

Chapter 7 karst values

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Introduction

Karsts are landscapes formed on rocks with a greater degree of natural solubility than is commonly found. Such areas are characterised by gorges, caves, deranged hydrological systems and many fascinating small-scale landscape features. Karst systems and processes are produced by a complex interplay of geology, soils, biology, climate and time (Kiernan 1988; Hamilton-Smith et al. 1998). The eight karst areas in Kosciuszko National Park are all limestone, although dolomite does occur at Cooleman Plain.

The significance and values of the karst resources of Kosciuszko National Park have been previously summarised in Nicoll and Brush (1976), Spate and Houshold (1989) and Good (1992). Since those times, little has changed in our knowledge of the karst systems except in relation to their biological and cultural values. Surveys reported in Eberhard and Spate (1995), further work by Spate (unpublished) and reviews by Thurgate et al. (2000, 2001ab) have greatly refined our knowledge in this regard, most markedly in relation to Yarrangobilly and Cooleman Plain.

In addition, our understanding of the concepts of the value and significance of these and other Australian karst areas has been refined so that we may be better able to place the eight Kosciuszko areas into their correct rank. It must be recognised that assessment of significance does not produce a finite rank. As our knowledge of these and other Australian sites grows, our concepts of importance and significance will change; thus, our appreciation of individual sites or their contents will evolve.

Over the last three or four decades, the importance of karst has been increasingly apparent, as have the dimensions and importance of its non-geologic values. This is perhaps best demonstrated - and dramatically demonstrated - by the increasing worldwide acceptance of the World Conservation Union (IUCN) guidelines for the management of caves and karst, largely developed by Australians (Watson et al. 1997). These guidelines are already in use by the New South Wales (NSW) National Parks and Wildlife Service (NPWS) for steering plans for management in other parks across the state. Their use has been reinforced by a recent textbook dealing with protected area management (Worboys et al. 2001).

The karst areas within Kosciuszko National Park have a wide range of geological, geomorphological, botanical, zoological and recreational values in addition to their cultural significance to both indigenous people and later arrivals. At least two of the eight areas appear not to have cave systems - or at least not cave systems that can be entered by humans - but they have much of interest. Carne and Jones (1919) reported additional limestone areas, notably on the Main Range, but these seem to be errors or misreporting of locations. These areas are either not listed or dismissed in Lishmund et al. (1986).

The eight karst areas are of local, regional, state or national significance, predominantly from a cultural perspective in the field of scientific endeavour. Some people, including the present author, would argue that certain features are of international significance. Whether these would ever meet the world heritage criterion for 'outstanding universal value' is very much open to discussion.

In addition to the karsts developed in soluble rocks, there are a number of small-scale pseudokarst features, chiefly in granite, scattered across the park, including boulder caves along the Snowy and Ingeegoodbee rivers (Finlayson 1981). Ephemeral caves in ice and snow should also be mentioned in passing (Halbert and Halbert 1972). These sometimes contain many forms analogous to 'traditional' karst caves.

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All karst and pseudokarst areas in the park have considerable value for interpretation, especially in regard to landscape development and evolution. This is especially true of Yarrangobilly and Cooleman Plain (and perhaps Cooinbil because of its easy access). The show cave tours at Yarrangobilly provide excellent interpretation of caves and karst. The situation is not as good across the rest of the park. The large range of environmental information proffered by karst terrains deserves far greater attention from the NPWS.

A number of the karsts within Kosciuszko National Park were affected by fire in January and February 2003 (Spate 2003a, Spate in press). Details of the impacts on each area are provided below although quantitative measures are not available. It may also be many years before the impacts become evident. The development of the park's karst and dependent caves has occurred over many thousands or millions of years and thus have been exposed to many fire events.

General discussion

Description

The eight karst areas within the park (excluding the pseudokarst granite and ice caves) are all developed in Silurian or Devonian limestones or their derivatives (Owen and Wyborn 1979, Wyborn et al. 1990, Spate and Spate in press). Nicoll and Brush (1976) provide details on many of the significant caves. See Map 7.1 for location of karst areas within the park.

All the areas are within the Lachlan Fold Belt, but there are significant differences from a geological perspective. These are described in the introductory chapters in Lishmund et al. (1986), but are not important from a karst perspective.

A grouping of the areas is discussed below, and each area is discussed in detail. It is obvious that the areas are distinct from other NSW karst areas in that they lie near the crest of the eastern highlands - the so-called Great Dividing Range - and are in alpine, subalpine or montane environments; for further discussion of their geomorphic settings see Houshold et al. (1986). Cooleman and Yarrangobilly have outstanding above-ground karst landscapes, particularly gorges and rising streams. Ravine has unusual Quaternary karst features – perhaps unique in New South Wales.

Each of the areas has distinctive characteristics in terms of topographic setting, broad vegetation type, degree of karstification and degree of karst hydrological integration. Only two areas, Cooleman and Yarrangobilly, have been surveyed for their dependent cave invertebrate populations (Eberhard and Spate 1995), and even these surveys were only at reconnaissance level. Both areas have endemic plant species. Some sites, particularly Yarrangobilly and, to a lesser extent, Cooleman, have significant subfossil deposits, including the Smokey Mouse (*Pseudomys fumeus*) and Thylacine (*Thylacinus cynocephalus*).

Basis for management

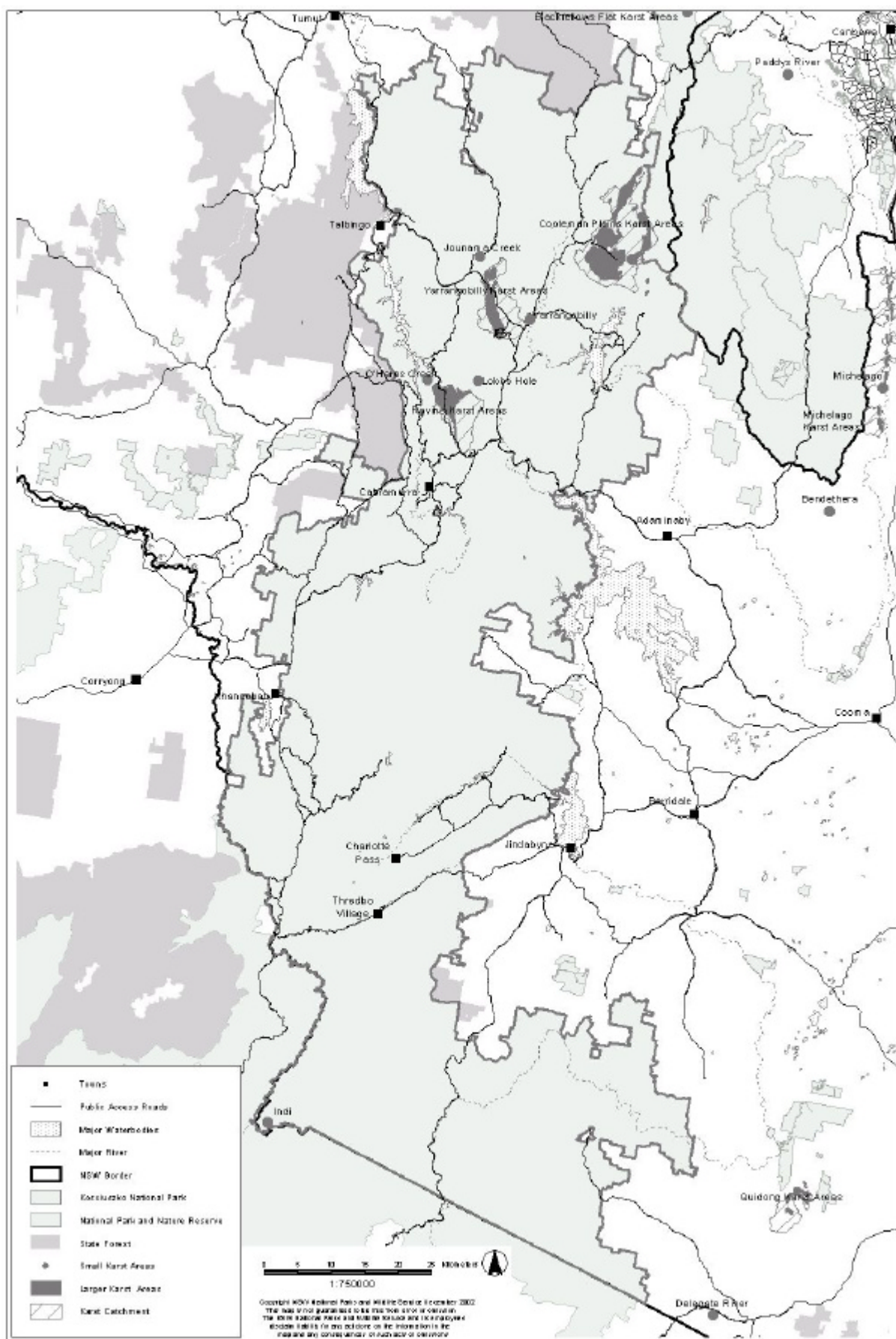
Currently, the management of the eight karst areas is based on ten sets of provisions:

- the National Parks and Wildlife Act 1974 (NSW) and Regulations
- the 1988 Plan of Management for Kosciuszko National Park
- the 1987 Karst Area Plan for the Cooleman Plain Management Unit and consequent amendments to the 1982 plan
- a draft plan of management for the Yarrangobilly Management Unit
- the provisions relating to Kosciuszko National Park's listing on the Register of the National Estate
- the 1999 Kosciuszko National Park Fire Management Plan
- the United Nations Educational, Scientific and Cultural Organization (UNESCO) Man and the Biosphere listing
- the Wilderness Act 1987
- various policy documents issued by NPWS (e.g. field management policies)
- informal policies for cave access at Indi, Black Perry and Jounama Creek.

Clearly many of these instruments will be subsumed into the new Plan of Management for Kosciuszko National Park. However, most of the current management practices are adequate although if better staff resources were available management could be improved.

As mentioned above, the IUCN guidelines should be the guiding principles for future management of Kosciuszko's karst areas. These guidelines will need to be supplemented by specific management prescriptions for each area, and in many cases for individual caves. Previous approaches to cave and karst area management based on such cave classification schemes have been found wanting across Australia. Approaches such as those outlined by Spate and Webb (1998) might be more useful and acceptable to users who regard the 'classification for management' methodology and process as overly proscriptive and clumsy. Worboys et al. (2001) provide a partial list of the range of actions that karst managers should consider in the management and use of these areas.

Map 7.1 Location of karst areas in Kosciuszko National Park



As with all other karst areas under the control of the NSW NPWS (with the exception of Ashford, some small areas in Deua National Park and, perhaps, Yessabah), all eight karst areas in Kosciuszko National Park have their entire catchment areas within NPWS estate. This makes their management easier from the viewpoint of total catchment protection. However, the remoteness and ruggedness of most karst areas presents many management challenges.

Significance

The significance of the eight karst areas ranges from national to local. Some might argue that aspects of Cooleman and Yarrangobilly are of international significance. Given that the whole park is internationally recognised as a UNESCO Man and the Biosphere Reserve and is nationally recognised as a result of its listing on the Register of the National Estate, an extensive discussion of significance may not be relevant here. The significance of individual areas is discussed below, disregarding UNESCO and National Estate listings.

In general, the suite of karst areas has outstanding or representative significance, at state to national scale, for geomorphology, landscapes above and below ground, and flora and fauna.

Table 7.1, updated from Spate and Houshold (1989), shows the scientific significance of each of the eight karst areas.

Table 7.1 Degree of scientific significance of eight karst areas in the Kosciuszko National Park, after Spate and Houshold (1989)

	Geology	Geomorphology	Climate	Hydrology	Sedimentology	Palaeontology	Archaeology	Botany	Zoology
Cooleman Plains									
Representativeness	2	2	2	1	3	3	3	3	2
Outstandingness	2	2	2	2	3	3	3	4	2
Upper Goodradigbee									
Representativeness	3	3	4	4	–	4	3	4	4
Outstandingness	4	3	4	4	–	4	2	4	4
Cooimbil									
Representativeness	3	3	4	4	4	–	–	–	–
Outstandingness	4	4	4	4	4	–	–	–	–
Yarrangobilly									
Representativeness	2	2	2	2	2	3	3	3	2
Outstandingness	2	2	2	2	2	3	3	3	2
Jounama Creek									
Representativeness	3	4	4	4	4	–	4	4	4
Outstandingness	3	4	4	4	4	–	4	4	4
Indi									
Representativeness	3	3	3	4	3	4	4	–	4
Outstandingness	4	4	4	4	4	4	4	–	4
Cowombat Flat									
Representativeness	4	4	4	4	4	–	–	–	–
Outstandingness	4	4	4	4	4	–	–	–	–
Ravine									
Representativeness	3	2	3	3	3	4	–	–	–
Outstandingness	3	3	3	3	3	4	–	–	–

1 = international; 2 = national; 3 = regional; 4 = local; – = data not available

Dependence

The karst areas are sites within the park and are thus dependent on the park. They are, in the proper sense of the word, 'unique'. Karst systems are part of complex biophysical processes operating over extended time. Proper management of karst requires environmental conditions to remain essentially unchanged over time, within the bounds of natural environmental variability. However, definition of the time scale over which natural variability is to be considered can be very problematic. For example, even conditions in, and thus management of, two closely related caves such as Jersey and Jillabean at Yarrangobilly relate to very different time scales, ranging from 10 years to 10 million years. Such time scales are markedly different from those for most natural area management regimes and certainly much longer than political cycles or theoretical enthusiasms.

Recent work by Osborne (2001ab) has brought into question whether the fundamental tenet of karst management - that of whole catchment management - is an appropriate management strategy in New South Wales, given that many eastern Australian karst areas may have developed from rising groundwater rather than sinking surface waters. Osborne's finding may not relate to karst areas within Kosciuszko, but it is worth remembering that simple and long-held management paradigms must be questioned from time to time. Osborne (1996) has also pointed out the important role of sulfide mineralisation in the development of caves at Yarrangobilly and perhaps Cooleman. Both these concepts reinforce the comments above about time scales and environmental variability.

Condition and trend in condition

In general, the condition of all eight areas is stable or improving, except in relation to the spread of weeds and possibly the impacts of feral animals (at Cooleman) and visitor pressures (at Cooleman, Indi and Yarrangobilly). Following the 2003 fire event, Yarrangobilly, Ravine, probably Indi and part of Cooleman are now recovering from fires of various intensity (Spate 2003, Spate in press).

Pressures

As intimated above, pressures on karst areas arise largely from weeds, feral animals and visitor influences. Weed spraying can present considerable challenges in karst areas. Fire and fire suppression activities are also of concern. Holland (1994) and Spate (2003b) discuss the impacts of fire on karst landforms although there is little quantitative information on this subject anywhere in the world.

Knowledge gaps

There has been considerable research at Cooleman and Yarrangobilly, focused largely on cave documentation, karst geomorphology and hydrology, terrestrial vegetation and cave-dependent fauna. Much more research, survey and documentation work could be done in these and other areas. Particular issues include terrestrial flora, subterranean fauna, hydrological relationships, long-term fire history and landscape evolution. As pointed out above, the manifold values of karst provide many opportunities for research and interpretation of natural environments.

The remoteness, ruggedness and problems inherent in using biocides in karst landscapes point to biological control as the only effective methods for weed control in these areas (and much of Kosciuszko National Park).

Opportunities

Strategic management of the karst areas requires consideration of the maintenance of essentially natural conditions upstream and over the karst itself, on one hand, and visitor management, on the other. There are bound to be conflicts between the hopes and aspirations of users and management.

In general, the management of Kosciuszko karsts is adequate but could be improved by better control of weeds and perhaps feral animals, by more involvement of staff (especially at Cooleman and Indi) and by recognition that the availability of caves and karst is finite and that many karst features are essentially unrenovable or unrepairable, especially in human time frames.

The 1999 Kosciuszko National Park Fire Management Plan specifically addresses karst management in relation to prescribed burning and wildfire suppression. Further management guidelines and policies are set out in the various documents referred to above.

Indicators and monitoring

Experience elsewhere in NSW and around the world points to the difficulty of establishing effective and reliable indicators for environmental monitoring in karstic terrains without costly monitoring programs and practices. This is particularly so given the range of environmental parameters that go to support karst and karst processes. These parameters include geology, topography, soils, climate, vegetation and, importantly, time. Some suggestions are made below for individual karst areas.

The areas

The eight areas are considered in turn below. They fall into four groups based on geology and location as follows:

- Cooleman Plains, Upper Goodradigbee (which includes part of Bimberi Nature Reserve) and Cooinbil - Silurian limestones
- Yarrangobilly and Jounama Creek/Black Perry - Silurian limestones and skarns
- Indi and Cowombat Flat in the upper Murray headwaters - Silurian limestones
- Ravine (O'Hares Creek–Lobs Hole) - Devonian and Quaternary limestones.

The first three have varying proportions of subalpine grasslands and forests and montane forest communities. Ravine has been highly disturbed by grazing, fire and weed invasion and appears to be somewhat of a rain shadow area. The 1982 plan of management defines the main environmental type at Ravine as montane forest but this is somewhat misleading.

Cooleman Plains

Description

For the purposes of this discussion, the 1982 Cooleman Plain Management Unit has been split into Cooleman Plain above the Cave Creek junction with the Mount Murray branch of the Goodradigbee River, and an area termed Upper Goodradigbee, which is discussed below. Parts of both areas lie within the Bimberi Wilderness.

The best general description of the area is to be found in the Cooleman Plain Karst Area Management Plan, adopted in July 1987 as a supplementary plan to the Kosciuszko National Park Plan of Management and formalised in the 1988 amendments to that plan.

The area includes the very popular car-based attraction of Blue Waterholes (the largest karst spring in the mainland part of the eastern highlands), a number of spectacular gorges, many caves and other karst features. It is a popular walking and horse riding area, and includes a number of sites of significance for both Aboriginal and European cultural heritage. Perhaps the most important of these is the Coolamine homestead complex. Grazing continued on part of the area until 1977.

Significance

Spate and Houshold (1989) argued at the First Fenner Conference that aspects of Cooleman Plain had levels of significance ranging from international to local in a number of fields of scientific endeavour. They suggested that the quality and range (and citations) of the geomorphological and hydrological research conducted by the late Joe Jennings and others gave credence to a view supporting international significance. The gorges, blind valleys, springs, caves and other karst features, including the probable exhumed Devonian karst features around 'Bung Harris Dam', are an important part of the suite of Australian karst landscapes. Others argued, in discussion at the conference, that the grounds for international significance were overstated.

Since 1989, work conducted by Eberhard and Spate (1995), reviewed in Thurgate et al. (2001ab), has demonstrated the presence of a number of aquatic crustaceans of considerable significance. These aid our understanding of the evolution of the fauna of continental Australia (George [Buz] Wilson, Australian Museum, pers. comm., 2000). Thus, this aspect of the significance of Cooleman Plain rises from regional to national. Table 1 above gives an overall assessment of the scientific significance of Cooleman.

There is much more to Cooleman Plain than scientific values, as evidenced by the number of visitors, including many who have come back frequently over many decades. The area is important for both active and passive recreation; as a destination; for its indigenous and European heritage of occupation, grazing and use of caves; and as a gateway to other parts of the park, notably the Bimberi Wilderness and Namadgi National Park. Its significance for these sorts of values is at least at a regional level.

Dependence

The Cooleman Plain area is a very important part of Kosciuszko National Park. Much of its importance is dependent on its karst values - aesthetic, scientific and recreational. This was recognised in the 1982 plan of management through its identification as an area of 'Outstanding Natural Value' and as requiring a specific set of planning and management strategies that culminated in the Karst Area Management Plan.

Its values are dependent on the maintenance of its natural values on one hand and on the various cultural features on the other. It provides both a significant destination and an access route - features that render it susceptible both to 'being loved to death' and to being over-managed. Keeping the Blue Waterholes area in a natural condition but allowing heavy use is a particular challenge.

Condition and trend in condition

Most of the area is in good condition. Recovery following cessation of grazing, especially by rabbits, is proceeding adequately, although it is slow on some sites, particularly on the Blue Waterholes geological formation. There is some concern about the apparent dominance of Needlebush (*Hakea microcarpa*) and Poison Pimelea (*Pimelea pauciflora*), but this appears to be a successional phase in the recovery of the sod tussock grasslands.

Other than the impact of campers and managers - specifically at Blue Waterholes and environs - the most disturbing impacts at Cooleman are from horses and walkers, especially in Nicole Gorge up to Murrays Cave, and from illegal use of four-wheel drive vehicles away from the Blue Waterholes fire trail. Weeds, particularly briar, blackberry and willows, are also a problem, but on more limited areas, concentrated along Cave Creek, particularly below Blue Waterholes, and around the margins of the plains. Pigs are of concern around the margins and along the foot slopes, and feral horses are an ongoing concern. It can be argued that management activities such as roading and provision of facilities such as toilets and interpretive structures have also contributed to impacts on the environment.

Four caves have been quite heavily used by visitors over a long time. They are relatively robust, and in several of them occasional floods repair some of the visitor impacts. Without on-ground ranger presence, it is impossible to better manage these caves, so their use has been freely permitted in an attempt to divert attention from other, less-impacted caves. Disturbance is apparent in all of these, but is not regarded as critical, although three of the four have only a limited ability for self-recovery.

Pressures

As noted above, the pressures on this area arise from the presence of visitors, weeds, feral animals and illegal activities. Wildfire and fire suppression activities are of potential concern. The issues are addressed in the 1999 Kosciuszko National Park Fire Management Plan.

The 2003 fires burnt the area north of the Blue Waterholes Fire trail both as backburn and wildfire. Although the area has not been closely examined it would appear that the lack of fuel on the grasslands and in the gorges has not led to significant impacts on this area.

There may be potential for visitor use to impact on water quality at Blue Waterholes. Water testing over many decades has indicated that the plentiful algae at this site are a natural feature. Sediments, perhaps arising from overgrazing and consequent erosion, have partially silted up the main rising at Blue Waterholes and will be in train through the system for many millennia.

Knowledge gaps

The Cooleman Plain Karst Area Management Plan identifies a number of research avenues available or needed in the area. Because of the many years of research at Cooleman, we probably have better knowledge of this area than much of the rest of the park, with the exception of the alpine areas. However, historical research into indigenous values and uses of the area and into biospeleological aspects deserves attention. Examination of the Campbell papers¹ in the National Library of Australia if and when they become available, may provide much of interest on both European and Aboriginal use of the area.

Opportunities

Management of the area should continue to be as outlined in the Karst Area Management Plan, the 1999 Kosciuszko National Park Fire Management Plan and the currently used policies and practices for cave access.

Management of the Blue Waterholes area requires considerable, careful attention, both to prevent ongoing degradation and to avoid over-development, which has led to some degradation in the past. Placing of infrastructure requires considerable care for both aesthetic and karst sensitivities viewpoints.

There may well be a need to consider carefully the management of both feral horses and horse riding, especially in gorges.

Indicators and monitoring

There is a demonstrable need to monitor the spread of weeds and the activities of horses and pigs, and to act where necessary. It is suggested that a formal photo-monitoring program be instituted to document any environmental changes in:

- foot tracks in the gorges;
- horse tracks in the gorges;
- creek crossings in the gorges;
- visitor impacts in Murrays, Cooleman and Barbers Caves; and
- campsites, fireplaces and various sites in the Blue Waterholes environs (particularly access points to the Waterholes themselves).

Upper Goodradigbee

Description

Upper Goodradigbee is defined here as the various karst features along the Mount Murray branch of the Goodradigbee River, above the Cave Creek junction, and those along the Goodradigbee River down to Brindabella, below the Cave Creek junction. Most of the area is within the Cooleman Plain Management Unit as defined in the 1982 plan of management but some is within Bimberi Nature Reserve. It all falls within the Bimberi Wilderness. Its remoteness suggests that it should not be considered, in a

¹ The Campbells of Duntroon were early settlers of the area and the family papers are under embargo.

management context, in conjunction with Cooleman Plain proper. There are also some geological grounds for this argument. Many of the caves are described in Montgomery (1971).

The area is accessed by foot through the Bimberi Wilderness from Mount Ginini, from Pockets Saddle, or from Blue Waterholes.

There are a number of items of natural and cultural heritage value, including a number of caves, Aboriginal sites and a cave bat roost.

Significance

The significance of Upper Goodradigbee is probably at best regional to local (Table 1). However, the long-documented Aboriginal heritage (Spate 1993) and recent discoveries reinforce the importance of this area. Its pristine nature adds to its value.

Dependence

The area is an important part of Kosciuszko's heritage.

Condition and trend in condition

The condition is stable apart from the spread of weeds and perhaps of feral animals.

Pressures

The remoteness of this area and the lack of disturbance mean that this area is in good condition. Weeds and feral animals are a problem, especially blackberry, briar, pigs and possibly horses. Some illegal horse riding occurs in the area, and perhaps construction of yards and camping areas has taken place.

The area has not been inspected since the 2003 fires. The presence of forest and understorey and steep slopes may have resulted in high fire intensities and some destruction of surface karst features or sedimentation of caves.

Knowledge gaps

The area is not well known. There are persistent written and oral historical accounts (Spate 1993) of significant items of Aboriginal heritage associated with caves, and recent discoveries perhaps confirm these accounts. The area has not been investigated for its biospeleological values. One cave is probably an important roost for the Large Bentwing Bat, *Miniopterus schreibersii*, although at what stage in its life cycle is not known. The roost here is probably part of the population dependent on the maternity site in Church Cave, Wee Jasper.

Opportunities

Specific site management practices have recently been instituted to protect Aboriginal heritage sites. The area should be managed under the provisions of the Cooleman Plain Karst Area Management Plan, the 1999 Kosciuszko National Park Fire Management Plan and the existing provisions of the Bimberi Nature Reserve Plan of Management.

Indicators and monitoring

No specific recommendations are made for this area. However the spread of weeds in remote areas such as this should not be ignored and efforts should be made to provide some form of long-term documentation of condition.

Cooinbil

Description

The tiny Cooinbil karst (< 2 hectares) is a fascinating site. It is within the 1982 Long Plain Management Unit. Although located very near the intensely used Cooinbil Hut horse use area, it is not disturbed by current park use.

Significance

The area has local significance, but is potentially significant a site for education about and interpretation of karst and the impacts resulting from climate change and European occupation.

Dependence

There is a relatively robust and accessible display of a range of surface and subsurface karst features.

Condition and trend in condition

The condition of the area is stable at this time, but is demonstrating the impacts of post-glacial climate change, Aboriginal burning regimes and possibly some impacts of European settlement, via erosion that may be a result of rabbits, grazing or fire.

Pressures

There may be some pressure from visitor use associated with horse riding and weeds. This area was not burnt in January/February 2003.

Knowledge gaps

There has been no proper assessment of this fascinating site, but it is unlikely to possess significant biospeleological values.

Opportunities

The site has potential as an interpretation site for karst and the impact of factors such as climate change and grazing on karst.

Indicators and monitoring

The spread of weeds, and the potential impacts of horses and pedestrians, should be monitored and controlled if necessary.

Yarrangobilly

Description

The 1982 Yarrangobilly Management Unit (Management of Outstanding Natural Resources) includes the very large Yarrangobilly karst area. Parts of the management unit lie within the Goobarragandra Wilderness. It also includes the Jounama pine plantation (currently being harvested and returned to native species) that partially overlies the karst. There is also a small, and enigmatic, part of the Yarrangobilly karst in the Bogong Peaks Management Unit (Management of Special Scientific Values) and the Bogong Wilderness. This area, to the west of the Jounama pine plantation, is of uncertain hydrological affinities and lies in the Jounama Creek catchment rather than that of the Yarrangobilly River.

The Yarrangobilly karst area is considered in one block in the discussion below, but can be arbitrarily split into three broad zones based largely on the degree of disturbance, visitor use and management intensity. From south to north these are as follows:

- the show caves precinct (up to the north side of Harriewood Gorge and including Grotto and Castle caves), which is intensely disturbed, used and managed; this area has been termed the Yarrangobilly Caves Precinct in a variety of planning documents;
- the so-called Yarrangobilly 'Plateau' from Harriewood Gorge to the north side of Wombat Creek (the creek line along which Yans Crossing fire trail runs), including all drainage to Coppermine Cave. Cave access is tightly controlled but the area is little disturbed (except by the presence of the Snowy Mountains Highway) and is minimally used. The area has allegedly not been burnt by wildfire since 1909 (Jack Bridle, Talbingo, pers. comm., November 2002); and
- this area is largely north of the Snowy Mountains Highway and includes the former Yarrangobilly racecourse, Garnet Hill, Yarrangobilly village and Jounama pine plantation; and a small area in the headwaters of Jounama Creek around GR 305 567 (Yarrangobilly 1:25,000) - outside of the 1982 Yarrangobilly Management Unit but within the Bogong Peaks Management Unit and. This area is intensely disturbed, being heavily used for recreation, pine harvesting and rehabilitation.

There are several hundred caves at Yarrangobilly as well as a large number of other karst features (for example, blind valleys and pinnacle fields like 'The Tombstones'), endemic plants and animals (including rare and endangered species), and a considerable number of European cultural features. The number of Aboriginal sites and cultural features appears to be limited, although this may reflect a lack of knowledge rather than the actual situation. This is changing through better communication with the local Aboriginal Land Council and through identification of whole-of-landscape values as well as specific sites.

The area south and west of the Snowy Mountains Highway (that is, the first two zones defined above were burnt by wildfire and backburn in January 2003. The fire varied very widely in intensity dependent on fuels, slopes and weather conditions. The impacts are further discussed below.

Significance

The scientific significance of the Yarrangobilly karst area is summarised in Table 1. The levels of both scientific and cultural significance range from local to national. These assessments have been reinforced most recently by NPWS (2000). There is a suite of rare and endangered plant and animal species here as well as limestone-endemic species. The Blackthorn species, *Bursaria calcicola* and *B. spinosa* var. *lasiophylla* have recently been identified. The presence of the latter variety is of considerable interest as it is the host for the Bathurst Copper Butterfly, *Paralucia spinifera*, and its associated ant, *Anonychomyrma itinerans*. If the butterfly is confirmed at Yarrangobilly it will be a very large extension of range for this rare and endangered species. There are significant subfossil deposits within some of the caves.

The area has very considerable aesthetic and recreational significance. The gorges, blind valleys, springs, caves and other karst features are an important part of the suite of Australian karst landscapes and a number are described in the Australian Landform Example series published in the *Australian Geographer* and are thus of national significance. A very large number of recreational activities are undertaken within the management unit and karst area. The area is recognised nationally as a site of very great recreational value (Davey 1984). The show caves at Yarrangobilly are widely recognised for the excellence of their speleothems and for the quality of their cave tours.

Dependence

As with all karst areas, the ongoing health of the karst requires that soil and vegetation conditions remain essentially unchanged through time. However, it must be recognised that karst areas and processes provide some buffer to environmental change and that the area provides a record of environmental conditions going back many million years.

Visitor pressures on the surface and underground need to be managed, as do wildfire, fire suppression activities, and maintenance activities on the Snowy Mountains Highway and in the caves precinct.

Condition and trend in condition

The condition of the karst area varies enormously from very intensely disturbed (e.g. Jounama pine plantation, Yarrangobilly village, along the Snowy Mountains Highway and in the Yarrangobilly Caves Precinct) to completely pristine (e.g. deep in North Deep Creek Cave). Recent work on the mosses, comparing the situation between 1906 and the late 1990s, shows just how insidious vegetation change can be (Downing and Oldfield 2002).

The condition of the cultural resources similarly ranges from very actively managed, as is Yarrangobilly Caves House, to the decomposing ruins of Spicers Hut.

Weeds are an ongoing, severe and possibly intractable problem, especially in the precinct, in and around the plantation and along rivers and creeks. Feral animals are not currently as big a problem as they have been in past decades. There is a certain irony in the fact that blackberries may be providing protection from feral cats for the endangered Smoky Mouse (*Pseudomys fumeus*).

Pressures

Pressures on the area are evident from the discussion above: fire, visitors, weeds, feral animals, inappropriate management operations and possibly climate change all present challenges. Several of the caves (for example, Village, Coppermine and Old Inn Caves) are all susceptible to 'illegal' caving pressures and therefore may be more at risk than those less easily located.

Specific issues that confront the Yarrangobilly karst include maintenance of the Snowy Mountains Highway and Main Road 324. The use of salt for de-icing on the highway is of concern. The sewerage system at Yarrangobilly Caves is undergoing a much-needed upgrade, which will reduce pressures from this source.

The wildfire and backburn that occurred in January 2003 has had a greater affect on Yarrangobilly than on the other karst areas within Kosciuszko National Park although the Indi area has not been inspected (Spate 2003, Spate, in press). The much lower slopes there probably mean that fire intensities were lesser. At Yarrangobilly the intensities ranged from unburnt through the entire spectrum to extreme (or beyond) fire behaviour.

There appears to have been no direct impact on the caves at the time of writing (mid-April) although there may have been some sediment transfer into caves and dolines. The absence of torrential rainfall in this area has certainly helped in this regard. However, there are many unstable, steep, soil and scree deposits on slopes of up to 50° - much more movement on these of these can be expected.

In areas of high intensity fire, there has been spalling or calcining (the conversion of limestone to calcium oxide, quicklime) of the limestone surface (Holland 1994, Spate 2003b). This results in a white, rather than blue-grey, limestone surface and some localised destruction of minor solution features. Judging from experience in Tasmania and in the nearby Jounama Pine Plantation the transition it will take a few decades before the limestone surface are re-occupied by the algae and lichens which give these limestones their characteristic colour. New karren to replace that destroyed will take centuries. By the very nature of karren fields, they do not usually have much fuel and thus any destruction is very localised.

These karst landscapes have not developed in the absence of fire and we have the very human difficulty of relating our 'three-score years and ten' to that of complex biophysically produced landforms and ecosystems. However, fire disturbance is in addition to the impacts produced by human use of these areas.

Knowledge gaps

The Aboriginal resources of the management unit and its karst area are inadequately documented. More work is required on the biospeleological aspects, especially on the aquatic fauna, which appears to be depauperate at Yarrangobilly, unlike similar-sized areas across New South Wales.

Although there has been some research into the sediments in Yarrangobilly caves, this is incomplete and little has been written up. A record of bushfires preserved in Jersey Cave is nearly half a million years old and is currently receiving research attention.

Survey work in the mid-1970s identified a number of limestone endemics amongst the higher plants; this should be confirmed.

Opportunities

There is an adequate basis for management under the existing provisions of the 1982 plan of management, the 1999 draft karst area management plan, the Jounama Environmental Impact Statement and the policies and practices in place for cave access.

However, even if the instruments exist, there is a need for more active management of areas such as Yarrangobilly village, for better area-wide interpretation (for which there is an amazing array of opportunities in very many disciplines) and for a better understanding of the nature and distribution of the resources of the area.

Weeds, wildfire and wildfire suppression activities are all of ongoing concern.

Indicators and monitoring

There is a demonstrable need to monitor the spread of weeds and the activities of feral animals and to act where necessary.

It is suggested that a formal monitoring program be instituted to document changes in:

- the distribution of weeds;
- tree lines in the Y45–Garnet Hill–Yarrangobilly village area;
- vegetation change on the Yarrangobilly plateau;
- European cultural sites outside the Yarrangobilly Caves Precinct;
- visitor impacts in both show and 'wild' caves; and
- campsites, fireplaces and various sites around Yarrangobilly village.

Jounama Creek/Black Perry Mountain

Description

The area consists of a north-westerly extension of the Silurian Yarrangobilly Limestone in the valley of Jounama Creek and its tributary Cave (or Clive) Creek. Most of the carbonate rocks are found in the highly metamorphosed and mineralised ridge that forms Black Perry Mountain. A single small, and unusual, cave is found high up on the eastern flank of the ridge and 15 small caves are found further north in the Cave Creek valley. Other areas of limestone may exist on Jounama Creek below the Cave Creek junction. The area is within the Bogong Wilderness and the Bogong Peaks Management Unit (as defined in the 1982 plan of management) set aside for the 'Management of Special Scientific Values'.

The Black Perry ridge is accessed by foot from the Snowy Mountains Highway. The caves in Cave Creek are best accessed from the Waragong fire trail.

This area was not burnt in early 2003.

Significance

The significance of the karst and caves is probably little more than local, although the cave on Black Perry may rank more highly than this. The topography and mineralisation of Black Perry Mountain and the ridge leading to it are of state to national significance. At least one mineral present here (Babingtonite) is only known from a few (perhaps only two) other localities worldwide (Gole 1981).

Dependence

The continued existence of the unusual minerals is dependent on collection only under a NPWS scientific consent. The karst features require continued catchment, soil and vegetation stability to maintain their current environmental conditions.

Condition and trend in condition

Other than the spread of weeds, chiefly blackberries, briar and *Pinus* wildings from the Jounama pine plantation and from the plantations to the west of the Tumut River, the environmental condition is stable. The caves are very infrequently visited and are in excellent condition.

Pressures

The spread of briar, pine and blackberries and possibly wildfire threaten the area.

Knowledge gaps

The caves have been relatively thoroughly documented. Archaeological values appear to be absent and geomorphic values appear minimal. The area has not been assessed for its biological values.

Opportunities

The area requires no specific additional management, weed control is more than desirable, but probably impossible given the access difficulties. Current cave access conditions are adequate.

Some 'vista clearing' and good interpretation at the Black Perry rest area on the Snowy Mountains Highway would be valuable because Black Perry Mountain is an unusual and spectacular landscape element.

Indicators and monitoring

The spread of weeds should be monitored.

Indi

Description

This small area consists of two small limestone lenses north of McHardies Flat on the upper Murray River. There may be more limestone outcrops further north. They are accessed via four-wheel drive tracks from Victoria (with little prospect of these being closed) and are essentially isolated in winter. Indi is within the 1982 plan's Murray Headwaters Management Unit (Management of Outstanding Natural Resources). Part may lie inside the Pilot wilderness, depending on exactly where the wilderness boundary runs.

The area is unusual in that the 13 small caves are perched on a small terrace 10–15 metres above river level. It is not known if this bench is structural or a river terrace cut in the limestone. The caves appear to be hydrologically isolated by thick clayey sediments in their lower parts, so small ephemeral lakes exist in wetter periods.

It is not known if this area was significantly affected by wildfire in early 2003 as inspection has not been possible. The lower slopes and lesser fuel loads on this karst probably mean that fire intensities were not high and thus impacts may not have been high. The catchment geometry means that erosion and sediment deposition will probably not be an issue.

Significance

The significance of the Indi karst is local to regional (Table 1). Although some research on the geomorphology of the karst and its regional setting has been undertaken, the results have not been published.

The regional level of significance here arises from the perched watertable, the possible palaeoclimatic significance of the clay sediments, and the associations with Aboriginal prehistory (Spate 1993). The area has not been adequately surveyed for its biospeleological attributes, especially aquatic invertebrates.

Dependence

The ongoing stability of this area is dependent on the maintenance of soils and vegetation of the site.

Condition and trend in condition

The condition of the area is generally stable apart from the spread of dense thickets of blackberry along the Murray River and some problems with other woody weeds. Feral animals may be a problem.

Closure of the Murray River vehicular crossing has allowed for some improvement in the area's condition.

Pressures

The spread of weeds is an ongoing issue. As was demonstrated several years ago, fire suppression activities may present problems, as the values of the area are not well known. Remoteness and unfettered access have resulted in some excessive visitor impacts such as rubbish, graffiti and un-needed 4WD tracks.

Knowledge gaps

The biospeleological aspects deserve further attention. Documentation of the European history might prove of interest. For example, it would be interesting to know who McHardie (of McHardie's Flat) was.

Opportunities

The need for weed control, especially along the river, is demonstrable, but such control is probably impossible. Only closure of the Victorian track would seem to offer options for better regulation of the use of the caves. Some gating might be used to protect some parts of some caves but the remoteness means that the required inspection and maintenance are probably not going to occur.

Indicators and monitoring

The remoteness of the area means that almost all cave use is unregulated and the levels of use are unknown. Thus some monitoring of cave condition is required. Monitoring and control of weeds and feral animals are also required.

Cowombat Flat

Description

Cowombat Flat, precisely on the border between Victoria and New South Wales, possesses a few small dolines, demonstrating that there are both soluble rocks and a subterranean drainage system. A karst system must be present, albeit in an area of only a hectare or so. The NSW part is within the Pilot Wilderness and the 1982 Murray Headwaters Management Unit.

It is not known if this area was significantly affected by wildfire in early 2003 as inspection has not been possible. The lower slopes and lesser fuel loads on this karst probably mean that fire intensities were not high and thus impacts may not have been high. The catchment geometry means that erosion and sediment deposition will probably not be an issue.

Significance

The area's significance is at the local level.

Dependence

As in all karst areas, there is a need to maintain soils and vegetation in their natural condition.

Condition and trend in condition

I have not visited this area for many years so cannot provide a definitive statement about the area's condition other than to say that it was in good condition in the mid 1980s, with some modification resulting from human activities.

As both sides of the state border are now within defined wilderness areas, and vehicular access is barred, the condition of this area should improve if weeds and feral animals are held in check.

Pressures

Pressures on the area arise from weeds, horses, pigs, remoteness, ignorance and cross-border management differences.

Knowledge gaps

The remoteness, setting and site mean that we know virtually nothing about the karst, karst processes or biological attributes of this site. It has a low priority for research into karst.

Opportunities

Weeds and feral animals should be controlled as necessary. Continued control of vehicular access and maintenance of the tree lines (where humans have planted trees) are also recommended.

Indicators and monitoring

Monitoring of weeds, feral animals and tree lines is needed.

Ravine (O'Hares Creek–Lobs Hole)

Description

Although there is a great deal of limestone at Ravine, most is very thinly bedded, flaggy or impure and thus karst features are generally absent although there are persistent rumours of caves and one photograph of a cave entrance alleged to be on O'Hares Creek has been seen by the author. Andrews (1991) and Dunkley (2002) have discussed the journals of Granville W C Stapylton that contain a reference to "*Limestone Rock and Entrance to Caves*" in 1833. These caves have now been relocated (Spate and Spate in press). Searching over many years has not revealed any caves in the Devonian limestones although some small holes have been reported since the 2003 fires in the O'Hares Creek catchment (Tony Stubbs pers. comm.).

Groundwater has dissolved calcium carbonate from the Devonian limestones. This has been re-deposited in a number of places where the waters of the ephemeral streams tumble over the cliffs of the Milk Shanty Walls. In these sites, there are large tufa banks containing some caves of construction, massive stalactites and other karst forms (Spate and Spate, in press). Better intelligence and easy access following the January 2003 fires has revealed a number of small caves, including one about 20 metres long, containing significant speleothems, small mammal bones and possible some evidence of use by indigenous people. The fires have also revealed a suite of tufa terraces several hundred metres long partially buried by soil – possibly mobilised by European landuse practices.

These may be the largest deposits of tufa south of Far North Queensland. They have probably been deposited very recently — through the Quaternary Period (the last 2 million years). They are certainly the largest suites of this sort of constructural karst landscape in New South Wales.

Ravine has been highly disturbed by grazing, mining, recreational use, timber cutting, fire and weed invasion. It appears to be somewhat of a rain shadow area and soils are generally infertile.

The limestones lie within the 1982 Tumut Management Unit (Management of Natural Values).

Significance

The karst significance of this area appears to reside entirely in the massive tufa deposits and caves of construction that are considered to be of regional or wider significance (Table 1). It may be that the tufa preserves some record of vegetation and hence climatic change. The fossiliferous Lickhole Limestone is one of two sites identified as 'Geological Sites of Significance' by the Geological Society of Australia (NSW Division) within Kosciuszko National Park.

Dependence

The ongoing stability (and indeed preservation) of the tufa deposits requires the continuing supply of dissolved limestone from the Devonian limestones. This in turn requires stable catchment conditions without major changes in evapotranspiration rates. The occupation of the tufa deposits by blackberries may lead to their destruction.

Condition and trend in condition

The condition of this area is reasonable to poor and is deteriorating under the influence of past clearing, grazing and inappropriate fire regimes, and through the invasion of weeds as a result of these disturbances. The weed problem is particularly acute.

Pressures

The main pressure is from weeds: blackberries are claiming the tufa deposits.

Knowledge gaps

The tufa deposits have not been investigated for any evidence of vegetation or climate change. More study of these Quaternary landscape features is warranted.

Opportunities

A very intensive weed control program is required for the conservation of the karst and non-karst values of the Ravine area. The level of disturbance since the mid-1860s means that re-forestation is needed.

Indicators and monitoring

The weed problem is beyond monitoring; weed control action is required at a level considerably above current activity.

Conclusions

The conclusions of this brief survey of the karst resources and their significance in Kosciuszko National Park are as follows:

- each of the areas has some level of significance, and together they contribute to a high value for Kosciuszko's karst;
- there are many potential avenues for research activities, especially in the areas of landscape development and environmental and climatic change;
- there is some need for ongoing research, primarily in the biospeleological aspects;
- there is a park-wide need for better methods of control - and application of those methods - to address the very substantial weed problem in all areas, with the possible exception of Cooinbil;
- feral animals are an issue in some karst areas; and
- current cave access policies and practices are generally adequate. It is probably desirable that cave visitor use for all karst areas is managed centrally from Yarrangobilly Caves. Clearly, on-ground management at Indi would remain within the purview of Jindabyne Region.

Acknowledgments

I would like to thank the many cavers academics, researchers, NPWS staff and local residents who have assisted me in so many ways over the 40-odd years that I have been working within Kosciuszko National Park and its surrounds. They are too many to list individually, and any attempt to do so would inevitably result in accidental omissions.

However, I would particularly like to thank Jo Ingarfield, Manager, Yarrangobilly Caves, and Jane Gough, Karst Officer, Southern Conservation Programs and Planning Division, for their very considerable assistance over the past five years and for their inputs to this discussion paper. Input from my fellow members of the Independent Scientific Committee is also acknowledged.