Natural Values

Cultural Values

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Chapter 9
flora values

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Vegetation above the tree line

Introduction

The area above the tree line in Kosciuszko National Park, extending from about 1830 m to 2228 m at the summit of Mount Kosciuszko, covers some 250 square kilometres (Good 1992). Although this is only about 10% of the total area of snow country in the Australian Alps as a whole, it constitutes by far the largest truly alpine area on the mainland and includes the largest contiguous area of alpine vegetation (Good 1992, Green and Osborne 1994). Its assemblage of plant communities is found nowhere else in the world and has attracted attention from scientists and others since Europeans first ascended the alps around 1830 (Costin 1989, Good 1992).

The vegetation includes herbfields, heaths, bogs and fens, as well as very restricted areas of feldmark and snow patch communities, each with its distinctive assemblage of species, many of them unique to Kosciuszko (Costin et al 2000). The position of each community in the alpine landscape is controlled by the distribution of snow and groundwater, which in turn are determined by the physiography (Costin 1954, Costin et al 2000, Wimbush and Costin,1983).

Because of the limited flowering season, there are massed displays of wildflowers in the summer months that attract an ever-increasing number of visitors (Worboys and Pickering 2002). Less well known, but equally attractive, are the contrasting hues of the different vegetation patches in the autumn.

"Kosciuszko National Park's assemblage of plant communities is found nowhere else in the world."

Basis for management

Section 2A(1)(a) of the *NSW National Parks and Wildlife Act 1974* clearly states the objectives of the Act to be: the conservation of nature, including (i) habitat, ecosystems and ecosystem processes and (ii) biological diversity at the community, species and genetic levels.

Under the management principles for national parks (section 30E), the Act repeatedly emphasises the principle of conserving biodiversity and protecting the ecological integrity of ecosystems.

The objectives of plans of management (section 72AA) include: (b) the conservation of biodiversity, including the maintenance of habitat, ecosystems and populations of threatened species, and (g) the maintenance of natural processes.

Significance

The alpine areas of Kosciusko National Park are of international significance. They are a world-class example of mid-latitude alps, of which there are few in the southern hemisphere. They are also unusual in the development of alpine humus soils on a gently rounded landscape (Costin 1954, Good 1992).

The vegetation contains some 204 species of flowering plants, of which at least 21 are endemic and 33 are rare (Costin et al 2000). A list of species considered significant in Kosciuszko National Park is presented in Attachment 9A.

The alpine area is of critical importance nationally as it is the part of the water catchment area of the Snowy Mountains that receives the highest precipitation (Good 1992).

Dependence

Most of the plant community types that occupy the alpine areas of Kosciuszko National Park are present elsewhere in the Australian Alps, but nowhere else are they as well represented or present in so large a scale (Costin et al 2000). Much of the Victorian high country is still grazed by cattle; consequently the vegetation is highly modified (McDougall 1982, Walsh et al 1994). The 21 species endemic to Kosciuszko National Park are, by definition, totally dependent on the park for their existence (Costin et al 2000).

Condition and trend in condition

Much of the area was damaged by grazing in the days of snow leases, but since the leases were withdrawn and soil conservation work was completed there has been some recovery, especially of the tall herbfields (Wimbush and Costin 1979c, Good 1992, Scherrer et al, in press). Loss of topsoil on parts of the main range has caused a change in vegetation that is virtually permanent, with feldmark species colonising bare erosion pavements (Wimbush and Costin, 1979c). On the edges of these areas the remaining alpine humus profile is still subject to erosion and needs further conservation work. However, most of the vegetation on the Kosciuszko plateau has achieved a relatively stable state, with changes being cyclic in response to short-term changes in climate (Scherrer et al, in press). An exception is the continuing increase in some species such as Ribbony Grass (*Chionochloa frigida)* and the Anemone Buttercup (*Ranunculus anemoneus)* that were greatly reduced under stocking (Rath 1999, Costin et al 2000).

The northern area of the Kosciuszko plateau was withdrawn from grazing in 1944. Legal grazing continued for a further 14 years, and illegal grazing above the tree line for somewhat longer (Good 1992, Worboys and Pickering 2002). Subsequent changes to the vegetation have been monitored in a limited number of sites and these changes appear to be continuing, particularly in the recovery of *Sphagnum* bogs and the change from a grazing-induced disclimax short herbfield to tall herbfield (Scherrer et al, in press; authors' personal observations).

Pressures

The main and immediate pressure on the alpine vegetation in Kosciuszko National Park is the increasing number of people visiting the area in the summer (Pickering et al, in press, Scherrer and Pickering 2001, Worboys and Pickering 2002). The number of visitors in winter is low and of low impact, though over-snow service vehicles have the potential to damage vegetation when snow cover is light. However, by the summer of 1982, the passage of feet causing multiple track erosion prompted a radical solution: the construction of a raised steel walkway between Thredbo top station and Rawson Pass. Although the walkway solved the track erosion problem, it encouraged larger numbers of people to visit the summit, and also made access to other areas easier (Worboys and Pickering 2002).

The increasing foot traffic on and around the main range will inevitably cause similar damage in other places unless a great deal of attention is paid to the siting and maintenance of tracks and the education of visitors in their use (Worboys and Pickering 2002). Damage is already evident, for example, on the track between Charlotte Pass and Mount Stillwell, and the track between the Snowy River Bridge and the Crackenback chairlift. Another example of visitor damage is the popular Lakes Walk, which traverses the rare windswept feldmark, interrupting the slow march of prostrate shrubs downwind across the community (Good 1992).

Other threats to the vegetation include feral horses, which increasingly invade the alpine area in summer. The direct effects of trampling and selective grazing are becoming evident. There are also pressures from hares on the alpine communities. Weed invasion is another threat that has escalated over the years, with new species being recorded every time weeds are surveyed (Mallen 1986, Johnston and Pickering 2001a).

Opportunities

A number of management issues need to be addressed in order to improve the current condition and trends in condition of the flora values of the park. These issues include the following priorities:

- elimination of horses from the alpine area is both essential and achievable, in order to protect sensitive species and communities and their ecological integrity;
- control of exotic plants, particularly recent invaders such as yarrow (Johnstone and Pickering 2001b) — some invaders that are largely confined to disturbed areas (eg track verges) may be reduced, but it is unlikely that they can be eliminated (Johnston and Pickering 2002);
- restriction of the numbers of walkers in peak visitor periods is a possibility, particularly at the Thredbo end of the walkway (Worboys and Pickering 2002); and
- improvements in visitor education concerning the sensitivity of the alpine landscape, and interpretation of alpine vegetation pattern and process (Worboys and Pickering 2002).

Knowledge gaps

Global warming may affect the Kosciuszko National Park alpine plant communities in unknown ways. Concern has been expressed about decreasing snow deposition and its effects on the communities that depend on snowdrifts (Good 1998, Pickering and Armstrong 2000).

There are many gaps in knowledge about the ecology and taxonomy of Australian alpine plants and their relationships to plants in other countries (Smith 1986, Costin et al 2000).

Indicators and monitoring

Permanent transects in tall herbfield, sod tussock grassland and heath over the last 42 years have produced results that elucidate changes in vegetation due to short-term climate fluctuation as well as recovery from livestock grazing. It would be useful to maintain these transects and remeasure them periodically.

Long-term monitoring of snow patch vegetation using permanent reference points could give warning of long-term changes in climate.

Tree lines

Introduction

Tree lines are the boundaries between areas dominated by trees and those in which trees are absent. They may occur where summer warmth is insufficient to support the growth of trees (Daubenmire 1954, Wardle 1974), or may occur as a result of tree kill by ponded cold air (Slatyer 1989) or suppression of tree growth by waterlogging (Gilfedder 1988). Also, trees may be excluded because their establishment is reduced by competing dense tussock grasses on the better soils of flats (Fensham and Kirkpatrick 1992).

Significance

Internationally significant ecophysiological work has been undertaken on the tree lines of Kosciuszko National Park (eg Slatyer 1976, 1989). The upper slope tree lines are amongst few in the world in which the wooded side is dominated by open-crowned evergreen angiosperms (Kirkpatrick 1994b). The same characteristic applies to the inverted tree lines that are so well developed in the park. Good (1992) and Banks (2002) have suggested that Kosciuszko National Park has the most outstanding development of subalpine treeless flats and valleys in the world, because of its relatively deep soils, gentle topography and tree species that are not particularly frost resistant.

The schedule of significant features for Kosciuszko National Park (set up under section 8.1.4 of the 1988 plan of management) classifies long term (> 20 years) scientific study sites, such as those on the tree line, as extremely significant. The tree lines of Kosciuszko National Park have state significance because they are the only upper slope tree lines in New South Wales (NSW), and are the best examples of inverted tree lines in the state. Similarly, they are likely to have national significance as the best examples of tree lines in Australia, and possibly also international significance as the best examples of a structurally unusual type of tree line.

Dependence

Because the upper slope tree lines of Kosciuszko National Park are the only ones in NSW, the conservation of this ecological phenomenon in the state is totally dependent on activities within the park. Inverted tree lines can be found elsewhere in NSW (eg Barrington Tops and New England), but most of their length is in the Kosciuszko National Park.

At a national level, eucalypt-dominated upper slope tree lines are also found in Victoria and Tasmania. However, their best development is in Kosciuszko National Park. Inverted tree lines caused by cold air ponding do occur in Victoria (eg Wearne and Morgan 2001), but do not seem to occur in Tasmania, where other factors are apparently responsible for treelessness in the subalpine zone (Gilfedder 1988, Fensham and Kirkpatrick 1992).

Condition and trend in condition

Most of the tree lines of the park are intact as structural features. However, during the grazing era a substantial length of natural inverted tree line was eliminated through ringbarking of trees and burning of the forest (Banks 2002). There has been relatively little reinvasion of trees into these areas (Wimbush and Costin 1979ab, Banks 2002). On the treeless side of the tree line, the vegetation is still in the process of recovery from grazing (Wimbush and Costin 1979bc, Costin et al 2000). In general, the tree lines are in the process of recovery, the main exception being where they have been cleared for ski runs. Little (2000) has suggested that particular soil calcium and manganese concentrations can be used to discriminate between areas that supported trees before the grazing era and those that did not. Soil microtopography and extrapolation along contours from surviving tree lines are other methods that could be used to locate the original tree lines. If such a reconstruction were achieved, improvement in the condition of tree lines could be measured in terms of the proportion of the tree line being structurally intact.

The desired outcome would be an increased proportion of structurally intact tree lines.

Pressures

Clearance for ski runs is the major threat to tree lines, in both the present and the future.

Opportunities

Where no trees exist within dispersal distance of cleared areas, it may be possible to restore tree lines opportunistically by sowing the seed of local tree species after severe fire events.

Knowledge gaps

There is a need for research to establish the exact location of pre-European tree lines in areas where they have been destroyed.

Subalpine areas and frost hollows

Introduction

Subalpine areas in Kosciuszko National Park cover a total of about 1627 square kilometres comprising nearly 24% of the park (Good 1992). They are dominated by Snow Gum (*Eucalyptus niphophila)*, and occupy a band between about 1400 m altitude, the upper limit of montane forests and the climatic tree line at about 1860 m (Good 1992).

Associated eucalypts of considerable scientific importance but occurring in a small area, and which are usually marginally subalpine, include the mallees *E. perriniana* and *E. kybeanensis*, *E. stellulata*, *E. debeuzevillei*, *E. lacrimans* and *E. rubida.* The last two of the species in this list occur in frost hollows.

Treeless frost hollows occur with inverted tree lines around their margins where there are broad valleys with restricted exits for the drainage of cold air within the subalpine area and extending into the upper montane tract (Slayter 1989). Bogs, fens, heaths and grasslands are associated with these hollows and are also found in other subalpine areas.

Significance

Subalpine woodlands in Australia are unique in that they are dominated exclusively by broad-leaved evergreen species, whereas in most other countries, conifers and deciduous species form the tree line (Good 1992). They occur elsewhere in NSW (eg Barrington Tops) and in the Australian Capital Territory (ACT), Victoria and Tasmania, but those in the Kosciuszko National Park are of national significance because they are by far the largest.

Frost hollows that concentrate and retain cold air are particularly well developed in the Kosciuszko National Park due to the gently sloping terrain over much of the park. Alps elsewhere in the world usually have steep-sided, deeply dissected valleys (Slayter 1989). Moreover, examples of frost hollows in the Kosciuszko National Park span nearly the complete spectrum of altitudes, from near the tree line, where the vegetation is barely distinguishable from alpine vegetation in its floristics, to montane examples with very different characteristics. The subalpine, montane and lowland tussock grasslands (*Themeda triandra)* in the valley bottoms have high conservation significance because of the severe loss of this vegetation type elsewhere. The *Poa* tussock grasslands on carbonate rocks in the north of the park are among the best examples of this type of vegetation. The Kosciuszko National Park frost hollows therefore have a high degree of national significance.

The subalpine ecosystems at Kosciuszko provide habitat for a number of rare animal species. Two examples are the Mountain Pygmy-possum in *Podocarpus* heath, and the Corroboree Frogs in *Sphagnum* bogs (Green and Osborne 1994). These ecosystems are therefore of international significance.

Together with the alpine areas of the park, the subalpine areas are of critical importance in southeast Australia as water catchments and for this reason alone should be protected from disturbance and pollution.

The park conserves a hydrologic complex that is essential to the well-being of the country, from the major snowfields of the main range through alpine and subalpine groundwater areas and woodlands that trap snow and cloud, to the montane forests that stabilise the steep slopes of the eastern and western escarpments (Costin et al 1960, Costin et al 1961, Costin et al 1964, Costin and Wimbush 1961, Good 1992).

Dependence

While not exclusive to Kosciuszko National Park, subalpine woodlands and frost hollows are best represented in the park. The frost hollows are unique among conserved areas in containing populations of *E. lacrimans*, together with other endemic species (Good 1992).

Current condition and trends

As with many alpine areas at Kosciuszko, the subalpine tract suffered extensive damage from burning and grazing during the first 100-odd years of European occupation (Costin 1954, Costin et al 1959, Wimbush and Costin 1979a, 1979b, Good 1992). The damage included large areas of deforestation where livestock prevented the regeneration of Snow Gums after hot wildfires. Since 1958, when leases were withdrawn above 1400 m, the trend has been one of slow but steady recovery. Areas occupied by tussock grasses in 1958 are still covered in both grasses and a greatly increased number of other herbs. Areas denuded of vegetation are now largely occupied by shrub species. Where some topsoil remained, there was a slow decrease in shrubs and an increase in herbs, but where the soil profile had eroded down to pavement, shrubs seem likely to persist.

In some instances, subalpine groundwater areas have seen an increase in bog mosses and shrubs as streamlines became blocked and the watertable was raised locally. However, many streamlines were deeply eroded and have reached a new entrenchment that is unlikely to be reversed without active conservation work (Wimbush and Costin, 1983).

Pressures

As with the alpine areas, the main pressures on subalpine sections of the park come from increasing tourism, both in the ski fields and in the back country. The ski fields are at present all situated below the tree line and provide concentrations of resident and non-resident tourists in both summer and winter (Buckley et al 2000). The tourists can be a threat to subalpine ecosystems both within and around the lease areas through tracking, soil compaction, faecal contamination, demands on water and destruction of aesthetic amenity (Buckley et al 2000).

The combination of an apparent long-term downward trend in snow depth plus the increasing numbers of recreational downhill skiers means that there will inevitably be a threat to areas adjacent to the present lease areas from ski field operators wishing to extend their leases.

With back-country pressures, there are conflicts between nature conservation and recreation, particularly in wilderness areas. Among these conflicts are disturbance effects that favour weeds and feral animals (Johnston and Pickering 2001a).

Various aqueducts constructed by the Snowy Mountains Hydro-Electric Authority capture subalpine streams and lead them into high-altitude dams. Examples are the Perisher Range, Falls Creek, Rams Flat and Munyang River aqueducts leading to Guthega dam, and the Goodradigbee River aqueduct leading to Tantangara reservoir. These stream diversions alter both riparian and aquatic ecosystems. It could be argued that these aqueducts do not contribute to irrigation water, since they are well above the major diversion points, and add only a small proportion to hydroelectric capacity.

As in the alpine areas, encroaching weeds (mainly associated with disturbance) remain a constant threat, which is even greater at these lower altitudes. Serrated Tussock, Yarrow, Broom, Cat's Ear and various clovers are among many weeds present in numbers now past the possibility of eradication (Johnston and Pickering 2001a). Broom in particular poses a continuing threat to biodiversity and ecological integrity, as can be seen, for example, in the Barrington Tops National Park.

Feral horses and pigs pose an increasing threat to ecosystems. Rooting pigs can cause much disturbance, particularly in frost hollows (Green and Osborne 1994). Rabbits are well established in the lower subalpine tract in such areas as Kiandra and Snowy Plains where snow depths are not generally sufficient to prevent them from digging out of their burrows (Leigh et al, 1987). In areas such as roadsides, rabbits are able to push into higher country where snow clearing occurs.

Knowledge gaps

In describing the flora of a subalpine frost hollow, several species of particular conservation and/or taxonomic significance are listed in a recent paper (McDougall and Walsh, in press). Other frost hollows in Kosciuszko National Park have not been well studied and it is likely that their flora would also be of interest.

Opportunities

Protection of the Kosciuszko National Park subalpine flora depends upon a number of priority issues. These issues must be addressed within the new plan of management and assigned appropriate objectives and aims. Some issues for the subalpine areas are listed below.

- There are previously wooded areas where, through lack of recruitment, trees are still absent (Miller 2002). Some of these areas have been planted with tube stock grown from local seed, and the trees are now flourishing. This work could be continued.

- Streams such as Dicky Cooper Creek and Spencers Creek could be progressively semi-blocked in their headwaters using permeable barriers. This measure would reduce further erosion, increase sedimentation and raise watertables, thus encouraging the spread of valley bogs.

- Only a very small percentage of Snow Gum woodland in the park can be regarded as old growth. Most of it is in a seral state after top-kill by fire (Gill et al 1973, .Good 1973, Wimbush and Forrester 1988). Succession towards old-growth woodland would be improved by management measures aimed at keeping fires out of the subalpine tract in the park. Such measures would also encourage secondary succession in subordinate strata where pyric shrubs have partly replaced herbaceous species.

- Closure of high-level aqueducts would restore subalpine stream ecosystems. There is some water already allocated for montane streams for this purpose, stemming from the Snowy corporatisation process.

- Feral horses, pigs, goats and deer should be eradicated from the alpine and subalpine areas. Rabbit and fox numbers should be reduced as far as possible, and the most aggressive weeds should be controlled.

- Skifield lease boundaries should be permanent and not subject to review and associated clearing should be carried out in such a way that it does not further affect subalpine communities or species.

- The inclusion of the remaining portion of Snowy Plains still outside the park boundary would conserve virtually all high-level frost hollows and complete the altitudinal series. This inclusion would obviously be dependent upon availability.

Indicators and monitoring

Subalpine vegetation transects were established in the Guthega catchment in 1959 and measurements were continued for 20 years (Wimbush and Costin 1979ab), spanning eroded tussock, treeless areas and intact woodland. Some of these transects could be relocated and remeasured to give an accurate picture of long-term change in parts of the subalpine landscape.

A periodic low-level aerial photographic survey of areas under particular pressure, such as those within and surrounding ski fields, would give valuable information. For example, advance warning could be given of walking tracks proliferating due to the summer use of ski lifts.

An extremely telling way to monitor change is simply to locate the sites of old photographs, retake them periodically and assess any changes.

Lower Snowy Valley

The general sequence of environments in Kosciuszko National Park — an extensive north–south plateau of alpine/subalpine snow country steepening both on the western and eastern sides through montane forests to fringing tablelands — is deeply incised by the lower Snowy River south of Dalgety as it turns first westwards then southwards towards the Tasman Sea. The scenery of the Lower Snowy Valley is spectacular.

The juxtaposition of elevated cold moist watershed and the lower dry and warm valley produces ecosystems and groups and sequences of ecosystems not found elsewhere in the park, or as well developed elsewhere in Australia.

Of particular interest are the xeromorphic-mesothermal White Box (*E. albens*)–White Cypress Pine (*Callitris glaucophylla*) (box–pine) ecosystems within the valley. Although geographically isolated from coastal and inland areas, they show great affinities with both areas. They are also in close proximity to tableland, montane and subalpine ecosystems of the park. White box woodlands in the wheat/sheep belt are under extreme pressure and have recently been listed as endangered ecological communities under the *Environment Protection and Biodiversity Conservation Act 1999.* The box–pine community is considered by some ecologists to be a relict of earlier more widespread climatic conditions, still preserved within the refugium of the Snowy Valley.

On the steep western slopes of the valley, the usual more extensive sequence of subalpine woodland, wet sclerophyll forest and dry sclerophyll forest is telescoped into a few kilometres before passing into the box–pine woodlands and scrubs. By contrast, on the up-slope sequence on the drier eastern side of the valley, the dry sclerophyll forest persists above the box–pine vegetation but with patches of 'black scrub' or 'Byadbo scrub' characterised by *Acacia silvestris* and other species, also found near the NSW south coast.

The aquatic environment of the lower Snowy River, although now much modified by upstream dams and diversions above Jindabyne, is also unusual within the Kosciuszko National Park. Several short, fast-flowing, cold-water subalpine rivers (eg Jacobs River, Pinch River and Ingegoodbee River) discharge directly into the warmer waters of the lower Snowy River itself. Headwater diversions of these rivers have been considered.

The natural values of the Lower Snowy Valley are enhanced by their Aboriginal and early-European cultural history. The valley was an important living area and corridor for Aboriginal people (Scougall 1991). It also provided the exploration route from the Monaro into East Gippsland, soon followed by southward land occupation and increasing livestock movement between the two regions. Before about 1900, the box–pine woodlands apparently were more open and grassy with stable soils, but with livestock grazing and invasion by rabbits, the steeper slopes lost their ground cover and topsoil. With a decline in rabbits, the box–pine woodlands were partly replaced by dense regenerating stands of pine scrub. With little topsoil now remaining in which a protective grassy cover can reestablish itself, soil stability (now precarious) depends on the accumulation of leaf and bark remains on the surface. For this accumulation to happen, 'no fire' management is needed (Pulsford 1991). On the other hand, localised occasional fire may be necessary to regenerate the 'black scrubs'(Clayton-Greene and Wimbush 1988).

The river ecosystem has also been changed by the upstream diversion of most of its waters, especially the snow melt waters which caused strong freshes or flooding in the Lower Snowy Valley every year. Lack of regular flooding has also been associated with large changes in the extent and composition of the riparian scrubs along the river including invasion and spread of willows and other exotic weeds. The recent decision to increase Snowy River flows by 28% may ameliorate this situation but is unlikely to reverse it unless other weed control measures are also adopted.

Despite these partly irreversible changes in the terrestrial and aquatic ecosystems, the Lower Snowy Valley contains some of the most outstanding natural and cultural resources of the park, certainly of local and national and arguably of international importance.

The eucalypts — an ecological overview

Costin (1989) noted that southeastern Australia was unique in the world, in that one genus of trees, *Eucalyptus*, dominated the landscape continuously from sea level to the upper slope tree line, with many species of eucalypt replacing each other in altitudinal sequence, rather than species from different genera. Eucalypts are uniquely and characteristically Australian, possessing a globally unusual set of adaptations and ecological relationships, and also a globally outstanding propensity to evolve through wide and rapid radiation, adaptation and hybridisation (Kirkpatrick et al 1987, Costin 1989, Williams and Woinarski 1997).

Some of the ecological sequences are outlined below, with emphasis on the eucalypt communities that provide the strongest unifying thread. The longest sequences are those from north to south of the park along the main axes of the Fiery Range and Great Dividing Range. These are mostly sample subalpine woodland and high-montane sclerophyll forest, and reflect the limited altitudinal range. The west to east transects ascending from the moist western side of the mountains across the high divide then descending the drier eastern side are more complex (NPWS 2002).

The major sequence — from Kosciuszko eastwards towards the coast — starts with narrow fringing woodlands of Black Sally *(E. stellulata)* and Broad-leaved Sally *(E. camphora)* along the Geehi and Upper Murray rivers. On the steep ascent there is dry sclerophyll forest on drier slopes — Brittle Gum *(E. mannifera)*, Red Stringybark *(E. macrorhyncha)* and Broad-leaved Peppermint *(E. dives*). Then there is a broad band of wet sclerophyll forest of two main types, the lower belt including Ribbon Gum *(E. viminalis)*, Brown Barrel *(E. fastigata)*, Eurabbie *(E. bicostata)* and Narrow-leaved Peppermint *(E. robertsonii)*; and the upper belt Alpine Ash *(E. delegatensis)*, Mountain Gum *(E. dalrympleana)*, White Sally *(E. pauciflora)* and the rarer Bogong Gum *(E. chapmaniana)*. Within the wet sclerophyll forest belt, for example, near Geehi, there are patches of cool temperate rainforest with Sassafras *(Atherosperma moschatum)*.

Above the sclerophyll forest there is a steep, narrow belt of subalpine woodland and scrub of Snow Gum, then the complex of alpine vegetation along the main range beyond the tree line before the more gradual descent through snow gum woodland and sclerophyll forest on the drier eastern side. Here, the upper wet sclerophyll forest communities contain less Alpine Ash and the lower wet sclerophyll forest belt is largely replaced by dry sclerophyll forest of Broad-leaved Peppermint and Candlebark *(E. rubida)*. Associated savannah woodland on the gentler slopes contains White Sally, Candlebark and Ribbon Gum.

To the south, the Lower Snowy Valley descends steeply to elevations as low as 225 m above sea level, enclosing a drier and warmer environment with mesothermal woodlands and scrubs not found elsewhere in the park. Important species include White Box, Bundy *(E. goniocalyx)*, Yellow Box *(E. melliodora)*, Apple Box *(E. bridgesiana)*, White Cypress Pine, Currawang *(Acacia doratoxylon)*, Coast Myall *(A. binervia)* and Bodalla Wattle *(A. silvestris)*.

The steep ascent of the eastern (west-facing) slopes of the Lower Snowy Valley is through woodland and dry and wet sclerophyll forest, including a few stands of Alpine Ash around Mount Tingaringy, and approaches the easternmost occurrence of this species (Delegate Mountain). On the elevated (1448 m) marginally subalpine summit of Mount Tingaringy itself there is a disjunct patch of the wet mallee Tingaringy Gum *(E. glaucescens)*. The descent from Tingaringy approaches the southeast boundary of Kosciuszko National Park near the southern Monaro tableland around Delegate, with remnants of savannah woodland of White Sally and associated species.

Not far distant are the Snowy River, Erinundra and Coopracambra National Parks of Victoria and the South-east Forests National Park of New South Wales, containing sclerophyll forests rich in coastal eucalypt species, and the Croajingalong (Victoria), Nadgee and Ben Boyd (NSW) reserves along the NSW–Victorian coastline. Although other regions of Australia may contain more eucalypt species than the Kosciuszko- to-coast corridor, it is ecologically richest, with eucalypts able to exploit every habitat available to trees from climatic tree line to the ocean coastline. No other genus of trees has been shown to do this. The wide adaptive capacity of the genus *Eucalyptus* reflects the continuous gene flow within and between its species, providing suitable genetic combinations able to take advantage of almost any ecological challenge that might arise.

The eucalypts show responses to environmental gradients similar to those described earlier in the main zones of vegetation. There is also systematic variation at the species level, as seen in the various forms of what was formerly known as *E. pauciflora* sens lat. The normal woodland ecotype is clinally related to the taller forest form, the extreme cold air plain form (*E. lacrimans*), the large-fruited form (*E. debeuzevillei*) and the subalpine form (*E. niphophila*). Some of the old-growth Snow Gums on Mount Bimberi near the Kosciuszko National Park–Namadgi National Park border record in their growth rings and fire scars several centuries of ecological history (Banks 1987).

Basis for management

Eucalypt-dominated communities are natural features created by ecosystem processes. They are also rich in biodiversity. Thus their protection is an objective of the *National Parks and Wildlife Act 1974* under section 2A (1)(a). Section 30E (2)(a) makes the conservation of biodiversity, natural phenomena and landscapes a principle in national park management. Section 72A (1)(g) makes the maintenance of natural phenomena and processes a matter that should be considered in the drafting of a management plan.

The sequence from tree line to the sea would satisfy criteria 1 (a) for national significance, in that it is important in the pattern of Australia's natural history. It satisfies the definitional criterion (i) in that it is constituted of a group of biological formations that is of outstanding universal significance from the scientific point of view. It also satisfies listing criterion (ii) in that is an outstanding example of ongoing ecological and biological processes in the evolution and development of communities of plants and animals.

Dependence

The ‘snow country’ (alpine and subalpine areas) of Kosciuszko National Park, especially the main range area around Mount Kosciuszko itself, is a focal attraction both for scientific study and for mountain recreation (Barlow 1989, Good 1989, 1992, Green 1998, Buckley et al 2002, Worboys and Pickering 2002). These attractions tend to obscure the scientific significance and appreciation of other natural environments of the park, particularly the forest and woodland ecosystems below the winter snowline. These ecosystems occupy both a larger area than those of the snow country and extend through a greater altitudinal range. Furthermore, their contiguity or near-contiguity with other national parks and reserves in NSW, Victoria and the ACT extends them geographically from the inland across the Great Dividing Range to the south-east coastline. Superimposed on this broad climatically controlled pattern are the further variations associated with differences in geology, topography and soils. Such a comprehensive continuum of near-natural environments largely protected as national park has few parallels elsewhere in the world.

A more northerly west to east transect across the Tumut River near Ravine through Yarrangobilly and across the headwaters of the upper Murrumbidgee–upper Goodradigbee to Namadgi National Park in the ACT provides other examples of the Kosciuszko National Park’s ecological diversity. In this example, the high-elevation alpine environment is lacking, but cold air plains with inverted tree lines are better developed. Geological variation is greater, from acid granites and metasediments to basic basalt and limestone, with corresponding differences in some of the ecosystems. For example, the cold air plain near Cooleman contains few *Sphagnum* bogs, presumably because of free drainage of groundwater through the limestone, but on the limestone itself there is a richer moss flora.

The recognition of the summit to sea ecological story by national or international legal processes does not necessarily depend on the inclusion of Kosciuszko National Park, because the same sequence is found in Victoria. However, the case for listing would be strongest with the inclusion of all the Australian alps (Kirkpatrick 1994b).

Significance

Kosciuszko National Park has more than 30 eucalypt species, distributed from the western foothills of the Great Dividing Range to the rain shadow valley of the Snowy River. It contains a large part of the catena of eucalypts from the tree line to the sea that many have argued is of outstanding universal significance (Costin 1989, Good 1992, Busby 1990, Kirkpatrick 1993, Mosley and Costin 1992 and others).

The Blue Mountains area was successfully nominated for world heritage listing, largely because it was considered to be the best example, in a state of high integrity, of the diversity of eucalypts and the communities they dominated. In the process of nomination the World Conservation Union (IUCN) suggested that a serial listing, including the Australian alps and other areas, might be more appropriate than the Blue Mountains by themselves. The Australian government replied that it could achieve the effect of such a serial nomination through its national listing process under the *Environmental Protection and Biodiversity Conservation Act 1999*. There therefore is little doubt that the tree line to sea story has both international and national significance.

Condition and trend in condition

Most of the eucalypt forest and woodland in the Kosciuszko National Park has a minor component of introduced animal or plant species, and a large proportion has been structurally changed by high fire incidence and stock grazing. There is relatively little old-growth forest compared with the likely situation in the mid-eighteenth century (Good 1992). If stock grazing was totally excluded and fires less frequent, Kosciuszko National Park would be on a trajectory back to its probable mid-eighteenth century condition.

Trend in condition might thus be best measured by the proportion of old-growth eucalypt forest and woodland, with the management goal being to have this increase to pre-European levels, a necessarily protracted process.

Pressures

Eucalypts are regarded by many as one of the world's most important groups of trees. But the Achilles heel of the genus is its seed. The small size and high density of the seed limit dispersal to within a few tree-heights of the parent tree, and short seed longevity implies that even small areas that completely lose their tree cover may be unable to regenerate naturally other than by the slow peripheral spread from more distant communities. Genetic interchange between separated communities is also broken. This is why the large continuous sequences of eucalypt communities are of such ecological value and importance, with the potential of extending them further via other reserves.

Fire regimes that cause the death of older eucalypts are a threat to the transition to old growth. Invasion of exotic species is another threat associated with inappropriate fire regimes.

Opportunities

The preservation of the ecosytems of the Kosciuszko National Park, intact and in continuity, and hopefully in conjunction with the ecosystems of associated parks and reserves, is arguably the greatest safeguard to biodiversity in southeastern Australia, and is also of significance at national and international levels.

National and international recognition of the importance of the eucalypt forests and woodlands is possible.

Knowledge gaps

The fire regime requirements for a transition towards old growth need to be determined for some of the montane and lowland eucalypt dominated communities.

Indicators and monitoring

The proportion of old-growth eucalypt forest and woodland to total eucalypt forest and woodland is an appropriate indicator, and could be measured every decade. Sets of permanent plots in which the occurrence of exotics will be monitored every three years will be established randomly within eucalypt forest and woodland easily accessible by road. The data will relate to signs of exotic vertebrate animals (eg scats and prints) and broad cover classes for exotic plants.

Once a reconstruction is achieved, the indicator will be the proportion of original tree line that is structurally intact, to be monitored once a decade.

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Attachment 9A: Significant plant species of Kosciuszko National Park

Species	***Threatened Species Conservation Act 1995***	***Environment Protection and Biodiversity Conservation Act 1999***	**Endemic to Kosciuszko National Park**	**Plan of management significant feature**	**All NSW populations in Kosciuszko National Park**	**Alpine**	**Subalpine**	**Montane**	**Low total number of plants (< 1000)**	**Small number. of populations (< 10)**
Abrotanella nivigena				S	✔	✔				
Acacia dallachiana				S	✔			✔		
Aciphylla glacialis				S	✔	✔				
Agrostis joyceae			✔				✔			
Agrostis muelleriana				S	✔	✔				
Agrostis thompsoniae					✔	✔				
Asperula euryphylla					✔					
Astelia alpina var. novae-hollandiae					✔	✔	✔			
Astelia psychrocharis			✔	S		✔				
Astrotricha sp. 4					✔			✔	✔	✔
Bertya findlayi				S	✔			✔		
Brachyscome stolonifera			✔			✔				
Brachyscome tadgellii			✔	S		✔	✔			

E = Endangered V = Vulnerable, Vs = Very significant, H = High significance, S = Significant

Species	*Threatened Species Conservation Act 1995*	*Environment Protection and Biodiversity Conservation Act 1999*	Endemic to Kosciuszko National Park	Plan of management significant feature	All NSW populations in Kosciuszko National Park	Alpine	Subalpine	Montane	Low total number of plants (< 1000)	Small number. of populations (< 10)
Brachyscome tenuiscapa var. tenuiscapa					✔	✔				
Calotis glandulosa	V	V		Vs			✔			
Calotis pubescens	E				✔		✔		✔	✔
Caltha introloba					✔	✔				
Cardamine sp. A2			✔			✔				
Carex archeri					✔	✔				✔
Carex canescens					✔	✔				
Carex cephalotes			S	✔	✔	✔				
Carex hypandra				S	✔	✔				
Carex jackiana					✔	✔	✔			
Carex raleighii	E			H	✔	✔	✔			✔
Carpha alpina					✔	✔				
Carpha nivicola					✔	✔	✔			
Celmisia costiniana					✔	✔				
Chiloglottis cornuta					✔		✔			
Chionochloa frigida			✔	Vs		✔				
Chionogentias muelleriana subsp. alpestris			✔		✔					
Chionohebe densifolia				Vs	✔	✔				
Colobanthus affinis				✔	✔	✔				
Colobanthus nivicola			✔	Vs		✔				
Colobenthus pulvinatus			✔	Vs		✔				
Coprosma niphophila			✔	Vs		✔				
Coprosma nivalis					✔		✔			
Correa lawrenciana var. rosea			✔				✔	✔		
Craspedia alba				S	✔	✔				
Craspedia costiniana			✔	S		✔				
Craspedia lamicola				S	✔	✔				
Craspedia leucantha			✔	Vs		✔				
Craspedia maxgrayii			✔	S		✔				
Cystopteris tasmanica				S	✔	✔	✔			
Derwentia nivea					✔		✔			
Deyeuxia affinis				S	v	✔	✔			
Dichosciadium ranunculaceum					✔	✔				
Diplaspis nivis					✔	✔	✔			
Discaria nitida	V	V		H	✔		✔			

E = Endangered V = Vulnerable, Vs = Very significant, H = High significance, S = Significant

Species	*Threatened Species Conservation Act 1995*	*Environment Protection and Biodiversity Conservation Act 1999*	Endemic to Kosciuszko National Park	Plan of management significant feature	All NSW populations in Kosciuszko National Park	Alpine	Subalpine	Montane	Low total number of plants (< 1000)	Small number. of populations (< 10)
Drosera arcturi				✔	✔					
Epacris glacialis					✔	✔				
Epilobium curtisiae					✔		✔			
Epilobium sarmentaceum					✔	✔	✔			
Epilobium tasmanicum					✔	✔				
Erigeron paludicola					✔	✔				
Erigeron setosus			✔	Vs		✔				
Eucalyptus chapmaniana					✔			✔		
Eucalyptus lacrimans				S			✔			
Eucalyptus saxatilis	E	V		H	✔			✔	✔	✔
Euchiton argentifolius					✔	✔	✔			
Euchiton fordianus					✔	✔	✔			
Euchiton nitidulus	V	V		Vs	✔	✔	✔			
Euchiton poliochlorus					✔		✔			
Euchiton traversii					✔		✔			
Euphrasia alsa			✔	Vs		✔				
Euphrasia collina subsp. diversicolor					✔	✔	✔			
Euphrasia collina subsp. glacialis		✔	S		✔					
Euphrasia collina subsp. lapidosa		✔	S		✔					
Euphrasia sp. 3			✔	Vs		✔			✔	✔
Ewartia nubigena					✔	✔				
Galium roddii			✔	Vs			✔			✔
Genoplesium turfosum				Vs	✔		✔			
Geranium sessiliflorum subsp. brevicaule					✔		✔			
Gingidia algens			✔	S		✔	✔			
Glycine latrobeana		V			✔			✔	✔	✔
Grammitis poeppigiana					✔	✔				
Haloragis exalata subsp. exalata	V	V						✔		
Herpolirion novae-zelandiae					✔	✔	✔			
Hierochloe submutica				S	✔	✔				
Hovea sp. aff. heterophylla			✔				✔		✔	
Huperzia australiana					✔	✔	✔			
Irenepharsus magicus	E			H	✔			✔	✔	✔
Isolepis montivaga					✔	✔	✔			
Juncus antarcticus					✔	✔				
Juncus thompsonianus					✔	✔				
Kelleria dieffenbachii					✔	✔				

E = Endangered V = Vulnerable, Vs = Very significant, H = High significance, S = Significant

Species	***Threatened Species Conservation Act 1995***	***Environment Protection and Biodiversity Conservation Act 1999***	**Endemic to Kosciuszko National Park**	**Plan of management significant feature**	**All NSW populations in Kosciuszko National Park**	**Alpine**	**Subalpine**	**Montane**	**Low total number of plants (< 1000)**	**Small number. of populations (< 10)**
Leucopogon maccraei					✔		✔			
Luzula acutifolia subsp. nana			✔	S		✔				
Luzula alpestris					✔	✔				
Luzula atrata					✔	✔				
Luzula australasica subsp. dura			✔			✔				
Luzula novae-cambriae					✔	✔	✔			
Muehlenbeckia diclina subsp. stenophylla					✔			✔		✔
Olearia aglossa				S				✔		
Olearia lasiophylla			✔	Vs				✔		
Olearia stenophylla			✔				✔			✔
Oreobolus pumilio subsp. pumilio					✔	✔	✔			
Oreomyrrhis brevipes				S	✔	✔				
Oreomyrrhis pulvinifica					✔	✔				
Oschatzia cuneifolia				S	✔	✔	✔			
Pelargonium helmsii					✔	✔	✔			✔
Pentachondra pumila					✔	✔				
Phebalium ovatifolium			✔	S		✔	✔			
Pimelea alpina					✔	✔	✔			
Pimelea axiflora subsp. alpina					✔	✔				
Pimelea bracteata				S	✔		✔			
Plantago alpestris					✔		✔			
Plantago glacialis					✔	✔				
Poa fawcettiae					✔	✔	✔			
Poa petrophila				S	✔		✔			
Pomaderris cotoneaster	E	E		H				✔		
Pomaderris pallida	V	V		H				✔		
Prasophyllum retroflexum	V	V	✔				✔			
Ranunculus acrophilus			✔			✔				
Ranunculus anemoneus	V	V	✔			✔				
Ranunculus clivicola			✔	Vs			✔			
Ranunculus dissectifolius			✔	Vs		✔				
Ranunculus gunnianus					✔	✔	✔			
Ranunculus muelleri var. brevicaulis			✔			✔				
Ranunculus muelleri var. muelleri					✔	✔				
Ranunculus niphophilus			✔	Vs		✔				
Ranunculus productus			✔	Vs			✔			
Rytidosperma pumilum	V	V			✔	✔				✔

E = Endangered V = Vulnerable, Vs = Very significant, H = High significance, S = Significant

Species	*Threatened Species Conservation Act 1995*	*Environment Protection and Biodiversity Conservation Act 1999*	Endemic to Kosciuszko National Park	Plan of management significant feature	All NSW populations in Kosciuszko National Park	Alpine	Subalpine	Montane	Low total number of plants (< 1000)	Small number. of populations (< 10)
Rutidosis leiolepis	V	V		Vs			✔			
Rytidosperma australe					✔	✔				
Rytidosperma nivicola					✔	✔				
Schizeilema fragoseum					✔	✔				
Schoenus calyptratus					✔	✔	✔			
Scleranthus singuliflorus					✔	✔				
Senecio sp. 1 (Fl. Vict.)					✔	✔	✔			
Stackhousia pulvinaris					✔	✔				
Taraxacum aristum							✔			✔
Thesium australe	V	V		Vs			✔			
Trisetum spicatum subsp. australiense					✔	✔	✔			
Uncinia compacta					✔	✔				
Uncinia sinclairii					✔	✔				✔
Uncinia sulcata					✔	✔				
Wahlenbergia densifolia					✔		✔			

E = Endangered V = Vulnerable, Vs = Very significant, H = High significance, S = Significant

Attachment 9B: Regional Context of Vegetation Communities in Kosciuszko National Park.

After: Thomas, V, Gellie, N, and Harrison, T. (2000) *Forest Ecosystem Classification and Mapping for the Southern CRA Region*. A report undertaken for the NSW CRA/RFA Steering Committee, Project No NS 08EH.

Non-alpine communities Number in brackets, ie: (157) refer to forest ecosystem classifications used in the CRA mapping process.	**Total area in park (ha)**	**Total area extant (ha)**	**Total original area (ha)**	**Reserved area (ha)**	**% extant in park**	**% of original cleared**	**% extant reserved**
ACT/Monaro dry grassland (157)	2	289	84,685	2	1	100	1
Bogong gum Western escarpment shrub/grass forest (88)	587	587	587	587	100	0	100
Central tableland/ACT montane dry shrub forest (107)	586	36,301	607,98	3842	2	40	11
Central tablelands shrub/grass dry forest (76)	8623	39,908	111,951	8672	22	64	22
Eastern tableland dry shrub/grass forest (73)	282	72,286	266,778	2139	0	73	3
Kosciuszko western escarpment cool temperate rainforest (172)	106	106	106	106	100	0	100
Lower Snowy dry shrub/tussock grass forest (77)	42,974	69,920	74,513	42974	61	6	61
Lower Snowy rain shadow woodland/shrubland (41)	345	705	705	345	49	0	49
Lower Snowy white box dry shrub/herb woodland (78)	33,684	37,392	41,277	31,805	90	9	85
Montane/subalpine dry rocky shrubland (36)	2660	3038	3040	2699	88	0	89
Montane acacia/dry shrub/herb/grass forest (97)	49,740	81,896	84,082	51,541	61	3	63
Montane dry shrub/herb/grass forest (99)	6293	17,060	17,080	8698	37	0	51
Montane dry shrub/tussock forest (106)	28,454	29,543	30,126	28,454	96	2	96
Montane riparian moist shrub/grass/herb forest (83)	10	945	973	238	1	3	25
Montane riparian moist shrub/sedge/grass/forest (85)	230	5010	5094	652	5	2	13
Montane wet heath/bog (123)	162	892	892	872	18	0	98
Montane wet heath/herb grassland (125)	0	312	313	19	0	0	6
Northern slopes dry grass woodland (160)	4	12,902	335,030	102	0	96	1
North-western montane dry shrub/herb/grass forest (101)	18,390	41,243	42,858 1	8,390	45	4	45
South coast and Byadbo acacia scrubs (35)	1191	3980	3981	876	30	0	47

Non-alpine communities Number in brackets, ie: (157) refer to forest ecosystem classifications used in the CRA mapping process.	**Total area in park (ha)**	**Total area extant (ha)**	**Total original area (ha)**	**Reserved area (ha)**	**% extant in park**	**% of original cleared**	**% extant reserved**
Southeastern dry shrub/grass/herb forest (74)	6	50,223	131,522	2453	0	62	5
Subalpine dry shrub/herb/grass woodland (127)	74	1144	1144	178	6	0	16
Subalpine dry shrub/herb woodland (128)	41,174	45,870	45,943	41,009	90	0	89
Subalpine herbfield (131) - complex of various communities	32,736	32,810	35,100	32,677	100	7	100
Subalpine shrub/grass woodland (130)	65,979	66,429	66,925	66,000	99	1	99
Tableland acacia/herb/grass forest (104)	29,530	41,113	46,452	28,382	72	11	69
Tableland acacia moist herb forest (95)	9316	36,537	46,816	12,515	25	22	34
Tableland and escarpment wet layered shrub forest (58)	4022	21,891	23,331	12,028	18	6	55
Tableland dry heath shrub/herb/grass woodland (38)	242	1629	1636	782	15	0	48
Tableland dry herb/grass woodland (146)	278	2111	11,124	241	13	81	11
Tableland tussock grassland/ sedgelend/woodland (148)	1	307	15,646	1	0	79	0
Tablelands dry shrub/grass forest (110)	860	18,475	22,252	2612	5	17	14
Tablelands shrub/tussock grass forest (75)	14,131	4635	43,810	17,418	41	21	50
Western escarpment dry shrub forest (70)	1180	1567	1578	1180	75	1	75
Western escarpment moist shrub/herb/grass forest (87)	54,751	69,708	69,860	54,751	79	0	79
Western montane acacia fern/herb forest (82)	66,508	105,000	163,642	64,526	63	36	61
Western montane dry fern/grass forest (103)	20,386	49,502	74,061	25,502	41	33	52
Western montane moist shrub forest (98)	46,307	81,333	86,082	47,692	57	6	59
Western montane wet heath/herb grass woodland (124)	136	4390	5527	76	3	21	2
Western slopes grass/herb dry forest (121)	8042	68,732	104,415	11,637	12	34	17
Western subalpine moist shrub forest (86)	4043	4060	4061	4044	100	0	100
Western tableland dry shrub forest (71)	457	769	1487	457	59	48	59
Western tablelands dry herb/grass forest (108)	28,087	75,053	25,092	25,423	37	40	34

Non-alpine communities Number in brackets, ie: (157) refer to forest ecosystem classifications used in the CRA mapping process.	**Total area in park (ha)**	**Total area extant (ha)**	**Total original area (ha)**	**Reserved area (ha)**	**% extant in park**	**% of original cleared**	**% extant reserved**
Western tablelands dry shrub/grass forest (119)	4	36,146 1	36,156	4	0	73	0
Western tablelands herb/grass dry forest (93)	9506	32,412	85,523	506	29	2	29
Tall heath	2168	2168	2168	2168	100	0	100
Tall alpine herbfield (Poa — Celmisia)	5298	5298	298	5298	100	0	100
Tall Alpine Herbfield (Brachyscome - Austrodanthonia)	616	616	616	616	100	0	100
Fens and bogs	558	558	558	558	100	0	100
Feldmark (Epacris — Chionohebe)	162	162	162	162	100	0	100
Short alpine herbfield	78	78	78	78	100	0	100
Feldmark (Coprosma — Colobanthus)	27	27	27	27	100	0	100
Short heath	265	265	265	265	100	0	100

Source: Costin, A. et al (2000)