AUSTRALIAN ALPS

NATIONAL PARKS

The International Significance of the Natural Values of the Australian Alps

A report to the Australian Alps Liaison Committee

J B Kirkpatrick

May 1994

THE INTERNATIONAL SIGNIFICANCE OF THE NATURAL VALUES OF THE AUSTRALIAN ALPS

A report to the Australian Alps Liaison Committee J. B.

KIRKPATRICK

Department of Geography and Environmental Studies, University of Tasmania

October 1993

Contents

Summary

1. The Australian Alps have been argued to have international significance for many of their natural properties, including their geology, geomorphology, alpine ecosystems, the catena of eucalypt-dominated communities and their aesthetic qualities. Kosciusko National Park is already a Biosphere Reserve and is recognised internationally for the biological diversity of its plants.

2. The parks in the MOU area have undoubted international significance under the Convention for Biological Diversity and have qualities as a whole that should allow them to be readily recognised as the core of an enlarged Biosphere Reserve.

3. 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.

4. The outstanding natural attributes of the Australian Alps compare well with those that have been used as a basis for the recent successful nominations for World Heritage of other areas in Australia.

5. Unfortunately, the integrity of some parts of the Australian Alps, while being reasonable on an international scale, is comparatively poor compared to the same recent nominations, both as a result of past development and exotic species invasion, and as a result of continuing use of part of the area for purposes inconsistent with the maintenance of World Heritage qualities. The perception of poor integrity could put any nomination at risk of failure.

6. The chances for a successful nomination for World Heritage would be improved by further commitment to the elimination of current threatening processes, and the mitigation of the effects of past disturbances. A

commitment to the removal of stock grazing would be important.

7. Any nomination should exclude development areas, unless they are highly significant for threatened species. The arguments in the nomination would be improved by the inclusion of the Mt Buffalo National Park, the Baw Baw National Park, the Errinundra National Park, the Coopracambra National Park and the Croajingolong National Park. However, non-contiguity and the non-inclusion of the parks in southeastern New South Wales reduce the potential strength of the East Gippsland inclusions.

Introduction

The Australian Alps have long been recognised to have outstanding natural significance (Good 1989; Scougall 1992). Parts of the Australian Alps are found within Victoria, New South Wales and the Australian Capital Territory. One million five hundred and fifty-eight thousand hectares of the Australian Alps are contained within a contiguous set of reserves that are the subject of a Memorandum of Understanding in relation to their co-operative management (MOU), which is implemented through the mechanism of the Australian Alps Liaison Committee. These reserves are the Alpine National Park (Victoria), the Snowy River National Park (Victoria), the Avon Wilderness Park (Victoria), the Kosciusko National Park (NSW), the Scabby Range Nature Reserve (NSW), the Bimberi Nature Reserve (NSW) and the Namadgi National Park (ACT) (Figure 1).

The Kosciusko National Park has gained formal international recognition as a Biosphere Reserve and a Centre of Biological Diversity. However, the remainder of the MOU area has no such recognition, despite its similar and complementary natural qualities, and there is a substantial body of opinion that the MOU area and, in some cases, adjacent, but not contiguous reserves, deserve a higher level of international recognition (Mosley 1988, 1992a; Costin 1989, Busby 1990, Good 1989,1992a; Boden 1991; Mosley and Costin 1992). The publications by Busby (1990), Boden (1991) and Good (1992a) covered Victoria, Namadgi and Kosciusko respectively. Integrated appraisals of natural significance for the Alps as a whole can be found in the monograph of Mosley

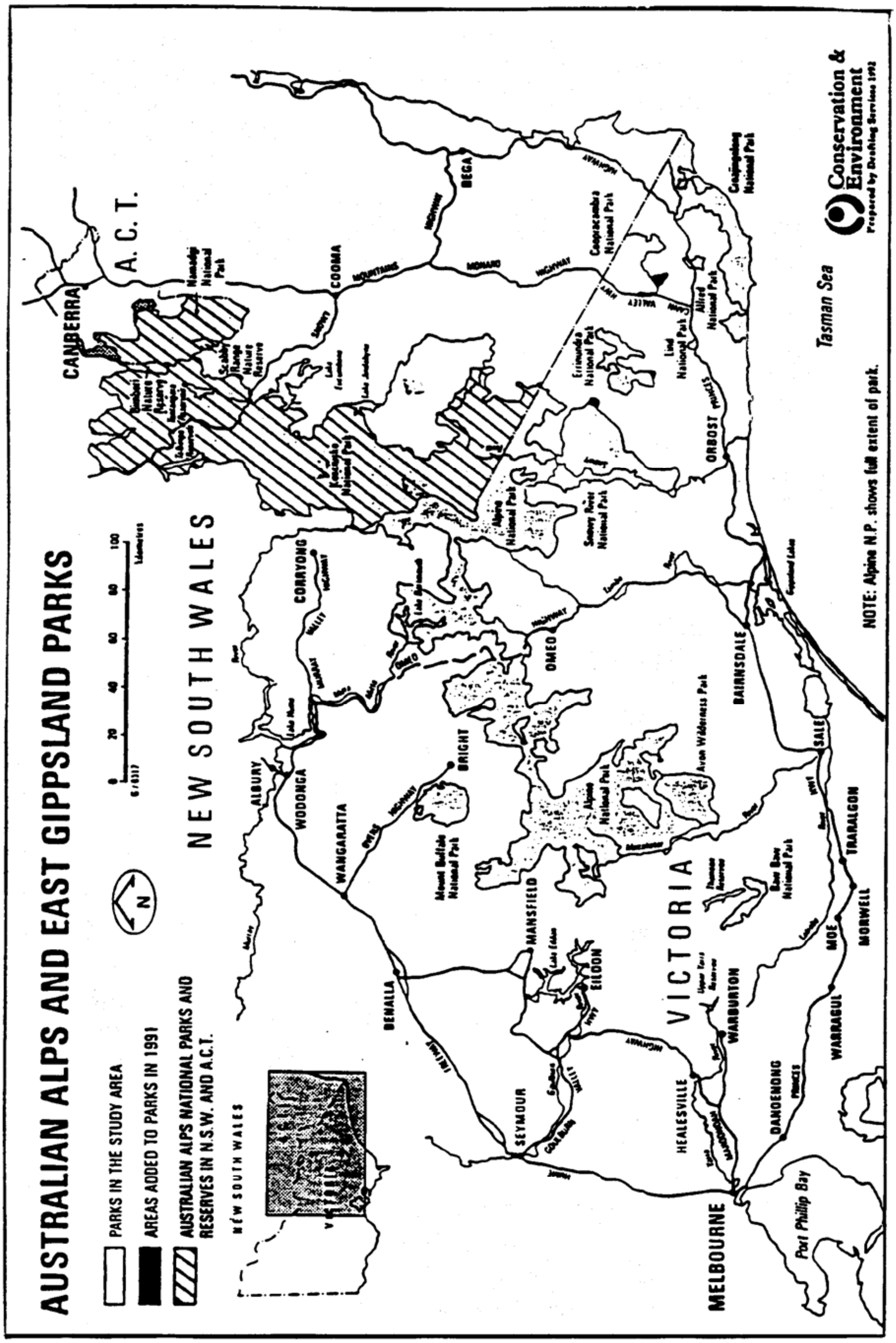


Figure 1. Australian Alps and East Gippsland Parks (modified from Busby 1990)

(1988) and the short papers of Costin (1989), which concentrated on the scientific aspects, Mosley and Costin (1992) and Mosley (1992a). The present paper was commissioned by the Australian Alps Liaison Committee. They believed that a detailed and comprehensive assessment was needed to determine if the Australian Alps are qualified for international recognition, and, if so, to determine at what level and for what reasons. My aims are to assess the arguments for international natural significance of the MOU area and to document this significance in an integrated fashion suitable as a basis for World Heritage nomination.

Given that the report of Busby (1990) identified natural qualities of international significance in the reserves adjacent to the MOU area in East Gippsland, I also consider whether the inclusion of these, and reserves outside the MOU area in the Australian Alps, would improve the likelihood of international recognition under the World Heritage Convention. This part of the work forms Appendix 1 to the main document. Consideration of the qualities of the southeastern New South Wales areas analysed by Mosley and Costin (1992) was outside the scope of the brief.

This introduction is followed by a discussion of the methods and criteria used to assess international significance, especially in the context of Biosphere Reserves, World Heritage Areas and Australia's obligations under the Convention on Biodiversity. The next section critically assesses previous statements on the international significance of the natural qualities of the Australian Alps. It leads to an integrated summary of the international distinctiveness of the study area. In order to gain some relative measure of the international significance of the natural qualities of the Australian Alps, they are then compared with six recently nominated World Heritage Areas in Australia. A similar analysis of integrity follows. The case for World Heritage listing of the Australian Alps is then presented in the form found in nomination documents. Finally, conclusions are drawn on the international significance of the area under the three means of international recognition.

Methods and criteria for assessing natural international significance

General principles

International significance may be conferred on the natural features of an area on either an informal or formal (legal) basis. The former must logically precede the latter, implying that international significance must be able to exist without formal recognition. Indeed, some aspects of international significance may not be recognisable in international treaties enforced by national law. For example, the giant waves of Oahu are an internationally celebrated natural feature that would be likely to fail the formal tests. However, given that most conceivable aspects of natural value are covered by international conventions, my assessment is largely undertaken in the context of their criteria. The formal criteria for international legal recognition of natural value provide the most convenient focus for assessment. These are particularly well-developed in the operations of the World Heritage Convention. Their application in the past can be used to provide an indication of appropriate threshold levels.

The first test for international significance of the natural features of the Australian Alps is the existence of international recognition. If an area has been partly or wholly recognised to have international significance for its natural values through international instruments, those aspects that have been so recognized can be taken to be proven to a degree determined by the selection criteria. Recognition under one instrument may aid the case for recognition under another instrument. Thus, the recognised status of an area as a Biosphere Reserve can be taken to prove eligibility for World Heritage listing to the degree that the criteria and their application are congruent.

Biosphere Reserves

Biosphere Reserves are designated by the International Co-ordinating Committee of the Man and the Biosphere Program (MAB) of the United Nations Educational, Scientific and Cultural Organisation after recommendation from national committees. Their major goals are to: conserve biodiversity; be ecological and environmental research areas; and be educational resources.

The guidelines for the selection of Biosphere Reserves reflect their role as a representational protected area system (Davis and Drake 1983). The goal is to have one or more such reserves in each of the major biogeographical, terrestrial and marine provinces of the world. The following criteria, the satisfaction of one of which is sufficient to establish status, are relevant to the Australian Alps: provide representation of a biome; unique communities or areas with unusual natural features of scientific or aesthetic interest. Other criteria relate to characteristics of modified or degraded areas, so are not generally relevant to the Australian Alps. Such areas are often included within Biosphere Reserves, although they are not necessary for the designation.

The conditions that apply to the relevant criteria include, most significantly, the requirement that the natural areas in Biosphere Reserves should be large enough to ensure that representative ecosystems remain self-sustaining, the requirement for monitoring of ecosystem health, the requirement for management planning, the requirement for effective management, and the requirement for educational and scientific use.

The World Heritage Convention

Article 2 of the World Heritage Convention describes the characteristics of areas worthy for listing. It emphasizes the scientific, conservation and aesthetic values of natural areas (Department of the Arts, Sport, the Environment, Tourism and Territories (DASETT) 1993):

-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 physiographica/ formations and precisely delineated areas which constitute the habitat of rare and 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.

Evidence of international scientific value can be provided through a critical assessment of the international scientific literature and the opinions of internationally recognized scientists.

I interpret conservation significance to pertain to the role of an area in maintaining the biodiversity and geodiversity of the planet. The role may be established by demonstrating that the area is important in representing a facies of global variation, as well as by demonstrating its uniqueness. As every part of the surface of the earth is representative or unique in some manner and to some degree, the threshold level for significance must be determined by precedent in the context of previous listings. This particularly pertains to representativeness. If a particular type of ecosystem is already well-represented in the World Heritage list, this would weaken the case for another area, unless, perhaps, this latter area was a better example of the type.

The question of international natural aesthetic merit is even more difficult than the previous two, in that perceptions of outstanding quality are filtered through cultural screens to a much greater degree than for scientific and cultural values. It could be argued that outstanding international aesthetic quality could only be proven through international celebration of an area in art and literature. Alternatively, it could be reasonably argued that, if an area presents an outstanding example of an aesthetic quality, or combinations of aesthetic qualities, that are recognized as important on a global scale, it is of international significance, even if this area has not been subject to international celebration. For example, the aesthetic qualities of rainforest landscapes are internationally well-celebrated. Yet, as a result of their inaccessibility, the rainforests of the Fly River catchment have not been particularly celebrated, despite having an aesthetic diversity in rainforest type and juxtaposition that is outstanding on a global scale.

International celebration may be lacking because a type of landscape exists nowhere else and clashes with the aesthetic preconceptions of other cultures. The eucalypt forests of Australia are aesthetically as well as biologically unique. They are celebrated aesthetically by Australians, but not to any great degree by the international community. The application of the principle of representativeness in aesthetic matters could be taken to include representativeness in aesthetic perception, as the international community would presumably value variability on cultural perceptions as much as variability in natural ecosystems.

World Heritage listing for natural values requires a demonstration of 'outstanding universal value' using at least one of the following criteria (DASETT 1993):

(i) be outstanding examples representing major stages of earth's history, including the record of life , significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features;

(ii) be outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, freshwater, coastal and marine ecosystems and communities of plants and animals;

(iii)contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance;

(iv)contain the most important and significant natural habitats for in situ conservation of biodiversity, including those containing threatened species of outstanding universal value for science or conservation.

The World Heritage criteria contain references to both 'outstanding examples' and 'superlative' andlor 'significant' phenomena. Thus it is clear that they encompass both the representative and the unique. If the descriptions and criteria are deconstructed, they cover:

1) physical formations of outstanding universal scientific value that represent

major stages of the earth's history (criterion i);

2) physical formations of outstanding universal scientific value in themselves (criteria i and iii);

I

3) natural areas or sites that are of outstanding universal significance for science for their representation of the major biological stages of the earth's history (criterion i);

4) natural areas or sites that are of universal scientific significance as outstanding examples of on-going ecological and biological processes (criterion ii);

5) natural areas that are the most important and significant for *in situ* conservation of biological diversity (criterion iv);

6) natural areas or sites that contain superlative natural phenomena (criterion iii);

7) physical formations, natural areas or sites of exceptional natural beauty/aesthetic importance (criterion iii);

t

8) areas that contain the habitats of threatened species of animals and plants of outstanding conservation value (criterion iv);

9) areas that contain the habitats of threatened species of animals and plants of outstanding scientific value (criterion iv).

Those features put forward as evidence of eligibility for entry on the World Heritage List must also satisfy conditions of integrity. The nominated areas must have security of tenure in relation to the values, and management plans in existence, preparation or prospective preparation that indicate, or will indicate, the manner in which the values will be perpetuated.

The areas should be demonstrably complete in relation to their heritage highlights. This means that they should include all or most of the key elements of the particular highlight and all the areas necessary to ensure the long term viability of these elements.

Heavy weight is placed on biological diversity, to the extent that it is expected that a nomination for biological processes should 'contain habitats for maintaining the most diverse fauna and flora characteristic of the biogeographic provinces and ecosystems.' It is also stated that it '... is only those sites that are most biologically diverse (that) are likely to meet criteria (ii) and (iv)', these criteria being the ones related to ecological processes, biodiversity and threatened species.

I have assumed that these statements do not invalidate listings for biodiversity reasons in relatively species-poor ecosystems and biogeographical provinces. If this were the case all further listings under criteria (ii) and (iv) would be for coral reefs and rainforests, which would leave the large proportion of the biological diversity of the globe that occurs outside these ecosystems without any possibility of international recognition as World Heritage.

The guidelines imply that alpha diversity (genotype, species and community richness at the local scale) and gamma diversity (genotype, species and community richness at the regional scale) are the prime object of concern, but do not logically exclude either beta diversity (the rate of changeover of species along environmental gradients) or spatial diversity (degree of spatial heterogeneity of genotype, species and community assemblages) from consideration.

There is an unfortunate logical inconsistency between Article 2 and the criteria and guidelines, in that the areas that are most important for the conservation of biological diversity are not necessarily the areas that are the most diverse, in any sense. For example, a natural area that consists of fragmentary remnants of the original ecosystems may be richer in all elements of biodiversity than another that is intact, but the prospects for the long term viability of the former

{

will be much less than those for the latter. There is also no necessary relationship between the distribution of threatened species of outstanding universal value for science or conservation, and diversity. The islands of Hawaii provide a lesson in this respect. It is hard not to conclude that the blind application of a numbers approach to biodiversity to a major segment of World Heritage significance is at variance with the words and spirit of Article 2.

The convention on biological diversity

This convention, when ratified, binds the Government of Australia to undertake particular actions in relation to its own biodiversity. One of these actions involves identification of: 'components of biological diversity important for its conservation and sustainable use' (p.29, article 7.1). The annex to article 7.1 (p. 45) indicates some criteria for this identification:

"1. Ecosystems and habitats: containing high diversity, large numbers of endemic or threatened species, or wilderness; required by migratory species; of social, economic, cultural or scientific importance; or, which are representative, unique or associated with key evolutionary or other biological processes;

2. Species and communities which are: threatened; wild relatives of domesticated or cultivated species; of medicinal, agricultural or other economic value, or social, scientific or cultural importance; or importance for research into the conservation and sustainable use of biological diversity, such as indicator species; and
3. Described genomes and genes of social, scientific or economic importance.'

The parties to the convention also undertake to: "Establish a system of protected areas or areas where special measures need to be taken to conserve biological diversity" (article 8a, p. 29), the implication being that these areas would be selected on the basis of the appropriate indicators in the annex to article 7. Thus, if the Australian Alps can be shown to satisfy the criteria for selection, they enjoy an international significance under the convention.

Most of the criteria are also explicitly covered by the World Heritage Convention and its operational guidelines. The notable exceptions are wilderness, which could only be interpreted as implicit in the World Heritage Convention guidelines, and economic importance, which is absent from the World Heritage Convention guidelines. However, I interpret the World Heritage Convention to require a much higher level on the common criteria than the Biological Diversity Convention, as the latter places responsibility on nations to maintain their biological diversity, while the former recognises the most outstanding examples of biodiversity phenomena.

In relation to the integrity of protected areas article 8 of the Biological Diversity Convention binds governments to: rehabilitate and restore degraded ecosystems (article 8f, p. 29), promote the recovery of threatened species (article 8f, p. 29), provide appropriate plans for the previous two actions (article 8f, p. 29), to exclude or control threatening introduced species (article 8h, p. 29), and to regulate or manage processes and activities that have significant adverse effects on biological diversity (article 81, p. 30).

These integrity conditions relate, at least in part, to the viability of areas dedicated to the conservation of biological diversity. They are all either implicitly or explicitly covered by the conditions of integrity developed for the World Heritage Convention.

Assessment of statements on international significance

General statements

The Kosciusko 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). Good (1992a) implies that this recognition establishes a case for further recognition.

The 1977 declaration of the Kosciusko National park as a Biosphere Reserve can reasonably be taken to testify to an international acceptance of this part of the study area as an outstanding example of alpine environments, and of the significance of the park for its unique communities and unusual natural features. However, does this acceptance imply that the other reserves within the study area, a large number and part of which did not exist in 1977, would qualify as part of an extended Biosphere Reserve?

There is no doubt that the natural features of the study area outside Kosciusko would justify such an extension. The representation of the alpine and eucalypt forest biomes would be markedly improved (Appendix 2), and the larger area and environmental range would increase the probability of the survival of their constituent ecosystems.

As indicated by Good (1992a) the status of Kosciusko National Park as a Biosphere Reserve strengthens its case, and that of the rest of the study area, for World Heritage listing, given that an international body has recognized that the park contains an outstanding example of alpine environments. The recent World Heritage requirement for the greatest biological diversity within exemplars would seem to be met by the high alpha diversity at the quadrat scale recorded for the Australian Alps compared with other southern mountains for which data are available. Within the alpine vegetation of Australia as a whole there are almost as many higher plant species in the Kosciusko area as there are in the whole of Tasmania, and the number of alpine obligates is considerably higher at Kosciusko and Bogong than in the whole of Tasmania (Kirkpatrick 1989). However, the New Zealand alpine vegetation has more obligates and total species than the alpine vegetation of the Australian Alps.

It is difficult to take exception to the opinion of Wardle (1989) that the Australian Alps "clearly are (of outstanding scientific significance) in their own right. 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." (p. 29). However, the critical question for World Heritage listing devolves down to the boundaries of biogeographical provinces. If the biogeographical province/s in which the study area is situated does/do not include New Zealand, then the Australian Alps are an outstandingly biologically diverse exemplar of their province/provinces, at least in relation to their alpine vegetation. It is only at the level of biogeographic realms that southeastern Australia would normally be included with New Zealand. Thus, it is reasonable to accept that the opinion of Wardle (1989) is valid in relation to World Heritage listing.

"...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." (Costin 1989, p. 18). This quotation directs attention towards two major attributes of the study area that help give it outstanding international significance. The first is that it includes one of the major extremes of environment and biota on a continent that has the most distinct biota of any other large landmass. This biota is not only very different, it is also very large. Australia is rightly regarded as one of the few megabiodiversity countries. The second attribute is its size, largely natural state and environmental diversity. These ensure that, with minimal appropriate management and after certain integrity issues have been addressed, World Heritage qualities have a high likelihood of persisting.

Mountain environments

Costin (1989) states that world interest in the natural history of the southern hemisphere was kindled partly by the lack of land, and its disjunct distribution, especially in the temperate zone (30-60 degrees south). He argues that the Australian Alps are especially significant in that there are few temperate southern hemisphere mountains that extend from the lowlands to the snow country (Australia, New Zealand, the Drakenbergs of South Africa, Patagonia) (Costin 1989). He states that these have remarkably disparate biotas, in contrast to the general similarities within the northern mountain zones, which are and have been far less separated. Wardle (1989) also points out that the Australasian alpine areas are far more maritime in their climates than most alpine areas of the world.

The combination of unusual highland climate, unusual degree and duration of isolation and unique biota would seem to lend strength to the qualification of the Australian Alps for World Heritage listing, while not being directly relevant to any of the four criteria.

Geology

Oilier (1986) argues that the Australian Alps are more ancient (90 million years) than others of the isolated southern hemisphere mountains which have originated in the last few million years. "The landscape of alpine Australia is on the same timescale as continental drift, global tectonics, and biological evolution." (Oilier and Wyborn 1989, p. 35). "The Australian Alps are thus seen to consist, in part, of huge fault blocks, uplifted in the Miocene. This has huge effects not only on elevation, but also on theories of Highland evolution." (Oilier and Wyborn 1989, p. 41). Rosengren and Peterson (1989, p. 190) state that "One could argue ..." that the Australian Alps have international significance purely on the basis of their intraplate location, their existence posing difficulties for models of plate tectonics and continental rifting (Bishop 1988)." They believe that this significance can be verified through the citable international literature.

Costin (1989) refers to the remarkable diversity of rock types dating back to Cambrian times. Some minerals within these Cambrian rocks are up to 3000 million years old, providing evidence of rock recycling at least on a continental scale (Costin 1989). There are complex records of marine sedimentation, igneous intrusions, lava flows and fresh water deposition (Costin 1989).

Busby (1990, p. 60) gives equivocal support to the international significance of these geological features in the Victorian Alps and East Gippsland in describing them as "... of national and perhaps international significance". Good (1992a, p. 22) is less equivocal on the subject of Kosciusko: "Kosciusko National Park contains a grand picture of geological and geomorphological processes and patterns and the evolution of life forms which is outstanding and probably not exceeded anywhere else on the continent. It contains a geological heritage of national and international importance ...".

Its status as part of an intraplate mountain range directly adjacent to an extremely narrow continental margin, makes the Australian Alps unique on a global scale (Bishop pers. comm.) and therefore of outstanding international scientific significance. The only problem with this attribute of the Alps in relation to World Heritage listing is that the study area could be considered to not contain all or most of the key interrelated elements in their natural relationship, as is required by the first condition of integrity, lacking as it does the plate margin, and consisting as it does of only one small part of an extensive mountain range. The key international scientific article in this area (Bishop 1988) shows four cross-sections, none of which traverse the study area. Nevertheless, the Alps are the most prominent manifestation of the intraplate mountain phenomenon and are adjacent to one of the narrowest parts of the continental margin. Therefore, there is a case for using the intraplate argument to support World Heritage listing under criterion (i).

The argument for international significance based on geological complexity and age has to be related to World Heritage criterion (i). Despite the statement of Good (1992a), the study area does not contain an outstanding record of the evolution of lifeforms, either in the form of descendants or in the fossil record. The most internationally significant fossil beds are probably in the rocks of Ordovician age, because they define the biostratigraphic zones for the subdivision of the period in Australasia, allowing correlation with similar zones elsewhere (Busby 1990). However, the parts of these beds within the study area are not the most significant for these interpretations (Busby 1990). The Devonian fish fauna at Mt Howitt has some claims to international significance, being regarded as one of the most important such deposits in the southern hemisphere (Marsden 1988).

In contrast to the situation with the evolution of lifeforms, the geologic record and its manifestation in landforms seem to have a strength that allows acceptance under criterion (i).

Geomorphology

Costin (1989) notes that uplifted plateaus within the alpine and subalpine zone are relatively rare on a world scale (Southern Otago Highlands, Australian Alps).

Current periglacial processes have attracted world interest, especially those related to long-lasting snow patches (Costin 1989). The work of Costin *et al.* (1973) and Jennings and Costin (1978) at Kosciusko have demonstrated that snow patches can undertake work previously only attributed to glaciers.

The global scientific interest in the periglacial and glacial landforms of the Australian Alps is said by Galloway (1989) to lie in their illumination and amplification of the remarkable events during the Quaternary cold intervals. One particularly interesting insight recorded by Galloway (1989) relates to the relative altitudes of the orographic equilibrium lines in similarly maritime mountains in the northern and southern hemispheres, with the Australian Alps having 900 m lower lines than those in equivalent latitudes. This suggests that the northern hemisphere was warmer than the southern, a counterintuitive proposition given the relative distributions of ice surfaces. Good (1992a) argues that the Kosciusko alpine landforms have international significance because they invite comparison with other small glaciated areas elsewhere.

Rosengren and Peterson (1989) rest their case for the World Heritage significance of the glacial and periglacial features of the Australian Alps on the value of research results to the world scientific community as a whole.

Cooleman Plain in northern Kosciusko National Park is well-known in the international geomorphic literature as a result of the studies of Jennings (Spate 1987), Gams (1985) and Spate *et al.* (1985) on karst morphology and process (Spate and Household 1989). Studies on localised limestone solution rates are stated by Spate and Household (1989) to have generated international interest. They also see the following features to have international significance: A-tents, low angle mudflows and the probable Silurian karst landscapes filled with Devonian sedimentary rocks.

Busby (1990, p. 60) sees the Victorian highlands to possess "national and perhaps international geomorphological significance". Good (1992a) attributes unequivocal international significance to the suite of landforms found in Kosciusko National Park.

While the glacial landforms of the study area might generate some international scientific interest on the basis of their highly marginal nature, it is difficult to see how they could qualify as outstanding examples of their type or be regarded as superlative natural features. The suite of features found at Kosciusko is also likely to be regarded as highly incomplete in its range of representation of glacial phenomena.

The suite of periglacial features is much more impressive, especially given the large body of scientific investigation and the unusually mild context for their development. The study area has outstanding international significance from the scientific point of view for features such as its migrating fjaeldmark, snow patch dynamics, aeolian-enriched solifluction lobes and stepped ponds. This set of features qualifies under all the appropriate conditions of integrity. Similar remarks are appropriate in relation to the set of karst features at Cooleman Plain. Their likely great age (Bishop 1988) gives the study area karst features added significance.

Soils

The Australian alpine mountains are highly unusual on a world basis in that they are almost entirely mantled by well-developed soils (Costin 1955). Most alpine mountains in the world have young, poorly-developed soils and substantial areas without soil.

Alpine humus soils are optimally developed under Australian conditions (Costin 1989). The Australian alpine humus soils differ from those described elsewhere (eg. Braun-Blanquet and Jenny 1926) in that they form on a wide range of parent materials, not just limestone, and attain depths of up to 1 m (Costin 1989). They support enormous earthworm populations (Costin 1989).

The alpine humus soils are thus an outstanding example of an ongoing ecological process and a superlative natural phenomenon, providing one of the main arguments for World Heritage listing under criteria (ii) and (iii).

Hydrology

Cullen and Norris (1989) see international significance lying in the similarities of the Australian alpine aquatic systems with those elsewhere as well as their uniqueness within Australia. However, Good (1992a, p.126) believes that it is "... the interaction of climate, soils, vegetation and geomorphology in their catchments which gives the streams and aquatic systems their importance and scientific interest and hence their national and international conservation significance." He notes that the rivers and streams of the Snowy Mountains have extremely low sediment loads on an international scale, extremely low nutrient loads and are the freshest of any in Australia. He also notes that Blue Lake is the only dimictic lake on the Australian mainland.

If the international significance of the hydrological systems lies in their similarities with systems elsewhere then they would be expected to be outstanding examples of their types. This is almost certainly not the case, given their restricted distribution. However, these systems may be relatively unusual on a global basis given their low sediment loads and their freedom from inputs of acid rain. This may make them of outstanding universal scientific importance for comparative studies. However, this case has not been established with any great certainty. One dimictic lake, international significance does not make.

Vegetation

Costin (1989, p. 15) believes that: "the outstanding scientific attribute of the Australian Alps is the extent and scale of continuous and interrelated environmental diversity as expressed in their ecosystems.", a conclusion echoed for Kosciusko National Park by Good (1992a). Costin sees global interest being centred on two main groups of features. The first set of features consists of those attributes that illuminate global evolutionary relationships. The close taxonomic affinities of the alpine flora with alpine floras elsewhere in the southern hemisphere (Costin *et a/.* 1979), and the remarkable convergences of growth form between alpine environments are used as examples. The second set of features consists of those that are uniquely and characteristically Australian. The remarkable dominance of eucalypts, from sea level to the treeline, and their globally unusual set of adaptations, are seen to be outstanding in this respect. The eucalypts are also regarded as being globally outstanding in their "...wide and rapid radiation, adaptation, hybridisation and continuing evolution..." (Costin 1989, p. '16).

While not stating directly that it is of global significance, Costin (1989) implies that the fact that more than half of the forms and sub forms of vegetation recognised on the Australian mainland by Beadle and Costin (1952) are found in the Alps, including some that are wholly or largely confined to this area, is of international significance, especially given their high degree of protection. Good (1992a) sees significance in the representation of the full range of forms of eucalypts within the Kosciusko National Park. He believes that about 10% of all eucalypt species occur within the Australian Alps as a whole.

Kirkpatrick (1989), in a comparison of Tasmanian and Australian alpine vegetation pointed out that the relatively fertile soils and herbaceous vegetation of the Australian Alps were much more similar to 'normal' alpine ecosystems than the Tasmanian alpine ecosystems. Busby (1990) accepts this proposition, but regards the Victorian alpine vegetation to have international significance, apparently largely for its representativeness of the type in Australasia.

The long term work on vegetation dynamics and succession in the alpine zone of the Australian Alps (Carr and Turner 1959ab, Wimbush and Costin 1979abc; Ashton and Williams 1989) has attracted world interest, especially on the subject of competition between herbs and shrubs (Costin 1989).

The subalpine treeless valleys and flats (parks) of the Australian Alps have some analogues elsewhere in the world (eg. western United States), but attain their best development within the Australian Alps (Costin 1989).

The crux of the argument for World Heritage listing of the Australian Alps lies in the vegetation, particularly the eucalypt-dominated forests and woodlands and the alpine communities, but also, generally, for its high level of diversity and representativeness. In particular, there seems little or no doubt that the alpine and eucalypt-dominated ecosystems would qualify under World Heritage criteria (ii) and (iv). The facts noted by Kirkpatrick (1989) should not affect listing. The Australian Alps alpine vegetation is largely distinct from that of Tasmania and is generally more locally diverse. Thus, under the conditions of integrity the Australian Alps would be preferentially listed if the Tasmanian alpine and mainland alpine vegetation were considered to be in the same biogeographic province, which would be unlikely. The two sets of alpine vegetation are certainly more different in their dominance and structure than the two sets of rainforest vegetation covered by the Queensland and Central Eastern listings. The herb and grass dominance exhibited over much of the Australian mainland alpine zone is certainly more similar to other alpine areas outside Australia than the shrub and cushion-dominated Tasmanian alpine vegetation. However, there are no great floristic similarities at the species level between the mainland alpine vegetation and that anywhere else in the world, and the structural expression of herb dominance is relatively unusual.

Flora

Barlow (1989) concludes that the flora of the Australian Alps, by which he means effectively the Kosciusko alpine zone, is a differentiate of a diverse southern hemisphere flora, its uniqueness lying in its presentation of colonisers of a young and ephemeral habitat, rather than in any concentration of primitive species and genera. He regards the flora of the Australian Alps as unique on a world scale, with its autochthonous Australian component setting it apart from all others, and with striking differences in the nature of the treeline, botanical composition, level of differentiation, species richness and botanical zonation in comparison to other southern alpine floras.

Kosciusko National Park is one of the six sites of plant biodiversity in Australia, and one of the 167 sites in the world, that have been recognized by IUCN (Good 1992a). Good (1992a) sees this as sufficient reason, in itself, for further listing under international conventions. Good (1992a) argues that the large area of the park allows the survival and evolution of a large number of plant species and genotypes, and therefore makes it of international significance. Good (1992a) also states that the Kosciusko alpine zone has a significantly higher level of endemism in its higher plants (10%) than most alpine floras (c5%).

The flora provides an outstanding example of adaptation to the climatic vagaries of the Pleistocene climatic upheavals, leading to a reasonable conclusion of qualification under criterion (i). The outstanding beauty of the alpine wildflower displays should enable qualification under criterion (iii). The large number of genotypes and species found within the study area should qualify it under criterion (iv).

Fauna

Good (1992a, p.116) states that: "The fauna of Kosciusko National Park as a whole has few outstanding or significant features when considered on a continental basis. All families and genera and most species occur as commonly or more commonly elsewhere at lower elevations in more favourable environments." He sees the most significant feature of the fauna being its parallel evolutionary radiation in isolation from other alpine regions.

Good (1992a) also notes that the park makes some contribution towards fulfilling Australia's international obligations under the migratory birds agreements (CAMBA and JAMBA).

Happold (1989) states that the Australian Alps, by which he means the subalpine and alpine zone, has an unique assemblage of native small mammals, one of which, *Burramys parvus,* is endemic to the area. The species richness of small mammals is shown to be low for similar environments on a world basis. Kosciusko is shown to be unusual on a world basis because the small mammals have roughly equal populations, rather than there being dominance in numbers by one species. The small mammals vary from the American pattern of substantial weight loss in winter. Busby (1990) sees *Burramys* as having 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. However, Busby (1990) believes that no particular significance lies in the fauna of mountain or eucalypt forest areas as a whole, or any of their other components.

Good (1992a) states that *Galaxias findlayi,* an alpine endemic found in only two lakes with divergent characteristics between the two, is of scientific significance. There are at least 40 taxa of aquatic invertebrates that are found only in the high mountain water of the Australian Alps (Campbell *et al.* 1986). Cullen and Norris (1989) believed that the uniqueness of the aquatic systems would lend weight to the arguments for World Heritage listing of the Australian Alps. However, Busby (1990) is diffident in relation to the significance of the aquatic fauna, seeing its distinct regional complexion, in terms of endemism and balance of faunal groups, as being typical of any region in Australia.

Costin (1980) considered the insects to be the most outstanding feature of the Kosciusko fauna, because of their biogeographic interest. Good (1992) notes the existence of many alpine endemic invertebrates including some 10 species of Megascolecid earthworms which play a major role in the formation of alpine humus soils, a grasshopper, *Kosciuscola tristis,* which is one of the few insects known to change colour in response to temperature, and the alpine endemic wingless grasshoppers *(Monistria* spp.).

Consideration of the international significance of the fauna has been biased towards vertebrates. The study area does contain most of the populations of a few rare and threatened vertebrates, one of which, at least, is of outstanding scientific interest. This lends strength to the acceptance of the area under World Heritage criterion (iv). The vertebrate fauna in general does not have outstanding features. The invertebrate fauna is poorly known. However, there seems no doubt that the set of alpine invertebrates is important under criterion (ii) and perhaps criterion (i), and I suspect that the invertebrates as a whole, when properly documented, will be of outstanding significance under the biodiversity representation aspect of criterion (iv).

Aesthetics

The outstanding beauty of the alpine wildflower displays, "probably unsurpassed by any ... throughout the world" , is noted by Good (1992, p. 170). He sees the lack of grazing animals, by which he probably means vertebrates, as critical in the evolution of the species that form this display. Costin *et al* (1979, p.37) describes the wildflower displays in the alpine zone as "a massed flowering in summer which is surpassed in few other parts of the world". On the other hand, Mosley (1992a, p. 541) states that "the area does not have alpine scenery that is superlative on a world scale." He does, however, believe that the 'Snowy-Indi Wilderness' could be a possible exception.

In the context of the previous discussion of the World Heritage significance of aesthetic qualities the opinion of Mosley (1992a) may incorporate an inappropriate element of cultural cringe. It is appropriate that Australian nominations should not downplay Australian aesthetics, especially given the known wide intercultural and intracultural diversity in aesthetic perception (eg. Dearden 1984). The Australian Alps are constituted of areas that have outstanding aesthetic significance by the aesthetic standards that prevail in much of both high and low culture in Australia. They should therefore be argued to have outstanding international significance in this area (see p. 8).

The international distinctiveness of the Australian Alps

Introduction

Mountains have always been a favoured location for protected areas because of their spectacular scenery, their geological and geomorphological interest and their varied and often relict biota. Many of the mountain protected areas of the world have been successfully nominated as Biosphere Reserves and World Heritage Areas, and many others might merit these forms of recognition of their qualities. In the previous section I assessed the arguments previously put forward for the international significance of the Australian Alps. This assessment revealed many attributes of the Australian Alps that make them distinctive on a global scale. In the present section I summarize those attributes that best discriminate the Australian Alps from mountain areas elsewhere in the world.

Climate and physiography

Most of the mid-latitude mountains of the northern hemisphere have highly continental climates, in contrast to the maritime climes of most southern hemisphere mountains. Maritimeness in mid-latitudes allows the development of alpine conditions at relatively low altitudes, and results in mountains with alpine ecosystems that do not experience glacial conditions, at least during the warmth of the Holocene. While the Australian Alps are not as maritime as the mountains found on islands, they are more maritime than most of the mountains of the world.

The term 'alp' conjures up images of snow, ice and precipitous peaks, the archetypes being the European Alps and the Himalayas. Mountain ranges such as these are usually in active uplift as the result of the collision of continental plates. They are widely distributed and well-celebrated. Other equally celebrated mountains have risen and are rising as the result of the same massive forces. These are caused by volcanic activity. The island of Hawaii, Vesuvius, Mt. St Helens and Mt. Kilimanjaro are examples of these cone-shaped phenomena. There are relatively few mountains in the world that extend above the climatic treeline that have convex slopes topped with gently undulating plateaus, as most have been carved into jaggedness by the erosional power of ice. The Southern Otago Highlands of New Zealand is one of the few examples of this unusual form outside the Australian Alps.

Geology, geomorphology and soils

Its status as part of an ancient, geologically complex, intraplate mountain range directly adjacent to an extremely narrow continental margin, makes the Australian Alps unique on a global scale. The Drakenbergs of South Africa share some of these characteristics, but do not manifest them all.

Geomorphologically, the form of the mountains as a whole (see above) and the outstanding degree of development of limestone-floored, subalpine parks make the Australian Alps highly distinctive on a global basis.

Alpine humus soils attain their best expression in the Australian Alps, where, unusually on a global basis, they form on a wide variety of substrates. The Australian Alps, unlike most others are mantled with soil, with relatively few outcrops of the country rock.

Biota and vegetation

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 (Kirkpatrick 1982). The Australian Alps represent one extreme in biotic variation in the most biotically distinct of continents.

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.-

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 (Kirkpatrick et al. 1987). 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. There are relatively few other temperate mountain areas of the world with forest vegetation in such a natural state.

Aesthetics

The Australian Alps are aesthetically unique. The combination of gently rounded slopes, highly floriferous alpine vegetation and the pastel untidiness of the eucalypt forest combine to form a highly natural and ineffable beauty.

Analysis of the comparative international significance of six Australian World Heritage Areas and the Australian Alps

None of the criteria that have been developed for assessment of international significance of natural world heritage values have sharply defined boundaries in the continuum from extreme international significance to extreme international insignificance. There are also no clear rules for weighting the different aspects of significance, beyond the necessity for outstanding performance on at least one criterion. Given the lack of operational clarity, boundary conditions can only be determined by precedent. Given that the application of criteria does not necessarily remain stable through time, these comparisons are best made with recent listings. Such comparisons will be most valuable where they involve areas with a suite of similar types of characters. Given that the Australian natural environment is highly distinctive in its natural characteristics, the comparison is best made within the Commonwealth. For the above reasons I undertake a detailed comparison of performance on the different criteria between the Australian Alps and six recently listed areas in Australia. These are the Tasmanian Wilderness World Heritage Area, the Central Eastern Rainforests of Australia (an extended nomination not yet approved), Fraser Island and the Great Sandy Region, the Wet Tropical Rainforests of North-east Australia, Kakadu National Park and Shark Bay, Western Australia.

The validity of my comparison with earlier nominations is affected to some degree by recent changes in the IUCN guidelines, which have deleted direct reference to a record of human impact on the landscape and now include reference to conservation of habitats important for biodiversity conservation in the criteria, and an emphasis on maximal biodiversity in the conditions for integrity. Some of the problems created by these changes have been discussed.

Implicit in the comparisons made below are comparisons on a global basis. It does not strengthen the case for a particular area if it has an outstanding example of a particular natural phenomenon, but other areas, whether inside or outside the World Heritage system, have more outstanding examples.

1) physical formations of outstanding universal scientific value that represent major stages of the earth's history

The geological complexity of the Australian Alps is rivalled only by the Tasmanian Wilderness World Heritage Area. The ancient nature of the mountains can be compared with the Tasmanian Wilderness and Kakadu WHA's. While it is difficult to compare highlights under this criterion the intraplate characteristics of the Australian Alps are at least as significant as the stromatolites of Shark Bay, the landform diversity of Kakadu, the Pleistocene sands of Fraser Island and the Great Sandy Region and the assemblage of glacial, glaciofluvial and glaciokarstic landforms of the Tasmanian wilderness. There is no doubt that the Tasmanian Wilderness is of greater scientific significance for the evolutionary history of glacial features than the Australian Alps. A wider range of landforms is represented, as is multiple glaciations, compared to the relatively subdued features, dated to one glaciation, found at Kosciusko.

2) physical formations of outstanding universal scientific value in themselves

This category covers those physical features that are not of universal scientific significance under the criterion above, but that have a more static universal scientific significance. In the case of the Australian Alps, the karst features at Cooleman Plain, periglacial landforms at Kosciusko, and alpine humus soils all perform outstandingly in terms of their recognition in the international scientific literature and their assessment by authorities. In each case there are certain unique attributes of the physical feature and others that are representative of the wider set of the type of feature. Unusual attributes increase from the karst, to the periglacial features, to the alpine humus soils.

Features of comparable scientific recognition that are found in the six WHAs are: the unusual hydrology and hypersalinity of Shark Bay; the landform catena in Kakadu; the landforms, lakes and soils of the Fraser Island and Great Sandy Region; the Mt Warning caldera in the Central East Rainforests; the Darwin meteorite crater in the Tasmanian Wilderness. As archetypes, the Great Sandy and Kakadu features compare with the alpine humus soils of the Alps.
Meteorite craters, calderas and hypersaline marine waters gain their significance under this criterion from scientific attention, which could have been directed to other alternative similar sites, in the same way as with the karst and periglacial features of the Australian Alps.

3) natural areas or sites that are of outstanding universal significance for science for their representation of the major biological stages of the earth's history

The Australian Alps gain outstanding significance under this criterion for their evidence of the major upheavals of the Pleistocene. Their alpine flora has attracted much scientific interest in relation to long distance migration and recent speciation, while their eucalypt-dominated communities represent a major and unusual adaptation to increasing aridity and fire frequency. Much of their fauna, and a small part of their flora also have Gondwanan links.

In terms of Gondwanan relicts and more primitive taxa, the Australian Alps fade into insignificance compared to almost all other listings, particularly those with extensive rainforest and austral-montane vegetation. Their living record of the Pleistocene climatic upheavals is, in contrast, outstanding in comparison to the six WHAs. Much is made of this aspect of scientific importance in the Fraser Island and Great Sandy Region nomination document. This area is marginal to the locations that experienced the greatest impact of climate change, whereas the Alps are central. However, sea level change would have severely affected the Fraser Island and Great Sandy Region while having little impact on the Alps. Nevertheless, the Alps have a much more diverse representation of the outcomes of this age of change. The scientific literature focussing on the biological outcomes of the Pleistocene is much larger for the Alps than for any of the other six areas.

4) natural areas or sites that are of universal scientific significance as outstanding examples of on-going ecological and biological processes

Research focus reflects and creates scientific importance, although it may be partly a function of accessibility. The Australian Alps have been the scene of internationally outstanding research into the dynamics of: alpine/subalpine vegetation, the upper slope and inverted tree lines and dry forest communities dominated by *Eucalyptus* and *Callitris.* They contain several major monitoring sites that have been maintained for many decades. None of the six WHAs have received as much scientific attention related to their ecosystem dynamics, and none have long term monitoring sites that have been established over such a long time period, although at least Kakadu has sites that are now well-established (eg. Kapalga).

5) natural areas that are the most important and significant for *in situ* conservation of biological diversity

This is very much a relational criterion. An area would gain a high rating on this criterion if it contained a large number of elements of biological diversity not represented elsewhere, or, at least, not represented elsewhere in the secure conservation estate. It would also gain a high rating if it could be demonstrated that, for reasons related to size, diversity and location, it was the best place to protect a substantial part of the biodiversity of the earth, even if other places had similar species and community composition.

Palynological research has shown that the Australian Alps were one of the areas of Australia the biota of which changed most dramatically during the climatic fluctuations of the Pleistocene. However, the wide variety of environments found within the Alps have enabled the survival and evolution of its current biota through local and regional migration in response to environmental fluctuations. Inasmuch as the Alps as defined by the MOU encompass all or most refugia and pathways to refugia, which is likely, the area has outstanding long term conservation significance. The environmental diversity and contiguity of Kakadu and the Tasmanian Wilderness are likely to give them equal resilience in the face of climatic change. The two rainforest listings are internally non-contiguous, but the biome that is their world heritage highlight is likely to largely retreat to smaller areas within its present range, rather than experience massive spatial shifts. They may be thus accorded tentative long term viability. The Fraser Island and Great Sandy Region listing cannot hope to maintain many of its universally outstanding features during the next glacial period. The heaths, seagrass beds and whale breeding grounds will disappear with a drop in sea level, and changes in precipitation are likely to fundamentally alter the hydrology of the perched lakes. Similarly, most of the outstanding features of the Shark Bay listing can only survive within that listing with a maintenance of present sea levels and climate. For example, the maintenance of relict populations of threatened marsupials will be difficult when islands become hills.

The degree of concentration of species within the six WHAs is not totally quantified. However, the Western Tasmanian Wilderness, the Queensland Wet Tropics and Kakadu appear to have over one hundred species each that are confined or predominantly confined to the listed area. The Australian Alps have a lesser number than these listings, but have a greater number than the other listings.

Figures for total number of species within the Alps and the six WHAs are not available. However, for terrestrial higher plants, the Alps are likely to lie behind at least Shark Bay, the Queensland Wet Tropics and Kakadu. Their marsupial, ant and reptile faunas are likely to be near the bottom, or on the bottom, of the relevant species richness lists. The Alps also do not compete in the area of marine flora and fauna.

In contrast to the middle to low range relative performance of the Alps in terms of species richness, they are outstanding in community richness. The most diverse range of communities in any other of the areas occurs in the Tasmanian Wilderness. Here, 192 plant communities have been recognised (Kirkpatrick 1991), compared to 177 in the Alps (Appendix 2). The Alps are second to the Tasmanian Wilderness in representation of alpine and treeless subalpine communities, but are first of all the seven in representation of eucalypt-dominated communities.

The Alps have the same significance for temperate eucalypt forest and woodland, particularly the drier facies, as Kakadu has for flood plain ecosystems and the monsoonal forests and woodlands, and as the Queensland Wet Tropics, Central East Rainforests and Tasmanian Wilderness listings have for the rainforest biome. The Fraser Island and Great Sandy Region area has equivalent significance for high rainfall heaths as the Alps have for alpine vegetation. Similar comparisons could be made between the representation of the alpine biome in the Alps, the representation of tall eucalypt forests in the Tasmanian Wilderness and the representation of Acacia-dominated vegetation at Shark Bay.

6) natural areas or sites that contain superlative natural phenomena

In previous nominations from Australia 'superlative' has been implicitly interpreted to mean either 'unusual', 'more of this than anywhere else' or a 'great example of'. The Australian Alps are most unusual on a global scale for their intraplate origin, their soil-mantled and topographically subdued alpine zone and the continuous sequence of eucalypt-dominated communities from the treeline to close to sea level. They are also a great example of the temperate, dry eucalypt forests. They do not seem to have more of anything than anywhere else, apart from their endemic species and communities which have been discussed above.

The Alps are obviously exceeded in the 'more of' aspect of superlativeness by those areas that do have 'more of's. These include Shark Bay with its stromatolites, dugongs and seagrass beds, the Queensland Wet Tropics with its concentration of primitive plants, Fraser Island and the Great Sandy Region with its outstanding area of sand and its prodigious number of perched lakes, the Central East Rainforests with their outstanding profusion of saprophytic orchids and the Tasmanian Wilderness with its outstandingly tall flowering plants.

It is difficult to compare unusualness with any rigour. Nevertheless, taking a broad brush approach, there is no doubt that the eucalypt forests of the Alps are more floristically, structurally and functionally different to other temperate forests outside Australia than any of the rainforest or monsoon forest types are to their equivalents outside Australia. There is also no doubt that the nature of the landscapes in the Australian Alps is more different from the typical mountains of the world, than the landscape features lauded in the six WHAs are different from their closest international analogues.

In terms of the 'great example of' aspect of superlativeness, the Australian Alps representation of the eucalypt forest catena bears comparison with the representation of tropical wetlands and escarpments of Kakadu, the representation of the features of humid sand country of Fraser Island and the Great Sandy Region, and the representation of Gondwanan relicts of the Queensland Wet Tropics, the Central East Rainforests and the Tasmanian Wilderness.

7) physical formations, natural areas or sites of exceptional natural beauty/aesthetic importance

With the exceptions of Uluru, the Great Barrier Reef, the Franklin River and Kakadu, the aesthetics of Australian natural landscapes are not internationally celebrated, and most of the international celebration of these areas has been at the tourist brochure/popular film end of the aesthetic continuum.

The aesthetic aspect of the Australian Alps that stands out among internationally recognised general elements is the outstanding wildflower display in the alpine environment. This floripulchritude is rivalled at Shark Bay, but nowhere else in the six Australian WHAs.

In the traditionally beautiful juxtaposition of water and land, the Australian Alps have a meagre supply of the former when compared to all except the Central East Rainforest area. In terms of local relative relief and phallic features the Australian Alps perform better than most of the six WHAs, the Tasmanian Wilderness being the clear best performer, but high local relative relief garnished by columns or elongated overhangs is not the aesthetic strongpoint of the ancient, worn Australian continent. The Australian Alps, with their characteristic rounded hills and gentle valleys are the most gynic of the seven areas, and are so on an international scale.

The Australian aesthetic of blue hills, gum leaf and straggly bark is better captured in the Australian Alps than in any other of the seven areas, most of which celebrate alien aesthetic codes. The blue hill aesthetic perception and reality is of international significance, being a superlative (ie. unusual) natural phenomenon.

A final way of comparing the aesthetic qualities of the seven areas is to accept the aesthetic assumption that the larger the area of natural landscape the higher is its natural aesthetic quality. This assumption has the virtue that it escapes sex-prejudice in aesthetic judgement, a gently rounded depression being as wondrous as a glacial arete, although it could be thought to be misanthropic. It also has the virtue of being quantifiable through wilderness analysis (Figure 2). On this criterion only the Tasmanian wilderness surpasses the aesthetic quality of the Australian Alps, although the Central East Rainforests and Kakadu are close behind.

8) areas that contain the habitats of threatened species of animals and plants of outstanding conservation value

Although some species are more important for conservation than others by virtue of their taxonomic and genetic remoteness from other species, or the empathy they stir in humans (eg. wart hogs vs lemurs), this character is most easily measured by the richness of rare and threatened species (RATS) that are conservable in an area. The Queensland Wet Tropics is the clear leader on this measure, followed in turn by the Central East Rainforests, the Tasmanian Wilderness, Shark Bay, the Australian Alps, Kakadu and Fraser Island and the Great Sandy Region. However, Shark Bay is the most important for animal RATS, the prominence of the rainforest listings being attributable to the concentration of relict plant taxa. The most important characteristic relevant to this criterion for the Australian Alps is its possession of almost the total range of the mountain pygmy possum *(Burramys).* This animal is at least as unusual as any of the vulnerable or endangered species found in the other six areas.

9) areas that contain the habitats of threatened species of animals and plants of outstanding scientific value

This criterion passes the set of RATS through the screen of outstanding universal scientific significance. For the Australian Alps, there is no doubt that *Burramys* would pass through this screen. All of the other six areas have some claims under the same criterion, especially Shark Bay and the rainforest nominations.

Synthesizing the relativities

Table 1 groups the seven areas under each of the above criteria into four classes: upper range; medium range; lower range; not universally significant. This subjective process is then exponentiated by deriving a total score composed of the number of upper range criteria plus a score of three for upper range, two for medium range and one for lower range.

Table 1: Relative performance on world heritage criteria of the Australian Alps and six recently listed Australian World Heritage Areas (AA =Australian Alps, SB = Sharks Bay, K = Kakadu, Q = Queensland Wet Tropics, Fl = Fraser Island and the Great Sandy Region, CE= Central Eastern Rainforests, TW= Wilderness

Criterion	upper	medium	lower	n.a.
Physical/earths history	AA,SB,K,FI,TW			Q, CE
Physical/features	AA, Fl, K	TW, SB, CE		Q
Biota/earths history	Q, CE, TW	AA, K, SB	Fl	
Biota/ongoing proc.	AA, K	TW, Q, SB, CE	Fl	
Biota/conservation	K, AA, TW, Q, CE		Fl, SB	
Superlative phen.	AA, K, Q, TW, SB	CE, Fl		
Natural beauty	TW, K	AA, SB, Fl, CE, Q		
RATS/cons.	Q	CE, TW, SB, AA	K, Fl	
RATS/science	SB, Q, CE, TW	K, AA, Fl		

The scoring system gives primacy to the Tasmanian Wilderness, closely followed by Kakadu, with 30 and 29 respectively. The Australian Alps follow with 28. There is then a gap to the Queensland Wet Tropics with 24. This area is followed by Shark Bay with 23, the Central Eastern rainforests with 22 and Fraser Island and the Great Sandy Region with 18. All areas were placed in the highest class in at least two, and up to six, criteria. At the very least this analysis shows that one observer places the Australian Alps well within the range and number of outstanding characteristics that have sufficed for World Heritage listing in the past.

One relative argument that might be put against the outstanding international significance of the Australian Alps is the existing representation of alpine and eucalypt forest ecosystems in Australian WHAs. Eucalypt forests were a feature emphasized in the nominations of the Tasmanian Wilderness, the Central East rainforests, the Queensland wet tropics and Kakadu. Alpine ecosystems featured prominently in the nomination of the Tasmanian Wilderness.

A general principle revealed by the existing Australian WHAs is that more than one nomination can be successful when based on the outstanding universal qualities of the same biome. Thus, we have two nominations based centrally on rainforest, and another that has rainforest as a major component in its argument. However, these nominations cover distinct types of the same biome. Given that the eucalypt forests in existing WHAs are almost entirely either the wet temperate type (Tasmanian Wilderness, Central East Rainforests) or the tropical type (Kakadu, Queensland Wet Tropics), there exists a large gap for the dry temperate eucalypt forests, the niche that is filled by the Australian Alps. Similarly, the alpine ecosystems of the Australian Alps represent a large section of a continuum of alpine variation that is not represented in the Tasmanian Wilderness.

Problems with Integrity

Current management

The Australian Alps National Parks and other reserves all have management plans, and their management is integrated across state and territory boundaries through the mechanism of the Memorandum of Understanding. These are very positive points for their integrity.

However, there are some aspects of the current management of the MOU area that might impede international recognition, because they violate conditions of integrity. In this section I review previous statements on these integrity problems, and discuss the changes that would be needed to ensure that they would not jeopardise international recognition under the World Heritage Convention. The perspective I necessarily adopt in this process is that deficiencies only exist if they threaten internationally important attributes of the

MOU area, or fall short of requirements that are necessary for listing.

Costin (1989) saw grazing by domestic stock, logging, tourism and fire policies as threats to the integrity of the Australian Alps. Mosley and Costin (1992) believed that problems with incompatible land uses in the Alpine National Park, such as grazing and logging, and inadequate protection of wilderness, would need to be tackled to allow a World Heritage nomination the best chance of success. Kirkpatrick (1989) saw the current level of disturbance of the alpine vegetation of the Australian Alps as being inconsistent with World Heritage listing. He referred to cattle, skiers and bushwalkers. Ashton and Williams (1989) concluded that stock grazing within Victorian National Parks had profound negative effects on their alpine and subalpine ecosystems and was inconsistent with nature conservation and National Park status.

Broome and Mansergh (1989) stated that most types of habitat degradation that affect *Burramys parvus* have been recorded in the Mt Hotham alpine resort, and definitely increased in this area between 1978 and 1984. This is not relevant to the present discussion (the resort not being in the MOU area) except that they also noted that significant *Burramys* habitat lies in areas of potential ski development in Kosciusko National Park. At present , 8% of *Burramys* habitat lies within ski resorts. Degradation of vegetation due to past stock grazing is also recognized as a problem for *Burramys,* although many areas are now recovering.

Cullen and Norris (1989) identified the following threats to the integrity of the high mountain aquatic ecosystems of the Australian Alps: 1) the encouragement of exotic fish species through the use of waters for recreational fishing in the context of known effects on native species and community structure; 2) the impact of resorts on water quality (they note amelioration in the case of Thredbo); 3) the impact of water extraction from streams for snow-making and the introduction of exotic bacteria to facilitate the formation of desirably-sized snow flakes during snow-making; 4) the local eutrophication that can occur through dispersed recreational activity; 5) the use of salt on roads.

Stock grazing is a use of the high country that has been forbidden in the conservation estate of New South Wales and the Australian Capital Territory, and in most of the Victorian reserves, yet which is permitted within a part of the high country in the Alpine National Park. 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 (eg. Ashton and Williams 1989, Leigh *et al.* 1991). The activity is therefore completely incompatible with the maintenance of the natural alpine and subalpine biological diversity that supports World Heritage listing under criteria (ii) and (iv).

The work of Wimbush and Costin (1979abc) in Kosciusko National Park has shown that the removal of grazing results in a relatively rapid recovery of most native species and ecosystems. The exceptions are where the accelerated erosion and deposition resulting from grazing and related activities has changed edaphic and topographic conditions. The lack of plans for a rapid phase out of stock grazing, to, at most, a ritual level, in the Alpine National Park could provide a serious impediment to World Heritage listing.

Another impediment to listing may be the once-off logging that is taking place within parts of the Alpine National Park of Victoria. This is planned to cease in 1999. The felling of remote old stands of eucalypts within a national park makes a mockery of the title, and obviously deleteriously affects World Heritage values under criteria (ii) and (iv).

Wild 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 (Dyring 1992). It is only in Namadgi National Park that they have been eliminated. In Kosciusko National Park they are effectively treated as a source of wild horse stock. Their known impact on native plant communities threatens qualities that justify World Heritage listing under criteria (ii) and (iv). It would therefore promote the case for World Heritage listing if control or elimination of this species was made a management goal in all of the MOU area, as is presently the case in Victoria and the ACT.

Rabbits are widespread and abundant and have been shown to deleteriously affect the native vegetation, especially after fire (Leigh *et al. 1987),* pigs have been a major management problem in some areas of open vegetation and introduced vertebrate carnivores have probably been largely responsible for the loss of several small native mammals in the critical weight range. Some of the parks in the MOU area have been the leading developers of control measures for some of these species. For example, highly effective methods for the control of pig populations have been developed in Namadgi. Unfortunately, these are not directly transportable to other parts of the MOU area because of poison regulations. Nevertheless, control measures for exotic vertebrates are detailed in management plans in all parks.

Introduced plants that threaten the local survival of native species are absent from much of the MOU area. However, several species present major local management problems with the potential for more extensive damage. Blackberries *(Rubus fruticosus* sp. agg.) and broom *(Cytisus, Genista)* species are two of the major threats. Direct management action is taken to control exotic weed populations. However, vectors such as stock, horses and four wheel drive vehicles need to be controlled to prevent the spread of the problem.

Recreational activity has the potential to degrade some of the internationally significant features of the Australian Alps. Impacts from walkers have been partly mitigated in the Kosciusko alpine zone, where the major problems are evident , by construction of raised metal walkways on one of the most popular tracks. Problems still exist with less-used tracks which pass through feldmark. In these cases the plants that used to cross from the windward to the leeward sides of the feldmark are trampled to death on the foot track. Rehabilitation continues.

Horseriding is a use that has greater potential for environmental damage than equal numbers of bushwalkers. It is a widespread use in the MOU area, although it is excluded from a large part of the sensitive alpine zone. Strategies have been developed to minimize its impact, which is potentially considerable (Whinam *et al.* in press).

A major recreational use, involving millions of people a year, is skiing. In Victoria downhill skiing resorts are excluded from the MOU parks. In New

South Wales they have been developed within the Kosciusko National Park. The local impact on natural values is extremely high. Ski resorts occupy only 3890 ha of the MOU area. However, their effects are concentrated in the alpine and high subalpine zones. It may be appropriate to exclude the ski resort areas from any World Heritage proposal and give assurance that they will be excluded in the future from any World Heritage Area. The problem of enclaves has been met in earlier Australian World Heritage listings. Ski resorts are certainly more natural value friendly enclaves than the uranium mines of Kakadu National Park.

Hunting of deer is permitted in some Victorian parts of the MOU area and fishing for trout is permitted in most parts of the MOU area. In both these cases, exotic organisms provide a recreational resource. It is known that trout are an endangering factor for some of the fauna of streams and lakes (Wager and Jackson 1993). The ecological impact of deer is not known. Most management plans for the area have the general aim of control or eradication of introduced species from those parts of the area in which they threaten native species.

Off road vehicles, including four wheel drives and trail bikes present a growing management problem which can only be controlled with adequate staffing for policing, as codes of behaviour and 'Tread Lightly' campaigns do not reach or affect all recreationalists. The lack of a substantial policing presence is a major management problem, especially in Victoria. This reflects the inadequate field staffing levels in most of the parks that compose the MOU area (e.g. 15 rangers in the Alpine National Park). While there is no simple relationship between area and the appropriate number of field staff, a comparison of the staffing of Kakadu National Park, the Tasmanian Wilderness World Heritage Area and the Australian Alps MOU area indicates the need for increases in the Alps, especially given their much higher level of accessibility by vehicles than the other two areas. The case for World Heritage listing would be improved by a commitment by the governments involved in the MOU to increase field staff to more adequate levels.

Cloud seeding has recently been proposed for the Kosciusko alpine zone with the aim of increasing snow fall by 10%. The draft environmental impact statement (Snowy Mountains Hydro-electric Authority 1993) concludes that there will be no significant adverse effects on the natural values of the Park, a seemingly reasonable deduction given their plans and the state of present ecological knowledge. However, the outcomes of perturbations of ecological systems are not easily or consistently predicted. It is therefore important to establish monitoring procedures that will enable any deleterious effects on the flora, fauna and landforms of World Heritage significance to be rapidly detected. It is also important to establish mechanisms to rapidly vary or eliminate the experiment in response to deleterious effects.

Boundaries are important for the integrity of World Heritage Areas. In the cases of Namadgi National Park and the Snowy River National Park, the boundaries either accord with natural features, or correspond to the boundaries between natural and degraded country. In contrast, the Alpine National Park has boundaries that relate in many places to the boundary between commercial and non-commercial forest. This creates some rather narrow connections between the larger parts of the park, and one substantial enclave (Figure 1).

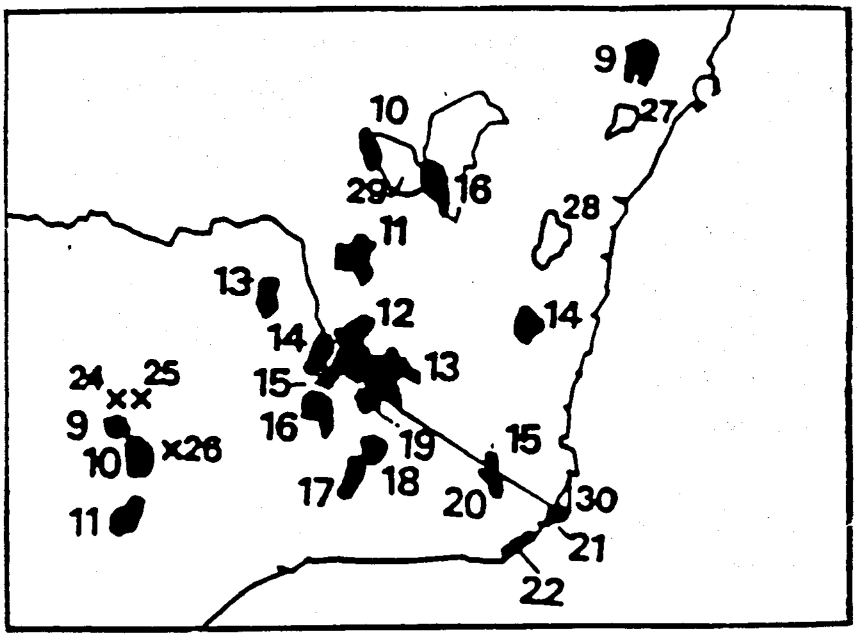
Past disturbance

It has been perceived by some that the MOU area has been too disturbed by past human activity to have the integrity to merit listing under the World Heritage Convention. It is true that much of the area has been grazed by domestic stock. The impact of stock grazing has been substantial. The Kosciusko alpine area is still in the process of recovery from its impact forty years after its cessation. The soils and productivity of the cypress pine forests are both depleted from the past effects of stock grazing. The presence of introduced plants in most of the mountain valleys of Victoria is probably largely the product of transport of exotic disseminules by stock and people.

It is true that small parts of the area have been logged or planted with pines, other small parts have been urbanized and yet other small parts have been inundated or drained in the cause of the development of hydro-electric power and irrigation. Hydro-electric lakes cover 4636 ha of the MOU area. The drive to Charlotte Pass in the heart of the Kosciusko National Park is more notable for alpine architecture than natural scenery.

Despite the above verities, the reality of the MOU area is that almost all of it is covered with vegetation that bears close resemblance to that present before European settlement, and which includes individual plants that were established before Europeans invaded Australia. Relatively little of the forest has been logged at all, much less clearfelled, and the forest that was selectively logged in the past is difficult to differentiate from uncut forest.

The other side of the MOU area to the small areas of ski resort and hydro-electric lake is the half a million hectares of formally designated wilderness contained in its boundaries (Figure 2). Admittedly, much of this designated wilderness is crossed by four wheel drive tracks, and there is an occasional hut or arboretum. Nevertheless, these are primitive and extensive natural areas which exclude



recreational mechanized access (Figure 2). Figure 2. Wilderness areas in the southeastern corner of Australia (modified from a map distributed by Prineas at the Fourth National Wilderness Conference, Sydney, October 1993). The dark areas are wilderness as recognized under legislation. The outline areas are wilderness not recognized in legislation, but protected in Conservation Reserves. Areas 9-1 1 and 14-19 in Victoria, 10-13 and 29 in New South Wales and 16 in the Australian Capital Territory are within the MOU parks. Areas 20-22 in Victoria are within parks discussed in Appendix 1. The areas marked by crosses have no protection and are not officially recognised as wilderness areas (they were designated remote and natural areas by the Land Conservation Council, Vic).

A comparison of the integrity of the Australian Alps and six recently listed World Heritage Areas in Australia

All suitable parts of the seven areas have been grazed by stock in the past, although this obviously had little or no impact on the rainforest listings or the oligotrophic part of the Tasmanian Wilderness listing. The past and continuing impact of stock grazing is greatest in the Australian Alps of any of the seven areas.

All seven areas have some recreational infrastructure. In terms of scale and area, the Australian Alps have suffered the greatest impact from this cause. However, ski resorts could readily be excluded from any World Heritage nomination.

The natural values of the Australian Alps have suffered to a greater degree from the construction of hydro-electric schemes than any other of the seven areas except the Tasmanian Wilderness. However, it needs to be noted in this respect that Lake Pedder, probably the most environmentally destructive of any impoundment in Australia, was included in the Tasmanian Wilderness World Heritage Area, as were hydro-electric works on the Central Plateau of Tasmania. The Central Plateau was included in the Tasmanian Wilderness World Heritage Area because of its concentration of rare and threatened plant species and communities. A similar concentration is found in the affected alpine areas of the Australian Alps.

Kakadu has integrity problems related to mines and mining infrastructure, which, while not included in the World Heritage Area, sit in enclaves within it. The rainforest listings have major boundary problems. Their perimeter/area ratios are high, and much of the land on their margins is devoted to intensive use. In comparison, most of the land on the margins of the MOU area is managed for extensive forestry.

Timber extraction is a use that is peculiar to the Australian Alps among all the seven areas. The proportion of the Australian Alps forests that have been cut in the past is much higher than for the Tasmanian Wilderness and Kakadu, but is less than for the rainforest listings and Fraser Island and the Great Sandy

Region.

Hunting and fishing for exotic species are permitted uses in several of the seven areas. Hunting for native species occurs in the Tasmanian Wilderness, and, for the Aboriginal community only, in Kakadu.

Problems with the invasion of exotic species are more severe in the Australian Alps than in any other of the seven areas, although Kakadu has potentially severe problems with exotic plant species.

It is clear from the above discussion that the Australian Alps have more severe integrity problems than any of the other six areas. Many of these problems could be resolved by changes in the type and intensity of management. Others are relics of past human activity. These latter problems are more severe on the whole than for the other six areas.

The above assessment needs to be placed in a wider context. The Australian Alps compare favourably on integrity with many mountain World Heritage Areas outside Australia where management is less adequate andlor major and more extensive modifications have occurred in the vegetation and landscape. For example, Yellowstone National Park and Yosemite National Park have large areas of development and extensive road systems and the Hawaii Volcanoes National Park has absurd boundaries in relation to its volcanic and biotic features, considerable development and is heavily invaded by exotic plants and animals. Thus, the integrity of the Australian Alps appears better on an international basis than it does on a national basis.

The case for World Heritage listing

This section is, in part, a pastiche and paraphrasing of material in the previous assessments (Good 1989, 1992ab; Busby 1990; Boden 1991). However, it only includes material that I consider to be relevant to the case for World Heritage listing. The case is presented in the same manner as in recent Australian World Heritage nomination documents.

Criterion (i)

be outstanding examples representing major stages of earth's history, including the record of life , significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features;

Geological/geomorphological processes/features

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 (not part of this nomination). The nature and timing of their origin in the context of their intraplate location has generated intense international scientific interest.

The development of that part of the lithosphere, the crust of which constitutes the Australian Alps, commenced in the Palaeozoic, with Cambrian to Carboniferous rocks that have been faulted, folded, intruded by granites and metamorphosed.

The Australian Alps exhibit a constancy of expression of geologic, tectonic and geomorphological events that give character to the Lachlan Fold Belt, a phenomenon that transgresses their boundaries, but which is best expressed in many of its aspects within their bounds. For example, the valleys that dissect either side of the Divide expose a cross-section of Palaeozoic tectonic, sedimentary and volcanic history. The Cambrian lavas and Ordovician fossiliferous sediments have particular significance.

The Cambrian rocks of the Mount Wellington Greenstone Belt are important in that they indicate the tectonic conditions that prevailed during the earliest stages of formation of the Fold Belt. These basic lavas with minor sediments delineate the margins of the Melbourne and Tabberabbera zones. They imply an eruptive origin in an arc-backarc oceanic basin system, although alternative theories are also given some credence.

The Ordovician rock system is internationally important as a type section for biostratigraphic division, largely as a result of its rich graptolite fossil fauna. The Australian Alps exhibit an interesting sparsity of this fossil material compared to areas directly adjacent. Recent scientific interest has turned to conodont fossils from the Australian Alps, which show promise for further refinement of the dating of the Ordovician sediments. In some places within the Australian Alps Ordovician felsic volcanic rocks survive on the surface with no evidence of intermediate burial, indicating the persistence of elements of an ancient landscape.

Silurian to Middle Devonian sedimentation and volcanic activity finally filled the Lachlan Fold Belt. A rich fossil flora was deposited in Upper Silurian and Lower Devonian sediments, which are largely exposed adjacent to, rather than inside, the nominated area. However, the best fossil exposures in the distinctive Upper Devonian/Lower Carboniferous 'red beds' and volcanics are in the Mt Howitt area. These include "one of the most important Devonian fish faunas from the southern hemisphere (Marsden 1988). The landscape and deposits of the Permian glaciations are preserved in some parts of the nominated area and directly adjacent to it. These give remarkable insights to the nature of ancient landscapes.

In the Mesozoic Australia was part of the megacontinent of Gondwana. At this time the area that is now the Australian Alps was remote from the sea. Outward flowing drainage patterns indicate that it was elevated as part of an east-west ridge that ran through the present location of Kosciusko.

Australia separated from Antarctica approximately 55 m y ago. Between about 80 m y ago and 60 m y ago seafloor spreading created the Tasman Sea. The form of this breakup was highly unusual, with a break at the continental edge, and a drifting away of the rift valley and associated sediments. The axis of uplift parallel to the continental margin was probably related to the creation of the Tasman Sea. Where this axis and the Mesozoic axis intercept there lies the highest mountain range in Australia, one of the outstanding features of the nominated area. Oilier and Wyborn (1989) see the Australian Alps to consist of huge fault blocks, uplifted in the Miocene. Similar patterns are found in South Africa and Brazil, but with much wider continental shelves.

The exact relationship between the evolution of the Australian Alps and the formation of the Tasman Sea is of great scientific interest and is yet to be resolved (Lister *et al.* 1986; Wellman 1987; Bishop 1988). Pre breakup heating of a very narrow strip of coastal Australia and crustal underplating in combination with basaltic vulcanism are only two of many mooted explanations (Bishop 1988; Oilier and Wyborn 1989). As Bishop (1988) points out the Alps are yet to be accommodated in plate tectonic theory. They are distant from plate margins and are not supported by unusually high heat flows or crustal rigidity, being in isostatic equilibrium (Bishop 1988). They are therefore a critical element in the global assessment of plate tectonic theory.

The ancient nature and slow rate of landscape evolution that has been documented for the Australian Alps has major implications for process studies at the international level. If, as seems likely, the karst landscapes of the Australian Alps have been subaerially exposed for much of Cainozoic and some of the Mesozoic their caves and associated features may be very old (Osborne 1984). If this is the case, the apparently youthful features of many of these caves may need to be reevaluated, along with ideas on the nature of karst-forming processes (Osborne 1984). The drainage patterns in the Australian Alps have also been shown to be of great antiquity, a conclusion gained from studies of the topography beneath Miocene and Eocene lava flows (Young 1983; Bishop 1988).

Because of the mildness of glaciation and the current climatic mildness of the alpine zone as a whole, the Australian Alps have a range of active and fossil periglacial features of great international scientific interest. For example, the studies of Costin *et al.* (1973) on Kosciusko snow patches showed that they had special properties that allowed them to act as erosional agents in a similar fashion to glaciers, including the rapid maturing of a pack formed from wet and heavy snow to densities approaching those of glacial ice (Jennings and Costin 1978). Slope deposits (Costin and Polach 1971), nonsorted steps (Costin *et al.* 1967), and frost cracks and earth hummocks (Costin and Wimbush 1973) are some of the many periglacial features documented for the Australian Alps in the international literature.

The Cooleman Plain in the north of Kosciusko National Park is internationally significant as a site for long term investigations into karst geomorphology and hydrology (Spate 1987; Spate and Household 1989). Research results and geomorphic features of international interest include localised limestone solution rates (Gams 1985), A-tents and low angle mudflows (Spate and Household 1989).

Biological evolution

The evolutionary significance of the biota lies largely in its living record of the impact of the major environmental upheavals of the Quaternary. This is not to say that the nominated area lacks evidence of earlier stages in the evolution of life, far from it, but rather that its outstanding universal quality is its epitomisation of the recent changes.
The Australian Alps, as probably the oldest of the Australasian alpine areas, are thought to have played a central role in the development of the Australasian alpine floras through long distance migration and subsequent adaptive radiation (Smith 1986). Cladistic and other biogeographic evidence suggests that the Australian Alps were both a receiver and sender of the founders of radiating alpine lines (Barlow 1989). The flora of the Australian Alps is an unique assemblage of colonists of a habitat thought to be less ancient than that of rainforest (Barlow 1989). The flora is thought to have been derived partly from lowland autochthones, partly from southern hemisphere peregrines and partly from northern hemisphere peregrines, with the earlier two components being dominant.

The eucalypt forests and woodlands that clothe most of the undulating hills of the nominated area provide outstanding evidence of very recent environmental change. Rainforest started to give way to open vegetation dominated by *Allocasuarina, Callitris* and Asteraceae approximately 6 million years ago, but it was only in the last 0.2 million years that *Eucalyptus* attained its present high level of dominance. This dominance is almost complete in the nominated area. There are few other parts of the range of *Eucalyptus* where it is so uninterrupted by rainforest or open vegetation. Nevertheless, the Australian Alps do contain some significant stands of the types of forest that preceded those dominated by *Eucalyptus.* These range from the *Callitris columellaris* woodland in the Snowy River Valley (Clayton-Greene and Ashton 1990) to the mixed *Allocasuarina-Callitris-Eucalyptus* communities of the Murrumbidgee Valley (Gilmour *et al.* 1987). Indeed, in the wide diversity of communities found in the Australian Alps there are even elements of the Gondwanan rainforest, with the primitive angiosperm, *Atherosperma moschatum ,* being found in a few sheltered and moist valleys.

Palynological research (eg. Kershaw *et al.* 1986) has indicated that the Australian Alps experienced some of the most massive biotic changes between glacial and interglacial that were experienced in the Southern Hemisphere. It seems likely that neither alpine vegetation as it is known today nor eucalypt forest were very extensive in the Australian Alps during the height of the Last Glacial, with species retreating to refugia or being found in vegetation types that would be atypical for their occurrence today.

As could be expected within recently developed vegetation types, there is considerable evidence of on-going divergence and speciation. Some of the earliest scientific work on the genetics of clines was undertaken by Pryor (1957) on *Eucalyptus pauciflora,* a species that is found from sea level to the tree line. The work of Barker (1986) on the genus *Euphrasia* demonstrates parallel vicarious series in which the differentiation is largely latitudinal.

integrity

The nominated area contains most of the most prominent features of the intraplate mountain range and the Lachlan Fold Belt. It contains a wide diversity of periglacial and karst features and includes all the catchments of the most critical karst areas and extends from the highest places in which periglacial features occur to below their lowest limit.

The nominated area contains almost all the alpine and treeless subalpine vegetation of the Australian mainland and a comprehensive cross-section of the eucalypt-dominated vegetation of southeastern Australia from the woodlands of the rainshadow areas, through the dry sclerophyll and grassy forests of the foothills and the montane wet sclerophyll forests to the subalpine forests and woodlands (Appendix 2). It also contains a large representative sample of the *Callitris* dominated woodlands and their intergrades with eucalypt forest. All the area is within conservation reserves with management plans, the implementation of which will ensure the future of the above features except for areas of the Alpine National Park where grazing or logging are permitted uses. Management of these reserves is integrated through a liaison process set up under the MOU.

Criterion (ii)

be outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, freshwater, coastal and marine ecosystems and communities of plants and animals

Dynamics of forests and woodlands

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 (Appendices 2 and 4). 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 hybridization and intergradation between the dominants of the eucalypt forest which covers almost all of the area.

It is only in Australia that a wide variety of species within a single genus, dependent on exogenous disturbance for their regeneration, dominate over the whole climatic gradient from warm temperate to subalpine. The nominated area is the best example of this phenomenon within contiguous largely undisturbed forest and woodland. It contains 46 species of *Eucalyptus* (Appendix 4), a substantial proportion of the global total.

Several features of eucalypts make them constitute one of the dynamically most unusual forests in the world. One of their most striking features is their adaptations to fire. In the dry sclerophyll and grassy woodlands and forests that cover much of the Australian Alps, the dominant eucalypts have thick or reflective bark, adventitious buds concealed beneath its protection,
underground, bud-rich woody swellings called lignotubers, and a store of seed

held constantly in woody capsules on the tree. Fire in these forests is followed by the rapid vegetative recovery of most individual trees and massive eucalypt seed germination. With the exception of unusual circumstances like landslip or flood scour, all regeneration that reaches reproductive age establishes in the open conditions provided by fire. The competition provided by the root systems of the recovering trees suppresses most regeneration. However, during each fire some trees are felled by basal attrition providing space for a new generation. Thus, the forests are typically multi-aged, the number of age classes depending on the frequency of fire.

As well as being outstanding survivors of fire, the eucalypts also aid its propagation. Their leaves are full of volatile oils, their open canopies allow drying out of the ground layer, their litter breaks down very slowly and their bark forms burning brands that propagate fire well ahead of the main front.

The eucalypt canopy allows approximately half the incident solar radiation to reach the ground. This allows the development of dense, species-rich understoreys which have their own dynamic relationships with fire regimes. A single fire in dry eucalypt forests seldom results in any major changes in vascular plant species composition. Successional processes fit the initial composition model rather than the globally more commonly manifested relay floristics model. However, the lifeform dominance and structure of the understorey are sensitive to the frequency, season and intensity of fire. For example grassy understoreys can result from highly frequent low intensity fire that repeatedly reduces the biomass of shrub species, or from the absence of fire in a period long enough to cause the senescence and death of shrubs species, as most of these require the disturbance of fire for regeneration.

Almost all of the profusion of understorey species either recover from fire vegetatively, store hard-coated seeds in the soil, have wind-dispersed propagules or a combination of these (Purdie 1977ab).

The wet sclerophyll forests that occupy part of the nominated area are often dominated by eucalypts that lack the ability to recover vegetatively after intense fire, although most large individuals will survive normal fires. Fires are less frequent where this forest type occurs than in those areas occupied by dry forests. The wet eucalypt forests tend therefore to have fewer age classes than the dry eucalypt forests. They are also more easily eliminated by frequent fire (Ashton 1981).

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.

Dynamics of the treeline

Eucalyptus pauciflora and the Tasmanian *Eucalyptus cocciferaform* the only upper slope treelines in the world dominated by open-crowned, evergreen angiosperms. The openness of their crowns allows most elements of the alpine biota to transgress its bounds. This could be of considerable importance in the response of the components of alpine vegetation to climatic change.

Despite being apparently morphologically unsuited to survive in the snow country, with its large snow-trapping leaves, *E. pauciflora* is photosynthetically suited to the environment and has the ability to acclimatise to winter cold (Slatyer 1989). The species does not experience internal water deficits in winter, in contrast to the perception for northern hemisphere trees (Slatyer 1976).

Recent increases in temperature in the southern hemisphere have not led to a change in the location of the treeline. This is not because trees cannot survive in the lower part of the alpine zone, experimental work has shown otherwise (Slatyer 1989), but rather because the eucalypts require substantial ground disturbance or freedom from competition for their establishment.

The Australian Alps have the most outstanding development of parks, or open treeless subalpine valleys, 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. At present work is underway exploring the position of past inverted treelines through the chemical signals left in the soil. It seems that tree colonization is possible with the disturbance of the grass sward, but that colonisers may be subject to occasional elimination from severe advection frosts.

The dynamics of alpine vegetation

The nominated area includes some of the longest monitored alpine environments in the world (Carr and Turner 1959ab; Williams and Ashton 1987, 1988; Wimbush and Costin 1979abc). Much of this work has been directed towards documenting the results of exclusion of exotic grazing animals, but this and other work has also revealed long term natural processes of outstanding international scientific interest.

One of the more unusual features of Australian alpine ecosystems is the absence of large native vertebrate grazing animals. Their absence may be the major cause of the widespread dominance of herbs, and of their spectacular summer flower displays (Kirkpatrick 1989). However, invertebrate herbivores, such as the larvae of swift and case moths cause small scale successional patterns in the native herbfield and grassland (Carr and Turner 1959a). Climatic fluctuations can also cause widespread dieback in the dominant *Poa* tussocks and their temporary replacement by herbs (Wimbush and Costin 1979b). There are fascinating dynamic relationships between shrubs and the grasses and herbs, with small scale disturbance favouring shrub invasion, and slowly senescing shrubs being invaded by herbs and grasses. In the closed heath there are examples of cyclic succession between shrub and shrub similar to the classical relationship between *Calluna* and *Arctostaphylos* in the Scottish moors (Ashton and Williams 1989).

There are outstanding examples of the dynamic interaction between vegetation and landform in the wide variety of peat ponds and string bogs found within the alpine and treeless subalpine zones (Costin *et al.* 1979; Ashton and Williams 1989). The globally outstanding alpine humus soils develop as the result of an interaction between the herbaceous component of the vegetation and enormous earthworm populations (Costin *et al.* 1952; Costin 1966).

Integrity

The nominated area contains almost all of the alpine and treeless subalpine ecosystems of the Australian mainland and has extensive examples of all types of ecosystems found in this environment. It also encompasses a large proportion of the eucalypt forest and woodland of southeastern Australia, containing all major physiognomic types from mallee to tall mixed forest, and a large proportion of the dominant tree species. The area is conserved within reserves with management plans directed to the perpetuation of the qualities described above, except for small areas of the Alpine National Park where grazing or logging are permitted uses. Management of these reserves is integrated through a liaison process set up under the MOU. The eucalypt forests and woodlands and the alpine vegetation are among the most species rich in their biogeographic provinces, while the diversity of ecosystem types is outstanding in Australia (Costin 1989), and therefore on a global basis.

Criterion (iii)

contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance

Superlative natural phenomena

The Australian Alps contain many superlative natural phenomena, not the least of which is their nature as an outstanding and unusual exemplar of intraplate mountain ranges. The character of the mountain ranges in the Australian Alps is markedly different from that of those in most other places. The relative lack of glaciation and tectonic processes have combined to create alpine mountains which largely consists of undulating plateaus mantled by atypically deep soils. The alpine humus soils of the alpine zone are the best-developed of their type in the world, being highly unusual in their development on a range of geological substrates and their massive earthworm activity (Costin 1989). The extensive areas of subalpine treeless vegetation or 'parks' are both unusual on a world scale and most prolific in the Australian Alps.

The wide diversity of structural types, ranging from very tall eucalypts over rainforest to multistemmed small trees over scleromorphic shrubs, dominant species and, particularly, environments that is found in the Australian Alps eucalypt forests makes them a superlative phenomenon on a global scale. The contiguous distribution of natural forests dominated by one genus from warm temperate environments close to sealevel to the treeline is unrepeated on a global scale.

Exceptional natural beauty

The early painters of the Australian Alps, such as Nicholas Chevalier and Eugene von Guerard, interpreted their scenery through romantically gothic and eurocentric eyes. Precipitousness was imposed on an essentially gentle landscape; the phallic dominated the essentially gynic.

These artists saw only that part of the Australian landscape that accorded with their imported aesthetic prejudices and moulded it to better fit. Frederick McCubbin, one of the initiators of the Australian bush aesthetic rejected their criteria in the celebration of the real form, texture, colour and mood of the Australian bush. This aesthetic is outstandingly epitomised in the Australian Alps, being, as it is, centred upon the subtleties of dry eucalypt bark and leaf and the gentle and ancient eucalypt-covered slopes. It is an aesthetic that may not be readily accepted by most of the people of the planet. Indeed, many of the first European invaders found the landscape harshly ugly (Taylor 1992). Nevertheless, it is an aesthetic as valid as any other, and one which imparts a superlative beauty to the nominated area.

The residuals of the landscape romanticism of the nineteenth century, which, as argued by Bonyhady (1991), saw beauty in an erroneous concept of primeval emptiness, survive in the contemporary wilderness movement (Mosely 1992a). The Australian Alps have several large wilderness areas and the potential for others (Mosley 1992b). The 330,000 ha 'Snowy-Indi Wilderness' (Mosley 1992a) even contains some gothic scenery as well as outstanding wild manifestations of the McCubbin aesthetic.

The summer wildflower displays in the Kosciusko alpine zone are internationally superlative (Costin *et al.* 1979), probably due to the fortuitous absence of large vertebrate herbivores. The most spectacular flowering species are daisies (Asteraceae), buttercups *(Ranunculus* spp.) and eyebrights *(Euphrasia* spp.). However, the colour contrasts in foliage add to the effect, with the light green of the fen, the dark khaki green of the bog, the pastel blue of the herbfield and the straw yellow of the tussock grassland being found in intimate mosaics.

Integrity

The nominated area contains all those areas that are necessary for adequate conservation and maintenance of these features. The area is conserved within reserves with management plans to the perpetuation of the qualities described above except for small areas of the Alpine National Park where grazing or logging are permitted uses. Management of these reserves is integrated through a liaison process set up under the MOU.

Criterion (iv)

contain the most important and significant natural habitats for in situ conservation of biodiversity, including those containing threatened species of outstanding universal value for science or conservation

Natural habitats for conservation of biological diversity

The nominated area is lithologically and climatically highly diverse. Substrates vary from the highly argillaceous to the highly siliceous. Precipitation varies from 400 to 3000 mm per annum. At lower altitudes there are places that seldom experience frost. At higher altitudes snow may cover the ground for most of the year. The mid-latitude situation of the Australian Alps maximises local habitat differences related to the angle of incidence of solar radiation, enabling mesic and xeric communities to be closely juxtaposed.

Fifteen Great Soil Groups occur within the nominated area. In the alpine zone there are found alpine humus soils, bog and fen peats, humified peats, meadow. soils, gleyed-podzols, silty bog soils, alluvial soils and lithosols. In the subalpine zone there are found transitional alpine humus soils, red loams and meadow gleyed-podzols. In the montane zone there occur brown podzols, iron podzols, red loams and grey-brown podzols. At lower elevation grey-brown podzols, brown podzolics, iron podzols, brown earths, rendzina soils, terra rossa soils, grey-brown podzolics and brown alluvial soils are found.

There is a wide variety of lentic and lotic environments, ranging from cirque lakes to lowland riparian scrub. There are also marked variations in soil drainage, particularly in the alpine and subalpine zones.

This great environmental heterogeneity is reflected in the development of a high degree of biological diversity, especially at the community level. More than half of the forms and subforms of vegetation that were recognised on the Australian mainland by Beadle and Costin (1952) are partly or wholly found within the nominated area. The subforms found within the Australian Alps are wet tussock grassland, sod tussock grassland, tall alpine herbfield, short alpine herbfield, valley bog, raised bog, dry heath, wet heath, dry scrub, wet scrub, wet mallee, savannah woodland, tall woodland, subalpine woodland, dry sclerophyll forest, wet sclerophyll forest and temperate rainforest. Appendix 2 lists the 177 plant communities recorded from the nominated area. This constitutes a very large proportion of the forest and alpine community diversity of Australia. A large proportion of these communities are dominated or co-dominated by eucalypts. The Australian Alps, while having fewer eucalypt species than the northeast of New South Wales, are rich in dry sclerophyll forest, woodland and wet mallee species. Appendix 4 lists those eucalypt species that have been recorded from the nominated area.

At the species level the Australian Alps contain a significant proportion of the biological diversity of Australia, and thus of the world. This is particularly striking with the higher plants. For example, the Rodger River Block, now part of the Snowy River National Park, consists of only 9200 ha, yet contains populations of over 300 higher plant species (Chesterfield *et al.* 1983). The 12,000 odd ha of the Mt Tennent-Blue Gum Creek area of the Namadgi National Park contain 570 higher plant species (Gilmour *et al.* 1987). Good (1992b) estimates that there are 750 higher plant species in the part of the nominated area above 400 m. This is a highly conservative figure for the area as a whole, which almost certainly has substantially more than 1000 higher plant species, many of which are confined or largely confined to the Australian Alps. This is more than 5% of the vascular flora of Australia which in turn has approximately 10% of the vascular flora of the world. Almost all of the species in the Australian Alps are Australian endemics.

The alpine zone flora is the best known. It consists of 230 higher plant species in 98 families. Eleven percent of these species are Australian Alps endemics, a high proportion of local endemism on a global basis, most mountain ranges having endemism levels of 5% or so. Most are Australian endemics.

Our knowledge of the invertebrate fauna is highly incomplete at less than 1000 taxa. However, it seems likely that ten times as many invertebrate species as higher plant species will be found within the nominated area (P. McQuillan pers. comm.). Approximately one third of Australia's avifauna has been recorded within the nominated area. Most of these taxa have most of their range outside the Australian Alps (Busby 1990), which, nevertheless are highly significant for their conservation.

The great diversity of habitats within a contiguous forested environment has favoured genetic differentiation within species, both clinally and ecotypically (eg. Pryor 1957; Kirkpatrick 1975). However, this aspect of biological diversity is poorly documented.

The biodiversity significance of part of the nominated area, Kosciusko National Park, has been recognized by the International Union for the Conservation of Nature, which has made it one of the six Australian sites of plant biodiversity, and one of the 167 world-wide (Good 1992a).

Threatened species

The Australian Alps contain most of the range of the nationally vulnerable *(Endangered Species Protection Act 1992)* mountain pygmy possum, *Burramys parvus.* Prior to the observation of a live individual in a ski hut at Mt Hotham in 1966, *Burramys* was known only as a fossil. It is the only alpine obligate marsupial and the largest member of the family Burramyidae. *Burramys* 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. It also contains populations of the nationally vulnerable brush-tailed rock wallaby *(Petrogale penicillata),* a species that has experienced a rapid diminution of its range, even within protected areas, and the nationally endangered long-footed potoroo *(Potorous longipes).* Others of the many rare and threatened animal species that are extant in the Australian Alps include the smoky mouse *(Pseudomys fumeus),* the glossy black cockatoo *(Calyptorhynchus lathami),* the alpine water skink *(Sphenomorphus kosciuskoi),* the spotted tree frog *(Litoria spencer),* the Macquarie perch *(Macquaria australasica)* and an alpine stonefly *(Thaumatoperia timmsii).*

Sixty-three rare or threatened higher plant species are extant within the nominated area (Briggs pers. comm. 1993; Appendix 3). One endangered species, *Gentiana bauerlenii is* known from Namadgi. The 12 vulnerable species are concentrated in the alpine zone. They include the spectacular white-flowered alpine buttercup, *Ranunculus anemoneus,* a Kosciusko species, a Victorian alpine *Euphrasia (E. eichleri),* and a small alpine grass, *Erythanthera pumila.* There is also a strong concentration of nationally rare species in the alpine zone.

Integrity

The nominated area contains almost the total variation in the alpine ecosystems of mainland Australia, and, with the Tasmanian Wilderness World Heritage Area covers the full range of habitats. It also contains a large sample of two of the sclerophyll biogeographic provinces: the Eastern Sclerophyll Open Forests and the Murray Darling Sclerophyll Woodland. It is a highly representative and diverse example of the former biogeographic province and is still in a largely natural state. It forms one extreme in the environmental and biological variation of the Australian continent. The area is conserved within reserves with management plans directed to the perpetuation of the qualities described above, except for small areas of the Alpine National Park where grazing or logging are permitted uses. In the case of areas where grazing is permitted licenses have conditions that provide for the protection of particular conservation values, such as populations of rare and threatened species. Management of these reserves is integrated through a liaison process set up under the MOU.

Conclusions

The Australian Alps and the Convention on Biological Diversity

There is no doubt that the MOU 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.

The Australian Alps and the Biosphere Reserve concept

As discussed above, there would seem to be no criterion-based barrier to extending Biosphere Reserve status to all of the MOU area. If the parks in the MOU area were treated as the core nature conservation area, the Biosphere Reserve could be extended to encompass those parts of the Australian Alps sensu lato that are not conservation reserves, but which have conservation qualities that could be maintained through appropriate integrated management.

The Australian Alps and World Heritage listing

There seems to be a strong case on the grounds of all four natural criteria for the listing of most of the MOU area under the World Heritage Convention. However, the area has a cultural legacy of disturbance of its natural integrity, and some unacceptable (in terms of World Heritage) activities continue.

The impression has been gained by many people involved in the World Heritage listing process that the Australian Alps have major natural integrity problems. Thus, to be successful, a nomination would need to emphasize the manner in which World Heritage listing would lead to the rectification of continuing threats to natural integrity, and result in the amelioration of manifestations of past disturbances.

I suggest that the following government commitments would be an appropriate minimum:

1. a rapid phase out of stock grazing in the area;
2. the further development of strong programs for the elimination/control of exotic terrestrial plants and animals;
3. increased field staffing;
4. no further intensive residential/recreational/hydro-electric development;
5. the development of a strong program of wilderness restoration.

I recommend that the area proposed for listing be designed to exclude large impoundments and associated works, and resort areas, except where they are essential habitats for threatened species. These occupy relatively small areas, given the size of the Australian Alps parks.

Appendix 1

The effect of inclusion of the other Alps and East Gippsland reserves on the case for World Heritage listing

The major disadvantage of including any or all of Mt Buffalo National Park, Baw Baw National Park, Errinundra National Park, Coopracambra National Park or Croajingolong National Park in the nomination would be their non-contiguous nature. Some of these parks also have boundaries that have been determined by the limits of actual or potential development rather than by ecological principles.

Non-contiguity and residual boundaries can be found in other recent Australian World Heritage nominations and listings, for example, the Central Eastern Rainforests. In this case, and the case of the Queensland Tropical Rainforests, the boundaries were designed to cover all substantial and significant remnants of a particular vegetation type in a particular region. The inclusion of the alpine and treeless subalpine environments of Baw Baw National Park and Mt Buffalo National Park in an Australian Alps nomination would be analogous. However, the inclusion of the non-contiguous East Gippsland parks might raise the question of incompleteness. There seems no logical reason for excluding areas of biologically diverse old growth eucalypt forest in southern New South Wales if disjunct areas are to be included in Victoria.

There are two major storylines in the Australian Alps World Heritage justification given above that could be deepened or embellished by the inclusion of some or all of the outside parks. These are the diverse alpine environments and eucalypt catena arguments.

Mt Buffalo National Park has several major attractions for inclusion in a nomination. It has five rare or threatened Victorian endemic plant species, including a locally endemic eucalypt, *Eucalyptus mitchelliana* (Appendix 3) . It has a western outlier of treeless subalpine vegetation and the catena of eastern slope eucalypt-dominated plant communities. It has roads, a small area of ski slopes, a dam, an inn and a chalet on the summit plateau. Its inclusion would not exacerbate the integrity problems facing an Australian Alps nomination, while improving the nomination under criterion iv.

Mt Baw Baw National Park contains one extreme of the variation in alpine ecosystems on the Australian mainland (Kirkpatrick 1989). The Baw Baw frog is restricted to the plateau that is largely covered by the park. The ski resort is outside the park, which has no major integrity problems. Its inclusion would strengthen the nomination under criteria (ii) and (iv).

The Errinundra National Park adds no rare or threatened species and few dry sclerophyll plant communities (Appendices 2 and 3). However, it has outstanding examples of wet sclerophyll and mixed forest and a fascinating small stand of *Podocarpus lawrencei* rainforest (Barker 1991). It is also close to the known glacial refugium site for eucalypt forest (Kershaw *et al.* 1986). The park has a boundary partly determined by the location of pre-existing logging coupes. It would strengthen the eucalypt catena theme, and the integrity of the nomination in relation to environmental change.

The Coopracambra National Park contains a wide variety of eucalypt-dominated communities, some of which are not in the MOU area, and several rare or threatened species of animals and plants that do not occur in the MOU parks (Appendices 2 and 3). The park has some disturbance and some problems with blackberry invasion. If the problem of non-completeness did not lead to its rejection, it would strengthen the case for listing under criteria (ii) and (iv).

The Croajingolong National Park is the missing link between the mountains and the sea. It has, in combination with Nadgee Nature Reserve in New South Wales, been declared a Biosphere Reserve. It contains a large number of plant communities absent from the MOU area and some rare and threatened species (Appendices 2 and 3). Its inclusion in the nomination would improve the eucalypt catena story from one that peters out in a river valley to one that has strength at both ends. The following extra eucalypt species would be included in the nomination: *Eucalyptus angophoroides, E. baxteri , if. botryoides, if. cephalocarpa, E. cinerea, E. considiana, E. fraxinoides, E. gummifera, if. sideroxylon.* Of course, the case would be strengthened even further if the Croajingolong Park could be linked to the Snowy River National Park, through Coopracambra and Errinundra. The incompleteness argument would not pertain in this case.

conclude that the additions of Mt. Buffalo National Park, Baw Baw National Park and Croajingolong National Park to a World Heritage nomination would definitely strengthen the case and raise no problems apart from their disjunctness. The additions of Errinundra National Park and Coopracambra National Park might raise the question of incompleteness (ie. the absence of the south coast NSW parks). However, both would be otherwise highly fitting parts of a World Heritage nomination based substantially on the eucalypt forest catena.

Appendix 2:

Recognised plant communities in the Australian Alps and adjacent reserves.

These data are from Boden (1991), Chesterfield *et al* (1983, Fraser (1988), Gilmour *et al* (1987), Good (1992a), & McMahon *et al* (1990).

Codes: AP = Alpine National Park; BB = Baw Baw National Park; CK Coopracambra National Park; ER = Errinundra National Park; K = Kosciusko National Park; N = Namadgi National Park; MB = Mt Buffalo National Park; WM = Wonnangatta National Park.

COMMUNITY/ASSOCIATION	AP	BB	CK	CR	ER	K	N	MB	SR	WM	FORMATION
Communities inside MOU											
Acacia silvestris-Eriostemon trachphyllus **open woodland**	**+**								**+**		rocky outcrop **woodland-scrub**
Acmena smithii closed forest				+					+		warm temperate rainforest
***Atherosperma moschatum-Elaeocarpus holopetalus* closed forest**					**+**				**+**		**cool temperate rainforest**
Baeckea gunniana heath	+									+	heath
Baeckea gunniana-Epacris *paludosa* heath	*4*	+						+			heath
Baeckea utilis-Epacris sp. wet heath							+				heath
Brachyscome nivalis-Danthonia *alpicola* herbfield						+				+	tall alpine herbfield
Callistemon pityoides-Baeckea gunniana-Epacris braviflora heath				+						+	heath
Callitris glaucophylla woodland	+					+			+		woodland
Calytrix tetragona-Kunzea parviflora **open scrub**	**+**										rocky outcrop **woodland-scrub**
Calf ha introloba-Oreobolus pumilio herbfield	+	+						+		+	wetland
Carex appressa sedgeland	+	+						+		+	wetland
Carex gaudichaudiana fen						+	+				fen
Carex gaudichaudiana-Cyperus *lucidus* **sedgeland**	**+**	**+**						**+**		**+**	wetland
Carex gaudichaudiana-Pratia surrepens sedgeland	+	+						+		+	wetland
Carex gaudichaudiana-Sphagnum cristatum **sedgeland**						**+**	**+**				montane /subalpine **bog**
Carex hebes sedgeland	+	+						+		+	wetland
***Celmisia asteliifolia* herbfield**	+	+								+	wetland
Celmisia ***asteliifolia-Poa*** spp. herbfield						+					tall alpine **herbfield**
Celmisia ***sericophylla*** sedgeland	+	+								+	**wetland**
Coprosma sp.-Colobanthus nivicola herbfield						+					**feldmark**
Empodisma *minus-Restio* ***australis-asperula*** *gunnii* **heath**	**+**										heath
Empodisma minus-Sphagnum sp. **herbfield/bog**	**+**	**+**								**+**	**wetland**
Epacris brevifolia-Blindia robusta heath							+	+			**montane/subalpine bog**
Epacris glacialis heath						+					heath
***Epacris glacialis-Empodisma minus* heath**	+										**heath**
Epacris microphylla heath	+										heath
Epacris microphylla-E. petrophila-Chinohebe densiflora **heath**						**+**					feldmark
Epacris paludosa-Sphagnum *cristatum* heath						+	+				**montane subalpine bog**
Epacris petrophila-Grevillea *australis* heath		+								+	heath
Eucalyptus albens woodland	+										**rainshadow woodland**
Eucalyptus albens-Callitris ***glaucophylla* woodland**	+					+				+	**rainshadow woodland**
Eucalyptus blakelyi-Acacia mearnsii woodland	+									+	rainshadow woodland
Eucalyptus blakelyi-E.melliodora woodland						+					savannah **woodland/woodland**
Eucalyptus ***bridgesiana-E.*** *dives-E. rubida* **open forest**							+				dry sclerophyll forest
***Eucalyptus bridgesiana-E. dives-E. viminalis* woodland**							+				**savannah woodland**
Eucalyptus ***bridgesiana-E. viminalis* open forest**			+	+			+			+	riparian forest
***Eucalyptus cameldulensis* woodland**						+					riparian woodland
***Eucalyptus camphora* low forest**								+			montane forest
Eucalyptus camphora woodland	**?** +					+					**riparian woodland/fringing woodland**
Eucalyptus ***cypellocarpa- E.obliqua* open forest**			**+**					**+**			damp sclerophyll forest
Eucalyptus ***cypellocarpa- E.obliqua-E. radiata-Acacia dealbata* open forest**	**+**										**damp sclerophyll forest**
Eucalyptus dalrympleana-E. *dives* **open forest**							**+**				dry sclerophyll forest
Eucalyptus dalrympleana-E. *dives* ***-E. pauciflora-E. viminalis*** **open** forest							**+**				**wet sclerophyll forest**

COMMUNITYIASSOCIATION	AP	BB	CK	CR	ER	K	N	MB	SR	WM	FORMATION
Eucalyptus dalrympleana-E. pauciflora open forest							+				wet sclerophyll forest
Eucalyptus dalrympleana-E. pauciflora-E. dives open forest							+				wet sclerophyll forest
Eucalyptus dalrympleana-E. robertsonii-E. dives tall open forest							+				wet sclerophyll forest
Eucalyptus dalrympleana-E. rubida open forest						+					wet sclerophyll forest
Eucalyptus delegatensis montane forest	+										montane forest
Eucalyptus delegatensis open forest	+							+	+	+	montane forest
Eucalyptus delegatensis tall open forest							+				montane forest
Eucalyptus delegatensis-E. dives tall open forest	+										montane forest
Eucalyptus delegatensis-E. radiate tall open forest								+			montane forest
Eucalyptus delegatensis tall to open forest	+						+				montane forest
Eucalyptus delegatensis-Acacia dealbata tall open forest	+										montane forest
Eucalyptus delegatensis-E. camphora open forest	+										montane riparian forest
Eucalyptus delegatensis-E. camphora open forest to closed scrub	? +										montane riparian forest
Eucalyptus delegatensis-E. dalrympleana tall open forest	+					+	+				wet sclerophyll forest
Eucalyptus delegatensis-E. dalrympleana-Acacia dealbata tall open forest	+										montane forest
Eucalyptus delegatensis-E. pauciflora open forest						+					wet sclerophyll open forest
Eucalyptus delegatensis-E. rubida tall open to open forest	+										montane forest
Eucalyptus delegatensis-E. rubida-E. pauciflora-E. dives Acacia dealbata tall open to open forest	+				+						montane forest
Eucalyptus delegatensis-E. viminalis open forest						+					wet sclerophyll open forest
Eucalyptus delegatensis-E. viminalis Acacia dealbata A . melanoxylon tall open forest	+					+	+				montane riparian forest
Eucalyptus dives open forest							+				dry sclerophyll forest
Eucalyptus dives-E. goniocalyx-E. mannifera open forest	+										dry sclerophyll forest
Eucalyptus dives-E. globulus ssp. bicostata-E. radiate open forest	+										damp sclerophyll forest
Eucalyptus dives-E. macrorhyncha open forest	+										dry sclerophyll forest
Eucalyptus dives-E. mannifera open forest	+										dry sclerophyll forest
Eucalyptus dives-E. mannifera ssp. maculate open forest						+					dry sclerophyll open forest
Eucalyptus dives-E. nortonii open forest							+				
Eucalyptus dives-E. pauciflora-E. rubida-Acacia dealbata woodland	+										montane sclerophyll woodland
Eucalyptus dives-E. pauciflora-E. rubida-Acacia dealbata open woodland-forest	+							+			montane sclerophyll woodland
Eucalyptus dives-E. pauciflora-E. rubida-E. radiata-E. dalrympleana-Acacia dealbata montane sclerophyll woodland	+										montane sclerophyll woodland
Eucalyptus dives-E. pauciflora-E. rubida-E. sp.aff. radiata-E. dalrympleana-Acacia dealbata open woodland-forest	+							+			montane sclerophyll woodland
Eucalyptus dives-E. nortonii open and low open forest							+				dry sclerophyll forest
Eucalyptus dives-E. radiata-E. mannifera open forest	+										dry sclerophyll forest
Eucalyptus dives-E. rubida-E. pauciflora-Acacia dealbata open woodland/forest	+							+			montane sclerophyll woodland
Eucalyptus dives-E. rubida-E. pauciflora-Acacia dealbata montane sclerophyll woodland	+			+		+		+			montane sclerophyll woodland
Eucalyptus fastigata-E. viminalis open forest						+	+				wet sclerophyll tall open forest
Eucalyptus glaucescens woodland							+				subalpine woodland
Eucalyptus globoidea-E. sieberi open forest			+					+			dry sclerophyll forest
Eucalyptus globulus ssp. pseudoglobulus open forest								+			montane forest

COMMUNITYIASSOCIATION	AP	BB	CK	CR	ER	K	N	MB	SR	WM	FORMATION
Eucalyptus macrorhyncha-E. mannifera-E. dives Acacia dealbata open woodland-forest	+							+			montane sclerophyll woodland
Eucalyptus macrorhyncha-E. dives open forest						+					dry sclerophyll forest/open forest
Eucalyptus macrorhyncha-E. mannifera-E. dives-Acacia dealbata woodland	+										montane sclerophyll woodland
Eucalyptus macrorhyncha-E. rossii open forest							+				wet sclerophyll forest
Eucalyptus mannifera-E. viminalis-E. dives-E. robertsonii open forest							+				dry sclerophyll forest
Eucalyptus melliodora woodland							+				savannah woodland
Eucalyptus melliodora-E. nortonii-Callitris endlicheri open forest and woodland							+				open forest/woodland
Eucalyptus nortonii-E. melliodora-Callitris endlicheri open and low open forest/woodland							+				open forest/woodland
Eucalyptus obliqua-E. cypellocarpa tall open forest			+					+			wet sclerophyll forest
Eucalyptus obliqua-E. radiata forest								+			montane forest
Eucalyptus pauciflora low open forest							+				snow gum woodland
Eucalyptus pauciflora open forest	+							+			snow gum woodland
Eucalyptus pauciflora open woodland	+						+	+	+		snow gum woodland
Eucalyptus pauciflora spp. niphophila woodland							+				snow gum woodland
Eucalyptus pauciflora-Acacia obliquinervia woodland	+										montane sclerophyll woodland
Eucalyptus pauciflora-Bossiaea bracteosa woodland	+										montane sclerophyll woodland
Eucalyptus pauciflora-Daviesia latifolia woodland	+										montane sclerophyll woodland
Eucalyptus pauciflora-E. camphora woodland	+										montane grassy woodland
Eucalyptus pauciflora-E. dalrympleana open forest							+				montane grassy forest
Eucalyptus pauciflora-E delegatensis woodland						+					subalpine woodland
Eucalyptus pauciflora-E. dives woodland						+					savannah woodland/woodland
Eucalyptus pauciflora-E. glaucescens woodland								+			montane sclerophyll woodland
Eucalyptus pauciflora-E. pauciflora ssp. niphophila woodland						+					subalpine woodland
Eucalyptus pauciflora-E. rubida woodland	+					+	+				montane sclerophyll woodland
Eucalyptus pauciflora-E. rubida open woodland	+							+			snow gum woodland
Eucalyptus pauciflora-E. stellulata woodland						+	+				savannah woodland (montane form)
Eucalyptus pauciflora-E. viminalis woodland						+					savannah woodland/woodland
Eucalyptus pauciflora-Phebalium squamulosum ssp. alpinum woodland	+										montane sclerophyll woodland
Eucalyptus pauciflora-Poa hothamensis woodland	+										montane grassy woodland
Eucalyptus pauciflora-Poa hothamensis-Oxylobium alpestre woodland	+										montane sclerophyll woodland
Eucalyptus polyanthemos-Acacia mearnsii-E. macrorhyncha-E. globoidea-E. cypellocarpa-E. melliodora open forest								+			dry sclerophyll forest
Eucalyptus polyanthemos-Acacia mearnsii open forest	+							+			dry sclerophyll forest
Eucalyptus polyanthemos-E goniocalyx-E. macrorhyncha open woodland to forest	+										box-stringy bark woodland
Eucalyptus polyanthemos-E. sieberi-E. macrorhyncha open forest	+		+					+			dry sclerophyll forest
Eucalyptus radiata grassy open forest	+										grassy sclerophyll forest
Eucalyptus radiata open forest	+						+				damp sclerophyll forest
Eucalyptus radiata-E. bridgesiana open forest						+					dry sclerophyll forest and woodland

COMMUNITYIASSOCIATION	AP	BB	CK	CR	ER	K	N	MB	SR	WM	FORMATION
Eucalyptus macrorhyncha-E. mannifera-E. dives-Acacia dealbata open woodland-forest	+							+			*montane* sclerophyll woodland
Eucalyptus macrorhyncha-E. dives open forest						+					dry sclerophyll forest/open *forest*
Eucalyptus ***macrorhyncha-E. mannifera-E. dives-Acacia dealbata*** **woodland**	+										*montane* sclerophyll **woodland**
Eucalyptus macrorhyncha-E. rossii open *forest*							+				*wet* sclerophyll *forest*
Eucalyptus mannifera-E. viminalis-E. dives-E. ***robertsonii open forest***							+				*dry* sclerophyll *forest*
Eucalyptus melliodora woodland							+				savannah woodland
Eucalyptus ***melliodora-E.*** *nortonii-Callitris endlicheri* **open** *forest and* woodland							+				*open* forest/woodland
Eucalyptus nortonii-E. ***melliodora-Callitris endlicheri*** **open** ***and*** **low** ***open*** **forest/woodland**							+				***open*** **forest/woodland**
Eucalyptus obliqua-E. cypel%ocarpa **tall** ***open forest***			+					+			*wet* sclerophyll *forest*
Eucalyptus obliqua-E. radiate forest								+			*montane forest*
Eucalyptus pauciflora low open forest							+				*snow gum* woodland
Eucalyptus pauciflora open forest	+							+			*snow gum* woodland
Eucalyptus pauciflora open woodland	+						+	+	+		*snow gum* woodland
Eucalyptus **pauciflora** **spp.** ***niphophila*** **woodland**							+				*snow gum* woodland
Eucalyptus pauciflora-Acacia obliquinervia **woodland**	+										***montane*** **sclerophyll woodland**
Eucalyptus ***pauciflora-Bossiaea*** *bracteosa* woodland	+										***montane*** **sclerophyll woodland**
Eucalyptus pauciflora-Daviesia latifolia woodland	+										**montane sclerophyll woodland**
Eucalyptus pauciflora-E. camphora woodland	+										**montane** ***grassy*** **woodland**
Eucalyptus pauciflora-E. dalrympleana open *forest*							+				*montane grassy forest*
Eucalyptus ***pauciflora-E. delegatensis*** **woodland**						+					**subalpine woodland**
Eucalyptus pauciflora-E. dives woodland						+					savannah woodland/woodland
Eucalyptus ***pauciflora-E. glaucescens*** **woodland**								+			***montane*** **sclerophyll woodland**
Eucalyptus pauciflora-E. pauciflora ssp. niphophila **woodland**						+					**subalpine woodland**
Eucalyptus ***pauciflora-E. rubida*** **woodland**	+					+	+				***montane*** **sclerophyll woodland**
Eucalyptus pauciflora-E. rubida ***open*** **woodland**	+							+			**snow** ***gum*** **woodland**
Eucalyptus pauciflora-E. ***stellulata*** **woodland**						+	+				**savannah woodland** ***(montane form)***
Eucalyptus pauciflora-E. viminalis woodland						+					savannah woodland/woodland
Eucalyptus pauciflora-Phebalium squamulosum ssp. *alpinum* **woodland**	+										***montane*** **sclerophyll woodland**
Eucalyptus ***pauciflora-Poa hothamensis*** **woodland**	+										montane *grassy* woodland
Eucalyptus ***pauciflora-Poa hothamensis-Oxylobium alpestre***	+										***montane*** **sclerophyll woodland**
Eucalyptus ***polyanthemos-Acacia mearnsii-E. macrorhyncha-E globoidea-E. cypellocarpa-E. melliodora open forest***								+			**dry sclerophyll** ***forest***
Eucalyptus ***polyanthemos-Acacia mearnsii open forest***	+							+			dry sclerophyll *forest*
Eucalyptus ***polyanthemos-E. goniocalyx-E. macrorhyncha open*** **woodland** *to forest*	+										***box-stringy*** **bark woodland**
Eucalyptus ***polyanthemos-E. sieberi-E. macrorhyncha*** **open** ***forest***	+		+					+			dry sclerophyll *forest*
Eucalyptus ***radiata grassy open forest***	+										*grassy* sclerophyll *forest*
Eucalyptus ***radiata open forest***	+						+				**damp sclerophyll** ***forest***
Eucalyptus ***radiata-E. bridgesiana*** **open** ***forest***						+					dry sclerophyll *forest* **and woodland**

COMMUNITY/ASSOCIATION	AP	BB	CK	CR	ER	K	N	MB	SR	WM	FORMATION
Eucalyptus radiata-E.cypellocarpa-E.dives-Acacia dealbata open forest	+										damp sclerophyll forest
Eucalyptus radiata-E dalrympleana open forest						+					dry sclerophyll forest and woodland
Eucalyptus radiata-E. globulus ssp. bicostata open forest						+					dry sclerophyll forest and woodland
Eucalyptus radiata-E. mannifera ssp. maculata open forest						+					dry sclerophyll forest and woodland
Eucalyptus radiata-E. rubida open forest						+		+			dry sclerophyll forest and woodland
Eucalyptus radiata-E. rubida-Acacia dealbata grassy open forest	+										grassy sclerophyll forest
Eucalyptus radiata-E. viminalis open forest						+					grassy sclerophyll forest
Eucalyptus radiata-E. viminalis-Acacia dealbata tall open forest	+										grassy sclerophyll forest
Eucalyptus radiata-E. viminalis-E. camphora Acacia dealbata closed scrub to open forest	+										grassy sclerophyll forest
Eucalyptus radiata ssp robertsonii-E. viminalis open forest							+				wet sclerophyll forest
Eucalyptus regnans-Acacia melanoxylon-A. dealbata tall open forest			+					+			wet sclerophyll forest
Eucalyptus regnans-E. nitens-E. obliqua open forest								+			montane forest
Eucalyptus rubida-E. bridgesiana-E. dives open and low open forest							+				dry sclerophyll forest
Eucalyptus rubida-E. dives open forest						+					dry sclerophyll forest/open forest
Eucalyptus stellulata-E. camphora woodland							+				savannah woodland (montane form)
Eucalyptus viminalis tall open forest	+							+			montane riparian forest
Eucalyptus viminalis-E. globulus ssp. bicostata open forest						+					wet sclerophyll open forest
Eucalyptus viminalis-E. radiata montane riparian forest	7 +										montane riparian forest
Eucalyptus viminalis-E. radiata ssp robertsonii open and tall open forest							+				dry sclerophyll forest
Eucalyptus viminalis-E. robertsonii-E. dalrympleana							+				wet sclerophyll forest
Eucalyptus viminalis-E. sp aff. radiata tall open forest	+				+			+			montane riparian forest
Eucalyptus viminalis-E. elata-E. sp aft. radiata open forest			+					+			riparian forest
Festuca hookeriana-Brachyscome scapigera-Juncus spp. wet herbfield							+				herbfield
Hakes microcarpa-Hovea montana heath										+	heath
Hovea montane heath	+									+	heath
Hovea montane- Poa costiniana heath	+										heath
Kunzea ericifolia heath	+									+	heath
Kunzea ericifolia-Grevillea australis heath	+							+		+	heath
Kunzea ericoides-Calytrix tetragona heath							+				heath
Kunzea muelleri-Leptospermum micromyrtus heath							+				heath
Oxylobium ellipticum-Podocarpus lawrencei heath							+				montane/subalpine heath
Oxylobium allipticum-Podocarpus lawrencei-Kunzea muelleri heath					+						montane/subalpine heath
Phebalium squamulosum ssp alpinum-Bossiaea foliosa heath	+										heath
Plantago glacialis-P. muelleri-Neopaxia australasica herbfield						+					tall alpine herbfield
Poa costiniana-Danthonia nudiflora-D. nivicola sod tussock grassland						+					sod tussock grassland
Poa costiniana-P. fawcettiae-Empodisma minus grassland	+									+	grassland
Poe costiniana-P. hiemata-P. fawcettiae grassland	+										grassland
Poe fawcettiae-Hellipterum albicans ssp. alpinum grassland	+									+	grassland
Poa hiemata-Danthonia penicllata grassland	+										grassland
Poa hothamensis grassland	+										grassland

COMMUNITY/ASSOCIATION	AP	BB	CK	CR	ER	K	N	MB	SR	WM	FORMATION
***Poa hothamensis-Grevillea australis* grassy heath**	+							+			**heath**
***Poa labillardieri* tussock grassland**							+				**grassland**
***Poa* spp. grassland -**							+		+		**tablelands grassland**
***Poa* spp.Danthonia *nudiflora* grassland**							+				**alpine/subalpine grassland**
***Podocarpus lawrencei-Tasmannia xerophila* heath**	+							+			**heath**
***Podocarpus lawrencei-Pimelea lingustrina* heath**	+							+			**heath**
***Prostanthera cuneata-Oxylobium alpestre* shrubland**	+									+	**shrublands**
***Richea continentis-Epacris paludosa* heath**	+	+						+		+	**heath**
***Stipa sp.-Danthonia* grassland**							+				**savannah**
***Tasmannia xerophila-Olearia phloggopappa-Oxylobium alpestre* heath**	+										**heath**
***Themeda triandra* tussock grassland**							+				**grassland**
communities outside MOU											
***Allocasuarina paludosa-Callistemon citrinus* heath**				+							**heath**
***Allocasuarina paludosa-Leptospermum continentale-Dillwynia glaberrima* heath**				+							**heath**
***Allocasuarina paludosa-Leptospermum continentale-Empodisma minus* heath**				+							**heath**
***Allocasuarina paludosa-Leptospermum continentale-Danthonia pilosa* heath**				+							**heath**
***Allocasuarina paludosa-Xanthorrhoea resinosa* heath**				+							**heath**
Banksia integrifolia-E. botryoides woodland				+							***Banksia* woodland**
***Banksia serrata* open woodland-forest**				+							**sclerophyll woodlands**
***Eucalyptus baxteri-E. sieberi-E. consideniana* open woodland-forest**				+							**sclerophyll woodlands**
***Eucalyptus consideniana* open woodland**				+							**sclerophyll woodlands**
***Eucalyptus delegatensis-E. nitens-Acacia dealbata* tall open forest**	+										**montane forest**
***Eucalyptus fastigata* open forest**			+								**riparian forest**
***Eucalyptus fastigata* tall open forest**			+		+						**wet sclerophyll forest**
Eucalyptus globoidea-E. bridgesiana-E.* sp aff. *radiate				+							**riparian forest**
***Eucalyptus globoidea-E. sieberi-E. botryoides* open forest**				+							**lowland sclerophyll forest**
***Eucalyptus globoidea-E. sieberi-E. consideniana-E. botryoides* open forest**				+							**lowland sclerophyll forest**
***Eucalyptus globoidea-E. sieberi-E.cypellocarpa* open forest**				? +							**lowland sclerophyll forest**
***Eucalyptus globoidea-E. sieberi-E. obliqua-E.cypellocarpa* open forest**				+							**lowland sclerophyll forest**
***Eucalyptus gummifera-Angophora floribunda* open forest**				+							**lowland sclerophyll forest**
***Eucalyptus gummifera-E. muelleriana-Banksia serrate* open woodland**				+							**sclerophyll woodlands**
***Eucalyptus nitens-E. fastigata* tall open forest**			+		+						**wet sclerophyll woodlands**
***Eucalyptus sieberi Angophora floribunda* open woodland-forest**				+							**sclerophyll woodlands**
***Eucalyptus sieberi-E. consideniana* open forest**				+							**lowland sclerophyll forest**
***Eucalyptus sieberi-E. oblique-E. baxteri-E. muelleriana* open forest**			+								**dry sclerophyll forest**
***Eucalyptus* sp aff. *cephalocarpa* open woodland**			+	+							**sclerophyll woodlands**
***Eucalyptus* sp aff. *cephalocarpa-E. globoidea* open woodland**				+							**sclerophyll woodlands**

COMMUNITY/ASSOCIATION	AP	BB	CK	CR	ER	K	N	MB	SR	WM	FORMATION
Eucalyptus viminalis-E. sp. *aff* ***radiata-Acacia melanoxylon-A.delabata*** *open forest*				+							riparian *forest*
Juncus krausii-Baumea juncea-Sarcornia quinqueflora **herbfield**				+							**coastal saltmarsh**
Kunzea ambigua-Dodonea triquetra open scrub			+	+							**rocky outcrop woodland-scrub**
Leptospermum grandifolium **closed scrub**		+									**shrublands**
Leptospermum ***grandifolium-Nothofagus*** *cunninghamii-Astelia alpina* **closed scrub**		+									**shrublands**
Leptospermum grandifolium-Nothofagus cunninghamii-Leucopogon *maccraei* closed scrub		+									**shrublands**
Leptospermum /aevigatum-Leucopogon parviflorus **shrubland**				+							dry coastal grasslands
*Leptospermum l****laevigatum-Monotoca elliptica*** **shrubland**				+							*dry* coastal grasslands
Melaleuca *armillaris* **shrubland**				+							**shrublands**
Melaleuca squarrosa-Leptospermum ?lanigerum-L. continentale **heath**				+							*heath*
Melaleuca squarrosa-M. ***ericifolia-Gahnia*** *clarkei* closed **shrubland-** scrub				+							**shrublands**
Melaleuca squarrosa-Xyris operculata-Leptospermum continentale heath				+							***heath***
Nothofagus cunninghamii **closed *forest***		+									**cool temperate *rainforest***
Podocarpus aff. ***lawrencei*** **closed *forest***					+						**undescribed *rainforest***
Pultenaea muelleri **shrubland**		+									**shrublands**
Spinifex ***sericeus-Acacia sophorae*** **grassland**				+							**dry coastal grasslands**
Stipa stipoides-Distichlis distichophylla **herbfield**				+							**coastal saltmarsh**
Xanthorrhoea resinosa-Allocasuarina paludosa-Leptospermum continentale-Hakea teretifolia heath				+							*heath*
Xanthorrhoea resinosa-Melaleuca squarrosa-Leptospermum continentale **heath**				+							*heath*

Appendix 3:

Rare and threatened plant species by reserve

These data are from the ROTAP data base, June 1993 (Briggs, pers. comm.)

Species	Code	Distribution	Reserves
Inside MOU area			
Endangered			
Gentiana bauerlenii	2ECit	N	Namadgi
Vulnerable			
Asplenlum hookerianum	3VC- +	V T	Alpine
Calotis glandulosa	3VC-	N	Kosciusko
Erythranthera pumila	3VC-t+	N	Kosciusko
Epllobium brunnescens ssp. *beaugleholei*	2VCit +	V	Alpine
Euphrasia eichleri	2VC-	V	Alpine
Glycine latrobeana	3VCa	S V T	Alpine
Gnaphalium nitldulum	3VCa +	V	Alpine
Kellerlia laxa	2VCit +	V	Alpine
Prasophyllum morganii	3VCit	N V	Kosciusko
Ranunculus anemoneus	2VCat	N	Kosciusko
Rutidosis leiolepis	3VC-	N	Kosciusko
Thesium australe	3VCi +	Q N V T	Alpine, Kosciusko
Status indeterminate			
Agrostis meionectes	3KC-	N V	Alpine, Mt Buffalo, Kosciusko
Chlloglottis turfosa	2KC-t	N	Kosciusko
Deyeuxia pungens	2KC-t	V	Alpine
Eucalyptus lacrlmans	2KC-	N	Kosciusko
Euphrasia scabra	3KCa	W S N V T	Alpine, Errinundra
Genoplesium turfosum	2KC-t	N	Kosciusko
Olearia aglossa	2KC-	N V	Kosciusko
Rare			
Abrotanella nivigena	3RCa	NV	Kosciusko, Alpine
Almaleea capitata	3RC-	NV	Alpine, Namadgi
Baeckea dentlculata	2RCa	N	Kosciusko
Bertya findlayi	3RCa	NV	Kosciusko
Brachyscome petrophila	2RC-	V	Snowy River
Brachyscome riparia	3RC-	V	Snowy River
Brachyscome stolonifera	3RCat	N	Kosciusko
Carex caplIlacea	3RC- +	NV	Alpine, Kosciusko, Namadgi
Carex cephalotes	3RCa + .	NV	Alpine, Kosciusko
Carex paupera	2RCi	V	Alpine
Carex raleighii	3RCa	N V T	Kosciusko, Alpine

Celmisia sericophylla	2RCa		Alpine
Chionochloa frigida	2RCat	N	Kosciusko
Chionohebe densifolia	2RC-ta	N	Kosciusko
Colobanthus nivicola	2RC-t	N	Kosciusko
Colobanthus pulvinatus	2RC-t	N T	Kosciusko
Craspedia alba	3RC-	N V	Alpine, Kosciusko
Craspedia leucantha	2RCat	N	Kosciusko
Cystopteris filix-fragilis	3RCa +	N V T	Alpine, Kosciusko
Deyeuxia accedens	3RC-	N T	Kosciusko
Deyeuxia affinis	3RC-	N V	Alpine, Kosciusko
Deyeuxia benthamiana	3RC-	V T	Alpine, Mt Buffalo
Deyeuxia talariata	3RCi	N V	Alpine
Disc aria nitida	3RC-	N V	Kosciusko
Discaria pubescens	3RCa	Q N V T	Alpine, Kosciusko, Namadgi,Scabby Range
Dodonaea rhombifolia	3RCa	N V	Snowy River
Drabastrum alpestre	3RC-	N V	Kosciusko, Alpine
Erigeron setosus	3RC-t	N	Kosciusko
Eucalyptus elaeophloia	2RC-	V	Alpine
Eucalyptus saxltalis	3RC-	N V	Kosciusko, Snowy R.
Eucalyptus triplex	2RCit	N	Namadgi
Euphrasia alsa	2RC-t	N	Kosciusko
Callum roddii	2RCi	N	Kosciusko
Gingidia algens	2RCa	N	Kosciusko
Grevillea diminuta	2RCat	N	Bimberi, Namadgi
Haloragodendron bauerlenii	3RCa	NV	Alpine, Snowy River
Hibbertia spathulata	2RC-	V	Alpine
Hierochloe submutica	3RC-	NV	Alpine, Kosciusko
lrenepharsus magicus	2RC-	NV	Kosciusko
Leucopogon riparius	2RCa	V	Snowy River
Leptospermum namadgiensis	2RCat	N	Namadgi, Scabby Rnge
Myoporum floribundum	3RCi	NV	Snowy River
Olearia frostii	3RCa	V	Alpine
Olearia lasiophylla	3RC-t	N	Kosciusko
Olearia sp. 2 (Sentry Box)	2RCit	N	Namadgi, Scabby Rnge
Oreomyrrhis brevipes	3RC-	NV	Alpine, Kosciusko
Oschatzia cuneifolia	3RC-	NV	Kosciusko
Parantennaria uniceps	3RC-t	NV	Alpine, Kosciusko, Namadgi
Poa hothamensis var. *parviflora*	3RC-	V	Snowy River
Pomaderris oblongifolia	2RCat	V	Snowy River
Prasophyllum montanum	3RC-	NV	Kosciusko, Namadgi

Prostanthera monticola	3RC-	NV	Kosciusko, Mt Buffalo
Pseudan thus divaricatissimus	3RCa	NV	Snowy River, Croajingolong
Ranunculus clivicola	3RCat	N	Kosciusko
Ranunculus dissectlfollus	3RCat	N	Kosciusko
Ranunculus eichleranus	2RC-	V	Alpine
Ranunculus niphophilus	2RCat	N	Kosciusko
Ranunculus productus	3RC-t	N	Kosciusko
Taraxacum aristum	3RC-	N V T	Alpine, Kosciusko, Namadgi
Viola improcera	3RC-	NV	Namadgi
Wahlenbergia densifolia	3RCa	NV	Kosciusko
Westringia cremnophila	3RCa	V	Snowy River
Westringia Iucida	3RC-	N	Kosciusko, Namadgi, Scabby Range

Outside MOU Area

Endangered			
?Pomaderris cotoneaster	3ECi	NV	Coopracambra
Vulnerable			
Baeckea crenatifolia	2VC-t	V	Mt Buffalo
Cryptostylis hunteriana	3VC-	NV	Croajingolong
?Pomaderris sericea	3VCi	NV	Coopracambra
Status indeterminate			
Caladenia clarkiae	3KC-	NV	Mallacoota
Rare			
Acacia dallachlana	3RC-	V	Mt Buffalo
Acacia phlebophylla	2RCa	V	Mt Buffalo
Eucalyptus mitchelliana	2RC-t	V	Mt Buffalo
Olearia allenderae	3RC-	V	Croajingolong
Pomaderris pauciflora	3RC-	NV	Coopracambra
Pratia gelida	2RC-	V	Mt Buffalo
Spyridium cinereum	3RCa	NV	Croajingolong

Appendix 4

Eucalypt species recorded from the parks in the MOU area

(sources: Busby 1990, Boden 1991, Heiman et al. 1976, Fraser 1988, Good 1992a, Briggs, pers. comm.). ALP = Alpine National Park, KOS = Kosciusko National Park, NAM = Namadgi National Park, SNO = Snowy River National Park

	ALP	**KOS**	**NAM**	**SNO**
Eucalyptus albens	X	X		X
E. baueriana				X
E. blakelyi	X		X	X
E. bosistoana				X
E. bridgesiana	X	X	X	
E. camaldulensis		X		
E. camphora		X		
E. chapmaniana	X	X		
E. consideniana	X			X
E. cypellocarpa	X			X
E. dalrympleana		X	X	
E. dealbata		X		
E. delegatensis	X	X	X	
E. dives	X	X	X	
E. elaeophloia				
E. elata				X
E. fastigata		X	X	X
E. glaucescens		X	X	
E. globoidea				X
E. globulus		X		X
E. goniocalyx	X	X		X
E. kybeanensis		X		
E. lacrimans		X		
E. macrorhyncha		X	X	X
E. mannifera	X	X		X
E. melliodora	X	X	X	X
E. moorei		X		
E. muelleriana				X

E. nitens				X
E. nortonii		X	X	
E. obliqua				
E. ovata	X	X		X
E. pauciflora	X	X	X	X
E. perriniana	X	X		X
E. polyanthemos	X	X		X
E. radiata	X	X	X	X
E. regnans				
E. rossii			X	
E. rubida	X	X	X	X
E. saxitalis	X	X		X
E. sieberi	X		X	X
E. smithii	X			
E. stellulata	X	X		
E. tereticornis	X			
E. triplex			X	
E. viminalis		X	X	X

References

Ashton D.H. (1981) Fire in tall open forests (wet sclerophyll forests). In: *Fire and the Australian Biota.* Gill A.M., Groves R.H. and Noble I.R. (eds.). Australian Academy of Science, Canberra.

Ashton D.H. & Williams R.J. (1989) Dynamics of subalpine vegetation in the Victorian region. In: *The Scientific Significance of the Australian Alps.* Good R. (Ed.) The Proceedings of the First Fenner Conference on the Environment. Canberra, September, 1988. The Australian Alps Liaison Committee, Canberra. pp. 143-168.

Barker P.C.J. (1991) *Podocarpus lawrencei* (Hook.F.): Population structure and fire history at Goonmirk Rocks, Victoria. *Aust. J. Eco%* 16: 149-158.

Barker S. (1989) Snow gum woodland: past, present and future. In: *The Scientific Significance of the Australian Alps.* Good R. (Ed.) The Proceedings of the First Fenner Conference on the Environment. Canberra, September, 1988. The Australian Alps Liaison Committee, Canberra. pp. 359-369.

Barker W.R. (1986) Biogeography and evolution in *Euphrasia* (Scrophulariaceae), particularly relating to Australasia. In: *Flora and Fauna of Alpine Australasia - Ages and Origins.* B.A. Barlow (ed.) CSIRO, Canberra, pp. 489-510.

Barlow B.A. (1989) The alpine flora: autochthones and peregrines. In: *The Scientific Significance of the Australian Alps.* Good R. (Ed.) The Proceedings of the First Fenner Conference on the Environment. Canberra, September, 1988. The Australian Alps Liaison Committee, Canberra. pp. 69-78.

Beadle N.C.W. & Costin A.B. (1952) Ecological classification and nomenclature. *Proc. Linn. Soc. NSW 77,* 61-82.

Bishop P. (1988) The eastern highlands of Australia: the evolution of an intraplate highland belt. *Progress in Physical Geography* 12, 159-182.

Boden (1991) *Review of the Significance of the Natural and Cultural Features of the Namadgi National Park.* Robert Boden and Associates, Griffith, Canberra.

Bonyhady T. (1991) *Images in Opposition: Australian Landscape Painting 1801-1890.* Oxford University Press, Melbourne.

Braun-Blanquet J. & Jenny H. (1926) Vegetations entwichlung and Bodenbildung in der alpinen Stufe der Zentralalpen (Klimax-gebiet des *Claricon curvulae).* Ergeb.d. wissench.Unters.d.Schweizer. National Parks. Denkschr. *Schwiez. Nat. Ges.* 63, 2.

Broome L.S. & Mansergh I.M. (1989) The mountain pygmy possum, *Burramys parvus* (Broom): an alpine endemic. In: *The Scientific Significance of the Australian Alps.* Good R. (ed.) The Proceedings of the First Fenner Conference on the Environment. Canberra, September, 1988. The Australian Alps Liaison Committee, Canberra, pp.241-264.

Busby (1990) *The National and International Scientific Significance of National Parks in Eastern Victoria.* National Parks and Public Land Department of Conservation and Environment, Victoria Occasional Paper No8.

Campbell, I.C., McKaige, M.E. and Lake, P.S. (1986) The Fauna of Australian High Mountain Streams: Ecology, Zoogeography and Evolution. In. *Flora and Fauna of Alpine Australasia - Ages and Origins.* B.A. Barlow (ed.) CSIRO, Canberra, pp. 83-104.

Carr S.G.M. and Turner J.S. (1959a) The ecology of the Bogong High Plains. I. The environmental factors and the grassland communities. *Aust. J. Bot.* 7. 12-33

Carr S.G.M. and Turner J.S. (1959b) The ecology of the Bogong High Plains. II. Fencing experiments in grassland *C. Aust. J. Bot.* 7: 34-63.

Chesterfield E.A., Macfarlane M.A., Allen D., Hutchinson M.N., Triggs B. & Barley R. (1983) *Flora and fauna of the Rodger River forest block, East Gippsland, Victoria.* Ecological Survey Report No. 1. Forests Commission, Victoria.

Clayton-Greene K.A. and Ashton D.H. (1990) The dynamics of *Callitris columellaris/Eucalyptus albens* communities along the Snowy River and its tributaries in south-eastern Australia. *Aust. J. Bot.* 38: 403-432.

Costin A.B. (1955) Alpine soils in Australia, with reference to conditions in Europe and New Zealand. *J.Soil Science6:* 35-50.

Costin A.B. (1966) Management opportunities in Australian high mountain catchments. In: *Forest Hydrology.* Sopper W.E. and Hull H.W. (eds.). Pergamon, pp. 565-577.

Costin A.B. (1989) The alps in a global perspective. In: *The Scientific Significance of the Australian Alps.* Good R. (Ed.) The Proceedings of the First Fenner Conference on the Environment. Canberra, September, 1988. The Australian Alps Liaison Committee, Canberra. pp.7-19.

Costin A.B., Gray M., Totterdell C.J. & Winbush D.J. (1979) *Kosciusko Alpine Flora.* CSIRO./Collins, Melbourne. 408 pp.

Costin A.B., Hallsworth E.G. and Woof M. (1952) Studies in pedogenesis in New South Wales. III. The alpine humus soils. *J. Soil Science 3:* 190-218.

Costin A.B., Jennings J.N., Black, H.P. and Thom, B.G. (1964) Snow action on Mt. Twynam, Snowy Mountains, Australia. J. *Glaciology* 5:

219-228.

Costin A.B., Jennings, J.N., Bautovich, B.C. and Wimbush, D.J. (1973) Forces developed by snowpatch action, Mt. Twynam, Snowy Mountains, Australia. *Arctic and Alpine Research* 5: 121-126.

Costin A.B. and Polach H.A. (1971) Slope deposits in the Snowy Mountains, southeastern Australia. *Quaternary Research 1:* 228-235.

Costin A.B., Thom, B.G. Wimbush D.J. and Stuiver M. (1967) Nonsorted steps in the Mount Kosciusko area, Australia. *J. Geol. Soc. America 78:* 979-992.

Costin A.B. and Wimbush D.J. (1973) Frost cracks and earth hummocks at Kosciusko, Snowy Mountains, Australia. *Arctic and Alpine Research* 5: 111-120.

Cullen P. & Norris R. (1989) Significance of lakes and rivers in the Australian mainland alps. In: *The Scientific Significance of the Australian Alps.* Good R. (Ed.) The Proceedings of the First Fenner Conference on the Environment. Canberra, September, 1988. The Australian Alps Liaison Committee, Canberra. pp. 281-295.

Davis B.W. & Drake G.A. (1983) *Australia's Biosphere Reserves: Conserving Ecological Diversity.* Australian National Commission for UNESCO. AGPS, Canberra.

Dearden P. (1984) Factors influencing landscape preferences: an empirical investigation. *Landscape Planning 2:* 293-306.

Department of the Arts, Sport, the Environment, Tourism and Territories (DASETT) (1993). World Heritage. Dasett, Canberra.

Dyring, J. (1992) Introduced animals in the Australian Alps, with special reference to feral horses. *Revue de Geographie Alpine* 80: 409-424.

Fraser I. (1988) The Northern Cotter Catchment, A.C.T. National Parks Association of the Australian Capital Territory Inc., Canberra.

Galloway R.W. (1989) Glacial and periglacial features of the Australian Alps. In: *The Scientific Significance of the Australian Alps.* Good R. (Ed.) The Proceedings of the First Fenner Conference on the Environment. Canberra, September, 1988. The Australian Alps Liaison Committee, Canberra. pp. 55-67.

Gams I. (1985) International comparative measurements of surface solution by means of standard limestone tablets. *Razprave IV. Razreda Sazu,* XXVI:361-386.

Gilmour P.M., Heiman C.E. & Osborne W.S. (1987) An ecological study of the Mount Tennent-Blue Gum Creek Area, A.C.T. An unpublished report to the Conservation Council of the South-East Region and Canberra.

Good R. (1992a) *Kosciusko heritage.* National Parks & Wildlife Service of NSW , Hurstville, NSW .

Good R. (1992b) The Australian Alps. *Revue de Geographie Alpine* 80: 39-64.

Good R. (Ed.)(1989) *The Scientific Significance of the Australian Alps.* The Proceedings of the First Fenner Conference on the Environment. Canberra, September, 1988. The Australian Alps Liaison Committee, Canberra.

Happold D.C.D. (1989) Small mammals of the Australian Alps. In: *The Scientific Significance of the Australian Alps.* Good R. (Ed.) The Proceedings of the First Fenner Conference on the Environment. Canberra, September, 1988. The Australian Alps Liaison Committee, Canberra. pp. 221-239.

Heiman, P.M., Jones, A.D., Pigram, J.L. and Smith, J.M.B. (1976) Wilderness in Australia - eastern New South Wales and Southeastern Queensland. Department of Geography, University of New England, Armidale.

IUCN (1979) *The Biosphere Reserve and its Relationship to Other Protected Areas.* UNESCO, Geneva.

Jennings & Costin (1978) Stone movement through snow creep, 1963-75, Mount Twynam, Snowy Mountains, Australia. *Earth Science Processes 3:* 3-22.

Kershaw, A.P., McEwen Mason, J.R., McKenzie, G.M., Strickland, K.M. and Wagstaff, B.E. (1986). Aspects of the development of cold-adapted flora and vegetation in the Cenozoic of southeastern mainland Australia.In. *Flora and Fauna of Alpine Australasia - Ages and Origins.* B.A. Barlow (ed.) CSIRO, Canberra, pp. 147-160.

Kirkpatrick, J.B. (1975) Geographical variation in *Eucalyptus globulus. Forestry and Timber Bureau Bulletin* No. 47: 1-64.

Kirkpatrick, J.B. (1982) Phytogeographical analysis of Tasmanian alpine floras. *J. Biogeogr.* 9, 255-271.

Kirkpatrick J.B. (1989) The comparative ecology of mainland Australia and Tasmanian alpine vegetation. In: *The Scientific Significance of the Australian Alps.* Good R. (Ed.) The Proceedings of the First Fenner Conference on the Environment. Canberra, September, 1988. The Australian Alps Liaison Committee, Canberra. pp.127-142.

Kirkpatrick J.B. (ed), (1991) *Tasmania's Native Bush: A Management Handbook*

Tasmanian Environment Centre, Hobart.

Kirkpatrick J.B., Lembit, R. and McMahon, A. (1987). *Australia's Eucalypt Forests: World Heritage Values.* ACF, Wilderness Society and South East Forest Alliance, Melbourne.

Leigh J.H., Wimbush D.J., Wood D.H., Holgate M.D., Stee A.V., Stranger M.G. and Forrester R.I. (1987) Effects of rabbit grazing and fire on a subalpine environment. I. Herbaceous and shrubby vegetation. *Aust. J. Bot.* 35: 433-464.

Leigh J.H., Wood D.H., Slee A.V. and Holgate M.D. (1991) The effects of burning and simulated grazing on productivity, forage quality, mortality and flowering of eight subalpine herbs in Kosciusko National Park. *Aust. J. Bot.* 39: 97-118.

Lister G.S., Etheridge M.A. and Symonds P.A. (1986) Detachment faulting and the evolution of passive continental margins. *Geology* 14: 254-250.

McMahon A.R.G., Carr G.W., Todd J.A. & Race G.J. (1990) *The Conservation Status of Major Plant Communities in Australia: Victoria.* Ecological Horticulture Pty. Ltd. Clifton Hill, Victoria.

Marsden M.A.H. (1988) Upper Devonian-Carboniferous. In: *Geology of Victoria.* Douglas J.G. and Ferguson J.A. (eds.). Victorian Division, Geological Society of Australia, Melbourne. pp. 147-194.

Mosley, G. (1988) *Australian Alps World Heritage Nomination Proposal.* Victorian National Parks Association, Melbourne.

Mosley, G. (1992a) The Australian Alps: a potential world heritage. *Revue de Geographie Alpine 80:* 531-535.

Mosley, G. (1992b) Wilderness protection in the Australian Alps. *Revue de Geographie Alpine* 80: 307-334.

Mosley, G. and Costin, A. (1992) *World Heritage Values and their Protection in far south east New South Wales.* Report to Earth Foundation, Australia.

Oilier C.D. (1986) The origin of alpine landforms in Australia. In: *Flora and Fauna of Alpine Australasia - Ages and Origins.* B.A. Barlow (ed.) CSIRO, Canberra, pp. 3-26.

Oilier C.D. & Wyborn D. (1989) Geology of alpine Australia.ln: *The Scientific Significance of the Australian Alps.* Good R. (Ed.) The Proceedings of the First Fenner Conference on the Environment. Canberra, September, 1988. The Australian Alps Liaison Committee, Canberra. pp. 35-53.

Osborne R.A.L. (1984) Multiple karstification in the Lachlan Fold Belt in New South Wales: reconnaissance evidence. *Journal and Proceedings of the Royal Society of New South Wales* 117: 15-34.

Pryor, L.D. (1957) Variation in snow gum *(Eucalyptus pauciflora* Sieb.). *Proc. Linn. Soc. N.S.W.* 81, 299-305.

Purdie R.W. (1977a) Early stages in regeneration after burning in dry sclerophyll vegetation. I. Regeneration of the understorey by vegetative means. *Aust. J. Bot.* 25: 21-34.

Purdie R.W. (1977b) Early stages in regeneration after burning in dry sclerophyll vegetation. II. Regeneration by seed germination. *Aust. J. Bot.* 25: 35-46.

Rosengren N.J. & Peterson J.A. (1989) The heritage values and the geological and geomorphological significance of the Australian alpine zone. In: *The Scientific Significance of the Australian Alps.* Good R. (Ed.) The Proceedings of the First Fenner Conference on the Environment. Canberra, September, 1988. The Australian Alps Liaison Committee, Canberra. pp. 187-204.

Scougall B. (ed.) (1992) *Cultural Heritage of the Australian Alps.* Australian Alps Liaison Committee, Canberra.

Slatyer R.O. (1976) Water deficits in timberline trees in the Snowy Mountains of south-eastern Australia. *Oecologia* 24: 357-366.

Slatyer R.O. (1989) Alpine and valley bottom treelines. In: *The Scientific Significance of the Australian Alps.* Good R. (Ed.) The Proceedings of the First Fenner Conference on the Environment. Canberra, September, 1988. The Australian Alps Liaison Committee, Canberra. pp. 169-184.

Smith, J.M.B. (1989) Origins of Australasian tropicalpine and alpine floras. In: *Flora and Fauna of Alpine Australasia - Ages and Origins.* B.A. Barlow (ed.) CSIRO, Canberra, pp. 109-128.

Snowy Mountains Hydro-electric Authority (1993) *Snowy Precipitation Enhancement Project - Draft Environmental Impact Statement.* Snowy Mountains Council, Cooma.

Spate A.P (1987) Cooleman Plain Karst Area Management Plan. NSW National Parks & Wildlife Service, Sydney.

Spate A.P. & Household I. (1989) The significance of the alpine karst areas of mainland Australia. In: *The Scientific Significance of the Australian Alps.* Good R. (Ed.) The Proceedings of the First Fenner Conference on the Environment. Canberra, September, 1988. The Australian Alps Liaison Committee, Canberra. pp. 205-219.

Spate A.P., Jennings J.N., Smith D.I. & Greenaway M.A. (1985) The micro-erosion meter: use and limitations. *Earth Surface Processes and Landforms 10,* 427-440.

Taylor K. (1992) Cultural values in natural areas. In:Cultural *Heritage of the Australian Alps.* Scougall, B. (ed.) Australian Alps Liaison Committee, Canberra. pp. 55-65.

Wagner R. and Jackson, P. (1993) *The Action Plan for Australian Freshwater Fishes.* Australian Nature Conservation Agency, Canberra.

Wardle P. (1989) The Australian mountains - worlds apart? In: *The Scientific Significance of the Australian Alps.* Good R. (Ed.) The Proceedings of the First Fenner Conference on the Environment. Canberra, September, 1988. The Australian Alps Liaison Committee, Canberra. pp. 21-31.

Wellman P. (1987) Eastern Highlands of Australia; their uplift and erosion. *BMRJ. Geol. Geophys.* 10: 277-286.

Whinam, J., Cannell, R., Kirkpatrick, J.B. and Comfort, M., in press. The impact and management of horses in the Central Plateau section of the World Heritage Area, Tasmania. *J. Env. Mngmt.*

Williams R.J. and Ashton D.H. (1987) The effects of disturbance and grazing by cattle on the dynamics of heathland and grassland communities on the Bogong High Plains, Victoria. *Aust. J. Bot..* 35: 413-431.

Williams R.J. and Ashton D.H. (1988) Cyclical patterns of regeneration in heathland communities on the Bogong High Plains, Victoria. *Aust. J. Bot.* 36: 605-619.

Wimbush D.J. and Costin A.B. (1979a) Trends in vegetation at Kosciusko. I. Grazing trials in the subalpine zone, 1957-1971. *Aust. J. Bot.* 27: 741-787

Wimbush D.J. and Costin A.B. (1979b) Trends in vegetation at Kosciusko. II. Subalpine range transects. 1959-1978. *Aust. J. Bot. 27:* 789-831

Wimbush D.J. and Costin A.B. (1979c) Trends in vegetation at Kosciusko. Ill. Alpine range transects, 1959-1978. *Aust. J. Bot. 27:* 833-871

Young R.W. (1983) The tempo of geomorphological change: evidence from southeastern Australia. *Journal of Geology* 91: 221-230.