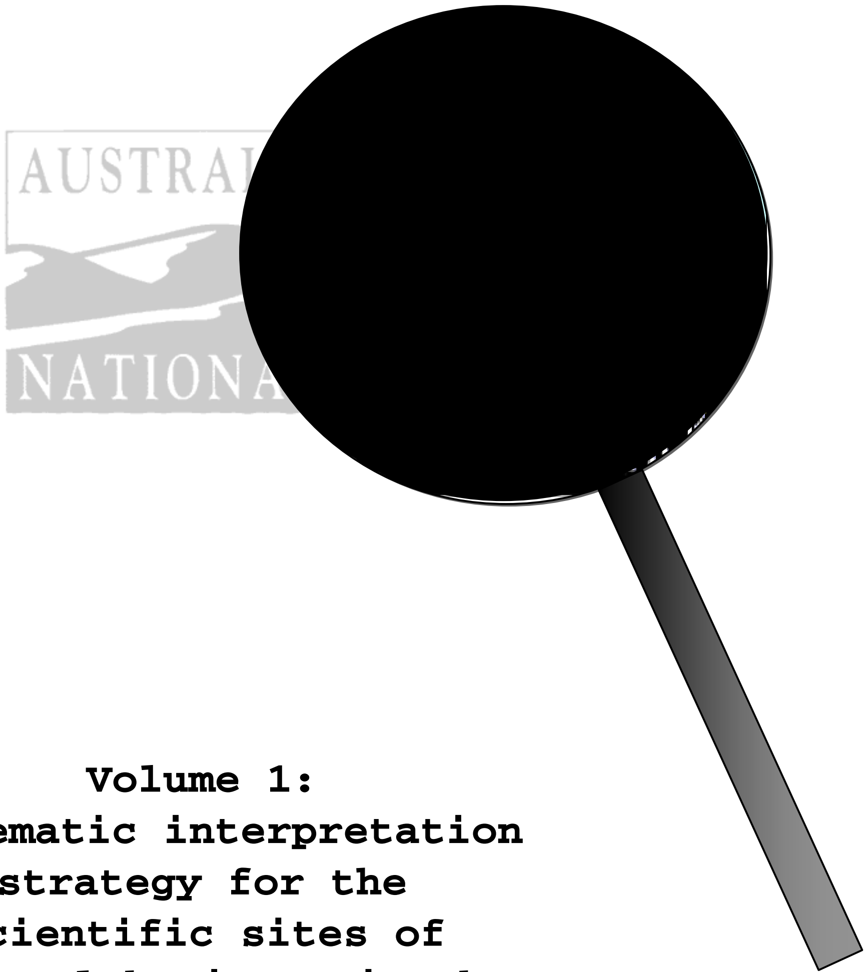
Mountains of Science



**Volume 1:
a thematic interpretation
strategy for the
scientific sites of
cultural heritage in the
australian alps**

Report to the Australian Alps Liaison Committee

P Macdonald and J Haiblen **December 2001**

List of Tables and Plates

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Joss Haiblen
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Abbreviations

AANP	Australian Alps national parks (as per Memorandum of Understanding)
AHC	Australian Heritage Commission
ANP	Alpine National Park (Victoria)
BHP	Bogong High Plains (part of ANP)
BP	Before Present
CRC	Cooperative Research Centre
KNP	Kosciuszko National Park (NSW)
MBNP	Mt Buffalo National Park (Victoria)
NNP	Namadgi National Park (ACT)
NPWS	National Parks and Wildlife Service (NSW)
SEC	State Electricity Commission (Victoria)
SMA	Snowy Mountains (Hydro-Electricity) Authority

1 A LIFE HISTORY OF SCIENCE IN THE AUSTRALIAN ALPS

1.1 The Cultural Standing of Alps Science

Scientific research is as much part of the cultural history of the Australian Alps as the well-recognised history of the gold miners, mountain cattlemen and dam builders. These latter histories have received considerable attention in recent years with the 'Man from Snowy River' films and the Mountain Cattlemen's rallies in downtown Melbourne, along with the 50th Anniversary celebrations of the Snowy Mountains Scheme and its published history. Their activities have left historic relics in the AANP that are easily recognised by the visiting public. In Victoria the mountain cattlemen's huts are still actively used, and their history interpreted at various key sites such as Wallace's Hut. In NSW park users visit huts and homestead remains and the life of the mountain graziers is interpreted in such places as Coolamine and Currango Homesteads. Goldmining is interpreted at key sites such as Kiandra and the Oriental Claims Historic Area (Victoria). The Snowy Mountains Scheme has extensive interpretation signage at many of the dam and hydro locations. Interpretive centres and published materials cover these historic themes.

What of the scientists? Their commitment and activities have not been broadly recognised and their stories are left untold to Australians generally. Those who visit Mt Kosciuszko may be aware of Clement Wragge's meteorological station but are unlikely to know of the work done by scientists to expand our knowledge of the very ecosystems they are passing through – the scientists who looked to discover the glaciation history of the high mountains, those who set up long-term monitoring of the vegetation changes once grazing was removed from the slopes of Kosciuszko, of the researchers who continue to look and experiment with ways to repair the extensive damage caused by roading, hydro development, grazing and contemporary visitor impacts.

These scientists and their research have their 'stories' and there is the romanticism of 'the hard life against the elements' while seeking knowledge of the mountains. In some cases there are even relics of their work. These relics are not as obvious as the structures from other human activities in the mountains. The scientists themselves do not wave a flag for their history. All these factors allow the scientists' stories and places to blend into the background.

We don't celebrate this important scientific history which will continue to inform our knowledge of the Alps. Unlike the dam builders, gold miners and the mountain graziers the work of scientists in the Alps is a tradition that will continue long into the future. We need to recognise their historic contributions, protect their research sites, and tell their stories so that their history is valued in the community.

1.2 Three Stages of Alps Science

The life of science in the Alps has passed through three stages so far. The first stage was “the science of exploration, a traveller’s and discoverer’s science mostly done by individuals” (Griffiths and Robin 1994, p 7). This stage provided the foundation for the next stages and is exemplified by internationally recognised scientists such as Meuller (botany), Lhotsky and Strezlecki (survey) and David (geology/geomorphology). An overview of the early science is provided below (1.2.1).

The next stage was that of the ecologists who established experimental science that was problem-oriented and sustained over repeated visits. It was institutional (i.e. government initiated) and required inter-disciplinary teamwork, with fieldwork that was often tedious and repetitive. This research was charged with identifying any processes that might compromise human requirements from the Alps – particularly water for irrigation and power. Maisie (Fawcett) Carr and Alec Costin stand out as representatives of this stage in the history of Alps sciences.

The next and current stage is that of ‘conservation science’ which is informed by a conservation philosophy and recognition of the uniqueness of the Australian Alps. There is a recognised need to understand and to know the resource and how it works in order to conserve it. Such scientific studies seek to enhance our knowledge of species/systems so that there is adequate knowledge for making judgements concerning possible impacts on them.

These last two stages, and the science resulting from them, form the body of this report.

1.2.1 The Early Science

The early scientific explorers and observers followed in the footsteps of, or accompanied, the early explorers, pastoralists and miners. There is an irony of scientific exploration and environmental damage going hand in hand in this early stage with the pastoralists and miners often helping those documenting the features of the Alps. There was a preoccupation with discovering ‘the utility of the bush’.

In the 1830’s John Lhotsky surveyed the highest peaks in the Snowy Mountains and made plant collections with detailed descriptions of their habitats. Strezlecki is the only explorer and early scientist to be afforded international recognition (International Congress of History of Sciences) for explorations of this country (Good 1992a). In 1846-47 the NSW Government Surveyor Thomas Townsend (Mt Townsend, KNP) surveyed the upper peaks in ascertaining the source of the Murray River to delineate the Victorian boundary.

The Rev WB Clarke (Mt Clarke, KNP) was commissioned by the NSW Government to search for new goldfields in the Alps in 1851, and made detailed geological notes during his travels. Similarly Alfred Howitt (Mt Howitt, ANP) led a surveying and prospecting party in the Victorian Alps in 1860.

Ferdinand Mueller, the Victorian government botanist, was an ardent botanical explorer, plant collector and taxonomist who perceived gold in another form – the unique flora of the Alps. Between 1853-61 he made 5 significant journeys into the Alps, collecting plants and making copious notes on their habitat and geographic distribution. He recorded many endemic plants, including the anemone buttercup *(Ranunculus anemoneus*) and the marsh marigold (*Caltha introloba*) – plants that epitomise the flora of the Alps. Many of his plant collections remain today as the type specimens for much of the Alps flora. His achievements are immortalised in *Ranunculus muelleri*, and Mueller's Peak (KNP), between Mt Kosciuszko and Mt Townsend. Of interest and regret today was Mueller's interest in providing future travellers with food in the form of blackberries – the seeds of which he scattered on his travels!

James Stirling (Mt Stirling, Victoria), district surveyor at Omeo in the 1870's, observed Alps geography, geology, botany and meteorology as well as noting the harmful effects of increasing numbers of stock on the high plains. He established the recording of weather conditions at Omeo – which has a continuous, comprehensive weather record from 1879 – the longest in the Alps region. Stirling is commemorated by the white daisy bush *Helichrysum stirlingii* (now *Ozothamnus*) named by Mueller.

In the 1885 the geologist Robert Lendenfeld completed a major survey of the Kosciuszko area, collecting plants along the way. He also worked in Victoria with Stirling, the two men sharing their enthusiasm for the Alps. In 1889-90 Dr JH Maiden and Richard Helms studied the Snowy Mountains flora and soils, identifying degraded catchments resulting from a long history of inappropriate land use – that is, grazing and associated burning "because the heavy rains wash the soil away and...the more or less constant diminution of humus in the soil of the slopes is a danger not generally recognised" (Good 1992a).

Between 1898 and 1902 Clement Wragge's (Wragges Creek, KNP) meteorological observatory on the summit of Mt Kosciuszko recorded instrument readings at half hourly and four hourly intervals. This remarkable effort attracted popular interest because of the harshness of the environment that the researchers had to endure. It is of interest to note that when Maiden visited the observatory in 1899 he expressed concern that invading weeds would be carried up "in the tails of horses, in human clothing, in packing cases for the observatory, &c" (Gillbank 1998, p 108).

Towards the end of the century there was increased interest in the glacial history of the high mountains in Australia. Edgeworth David with Helms and Pittman described glacial landscapes in the Kosciuszko area in 1901, and David incorporated meteorological data collected by Wragge into his assessment of past glaciation in Kosciuszko. Helm's Moraine is near Blue Lake and the David Moraine is in Spencers Creek. Hedley Tarn (below Blue Lake) commemorates the zoologist who helped dredge bottom dwelling fauna from Blue Lake at beginning of the 20th century.

Between 1907 and the 1930s little research was undertaken until interest in forestry resources for logging spurred foresters Charles Lane Poole and Baldur Byles to recognise the degenerate state of forested catchments and undertake a major soil erosion survey of the Snowy Mountains in 1931-32. Byles made note of the rapidly deteriorating alpine ecosystems and documented the widespread evidence of erosion, placing blame directly on grazing and the inappropriate fire regimes of the time. His report eventually resulted in the establishment of the NSW Soil Conservation Service in 1938.

Given we are still grappling with proven harmful activities in the Alps, it is sobering to note that concern over land degradation has been expressed from the 1870s onwards. "The vision of earlier scientists in terms of their predictions and warnings of future management issues appears to take many years to be heeded or acted upon" (Good 1992a).

2 SCOPE OF THIS REPORT

The scope of this report, and the approach it takes, are revealed by splitting its subtitle into constituent parts:

- Science
- Site
- Cultural heritage
- Australian Alps National Parks
- Interpretation
- Themes

2.1 What Do We Mean by Science?

This report is primarily concerned with the experimental sciences employing objective methodology that arrived in the Australian Alps in the 1940s.

Before that came 100 years of what might be termed 'exploration science' (Section 1.2). Many explorers and early travellers were keen naturalists or taxonomists. Specimens were collected and impressions recorded, some of which became of value to the later experimental scientists. While sites associated with exploration science are beyond the scope of this report, the story is worth telling through one of the forms of interpretation suggested in Recommendation #12.

Not all contemporary sciences are considered in this report, only those related to the natural history or the biophysical aspects of the Alps. Notable exclusions are:

- ***Archaeological science*** related to Aboriginal and European occupation of the Alps. There are rich scientific pickings here – see for example the early work on Aboriginal sites summarised by Josephine Flood (1980). There are also some interesting crossovers with biophysical sciences such as Joe Jennings' (1976) documentation of an Aboriginal stone arrangement while studying periglacial processes (Section 3.2.4.1).

- ***Engineering science*** related to water supply systems, hydroelectric schemes, and mining operations. Here too there is a link with biophysical sciences, through the hydrological studies sponsored by water/power authorities **(**Section 3.2.5), but engineering science *per se* is not covered.

- ***Communication science*** related to deep space tracking. While there is undoubted scientific and cultural significance in the former space tracking stations in NNP (e.g. first broadcast of the 1969 moon landing), this branch of science is also excluded.

- ***Geology, paleoecology, studies of pest/exotic species, arboreta, and certain native vegetation studies***. Science related to these categories has been excluded from full treatment due to the short time frame of the study. However they are briefly covered in Section 3 as an aid to future research. Only native vegetation research relating to grazing, fire and treelines has been fully covered. Starting points for investigating excluded research categories are suggested in the relevant Section 3 themes.

RECOMMENDATION #1
Document the non-biophysical sciences in the Australian Alps and assess sites for cultural heritage.

RECOMMENDATION #2
Assess sites for cultural heritage relating to geology, paleoecology, pest/exotic species, arboreta, and native vegetation categories excluded from this report.

2.2 What Do We Mean By A Site?

Physically a site can be readily identifiable on the ground, or there may be no markings to give it away. Maisie Fawcett's BHP exclosures dating from the mid 1940s are excellent examples of the former. The latter is typified by John Banks' dendrochronology sites – we know where they are, but we would be hard pressed to find the individual trees he studied. Both types of sites are covered in this report.

A site can be small or large. Andy Spate records micro-erosion at one spot in a cave; Griffiths and Robin (1994) list as significant an ecological study of Glenmaggie catchment covering 1890 sq km. We focus on the more discreet sites unless there is compelling cultural heritage value in a broadacre 'site'. In some cases what appears to be a large site actually consists of a number of discreet spots on the ground. For example Sue Barker's Jagungal Wilderness snowgum study covers a huge area but really consists of 15 identifiable sites. In cases like this it is useful to look at the *project* as a whole in assessing cultural significance (though one of its individual sites could be chosen as a representative for interpretation).

Then there are some research projects that are essentially 'site-less' – an excellent example being the study by Brereton et al (1995) which modelled the bioclimates of southeast Australian animals under various greenhouse-induced climate change scenarios. The perilous outlook for *Burramys parvus* renders this research too important to ignore for the sake of having no 'sites' (see Section 3.2.6.1).

As per the project brief (Appendix 1) we only considered sites located in the AANP. Nonetheless there is a range of interesting projects/sites located in the wider Alps at places like Lake Mountain (e.g. Ashton and Hargreaves 1983) and Mt Baw Baw (Littlejohn 1963, Watson et al 1985) that have cultural heritage significance.

RECOMMENDATION #3
Consider the documentation and assessment of scientific sites in the Australian Alps outside the AANP.

2.3 How Did We Find Out About Sites?

The two initial sources of information were Griffiths and Robin's *Science in High Places: The Cultural Significance of Scientific Sites in the Australian Alps* (1994) and the Australian Alps Scientific Sites Database as prescribed in the project brief (Appendix 1). It became clear that these sources contained only a partial view of potentially significant Alps science. For instance they contain no geomorphological sites in Victoria or the ACT. We now know that there are significant geomorphological sites in those parts of the Alps including sites in Victoria significant to the glaciation debate and predating Galloway's much heralded work in Kosciuszko.

We 'discovered' many sites by following the bibliographic trail in the original scientific papers and by interviewing some of the key scientists. It was a case of 'the more you look, the more you find'. Unfortunately we cannot be confident we have tracked down all the sites worthy of cultural heritage consideration in the short time available.

2.4 What Do We Mean By Cultural Heritage?

Griffiths and Robin (1994) used this definition:

> *A culturally significant scientific site will have important historical associations with key individuals, events, debates or scientific findings.*

We have taken this definition with the relevant Criteria for the Register of the National Estate (AHC 1990) to arrive at a set of 8 criteria for assessing the cultural heritage of scientific sites. These criteria are presented below – the headings are our wording, the text under each heading is drawn from the AHC Criteria.

2.4.1 Assessment Criteria

1. The site has important historical association with key individuals.

National Estate Criterion H: Its special association with the life or works of a person, or group of persons, of importance in Australia's natural or cultural history.

H1: Importance for close associations with individuals whose activities have been significant within the history of the nation, State or region.

Places may be sites for collecting, survey, research or monitoring of the natural environment, including but not restricted to the following disciplines: paleoclimateology, geology, geomorphology, soil science, botany, zoology, ecology. In general, the association between person and place needs to be of long duration, or needs to be particularly significant in the person's productive life. For a place to be eligible for its association with a prominent scientist the importance of the scientist must be established, scientifically or historically; and the place must have a clear, direct and important link to the work of that scientist – it cannot be simply a campsite or collecting locality. The scientist may be an amateur naturalist, providing that person does have a confirmed historical standing.

2. The site is associated with important historical events.

National Estate Criterion A: Its importance in the course or pattern of Australia's natural or cultural history.

A4: Importance for association with events, developments or cultural phases which have had a significant role in the human occupation or evolution of the nation, State, region or community.

Places associated with the development of theories in geology, geomorphology, botany, zoology, ecology, archaeology, anthropology or other sciences associated with the understanding of the natural environment and human interaction with the environment. A place eligible for its association with a significant scientific theory must have a clear and important relationship to the development of that theory or its early application in Australia. A place eligible for its history of science associations must have a strong connection with the work of an historically significant figure or with an historically significant scientific exploration/undertaking or methodological development.

3. **The research findings from a site were important in key scientific debates.**

   See National Estate Criterion A4 above.

4. **The site is associated with key scientific findings.**

   See National Estate Criterion A4 above.

5. **The site is associated with research that was of a pioneering nature.**

   See National Estate Criteria A4 and H1 above.

6. **The site is a long-term monitoring site that is likely to add to the knowledge of biological sciences.**

   National Estate Criterion C: Its potential to yield information that will contribute to an understanding of Australia's natural or cultural history.

   C1: Importance for information contributing to a wider understanding of Australian natural history by virtue of its use as a research site, teaching site, type locality, reference or benchmark site.

7. **The research site is a reference, benchmark or prime site for a particular field of research.**

   See National Estate Criterion C1 above.

8. **The site demonstrates a high degree of creative or technical achievement.**

   National Estate Criterion F: Its importance in demonstrating a high degree of creative or technical achievement at a particular period.

   F1: Importance for its technical, creative, design or artistic excellence, innovation or achievement.

> A place is eligible if it demonstrates clearly a particularly appropriate solution to a technical problem using or expanding upon established technology, or developing new technology, that solution being outstanding due to its conceptual strength.

These criteria were applied to the state-based lists of sites/projects (Volume 2 of this report) generated by the process described in Section 2.3 above. Sites that met two or more criteria were deemed to be culturally significant and were grouped into themes (see the tables throughout Section 3) for purposes of interpretation. Sites that met only one criterion (often #6) were included if their claim was considered strong.

Having 'unearthed' many sites/projects (and assessed them) not recorded on agency or Alps databases, it would be timely to update the records held around the Alps. Furthermore, sites of outstanding cultural heritage (generally those that meet a large number of criteria) should be nominated for heritage listing.

RECOMMENDATION #4
Update databases and other records around the Alps relating to scientific sites to include all sites in Volume 2 of this report. Update sites of significance registers at Alps agencies to include sites in Volume 2 assessed as culturally significant.

RECOMMENDATION #5
Nominate key sites, especially those with strong visual identifiers on the ground, for State and national heritage listing.

In the course of this project, we were impressed with the potential for *future* cultural significance in many sites/projects. A number of recent studies were excluded as any cultural significance is yet to emerge. There are many studies, often student projects, on the records of AANP agencies that do not appear in Volume 2 of this report. (It is worth noting that more than a few of the studies we found to be culturally significant began as student work.) Furthermore there are new streams of science emerging dealing with issues like climate change and the impacts of snow grooming (e.g. Pickering and Hill 2001).

RECOMMENDATION #6
Review Alps science in 5-10 years for new sites of cultural heritage.

2.5 Why the Australian Alps?

Since the Australian Alps Cooperative Management Program began in 1986, there has been a steadily growing interest in the cultural heritage of Alps science highlighted by books such as *The Scientific Significance of the Australian Alps* (Good 1989) and *Cultural Heritage of the Australian Alps* (Scougall 1992), and reports such as *Science in High Places* (Griffiths and Robin 1994). Sites have been assessed and now we are moving on to their interpretation.

Is this happening on regional scales elsewhere in Australia? The answer is basically "no" (James Hall AHC and Julie Ramsay AHC, pers comm). Why is this so? A passage of time is usually necessary to gain perspective on cultural significance. Science, especially experimental science using objective methodology, is only just coming of age in Australia in terms of the impact of its findings. It is no surprise that the cultural heritage spotlight is shining first on Alps science due to its long history, volume, variety and importance in "one of the most studied biophysical regions in Australia" (Good 1992a). Kirkpatrick (1994) states that none of the World Heritage Areas in Australia has received as much scientific attention regarding ecosystem dynamics as has the Australian Alps, and none has been subject to such long term monitoring.

2.6 Interpreting the Sites – How, What, When, Where, Why, and to Whom?

What need to be interpreted are the compelling stories embodied in the themes and the key scientific sites (Section 3). **Why** they need to be interpreted is a function of the importance of science as a human activity in the Alps. And not just its scientific importance, but its romance, its hardships, its battles and its victories – in short, its cultural heritage. Griffiths and Robin (1994) point out that scientists have triumphed over cattle graziers when it comes to science, but have lost out on heritage. Interpreting culturally significant Alps science is a necessary step in raising its profile.

The **when** of site interpretation has much to do with having a good story to tell. It goes without saying that the site must be culturally significant, but as discussed above (RECOMMENDATION #6) the assessment of cultural heritage is a dynamic process. Even after a site has been identified as culturally significant, its value may lie in its *potential* as with the recently established network of fire-specific monitoring sites (3.2.2.1). Where today there may not be much of a story to tell, there will inevitably come the time where significant changes to vegetation communities can be shown – all the better if photographs are available and if there are interesting or controversial management implications. Then is the time to interpret!

RECOMMENDATION #7
Review this strategy in 5-10 years with a view to identifying additional key sites for interpretation. Best undertaken hand in hand with RECOMMENDATION #6.

How we interpret the sites – or which media we use – is closely related to **where** we interpret and **to whom** (which audiences) we are trying to reach.

An audience of primary importance is the park visitor. At present visitors pass by (most) scientific sites without knowing of their existence. The most powerful interpretive experiences relating to a place are available when your audience is there in the flesh. And the most powerful form of delivery is person-to-person, face-to-face – for example ranger-guided activities.

RECOMMENDATION #8
Include training in the cultural heritage of Alps science as part of 'Trash and Treasure' or other general cultural heritage training programs for Alps staff.

There are many face-to-face techniques available other than the basic 'talk'. These include role plays, artistic expression, and hands-on sensory investigations which provide experiential insights into the significant features/findings of a site. In the case of Latrobe University's annual Alpine Ecology Course in Victoria participants have the opportunity to partake in active scientific research at culturally significant sites.

Face-to-face interpretation will of course only reach a small fraction of park visitors therefore there is a definite place for on-site signage. Many sites however are inappropriate for on-site signage for a range of reasons discussed at each theme in Section 3. Where signage is inappropriate (yet the site is still considered appropriate for visitation) a brochure may be considered. The brochure may be specific to a site, or the site information could be added to a more general brochure such as that for a walking track.

A brochure will provide the abovementioned on-site interpretive experience but only if the visitor has obtained it in advance. This drawback can be balanced against the fact that a brochure can function as off-site interpretation thereby reaching a wider audience such as visitors at information centres, potentially attracting them to the site. For those who do visit a site with a brochure, the brochure has added value as a take-home keepsake.

Some sites are managed so as to be off limits to visitors (reasons discussed at each theme in Section 3), usually by the expediency of no location-specific promotion. There may be an existing interpretive node (or one could be established) where the site (or indeed a group of sites) could be interpreted nearby. Where such a node is adjacent to a major road or at a place developed with substantial facilities, a 'tourist' audience can be reached as described below.

Other off-site possibilities include AANP agency visitor centres and regional visitor centres, and periodic AANP agency publications such as the seasonal *Kosciuszko Today*. Interpretation via these means will reach 'tourist' audiences often less informed about national park values than those who venture into the parks beyond developed areas. These audiences are important to reach if we are to elevate science in the general community's cultural image of the Alps. There are several options for Alps science at visitor centres. Scientific sites in the area served by the centre could be interpreted by static and/or interactive means as part of a 'permanent' exhibition. A more Alps-wide approach would be a travelling AALC exhibition that could tour the various visitor centres and also be available for selected conferences and workshops.

RECOMMENDATION #9
Encourage the treatment of Alps science in visitor centres and in AANP periodic publications. Contact visitor centre managers around the Alps to establish a schedule of anticipated new exhibitions (e.g. NNP Visitor Centre revamp expected in 2002). Provide interpretive material and possibly funding toward the treatment of Alps science.

A related recommendation to the one above would be to raise the profile of Alps science by inserting it into more general park planning processes.

RECOMMENDATION #10
Encourage AANP agencies to take account of scientific heritage in forthcoming management plans (due in the near future for KNP and NNP), interpretation plans, and recreation plans (one is being developed for northern KNP).

RECOMMENDATION #11
Consider development of a mobile Alps display on culturally significant science.

The big picture of Alps science covering all themes and the key researchers could be presented in a book or booklet, on websites (AANP agency or AALC), or by other digital means. A hard copy publication or a downloadable website would act as both ‘armchair’ interpretation and as a field guide to appropriate sites. While this report is tasked with creating a framework for the interpretation of individual sites or ‘places’, the heritage of Alps science is also worthy of a single cohesive ‘big picture’ presentation. Given the importance of the Alps science story in its entirety, we recommend a higher priority be given to an overall production than to the interpretation of individual sites.

RECOMMENDATION #12
Consider as a priority the production of a book or an electronic version of the entire Alps science story which could act as a field guide to appropriate sites.

There will be opportunities to piggyback Alps science onto more general publications where appropriate. For instance a future edition of the *Explore* travel guide (AALC 1998) could interpret some of the more easily accessible sites while publications such as *Cool Ideas For The Alps: a field studies guide for teachers and group leaders* (AALC 1993) would benefit from the inclusion of Alps science interpretation. A new edition of the *Australian Alps Education Kit* (AALC 1992) would be a prime medium for the treatment of culturally significant science. Reaching influential audiences like teachers can have a ripple effect in raising the profile of Alps science.

RECOMMENDATION 13
Identify forthcoming publications which would be appropriate for the inclusion of an Alps science component.

The options for interpretation outlined above are not mutually exclusive. For instance a signposted site could also be incorporated into visitor centre interpretation or a book.

3 THE THEMES

3.1 Australian Historic Themes

The Australian Heritage Commission (AHC 2001) has developed a thematic framework for use in heritage assessment and management. The themes are also designed to be useful to historians, teachers and interpreters in providing links between the different regional stories in Australia's history, and the heritage places that help to illustrate that history. Many of the themes are relevant to Australian Alps science. They are listed in Appendix 2 along with their relation to our 'Themes For Interpreting Australian Alps Science' presented below.

3.2 Themes For Interpreting Australian Alps Science

The major themes relating to Alps science revolve around:

- Grazing
- Fire
- Rehabilitation
- Geomorphology
- Hydrology
- Meteorology and Climate Change
- Palaeoecology
- Native Fauna
- Native Flora
- Arboreta
- Exotic Species

Each theme is presented below with this structure:

- An overview of the science relating to the theme.
- A section on interpreting the theme comprising:
  - constraints and considerations
  - the thematic statement
  - key messages for interpretation
  - key sites for interpretation.

The key messages are drawn from the overview. Together they provide material which will be useful for the generation of interpretive text, including references to other sources.

The overview and key messages are important as they cover **all** the significant sites/projects, not just those that have been selected as key sites for interpretation. **The key sites for interpretation are chosen for their potential and propriety for on-site or near-site interpretation –** they are not necessarily the 'best' sites for interpretation, many of which are inaccessible, sensitive, or have other constraints as outlined at each theme. Therefore the overview and key points should be drawn upon in any non site-based forms of interpretation as suggested in RECOMMENDATIONS #8, 9, 12 and 13.

The key sites for interpretation appear in tables at each theme followed by a discussion of matters pertaining to the delivery of interpretation for each site.

The discussion of constraints and considerations incorporates *conservation management strategies* as per the project brief, however that terminology is not used as it implies more than actions relating to the promotion of sites.

In order to graphically unify and organise the interpretive themes, a series of symbols or brands are suggested. A principal symbol could stand for the cultural heritage of Alps science as a whole. The example on the front cover of this report consists of a magnifying lens placed over the AANP logo. Subordinate symbols would relate to each theme – for example a hoof print in the lens (relating to 'Grazing'). While subordinate symbols will work in an all-encompassing presentation such as a book, they may lose their context when presented individually as at an on-site sign. One principal symbol may be preferable for isolated applications.

3.2.1 Grazing

3.2.1.1 Overview

The stream of science that flows from the grazing of domestic stock in the Australian Alps is of primary significance both culturally and scientifically. It has involved more people and occupied more person hours than all other scientific investigations in the Alps. It has produced more 'key individuals' than other areas of science. It has been going on for a very long time in the context of Australian science and represents the coming of age of ecology as a science in Australia. And it has produced internationally outstanding research into the dynamics of alpine/subalpine vegetation (Kirkpatrick 1994).

While the science of grazing impacts is, on the surface, about vegetation and soil – it has, in the best traditions of ecology, involved the study of fire, hydrology and more. Its focus has graded into the 'healing of the wounds' (rehabilitation) and broadened to strive for an understanding of nature conservation values. It was instrumental in the creation and maturing of national parks in the Victorian and NSW Alps.

After 60 or 70 years of largely unrestricted grazing of domestic stock in the Australian Alps, astute naturalists and government officers began to comment on the impacts of grazing and the associated burning for green pick. In 1887 James Stirling, district surveyor and lands officer at Omeo, attributed the disappearance of the showy anemone buttercup from Victoria's mountains to grazing (NPWS 1991a, Gillbank 1992). Dr JH Maiden and Richard Helms studied flora and soils in the Snowy Mountains in the 1890s. Helms (1893) reported on the soil erosion resulting from burning-off by graziers, noting that the despised woody shrubs were actually being promoted by frequent burning (NPWS 1991b).

Forester Baldur Byles made the same observations in the Upper Murray catchment in 1932. He emphasised the pressing need for an understanding of the ecology of the Alps. Byles was influential in the formation of the NSW Soil Erosion Committee in 1933 and the Soil Conservation Service in 1938. In Victoria the Soil Conservation Board (SCB) was formed in 1940 in recognition of the need to provide a reliable flow of silt-free water to irrigation and power generation schemes in the Hume and Kiewa catchments.

Everything was now in place for the entry of the young science of ecology into the Alps whereby experimentation, objective methodology and long-term monitoring would be applied to natural systems.

Stella Grace Maisie Fawcett was hired by the SCB in 1941 to investigate the causes and control of soil erosion in the foothill country near Omeo. She was supported by her colleague, Botany Professor John Turner at University of Melbourne, in establishing experiments based on grazing exclosures. She came to believe the erosion gullies observed in the foothills derived from overgrazing at higher altitudes, with fire as a contributing factor. She made her theories known to the SCB and the State Electricty Commission (SEC) who were then establishing the Kiewa hydro-electric scheme.

Fawcett and Turner now established the legendary Rocky Valley and Pretty Valley plots in 1945 and 1946 (Plates 5 and 6). Grazing exclosures were constructed and corresponding plots representing the various vegetation communities were set up inside and outside the exclosures. Fawcett had adapted the Levy point method of sampling to the mountainous terrain and vegetation near Omeo. She now applied this method to the Bogong High Plains work whereby the species of every leaf touched by a series of long thin needles lowered vertically through the vegetation at hundreds of points had to be recorded.

Fawcett's methods made her annual summer surveys labour-intensive social events bringing together authorities responsible for tertiary education, electricity generation, soil conservation and scouting. As we shall see the tradition continues over 50 years later with the expansion of sites, the involvement of new generations of scientists, and a reaching out to the community through initiatives such as the annual Alpine Ecology Course run by Latrobe University and Natural Resources and Environment (Victoria).

Several key players passed through Fawcett's 'school of alpine science' in the late 1940s. Dr David Ashton (Melbourne University) joined the Bogong High Plains surveys from 1949-53. Alec Costin (Sydney University) spent a season in 1947 studying Fawcett's methods and learning about alpine and subalpine ecosystems. Around this time, Fawcett's work was influential in securing government agreement to put in place some controls on grazing and burning.

Costin was recruited in 1953 to head the new Research Division of Victoria's Soil Conservation Authority (formerly SCB). He roamed the Alps from Lake Mountain to the Cobberras documenting among other things the widespread destruction of *Sphagnum* mossbeds. He published his report in 1957 (Costin 1957a).

Meanwhile in 1955 Costin had inspected the Snowy Mountains and recommended the elimination of high altitude grazing, along with effective fire prevention and more conservation work by the Snowy Mountains Authority (SMA) who were well into their massive water diversion and hydro-electricity scheme. He also called for the establishment of a CSIRO field station for catchment research (Gillbank 1998).

In May 1955 Costin was appointed head of the CSIRO's Alpine Ecology Unit at Island Bend, thus beginning a NSW 'school of alpine science' to rival (Fawcett) Carr's and Turner's in Victoria. Costin and his associates would go on to investigate climate, physiography, geology, glaciology, flora, fauna, soils, hydrology, fire and land use.

In 1957 Costin and Turner summarised the damage caused by domestic stock in their contribution to an Australian Academy of Science report (AAS 1957) on high mountain catchments in both NSW and Victoria. They drew attention to the now discernible dramatic recovery of the grassland inside (Fawcett) Carr's Pretty Valley exclosure, details of which were later published in the Australian Journal of Botany (Carr and Turner 1959).

State governments could not ignore the scientific evidence. In the late 1950s grazing was removed from Mts Hotham, Loch, Feathertop and Bogong in Victoria, and from Kosciuszko State Park above 1370m (i.e. the alpine area).

Not content to sit on any laurels Costin, with CSIRO colleague Dane Wimbush, set about establishing long-term studies to document the recovery from grazing in the NSW alpine area and the impacts of grazing in the subalpine. (There was much more - the full range of Costin/Wimbush investigations from the late 1950s to the late 1970s can be appreciated by referring to the other themes in this report.) Much pioneering work took place and innovative techniques were developed - for example the use of colour stereophotography in the measurement of vegetation (Wimbush et al 1967).

Meanwhile Walter Bryant (1969) of SCS NSW investigated (over 14 years commencing 1954) vegetation and ground cover trends inside and outside grazing exclosures at Long Plain (Plate 10), Kiandra and Plains of Heaven. He showed that grazing suppressed snowgum seedling growth thereby limiting the life of the community by preventing tree replacement, that selective grazing on herbs opened grasslands to erosion, and that after an initial post-grazing increase most shrubs declined in favour of grass and herbs. This last point was an early counterpoint to the contention of Newman (1954) and Taylor (1956) that grazing was necessary to control shrub growth and hence to prevent bushfires. Bryant concluded that grazing is not an acceptable practice where the primary objective is the maintenance of catchment values. Bryant's work at Nungar Plain (1971a, 1973) deals with sheep grazing but is of particular interest with regard to fire (3.2.2.1).

The Costin/Wimbush and Bryant work provided an unassailable scientific base for the complete banning of grazing stock from the new Kosciuszko National Park in 1969. This signified a major shift in Australians' cultural perspective on their highest mountains.

In Victoria the Land Conservation Council (LCC) was asked in 1973 to investigate the case for a national park in the Alps. Both (Fawcett) Carr and Costin submitted reports. In 1979 the LCC recommended four national parks which were gazetted in 1981 and linked in 1989 to become Alpine National Park.

1979 was also the year that Wimbush and Costin published three classic papers related to their long-term grazing studies in Kosciuszko (Wimbush and Costin 1979a, 1979b, 1979c); and it was the year that (Fawcett) Carr and Turner returned to the Bogong High Plains to re-survey their plots, spawning a new wave of research which was accompanied by an explosion in new study sites.

Keith McDougall of the Soil Conservation Authority started mapping vegetation, Harm van Rees began studying diet and behaviour of free-ranging cattle, Richard Williams (Melbourne and Monash Universities) began his investigations into Carr's earlier hypothesis on ecological processes in grassland and heathland, and Warwick Papst (SCA and Dept of Conservation and Natural Resources) began his diverse research on high country ecology.

William's work on the dynamics of subalpine vegetation in Victoria (Ashton and Williams 1989) concluded that grazing impact had been severe, particularly in the fen/bog system and the snowpatch herbfields. He also made the key finding that the invasion of cattle-free grassland by shrubs is the initial stage of a vegetation-healing process which, over 50 years, will lead to the re-establishment of shrub-free and erosion-free grasslands – a finding made possible by the long-term stream of science begun by Fawcett.

Meanwhile following (Fawcett) Carr's death in 1988 her husband offered all her data to Papst and Williams along with a scholarship for Monash University's Henrik Wahren to conduct an analysis. While Wahren worked on the data, Papst and Williams replicated the surveys. Their published analysis of the vegetation records from 1945 to 1994 (Wahren, Papst and Williams 1994) confirmed the spread of tall non-palatable shrubs in grazed areas at the expense of herbs, grass, and smaller palatable shrubs; also confirming that woody shrubs die and give way to grass after 40-50 years free of grazing. This once and for all put paid to the graziers' argument that 'grazing reduces blazing'.

An interesting macro view of these Victorian findings is presented by Ruth Lawrence and associates (Bruce et al 1999). She imported digital photographs derived from aerial photographs of the Watchbed Creek Catchment (1961, 1980 and 1994) into a Geographic Information System and analysed the data for catchment-scale changes to vegetation communities. She recorded significant increases in the cover of snowgum woodland, heathland and mossland; and a significant decrease in grassland/herbfield. The initial heathland increase and grassland decline accords with the micro-scale experimental findings of other Victorian researchers (i.e. the 50 year post-grazing transition). Lawrence notes that the declining rates of change for these two communities indicate that the grassland to heathland transition is slowing and the anticipated reversal may happen in the near future. This innovative approach offers catchment-scale validation of regenerative processes observed at a smaller scale. It would be most interesting to track the continuing story with future data.

The new wave of Victorian research built a case for the removal of further areas from grazing in the 1990s (Appendix 3).

The Victorian research on grazing impacts continues strongly today with the vast majority of sites established since 1945 still in use (upwards of 50 sites). A recently published study (Wahren et al 2001) uses three of the BHP monitoring plots established in 1980-81 to describe the grazing-induced degenerative processes affecting alpne/subalpine bogs. The authors (Wahren, Williams and Papst – all stalwarts of the second generation Victorian 'school of alpine science') also for the first time describe in detail the *regenerative* processes in the bogs and go on to propose a successional framework for *Sphagnum* bog vegetation. The work involved innovative transplant experiments using key species. They identify a time span of less than 5 years required to reduce a healthy bog to an erosion pavement under the trampling influence of cattle, whereas the time span for a full recovery would be 50 to >100 years. They conclude that cattle grazing is a direct threat to the recovery of BHP bogs (the only substantially undamaged one being within Fawcett's Rocky Valley exclosure) and, as a consequence, to stated national park objectives.

In NSW Costin and Wimbush left behind a rich legacy of plots, transects and study sites. Some of the research has been continued by Roger Good of the NSW NPWS who worked closely with Costin on revegetation or eroded areas from 1963 to 1974, but the impetus for research is not as strong as in Victoria given the long absence of domestic stock in Kosciuszko. Nonetheless the NSW work stands as the baseline against which future trends and impacts can continue to be monitored (Good 1992a).

In both states the studies have matured from a focus on grazing to a broader focus on nature conservation values and ecosystem dynamics in the face of a range of variables other than grazing pressure.

The grazing research theme is a story about Victoria and NSW. It is worth noting that cattle were removed from the highest part of the ACT immediately after the selection of Canberra as the national capital. The Cotter River Catchment was earmarked for water supply and Dr JHL Cumpston was put in charge of the Commonwealth Quarantine Service in 1913 (Spencer 1987, M Galloway pers comm). He cleared the catchment of stock on public health grounds, leaving little soil/vegetation damage behind due to low stock numbers. (Costin et al (1959) refer to the Upper Cotter's pre-eminent position in the Alps as an undamaged catchment with intact natural communities.) Elsewhere in the ACT high country, grazing ceased in the 1970s and 1980s as freehold was resumed and leases terminated over lands earmarked for the formation of Gudgenby Nature Reserve (1979) and its successor Namadgi National Park (1984). The grazing properties had been in montane valleys which were more robust than the alpine and subalpine ecosystems under threat in the Victorian and NSW Alps. There was little impetus for science related to stock grazing in the ACT.

3.2.1.2 Interpreting Grazing

Constraints and considerations general to this theme follow.

In choosing an interpretive catchcry for the grazing theme we need to be mindful of the currency of the issue in Victoria and the fact that it goes beyond science as an issue. Something more reserved than "The Battle Against Cattle" is required if AANP agencies are to interpret this theme. While it may be tempting to emphasise the obvious successes in Kosciuszko in translating science into conservation policy we need to remember, in arriving at an Alps-wide approach to this theme, that in Victoria the cattle are still largely there.

Several study sites, for example some of Wimbush and Costin's (1979c) alpine transects, are in declared wilderness areas thus precluding any on-site signage.

Several sites are in the Main Range alpine area of KNP where visitors are strongly advised to stay on the walking tracks provided. Good (1992b) remarks that visitor management in the treeless alpine zone is now a key component of vegetation management in the Australian Alps. In cases where on-site access is problematic, there are potential opportunities for 'near-site' interpretation via trailhead or trackside signage, or via a brochure for a nearby walking track.

Sites that are still active, or with potential for reactivation, should only be considered for on-site interpretation where visitation can be managed in such a way as not to alter soils and vegetation which are subjects of the research.

There has been a purposeful move away from brochures at KNP in favour of signs. There are no longer brochures relating to specific walking tracks or points of interest, but rather individual signs or interpretation bays, often at trailheads or key road junctions. KNP will be reviewing interpretive signage in 2002.

The thematic statement for grazing is:

Hard Hooves/Soft Mountains: the science of grazing in the Australian Alps.

Key messages for interpretation are:

- Grazing accounts for the major stream of science in the Alps.
- Grazing accounts for the majority of key scientists associated with the Alps.
- This research represents the coming of age of ecology as a science in Australia.
- It was instrumental in the creation and maturing of national parks in Victoria and NSW.
- Grazing research accounts for some of the longest active experimental study sites in Australia.
- Key findings include the promotion of soil erosion, the loss of biodiversity, and the severe impact on the fen/bog system and snowpatch herbfields.
- The 'grazing reduces blazing' argument is strongly countered by the finding (made possible by the long span of research) that grazing actually promotes woody shrubs – shrubs that will only give way to erosion-free grassland after 40-50 years free of grazing.
- This research has bequeathed the Alps numerous study sites capable of tracking a broad range of environmental changes and influences into the future.

Table 1 - Key Sites For Interpretation: Grazing

Project/Site*	Location	Cultural Significance (as per criteria in 2.4.1)
Maisie Fawcett's Soil Conservation Plots	Pretty Valley 5258 59158 Rocky Valley 5262 59168 (ANP)	**1** - Carr, Turner, Ashton, Williams, Papst, Wahren, McDougall, van Rees; **2** - Associated with removal and reduction of grazing pressure in parts of the Victorian Alps; **3** - Grazing impact debate; **4** - A host of significant findings relating to vegetation dynamics; grazing-induced processes leading to soil erosion and shrub promotion; and post-grazing recovery; **5** - Arrival of ecological research in the Alps; **6** - Longest continuous scientific research in the Alps and highly significant nationally; **7** - Reference and benchmark sites.
Grazing Impact on Watchbed Creek Catchment	5285 59195 (ANP)	**3** - Grazing impacts debate; **4** - Confirmation of micro-scale findings regarding grazing-induced heathland/grassland dynamics; and post-grazing recovery of snowgum woodland and mossbeds; **8** - Innovative application of GIS analysis to grazing research.
SCS Grazing Exclosures	Long Plain – 6405 60520, 6412 60530. Kiandra – 6360 60265, 6380 60275 (KNP)	**1** - Walter Bryant, Roger Good; **2** - Removal of grazing from KNP; the impact of grazing on fire risk; **3** - Grazing impact debate; **4** - Grazing retards snowgum regeneration, selective herb grazing exposes soil to erosion, following post-grazing increase most shrubs decline in favour of grass and herbs; **5** - First study to show benefit of excluding stock from snowgum regeneration; **6** - Monitored 1954-79; **7** - Long Plain reference site for post-grazing snowgum recovery.
Wimbush and Costin Grazing Trials	6332 59732 (KNP)	**1** - Alec Costin and Dane Wimbush; **2** - Removal of grazing from KNP; **3** - Grazing impact debate; **4** - Grazing damage to vegetation and exposure of soil to erosion; **6** - Monitored 57-90 and the 2 alpine transects monitored and assessed 2000 (Pascal Scherrer); **7** - Reference sites for post-grazing recovery.
Bryant's Nungar Plain Fire/Grazing Research	6526 60289 (KNP)	**1** - Walter Bryant; **2** - Removal of grazing from KNP; **3** - Grazing impact debate, the use of fire for hazard reduction; **4** - Destructive impact of sheep and controlled burns on snowgum regeneration, destructive impact of controlled burns on grassland condition and soil stability.

* see Volume 2 of this report for detailed site specifications

Maisie Fawcett's Soil Conservation Plots

These premier scientific sites include one of the few in the Alps that is well interpreted thanks to the *Maisie's Pretty Valley Plots* brochure (Appendix 5, Plate 5) produced in 2001 by Latrobe University with Parks Victoria funding. The site is also the subject of regular ranger-guided walks and is "one of the most visited sites on the High Plains" (Ron Riley, pers comm) thanks to secondary and tertiary student field trips. Latrobe plans to augment the brochure with an interpretive sign on the exclosure fence in the near future. At present the brochures are distributed through Parks Victoria outlets but there are plans to install an on-site dispenser box.

The scientific community (led by Warwick Papst) is concerned about the possible reaction to any signage that highlights the negative impacts of grazing – fearing damage to the sign or, much worse, to the plots themselves. As such the planned sign will present the soils and vegetation research without drawing 'controversial' conclusions. As far as attracting inappropriate numbers of people is concerned, the brochures are not expected to do so (the location map is a bit cryptic). There is a strong feeling against any directional signage on the nearby road. The site is only 100m from the Bogong High Plains Road which carries substantial seasonal traffic.

Future brochure reprints or sign updates would provide the opportunity to incorporate Alps Science branding. A future brochure could also include the nearby Rocky Valley Plots (keeping with the 'Maisie' theme; Plate 6) or even tackle adjacent scientific sites such as the Rocky Valley snowcourse (3.2.6.2; Plate 4). There is in fact a good case for a 'Science on the Bogong High Plains' brochure due to the concentration of significant sites relating to themes such as 'Hydrology', 'Meteorology', 'Rehabilitation' and 'Grazing'. Such a brochure would open the field to more sites than those identified herein as 'Key Sites For Interpretation'. Rather any of the significant sites/projects covered in the theme overviews could be included. For instance, while the Pretty Valley and Rocky Valley Plots are the flagship sites of Victorian grazing research, that stream of science also relies on the many dozens of long-term monitoring sites on the BHP (see Volume 2 of this report).

This Rocky Valley Plots are only 1km from Pretty Valley Plots and are also very close (150m) to the Bogong High Plains Road. There are plans to install an interpretive sign on-site as per the planned sign at Pretty Valley Plots. There are no plans at present for any brochure treatment. Given the fact that Rocky Valley contains a number of different vegetation communities to Pretty Valley, and given their histories are so closely linked, there is scope for treating them together in a brochure and perhaps providing a line of markers across the 1km of grassland separating the sites. Should a sign be installed at Watchbed Creek (see below), future signs at Pretty and Rocky Valley should refer to Watchbed as the macro side of grazing research.

Grazing Impact on Watchbed Creek Catchment

To be interpreted on-site, this research needs an expansive view over the various vegetation communities in the Watchbed Creek Catchment. Such a vantage point, with suitable room to park, can be found 800m up the Big River Fire Track (this section open to the public) from the Bogong High Plains Road. This would be the place for a science-specific sign. The other option is inclusion in a 'Science on the Bogong High Plains' brochure as discussed immediately above. Any on-site sign should refer to the Pretty and

Rocky Valley Plots as the micro side of this research. Mapped representations of the changes to vegetation communities are available from Ruth Lawrence at Latrobe University. They would be an excellent inclusion in any interpretation.

SCS Grazing Exclosures

Two of Walter Bryant's three 1950s grazing exclosure plots are in the northern part of KNP. They are immediately adjacent to public roads. The fences are no longer standing and active research has long ceased. These sites are prime candidates for on-site interpretation using signs.

The Long Plain site (Plate 10) is located on the western side of the Long Plain Road approx 9km north of the Snowy Mountains Highway and 500m south of Spicers Creek. There is an interpretation bay at the Snowy Mountains Highway/Long Plain Road junction. The Long Plain Road is a dirt road of 2WD standard in dry weather. It is closed in winter. A low-key parking bay would likely be required to facilitate visits to the site.

The impact of grazing on snowgum regeneration can be well interpreted using photographs of the exclosure near the beginning and end of its operation, and by positioning the sign on the alignment of the 'front' fence. Roger Good should be consulted regarding photos and the precise location of the fence.

While Costin singles out the Long Plain plots for their significance (Griffiths and Robin 1994, p 37), some thought should be given to interpreting the Kiandra grassland plots as the site is on the all-weather Snowy Mountains Highway near the Eucumbene River crossing 'one mile' southwest of Kiandra. This is an appropriate place for a sign (there is none at present) as many people stop here for a picnic, for fishing or to explore the historic gold diggings. The fences are long gone and Roger Good should be consulted regarding photos and the precise exclosure location.

Wimbush and Costin Grazing Trials

The grazing trials that took place in the Rainbow Lake area are particularly suitable for interpretation given the existing walking track (approx 1.5km) that heads south from a trailhead carpark on the Kosciuszko Road between the Hotel Kosciusko and Dainers Gap. The trail crosses the remains of the fence marking the boundary of the 1939 Hotel Kosciusko Water Reserve (Plate 13) and proceeds to its main feature – Rainbow Lake. The view across the lake takes in the area of the grazing plots (Plate 14).

The existing interpretation panel at the carpark mentions the use of the area as a water supply for the hotel, but does not cover the historical significance of the 1939 exclusion from grazing nor the Wimbush/Costin trials. Excellent photos for interpreting the trials can be found in the Kosciuszko Long Term Monitoring Plots folder at Jindabyne. These can be used to interpret the site on an updated sign at the trailhead carpark. A better option may be to flag the science on an updated sign at the carpark and to install a new science-specific sign at the Rainbow Lake terminus of the walk (where presently there is no sign).

Bryant's Nungar Plain Fire/Grazing Research

This key site relates to both 'Grazing' and 'Fire'. Its interpretation is discussed under 'Fire' at 3.2.2.2.

3.2.2 Fire

3.2.2.1 Overview

The science of fire has a wider reach in the Alps than the other sciences. It does not depend on whether a site has been grazed or on whether a rare species or notable geomorphologic feature exists. Fire effects are felt everywhere and, given that our approach to fire in conservation areas can be a contentious issue, it is not surprising that science has 'attacked' fire the length and breadth of the Alps.

Not only is fire *everywhere*, it is connected with *everything* as far as scientific themes in the Alps are concerned. Some examples:

- *Pest species* - the impact of rabbits is interconnected with the impact of fire (e.g. Leigh et al 1987, Wimbush and Forrester 1988).
- *Native species* - fire may be critical to the survival of the Smoky Mouse (ACT Government 1999).
- *Geomorphology* – fire has been instrumental in triggering contemporary active periglacial processes (McPherson 1998).
- *Paleoecology* – fire and its history are inexorably linked with other ecological processes in the science of paleoecology (e.g. Clark 1986)
- *Hydrology* – fire has a proven impact on discharge rates and sediment load (e.g. Brown 1972, O'Loughlin et al 1982).
- *Rehabilitation* – fire is an ingredient in the need for some of the major Alps rehabilitation trials/works (e.g. Clothier and Condon 1968).
- *Grazing* – the impacts of grazing by domestic stock and the impacts of burning to facilitate such grazing are intertwined in the major stream of Alps science discussed above in section 3.2.1.

While the above themes are dealt with separately, 'Fire' merits a place of its own on account of:

a) Fire-specific monitoring plots.
b) Fire history studies involving dendrochronology and fire scarred trees.
c) Vegetation studies following wildfire and burning-off practices.
d) Fire ecology studies involving experimental controlled fire.
e) Fire ecology studies involving 'experimental wildfire'.

a) Fire-specific monitoring plots

The Australian Alps Vegetation Fire Response Monitoring Plots were established in 1996 in a variety of vegetation types, districts, and altitudes and with a variety of fire histories. The 47 plots are located in NSW (28), Victoria (10) and the ACT (9). Data is collected on plant fire response, total species and vegetation structure. NSW NPWS also established an additional 9 Fire Monitoring Plots in KNP in 1996. The long-term scientific potential of these plots affords them cultural significance given the widespread ecological impact of fire as discussed above, controversy surrounding the use of fire, and the impact of fire on human activity in the Alps.

b) Fire history studies involving dendrochronology and fire scarred trees

Lyndsay Pryor used dendrochronology techniques on snowgums and alpine ash in 1939 near Bulls Head in the Brindabella Range (Banks 1989). He found a dramatic increase in fire frequency after 1860 corresponding with Helms' (1893) and Byles' (1939) reports on graziers' burning practices. John Banks understands this to be the first use of dendrochronology techniques in Australia (Griffiths and Robin 1994).

In 1955 Raeder-Roitzsch and Phillips (1958) conducted an investigation into the relationships between fire and soil erosion. They dated 275 trees across 24,000ha of the upper Tooma River catchment returning results similar to Pryor's. However both studies were plagued by diminishing data in the older part of the fire record – i.e. not enough really old trees.

Banks (1982) conducted a major fire history study in 1974 at five snowgum sites in the Brindabella Range and one in the Bimberi Range, largely confirming the enhanced post-1860 fire frequency. During this study he identified an indicator of past fires not reliant upon charcoal – namely the post-fire growth pulses fuelled by an enhanced nutrient supply.

Significantly Banks (1986) also studied tree rings from trees cleared from the Thredbo ski slopes. These even-aged stands were commonly thought to date from the 1939 bushfire but were found to predate that fire by 20-40 years. Analysis of old growth trees nearby revealed a mean fire-free interval of 50 years, much longer than the results (especially post-1860) from the Brindabellas. An even longer interval of 140 years was revealed in an even-aged stand at Schlink's Pass (Banks 1982).

Banks' work is often quoted as evidence that fire in the higher portion of the Australian Alps was rare prior to European settlement. This counters the argument by some graziers and bushfire authorities that frequent fire is a natural part of alpine and subalpine ecosystems.

If pre-European fire was rare over the generality of the Alps, it was essentially absent from wetland areas. Clarke (1986) found that the 1983 Gudgenby Fire (NNP) burned the *Sphagnum* of Rotten Swamp for the first time in 10,000 years.

In a recent study Rochelle Richards (2000) made elegant use of the Piccadilly Fire Ecology Plots (discussed separately below; Plates 19 and 20) and Banks' Brindabella work (1982) to test an inference by Bowman (1980). Bowman contended that the low record of fire scars found by Banks prior to European settlement did not preclude the likely practice of frequent low intensity Aboriginal burning, as snowgums are not sensitive to scarring by low intensity wildfire. Richards used the Piccadilly Plots to show that the vast majority of low intensity fires will indeed result in recognisable scars. She concluded that there is no evidence for Aboriginal burning in the snowgum forest of the Brindabellas and furthermore that Banks' evidence represents the true fire history.

These findings send a message to contemporary fire managers who quote a supposed pre-European low intensity fire regime as justification for modern hazard reduction or biodiversity burning. The study also demonstrates the scientific potential embodied in long-term study sites such as the Piccadilly Fire Ecology Plots.

c) Vegetation studies following wildfire and burning-off practices

While the work of Alec Costin and associates has been given prominence under the theme 'Grazing' (3.2.1), it is of course difficult to divorce the impact of fire, notably burning by graziers and the 1939 wildfire, from their research. Much of their work documents the increase in nature conservation and catchment values since the cessation of widespread burning-off in Kosciuszko in 1951 (e.g. Wimbush and Costin 1979a, 1979b, 1979c). While the research of Carr and Turner (e.g. 1959) and their descendants (e.g. Wahren et al 1994) in Victoria focuses more singularly on grazing, they document how their sites were shaped by fire to start with.

Walter Bryant (1971a, 1973) of the NSW Soil Conservation Service established belt transects at Nungar Plain to investigate the effects of sheep grazing on grassland and on snowgum seedling regrowth and regeneration. His research in the 1960s coincided with the last years of grazing leases in Kosciuszko. Near the beginning of his work the Park's then regular program of hazard reduction burning targeted the Nungar area. Bryant responded with additional transects. He discovered that snowgum seedlings would only grow in the absence of sheep grazing but that any fire (wild or controlled) damaged saplings below at least 10 feet in height. Furthermore fire caused a deterioration of grassland condition and ground cover exposing the soil to erosion. He reached the then controversial conclusion that regular prescribed burning for fuel control should be avoided.

Sue Barker (1988**,** 1989) sampled 15 snowgum woodland sites in the Jagungal Wilderness Area in 1972-73. She documented the impact of 100 years of burning for pasture improvement – namely dense stands of lignotuber regrowth with dense seedling regrowth following the removal of grazing, the end result being loss of the original open woodland and loss of old growth snowgums. While Good (1992b) recommends that there be no further burning in the Park until the majority of trees are in the older age classes (over 100 years), Barker forcasts that it may be several centuries (largely free of fires) if ever before a woodland composed of single stemmed trees is achieved.

In the Victorian Alps the first landscape-scale wildfire since 1939 (the only other being the 1998 Caledonia Fire discussed below) burned 11,000ha at Mt Buffalo in January 1985. Transects and photo points were established at Lyrebird Plain and Wild Dog Plain (Plates 18 and 21), and study sites from research undertaken in 1982 were reactivated to enable pre-fire comparisons. A key early finding was that the fire was more severe in drainage lines (with complete incineration of *Sphagnum*) than in adjacent grassy slopes and woodland. Scientists cautioned against the use of fire as a management tool on the assumption that mossbeds do not burn (Rees and Walsh 1985).

Results show that fire-free periods of at least 20 years are required for the recovery of treeless subalpine vegetation, that there is no evidence to suggest that fire is necessary to retain the integrity or conservation values of such vegetation (the opposite is in fact true), and that fire cannot be used to control shrub growth or cover in treeless alpine communities because fire in fact promotes shrubs. The Mt Buffalo monitoring plots are considered particularly valuable to science because of the paucity of alpine or subalpine areas that have been subject to landscape-scale fire for which there are pre-fire data (Wahren and Walsh 2000).

Some of the many second generation Victorian grazing impact sites were established in 1991 by Wahren and Papst (1999) at Holmes and Wellington Plains. Additional transects and plots (some fenced off) were added in 1998 following the Caledonia Fire which burnt large areas of montane and subalpine forest in the southeast of ANP as well as areas of subalpine heathland, grassland and wetland. The researchers state that little is known about the detailed impact of fire and post-fire regeneration, particularly in individual species and wetland vegetation, due to the scarcity of fire in the Alps. As such the Caledonia Fire represented a rare opportunity. This long term study will address issues such as the rate of accumulation of the important litter component in grassland, the role of soil seed bank in post-fire regeneration, factors controlling regeneration of scorched *Sphagnum*, and identification of wetland sites requiring special protection and/or rehabilitation.

Data collected at Mt Buffalo and Holmes/Wellington Plains are contributing to the development of a predictive framework for assessing the influence of fire on alpine and subalpine ecosystems (Wahren and Walsh 2000).

d) Fire ecology studies involving experimental controlled fire

The Piccadilly Fire Ecology Plots (Plates 19 and 20), together with a sister study in the Top End of the Northern Territory, are thought to represent the longest running fire ecology experiment in Australia and possibly the world. They were established in 1973 in the Brindabella Range by CSIRO under Phil Cheney to investigate the effects of fire on subalpine vegetation (Hoare and Jacobsen 1996). Plots, some fenced to exclude grazers, are burnt with a variety of different frequencies and in different seasons. Study topics include vegetation and fuel dynamics, and fire behaviour. Phil Cheney (letter to NNP July 1997) declares the site to be a valuable educational resource (with Australian National University involvement). He also says that it will be another 25 years before trends become clear by which time it will be a truly unique resource for land managers and scientists. Since 1997 NNP staff have had a direct involvement with this study by virtue of their responsibility for the burning treatments.

In 1976 Dane Wimbush and John Leigh of CSIRO and others established plots at Kiandra to investigate the effects of two experimental low intensity fires and/or grazing by rabbits and native grazers in grassland and woodland (Leigh et al 1987, Wimbush and Forrester 1988). Roger Good of NPWS continued the work to 1989 and Dane Wimbush rephotographed the sites as recently as 1998. They recorded a significant decrease in shrubs in unburnt plots, particularly on the open plain. They predicted that in the absence of fire, shrub cover will reduce such that by 2030 the herb/shrub balance will return to its year 1800 level. They found no evidence that low intensity burning would decrease wildfires, rather it will expose soil to erosion and promote rabbits. Additionally, the combination of fire and rabbits will result in the death of snowgum and black sallee saplings – the fire denuding the trees and the rabbits grazing basal regrowth. The ideal course of action to restore ecological balance is to accept occasional wildfires and control rabbits, particularly after fire.

e) Fire ecology studies involving 'experimental wildfire'

In 1980 the only experimental large scale high-intensity burn undertaken in the Australian Alps was lit in the Bushranger's Creek Catchment in the Brindabella Range by CSIRO Division of Forest Research (Terrill 1998). The 100ha burn in long-undisturbed montane and subalpine forest took place in mid February on a day of Very High fire danger in order to achieve complete elimination of forest transpiration through burning of all vegetation from crowns to wet areas (O'Loughlin et al 1982). The Bushrangers and nearby Pago catchments had been established as hydrology experimental areas in 1967 with the installation of a network of meteorological and stream gauging stations.

The dramatic and immediate increase in water flow during the fire demonstrated the tight relationship between evapotranspiration and streamflow **(**Ian Gordon, pers comm). Bushranger flow continued at double Pago flow during the ensuing 2 dry years until vegetation recovery restored forest transpiration.

A multi-disciplinary research effort was intended to follow the fire, but little if anything was undertaken or published outside hydrology (Jim Gould pers comm). Ian Fraser (1988) cites this as a case for greater control of research. The fire is therefore surrounded by some controversy, not least because a high intensity burn in tall forest on steep slopes west of Canberra would scarcely be permitted today.

In a postscript to this research Ian Gordon (pers comm) tells of the response of the Licking Hole Creek Catchment (part of the Upper Cotter Catchment) to the large 1983 Gudgenby Fire. The creek had run dry in the drought leading up to the fire but commenced flowing strongly immediately after the fire. This observation was made possible by a stream gauging station typical of the many throughout the Alps. Such facilities are generally associated with the engineering activities of water and power authorities and are beyond the scope of this report but should be considered in the future as per RECOMMENDATION #1.

3.2.2.2 Interpreting Fire

Constraints and considerations general to this theme follow.

Several studies relating to fire, such as Sue Barker's (1988) are in declared wilderness areas, thus precluding any on-site signage.

Several sites are in the Main Range alpine area of KNP where visitors are strongly advised to stay on the walking tracks provided. Good (1992b) remarks that visitor management in the treeless alpine zone is now a key component of vegetation management in the Australian Alps. In cases where on-site access is problematic, there are potential opportunities for 'near-site' interpretation via trailhead or trackside signage, or via a brochure for a nearby walking track.

Sites that are still active, or with potential for reactivation, should only be considered for on-site interpretation where visitation can be managed in such a way as not to alter soils and vegetation which are subjects of the research.

There has been a purposeful move away from brochures at KNP in favour of signs. There are no longer brochures relating to specific walking tracks or points of interest, but rather individual signs or interpretation bays, often at trailheads or key road junctions. KNP will be reviewing interpretive signage in 2002.

The thematic statement for fire is:

Fire on Five Fronts: the science of fire in the Australian Alps.

Key messages for interpretation are:

- Fire research sites are more widely spread around the Alps than those related to other themes.
- Fire is such an all-pervasive environmental force that it has an impact on every other area (theme) of science in the Alps.
- Fire research has proceeded on five fronts:
  - Fire-specific monitoring plots – have tremendous long-term scientific potential to resolve contentious issues surrounding wildfire impacts and the use of controlled fire.
  - Fire history studies involving dendrochronology and fire scarred trees – have used pioneering techniques to establish the relative rarity of pre-European fire in the Alps, thus countering justifications for contemporary use of fire based on supposedly frequent natural or Aboriginal fire.
  - Vegetation studies following wildfire and burning-off practices – have documented reductions in grassland condition, exposure of soil to erosion, and loss of open snowgum woodland and old growth snowgums. This research has probably influenced the trend away from regular prescribed burning for fuel control, and is moving toward the development of a predictive framework for assessing the influence of fire on alpine and subalpine ecosystems.
  - Fire ecology studies involving experimental controlled fire – includes the longest running fire ecology experiment in Australia (established 1973) set to

run for at least another 25 years with great potential as per the ‘fire-specific monitoring plots’ above.
  - Fire ecology studies involving ‘experimental wildfire’ – a controversial high intensity burn demonstrating the tight relationship between evapotranspiration and streamflow.
- Several fire sites have proved valuable for research unintended by the original study, or have themselves made use of sites established for other purposes.

Table 2 - Key Sites For Interpretation: Fire

Project/Site*	Location	Cultural Significance (as per criteria in 2.4.1)
Mt Buffalo Post-fire Research	Wild Dog Plains 4791 59336 Lyrebird Plain 4794 59334 (MBNP)	**1** - Wahren, Walsh, van Rees; **3** - The longest post-wildfire recovery study in the Alps; **4** - Fire-free periods of at least 20 years are required for recovery of treeless subalpine vegetation; no evidence that fire is necessary to retain integrity or conservation values; **6** - Particularly valuable long term monitoring due to the existence of pre-fire data; **7** - Rare opportunity for post-wildfire research in the Victorian Alps.
Bryant’s Nungar Plain Fire/Grazing Research	6526 60289 (KNP)	**1** - Walter Bryant; **2** - Removal of grazing from KNP; **3** - Grazing impact debate, the use of fire for hazard reduction; **4** - Destructive impact of sheep and controlled burns on snowgum regeneration, destructive impact of controlled burns on grassland condition and soil stability.
Kiandra Grazing/Fire Plots	6320 60350 6320 60360 (KNP)	**1** - Wimbush, Leigh and Good; **3** - The use of fire for hazard reduction; **4** - Post-grazing reduction in shrubs and increase in herbs; low intensity burning promotes soil erosion and rabbits and does not decrease wildfires; rabbits most destructive after fire; **6** - Monitored 1976-89.
Hydrological Impact of Fire at Yarrangobilly	Junction of Yarrangobilly R and Wallaces Ck (KNP)	**4** - Massive initial post-fire increases in sediment loads due to a thousand-fold increase in the rate of soil erosion.
Brindabella Range Fire History - Pryor	Bulls Head (NNP)	**1** - Lyndsay Pryor; **3** - Debate about historical fire frequency; **4** - Dramatic increase in fire post-1860; **5** - First use of dendrochronology techniques in Australia.
Brindabella Range Fire History - Banks	Bulls Head (NNP)	**1** - John Banks; **3** - Debate about historical fire frequency; **4** - More extensive confirmation of increased fire frequency post-1860; **8** - Identified growth pulses in tree rings as nutrient fuelled indicator of past fires.
Piccadilly Fire Ecology Plots	6673 60854 (NNP)	**1** - Phil Cheney; **3** - The use of fire for hazard reduction; **5** - first (and longest running) experiment in fire ecology in Australia; **6** - Long term monitoring with significant continuing potential.
Cotter Catchment Hydrology Studies	Bushrangers Ck Catchment (NNP)	**1** - Phil Cheney; **3** - Controversy has surrounded this study's use of large-scale high-intensity fire for research; **4** - The Bushrangers 'experimental wildfire' dramatically demonstrated the tight relationship between evapotranspiration and streamflow; **5** - The only experimental large-scale high-intensity burn undertaken in the AANP.

* see Volume 2 of this report for detailed site specifications

Mt Buffalo Post-fire Research

Both of the sites associated with this research are suitable for on-site signage, ideally featuring identical signs at each site. The Wild Dog Plain site (Plate 18) is accessible to walkers accessing the more remote parts of the park along the Rocky Creek Track. The Lyrebird Plain site is on the last stretch of the main road out to The Horn lookout. There is space for several cars to pull off on the northern side of the road. A 50m walking track would need to be provided to access a vantage point over the plain – the ideal spot for a sign (Plate 21). The researchers (Wahren and Walsh 2000) hold photographs suitable for interpreting the fire impacts and recovery.

Bryant's Nungar Plain Fire/Grazing Research

The Nungar Plain plots are located in the central part of the Plain some 5km east of the Tantangara Road – a 2WD standard gravel road between the Snowy Mountains Highway and Tantangara Dam. 8km north of the Snowy Mountains Highway the road crosses Nungar Creek at a point downstream of the Plain.

There is an existing interpretation bay at the Snowy Mountains Highway/Tantangara Road junction. Here the Nungar Plain sites can be interpreted on an updated panel either in full or ideally with a reference to a science-specific sign where the Tantangara Road crosses Nungar Creek.

Kiandra Grazing/Fire Plots

Another option for interpreting the impact of controlled fire in northern KNP is the Wimbush and Leigh research at Kiandra Plain. While the sites are within 2km of the Snowy Mountains Highway at a point approximately 7km north of Kiandra, there is no appropriate stopping point on the highway nor is there any track into the sites.

The best option would be to combine the interpretation of these sites (for which there are photos in the Kosciuszko Long Term Monitoring Plots folder at Jindabyne) with the interpretation of Brown's Ravine wildfire research. This can be done at 3 Mile Dam (see below) providing an interesting juxtaposition of controlled fire and wildfire.

Hydrological Impact of Fire at Yarrangobilly

None of the sites in KNP dealing with wildfire impacts is easily accessible. This includes Brown's sites at Ravine on the Yarrangobilly River (Plate 12). Access from the north (Snowy Mountains Highway) involves 21km of 4WD standard road and from the south

(Cabramurra Road) involves 15km of 4WD standard road. However there are opportunities for interpretation out on the sealed Cabramurra Road in the 3 Mile Dam area. There are existing interpretation panels on the Cabramurra Road at the 3 Mile Dam turnoff and also at the popular main camping area on the southern peninsula of the Dam. Situated near the top of the Wallaces Creek Catchment (one of the subjects of the research) these panels, when they are updated, would be suitable for interpreting Brown's research.

Brindabella Range Fire History – Pryor, Brindabella Range Fire History - Banks

The Bulls Head picnic area is an ideal location for interpreting this research (Plate 17). The existing interpretation bay is one of 10 around NNP that are due for updating as per the *Draft Namadgi District Interpretation Strategy and Program* (ACT Government 2001). This research and potentially the following two sites/projects are excellent candidates for interpretation at this, the major recreation facility in the Brindabellas.

Piccadilly Fire Ecology Plots

This site invites the visitor to explore the different plots where the impacts of the various fire treatments are often readily apparent (Plate 20). The research and the layout of the plots is explained on a CSIRO sign (Plate 19). On-site interpretation options are to update this sign to include the more recent treatments as well as Alps Science branding, or to leave the sign as is (the sign itself gives a sense of historical significance) and install an Alps Science sign nearby. Such a sign could also interpret the adjacent Piccadilly Arboretum (3.2.10).

Access to the site is problematic in that the short bush tracks off the Brinbabella and Mt Franklin Roads are rough, sometimes locked, and there is no provision for parking. This is not a problem at present as the site is not promoted in any way. Therefore the options are to leave the unpromoted access as is (but still provide the on-site interpretation for those who do visit the site), or to provide parking and directional signage. Depending on which approach is taken, the site can be flagged with or without location identifiers at an updated interpretation bay at the nearby Bulls Head picnic area (Plate 17).

Cotter Catchment Hydrology Studies

This is yet another candidate for interpretation or flagging at Bulls Head as the top of the experimentally burned Bushrangers Catchment is not far away. There is also an opportunity for a more on-site treatment via a new science-specific sign (there is no sign at present) where the Bendora Road crosses Bushrangers Creek just before it joins the

Cotter River. Here you are at the bottom of the burned catchment close to where the significant streamflow readings were recorded. There is already a pull-off area suitable for parking.

3.2.3 Rehabilitation

3.2.3.1 Overview

Rehabilitation is one of the great stories of the Australian Alps. Engineering activities, fire, grazing, mining and forestry caused tremendous damage to soils and vegetation in the period before conservation-minded regulation was put in place. The need to repair the damage was already apparent in the 1930s prompting the establishment of soil conservation agencies in NSW and Victoria. The need was backed up by the great scientific investigations spearheaded by Fawcett and Costin.

Alps rehabilitation began in 1957 in the alpine area of Kosciuszko where grazing and fire had removed the fragile 'skin' of vegetation triggering massive erosion that carried away soil to a depth of 60cm and created gullies in drainage lines (Irwin and Rogers 1986). The magnitude of the damage imparted urgency to the work. It could be argued that the huge rehabilitation effort launched in 1957 did not constitute experimental science. This would be wrong. While it did not leave behind many pegged plots or published papers relating to micro-scale sites, continuous purposeful and structured monitoring of the effects of various treatments and techniques (discussed below) yielded findings that were immediately applied.

The results are there to be seen on the Main Range. The results are so good that most people take what they see as a pristine natural area for granted.

The major broad scale rehabiltation works began at Carruthers Peak and moved on to Mt Twynam continuing into the 1980s. Many workers were involved and they faced great hardships due to the difficulty of the terrain, the harshness of the weather, and the challenges of transporting supplies and equipment (including 4-5 tons of materials for each acre treated). One violent storm destroyed the workers' tent camp forcing a hazardous pre-dawn evacuation to the shelter of the Spencers Creek weather station (Clothier and Condon 1968).

The work began with plant species and fertiliser trials. While they were progressing there was urgent need to control runoff and again several techniques were tested. Both contour banks and downhill flumes were required. Initially they were lined with large stones and later trials were conducted with jute-mesh, fibreglass matting and snowgrass sods.

Once runoff was under control sites were prepared for seeding by smoothing rilled surfaces, roughening slaked surfaces, and spreading any remaining topsoil. In steep or difficult terrain this was done by hand. Where possible a small bulldozer was used for both site preparation and runoff control. Highly skilled operators well versed in conservation requirements were essential.

The plant species trials identified a mix of exotic grasses and legumes suitable for rapidly stabilising the extensive damaged areas. (Appropriate native seed was not available then and would probably not be available today in the quantities that were required.) Seeds and then fertiliser were broadcast by hand or backpack blower. Experimentation helped determine a balance in the application of artificial fertiliser such that exotic species (requiring high soil fertility) established quickly while allowing native vegetation (unable to cope with artificially high soil fertility) to recolonise (Good 1992b).

Next came mulching to insulate the soil against frost heave and provide the conditions for germination and establishment. The early mulch of choice was straw and it had to be applied by hand to get the coverage and depth right. Jute-mesh was used on extremely steep slopes. The straw had to be held down against the high velocity winds. The material of choice was ungalvanised wire netting although materials trialed included fishing net, paper mesh and liquid polymer. Water-soluble bitumen proved effective in irregular areas with large rocks or non-eroded islands.

Treated areas were assessed each summer and follow-up work undertaken as necessary. Adjustments to treatment methods were prompted by Walter Bryant's research (1971b, 1972). He sampled 7 subalpine and 8 alpine sites for soil nutrient deficiencies to formulate a fertiliser mixture for use in the stabilisation of borrow pits, roadside batters and other eroded areas. He also identified the successes and failures of plant species used to date and tested species from phytogeographically similar areas in the world. He lamented the lack of success in applying native species seed heads to treated areas.

The growing realisation that native species held the key to the ultimate repair of damaged vegetation communities was furthered by Peter Keane's (1977) study of the ecology of 14 observed colonisers in the Carruthers/Twynam rehabilitation area. His assessment of their potential for rehabilitation pointed to the future of rehabilitation in the Alps.

One important long term study recorded the changes in exotic/native species levels under differing applications of fertiliser on Mt Twynam (Rogers 1988). The SCS established 4 plots in the previously rehabilitated area and data were collected from 1976 to 1994. The study prompted follow-up maintenance plantings of natives on previously rehabilitated sites, in particular the intertussock herbs removed by stock during the grazing era. There has also been work on repairing fen and bog areas using straw bales and rock weirs to spread water and promote the recovery of wetland vegetation (Good 1992b).

The urgent need to spread water in damaged alpine and subalpine bogs was noted by many scientists (e.g. Wimbush and Costin 1983). CSIRO's Robin Clark (1986) made the same call in relation to Rotten Swamp (NNP) as part of her study into its fire history. Rotten Swamp, Creamy Flats (Little and Big) and Top Flats were all burnt in the Gudgenby Fire of 1983. Namadgi staff used sandbags and marine ply to halt stream entrenchment at Top Flats and Rotten Swamp in 1987 (Terrill 1998). Monitoring to 1991 showed good results and potential exists for the assessment of longer term results.

In Victoria Keith McDougall (2001) sampled a fire trail verge on the Bogong High Plains that was revegetated with exotic seed (and fertilised) in the late 1950s. He found that by 1999 exotic species still provided 50% of the cover, therefore calling into question the assumption that native species would replace exotic species once soil nutrient levels dropped to those found in native vegetation. The exotic grass *Agrostis capillaris* covered one third of the site and clearly did not require the presumed high nutrient levels. Furthermore *A capillaris* and several other exotics used in rehabilitation are known to invade high altitude vegetation communities. McDougall made recommendations for future rehabilitation work – that grazing and trampling be minimised, that fertiliser be excluded unless it significantly benefits natives, that invasive exotics be avoided, and that successful native colonisers (as identified from the 1950s road verge) be used.

More recent rehabilitation work in the Victorian Alps has featured the use of native species. The work has benefited from the lessons of 50+ years of grazing research, and from trials established under the leadership of Warwick Papst (Plate 7). The major trial area was established at Rocky Valley in 1993 and continues to be maintained and monitored (Plates 2 and 3). This research has taken the use of alpine natives to a new level and has been applied in Victoria and KNP. Full details of the various sites were unavailable during the preparation of this report, but can be obtained from Warwick Papst.

Rehabilitation of a different kind is occuring on the sites of two former pine plantations – Jounama in KNP (Plate 11) and Boboyan in NNP. These long-term projects (Jounama commenced 1984, Boboyan 1996) involve removal of the pines and restoration of local native vegetation. The areas involved are large – Jounama 602ha, Boboyan 380ha. Jounama is the first such project of its kind in Australia (O'Brien 1993, Spate et al 1986). It attracted early action due to its inappropriate location atop the Yarangobilly Karst and because it was a potent source of wildings spreading into the adjacent native forest.

The Boboyan Pine Plantation was inherited by NNP in 1984 one year after it (the plantation) had been extensively damaged by the Gudgenby Fire. Furthermore there was a wildling problem in adjacent forest areas. The nature and extent of the rehabilitation project at Boboyan is culturally significant. Volunteer bushcare groups have a major involvement. However the cultural significance is not (at least at this stage) related to science. The only work has been a student project (Webb 2001) on the impact of macropod browsing and a CSIRO (1998*) Landscape Framework for Ecosystem Rehabilitation* which has yet to be applied. Additionally, NNP staff monitor water quality in the rehabilitation area. There is an interesting story at Boboyan but it is not (yet) a science story. However this is a good example of a long term project that should be revisited as per RECOMMENDATION #6.

Jounama, on the other hand, has had a significant scientific component (Spate et al 1986). Permanent reference plots (some fenced to exclude grazers) were established to monitor the post-logging successional process. Seed viability trials have involved germination tests and pre-germination treatments for species with a hard seed coat. Seedling establishment experiments tested seedling survival under a range of conditions. Soil preparation experiments compared broadcast seeding with direct seeding under different surface preparations including the use of hot fire. Different sowing densities (seeds/ha) and different species mixes were trailed at different times in the logging cycle, and for various desired vegetation communities (e.g. riverine). Experimental plots were established to test mechanical methods of native seed collection. Findings include the ability of hot fire surface preparation to grow broadcast seed to a complete canopy cover in 4 years. While most of this research took place in the 1980s, the results have been applied and rehabilitation techniques have been developed with potential for use elsewhere (O’Brien 1993, Jessup 1994).

A current focus for rehabilitation in the Alps is the impact of recreational activities such as walking and horseriding – activities that boomed with increased leisure and mobility in the late 20th century. While much repair work has taken place in the absence of scientific experimentation, there have been some studies of the impact of trampling (Edwards 1977, Keane et al 1979) and of stabilisation techniques (Jacobs 1992) although none are considered as culturally significant for the purposes of this report.

3.2.3.2 Interpreting Rehabilitation

Constraints and considerations general to this theme follow.

Several sites are in the Main Range alpine area of KNP where visitors are strongly advised to stay on the walking tracks provided. Good (1992b) remarks that visitor management in the treeless alpine zone is now a key component of vegetation management in the Australian Alps. In cases where on-site access is problematic, there are potential opportunities for 'near-site' interpretation via trailhead or trackside signage, or via a brochure for a nearby walking track.

Sites that are still active, or with potential for reactivation, should only be considered for on-site interpretation where visitation can be managed in such a way as not to alter soils and vegetation which are subjects of the research.

There has been a purposeful move away from brochures at KNP in favour of signs. There are no longer brochures relating to specific walking tracks or points of interest, but rather individual signs or interpretation bays, often at trailheads or key road junctions. KNP will be reviewing interpretive signage in 2002.

The thematic statement for rehabilitation is: **Healing the Wounds: scientific rehabilitation of the Australian Alps.**

Key messages for interpretation are:

- The Main Range was not a pristine natural area at the end of the grazing era.
- Massive erosion was halted and vegetation restored by large scale decades-long heroic effort.
- The rehabilitation was supported by scientific trials and experiments.
- Today applied research is returning native species to damaged areas.
- Australia's largest pine plantation rehabilitation projects are taking place in the AANP.
- Rehabilitation is increasingly focusing on the impacts of recreation (walking, horseriding, etc) as the historical impacts (construction, mining, grazing, etc) are controlled.

Table 3 - Key Sites For Interpretation: Rehabilitation

Project/Site*	Location	Cultural Significance (as per criteria in 2.4.1)
Rocky Valley Alpine Rehabilitation Project	5275 59192 (ANP)	**1** - Papst; **4** - Identification of native species and techniques for alpine rehabilitation; **5** - Pioneering applied research into the use of native species in alpine rehaibiltation; **6** - Monitored since 1993; **7** - Reference site for alpine rehabilitation.
Twynam/Carruthers Soil Con Works	6161 59699 6168 59707 6162 59696 (KNP)	**1** - Roger Good; **2** - Alpine grazing in the Snowy Mountains. - its damage and repair; **4** - Alpine soil conservation/rehabilitation techniques; **5** - Pioneering research in alpine soil conservation /rehabilitation techniques; **6** - Monitored long term (63-74) and Roger Good continues to photo monitor these sites annually; **8** - Successful application of research over a large fragile area.
Other Rehabilitation Trial/Investigations	6169 59698 (KNP)	**1** - Walter Bryant; **4** - Alpine/subalpine soil conservation/rehabilitation techniques; **8** - Development of a fertiliser mix for alpine/subalpine rehabilitation.
Native Species Rehabilitation Investigations	Throughout Twynam / Carruthers rehab area (KNP)	**5** - First ecological assessment of the potential of native species for alpine rehabilitation.
Jounama Pine Plantation Rehabilitation	Jounama Pine Plantation (KNP)	**4** - Optimal techniques for native rehabilitation of pine plantations; **5** - Research associated with first project in Australia to rehabilitate a large pine plantation to native vegetation; **6** - Various plots monitored in the 1980s with potential for revisiting; **7** - Benchmark sites for pine plantation rehabilitation.

* see Volume 2 of this report for detailed site specifications

Rocky Valley Alpine Rehabilitation Project

This site is located in the narrow strip between the Bogong High Plains Road and the northeastern arm of Rocky Valley Dam (Plates 2 and 3). There is already a sign with some interpretation but it could be improved upon. This accessible and interesting site, well worth interpreting in its own right, can act as a central point for interpreting the various rehabilitation trials and works around the High Plains, details of which are largely unpublished but are available from Warwick Papst. A sign is vital here regardless of any other treatment, however rehabilitation should be included in any ‘Science on the Bogong High Plains’ brochure as discussed under ‘Maisie Fawcett’s Soil Conservation Plots’ (3.2.1.2).

Twynam/Carruthers Soil Con Works, Other Rehabilitation Trial/Investigations, Native Species Rehabilitation Investigations

This research centres on Mounts Carruthers and Twynam on the Main Range of the Snowy Mountains. The area is accessible via the Lakes Walk from Charlotte Pass.

While rehabilitation is covered on one quarter of one of the many interpretation panels at Charlotte Pass, the *science* of rehabilitation is not mentioned.

Rehabilitation science should be flagged on updated panels at Charlotte Pass and then interpreted fully on a sign at the old Soil Con Hut site on the Lakes Walk several hundred metres west of the Blue Lake turnoff. This site, as well as having been the base for much of the rehabilitation work, looks across to still-visible contour banks on the flank of Carruthers Spur (Plate 15). Dramatic before and after photos are held by the NSW Soil Conservation Service. Any interpretation in the Main Range area should remind people to stay on the track. Any sign must be constructed with snow load in mind (the snows of 2001 destroyed the sign at the Blue Lake lookout).

Jounama Pine Plantation Rehabilitation

The plantation area (only 75ha remain under pines in late 2001; Plate 11) stretches along the north side of the Snowy Mountains Highway directly across the road from the Yarrangobilly Village site, now a picnic and camping area but still featuring the historic Cotterill's Cottage. The existing interpretation bay at Yarrangobilly Village mentions Jounama but not in the context of science. The Tumut office of NPWS is planning to develop (over the next few years) interpretation of the historical aspects of Jounama in text and photos (Mick Pettitt, pers comm). An update of the interpretation bay at Yarrangobilly Village would provide the ideal opportunity to present the science and history of Jounama.

3.2.4 Geology and Geomorphology

This section covers geomorphology but excludes geology as per Section 2.1. The study of the geology of the Alps has a long history with the expeditions of early geologists such as the Reverend William Clarke (Mt Clarke, KNP) who was commissioned in 1851 to search for new goldfields in the Alps. In Victoria Alfred Howitt (Mt Howitt, ANP) led a prospecting party over a large part of the Victorian Alps (1860), and on his return to the Alps in 1863 spent many years trekking large distances between goldfields and expanding his knowledge of the geology. James Stirling (1880s) shared Howitt's interests in the Alps and led a geological survey into the little known part of the country west of the Mitta Mitta. All the early explorations and development of geologic knowledge were spurred on by the search for gold. By the end of the nineteenth century geologists had become interested in surface features that seemed to indicate periods of glaciation in the Alps. This research will be covered under 'Geomorphology' below.

There is a considerable body of research that looks to explain the geologic history of the Alps. It places the landscape of the Australian Alps on the same time scale as continental drift, global tectonics and biological evolution. This work is well summarised by Ollier and Wyborn (1989). Rosengren and Peterson (1989) list scientific heritage values for 35 sites in the Australian Alps, with a strong emphasis on the Victorian sites. A study of the geology of KNP is covered by Worboys (1982), and O'Sullivan et al (2000) review the geological origins of the Mt Buffalo region. (See also notes from a conversation with Neville Rosengren Appendix 4.)

This report does not assess Alps geologic research because its complexity requires assessment by a suitably qualified geologist. Such a person should be involved in further investigations as per RECOMMENDATION #2.

3.2.4.1 Overview of Geomorphology

Two different topic areas will be covered in this section. They are treated separately because they are different fields of geomorphic research, namely research into glacial and periglacial features, and research into geomorphic processes in karst.

Definitions:

- **Geomorphology** is the study of the processes that form the earth's surface.

evolved into the most detailed quantified studies of processes. The whole forms an excellent example of scientific method and of adoption of appropriate techniques" (Spate and Spate 1985).

Academically Joe Jennings was versatile (see 'Periglacial Process Studies' above) and studied a wide range of issues in geography and earth sciences, with forays into zoology, cartography, coastal studies, glacial and periglacial landscapes, historical geography and climatic change. He did not restrict himself to Australia but carried out studies in New Guinea, Malaysia, China, New Zealand, Canada and the US. "The only way to comprehend the breadth of Joe's work is to peruse his bibliography which numbers over 200 publications, with about half devoted to karst" (Spate and Spate 1985).

Another special feature of Joe Jennings the scientist was his mentoring of students and associates and his respect for amateurs – anyone with a genuine curiosity. "Most of Jennings writings are multi-authored – one of Joe's methods of bringing out his collaborators . . . for many this was the encouragement needed to start or re-start their careers".

Jennings' extensive studies of the Cooleman karst began in 1965. The sites to follow have been selected by Andy Spate (Griffiths and Robin 1994, p 42) as being of particular importance in terms of research results and their long-term research and monitoring significance.

Research at Blue Waterholes into rates of solution of limestone was based on two separate periods of data recording:

- March 1965 – April 1969. Monthly observations of the discharge regime were recorded at three sites along Cave Creek, below Blue Waterholes. Discharge, temperature, pH, and specific conductivity were recorded and water samples were collected for later chemical analysis in the laboratory.

- April 1969 – April 1977. Only one site was monitored in this period (the first site downstream of Blue Waterholes, as used in first study). Records provided 8 years data on discharge and rainfall, 7 years on evaporation and four years for temperature. Jennings and Spate encountered recording difficulties due to interference with the equipment, inaccessibility and the rigorous climate.

(Throughout this research Jennings noted the difficulty they encountered with access in winter due to snow and he thanked the RAAF who, on seven separate occasions, deflected their helicopter training flights to Cooleman to deliver the researchers to their site. In winter of 1968 they had a period of 82 days without records because of snow and the grounding of the helicopters!)

The main conclusion from this research was that the bulk of limestone solution takes place superficially, or beneath the soil and in planes of weakness close to the surface. The solution that occurs in the caves is relatively unimportant (Jennings 1972, 1983a, 1983b).

These studies were part of an international theme to determine solution rates of limestone across the full range of climatologic variation, and to determine limestone denudation rates. There is a quantitative interest in the time and space distribution of limestone solution, and Cooleman was the first time this type of research was attempted in Australia, an example of mid-latitude karst.

These karst solution process and hydrology sites are the longest such monitoring sites in Australia. “The micro solution monitoring (tablets and micro-erosion metering work) has been going on for over 25 years and there are not many places in the world where such monitoring has been done. With the same instruments you could return to the Yarrangobilly and Cooleman sites and do the same measurements in 200 years” (Andy Spate pers comm). Since changes in solution rates in limestone are affected by climate change this research may well prove to be an early indicator of such change. The monitoring program of 1965-1969 was picked up by Andy Spate in 1974, and he continues to monitor these sites every 2-3 years.

Limestone tablet experiments are used to assess rates of erosion of limestone. Tablets of limestone (approx 40x25x10mm in size) are cut, dried and then precisely weighed. They are then exposed in the field, retrieved, cleaned, dried then re-weighed. Data is then calibrated with other factors such as precipitation to assess rates of erosion.

As part of an international study by the Commission on Karst Denudation of the International Speleological Union, under Prof. I Gams, limestone tablets from one particular limestone (from Yugoslavia) are exposed in standard ways in many different parts of the world, to compare the losses suffered by the tablets under various influences. Cooleman Plain was chosen as one of the Australian sites.

Experiments to assess erosion rates using local limestone tablets have also been conducted at Cooleman and Yarrangobilly. Six sets of five tablets each were exposed. Two sets were placed under 16-18cm of soil above Murray Cave with another set being buried at the soil/rock interface under 40cm of soil. The other three sets were suspended in nylon cages in a metal frame bolted to the floor of the River Cave stream. The tablets were measured for erosion in the mid 1970s and again in the late 1970s. During the second exposure period there was considerably less precipitation, and therefore reduced erosion in the soil tablets. Lower rainfall would have also reduced plant and microbial growth, thus reducing biogenic carbon dioxide which enhances dissolving of the limestone (Jennings 1981).

The tablet method is a valuable one but needs substantial replication to yield results. These tablets remain in position and Andy Spate continues the long-term monitoring of them.

"A quite rare and remarkable set of minor landforms is found on the limestone at Cooleman, although they are entirely unrelated to solutional landforms. These are the 'A-tents' (Jennings 1978). These features have been described for granite landscapes elsewhere in the world but the Cooleman A-tents are the first described for limestone. It is assumed they are produced by unloading stresses produced when overlying compressing layers are removed. In the case of the Cooleman A-tents the off-loading of the overlying layers is by solution of limestone. The result is that the surface shell of limestone buckles up and may later crack into small sheets or flakes which are tilted up against each other, sometimes in tent-like shapes (Jennings 1971, 1978a).

In a study of a mud flow in a dry valley, Jennings looked at degradational (eroding) and aggredational (accumulating) features to discuss karst development and rejuvenation through geologic uplift and climatic change (Jennings 1973). "A colder, wetter climate is postulated as being responsible for a very low angled mudflow occupying a dry valley on the southern side of the Plain" (Jennings 1976).

The mud flow (an aggredational feature) is postulated to be the result of a cold climate phase, probably between 30,000 and 15,000 years BP. The mud flow resulted in the blockage of the caves in the dry valley and the temporary restoration of surface drainage and channel cutting. Flow of the stream gradually reduced and the stream sank again, this time further up the valley. (There is an excellent explanatory diagram in Jennings 1982, p145.)

Cooleman Plain illustrates a facet of a complex interrelationship between karst and cold climate geomorphology. How landscapes develop is often complex, and an understanding of processes that may have been active in previous times and climates influences what we see today. Such an understanding results from extensive and intensive research and can indicate directions of landscape processes that may occur with future climatic changes.

Jennings (1967) also examined three small dolines or sinkholes above Murray Cave on Cooleman Plain. At first sight they all appeared similar, and since it was thought that they probably overlay an extension of Murray Cave, Jennings attributed their origin to collapse. Later US studies showed that doline proximity to cave passages did not necessarily imply a collapse process. The simple fact that the three dolines are close to each other does not mean that they all formed by the same processes. Detailed analysis of the doline shape indicated that two of the dolines were more likely to be caused by solution and the smaller, steeper doline was likely to be a collapse doline. However, some degree of uncertainty remained with the analysis based only on morphometric analysis.

A drought in 1968 opened up a water trap in the Murray Cave and allowed access to the cave passage below the dolines. Under the two solution dolines the cave had an intact roof, which supports the solutional origin of these two dolines. At the third doline the rock roof sloped upward and ended at a tall rock pile collapse, supporting the process of collapse as the dominant process in the development of this doline. This study "illustrates the strengths and limitations of different kinds of evidence for doline origin. Whenever possible, underground evidence should be sought" (Jennings and Bao 1980).

Griffiths and Robin (1994) also refer to climate stations. Two stations were set up at Cooleman Mountain and at Peppercorn and their data were used to support the solution studies and the Blue Waterholes studies. They have been dismantled and the sites are not marked.

In 1974 Joe Jennings initiated research at Yarrangobilly into karst processes, karst hydrology and speleochronology. While Yarrangobilly and Cooleman are at similar altitudes they experience different climates and environments. Jennings replicated the Cooleman monitoring studies at several sites at Yarrangobilly (Spate and Household 1989). The data from these sites reveal different erosion rates resulting from the differing climate (Smith et al 1995, and Moses et al 1995). Andy Spate continues to monitor these sites.

3.2.4.2 Interpreting Geomorphology

Constraints and considerations general to this theme follow.

Some sites may be easily disturbed. It is important that sites which are still active should only be considered for on-site interpretation where visitation can be managed in such a way as not to interfere with the research.

Several sites are in the Main Range alpine area of KNP where visitors are strongly advised to stay on the walking tracks provided.

Some sites are distant from road or track access, and will be better interpreted at a nearby trailhead.

There has been a purposeful move away from brochures at KNP in favour of signs. There are no longer brochures relating to specific walking tracks or points of interest, but rather individual signs or interpretation bays, often at trailheads or key road junctions. KNP will be reviewing interpretive signage in 2002.

The thematic statement for geomorphology is:

Sculpted by Snow, Ice and Water: the science of geomorphology in the Australian Alps.

Key messages for interpretation are:

- The debate over the extent and influence of glaciation.
- The varied and innovative methods of dating glaciation.
- The relative importance of periglacial processes in the Australian Alps.
- Joe Jennings - his passion, and his influence.
- The international importance of the karst research at Cooleman/Yarrangobilly.
- Limestone processes alter with climatic changes and therefore offer a means to interpret past climates.
- The potential of long-term karst monitoring to indicate climatic change.
- The evolution of similar landscape features (e.g. dolines) from different processes.
- Landform processes are not necessarily what they seem (e.g. the bulk of limestone solution does not take place in caves).

Table 4 - Key Sites For Interpretation: Geomorphology

Project/Site*	Location	Cultural Significance (as per criteria in 2.4.1)
Costin's 'Glacial' Research	Dickson's Falls Ck, Tatra Valley ski area (MBNP)	**1** - Costin; **3** - The extent of glaciation in Australia; **4** - Evidence toward the now accepted conclusion that there was no glaciation in Victoria during the last glacial period in Kosciuszko.
Geological/Glaciation Research Sites	David Moraine and Guthrie Saddle near Spencers Ck picnic area (KNP)	**1** - David, Browne, and Galloway; **3** - The extent of glaciation in Australia; **4** - There were no ice sheets in the last glaciation, only cirque glaciers.
The Railway Embankment Glacial Dating Site	Muellers Pass above Lake Albina (KNP)	**1** - David; **4** - Dating of glacial activity; **5** - One of the first attempts in the world at defining a date for a glacial feature.
Cooleman Plain Karst Area Research	Cooleman Plain (KNP)	**1** - Jennings and Spate; **4** - Significant findings regarding limestone solution rates, A-tent formation, doline formation and other karst processes; **6** - Most sites monitored since 1960s, and continuing; **7** - Benchmark karst area; the most researched karst area in Australia.
Yarrangobilly Caves Karst Area Research	Yarrangobilly Caves (KNP)	**1** - Jennings and Spate; **4** - Significant findings regarding limestone solution rates, doline formation and other karst processes; **6** - Most sites monitored since 1970s, and continuing; **7** - Benchmark karst area.

* see Volume 2 of this report for detailed site specifications

Costin's 'Glacial' Research

This site is now occupied by the popular Tatra Valley ski area at Mt Buffalo (Plate 22). At the main lodge there are some outdoor panels on snow safety and, in the winter season, MBNP maintains an indoor exhibition. Here is an ideal place to interpret the Victorian glaciation controversy.

Geological/Glaciation Research Sites

The David Moraine and the Guthrie Saddle sites are visible from the Spencer's Creek Picnic Area on the Kosciuszko Road (Plate 16) – in fact the road does a sharp bend to get around the moraine. The picnic area has a sign which interprets matters of local cultural history other than science. An update of this sign would provide the opportunity for on-site interpretation of the glaciations sites as well as the Spencer's Creek snowcourse (Section 3.2.6.2).

The Railway Embankment Glacial Dating Site

This site is on the Lakes Walk near Muellers Pass above Lake Albina on the Main Range. While there are some signs around the Lakes Walk, they tend to be on the slopes or in locations below the ridgeline. This site is worthy of interpreting through signage to the many walkers who pass by, but the siting of any sign needs careful consideration so as not to be visibly intrusive from a distance, and so that it has some protection from the elements.

Cooleman Plain Karst Area Research

The research sites around the Cooleman Plain vary from robust to extremely sensitive. Some are located in the Bimberi Wilderness thus precluding any on-site signage. The obvious place for interpretation through signage is at the central visitor node – Blue Waterholes. Here Joe Jennings is commemorated in two walking tracks – the Jennings Walks (Plate 8). Here also is an interpretation bay covering karst processes but from a descriptive view rather than a scientific view. One option is to include the science on an update of these panels.

The move away from brochures at KNP includes the lapsing of the Jennings Walk brochure (Appendix 5) which is unlikely to be reproduced (Russell Knutson pers comm). This is unfortunate for this area as such a publication interprets karst features when visitors are actually standing before them. Such a publication would be able to provide a more immediate interpretation of the science by, say, directing walkers to an actual doline as part of interpreting doline research.

Yarrangobilly Caves Karst Area Research

The sites associated with this research are located in areas away from general public access, including well underground in locked caves. The Yarrangobilly Caves Visitor Centre, like the Blue Waters interpretation bay, covers karst processes descriptively rather than scientifically. The Centre is the place to interpret the Yarrangobilly research and should also make reference to Cooleman given the large audience, most of whom are unlikely to go to Cooleman.

3.2.5 Hydrology

3.2.5.1 Overview

While hydrology as an Alps science is naturally one of altitude, it is also one of attitude in its attempts to defy efforts to place it in a thematic basket of its own. In the best interconnected traditions of ecology, hydrology appears in a number of the other themes in this report. Catchment hydrology reflects catchment health so its eclectic nature is no surprise. A judgement has been made as to the strongest or defining feature of each piece of Alps research. So for instance the hydrological research associated with the Bushranger's Catchment 'experimental wildfire' is discussed under the 'Fire' theme due to the uniqueness of that particular fire. Having said that, it also appears in Table 5 associated with 'Hydrology'. The 'finished' interpretation for sites like this may have to appear under more than one thematic banner. This of course will also apply to sites such as Hotel Kosciuszko where completely different studies relating to different themes took place on the same site.

Missing from this theme are the majority of the stream gauging stations installed by water and power authorities all over the Australian Alps as they are considered to relate to engineering science which is excluded from this report as per Section 2.1. The SMA alone had 122 hydrometric stations in operation in 1958. Indeed there are few if any alpine regions in the world that have such an extensive array of hydrologic and meteorologic data available as the Snowy Mountains (Brown and Millner 1989). Nonetheless some hydrometric stations are included under this and other themes where data were collected for purposes of culturally significant studies.

In the late 1950s Costin, Wimbush and associates conducted a series of studies in catchment hydrology covering surface run-off and soil loss (Costin et al 1960); snow investigations (Costin et al 1961); interception by trees of rain, cloud and fog (Costin and Wimbush 1961); and soil moisture characteristics and evapotranspiration (Costin et al 1963). The findings relating to surface run-off and snow are particularly significant.

The 12 sites from Sawpit Creek (forest) to Carruthers Peak (alpine) in KNP measuring soil loss and surface run-off revealed the high conservation and hydrological value of vegetation communities with a dense continuous ground cover. The researchers pointed to the need for management practices which encouraged succession from the widespread depleted and regrowth conditions of the time, towards more natural vegetation communities. They also indicated that catchment management should be geared to meet stress periods rather than just average conditions. This research supported the need for rehabilitation of damaged vegetation communities.

The snow surveys in the Rennix Gap/Hotel Kosciusko subalpine area confirmed the importance of tree cover in relation to the accumulation and persistence of snow. Snow accumulation under fire killed snowgums was only half that under living ones and the snow cover melted much earlier resulting in winter-killed ground vegetation, reduced soil infiltration, increased soil erosion, and losses in value for hydroelectricity. The presence of trees delayed snowmelt especially in a woodland with numerous small clearings over which turbulence produces greater fall-out of snow – the ideal condition being a mature snowgum woodland.

This research is yet another argument for allowing vegetation communities to reach a steady climax state. It showed that snowgum woodland in this condition will supply longer slower snowmelt to water storages with fewer losses to over-spillage and less erosive force on streamlines.

In 1959 Wimbush and Costin (1983) selected six small subalpine catchments in Kosciuszko where streams were cutting into their banks due to the removal of water-spreading bog vegetation by grazing stock and associated burning-off. These damaging influences had only recently been removed. The research continued for 20 years recording a widening of stream profiles in the larger streams despite recovery of bog vegetation in the head gullies. These 'hydro-ecological' ruts showed no sign of stability after 20 years and may be self-perpetuating for a long time.

This study quantifies yet another significant impact of grazing and burning – and a long term one at that. The continuing story would be of great interest but the marker pegs cannot be relocated for some of the sites. This demonstrates the need to conserve the potential of significant scientific sites – a message reinforced by the *Science in High Places* report (Clarke 1998, Papst 1998, Terrill 1998).

JAH Brown (1972) recorded the hydrological impact of the severe bushfire of March 1965 that burnt a large area of northern Kosciuszko. Hydrometric stations had been in place since 1952 in the Yarrangobilly River and Wallaces Creek near Ravine (Plate 12). Significant areas of these two catchments were denuded of vegetation and topsoil. Brown recorded massive initial increases in sediment loads due to a thousand-fold increase in the rate of soil erosion (Good 1992b). Discharge rates were very high despite low rainfall immediately post-fire and it took five years for hydrological function to return to its pre-fire level.

Good (1973) also recorded increased discharge rates and sediment loads in the catchments of the Geehi and Swampy Plains Rivers as a result of the severe Grey Mare Fire in the summer of 1972-73.

The 1983 Gudgenby Fire in NNP together with the network of stream gauging stations operated by (the then) ACT Water provided the raw material for an interesting piece of research (Kulik and Daniell 1988). The researchers identified critical minimum runoff rates which could act as predictors of fire – more reliable predictors than fickle weather conditions. Their 'hydroforecast of the critical fire danger' has been used by ACT bushfire authorities since the 1980s. The research and its application are pioneering on a national scale (Rick McRae, pers comm).

In Victoria Ruth Lawrence (1992, 1995, 1999a, 2001) studied the effect of different land uses and natural phenomena (grazing, insect attack, bushfire, hydroelectricity development, downhill ski development, mining) on the hydrology of the Bogong High Plains. She made use of data from 12 stream gauges installed by the SEC and monitored from as early as 1925 to as late as 1995. In one of the catchments (Watchbed Creek) the main pressure was grazing. Lawrence attributed decreasing runoff since the 1940s to declining grazing pressure over that period. In other words she demonstrated a positive relationship between large cattle numbers and high runoff values. As we know from other research (e.g. Wimbush and Costin 1983) the critical factor is the damage to vegetation and soil caused by grazing.

During the very years Watchbed Creek runoff was decreasing, Lawrence found a significant increase in runoff from the Pretty Valley Creek (Plate 1) and Rocky Valley Creek Catchments. These two catchments were disturbed by the construction of the Kiewa Hydro-electric Scheme from the late 1930s to the early 1960s. Heavy earthmoving was involved in the construction of 100km of roads, work sites, reservoirs, aqueducts and quarries (Lawrence 1999b). Lawrence was able to demonstrate that this sort of gross impact (caused to a lesser extent by mining and ski development) has the potential to permanently alter hydrological function, whereas recovery is the norm in the case of bushfires (even 1939), incidents such as the 1948-52 Cope Creek Catchment swiftmoth plague, and reduction or removal of cattle. Regarding fire, this accords with findings from Kosciuszko (Brown 1972) and the ACT (O'Loughlin et al 1982) discussed in Section 3.2.2.1.

Lawrence concludes from her studies that given the Australian Alps are so important for water production on a national scale we should learn from inappropriate land management of the past and pursue only strategies that will produce hydrological sustainability today.

If streams can serve as a barometer of catchment health by virtue of their flow characteristics, they can also do so by virtue of their biota. In 2001 the CRC for Freshwater Ecology used the Australian Rivers Assessment Tool (AUSRIVAS) to gather baseline data from 79 reference sites throughout the Australian Alps (Anon 2000). This enabled the formulation of a model to predict the number and type of macroinvertibrate species likely to be found in an undisturbed aquatic ecosystem. The model can then be used to identify disturbed areas, with great potential as an 'early warning tool'. As with the Alps fire monitoring plots, this systematic work is culturally important in terms of the great long-term potential for significant findings and as a 'performance indicator' of park management.

3.2.5.2 Interpreting Hydrology

Constraints and considerations general to this theme follow.

Several sites are in the Main Range alpine area of KNP where visitors are strongly advised to stay on the walking tracks provided. Good (1992b) remarks that visitor management in the treeless alpine zone is now a key component of vegetation management in the Australian Alps. In cases where on-site access is problematic, there are potential opportunities for 'near-site' interpretation via trailhead or trackside signage, or via a brochure for a nearby walking track.

Many of the hydrology 'sites' are stream gauging stations or, looking at it another way, the 'sites' are entire catchments. Where a station is close to an existing node of visitor activity, interpretation might proceed along the lines of: "Information from this station proved that . . ." Otherwise relevant points in the affected catchment could host messages such as: "Stream gauges downstream from here show that xyz activity in this area caused . . ."

There has been a purposeful move away from brochures at KNP in favour of signs. There are no longer brochures relating to specific walking tracks or points of interest, but rather individual signs or interpretation bays, often at trailheads or key road junctions. KNP will be reviewing interpretive signage in 2002.

The thematic statement for hydrology is: **Healthy Mountains Go With The Flow: the science of hydrology in the Australian Alps.**

Key messages for interpretation are:

- Catchment hydrology reflects catchment health by revealing the impact of major land uses and natural phenomena.
- Research shows that a dense continuous cover of ground vegetation is required for hydrological sustainability.
- Mature snowgum woodland is the hydrological ideal in accumulating snow and delaying snowmelt.
- Damage to wetlands causes stream entrenchment and erosive impact on stream banks lasting well beyond the cessation of the damage mechanism.
- Hydrological research supports the maintenance and protection of conservation values and the need for restoration of those values (rehabilitation) where damage has occurred.
- Major wildfire and other high-impact natural phenomena like insect plagues have a short but dramatic impact on catchment hydrology.
- Land uses involving heavy earthmoving (hydro-electricity construction, mining, downhill ski development) have the potential to permanently alter hydrological function.
- Grazing of domestic stock, if uncontrolled, is capable of catchment-scale damage although a slow recovery of hydrological function is possible after grazing pressure is removed.
- Hydrological studies are capable of corroborating the findings of small-scale experimental research within catchments.

Table 5 – Key Sites For Interpretation: Hydrology

Project/Site*	Location	Cultural Significance (as per criteria in 2.4.1)
Hydrological Research by Ruth Lawrence	All catchments, Bogong High Plains (ANP)	**4 –** Demonstrated relative impact of various land uses and natural phenomena on BHP catchments including permanent impact of hydro-electricity construction works, and positive relationship between grazing pressure and runoff.
Costin and Wimbush Catchment Hydrology Research	Hotel Kosciusko area (KNP)	**1** – Costin and Wimbush; **2 –** The evolution of national park management toward the protection of catchment values; **4 –** The importance of continuous natural ground cover for conservation and hydrological values; the need for catchment management to gear for stress periods rather than just average conditions; the importance of mature snowgum woodland to the accumulation and persistence of snow.
Hydrological Impact of Fire at Yarrangobilly	Junction of Yarrangobill y R and Wallaces Ck (KNP)	**4** – Massive initial post-fire increases in sediment loads due to a thousand-fold increase in the rate of soil erosion.
Cotter Catchment Hydrology Studies	Bushrangers Ck Catchment (NNP)	**1** – Phil Cheney; **3 –** Controversy has surrounded this study's use of large-scale high-intensity fire for research; **4** – The Bushrangers 'experimental wildfire' dramatically demonstrated the tight relationship between evapotranspiration and streamflow; **5** – The only experimental large-scale high-intensity burn undertaken in the AANP.

* see Volume 2 of this report for detailed site specifications

Hydrological Research By Ruth Lawrence

Pretty Valley Dam offers an excellent 'on-site' location for interpreting this extensive research. The view north/northwest from the picnic area at the causeway takes in quarries, roads and other disturbed areas associated with construction of the Kiewa Hydro-electric Scheme – the major impact on BHP hydrology as identified by this research (Plate 1). The research covered a much greater area of the BHP and as such is yet another candidate for inclusion in a 'Science on the Bogong High Plains' brochure as discussed under 'Maisie Fawcett's Soil Conservation Plots' (3.2.1.2).

Costin and Wimbush Catchment Hydrology Research

This research did not leave permanent markers on the ground. It took place at about a dozen sites along the Kosciuszko Road corridor from Sawpit Creek to Charlotte Pass and also at one site on Carruthers Peak. The snow survey research is particularly interesting. Four of its 5 sites are in the Hotel Kosciusko area, one of them being in the Water Reserve about 500m east of Rainbow Lake.

One possibility for interpretation is a new sign (there is none at present) at the small picnic area across the pond from the Hotel Kosciusko. Another is to piggyback on the signage for the grazing sites at Rainbow Lake as discussed at 3.2.1.2 (Plate 14).

Hydrological Impact of Fire at Yarrangobilly

This key site relates to both 'Hydrology' and 'Fire'. Its interpretation is discussed under 'Fire' at 3.2.2.2.

Cotter Catchment Hydrology Studies

This key site relates to both 'Hydrology' and 'Fire'. Its interpretation is discussed under 'Fire' at 3.2.2.2.

3.2.6 Meteorology and Climate Change

3.2.6.1 Overview

The Alps climate is unique in the context of Australia. It has attracted the scientific attention of the Bureau of Meteorology, water development authorities, and research organisations. The SMA alone has operated 309 stations measuring everything from thunderstorm activity to hours of sunshine. There are few if any alpine regions in the world that have such an extensive array of meteorologic data available (Brown and Millner 1989).

Snow is a defining feature of the Australian Alps and it has been well studied. The longest records for snow cover are those collected by the SEC in Victoria. The longest and most reliable snow depth record in Victoria dates from 1935 at the SEC's Rocky Valley snowcourse (Plate 4). The longest and most reliable such record in Kosciuszko dates from 1953 at the SMA's Spencer's Creek snowcourse (Osborne et al 1998). (Spencer's Creek data features in the popular annual snowcharts marketed from outlets around the Snowy Mountains – see example in Appendix 5.) Data from these and many other meteorological sites around the Alps have supported a bewildering array of studies including those specific to climate and those that introduce other research with a discussion of the climate experienced at the site(s) in question. It can almost be said that meteorological data supports every piece of research conducted in the Alps.

One interesting study (Slatyer et al 1985) used the snow gauging network (including stations operated by the Thredbo ski resort) to calculate the mean extent and duration of snow, concluding that the area covered by snow each winter in Switzerland was far greater than that on the mainland of Australia. They found that Switzerland has a 41 times greater area of 90-day duration snow cover, and a 167 times greater area of 120-day duration snow cover. These findings refuted the long held view in popular folklore (not to mention tourism promotions) that Australia had more snow that Switzerland. The analysis also yielded an estimate for the theoretical elevation at which there would be permanent snow in the Snowy Mountains – namely 2740-2800m or some 500+m higher than the summit of Mt Kosciuszko.

One meteorological story that needs no embellishment is that of Clement Wragge's weather station in the coldest and windiest place in Australia – the summit of Mount Kosciuszko. Wragge and his team established this station in 1897 with the backing of an international meteorological conference held the year before in Paris. The tent used to house the men for the first season was carried away in a storm. An 8x3m weatherboard hut was built with a fixed rope from its door to the instruments. Four-hourly observations continued through all weathers including blizzards. One man was overtaken by 'snow-sleep' (hypothermia) and nearly lost his life (Green 1999).

The observatory was widely reported in the press and attracted the first tourist trips to the summit, organised on horseback by local graziers. The observatory only operated for a few years before funding was withdrawn. While some data has been lost, the 1898 data stands as an early and unique benchmark for this most inhospitable of locations.

Today, an emerging research priority is climate change. It is the subject of some pioneering research.

Peter Whetton (Whetton et al 1996, Whetton 1998) modelled snow cover (yet again using data collected from Alps weather stations as a starting point) as it would be in 2030 and 2070 under projected greenhouse-induced mean temperature rises (best case +0.3^{o}C and worst case +1.3^{o}C for 2030; best case +0.6^{o}C and worst case +3.4^{o}C for 2070). The results are dramatic, particularly for 2070 and particularly for the worst case scenario which would see the virtual disappearance of snow from the Australian Alps. The potential impacts on ecosystems, hydrology, water/power schemes and tourism are enormous. This research can be seen as a wake-up call to Australians and their governments to act on greenhouse emissions.

A similarly pioneering study (Brereton et al 1995) looked at the effect of climate change (including mean temperature rises of 1^{o}C to 3^{o}C and various rainfall regimes) on the bioclimates (potential habitable ranges) of 42 animal species in southeastern Australia. The climate change impact on each species was derived from 19 climate parameters and from species distribution data that were modelled to predict bioclimatic ranges under present and enhanced greenhouse climate. One of the most severely effected species was the Mountain Pygmy-possum whose bioclimate vanished under a mere 1^{o}C temperature rise. This was the first study in Australia to assess animal species distribution in the context of climate change.

An innovative investigation into the impact of atmospheric ozone depletion was undertaken by Sara Broomhall (1998) at three elevations (1380m, 1600m and 1930m) in the Thredbo Valley. Broomhall raised tadpoles of several species in the open and under Ultraviolet-B radiation shields at each site. The results were most pronounced at the highest altitude where virtually all unprotected embryos and tadpoles died within two weeks (Hunter et al 1997). This suggests that ozone depletion is implicated in the decline of alpine frogs, particularly the severe decline of the Alpine Tree Frog which has disappeared from areas above 1500m. As a high elevation, mid-to-high latitude part of the Southern Hemisphere, the Alps are vulnerable to enhanced UV-B radiation. This study is a warning that frogs could be an early indicator of more widespread impacts on fauna and flora.

A joint research report between the CRC for Sustainable Tourism and the Australian Institute of Alpine Studies is currently being finalised and will have relevance to this theme. It is titled *Climate Change and the Plant Communities of the Kosciuszko Alpine Zone in the Australian Alps* by C Pickering and T Armstrong.

In 2001 the Applied Ecology Research Group (University of Canberra) in conjunction with the Australian Institute of Alpine Studies and NSW NPWS established the only permanent UV-B monitoring installations in Australia outside of a capital city (Osborne and Green 1999). The pyranometers at Berriedale and Perisher Valley will allow for a better understanding of seasonal trends in ultraviolet radiation, and will resolve questions such as the influence of cloud cover on UV-B penetration to ground level. As with the Alps fire monitoring plots, this work is culturally important in terms of the great long-term potential for significant findings.

Recent research (Wearne and Morgan 2001, Dredge 2001) has attributed a large advance of the treeline onto frost hollow grasslands in the Mt Hotham area to global warming. This research and its interpretation is discussed together with other treeline research in section 3.2.9.

3.2.6.2 Interpreting Meteorology and Climate Change

Constraints and considerations general to this theme follow.

On-site interpretation where active recording instruments are in place (e.g. Perisher Valley UV-B Radiation Station) should be avoided unless the installation is well protected.

There has been a purposeful move away from brochures at KNP in favour of signs. There are no longer brochures relating to specific walking tracks or points of interest, but rather individual signs or interpretation bays, often at trailheads or key road junctions. KNP will be reviewing interpretive signage in 2002.

The thematic statement for meteorology and climate change is: **Australia's Early Warning System: meteorology and climate change in the Australian Alps**

Key messages for interpretation are:

- Few if any alpine regions in the world have such an extensive array of meteorologic data available.
- Meteorological data supports virtually every piece of research conducted in the Australian Alps.
- Early meteorological records are the product of hard work and hardship,
- Greenhouse-induced climate change has the potential to greatly reduce snow cover in the Alps with consequent impacts on ecosystems, hydrology, water/power schemes and tourism.
- UV-B radiation fuelled by atmospheric ozone depletion already exhibits negative ecosystem impacts.
- The Alps may prove to be an Australian early warning system with regard to climate change and ultraviolet radiation.

Table 6 – Key Sites For Interpretation: Meteorology and Climate Change

Project/Site*	**Location**	**Cultural Significance (as per criteria in 2.4.1)**
Rocky Valley Snowcourse	5267 59172 (ANP)	**4** – Rocky Valley snowcourse important to a wide range of research; **6** – Snowcourse data since 1935 – longest and most reliable snow cover record in the Alps.
Mt Hotham Treeline Research	JB Plain (ANP)	**4** - Significant movement of treeline in past 25 years may indicate the impact of global warming.
Clement Wragge's Weather Observatory	Mt Kosciuszko summit (KNP)	**1** – Clement Wragge; **5** – Pioneering high altitude meteorological work; **7** – Benchmark meteorological data for the Kosciuszko Main Range; **8** – Round-the-clock observations in extreme conditions.
Spencers Creek Weather Station	6207 60678 snowcourse (KNP)	**4** – Spencer's Creek snowcourse important to a wide range of research; **6** – Snowcourse data since 1953.
UV-B Radiation Station	Perisher Valley (KNP)	**3** – Climate change impacts; **6** – Long term monitoring with very high potential.
UV-B Radiation and Frogs	Thredbo Valley (KNP)	**3** – Climate change impacts; causes of frog population declines; **4** – Severe mortality in frog embyos/tadpoles without UV-B protection.

* see Volume 2 of this report for detailed site specifications

Rocky Valley Snowcourse

This site cuts across the Bogong High Plains Road within several hundred metres of the Rocky Valley Plots (3.2.1.2). Options for interpretation include an on-site roadside sign or inclusion in a brochure as discussed under ‘Maisie Fawcett’s Soil Conservation Plots’ (3.2.1.2).

Mt Hotham Treeline Research

An accessible key site associated with this research is at JB Plain near Mt Hotham. Its interpretation is discussed under ‘Treelines’ at 3.2.9.2.

Clement Wragge’s Weather Observatory

There is currently no on-site or near-site interpretation for this site. Options for signs include the Summit Walk trailhead at the top of the Thredbo chairlift, Rawsons Pass at the foot of the final climb, or the Mt Kosciuszko summit itself. Many people prefer a significant summit (and Mt Kosciuszko is surely that) to be uncluttered by signs and other structures. The better option is to flag the site on updates of the existing panels at the top of the chairlift, and to provide a fuller treatment at Rawsons Pass. It may be inappropriate for new signage at Rawsons Pass to deal with this site alone or even with a collection of the high altitude scientific sites alone. Rather science could be included as part of a broader presentation of the natural and cultural features of the summit area.

Spencers Creek Weather Station

Located on the western bank of Spencers Creek just north of the Kosciuszko Road this early weather station once boasted a hut that featured in the Clement Wragge story (3.2.6.1). Scientifically significant is the snowcourse on the nearby flank of Guthrie Ridge. The picnic area between the road and the creek has views across to the ridge. There is a sign which covers some aspects of local cultural heritage but nothing relating to the nearby scientific sites. An updated sign would provide the opportunity to interpret the snowcourse as well as the glaciation sites at David Moraine and Guthrie Saddle (see 3.2.4.2; Plate 16).

UV-B Radiation Station

The pyranometer at Perisher Valley presents an opportunity to interpret research relating to the impact of UV-B radiation (which should mention projects/sites located elsewhere such the frog research in the Thredbo Valley discussed immediately below. This could be done at the installation itself, or perhaps more appropriately at the NPWS Visitor Centre at Perisher.

UV-B Radiation and Frogs

NPWS has an interpretation bay in Thredbo Village. They are planning on rationalising the various different signs into a more cohesive display. This presents an opportunity to include the science relating to UV-B impact on frogs where it will be seen by many people. It should also be referred to on any sign at Perisher relating to the UV-B Radiation Station (see above).

3.2.7 Paleoecology

The science of palaeoecology (the study of the ecological relationships which prevailed among fossil plants and animals) is excluded from this report as per Section 2.1. Studies in this field that may be culturally significant need to be nominated for consideration by scientists familiar with the relevant research and the criteria developed to determine cultural significance.

Starting points for investigating culturally significant sites/projects are Kershaw et al (1989), Ride et al (1989), Barlow (1986), Hope et al (1984), Hope (1989) and Williams (1982). See also Volume 2 of this report for palaeoecology studies listed in the Australian Alps Scientific Sites database.

3.2.8 Native Fauna

A full investigation of culturally significant scientific research covering native fauna has not been carried out (as per Section 2.1) due to the short timeframe of the current project. This field of research includes studies on native mammals, birds, reptiles, frogs, fish, and invertebrates. Studies in these fields that may be culturally significant need to be nominated for consideration by scientists familiar with the relevant bodies of research and the criteria developed to determine cultural significance.

Starting points for investigating culturally significant sites/projects are:

- Green and Osborne's (1994) comprehensive guide to alpine fauna – *Wildlife of the Australian Snow-Country*.
- Endangered and Threatened Species Recovery Plans (NSW NPWS), Action Plans (Environment ACT), and Flora and Fauna Guarantee Action Statements (DNRE Victoria).
- Reports to the Australian Alps Liaison Committee on vulnerable, threatened or endangered species (eg. Spotted-tailed Quoll, Brush-tailed Rock Wallaby, Smoky Mouse).

Initial investigations were commenced and the following four topic areas were reviewed:

a) small mammal research,
b) frog research,
c) entomology, and
d) ornithology.

These topics are included here as a start on this broad field of research because of the cultural significance of the research and sites, and the important stories associated with them. These topics have not been comprehensively assessed across all the research that may have been done in these fields.

3.2.8.1 Overview

a) Small Mammals

The small mammal community of the Australian Alps is different to anywhere else in Australia and does not have a high diversity. The seven species are indigenous to Australia and two of them are endemic to the mountains. (Agile Antechinus – *Antechinus agilis,* Dusky Antechinus – *Antechinus swainsonii*, Mountain Pygmy-possum – *Burramys parvus*, Bush Rat – *Rattus fuscipes*, Broad-toothed Rat – *Mastacomys fuscus,* Smoky Mouse – *Pseudomys fumeus* and Water Rat – *Hydromys chrysogaster*).

The following two research sites have been selected as culturally significant scientific sites. There may be other small mammal research sites in the Alps that are of cultural significance.

- Mountain Pygmy Possum (*Burramys parvus)* and the Tunnel of Love

The Mountain Pygmy Possum was first discovered as a Pleistocene fossil in the Wombeyan Caves in 1894. It was not discovered as a living species until 1966 when a live animal was found in the University Ski Club lodge at Mt Hotham in the Victorian Alps. Since then extensive research has been undertaken to identify its distribution (discovered in KNP in 1970), examine its habitat and understand its ecology (Broome and Mansergh 1989).

The Mountain Pygmy Possum is the only endemic mammal in the Alps (i.e. it lives nowhere else) and appears to have adapted to survive in the cold climate of the alpine and sub-alpine regions. It has a unique ability (among alpine and sub-alpine small mammal fauna) to store fat under its skin and to undergo extensive periods of torpor (a light aestivation from which the animals arouse themselves several times) during the winter. It lives in rocky areas of boulder streams and screes associated with the Mountain Plum Pine (*Podocarpus lawrencei*, an important dietary component along with Bogong Moths). The shrub cover and the spaces between the boulders provide a protected, cool environment during summer and a substantial under snow living space in winter.

The Mount Hotham area (Mt Higginbotham-Mt Loch) contains the highest density and largest contiguous population of *Burramys* known, and trapping sites have been monitored annually since 1979. Habitat fragmentation resulted from construction of a road at Mt Higginbotham. This prevented adult males leaving the upper slopes after breeding, and juveniles did not disperse after independence, thus affecting the population structure. To enable the animals to continue breeding with less disruption a tunnel (the 'Tunnel of Love') was constructed under the road in 1986. Designed by Ian Mansergh and David Scotts, the tunnel floor was rock covered to imitate the pygmy-possums' natural habitat. This was an innovative and successful piece of environmental design based on detailed scientific research into the social organisation and breeding habits of the Mountain Pygmy Possum. The tunnel also successfully reconciled a conflict between conservation and skiing interests (Mansergh 1988).

In KNP two of the major habitats occur in ski resort areas (Charlotte Pass and Blue Cow). Radio tracking of *Burramys* in summer showed that they move between boulder areas using dense shrub cover, never venturing out onto grasslands. A ski slope development at Blue Cow meant that two important habitats were separated by a ski run. Following on from the success of the 'Tunnel of Love' possum crossings (consisting of boulder-filled culverts) were constructed across the ski slope.

Research and monitoring continue in both Victorian and NSW sites. *Burramys parvus* is listed as an endangered species and, as such, a recovery plan for its long-term management has been developed (Broome 1995). A study by Brereton *et al* (1995) reveals *Burramys'* perilous status in the face of climate change (see Section 3.2.6.1).

- Smiggin Holes Small Mammal Research Site

D Happold established this site in 1978, to study 3 species of small mammals: Dusky Antechinus (*Antechinus swainsonii)*, Bush Rat (*Rattus fuscipes)*, and Broad-toothed Rat (*Mastacomys fuscus)*. Along with colleagues from ANU Botany and Zoology Happold trapped and monitored these species from 1978 to 1996 and Ken Green (KNP) has continued the monitoring since 1997.

The emphasis of these studies has been on community ecology (rather than just a particular species), and it has been possible to illustrate the range of characteristics which have evolved in sympatric species in response to alpine conditions. There are very few long-term studies of small mammals in the world and most do not give basic information for understanding diversity in alpine communities and the ways in which mammals respond to seasonal and annual changes in the environment.

b) Frogs

Alps frog research sites are culturally significant under point 6 of the assessment criteria developed for this project – that is they are culturally significant as long term monitoring sites, both for the information that they have already produced, and that which will evolve in the future. This research is very important because of the disappearance or drastic reduction of some frog species.

Frogs are among the most sensitive vertebrates to changes in their environment, and have been referred to as the equivalent of the miner's canary. There has been growing concern in many countries about declines and extinctions of amphibians. Severe declines have been reported for populations of frogs in eastern Australia, with many of the reported declines being from high altitude areas.

Osborne reported that the swamp frogs (*Litoria aurea* and *L* sp. Affin. *Castenea*) and the Brown Toadlet (*Pseudophtyne bibroni*) have disappeared from the Southern Tablelands of NSW and ACT. At higher altitudes the Corroboree Frog (*Pseudophryne corroboree*) has suffered population decline and partial contraction of its range (Osborne 1989) and the decline may be continuing. The Baw Baw frog (*Philoria frosti*) has undergone a significant decline – from 10 to 15 thousand individuals in 1985 to less than 100 individuals recorded in surveys in 1993 and 1994! The endangered Spotted Tree Frog (*Litoria spenceri*), a species associated with mountain streams, has also declined significantly (Hunter et al 1997).

A number of factors may predispose frogs in the Australian Alps to population decline. The area is subject to a wide range of human impacts, including ski resort development, hydrological modifications for electricity generation and water supply, timber harvesting, grazing and a wide range of recreational activities. While many of these activities may be relatively localised, they are generating increasing pressure on important frog habitats. Concerns about climate change have particular significance for the conservation of cool-adapted frog species in the Alps. The present contraction in the range of species such as the Corroboree Frog and the Spotted Tree Frog may herald the early stages of a loss of biodiversity in alpine areas (Gillespie et al 1995).

An intensive long term monitoring program has been put in place to monitor the populations of Corroboree frogs (*Pseudophryne corroboree* and *pengilleyi*) in both KNP and NNP.

The Alpine tree frog (*Litoria verreauxii alpina*) was re-surveyed in 1996-97 (Hunter et al 1997). This research revealed that there had been a drastic reduction of Alpine Tree Frog numbers. All Alpine Tree Frog populations in high elevation sites (above 1500m) had disappeared and there seemed to be a clear inference that change in UV-B radiation was responsible (Hunter et al 1997). A replicated and controlled pilot study in the Thredbo Valley examined the effect of different levels of UVB on the survival of Alpine Tree Frog and Common Eastern Froglet tadpoles and embryos. The study revealed the Alpine Tree Frog experienced significantly greater deaths with increased exposure to UVB (Broomhall 1997). Research on this aspect of climate change continues, and has important implications for the Alps bioregion (see Section 3.2.6).

The sensitivity of frogs to environmental change means that recent research may quickly become both scientifically and culturally significant.

Murray Littlejohn, a specialist in frogs, supervised and collaborated in significant alpine research since his first trip to the Bentley Plains in 1961. His principle alpine work has focused on hybridisation as a function of altitude – hybrid zones are of particular importance in research, and Littlejohn's principle conservation concern is for the preservation of sites in hybrid zones. Greame Gillespie is currently building on this work. Littlejohn's study of the Baw Baw frog is considered culturally significant but the study site has been demolished by ski village construction, and the site is not included in the AANP.

c) Insects

There has been a relatively large body of research into insects in the Alps. In the 1940s the Linnaean Society of NSW found 40 different insect families representing 77 species above 1700m in the Snowy Mountains. By the 1990s that list had increased to 175 families and 979 species, but remains "far from complete" (Green and Osborne 1994). The importance of insects in the ecology of the Alps cannot be overemphasised – their effect as pollinators, as grazers and as a food source for other animals are just a few of their impacts. This field of research has not been assessed for its cultural heritage significance (see section 2.1). However the following research is culturally significant, and forms the basis for ongoing research in this field.

Early in the history of European settlement in Australia popular accounts of the immense aggregations of Bogong Moths were recorded. In 1867 the moths invaded Sydney in such vast numbers that they constituted a public nuisance. Helms (1893) observed Bogong Moths in the Snowy Mountains and amplified earlier accounts of Aboriginal feasts. With the discovery of the Mountain Pygmy Possum (*Burramys parvus*) in 1966, investigations of its biology revealed that Bogong Moths form a significant component of their diet. They also form part of the diet Little Ravens, Currawongs, Owls and other birds, as well as bats, bush rats and foxes.

The research conducted by Dr Ian Common on Bogong Moths (*Agrotis infusa*) is a good example of an insect study that has cultural heritage value (Common 1954). For three summers (1951-1954) Common made observations on the ecology and behaviour of the Bogong Moth. His study site was at Mt Gingera in NNP and is representative of the granite tors and rock screes in which the moths aestivate across the Alps. This site at Mt

Gingera continues to be being monitored occasionally by Dr Ken Green (KNP) and is used by other researchers.

The Bogong Moth research story has recently taken a new turn. Monitoring of the ecology of the Mountain Pygmy Possum has included monitoring Bogong Moths at key sites within possum habitats in KNP. Recent analysis has indicated that some moths have sublethal levels of arsenic accumulated within their bodies. When they gather in large numbers to aestivate, the arsenic concentrates at specific locations and can reach lethal levels for surrounding vegetation once rain washes the arsenic out of the rock crevices. The potential implications for species such as the Mountain Pygmy Possum, for whom moths form an important dietary component, are drastic (Green et al 2001). While this research is not necessarily culturally significant at this stage it may attain that status in the near future. It demonstrates the importance of monitoring, and is important in demonstrating the need for continuity in scientific research.

d) Birds

While there is a solid body of research on birds in the Australian Alps region (see Green and Osborne 1994, chapter 5) this report has not fully assessed the research for cultural significance as per section 2.1. The following site however has been assessed as culturally significant, and is worthy of interpretation.

- The Brindabella Bird Banding Site

This site is on the New Chums Road in NNP. In 1961 25 mist net sites were established, and mist netting and bird banding commenced. This probably represents the earliest use of this trapping technique in Australia. The study site resulted in capture histories of 10,000 individuals of 20 species of passerines.

It is the longest continuously monitored banding site in Australia. Sampling on a monthly basis continued from April 1961 until June 1982 and has continued on a less regular basis since then (Tidemann et al 1988, Terrill 1998). The initial motivator for this work was Steve Wilson, who involved many other people in the earlier years. His early helpers included many school children, some of whom went on to be recognised ornithologists in their own right - a tribute to his enthusiasm.

3.2.8.2 Interpreting Native Fauna

Constraints and considerations general to this theme follow.

Protection of fauna research sites, especially those relating to endangered or threatened species, is such a critical issue that some scientists no longer put site details onto publicly accessible databases such as the Alps Scientific Sites Database, let alone encourage on-site visits (Ken Green pers comm).

The Mt Gingera Bogong Moth site is in the Bimberi Wilderness Area, thus precluding any on-site signage.

There has been a purposeful move away from brochures at KNP in favour of signs. There are no longer brochures relating to specific walking tracks or points of interest, but rather individual signs or interpretation bays, often at trailheads or key road junctions. KNP will be reviewing interpretive signage in 2002.

The diversity of native fauna in the Alps makes it difficult to formulate a meaningful and cogent overall thematic statement. Themes relating to endangered status or climate change threats relate to some but not all species. The common thread is the search for ecological understanding – not a strong thematic banner to fly for interpretive purposes. It may be better to come down to the species level in formulating thematic statements. Frog research could go out under an ‘Alpine Canary’ banner in recognition of frogs’ role in the early warning of climate change. ‘We’re all going on a summer holiday’ could apply to Bogong Moths, and of course the ‘Tunnel of Love’ idea is already well known for *Burramys*.

Key messages for interpretation are:

- Small mammals in the Alps have unique adaptations to the extreme conditions, for example the form of aestivation undertaken by *Burramys* – unique in Australia.
- Some frog and small mammal species appear to be threatened by climate change.
- Scientists have employed creative design to facilitate movement of *Burramys* in developed areas, to test the sensitivity of frogs to UV-B radiation, and in introducing the mist net bird-trapping technique to Australia.
- Nationally and internationally significant long-term research includes the small mammal community ecology work at Smiggin Holes (one of the few long term studies of its type in the world), and the Brindabella Bird Banding Project (the longest continuously monitored banding site in Australia).
- Several of the long term sites are teaching sites where new generations of scientists have been trained.

Table 7 – Key Sites For Interpretation: Native Fauna

Project/Site*	Location	Cultural Significance (as per criteria in 2.4.1)
***Burramys* Monitoring Sites**	Mt Higginbotham (ANP)	**1** - Mansergh; **4** - Ecology of *B parvus*; **6** - 1979 and continuing; 7 - Prime site for *B parvus* research; **8** - "Tunnel of Love" an innovative and successful piece of environmental design.
Kosciuszko *Burramys* Reasearch	Blue Cow (KNP)	**1** - Linda Broome; **4** - Ecology of *B parvus*; **6** - Long term monitoring sites since 1986 and continuing; **7** - Prime sites for *B parvus* research.
Happold's Small Mammal Research	Smiggin Holes (KNP)	**1** - Happold, Green; **4** - Community ecology in sympatric species in response to alpine conditions; **5** - First Australian study into community ecology of a group of species; **6** - Monitored since 1982 and ongoing.
UV-B Radiation and Frogs	Thredbo Valley (KNP)	**3** – Climate change impacts; causes of frog population declines; **4** – Severe mortality in frog embyos/tadpoles without UV-B protection.
Brindabella Bird Banding	New Chums Road (NNP)	**1** - Wilson; **4** - Montane movements of bird species; **5** - One of the longest term bird banding studies in Australia in general and in a montane environment in particular; **6** - Monitored 1961 to 1982 and occasionally thereafter; **7** - Benchmark site for passerine research; **8** - Probably earliest use of mist net trapping technique in Australia.
Bogong Moth Research	Mt Gingera summit (NNP)	**1** - Common; **4** - Ecology of Bogong Moth; **7** - Benchmark site for Bogong Moth research with continued visits by K Green and others.

* see Volume 2 of this report for detailed site specifications

Burramys Monitoring Sites

The 'Tunnel of Love' site at Mt Higginbotham (Plates 23 and 24) has a sign that directs people to a display in the Alpine Resorts management office at Mt Hotham. The information at the site is very limited, and while the resort display is quite extensive it is in an obscure location. An updated sign at the site is suggested. There is adequate road-side parking and a pull-off bay 20m away. As the site is within the jurisdiction of the Alpine Resorts Commission consultation with them would be required regarding a new sign. The sign would not necessarily replace the existing interpretation at the resort office as the ecology of the species is covered more extensively than would be possible on-site.

Kosciuszko *Burramys* Reasearch

In cooperation with the managers of Blue Cow Resort, the possibility of providing a display at the resort should be investigated. Such a display should interpret the innovative possum crossings, and the resolution of conservation and skiing conflicts.

Happold's Small Mammal Research

This research is much too sensitive to interpret at the Smiggin Holes site. It is more appropriately included in any treatment of science at the nearby NPWS Visitor Centre at Perisher along with the UV-B research discussed at 3.2.6.2 and the treeline research discussed at 3.2.9.2.

UV-B Radiation and Frogs

This key project relates to both 'Native Fauna' and 'Climate Change'. Its interpretation is discussed under 'Meteorology and Climate Change' at 3.2.6.2.

Brindabella Bird Banding

New Chums Road is a locked fire trail in the northern Brindabella area of NNP. It is out of the way for most visitors. It has not been used by vehicles for many years and is becoming difficult to walk as it grows over. It would be most effectively interpreted at a node where other research sites are interpreted. The node covering this area is the Bulls Head Picnic Area (Plate17) for which the interpretation of fire research has been suggested in Section 3.2.2.2.

Bogong Moth Research

The nearest interpretation node to the Wilderness Area site at Mt Gingera is the trailhead for the walk at Mt Ginini car park. Located here is one of the 10 NNP interpretation bays scheduled for updating in 2002 as discussed with relation to Bulls Head Picnic Area - 3.2.2.2.

3.2.9 Native Flora

Only the research on native vegetation as it relates to grazing, fire and treelines has been covered in this report (as per Section 2.1). Considerable research into other aspects of native flora in the Australian Alps has been carried out. Studies that may be culturally significant need to be nominated for consideration by scientists familiar with the relevant bodies of research and the criteria developed to determine cultural significance.

Starting points for investigating culturally significant sites/projects are Barlow 1989, Kershaw and Strictland 1989, Kirkpatrick 1989, Ashton and Williams 1989, McDougall 1982, and Coyne 2000. Also of value are the NSW NPWS Threatened Species Recovery Plans, ACT Endangered (or Threatened) Species Action Plans, and the Victorian Government Flora and Fauna Guarantee Action Statements.

3.2.9.1 Overview of Treelines

The study of treeline dynamics is extensively represented in the international literature. Research on Australian treelines has led this field in a number of areas, specifically the work of Ralph Slatyer, Australia's first Chief Scientist. "The Australian Alps have been the scene of internationally outstanding research into the dynamics of alpine/subalpine vegetation and the upper slope and inverted treelines" (Kirkpatrick 1989, p 33).

Treelines world wide are generally clear ecotones, i.e. the transition from forest to grassland is clearly visible. In the Australian Alps two types of treeline are identifiable – the alpine treeline and the valley bottom treelines (also referred to as inverted treelines) that occur in mountain valleys experiencing cold air drainage and temperature inversions.

As the alpine treeline is approached the trees tend to become increasingly shrub-like and there may be some wind-flagging of the trees. The alpine treeline is formed by *Eucalyptus pauciflora* – snowgums – the only tree to be found above 1500m in the Alps. The treeline occurs up to 2050m altitude (NSW) on the exposed northern and western slopes and at about 200m lower on the southern and eastern lee slopes (1750m Victoria). The alpine treeline is generally determined by macroclimate. Valley bottom treelines are generally characterised by a sharp transition zone with forest forming an abrupt edge with grasslands. Several *Eucalyptus* species occur at these treelines. Valley bottom treelines tend to be local phenomena, strongly determined by local topography and local air drainage patterns.

Treelines being such notable features, questions about their causes were raised quite early. What stops trees from growing in these alpine and grassland areas? The Australian studies investigated physical and biological factors affecting treelines.

Treelines occur at an elevation where individual trees are no longer able to maintain a positive carbon balance. Globally this generally occurs where the mean summer temperature for the warmest month is 10^{o}C – and this is true for the Australian Alps. How long a tree can persist in a negative carbon balance is influenced by its stage of growth and its carbon reserves. When trees are young, with modest carbon reserves, they are particularly sensitive to prolonged negative balances. Carbon gains are influenced by the factors that affect photosynthesis rate and duration – temperature and length of time available for growth. Snowgums show a high degree of photosynthetic adaptation to the environment and the ability to acclimate progressively to seasonal conditions. Slatyer and Morrow (1977) showed that the temperature optimum for photosynthesis in *E. puaciflora* changed markedly over the growing season, more or less tracking the mean air temperature, and Ferrar *et al* (1989) showed that the preferred temperature for photosynthesis declines from 29^{o}C at 900m to about 19^{o}C at the treeline.

The other main loss of carbon reserves is direct physical damage to branches, shoots and leaves. For many years it was considered that leaf and shoot dieback was one of the most important eco-physiological limitations to tree growth above snow line. This was thought to be primarily caused by internal water deficits in winter. Slatyer (1976) showed that this was not the case in a study at the treeline on Mt Perisher. Cochran and Slatyer (1988) later demonstrated that there was no gradient of water potential with elevation (using the Thredbo study site described below).

Several experimental studies were established to investigate whether trees could establish beyond the treeline. At Thredbo Ferrar *et al* (1988) set up an experiment to look at the survivability of snowgum seedlings at different elevations. Alongside one of the ski lifts they sowed seeds, planted seedlings and saplings at 4 different elevations – below treeline, at treeline and 50m and 200m above treeline. They followed their development till they reached reproductive age or died. Snowgum seedlings were able to establish above the treeline. The most critical period for seedling establishment was the first growing season and first winter. Tolerance to physical environmental conditions was more important for survival than competition from surrounding vegetation. The probability of survival was enhanced as plant biomass increased. They concluded that if there was sufficient seed, at sites where competition from surrounding vegetation was substantially reduced, *Eucalyptus pauciflora* could become established at elevations well above the present treeline.

Slatyer (1989) suggests that alpine treelines have a high degree of inertia . Seeds need to be distributed uphill, and the closed herb and shrub layers of the alpine community make it difficult for trees to move uphill. He suggested that treelines have been relatively stable in the Alps since 8,000 to 4,000 years BP. A change in climate or vegetation structure would be needed to destabilise them. Slatyer claims that any response of the alpine treeline to global warming will lag well behind the potential for upward movement. From the seedling establishment trials he calculated that in favourable conditions treelines might move up 3m in 100 years.

Both Moore and Williams (1976) and Harwood (1976) investigated valley bottom treelines at Seventeen Flat north of Tantangara Dam in KNP. Moore and Williams' is the earliest investigation of inverted treelines in the Alps. They carried out their field work between 1953 and 1956. They planted seedlings out along a transect that crossed the valley bottom treeline and examined their survival. (One of the trees in the grassland was still alive in 1975.) They concluded that competition from snowgrass was the major factor, after frost, in restricting tree establishment.

Harwood used the data from the Moore and Williams study as a basis for his PhD work at both Seventeen Flat and Nungar Plain. Harwood also planted seeds and seedlings on a transect across the valley bottom treeline. He confirmed the findings of the previous study and noted that frost effects were most pronounced when seedlings reached the height of the surrounding herbfield, and the seedlings required a sustained period free of frost damage to reach a height (about 1m) after which they were more able to survive frost damage. Trees from this experiment still survive, raising the prospect that inverted treelines could progressively advance. Inverted treelines do not have to overcome slope as do alpine treelines, and as such may respond to global warming trends earlier than alpine treelines.

Investigations into treeline physiology and dynamics have continued and these more recent studies may quickly become culturally significant as factors such as climate change impact on the Alps ecology.

In the ACT scientists from the ANU Ecosystem Dynamics group have continued to investigate the factors limiting snowgum growth, with research work in the Orroral and Gudgenby Valleys in NNP. They have focused on the mechanics of cold-induced photoinhibition.

Early research noted that there was an asymmetrical pattern of seedling establishment around adult snowgums. Seedling density was greater and seedlings more vigorous

5 REFERENCES

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6 APPENDICES

6.1 Appendix 1 – Project Brief

6.2 Appendix 2 – Australian Heritage Commission Historic Themes

6.3 Appendix 3 – Areas Removed From Grazing in Victoria

6.4 Appendix 4 – Notes from Conversation with Neville Rosengren

6.5 Appendix 5 – Existing Interpretive Brochures Relating to Alps Science

6.1 Appendix 1 – Project Brief

BRIEF FOR DEVELOPMENT OF AN INTERPRETATION STRATEGY FOR THE SCIENTIFIC SITES OF CULTURAL SIGNIFICANCE IN THE AUSTRALIAN ALPS NATIONAL PARKS

1. CLIENT

Cultural Heritage Working Group (CHWG) of the Australian Alps Liaison Committee (AALC)

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3. INTRODUCTION

The Australian Alps national parks stretch from Canberra through the Brindabella Range in the ACT, the Snowy Mountains of NSW and along the Great Dividing Range through Victoria. The alpine and sub-alpine environment within the parks is a unique part of Australia, a mountainous biogeographical region in a predominantly dry and flat continent.

The national parks and reserves in the Australian Alps cross State and Territory borders and comprise over 1.6 million-hectares of protected areas across the rooftop of Australia. Nine conservation reserves are collectively referred to as the *'Australian Alps national parks'*. The major reserves, Kosciuszko, Namadgi, Alpine and Mount Buffalo National Park are well known to much of the community of south-eastern Australia. Brindabella National Park, Bimberi Nature Reserve, Scabby Range Nature Reserve and the Avon Wilderness are also becoming better known.

The Aboriginal and non-Aboriginal heritage of the Alps documents the human history that has influenced and been influenced by this unique Alpine and sub-Alpine environment. This cultural heritage is collectively considered to be of national significance and includes significant individual places.

A tri-state co-operative management program for the Australian Alps, administered by the Australian Alps Liaison Committee (AALC), seeks to achieve excellence in conservation management and sustainable use through a strong program of cross-border co-operation. The protection of the Alps is an integral part of this program.

4. BACKGROUND

The *Cultural Heritage Research and Implementation Report* undertaken by the Cultural Heritage Working Group (April 2000) has identified a number of gaps in our knowledge of cultural heritage in the Australian Alps National parks. One of these gaps is to be the focus of this project: the need for a strategy for protection and interpretation of the cultural heritage values of scientific sites in the Alps national parks.

Early alpine scientists were inspired to undertake research in the alpine flora, so different from the rest of the continent. The affinities with alpine flora of other continents were of interest to local and overseas botanists, who pursued studies of flora under remote and trying conditions. In the mid 1800s, geologists and geomorphologists began studies in the Alpine region. Following the initial discovery of the scientific significance of the mountains, a great wave of scientific investigation occurred in the 1900s. Many important cultural features remain from this work.

In 1994, the AALC commissioned Griffiths and Robin to assess the cultural heritage significance of scientific sites (as opposed to their acknowledged scientific significance). They identified 48 sites of outstanding cultural significance.

The AALC has developed an Australian Alps Scientific Sites Database, which contains data on sites, publications and contacts relating to long term monitoring and other significant research in the Australian Alps. This database is in Microsoft Access and may be used at the NSW National Parks and Wildlife Service office at Jindabyne, at the ACT Parks and Conservation, Namadgi Office and at Parks Victoria, Bright Office.

The AALC intends to second a suitable person for a period of up to four months from a State or Commonwealth government agency with involvement in Australian Alp’s cultural heritage to develop a thematic interpretation strategy for scientific sites of cultural significance in the Australian Alps national parks.

5. AIMS

- Using the list of scientific sites of cultural heritage significance in Robin, L. and Griffiths, T. 1994. *Report on the cultural significance of scientific sites in the Australian Alps (*AALC) identify
    - key themes in scientific research
    - places associated with each key scientific theme in each of the Australian Alps national parks
    - establish the significance of these places

- Develop conservation management strategies for each set of thematic sites
- For each theme, identify the sites that best represent that scientific significance.
- Develop an interpretation strategy for promoting to the public the most appropriate places which represent each theme, including an outline of options for interpretation.

6 EXTENT OF WORK

6.1 Consultation

In developing this report the successful applicant shall:

- Prior to commencing the project, consult with the Steering Committee members of the CHWG. In particular, discussion will focus on the aims of the project and proposed methodology to ensure that it will facilitate these aims.

- Discuss this project with staff at Alps parks agencies Attachment A. The consultant will discuss known scientific sites with Parks managers and relevant staff to decide which ones are likely to be suitable for promotion to the public, in terms of conservation requirements, accessibility and other relevant considerations.

- Seek the views of major stakeholders in relation to cultural heritage significance and promotion of sites. In particular, relevant persons in scientific organisations (eg CSIRO, Forestry research institutions, Universities, professional organisations), researchers who initiated the fieldwork at the sites (where possible) and those currently using the sites for scientific research, should be consulted.

6.2 Tasks

(a) Identify the key cultural heritage themes of scientific research which can be interpreted across the Parks (e.g. research sites relating to the effects of grazing, timber harvesting, arboreta, human induced change, etc)

(b) Identify the sites which best demonstrate the identified themes and which of these should be promoted to the public

(c) Document the heritage significance of the identified sites associated with the key scientific themes. Use assessments previously undertaken in the Regional Forest Agreements if appropriate. It may be useful to become familiar with specific reports on the scientific sites and research conducted at the sites.

(d) Develop conservation management strategies for sites representing each theme, addressing issues relating to their promotion, such as visitor impact and interpretation issues, and additional management requirements if presented to the public. These strategies should be in sufficient detail to allow park staff to implement the recommended actions.

(e) Outline the strategy for interpretation/presentation by reviewing models from similar sites in other Australian or overseas parks.

(f) Formulate the interpretation message for promotion of these sites, including the significance of the sites in relation the links between science, conservation and protected area management (it is not a requirement to devise the text for any promotion)

(g) Determine the most appropriate style of promotion for each theme of sites (signage, pamphlet, etc) and outline the key likely costs for interpretation/presentation and additional interpretation management of the selected sites and/or particular interpretation programs

7. SUBMISSIONS

The following copies of the report are required at submissions:

7.1 Draft submission: one unbound copy suitable for photocopy reproduction which includes but should not necessarily be limited to:

7.1.1 Title Page

7.1.2. Table of Contents

7.1.3. Summary of the Report

7.1.4. Aims and any limitations of the project.

7.1.5. Full report addressing Items 5 and 6 above.

7.1.6. Bibliography.

Draft reports shall be submitted to the members of the Project Management Team who will arrange for comments from stakeholders and Alps agencies. The successful applicant will need to anticipate a turnaround time for comment to be returned on draft reports as per the program (below).

7.2 Final submissions

The successful applicant shall address the comments (Item 7.1) and prepare:

Final submissions comprising

Four bound copies
One unbound copy suitable for photocopy reproduction
Text in Microsoft Word 6 or Word 97 for PC compatible format on 3.5”disc or CD-rom
Copies of key photographs in j.peg or .tiff format on 3.5” disc or CD rom (consultant to allow for up to 20 images unless otherwise negotiated)

6.2 Appendix 2 – Australian Heritage Commission Historic Themes

This appendix presents the Australian Heritage Commission Historic Themes (AHC 2001) relevant to Alps science as foreshadowed in Section 3.1. AHC text is in *italics*, text relating to this report is in normal font.

Theme Group 1 – Tracing the Evolution of the Australian Environment

Theme 1.1 – Tracing climatic and topographic change

This applies to Geomorphology (3.2.4) and Meteorology and Climate Change (3.2.6).

Theme 1.3 – Assessing scientifically diverse environments

On a national scale the Alps represent a unique environment. On a regional scale there is diversity due to the great range in elevation, and the multitude of ways in which slope, aspect and the availability of water express themselves.

Theme Group 3 – Developing Local, Regional and National Economies

Theme 3.4 – Making forests into a saleable resource

This was one of the ultimate objectives in the establishment and monitoring of Arboreta (3.2.9).

Theme 3.11 – Altering the environment

Sub-themes 3.11.1, 3.11.3, 3.11.5 – Regulating waterways, irrigating land, establishing water supplies

While the science related to these themes is largely excluded from this report (2.1), some of the hydrometric stations were employed in research on Fire (3.2.2) and Hydrology (3.2.5).

Theme Group 5 – Working

Theme 5.1 – Working in harsh conditions

This applies across the board to Alps science.

Theme Group 7 – Governing

Theme 7.6 – Administering Australia

Sub-themes 7.6.10 and 7.6.12 – Conserving fragile environments and conserving Australia's heritage

This applies strongly to Rehabilitation (3.2.3) but also to the majority of Alps science in its search for understanding as a necessary precursor to conservation.

Theme Group 8 – Developing Australia's Cultural Life

Theme 8.7 – Honouring achievement

This and earlier reports (Good 1992a, Griffiths and Robin 1994, Gillbank 1992) pay tribute to the cultural contributions of the keys Alps scientists. Those of the first generation (including Fawcett, Ashton, Costin, Wimbush, Bryant, Browne and Jennings), and many from the second generation, are recognised on a continuing basis in the scientific literature for their fundamental contributions.

Theme 8.10 – Pursuing excellence in the arts and sciences

Sub-theme 8.10.5 – Advancing knowledge in science and technology

This applies to all Alps science covered in this report.

6.3 Appendix 3 – Areas Removed From Grazing in Victoria

Areas	Year/s Grazing Removed	Reason
Mount Bogong	1955	To protect water catchments and sesnitive areas.
Mounts Hotahm, Loch and Feathertop.	1958	To protect water catchments and sesnitive areas.
[1]Parts of Bogong High Plains (east and north east of Falls Creek), The [2]Bluff , Avon Wilderness and Wabonga Plateau	1992	Government implemented LCC recommendations
East of Snowy River	1988	Government implemented LCC recommendations
Howitt Plains and Wonnangatta Station	1988/9	Government purchase of Wonnangatta Station implementation of LCC recommendations

Exclusion Fencing (Bogong Area)		
Masie's Plot	1944	Research Project
New Species Fence	1985?	Research?
Rock Valley Fence	1955-1960	Research?
Northern Cattle Fence	1992	To implement 1992 withdrawal of cattle from parts of the Bogong High Plain *(see 1 above)*.
J B Plain	1998	Not permanent. Fenced to allow revegation of Dinner Plain Trail
Exclusion Fencing (Mansfield Area)		
Bluff Exclusion Fence		To implement 1992 withdrawal of cattle from the Bluff Exclusion Zone *(see 2 above)*.
Exclusion fencing (Heyfield Area)		
Wellington Plains Exclusion Fences	Fencing Complete December 1999.	Area affected by January 1998 Caledonia Fire. Fences to protect fire affected bogs. NB. ANP Caledonia fire-affected area has not been grazed since the fire
Homes Plains Exclusion Fence	Fencing Complete December 1999	Area affected by January 1998 Caledonia Fire. Fences to protect fire affected bogs. NB. ANP Caledonia fire-affected area has not been grazed since the fire.

Sources

- Alpine National Park Management Plan
- Grazing in the Alpine National Park – Some Questions Answered (DCE Pamhplet – 1991)
- Australian Alps National Parks Website
- Ron Riley, Parks Victoria Ranger, Mt Beauty.

6.4 Appendix 4 – Notes from a telephone conversation with Neville Rosengren

The following points were made by Neville Rosengren, geologist/geomorphologist at Latrobe University, in October 2001.

Glaciation

- Costin and Carr's sites are important because they include sites on the Bogong High Plains and Mt Buffalo.
- There may have been a paper on glaciation by Edmund Gill, commenting on these glaciation features.
- Beavis (1959) and Peterson (1971) plus earlier papers, questioned the extent or fact of glaciation in Victoria. Peterson refers to the Mt Howitt site.

Frank Gibbons was a brilliant scientist who looked at landscape evolution. He worked for the Victorian Soil Conservation Service. Their reports were very important for their methodology approach. This was very pioneering stuff – it set the benchmark for the global approach to evaluating landscape. They used good strong ecological principles, which were related back to the land. This was seminal – it involved some of the first scientific approaches to conservation in Australia. Also Ken Rowe (contactable through Warwick Papst).

Block-streams. John Talent's (1965) was a seminal paper about rock rivers and block-streams. David Ashton and Moore in the mid 1970s produced a paper on the ecology of block-streams.

ANU – Tim Stone dated block-streams using the cosmogenic dating technique. This technique is very good for dating moraines, periglacial features and weathering processes.

Basalt is important in preserving buried landscapes, and can date incisions. See Ollier on the formation of the great escarpment in Eastern Australia.

Peter Kershaw – a paleonologist at Monash – has been dating peat and swamp deposits. eg Tali Karng – dated material on the lake floor to give the date of the landslide that created the lake. He has also worked at Mt Buffalo, analysing pollen sequences and describing environmental changes.

Andrew Gleadow – Professor of Earth Sciences at Melbourne University. Produced a paper on the Bogong High Plains – pioneered fission-tracking dating. This method can track the rate of stripping of the surface.