managing agencies.

Recommendation 4

That natural features of significance which have not been identified in this project, especially cryptogammic plants and invertebrates, be identified and documented.

Recommendation 5

That study of poorly known taxa, especially those with the potential to affect ecosystem function, be strongly encouraged.

A database of biological and ecological information, with source references, would be a valuable aid to effective park management. This has been recognised by agencies, which have developed and used park and State databases. The Victorian Resource Manuals comprehensively use information from the State databases, such as Wildlife Atlas and Flora Information System, overlaid by park boundaries, to provide species lists with a great deal of information on their status.

Apart from this project, there does not seem to be any consolidated source of information which spans jurisdictional boundaries, although the ecosystems and their components are shared.

A single Australian Alps database would be a great aid to park management by enabling managers to see the full picture rather than looking through an artificial window blocking out the view of surrounding areas.

The database developed during this project, limited as it is by the short time available, might provide a useful starting point. While containing information across the Australian Alps national parks, in electronic form it allows easy filtering by State or by park, and/or by species, as well as by a range of other characteristics. It would need to be built on by agency and park staff and by scientists outside the managing agencies.

Recommendation 6

That pending development of a more sophisticated database, the database developed during this project be distributed as widely as practicable and updated regularly. It should be updated centrally, perhaps every six months, and redistributed to ensure current information is used by park staff and researchers.

This project developed a system to allocate priorities to natural features and to threats. Considering it was used as an untested prototype it worked well. A systematic approach to prioritising is needed and this system might be a suitable starting point from which enhancements can be made based on experience at the workshop and subsequently.

Recommendation 7

That a systematic approach be further developed to allocate priorities for resourcing across the Australian Alps.

STRATEGIC RECOMENDATIONS WITH IMPLICATIONS FOR THE NATURAL HERITAGE WORKING GROUP

Adopting a Total Quality Management approach to management issues across the Australian Alps national parks would be beneficial. Under this approach the managing agencies would jointly develop and document the best approach to a management issue, then apply and always seek to improve the single best management model. All potential sources should be encouraged to suggest improvements. Importantly, the AALC has been pursuing this approach by sponsoring workshops, reports and strategies on specific management issues.

Recommendation 8

That the managing agencies cooperate to develop and document a series of trans-alps procedures manuals dealing with specific generic management issues (such as fire management, pig control or ecological monitoring), and that ongoing improvements be sought and introduced.

As already discussed, an Alps-wide natural resource database would be a valuable aid to park management and would provide the integrated, trans-jurisdictional view more aligned to natural boundaries which until this project appeared to be missing. Although the database arising from this project could serve as a starting point, substantial development of such a database would be worthwhile. A number of important issues need to be resolved:

- *The platform for the database* — the present database is on Microsoft Excel 97, which is widely available and allows easy searching and filtering, but is not designed to provide full database functions. Several people have suggested the database should be on Microsoft Access. The platform selected must enable staff at all levels to use it without special training, and must provide the necessary range of functions. A database accessible through the World Wide Web would be most useful as it would be readily available to people outside the agencies and would be more easily updated than a database stored on numerous local computers.
- *The data to be stored* — the present database has information on individual plant and animal species or sometimes sub-species, ecological communities, sites, geomorphological features, pest species and other threats, and a list of references. To keep it simple it does not have GIS capability although GIS would be a great advantage.
- *The level of write-access* — to be current and comprehensive, park staff and external scientists will need to be able to add records directly, or at least readily and promptly.
- *Data validation* — a process to formally check, validate, and remove incorrect records will be needed.
- *Data custody* — responsibility for legal custody of the data will need to be settled.
- *System hosting* — with four governments involved in the AALC a system might be developed for shared hosting (along the lines of the Environmental Resources Information Network). Alternatively a single host will need to be identified and supported.

Recommendation 9

That priority be given to developing and using a trans-alps database for the storage and provision of information on the natural resources of the Australian Alps and the threats to them.

Usually managing ecological communities will be more efficient and more effective than managing individual species. Consistent mapping of communities, with the significant species linked to communities, would be a valuable step towards achieving community-based management.

Recommendation 10

That an Australian Alps ecological community classification and map be developed, and that the individual species listed in this report then be linked to the communities.

Individual threats adversely affect whole ecosystems, communities or at least a suite of species. This does not appear fully reflected in this project because of its focus on identified "significant" species. Table 4.9 records the identified threats to the listed fauna species. From a crude count,

- 18 species (8 mammals, 6 birds, one reptile and 3 frogs) are threatened by fire;
- 16 species are threatened by introduced species;
- 11 species are threatened by grazing;
- 10 species are threatened by roads or road construction;
- 8 species are threatened by pest control;
- 6 species are threatened by cats;
- 5 species are threatened by foxes; and
- 2 species are threatened by each of rabbits and weeds.

As another example of the broad effect of threats, English broom is known to induce complex ecological changes, with ecological conditions moving towards a more mesic habitat. Broom also fixes nitrogen so may alter soil fertility and therefore plant species composition.

The threats ranked as high priority in this project are:

- Foxes;
- Horses;
- Pigs;
- Rabbits;
- Trout;
- Grazing by stock;
- English broom (*Cytisus scoparius*);
- Blackberry (*Rubus discolor*);
- Crack Willow (*Salix fragilis*);
- Grey Sallow (*Salix cinerea cinerea*);
- Black Willow (*Salix nigra*);
- Rusty Sallow (*Salix cinerea oleifolia*);
- Introduction/spread of aquatic diseases and parasites;
- Streams - Alteration to the natural temperature regimes of rivers and streams;
- Streams - Prevention of passage of aquatic biota as a result of the presence of instream structures;
- Streams - water level fluctuation;
- Streams - Alteration to the natural flow regimes of rivers and streams;
- Damming of streams;
- Impacts originating elsewhere (eg on Bogong moth larvae in western NSW);
- Recreation and tourism; and
- Managed fires (artificial fire regime).

Recommendation 11

That all known threats be systematically assessed for their potential long-term affects, and management effort be directed accordingly. Pending more comprehensive assessment, the priority rankings of this project should be used.

HIGH LEVEL RECOMENDATIONS FOR CONSIDERATION BY THE AALC OR THE AGENCIES

The management of the individual parks, constrained by State law, generally takes a parochial State view and inadequately recognises the Australian Alps national parks as a single ecological entity. Although some animals can undoubtedly recognise sanctuary on one side of a cadastral boundary, ecosystem function does not stop at the imaginary dotted line which represents the park or State border. The Australian Alps national parks are separated from surrounding areas, not just from one another, only by those imaginary dotted lines. The use of international references in this report is intended to emphasise the need to view the Australian Alps in the broadest context.

This project identified the inconsistency between the management plans (where they exist) of the various parks. The different plans might all be effective, but only one approach can be the best. As well as striving for the best approach, consistent presentation of management plans would be a major step to convey the unity of the Australian Alps. Current plans are due for updating or replacement, and some of the Australian Alps national parks do not yet have management plans, so now is a fortuitous time to develop and apply a standard approach.

Recommendation 12

That greater emphasis be given to managing the Australian Alps national parks as a single ecological entity rather than as discrete functional units. Greater integration could be assisted by:

- ***Consistent, meaningful, management objectives for all the parks (see Recommendation 13);***
- ***Greater cooperation between parks and agencies to develop and consistently apply the best possible management techniques for specific issues (see Recommendation 8 and discussion preceding Recommendation 14);***
- ***Consistent management plans (see Recommendation 14);***
- ***Endangered species recovery plans written for each species across its range rather than separately State-by-State (or better still, plans be developed for ecological communities or for several species which could be managed together) (see Recommendation 15);***
- ***A single database for all the Australian Alps national parks (see Recommendation 9); and***
- ***A single vegetation communities classification scheme and map (see Recommendation 10).***

The management objectives for the individual Australian Alps national parks, established under the relevant jurisdictional legislation, might be superficially consistent and sensible, but closer examination reveals some lack of clarity and internal inconsistency (Chapter 2). Consistent, clear, meaningful, management objectives are necessary to underlie consistent management across the Australian Alps national parks.

Recommendation 13

That the agencies cooperate to develop management objectives for the Australian Alps national parks that are consistent, clear and meaningful.

A consistent and, where possible, trans-alps approach to management plans would be ecologically and economically sensible. It would help ensure that the best management approaches are applied as well as improving consistency. A suitable scheme might be:

- A single trans-alps resource document (for which this report might provide a useful starting point) rather than separate, single park, resource descriptions which both duplicate effort and obscure the broader picture;
- Simple, generally consistent, management plans for each park to comply with legal requirements and to deal with park-specific issues; and
- A series of trans-alps procedures manuals dealing with specific generic management issues (such as fire management, pig control or ecological monitoring).

This would allow economies of scale in the documentation while enabling comprehensive resource description. It would greatly help to dissolve the artificial borders we have erected which currently subdivide the Australian Alps. It would also allow independent revision or updating of the resource document, park management plans and management issues documents.

Recommendation 14

That management planning so far as possible be consistent across the Australian Alps national parks using the scheme outlined above.

Recovery plans for individual species within single jurisdictions meet legislative requirements and provide a sound basis for management for that species within that jurisdiction. For a more consistent approach, a single recovery plan across the range of the species would be preferable. Given the constraints on resourcing, and the costs of managing species individually (both financially and ecologically), a community-based approach to management would be even better.

Recommendation 15

That where possible the management needs for individual species be accommodated within community-based management, but if a species must be managed individually, management be under a single plan across its range. (See also Recommendation 17.)

This project identified faunal and floral taxa, and other features of high priority. They are:

Fauna

Burramys parvus	Mountain pygmy -possum;
Potorous longpipes	Long-footed potoroo;
Pseudomys fumeus	Smoky mouse;
Litoria sp. affin. phyllochroa	Cotter River frog;
Litoria verreauxii alpina	Alpine tree frog ;
Philoria frosti	Baw Baw frog;
Pseudophryne corroboree	Southern corroboree frog;
Maccullochella macquariensis	Trout cod;
Macquaria australasica	Macquarie perch; and
Neoniphargus sp.	(a cave invertebrate).

Flora

Gentiana baeuerlenii;	
Kelleria laxa	Drapetes
and possibly:	
Banksia marginata stand at Yarrangobilly	
Pomaderris cotoneaster	Cotoneaster Pommaderris
Calotis cuneata subsp pubescens	
Asplenium hookerianum	Maidenhair Spleenwort
Babingtonia crenulata	Fern-leaf Baeckea
Baeckea denticulata	Thyme Heath Myrtle
Carex raleighii	Raleigh Sedge
Chiloglottis turfosa	Bog Bird Orchid
Chionogentias sylvicola	Late Forest Gentian
Eucalyptus elaephloia	
Eucalyptus mitchelliana	Buffalo Sallee
Eucalyptus neglecta	Omeo Gum
Eucalyptus saxatilis	Suggan Buggan mallee
Eucalyptus triplex	
Genoplesium turfosum	Bog Midge Orchid
Irenepharsus magicus	Elusive Cress/Branched Cress
Monotoca rotundifolia	Trailing Broom-heath
Myoporum floribundum	Slender Myoporum
Olearia aglossa	Alpine Daisy Bush
Pomaderris sericea	Bent Pomaderris
Pratia gelida	Snow Pratia
Rytidosperma pumilum	Mountain Grass/Small Alpine Grass/Feldmark Grass
Westringia cremnophila	Snowy River Westringia

Other natural features

Rainforest remnant vegetation (e.g. *Atherosperma moschatum*), Kosciuszko NP;
Bog communities associated with the thermal spring area, Yarrangobilly;
Windswept feldmark (*Epacris – Chionohebe*), Kosciuszko NP;
Snowpatch feldmark (*Coprosma – Colobanthus*), Kosciuszko NP;
Short-alpine herbfield, Kosciuszko NP;
Alpine snowpatch community;
Podocarpus lawrencei (Mountain Plum Pine) heathland, Kosciuszko NP;
Yarrangobilly plant species which appear to be restricted to limestone at Yarrangobilly and Wee Jasper;
Important Wetland - Big Creamy Flats - AA001AC;
Important Wetland - Davies Plain - AA005VI;
Important Wetland - Ginini and Cheyenne Flats - AA006AC;
Important Wetland - Mount Buffalo Peatlands - AA008VI;
Important Wetland - Rennex Gap - AA009NS;
Important Wetland - Rotten Swamp - AA011AC;
Important Wetland - Snowgum Flat - AA013NS;
Kosciuszko Alpine Landscape Conservation Area;
Glacial lakes (cirque basins, moraines), Kosciuszko NP;
Non-sorted steps, contour trenches (string bogs - contour banks), Kosciuszko NP;
Nivation cirque, Mount Howitt;
Moraine dumps (kettle lakes), Kosciuszko NP;
Nivation hollows, Kosciuszko NP;
Roche moutonnee, Kosciuszko National Park;
Skarn rock outcrops, Kosciuszko National Park;
Solifluction terraces, Kosciuszko National Park;and
Landslide-dammed lake (Tali Karng)

Not surprisingly, given legislative responsibilities, there is a tendency to focus management effort on individual endangered species, some of which were not ranked highly in this project compared with others which are not formally considered endangered or vulnerable. For example, only eleven of the 24 nationally endangered or vulnerable plant species (Table 5.1) were in the workshop's high or medium priority rankings (seven were ranked low and six were not scored). One disadvantage of managing species individually is that unknown species miss the attention. Focussing on individual species also creates the possibility, if not the probability, that management for the chosen species will disadvantage other species. Recognising the inevitable limitations on resourcing, managing individual species might be a luxury we can rarely afford. Managing at a community or ecosystem level might prove to be more efficient at conserving the biodiversity of the Australian Alps national parks, even if some individual species are lost in the process. At present a great deal of effort is devoted to trying to save species (or sub-specific taxa) which might be doomed anyway. One unwelcome lesson which is clear from this study is that extinctions will occur, in our National Parks and outside them, at an accelerating rate. Nine species of the Australian Alps were considered by workshop groups as likely to be extinct within fifty years. The project workshop raised the dilemma of whether to save the saveable or try to save those most likely to perish but did not resolve it — and its resolution will probably be drawn out and difficult. The ultimate aim must be to conserve native biodiversity as comprehensively as possible with the limited resources available.

ANZECC and its subcommittees might be an appropriate forum to consider this as the issue is broader than the Australian Alps. A policy to apply resources to ecosystem management rather than to individual endangered species would need ministerial decision and possible legislative change.

Recommendation 16

That a process be developed to consider the appropriate emphasis on management for individual species compared with management of broader communities or ecosystems.

Recommendation 17

That so far as possible, consistently with the outcome of Recommendation 16, management be directed at ecological communities or ecosystems rather than individual species.

Essential to managing threats is good information on their ecological role and characteristics. This is a field well-suited to study by university students.

Recommendation 18

That park management agencies continue to encourage study by universities and university students of the ecology of threats and threatening processes, and provide all reasonable assistance to maximise the efficiency of information acquisition.

Many threats to the Australian Alps national parks are caused by people's desire for pleasure or profit. For example, trout bred and released for the benefit of anglers threaten native fish, frogs and probably some invertebrates. The skiing industry and the mountain pygmy-possum favour the same sites. Deer hunting and grazing are allowed in some Victorian national parks, but are considered inappropriate in other national parks.

Recommendation 19

That where threats arise from choice, the facts of the conflict be documented and made public so the choice is informed.

Effective ecological management requires the monitoring of key attributes, processes, treatments and issues. Comprehensive monitoring would provide a lot of information but would require considerable resources. Simplification to a few key indicators would reduce the cost but might provide almost as much essential information.

Recommendation 20

That a simple trans-alps ecological monitoring program be developed, based on a few key indicators. This might be undertaken efficiently by the parks agencies jointly with a university.

Recommended Action Plan

AALC to:

- Establish a task force to develop consistent, clear and meaningful management objectives (immediately).
- Establish a task force to standardise the approach to management of the Australian Alps national parks (immediately).

A single task force might be appropriate to undertake both the above functions.

- Develop and issue documentation proposed in Recommendation 1 (progressively).

NHWG to establish task forces to develop:

- a resource description document, building on the outputs of this project (immediately);
- a database, building on the outputs of this project (immediately);
- vegetation communities classification and map (within one year);
- management approaches for individual issues (progressively); and
- an ecological health monitoring program (within two years).

NHWG to initiate strategic studies into high priority threats and features identified in this plan (within one year).

NHWG to review and enhance or replace the priority setting system and repeat the priority setting exercise every two–three years (within two years).

NHWG and agencies to encourage partnerships with universities and volunteer groups for research, survey and monitoring activities (immediately).

Agencies, perhaps through an ANZECC committee, review the emphasis on managing individual species.

Bibliography

The great majority of the following references have been used in the text of this report or the database, but some have been included as relevant although they were not used. Additional relevant bibliographical references are listed in Appendix 2.

Publications or reports of the AALC are identified in the text by a "#" next to the author-date reference.

Wherever possible the Universal Resource Locater (URL) has been provided to enable remote users to gain electronic access to documents. The World Wide Web is a powerful tool, but its very nature is fluidity and flexibility. Web sites frequently change, so URLs often become outdated quite quickly. Readers will at least know that a document is available on the web and might still be able to find it if the URL listed here is no longer current.

AALC, 1986, Memorandum of Understanding

AALC, 1991, Australian Alps national parks Pest Species Workshop, Khancoban,

AALC, 1994, Alpine Ecology Course — course notes, AALC

AALC, 1995, Fire Management Planning Workshop, AALC

AALC, 1998, Instructions for use of the Scientific Sites Database, AALC

ACT Government, 1997, Fish Stocking Plan for the Australian Capital Territory, Environment ACT, Canberra.

ACT Government, 1998a, The ACT Nature Conservation Strategy, http://www.act.gov.au/environ/natstrat98/intro.html

ACT Government, 1998b, Fact Sheet No. 5 A. Subalpine Herb (*Gentiana baeuerlenii*) An endangered species , Environment ACT, Canberra http://www.act.gov.au/environ/factsheets/sheet5.html

ACT Government, 1998c, Fact Sheet No. 6 Northern Corroboree Frog (*Pseudophryne pengilleyi*) A. vulnerable species, Environment ACT, Canberra http://www.act.gov.au/environ/factsheets/sheet6.html

ACT Government, 1998d, Button Wrinklewort (Rutidosis leptorrhynchoides): An endangered species. Action Plan No. 8., Environment ACT, Canberra http://www.act.gov.au/environ/actionplans/BUTTONWR.html

ACT Government, 1999b, Brush-tailed Rock Wallaby (*Petrogale penicillata*): An endangered species., Action Plan No. 22. Environment ACT, Canberra http://www.act.gov.au/environ/actionplans/

ACT Government, 1999c, Button Wrinklewort *Rutidosis leptorrhynchoides*. Action Plan No. 8, Environment ACT, Canberra http://www.act.gov.au/environ/actionplans/BUTTONWR.html

ACT Government, 1999d, Macquarie Perch (*Macquaria australasica*) An endangered species, Action Plan No. 13. Environment ACT, Canberra http://www.act.gov.au/environ/actionplans/

ACT Government, 1999e, Murray River Crayfish (*Euastacus armatus*): A. vulnerable species, Action Plan No. 14. Environment ACT, Canberra http://www.act.gov.au/environ/actionplans/

ACT Government, 1999f, Regent honeyeater (*Xanthomyza phrygia*), Action Plan No. 20. Environment ACT, Canberra http://www.act.gov.au/environ/actionplans/

ACT Government, 1999g, Smokey Mouse (*Pseudomys fumeus*): An endangered species., Action Plan No. 23. Environment ACT, Canberra. http://www.act.gov.au/environ/actionplans/

ACT Government, 1999h, Swift parrot (*Lathamus discolor*), Action Plan No. 16. Environment ACT, Canberra http://www.act.gov.au/environ/actionplans/

ACT Government, 1999i, Trout Cod (*Maccullochella macquariensis*): An endangered species, Action Plan No. 12. Environment ACT, Canberra. http://www.act.gov.au/environ/actionplans/

ACT Government, 1999j, Two-spined Blackfish (*Gadopsis bispinosus*): A. vulnerable species., Action Plan No. 11. Environment ACT, Canberra. http://www.act.gov.au/environ/actionplans/

ACT Heritage Council, 1999, ACT Heritage Places Register, ACT Heritage Council http://www.act.gov.au/environ/heritage/list.html

ACT P&CS, 1986, Management Plan for Namadgi National Park, ACT, ACT P&CS

Adair R. J. & Groves R. H., 1998, Impact of Environmental Weeds on Biodiversity: A. Review and Development of a Methodology, BG EA

Albritton, D. L. & Kuijpers, L. (eds), 1999, Synthesis of the Reports of the Scientific, Environmental Effects, and Technology and Economic Assessment Panels of the Montreal Protocol, United Nations Environment Programme Ozone Secretariat http://www.unep.org/ozone/pdf/Synthesis-Complete.pdf

Amery, A., 1999, Noxious Weeds Act 1993. Order No 14. Order declaring certain plants to be noxious weeds and specifying control categories for noxious weeds., http://www.agric.nsw.gov.au/ap/weeds/order14.pdf

Anon, 1981, Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment (JAMBA), http://www.austlii.edu.au/au/other/dfat/treaties/1981/6.html

Anon, 1988, Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment (CAMBA), http://www.austlii.edu.au/au/other/dfat/treaties/1988/22.html

Anon, 1992, National Strategy for Ecologically Sustainable Development, AGPS, Canberra

Anon, 1996, The National Strategy for the Conservation of Australia’s Biological Diversity, http://www.environment.gov.au/portfolio/esd/biodiv/strategy/contents.html

Anon, 1999a, The National Weeds Strategy: A. Strategic Approach to Weed Problems of National Significance, ARMCANZ, ANZECC and Forestry Ministers http://www.nra.gov.au:80/corporate_docs/publications/pdf/nrm/landcare/nws.pdf

Anon, 1999b, Unwanted Falls Creek Resident, Parks Victoria and Falls Creek Management Board

Anon, 2000a, Draft National Blackberry Strategy, http://www.weeds.org.au/natsig.htm

Anon, 2000b, Draft National Strategy for Serrated Tussock, http://www.weeds.org.au/natsig.htm

ANPWS, 1992, Cats in Australia (leaflet), ANPWS, Canberra

ANZECC, 1998, National Koala Conservation Strategy, Environment Australia

ANZECC, 1999, ANZECC Threatened Fauna List, http://www.biodiversity.environment.gov.au/threaten/lists/anzecc/fauna-ind.htm

ANZECC Endangered Flora Network, 1999, Treatened Australian Flora, ANZECC

Armstrong, T., 1998, Impacts of Habitat Change on Alpine *Ranunculus* Species: Extinction Through Hybridization, in Australian Inst of Alpine Studies Newsletter No 1 http://www.aias.org.au/

Arthington, A. H. & Blühdorn, D. R., 1995, Improved Management of Exotic Aquatic Fauna: R&D for Australian Rivers, Occasional Paper 04/95. Land and Water Resources Research and Development Corporation, Canberra

Australian Council of National Trusts, 2000, Internet site of the Australian Council of National Trusts, http://www.austnattrust.com.au/frame.html

Australian Heritage Commission, 2000a, Register of the National Estate, http://www.environment.gov.au/heritage/register/

Australian Heritage Commission, 2000b, Register of the National Estate Database, Australian Heritage Commission http://www.environment.gov.au/heritage/register/

Australian Institute of Agricultural Science, 1976, The Threat of Weeds to Bushland. A. Victorian Study, Australian Institute of Agricultural Science

Australian Museum, 2000, Climbing Galaxias *Galaxias brevipinnis* Günther, 1866 http://www.austmus.gov.au/fishes/fishfacts/fish/gbrevi.htm

Australian National Botanic Gardens , 2000, Environmental Weeds in Australia, http://www.anbg.gov.au/weeds/weeds.html

Baker, B., Austin, M., Barnett, G., Kearns, A. & Shugart, H., 2000, Global Warming, Local Consequences...Can we predict the likely impacts of climate change in the ACT region?, http://www.act.gov.au/environ/greenhouse/greenchoice_typeset.pdf

Banks, J. C. G., 1989, A. History of Forest Fire in the Australian Alps , pages 265–280 in Good, R. (Ed), 1989, The Scientific Significance of the Australian Alps, AALC & Australian Academy of Science

Barker, J., 1990, Spiny freshwater crayfish management strategy, Fisheries management report No. 34, Department of Conservation and Environment, Victoria.

Barnham, C., 1998, Freshwater Fish of Victoria — Macquarie Perch, DNRE Notes Series No FN0050 http://www.nre.vic.gov.au/web/root/domino/infseries/infsheet.nsf/c3bc9da6cf25dd844a2565190029c480/21103fc1ee3512564a25664300095e73?OpenDocument

Bayly, I. A. E., 1999, Rock of Ages: Human use and natural history of Australian granites, University of Western Australia Press, Nedlands, WA

Bennett, B., 1995, Herefords or Herbfields?, Ecos 83 29–35???

Berger, L., Speare, R. & Hyatt, A., 1999, Chytrid fungi and amphibian declines: Overview, implications and future directions, pages 23–33 in Declines and Disappearances of Australian Frogs. EA http://www.environment.gov.au/bg/threaten/information/frogs/pubs/frogs.pdf

Berman, D., 1992, Feral Horse Biology, Reproduction, Behaviour and Population Predictions, pages 5–8 in Feral Horses in the Alps

Bloomfield, T. (ed), 1999a, Foxes and their impact, DNRE Landcare Notes No PA0014 http://www.nre.vic.gov.au/web/root/domino/infseries/infsheet.nsf/6adff5ed78795dc64a256516001f223e/b9ccca7af63932c14a2567520001cee9?OpenDocument

Bloomfield, T. (ed), 1999b, Foxes: some useful references, DNRE Landcare Notes No PA0023 http://www.nre.vic.gov.au/web/root/domino/infseries/infsheet.nsf/6adff5ed78795dc64a256516001f223e/9d5c60c8caf02d634a2566ca00174e52?OpenDocument

Boden, R., 1995, Regional overview: Australia and New Zealand, pp 433–518 in Centres of Plant Biodiversity. A. Guide and Strategy for their Conservation. Volume 2. Asia, Australasia, and the Pacific. WWF and IUCN. IUCN Publications Unit, Cambridge, UK

Bradstock, R. A., Keith, D. A. & Auld, T. D., 1995, Fire and conservation: imperitives and constraints on managing for diversity, pp 322–333 in Bradstock, R. A., Auld, T. D., Keith, D. A., Kingsford, R. T., Lunney, D., & Sivertsen, D. P. (eds), Conserving Biodiversity: Threats and Solutions, Surrey Beatty & Sons, Chipping Norton, NSW

Bramwells, H., 1993, Flora and Fauna Guarantee Action Statement No. 54 Leafy Greenhood *Pterostylis cucullata,* Department of Natural Resources & Environment, East Melbourne http://www.nre.vic.gov.au/

Brereton, R., 1998, The Potential Effect of the Enhanced Greenhouse Climate Change on Selected Flora and Fauna of the High Country of Mainland Australia, in Australian Inst of Alpine Studies Newsletter No 1 http://www.aias.org.au/

Briese, D. T., 1997, Population dynamics of St. John's wort in south-eastern Australia, pp 59–63 in St John's wort: *Hypericum perforatum* L. Integrated control and management. Proceedings of a workshop held at CSIRO Entomology, Canberra, ACT on 13–24 November 1997

Briggs, J. D., 1997, Impact of blackberry on an endangered species, p 179 in Towards an integrated management system for Blackberry (*Rubus fruiticosus* L. agg) Proceedings of a workshop held at Charles Sturt University, Albury, NSW on December 15–16 1997

Briggs, J. D. & Leigh, J. H., 1996, Rare or Threatened Australian Plants: 1995 Revised Edition. , CSIRO Publishing: Melbourne

Broome, L. S. & Green, K. , 1998, Re-assessment of Burramys parvus population size and distribution of habitat in Kosciuszko National Park: 1997 Progress Report. , AIAS Newsletter No 2 http://www.aias.org.au/

Broomhall, S., 1998a, The implications of ozone depletion for the Australian Alps: a review, pages (ACT Government 1999g)–247 Green, K. (Ed), 1998, Snow: A. Natural History; an Uncertain Future, AALC

Broomhall, S., 1998b, The Implications of Ozone Depletion on the Fauna of the Australian Alps, in Australian Inst of Alpine Studies Newsletter No 1 http://www.aias.org.au/

Brownsey, P. J., 1988, Aspleniaceae, Flora of Australia 48:295–327.

Bruzzese, E., 1997, The biology of blackberry in south-east Australia, pp 160–162 in Towards an integrated management system for Blackberry (*Rubus fruiticosus* L. agg) Proceedings of a workshop held at Charles Sturt University, Albury, NSW on December 15–16 1997

Bruzzese, E. & Lane, M., 1996, The Blackberry Management Handbook, Keith Turnbull Research Institute

Bruzzese, E., McLaren, D. A. & Grace, B., nd, Biological Control of Blackberry — an update, Keith Turnbull Research Institute

Bruzzese, E., Mahr, F. & Faithfull, I., 2000, [Draft] Best Practice Management Guide 5. Blackberry, *Rubus fruiticosus* aggregate, CRC for Weed Management Systems

Bunbury, S., 1992, Into the High Country, DCE, Melbourne

Bunn, S. & Arthington, A., 1997, Fragile Future. Downstream impacts of dams and flow regulation, Centre for Catchment and In-Stream Research. Faculty of Environmental Sciences, Griffith University

Busby, D., 1997, *Hypericum*: current control strategies in the Australian Capital Territory, p 101 in St John's wort: *Hypericum perforatum* L. Integrated control and management. Proceedings of a workshop held at CSIRO Entomology, Canberra, ACT on 13–24 November 1997

Busby, J., 1990, National and International Scientific Significance of National Parks in Eastern Victoria, DCE, Melbourne

Cadwallader, P. L., 1978, Some causes of the decline in range and abundance of native fish in the Murray-Darling River system, Proceedings of the Royal Society of Victoria 90: 211–(ACT Government 1999g).

Cadwallader, P. L., 1996, Overview of the Impacts of Introduced Salmonids on Australian Native Fauna., Australian Nature Conservation Agency, Canberra

Caling, T. M. & Adams, R., 1999, Ecological Impacts of Fire Suppression Operations in a Small Vegetation Remnant, Australian Bushfire Conference, Albury, July 1999. http://life.csu.edu.au/bushfire99/papers/

Campbell, A. (ed), 1999, Declines and Disappearances of Australian Frogs., EA http://www.environment.gov.au/bg/threaten/information/frogs/pubs/frogs.pdf

CCSERC (Conservation Council of the South-East Region and Canberra), 1996, ACT Weeds Strategy, http://www.spirit.com.au/envoz/weedweb/actstrat.htm

CCSERC (Conservation Council of the South-East Region and Canberra), 1998a, ACT Weed List, http://www.spirit.com.au/envoz/weedweb/weedlist.htm, wl2

CCSERC (Conservation Council of the South-East Region and Canberra), 1998b, WEEDWEB The ACT Environmental Weed Manual, http://www.spirit.com.au/envoz/weedweb/actweeds.html

China–Australia Migratory Birds Agreement, , http://www.austlii.edu.au/au/other/dfat/treaties/1988/22.html

Clarke, J., 1998, Science in High Places: Research and monitoring (1) Introduction and sites in NSW, Jo Clarke for the AALC

Clunie, P., 1994, Flora and Fauna Guarantee Action Statement No 60 White-bellied Sea-eagle *Haliaeetus leucogaster,* Department of Natural Resources & Environment, East Melbourne http://www.nre.vic.gov.au/

CoAG, 1992, Intergovernmental Agreement on the Environment, February 1992, Council of Australian Governments.

Cogger, H. G., 1994, Reptiles and Amphibians of Australia, Reed Books, Chatswood, NSW

Costin, A. B., 1989, The Alps in a Global Perspective, pp 7–19 in Good, R. (Ed), 1989, The Scientific Significance of the Australian Alps, AALC & Australian Academy of Science

Costin, A. B., Gray, M., Totterdell, C. J. & Wimbush, D. J., 1979, Kosciusko Alpine Flora, CSIRO, East Melbourne and Collins, Sydney

Cremer, K., 1999, Willow management for Australian rivers, pages 2–22 in Natural Resource Management Special Issue: December 1999.

Croom, M. & Crosby, M. P., 1997, Description of Dimensionless Analyses and Delphic Priority Ranking Methodologies for Selecting Marine and Coastal Protected Areas, pp 108–109 in Crosby, M. P., Geenen, K., Laffoley, D., Mondor, C. & O'Sullivan, G. Proceedings of the Second International Symposium and Workshop on Marine and Coastal Protected Areas: Integrating Science and Management. National Oceanic and Atmospheric Administration, Silver Spring, MD, USA.

Cross, J., 1990, The Feral Cat — Justification for its Control, a project submitted to the Charles Sturt University — Riverina

Csurhes, S. & Edwards, R., 1998, National Weeds Program — Potential Environmental Weeds in Australia — Candidate Species for Preventative Control, BG EA

Cullen, P., 1992, Management of water quality in the Australian Alps, pages 425–449 in Good, R. & Grenier, P. (eds), 1992, Les Alpes australiennes/The Australian Alps, AALC & Grenoble University (France)

Cullen, P. & Norris R., 1989, Significance of Lakes and Rivers in the Australian Mainland Alps, pp 281–295 in Good, R. (Ed), 1989, The Scientific Significance of the Australian Alps, AALC & Australian Academy of Science

Davies, N. & Norris, R., 1999, Development of a sampling framework for the Australian Alps stream health monitoring project, Cooperative Research Centre for Freshwater Ecology, Uni of Canberra

DCE, 1992a, Management Plan — Alpine National Park Bogong Unit, DCE, Melbourne

DCE, 1992b, Management Plan — Alpine National Park Cobberas–Tingaringy Unit, DCE, Melbourne

DCE, 1992c, Management Plan — Alpine National Park Dartmouth Unit, DCE, Melbourne

DCE, 1992d, Management Plan — Alpine National Park Wonangatta–Moroka Unit, DCE, Melbourne

DCNR, 1995a, Code of Practice for Fire Management on Public Land, DCNR, East Melbourne

DCNR, 1995b, Fire Management on Public Land in Victoria. Background Document prepared for the code of practice for fire management project, DCNR

DEGS, MMU (Department of Environmental and Geographical Sciences, Manchester Metropolitan University), 2000a, Climate Change Fact Sheet 10 Climate change in the 21st Century, http://www.doc.mmu.ac.uk/aric/ace/factsheets/facts_html.html

DEGS, MMU (Department of Environmental and Geographical Sciences, Manchester Metropolitan University), 2000b, Climate Change Fact Sheet 15 Climate Change, Ecosystems and Biodiversity, http://www.doc.mmu.ac.uk/aric/ace/factsheets/facts_-html.html

DEGS, MMU (Department of Environmental and Geographical Sciences, Manchester Metropolitan University), 2000c, Ozone Depletion Fact Sheet 14 Ozone Depletion and Aquatic Life, http://www.doc.mmu.ac.uk/aric/ace/factsheets/facts_html.html

DEGS, MMU (Department of Environmental and Geographical Sciences, Manchester Metropolitan University), 2000d, Ozone Depletion Fact Sheet 15 Effects on Land Vegetation, http://www.doc.mmu.ac.uk/aric/ace/factsheets/facts_html.html

DEGS, MMU (Department of Environmental and Geographical Sciences, Manchester Metropolitan University), 2000e, Ozone Depletion Fact Sheet 2 Ultraviolet Radiation, http://www.doc.mmu.ac.uk/aric/ace/factsheets/facts_html.html

Dickens, J., 1992, Flora and Fauna Guarantee Action Statement No. 30 Slender Myoporum *Myoporum floribundum*, Department of Natural Resources & Environment, East Melbourne http://www.nre.vic.gov.au/

Dickins, J. & White, M., , A. preliminary investigation into the distribution of *Juncus effusus* L. (Soft Rush) in Victorian sub-alpine peneplain., Unpublished report to the NPS, DNRE

Dickman, C. R., 1996, Overview of the Impacts of Feral Cats on Australian Native Fauna, ANCA

DNRE, 1995, Snowy River National Park Management Plan, DNRE, East Melbourne

DNRE, 1996a, Mount Buffalo National Park Management Plan, DNRE, East Melbourne

DNRE, 1996b, Atlas of Victorian Wildlife,

DNRE, 1997a, Heritage Rivers and Natural Catchment Areas — Draft Management Plans — Volume 2 — North East, DNRE, East Melbourne

DNRE, 1997b, Heritage Rivers and Natural Catchment Areas — Draft Management Plans — Volume 3 — Gippsland, DNRE, East Melbourne

DNRE, 1997c, Mountain Pygmy-possum: Managing an Endangered Species (leaflet), DNRE, East Melbourne

DNRE, 1997d, Victoria's Biodiversity: Directions in Management, DNRE, East Melbourne

DNRE, 1998, Victoria's Biodiversity: Sustaining our living wealth, DNRE, East Melbourne

DNRE, 1999a, [Draft] North East Region Interim Wild Dog Action Plan, DNRE

DNRE, 1999b, [Draft] Wild Dog Management East Gippsland 1999–2003, DNRE

DNRE, 1999c, [Draft] Wild Dog Management Victoria 1999–2003, DNRE

DNRE, 1999d, [Draft] Wild Dog Management West Gippsland 1999–2003, DNRE

DNRE, 1999e, Victorian Weeds Strategy, DNRE, East Melbourne

DNRE, 1999f, Victorian Weeds Strategy, http://www.nre.vic.gov.au/plntanml/pests/weedstrategy/

DNRE, 1999g, Victoria's Biodiversity: Our living wealth, DNRE, East Melbourne

DNRE, 2000a, Threatened Species Information Sheet. Brush-tailed Rock-wallaby *Petrogale penicillata*, Department of Natural Resources & Environment, East Melbourne http://www.nre.vic.gov.au/web/root/domino/cm_da/nrenpa.nsf/frameset/NRE+Plants+and+Animals?OpenDocument&[/web/root/domino/cm_da/nrecpa.nsf/bc56f7d98e22b2434a2568a90007e67a/b804c90a4ae8a23d4a25680900025142?OpenDocument]

DNRE, 2000b, Threatened Species Information Sheet. Long-footed Potoroo *Potorous longpipes* , Department of Natural Resources & Environment, East Melbourne http://www.nre.vic.gov.au/web/root/domino/cm_da/nrenpa.nsf/frameset/NRE+Plants+and+Animals?OpenDocument&[/web/root/domino/cm_da/nrecpa.nsf/bc56f7d98e22b2434a2568a90007e67a/2eb1e24180fafd3d4a2568090022b163?OpenDocument]

DNRE, , Flora Information System, DNRE, Heidelberg

Douglas, J. W., Gooley, G. J. & Ingram, B. A., 1994, Trout Cod, *Maccullochella macquariensis* (Cuvier) (Pisces: Percichthyidae) , Resource Handbook and Research and Recovery Plan

Dove, A. D. M., 1998, A. silent tragedy: parasites and the exotic fishes of Australia, Proceedings of the Royal Society of Queensland 107: 109–113

Dove, A.D.M. & Ernst, I., 1998, Concurrent invaders – four exotic species of *Monogenea* now established on exotic freshwater fishes in Australia , International Journal for Parasitology 28: 1755–1764

Downing. A.J., Selkirk, P.M. & Oldfield, R.J., 1997, The mosses of the Yarrangobilly Caves district, New South Wales, Australia — A. review of the mosses collected by the Reverend W. W. Watts in 1906, *J. Hattori Bot. Lab. No. 82: 105–121*

Driver, P. D., Harris, J. H., Norris, R. H. & Closs, G. P., 1997, The role of the natural environment and human impacts in determining biomass densities of common carp in New South Wales Rivers, Pp (ACT Government 1999b)–250 in Harris, J. H. & Gehrke, P. C. (eds) Fish and Rivers in Stress: The NSW Rivers Survey. New South Wales Fisheries and the Cooperative Research Centre for Freshwater Ecology

Duncan, A., 1997a, R.O.T.A.P. species in Kosciuszko National Park, Folder in Jindabyne NPWS office

Duncan, A., 1997b, Threatened Plants in Kosciuszko National Park. NSW Scheduled List and ROTAP List, Folder in NPWS Jindabyne office

Dunn, J., 1980, Sambar Deer in Kosciusko National Park , NPWS unpub report

Dyring, J., 1990, The impact of feral horses (*Equus caballus*) on sub-alpine and montane environments in Australia, M.App.Sc. Thesis, University of Canberra

Dyring, J., 1992, The impact of feral horses on sub-alpine and montane environments in Australia, pages 13–14 in Feral Horses in the Alps

Eberhard, S. & Spate A., 1995, Cave Invertebrate Survey: Toward an Atlas of NSW Cave Fauna, Copyright Dept Urban Affairs and Planning and the Australian Heritage Commission

Ecology Australia, 1995, Distribution and Management of Willows (*Salix*) in the Australian Alps national parks, AALC

Edgar, G., 1969, Report to the Honourable T. L. Lewis, Minister for Lands, on Investigations into Controlled Grazing and Longer Term Leases in the Kosciusko National Park

Elliot, W. R. & Jones, D. L., 1993, Encyclopedia of Australian Plants Suitable for Cultivation, Vol 6, Lothian Books, Melbourne

Endangered Species Advisory Committee, 1992, Australian National Strategy for the Conservation of Australian Species and Communities Threatened with Extinction, ANPWS, Canberra http://www.biodiversity.environment.gov.au/threaten/strategy/strategy.htm

Environment Australia, 1998, Biodiversity. Nature's Variety — Our Heritage — Our Future, Environment Australia

Environment Australia, 1999a, Threat Abatement Plan for Competition and Land Degradation by Feral Goats, BG EA http://www.biodiversity.environment.gov.au/wildlife/plans/tap/land_deg-goats/

Environment Australia, 1999b, Threat Abatement Plan for Competition and Land Degradation by Feral Rabbits, BG EA http://www.biodiversity.environment.gov.au/wildlife/plans/tap/land_deg-rabbits/

Environment Australia, 1999c, Threat Abatement Plan for Dieback caused by the root-rot fungus (Phytophthora cinnamomi), EA http://www.biodiversity.environment.gov.au/wildlife/plans/tap/root-rot/rootrot.pdf

Environment Australia, 1999d, Threat Abatement Plan for Predation by Feral Cats, BG EA http://www.biodiversity.environment.gov.au/wildlife/plans/tap/predation-cats/index.htm

Environment Australia, 1999e, Threat Abatement Plan for Predation by the European Red Fox, Environment Australia http://www.biodiversity.environment.gov.au/wildlife/plans/tap/predation-foxes/

Environment Australia, 2000, A. Directory of Important Wetlands in Australia (new edition available only on the www) , Environment Australia http://www.environment.gov.au/wetlands/

Environment Australia, nd, A. National Overview of Phytophthora cinnamomi in Australia — Supplementary information to accompany the draft national Threat Abatement Plan, Environment Australia

Fallavollita, E. & Norris, K., 1992, The occurrence of Broom, *Cytisus scopariu*s, in the Australian Alps National Parks, AALC

Faragher, R. A. & Lintermans, M., 1997, Alien fish species from the New South Wales rivers survey, Pp 201–223 in Harris, J. H. & Gehrke, P. C. (eds) Fish and Rivers in Stress: The NSW Rivers Survey. New South Wales Fisheries and the Cooperative Research Centre for Freshwater Ecology

Faragher, R. A., Brown, P. & Harris, J. H., 1993, Population surveys of the endangered fish species trout cod (*Maccullochella macquariensis*) and eastern cod (*M. ikei*), Report for the Australian National Parks and Wildlife Service Endangered Species Program. NSW Fisheries, Cronulla

Fire Ecology Working Group, 1999, Interim Guidelines and Procedures for Ecological Burning on Public Land in Victoria, DNRE and Parks Victoria

Fletcher, A. R., 1986, Effects of introduced fish in Australia, Pp 231–238 in De Decker, P. & Williams, W. D. (Eds) Limnology in Australia. CSIRO, Melbourne and Junk, Dordrecht

Forward, L. & Hag, R. M.,1997, Alps Vegetation Fire Response Monitoring System —final project report, AALC

Gare, N. C., 1992, The Snowy Mountains Scheme, pages 201–(ACT Government 1999b) in Good, R. & Grenier, P. (eds), 1992, Les Alpes australiennes/The Australian Alps, AALC & Grenoble University (France)

Gibbs, R., 1993, Horse Riding Management Strategy A. report on issues relating to the management of recreational horse riding in the Australian Alps National Parks, AALC

Gill, A. M., Moore, P. H. R. and Martin, W. K. , 1994, Bibliography of Fire Ecology in Australia (including Fire Science and Fire Management), Edition 4., NSW National Parks and Wildlife Service, Hurstville. http://lorenz.mur.csu.edu.au/firenet/firebib.html

Gillespie, G. R., 1999, New South Wales Recovery Plan for the Booroolong Frog *Litoria booroolongensis* — Background Information, Arthur Rylah Institute, Heidelberg, Victoria

Gillespie, G. R., Osborne, W. S. & McElhinney, N. A., , The Conservation Status of Frogs in the Australian Alps: A. Review, AALC

Given, D. R. & Morrison, K., 1998, Ecological and Hydrological Aspects of Global Warming in New Zealand, in Australian Inst of Alpine Studies Newsletter No 1 http://www.aias.org.au/

Good, R. (Ed), 1989, The Scientific Significance of the Australian Alps, AALC & Australian Academy of Science

Good, R., 1992a, Kosciusko Heritage. The Conservation Significance of Kosciusko National Park, NSW NPWS

Good, R., 1992b, The Australian Alps, pages 39–63 in Good, R. & Grenier, P. (eds), 1992, Les Alpes australiennes/The Australian Alps, AALC & Grenoble University (France)

Good, R., 1992c, Vegetation management in the Alps, pages 361–379 in Good, R. & Grenier, P. (eds), 1992, Les Alpes australiennes/The Australian Alps, AALC & Grenoble University (France)

Good, R., 1995, Australia:CPD Site AU 1. Australian Alps New South Wales, Victoria and Australian Capital Territory, Australia, pp458–461 in Boden, R., 1995, Regional overview: Australia and New Zealand, pp 433–518 in Centres of Plant Biodiversity. A. Guide and Strategy for their Conservation. Volume 2. Asia, Australasia, and the Pacific. WWF and IUCN. IUCN Publications Unit, Cambridge, UK

Good, R., 1998a, Changing snow regimes and the distribution of alpine vegetation, pages 98–112 in Green, K. (Ed), 1998, Snow: A. Natural History; an Uncertain Future, AALC

Good, R., 1998b, The impacts of predicted changes in snow regimes on the distribution of alpine vegetation., in Australian Inst of Alpine Studies Newsletter No 1 http://www.aias.org.au/

Good, R. & Grenier, P. (eds), 1992, Les Alpes australiennes/The Australian Alps, AALC & Grenoble University (France)

Gooey, M., 1999, Wayward willows weep, pages 23–25 in Natural Resource Management Special Issue: December 1999.

Green, K., 1995, A. Checklist of the Fauna Occurring Above 1500 m in Kosciusko National Park, Unpublished, Kosciuszko National Park

Green, K., 1998, A. winter niche: the subnivean space, pages 125–140 in Green, K. (Ed), 1998, Snow: A. Natural History; an Uncertain Future, AALC

Green, K. (Ed), 1998, Snow: A. Natural History; an Uncertain Future, AALC

Green, K. & Osborne, W., 1994, Wildlife of the Australian Snow-Country, Reed Books, Chatswood

Green, K. & Osborne, W.S., 1998, Snow as a defining character of the alpine/subalpine fauna, pp 141–164 in Green, K. (Ed), 1998, Snow: A. Natural History; an Uncertain Future, AALC

Green, K. (ed), Feb-98, Australian Inst of Alpine Studies Newsletter No 1, Australian Institute of Alpine Studies http://www.aias.org.au/

Green, K., Mansergh, I. R. & Osborne, W. S. 1992, The fauna of the Australian Alps: conservation and [management], pp 381–407 in Good, R. & Grenier, P. (eds), 1992, Les Alpes australiennes/The Australian Alps, AALC & Grenoble University (France)

Griffiths, T. & Robin, U., 1994, Science in High Places Report on the cultural significance of scientific sites in the Australian Alps, AALC

Groves R. H., 1998, Grazing in the Victorian High Country. An assessment of the scientific adequacy of grazing studies in the Victorian High Country 1945–1998, with some recommendations for future research., Report to Parks Victoria; CSIRO Plant Industry, Canberra

Groves, R. H., 1996, St John's wort: Introduction, pp 1–2 in St John's wort: *Hypericum perforatum* L. Integrated control and management. Proceedings of a workshop held at CSIRO Entomology, Canberra, ACT on 13–24 November 1997

Groves, R. H. & Willis, A. J., 1999, Environmental weeds and loss of native plant biodiversity: some Australian examples, Aus. J. Env. Mgt. 6:164–171

Groves, R. H., Williams, J. & Corey, S., 1998, Towards an integrated management system for Blackberry (*Rubus fruiticosus* L. agg) Proceedings of a workshop held at Charles Sturt University, Albury, NSW on December 15–16 1997, Plant Protection Quarterly Vol 13(4)

Haiblen, J. (compiler), 2000, Sites of Significance Database for Namadgi NP,

Hall, T., 1992, "Banjo" Patterson's High Country, Cornstalk Publishing, Pymble, NSW

Hancock, W. K. (Sir Keith), 1972, Discovering Monaro. A. Study of Man's Impact on his Environment , Cambridge University Press, London

Harding, M. A., 1999, Southland Protection Strategy, Nature Heritage Fund, Wellington, NZ

Harris, J., 1992, Acceptable impacts — Bona Fide Horse Operations, page 25 in Feral Horses in the Alps

Harris, J.H., 1999, Threatened Aquatic Species of the Snowy Hydro Scheme Area. Reeport prepared for Environment Australia, September 1999

Harris, J. H. & Rowland, S. J., 1996a, Australian freshwater cods and basses, pp 150–163 in Freshwater Fishes of South-eastern Australia [second edition] (R McDowall, ed) Reed Books, Sydney

Harris, J. H. & Rowland, S. J., 1996b, Family Percichthyidae: Australian freshwater cods and basses, Pp 150–163 in McDowall, R. M. (Ed.) Freshwater Fishes of South-eastern Australia. Second edition. Reed Books, Australia

Hayes, M., 1999, Before We're Forgotten. The Spirit of the Snowy River, ABC Books, Sydney

Helms, R., 1893, Report on the Grazing Leases of the Mount Kosciusko Plateau, Agricultural Gazette of NSW v4: 530–531

Hiebert, R. D. & Stubbendieck, J., 1993, Handbook for Ranking Exotic Plants for Management and Control, US National Park Service, Natural Resources Publication Office, Denver, Colorado http://www.nature.nps.gov/pubs/ranking/

Higgins, P.J. (ed), 1999, Handbook of Australia, New Zealand & Antarctic Birds. Volume 4 Parrots to Dollarbird. Oxford University Press, Melbourne

Higgins, P.J. & Davies, S.J.J.F. (eds), 1996, Handbook of Australia, New Zealand & Antarctic Birds. Volume 3 Snipe to Pigeons. Oxford University Press, Melbourne

Hill, R. & Baker-Gabb, D., 1991, Flora and Fauna Guarantee Action Statement No. 19 Brush-tailed Rock-wallaby *Petrogale penicillata,* Department of Natural Resources & Environment, East Melbourne http://www.nre.vic.gov.au/

Holth, T., 1980, Cattlemen of the High Country, Rigby, Sydney

Horner, A. & Platt, S., 1993, Foxes — options for control in wildlife habitat, DNRE Land for Wildlife Notes No LW0024 http://www.nre.vic.gov.au/web/root/domino/infseries/infsheet.nsf/6adff5ed78795dc64a256516001f223e/2c44442070581e814a256602001ce8a3?OpenDocument

Horwitz, P., 1990, The conservation status of Australian freshwater crustacea, Australian National Parks and Wildlife Service, Report Series 14. Canberra.

Horwitz, P., 1995, The conservation status of Australian freshwater crayfish: review and update, Freshwater Crayfish 10: 70–80.

Hosking, J. R., Sheppard, A. W. & Smith, J. M. B., 2000, [Draft] Best Practice Management Guide 2. Broom, *Cytisus scoparius*, CRC for Weed Management Systems

Humphries, R. K., 1993, Flora and Fauna Guarantee Action Statement No 47 Hairy Anchor Plant *Discaria pubescens,* Department of Natural Resources & Environment, East Melbourne http://www.nre.vic.gov.au/

Humphries, R. & Seebeck, J., 1997, Flora and Fauna Guarantee Action Statement No 79 Brush-tailed Phascogale *Phascogale tapoatafa,* Department of Natural Resources & Environment, East Melbourne http://www.nre.vic.gov.au/

Humphries, R.K. & Webster, A., 1992, Flora and Fauna Guarantee Action Statement No. 28 Button Wrinklewort *Rutidosis leptorrhynchoides,* Department of Natural Resources & Environment, East Melbourne http://www.nre.vic.gov.au/

Hunter, D., Osborne, W. & Smith, M., 1997, Distribution and abundance of the Alpine Tree Frog (*Litoria verreauxii alpina*) in the Australian Alp's National Parks: report on the first seasons survey 1996–1997, AALC

Irwin, F. & Rogers, J., reprinted 1991, Above the Treeline: How the High Country Was Rescued, Soil Conservation Service of NSW

IUCN, 2000, Threatened Animals of the World, http://www.wcmc.org.UK/species/animals/animal_redlist.html

Jackson, P. D., 1981, Trout introduced into south-eastern Australia: Their interaction with native fishes, Victorian Naturalist 98: 18–24

Jackson, P. D. & Williams, W. D., 1980, Effects of brown trout, *Salmo trutta* L., on the distribution of some native fishes in three areas of southern Victoria, Australian Journal of Marine and Freshwater Research 31: 61–67

Jackson, P. D., Koehn, J. D., Lintermans, M. & Sanger, A. C., 1996, Family Gadopsidae: Freshwater blackfishes, Pp 186–190 in McDowall, R. M. (Ed.) Freshwater Fishes of South-eastern Australia. Second edition. Reed Books, Australia.

James, M. & Morey, J., 1993, Flora and Fauna Guarantee Action Statement No 55 Baw Baw Frog *Philoria frosti,* Department of Natural Resources & Environment, East Melbourne http://www.nre.vic.gov.au/

Japan–Australia Migratory Birds Agreement, , http://www.austlii.edu.au/au/other/dfat/treaties/1981/6.html

JCVRFASC (Joint Commonwealth and Victorian Regional Forest Agreement (RFA) Steering Committee), 1998a, North East Victoria — Comprehensive regional assessment report, Joint Commonwealth and Victorian Regional Forest Agreement (RFA) Steering Committee http://www.rfa.gov.au/rfa/vic/ne/index.html

JCVRFASC (Joint Commonwealth and Victorian Regional Forest Agreement (RFA) Steering Committee), 1998b, North-east Victoria Biodiversity Assessment, joint Commonwealth and Victorian Regional Forest Agreement (RFA) Steering Committee http://www.rfa.gov.au/rfa/vic/ne/index.html

JCVRFASC (Joint Commonwealth and Victorian Regional Forest Agreement (RFA) Steering Committee), 1999, Gippsland Comprehensive Regional Assessment Report, joint Commonwealth and Victorian Regional Forest Agreement (RFA) Steering Committee http://www.rfa.gov.au/rfa/vic/gipps/index.html

JCVRFASC (Joint Commonwealth and Victorian Regional Forest Agreement (RFA) Steering Committee), 1996, East Gippsland Environment and Heritage Report, joint Commonwealth and Victorian Regional Forest Agreement (RFA) Steering Committee http://www.rfa.gov.au/rfa/vic/east/index.html

Jessup, H., 1995a, Methods of Native Rehabilitation over Logged Pine, Plantations: Literature Review/Research, AALC

Jessup, H., 1995b, Methods of removal or control of pine wildings from Native Forests, AALC

Johnston, F. M., 2000, Review on the ecology of *Achillea millifolium* and its implications for Koscuizsko National Park, Australia., Unpub. draft paper

Johnston, F. M. & Pickering, C. M., 2000, Alien plants in the Australian Alps, Draft paper

Johnston, S., in press, The influence of Aeolian dust deposits on Alpine Soils in South-East Australia, Journal of Soil Research

Johnston, S. & Ryan, M., in press, Occurrence of Arbuscular Mycorrhizal Fungi Across a Range of Alpine Humus Soil Conditions in Kosciuszko National Park, Australia , Journal of Arctic, Antarctic and Alpine Research

Johnston, S. W., 1998, Managing degraded Alpine Humus Soils in Kosciuszko National Park NSW: 1 — Soil Properties, ASSSI National Soils Conference, Brisbane

Jones, H. A., Rutzou, T. & Kukolic, K., 1990, Distribution and relative abundance of fish in the Naas–Gudgenby catchment, Research Report 3, ACT Parks and Conservation Service, Canberra

Jupp, P. W., Briese, D. T. & Groves, R. H. (eds), 1997, St John's wort: *Hypericum perforatum* L. Integrated control and management. Proceedings of a workshop held at CSIRO Entomology, Canberra, ACT on 13–24 November 1997, Plant Protection Quarterly Vol 12(2)

Kanowski, PJ; Gilmour, DA; Margules, CR; and Potter, CS, 1999, International Forest Conservation: Protected Areas and Beyond, Commonwealth of Australia

Keith Turnbull Research Institute, 1992, Biological control of European Blackberry by the rust fungus *Phragmidium violaceum,* Keith Turnbull Research Institute

Keith Turnbull Research Institute, , Biological control of English Broom — Annual Report 1996–97, Keith Turnbull Research Institute

Keith Turnbull Research Institute, 1998a, English broom, DNRE Landcare Notes No PP0041 http://www.nre.vic.gov.au/web/root/domino/infseries/infsheet.nsf/6adff5ed78795dc64a256516001f223e/eb64f6dd641f05974a256652001c10d5?OpenDocument

Keith Turnbull Research Institute, 1998b, Under Control: Pest Plant and Animal Management News (Number 5), KTRI, Frankston

Kershaw, A. P. & Strickland, K. M., 1989, The Development of Alpine Vegetation over the Australian Mainland, pages 113–126 in Good, R. (Ed), 1989, The Scientific Significance of the Australian Alps, AALC & Australian Academy of Science

Kershaw, A. P., James S. C. & Gill, A. M., 1999, A. history of fire in Australia, Australian Bushfire Conference, Albury, July 1999. http://life.csu.edu.au/bushfire99/papers/

Kestell Research, 1988, The Australian Alps National Parks Co-operative Management. A. bibliography of information on the conservation and management of alpine ecosystems, ANPWS, Canberra (Report Series No 13)

Kirkpatrick, J., 1994, The International Significance of the Natural Values of the Australian Alps, a report to the Australian Alps Liaison Committee

Knutson, R., 1996, *Hypericum* in National Parks: current control strategies in New South Wales, pp 102–103 in St John's wort: *Hypericum perforatum* L. Integrated control and management. Proceedings of a workshop held at CSIRO Entomology, Canberra, ACT on 13–24 November 1997

Koehn, J. D. & O'Connor, W. G., 1990b, Threats to Victorian native freshwater fish, Victorian Naturalist 107: 5–12.

Koehn, J. D., Gehrke, P. C. & Brumley, A. R., 2000, Managing the Impacts of Carp, Bureau of Rural Sciences, Canberra.

Laffoley, D., Coyne, P., Ray, G. C. & Crosby, M. P., 1997, Overview of Group Evaluation Process, Comments and Results of the Dimensionless Analyses and Delphic Exercises, pp 110–117 in Crosby, M. P., Geenen, K., Laffoley, D., Mondor, C. & O'Sullivan, G. Proceedings of the Second International Symposium and Workshop on Marine and Coastal Protected Areas: Integrating Science and Management. National Oceanic and Atmospheric Administration, Silver Spring, MD, USA.

Land Conservation Council, 1979, AlpineArea — Final Recommendations, Land Conservation Council, Melbourne

Land Conservation Council, 1983, AlpineArea Special Investigation — Final Recommendations, Land Conservation Council, Melbourne

Land Conservation Council, 1991, Rivers and Streams Special Investigation — Final Recommendations, Land Conservation Council, Melbourne

Land Conservation Council, 1991, Wilderness Special Investigation — Final Recommendations, Land Conservation Council, Melbourne

Lane, B.A. & Parish, D., 1991, A review of the Asian–Australian flyway system. Pp 291–312 in Salathe, T. (ed) Conserving Migratory Birds, ICBP, Cambridge, UK

Langdon, J. S., 1989b, Experimental transmission and pathogenicity of epizootic haematopoietic necrosis virus (EHNV) in redfin perch *Perca fluviatilis* L. & 11 other teleosts, Journal of Fish Diseases 12: 295–310

Langdon, J. S. & Humphrey, J. D., 1987, Epizootic haematopoietic necrosis, a new viral disease in redfin perch *Perca fluviatilis* L., in Australia, Journal of Fish Diseases 10: 289–297

Larson, H. K. & Hoese, D. F., 1996, Family Gobiidae, subfamilies Eleotridinae and Butinae. Gudgeons, pp 200–219 in Freshwater Fishes of South-eastern Australia [second edition] (R McDowall, ed) Reed Books, Sydney

Leigh, J. H. & Briggs, J. D. (eds), 1992, Threatened australian plants: overview and case studies, ANPWS

Leigh, J. H., Boden, R. & Briggs, J. D. (eds), 1984, Extinct and Endangered Plants of Australia, Macmillan, South Melbourne

Lennon, J., 1992, European Exploration, pages 143–154 in B. Scougall (ed) Cultural Heritage of the Australian Alps. AALC

Lintermans, M., 1986, The broad-toothed rat *Mastacomys fuscus* in the ACT., ACT Parks and Conservation Service, unpublished internal report

Lintermans, M., 1988, A. survey of Mt. Kelly for *Pseudomys fumeus* — Progress Report, Unpublished internal report, ACT Parks and Conservation Service

Lintermans, M., 1991a, The decline of native fish in the Canberra region: The effects of habitat modification, Bogong 12(3): 4–7.

Lintermans, M., 1991b, The decline of native fish in the Canberra region: The impacts of introduced species, Bogong 12(4): 18–22.

Lintermans, M., 1992, The Murray cray fishery in the ACT – Review and options for management, Internal Report 92/6 ACT Parks and Conservation Service.

Lintermans, M., 1993a, Oriental weatherloach *Misgurnus anguillicaudatus* in Lake Burrinjuck, Unpublished report to NSW Fisheries

Lintermans, M., 1993b, Oriental weatherloach *Misgurnus anguillicaudatus* in the Cotter River: A. new population in the Canberra region, Technical Report 4, ACT Parks and Conservation Service

Lintermans, M., 1993c, A. reprieve for Murray crays in the ACT, Bogong 14(4): 8–9.

Lintermans, M., 1995, The status of trout cod *Maccullochella macquariensis* in Bendora Reservoir, ACT: Results of 1992/93 and 1995 monitoring, Internal Report 95/4, ACT Parks and Conservation Service

Lintermans, M., 1998a, The Ecology of the Two-spined Blackfish *Gadopsis bispinosus* (Pisces: Gadopsidae), Unpublished M. Sc thesis, Division of Botany and Zoology, Australian National University, Canberra

Lintermans, M., 1998b, The Need for Enhanced Environmental Flows in the upper Murrumbidgee River below Tantangara Reservoir, Submission to the Snowy Water Inquiry

Lintermans, M., 2000a, The successful re-establishment of the endangered fish Macquarie Perch *Macquaria australasica* in the Queanbeyan River, CRC for Freshwater Ecology Technical Report (In Press)

Lintermans, M., 2000b., Recolonisation by the Mountain Galaxias *Galaxias olidus* of a montane stream after the eradication of rainbow trout *Oncorhynchus mykiss* , Manuscript submitted to Marine and Freshwater Research

Lintermans, M., 2000c, Comments on draft database, pers. comm.

Lintermans, M. & Burchmore, J., 1996, Family Cobitidae: Loaches, Pp 114–115 In: McDowall, R. M. (ed.). Freshwater Fishes of South-eastern Australia. Reed Books. Sydney

Lintermans, M. & Rutzou, T., 1990a, A. new locality for the two-spined blackfish (Gadopsis bispinosus) outside Victoria, Victorian Naturalist 107: 26–27

Lintermans, M. & Rutzou, T., 1990b, The fish fauna of the Cotter River catchment, Research Report 4, ACT Parks and Conservation Service, Canberra

Lintermans, M. & Rutzou, T., 1991, The status, distribution and management of the Murray crayfish Euastacus armatus in the Australian Capital Territory , Research Report 6 ACT Parks and Conservation Service.

Lintermans, M. Kukolic, K. & Rutzou, T., 1988, The Status of the trout cod, *Maccullochella macquariensis* in the Australian Capital Territory, Victorian Naturalist 105: 205–207.

Lintermans, M., Rutzou, T. & Kukolic, K., 1990a, The status, distribution and possible impacts of the oriental weatherloach Misgurnus anguillicaudatus in the Ginninderra Creek catchment, Research Report 2, ACT Parks and Conservation Service

Lintermans, M., Rutzou, T. & Kukolic, K., 1990b, Introduced fish of the Canberra region – recent range expansions, In: D. Pollard (ed.), Australian Society for Fish Biology Workshop: Introduced and Translocated fishes and their Ecological effects. Bureau of Rural Resources Proceedings No. 8, Australian Government Publishing Service, Canberra

Low, T., 1999, Feral Futures, Viking, Ringwood, Victoria

McArthur, K., 2000, Broom (*Cytissus scoparius*) Management Strategy for the AANP, KTRI, Frankston

McDougall, K. (compiler), 1982, The Alpine Ecosystem — An Indexed Bibliography, Soil Conservation Authority, Kew

McDougall, K., 1989, The Effect of Excluding Cattle from a Mossbed on the Bogong High Plains, Victoria, Arthur Rylah Institute for Environmental Research, Technical Report Series No. 95

McDowall, R. M., 1996a, Family Prototroctidae Southern Graylings, pp 96–98 in Freshwater Fishes of South-eastern Australia [second edition] (R McDowall, ed) Reed Books, Sydney

McDowall, R. M. , 1996b, Family Poeciliidae Livebearers, pp 200–219 in Freshwater Fishes of South-eastern Australia [second edition] (R McDowall, ed) Reed Books, Sydney

McDowall, R. M. & Fulton, W., 1996, Family Galxiidae Galaxiids, pp 52–77 in Freshwater Fishes of South-eastern Australia [second edition] (R McDowall, ed) Reed Books, Sydney

Macfarlane, M., Lowe, K. W. & Smith, J., 1995, Flora and Fauna Guarantee Action Statement No 62 Leadbeater's Possum *Gymnobelideus leadbeateri,* Department of Natural Resources & Environment, East Melbourne http://www.nre.vic.gov.au/

Mallen-Cooper, J., 1990, Introduced plants in the high altitude environments of Kosciusko National Park, South-eastern Australia, Thesis submitted for the deegree of Doctor of Philosophy, Department of Biogeography and Geomorphology, Australian National University

Mansergh, I. & Marks, C., 1993, Predation of Native Wildlife by the Introduced Red Fox *Vulpes vulpes,* DNRE Action Statement No. 44 http://www.nre.vic.gov.au/web/root/domino/cm_da/nrenpa.nsf/frameset/NRE+Plants+and+Animals?OpenDocument&[/4A25676D00283C7B/BCView/369E80C85605E6454A25684E001E0368?OpenDocument]

Mansergh, I., Kelly, P. & Johnston, G., 1991, Action Statement No 02 Mountain Pygmy-possum *Burramys parvus,* DNRE http://www.nre.vic.gov.au/web/root/domino/cm_da/nrenpa.nsf/frameset/NRE+Plants+and+Animals?OpenDocument

Mansergh, I., Kelly, P. & Scotts, D., 1989, Management strategy and guidelines for the conservation of the Mountain Pygmy-possum, (*Burramys parvus*) in Victoria, Arthur Rylah Institute for Environmental Research Technical Report Series No. 66

Mansergh, I. & Belcher, C., 1992, Flora and Fauna Guarantee Action Statement No 15 Tiger Quoll *Dasyurus maculatus,* Department of Natural Resources & Environment, East Melbourne http://www.nre.vic.gov.au/

Marchant, S. and Higgins, P.J. (eds), 1993, Handbook of Australia, New Zealand & Antarctic Birds. Volume 2 Raptors to Lapwings. Oxford University Press, Melbourne

Maxwell, S., Burbidge, A. A. & Morris, K. (eds), 1996a, Action Plan for Australian Marsupials and Monotremes. Taxon summary: Brush-tailed Phascogale (S mainland), Environment Australia http://www.biodiversity.environment.gov.au/threaten/plans/action/marsupials/25.htm

Maxwell, S., Burbidge, A. A. & Morris, K. (eds), 1996b, Action Plan for Australian Marsupials and Monotremes. Taxon summary: Koala, Environment Australia http://www.biodiversity.environment.gov.au/threaten/plans/action/marsupials/25.htm

Maxwell, S., Burbidge, A. A. & Morris, K. (eds), 1996c, Action Plan for Australian Marsupials and Monotremes. Taxon summary: Squirrel Glider, Environment Australia http://www.biodiversity.environment.gov.au/threaten/plans/action/marsupials/29.htm

Maxwell, S., Burbidge, A. A. & Morris, K. (eds), 1996d, Action Plan for Australian Marsupials and Monotremes. Taxon summary: Yellow-bellied Glider (S subspecies), Environment Australia http://www.biodiversity.environment.gov.au/threaten/plans/action/marsupials/28.htm

Mayo, G., 1987, The smokey mouse (*Pseudomys fumeus*) outside Victoria, Vic. Nat. 104: 188

Mazzer, T., 1994, Flora and Fauna Guarantee Action Statement No 61 Giant Burrowing Frog *Heleioporus australiacus*, Department of Natural Resources & Environment, East Melbourne http://www.nre.vic.gov.au/

Menkhorst, P., 1993, Flora and Fauna Guarantee Action Statement No 41 Regent Honeyeater *Xanthomyza phrygia*, Department of Natural Resources & Environment, East Melbourne http://www.nre.vic.gov.au/

Merrick, J. R., 1995, Diversity, Distribution and conservation of freshwater crayfishes in the eastern highlands of New South Wales, Proceedings of the Linnaean Society of NSW 115: 247–258.

Missing Link Tourism Consultants, 1999, Australian Alps national parks. Recreation Strategy — All Management Units Summary Report, Missing Link Tourism Consultants, Crows Nest, NSW

Molsher, R., 1998, Interactions between feral cats and red foxes in NSW: Evidence for competition?, pages 227–231 in Proceedings of the 11th Australian Vertebrate Pest Conference, Bunbury, Western Australia. 3–8 May 1998

Moriarty, O., 1973, Letter to the President, Australian Academy of Science, reporting the conclusions of a Symposium on Grazing and Controlled Burning in the High Country of New South Wales and Victoria, 5 February 1973

Mosley, G., 1992, The Australian Alps: a potential world heritage, pages 531–545 in Good, R. & Grenier, P. (eds), 1992, Les Alpes australiennes/The Australian Alps, AALC & Grenoble University (France)

Mountain Cattlemen's Association, 1999, Renewal of Seven Year Alpine Park Grazing Licences — A. report into the Renewal Negotiations, Voice of the Mountains No. 22, 20–27

Murray, A., 1998, Tigers and 1080 Threat posed by buried poison baits to Spotted-tailed Quolls in the Australian Alps national parks, Dept Natural Resources & Environment

National Parks Service, 1995, National Parks and Conservation Reserves Guidelines and Procedures Manual, Volume 1, DCNR

Newman, R. L., 1964, Phasmatid Insect Plague Control in the Kiewa Hydro-Electric Works Catchment, Victoria, Australia., State Electricity Commission of Victoria, Melbourne

Newsome, A., Pech, R., Smyth, R., Banks, P. & Dickman, C., 1997, Potential Impacts on Australian Native Fauna of Rabbit Calcivirus Disease, BG EA

Noble, W. S., 1977, Ordeal by Fire. The Week the State Burned-Up, W. S. Noble, Melbourne

Norman, T. & Finegan, A., 1997, Fauna usage of three underpasses beneath the F3 freeway between Sydney and Newcastle, Australian Museum Business Services report to Roads and Traffic Authority

NSW Agriculture, 1998, New South Wales Weeds Strategy, http://www.agric.nsw.gov.au/reader/1981

NSW NPWS, 1987, Cooleman Plain Karst Area Management Plan, NSW NPWS

NSW NPWS, 1988a, Kosciusko National Park — Mt Blue Cow Resort, NSWNPWS

NSW NPWS, 1988b, Kosciusko National Park Plan of Management Second Edition, NSW NPWS

NSW NPWS, 1995, Pest Species Status Report. September, 1995. Snowy Mountains Region, Unpub. document NSW NPWS

NSW NPWS, 1997a, Kosciuszko National Park Fire Management Resource Document, NSW NPWS, Jindabyne NSW

NSW NPWS, 1997b, Wilderness - Securing the future. http://www.npws.nsw.gov.au/wildlife/wildern.htm

NSW NPWS, 1998a, [Draft] Kosciuszko National Park Fire Management Plan, NSW NPWS, Jindabyne NSW

NSW NPWS, 1998b, Pest Species Control Plan. October 1998. Snowy Mountains Region, Unpub. document NSW NPWS

NSW NPWS, 1999a, Kosciuskzko Today — Newsletter Summer 1999/2000, NSWNPWS

NSW NPWS, 1999b, Recovery Plan for the Northern Corroboree Frog (Pseudophryne pengilleyi) — Draft for Public Comment, NSW NPWS

NSW NPWS, 1999c, Recovery Plan for the Southern Corroboree Frog (Pseudophryne corroboree) — Draft for Public Comment, NSW NPWS

NSW NPWS, 1999d, Recovery Plan for the Spotted Tree Frog (*Litoria spenceri*) — Draft for Public Comment, NSW NPWS

NSW NPWS, 1999e, Schedule of Significant Natural Features. 1999 Draft Revision. Kosciuszko National Park, Draft document in NPWS Jindabyne office

NSW NPWS, 1999f, Threatened alpine plant species Recovery Plan: Amemone Buttercup (*Ranunculus anemoneus*), Feldmark Grass (*Erythranthera pumila*), Raleigh Sedge (*Carex raleighii*), Shining Cudweed (*Euchiton nitidulus*) — Draft for public comment, NSW NPWS

NSW NPWS, 1999g, Threatened Species Information. Brush-tailed Phascogale *Phascogale tapoatafa,* NSW NPWS http://www.npws.nsw.gov.au/wildlife/thr_profiles/btphas.pdf

NSW NPWS, 1999h, Threatened Species Information. Long-footed Potoroo *Potorous longipes,* NSW NPWS http://www.npws.nsw.gov.au/wildlife/thr_profiles/longpoto.pdf

NSW NPWS, 1999i, Threatened Species Information. Smoky Mouse *Pseudomys fumeus*, NSW NPWS http://www.npws.nsw.gov.au/wildlife/thr_profiles/smkmse.pdf

NSW NPWS, 2000a, Yarrangobilly and Cooleman Caves database,

NSW NPWS, 2000b, Yarrangobilly Management Unit Kosciuszko National Park Karst Area Management Plan (draft), NSW NPWS

NSW NPWS, 2000c, Draft Recovery Plan for the Mountain Pygmy-possum, *Burramys parvus,* NSW NPWS, Hurstville NSW

NSWNPWS, 2000d, Atlas of NSW Wildlife (AANP list of all fauna), NSWNPWS

NSWNPWS, 2000e, Atlas of NSW Wildlife (AANP list of all flora), NSWNPWS

NSWNPWS, 2000f, Atlas of NSW Wildlife (AANP list of threatened fauna), NSWNPWS

NSWNPWS, 2000g, Atlas of NSW Wildlife (AANP list of threatened flora), NSWNPWS

Oliver, L., 1999, Threatened Species of South-eastern NSW Riverina Highlands, NSW NPWS

Olsen, P., 1998, Australia's Pest Animals. New solutions to old problems, Bureau of Resource Sciences and Kangaroo Press

Osborne, W. & Davis, M., 1997, Long-term Variability in Temperature, Precipitation, and Snow Cover in the Snowy Mountains: Is There a Link With the Declint of the Southern Corroboree Frog (*Psedophryne corroboree*)?, Applied Ecology Research Group, University of Canberra

Osborne, W., Hunter, D. & Hollis, G., 1999, Population declines and range contraction in Australian alpine frogs, pages 145–157 in Declines and Disappearances of Australian Frogs. EA http://www.environment.gov.au/bg/threaten/information/frogs/pubs/frogs.pdf

Parkes, J., Henzell, R. & Pickles, G., 1996, Managing Vertebrate Pests: Feral Goats, AGPS, Canberra

Parks Victoria, 1998, Directions in Environmental Management (Draft for consultation — September 1998), Parks Victoria

Parks Victoria, 1999, Park Profiles for the State of the Parks Report, Parks Victoria

Parks Victoria, 2000, Resource Manual for Environmental Management Program Development 2000/2001. Alpine District, Parks Victoria

Pendlebury, P., 1997, Hydrology report to the upper Murrumbidgee River expert panel, Pp 28–45 In Anon., 1997. Expert Panel Environmental Flow Assessment of the Upper Murrumbidgee River. Report prepared for the NSW Environment Protection Authority

Pickering, C. and Armstrong, T., 2000a, Check list of Australian alpine plants that may be at risk from climate change, Draft paper

Pickering, C. and Armstrong, T., 2000b, Possible impacts of predicted climate change on plant communities in the Kosciuszko alpine zone in Australia, Draft paper

Pigott, J. P., 1999, The Environmental Weeds Home Page, http://weeds.merriweb.com.au/

Pittock, J., 1992, The involvement of non-government conservation groups in the management of the Australian Alps, pp 511–530 in Good, R. & Grenier, P. (eds), 1992, Les Alpes australiennes/The Australian Alps, AALC & Grenoble University (France)

Randall, R. P., 2000, “Which are my worst weeds?” A. simple ranking system for prioritising weeds, Accepted for publication by Plant Protection Quarterly, Melbourne, Vic.

Rath, H., 1999, Determination of some parameters that limit the distribution of *Ranunculus anemoneus*: an endemic buttercup found in knp, nsw, Thesis for M.Nat.Res., School of Natural Resources, The University of New England, Armidale

Reed, J., 1993, Flora and Fauna Guarantee Action Statement No 38 Trout Cod *Maccullochella macquariensis,* Department of Natural Resources & Environment, East Melbourne http://www.nre.vic.gov.au/

Regan, K., 1994a, Feral cats in Victoria, DNRE Landcare Notes No PA0019 http://www.nre.vic.gov.au/web/root/domino/infseries/infsheet.nsf/6adff5ed78795dc64a256516001f223e/eea655ad30c9998f4a256616000c7a5b?OpenDocument

Regan, K., 1994b, Feral pigs in Victoria, DNRE Landcare Notes No PA0016 http://www.nre.vic.gov.au/web/root/domino/infseries/infsheet.nsf/7630af4db04fd26c4a256532001786f5/6cc5f8cccceacaf64a25663f0079796f?OpenDocument

Regan, K., 1994c, Wild dogs and dingoes in Victoria, DNRE Landcare Notes No PA0027 http://www.nre.vic.gov.au/web/root/domino/infseries/infsheet.nsf/7630af4db04fd26c4a256532001786f5/eb54a2232026f5494a25663f007a5e2f?OpenDocument

Reside, J., 1998, Monitoring techniques, for the Brushtailed Rock-wallaby *Petrogale penicillata* in the Australian Alps National Parks, Jim Reside for AALC

Reside, J. & Martin, R., 1997, The Status of Brush Trailed Rock Wallaby *Petrogale penicillata* in the Australian Alps National Parks, AALC

Ride, W. D. L., Taylor, G., Walker, P. H. & Davis, A. C., 1989, Zoological History of the Australian Alps — the mammal fossil-bearing deposits of the Monaro, pages 79–110 in Good, R. (Ed), 1989, The Scientific Significance of the Australian Alps, AALC & Australian Academy of Science

Risbey, D. A. & Calver, M. C., 1998, Can current control strategies against introduced predators endanger native mammals?, p 233 in Proceedings of the 11th Australian Vertebrate Pest Conferrence, Bunbury, Western Australia. 3–8 May 1998

Roberts, G., 2000, Bee plan a potential disaster, Sydney Morning Herald 4/1/2000

Robertson, Morgan and White, 1999, Use of prescribed fire to enhance the control of English Broom, (*Cytisus scoparius*) invading into a subalpine Snowgum woodland near the Bogong High Plains, Victoria (DRAFT),

Robinson, K., 1996, Australian Alps Weed Management Manual. An identification and treatment guide for staff and contractors working in the Australian Alps National Parks, Ecoplan for AALC

Robinson,K & Ecoplan, 1996a, Himalayan Honeysuckle, AANP Weed Control Sheet Number 9

Robinson,K & Ecoplan, 1996b, Soft Rush , AANP Weed Control Sheet Number 19

Rodríguez-Trelles, F., Rodríguez, M. A. & Scheiner, S. M., 1998, Tracking the genetic effects of global warming: *Drosophila* and other model systems., Conservation Ecology Volume 2 Issue 2 http://life.csu.edu.au/consecol/vol2/iss2/

Sainty, G., Hosking, J. & Jacobs, S., 1998, Alps Invaders — Weeds of the Australian High Country, AALC

Sanecki, G., 1998, Perisher Range Ski Resorts Rabbit Control Program, Kosciuszko National Park, March 1998, NSW NPWS unpub. report

Scarlett, N., Bramwell, M. & Earl, G., 1994, Flora and Fauna Guarantee Action Statement No 56 Austral Toad-Flax *Thesium australe,* Department of Natural Resources & Environment, East Melbourne http://www.nre.vic.gov.au/

Schmedding, R., ND, Bogong moths — making the annual trek (leaflet), CSIRO Division of Entomology, Canberra

Seebeck, J. & Clunie, P., 1997, Predation of Native Wildlife by the Cat *Felis catus,* DNRE Action Statement No. 80 http://www.nre.vic.gov.au/web/root/domino/cm_da/nrenpa.nsf/frameset/NRE+Plants+and+Animals?OpenDocument&[/4A25676D00283C7B/BCView/76BD23E4CD738D594A25684E000F67C2?OpenDocument]

Shields, B., 1993, Patch Dieback of the Subalpine Snow Gum forest, *E. pauciflora* in Kosciusko National Park, Thesis for B.Sc. (Forestry) Hons, ANU

Smith, J. M. B., 1994, The changing ecological impact of broom (*Cytisus scoparius*) at Barrington Tops, New South Wales, Plant Protection Quarterly 9(1):6–11

Spate, A. P., 1990, Yarrangobilly Management Unit Kosciuszko National Park Karst Area Management Plan (draft), NSW NPWS

Spessa, A., 2000, The buzz on honey bees, Ranger — a journal for conservation managers No 50, pp 14–15

Stewart, J. E., 1991, Introductions as factors in diseases of fish and aquatic invertebrates, Canadian Journal of Fisheries and Aquatic Sciences 48 (Supplement 1): 110–117

Stubbs, T., 1997, Peregrine Falcons in the Northern District of Kosciuszko National Park 1996–97, Unpub report

Supple, R., 1992, Mining in the Victorian Alps, pages 243–257 in B. Scougall (ed) Cultural Heritage of the Australian Alps. AALC

Swales, S., 1992, Report on the occurrence of oriental weather loach (*Misgurnus anguillicaudatus*) in Lake Eucumbene., Unpublished report, Fisheries Research Institute, New South Wales Fisheries.

Tasmanian Parks and Wildlife Service, 1994, *Phytophthora cinnamomi* Hygiene Manual, Tasmanian Parks and Wildlife Service, DELM, Hobart

Thackway, R. & Cresswell, I. D. (Eds), 1995, An Interim Biogeographic Regionalisation for Australia: a framework for establishing the national system of reserves, Version 4.0., Australian Nature Conservation Agency, Canberra. http://www.environment.gov.au/bg/nrs/ibraimcr/ibra_95/

The Coordinating Group on Alien Pest Species, 2000, Hawaiian Ecosystems at Risk Project, http://www.hear.org/

The National Trust of Australia (New South Wales), 1982, National Trust Register, The National Trust of Australia (New South Wales)

The Ramsar Convention Bureau, 2000, The Ramsar Convention on Wetlands, http://www.ramsar.org/

The Secretariat of the United Nations Convention on Climate Change, 1999a, Climate Change Information Sheet 12 — Biological diversity and ecosystems , http://www.unfccc.de/resource/iuckit/fact12.html

The Secretariat of the United Nations Convention on Climate Change, 1999b, Climate Change Information Sheet 5 — How will the climate change ? , http://www.unfccc.de/resource/iuckit/fact05.html

Thomas, V. C., Henry, S. R. and Baker-Gabb, D. J. , 1994, Flora and Fauna Guarantee Action Statement No 58 Long Footed Potoroo *Potorous longipes*, Department of Natural Resources & Environment, East Melbourne http://www.nre.vic.gov.au/

Thompson, B., 1992, Flora and Fauna Guarantee Action Statement No 10 Rough Eyebright *Euphrasia scabra*, Department of Natural Resources & Environment, East Melbourne http://www.nre.vic.gov.au/

Tilzey, R. D. J., 1976, Observations on interactions between indigenous Galaxiidae and introduced Salmonidae in the Lake Eucumbene catchment, New South Wales, Australian Journal of Marine and Freshwater Research 27: 551–564

Tilzey, R. D. J., 1977, Key factors in the establishment and success of trout in Australia, Proceedings of the Ecological Society of Australia 10: 97–105.

Turner, J.S., 1960, The Conservation of Alpine Catchments —An Historical Account, University of Melbourne Science Review pp 27–30

UNCED, 1992, Agenda 21, United Nations Conference on Environment and Development (UNCED) held in Rio de Janerio, Brazil, 3 to 14 June 1992. http://www.un.org/esa/sustdev/agenda21.htm

UNEP, 1996, Convention on Biological Diversity (1992), http://www.unep.ch/bio/conv-e.html

UNEP/CMS Secretariat, Convention on Migratory Species, http://www.wcmc.org.uk/cms/

UNESCO, 1998, World Heritage Convention web site, http://www.unesco.org/whc/nwhc/pages/doc/main.htm

UNESCO, 2000, The Man and the Biosphere (MAB) Program, http://www.unesco.org/mab/

US National Park Service, 1996, Preserving Our Natural Heritage — A. Strategic Plan for Managing Invasive Nonnative Plants on National Park System Lands, US National Park Service http://www1.nature.nps.gov/wv/strat_pl.htm

US National Park Service, 1999, Biological Diversity, US National Park Service http://www1.nature.nps.gov/wv/biodiv.htm

van Rees, H., 1984, Behaviour and diet of free-ranging cattle on the Bogong High Plains Victoria, Publication No. 409, Environmental Studies Series, Ministry for Conservation, Melbourne

Various, Papers on fire (for a fire ecology monitoring project), Folder at Namadgi National Park

Venn, D. R., 1997, Flora and Fauna Guarantee Action Statement No 83 Grey Falcon *Falco hypoleucos*, Department of Natural Resources & Environment, East Melbourne http://www.nre.vic.gov.au/

Wahren, C-H A., Papst, W. A. & Williams R. J., 1999a, Post-fire regeneration in Victorian alpine and subalpine vegetation, Proceedings of the Australian Bushfire Conference, Albury 7–9 July 1999. Pp 425–430. Http://life.csu.edu.au/bushfire99/papers

Wahren, C-H A., Papst, W. A. & Williams R. J., 1999b, Post-fire regeneration in Victorian subalpine vegetation, AALC

Wahren, C-H A., Papst, W. A. & Williams R. J., 1999c, Post-fire Regeneration in Victorian Subalpine Vegetation, unpublished report

Walker, B. & Steffen, W., 1997, An Overview of the Implications of Global Change for Natural and Managed Terrestrial Ecosystems, Conservation Ecology Volume 1, Issue 2 http://life.csu.edu.au/consecol/vol1/iss2/

Walsh, N., 2000, Comments on draft database, pers. comm.

Walsh, N. G. & Entwhistle, T. J., 1994, Flora of Victoria Vol 2 Ferns and allied plants, Conifers and Monocotyledons, Inkata Press, Melbourne

Walters, B., 1996, Report on the Feasibility of Assessing Feral Horse Densities in the Australian Alps National Parks using a Strip-Transect Method, Ecoplan for AALC

Walters, B. & Hallam, H. (eds), 1992, Feral horses in the Alps — report of a Workshop, Howmans Gap, Victoria, 12–14 October 1992, AALC

Wardlaw, I., 1998, Plant activity beneath the snow, pages 113–124 in Green, K. (Ed), 1998, Snow: A. Natural History; an Uncertain Future, AALC

Wardle, P., 1989, Australasian Mountains — Worlds Apart, pages 21–29 in Good, R. (Ed), 1989, The Scientific Significance of the Australian Alps, AALC & Australian Academy of Science

Weeds Australia, 2000, National Weeds Strategy Fact Sheet. Weeds of National Significance, http://www.weeds.org.au/docs/WONSmaps.pdf

Whetton, P., 1998a, Climate change impacts on the spatial extent of snow-cover in the Australian Alps, pages 195–206 in Green, K. (Ed), 1998, Snow: A. Natural History; an Uncertain Future, AALC

Whetton, P. , 1998b, Climate Change Impacts on the Spatial Extent of Snow Cover in the Australian Alps., in Australian Inst of Alpine Studies Newsletter No 1 http://www.aias/org/au/

White House Climate Change Task Force, 1999, New Climate Science Findings — Fact sheet released by the White House Climate Change Task Force, http://www.state.gov/www/global/global_issues/climate/fs-9910_climate_finds.html

Willis, J. H., 1972, A Handbook to Plants in Victoria Vol II Dicotyledons, Melbourne University Press

Wilson, G., Dexter, N., O'Brien, P. & Bomford, M., 1992, Pest Animals in Australia. A. survey of introduced wild animals, Bureau of Rural Resources and Kangarooo Press, Kenthurst, NSW

Wimbush , D. J. & Costin, A. B., 1979a, Trends in Vegetation at Kosciusko. I. Grazing Trials in the Subalpine Zone, 1957–1971, *Aust. J. Bot.*, **27,** 741–87

Wimbush , D. J. & Costin, A. B., 1979b, Trends in Vegetation at Kosciusko. II Subalpine Range Transects, 1959–1978, *Aust. J. Bot.*, **27,** 789–831

Wimbush , D. J. & Costin, A. B., 1979c, Trends in Vegetation at Kosciusko. III Alpine Range Transects, 1959–1978, *Aust. J. Bot.*, **27,** 833–71

Winston-Gregston, J., 1992, Mining in the Uplands, pages 237–241 in B. Scougall (ed) Cultural Heritage of the Australian Alps. AALC

World Meteorological Organization, 2000, Common Questions about Climate Change, http://www.gcrio.org/ipcc/qa/cover.html

Wright, G. T. , 1999, Field survey for the Suggan Buggan mallee (*Eucalyptus saxatilis*) in Kosciuszko National Park 1998/1999, NSW NPWS

Wright, G. T. , 2000, Field survey for the Monaro golden daisy (*Rutidosis leiolepis*) in Kosciuszko National Park 1998/1999, NSW NPWS (Updated January 2000)

Wright, G. T. & Briggs, J. D., 1999, Population survey and notes on the ecology of the Leafy Anchor Plant (*Discaria nitida*) in New South Wales, NSW NPWS

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