Chapter 8

aquatic values

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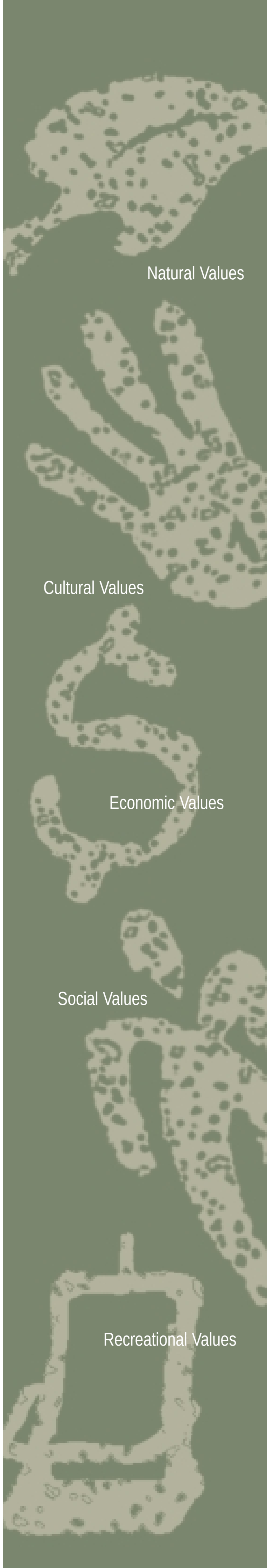
Freshwater habitats in Kosciuszko National Park comprise rivers, lakes (plus underground water bodies) and dams. I will deal with the values of each of these ecosystems separately, primarily from a biological point of view. Previously, freshwater habitats have not been specifically considered in management plans for Kosciuszko National Park (Cullen and Norris 1989), despite the fact that the water catchments, and hence water quality, of the region were of central concern for development of the Snowy Mountains Hydro Electric Scheme. The headwaters of the Murray, Murrumbidgee, Tumut, Swampy Plains and Snowy rivers all lie within Kosciuszko National Park. These rivers are highly important economically as they provide irrigation water and hydroelectricity.

The Scheme captures and diverts the headwaters of 12 rivers and 71 creeks (SMA, 1992: plan diagrams). This capture and diversion totals 99% of the stream flows in the Snowy Mountains area (SMA, 1993). The natural flows in the affected streams are therefore greatly reduced, and in some rivers the timing of flow has also been changed by the operation of the Scheme (Bevitt et al, 1998). These changes to natural stream flow have greatly affected the geomorphology and ecology of these rivers and streams (Bevitt et al, 1998).

"Previously, freshwater habitats have not been specifically considered in management plans for Kosciuszko National Park."



Lakes

Basis for management

Lakes are discrete and clearly recognised habitats. One of the objects of the *NSW National Parks and Wildlife Act 1974* is the conservation of habitats. A management principle stated in the Act is to protect and conserve 'outstanding or representative ecosystems' and an objective of a plan of management (defined in the Act) is 'the conservation of biodiversity, including the maintenance of habitat'. By all these criteria, lakes in Kosciuszko National Park fit the definition of objects that require conservation and management. Furthermore, one lake (Blue Lake) is also listed under the Ramsar Convention, which is an international treaty for the conservation and of wetlands, of which Australia is a signatory. The management objectives for this area are listed under the *Environmental Protection and Biodiversity Conservation* (EPBC) Act.

Significance

The are four small (1.6–14.4 ha) natural lakes in Kosciuszko National Park (Albina, Blue, Club and Cootapatamba). These are unique in that they are the only lakes on the Australian mainland that were formed by glacial action. (Tasmania is the only other region in Australia to have glacially-formed lakes.) Thus, at the state, regional or park scales, these glacially formed lakes are significant habitats; they are also the highest lakes (1890–2070 m) in Australia. Such alpine or glacially formed lakes are, however, not unique or uncommon on an international or national scale; they occur widely in Tasmania (Boulton and Brock 1999) and in the northern hemisphere (Europe, North America, Asia and Africa), New Zealand and South America. Blue Lake and the associated smaller water body of Hedley Tarn (see below) are also considered significant as RAMSAR Wetlands and as such recognised as having international significance.

There are some other small natural lakes in Kosciuszko National Park. Hedley Tarn is downstream from Blue Lake, on the stream that connects both water bodies to the upper Snowy River. Two further lakes, both less than one hectare, are found in the north of Kosciuszko National Park. Both are associated with karst systems and are dolines (karst depressions) fed by ephemeral streams. 'Bung Harris Dam' is found at Cooleman Plain and is part of the integrated karst drainage system rising at Blue Waterholes. The other, unnamed, is several hundred metres to the west of the Jounama pine plantation. Its karstic affinities are unclear. Nothing is known about the ecology of any of these lakes, although the two northern lakes contain trout (A Spate, Optimal Karst Management, pers comm, September 2002).

There are a number of subterranean water bodies within Kosciuszko National Park, the most obvious being those associated with karst systems, which are discussed more fully by A Spate in Chapter 7. Cooleman Plain is of at least state, and possibly higher, significance as a result of its relatively rich aquatic invertebrate fauna (Thurgate et al 2001). Hyporheic systems (underground water in the gravels and sands underlying and adjoining rivers and streams) are widespread, but their communities, let alone ecology, have not been investigated within Kosciuszko National Park. The same comment applies to the potential ecosystems dependent on the deep leads underneath the basalt flows in the northern parts of the park.

Dependence

As these are the only glacial lakes on the mainland, their continued existence undisturbed by human development relies strongly on their inclusion in Kosciuszko National Park. It is very probable that if they were anywhere other than in a national park their nutrient status (see below) at least would be altered. The northern lakes are dependent on unchanged karst hydrological regimes.

Condition and trend in condition

Physicochemical measurements indicate that water in all the alpine lakes is very fresh, with extremely low salinities (< 3 ppm), slight acidity (pH (6.0–6.2) and very low levels of nutrients (Williams et al 1970). No other lakes in mainland Australia have lower salinities, and few glacial lakes anywhere are as dilute. The low nutrient levels are comparable with those measured in highland regions in the United States and United Kingdom. Salinity records taken in the late 1960s and early 1980s in Lake Cootapatamba are virtually identical (Benzie 1984).

The only section of the aquatic biota to have been examined in detail in these lakes is the invertebrate community. Approximately 8–11 species of benthic invertebrates have been identified from deep (0.5–26 m) regions of these lakes and 15–26 species from samples taken in the shallow littoral region (Timms 1980a,, Hancock et al 2000). Littoral samples were taken in December and March; benthic samples were taken once in January. In one lake (Cootapatamba), seasonal observations during the ice-free period have also been made on the zooplankton. Eight planktonic species were recorded over two ice-free seasons (Benzie 1984).

The invertebrates in these lakes are typically found in other upland regions in south-eastern Australia, and species richness is comparable to that of highland lakes in Tasmania (Timms 1980b,, Hancock et al 2000). Species richness is higher in lowland lakes and in many northern hemisphere lakes with similar rocky shorelines. It is thought that this relative impoverishment is a result of the small size of these lakes. Two of the lakes (Blue and Club) contain native fish (Mountain Galaxias) and their benthic fauna is dominated by aquatic insects and molluscs (largely bivalves). The two fishless lakes are dominated by crustaceans (isopods and amphipods). None of the invertebrate species currently recognised is confined solely to these lakes. There is however a species of mayfly (*Tillyardophlebia alpina*) that appears to be confined to the lakes and streams of the Kosciuszko region. Future taxonomic work may well modify this conclusion.

No indication of seasonal variation in the benthic fauna can be given because sampling has occurred only in summer. In Lake Cootapatamba, zooplankton densities were highest in March and declined to zero before the lake froze. Long-term variations in these assemblages are unknown. However, a species of oligochaete worm, first discovered in Blue Lake in 1906, was found in that lake, Club Lake, Lake Cootapatamba and nearby rivers in 1992 (Pinder and Brinkhurst 1997). This species was not found by Timms (1980a) or Hancock et al (2000) during their surveys, indicating that some of the invertebrate species may be cryptic but present over long periods. Such irregularities demonstrate the difficulty of providing complete species lists of the benthic invertebrate fauna from any particular survey. Recent sampling in January 2002 in Lake Cootapatamba (BV Timms, University of Newcastle, pers comm, July 2002) confirms the presence of this oligochaete. The benthic species composition of this lake was essentially unchanged from that found in earlier studies.

It is thus not possible to come to any specific conclusions about temporal trends in the invertebrate fauna of these lakes. Given the nature of the habitat and the current very low concentrations of nutrients and ions, it seems unlikely that marked changes in physicochemical conditions have occurred since European settlement. As both the benthic and planktonic communities would be sensitive to changes in these conditions, it is reasonable to suggest that neither of these assemblages has changed greatly in the last 200 years as a result of changes in water quality.

However, random changes in species composition cannot be excluded.

Developed karst hydrologic systems are found in all the karst areas of Kosciuszko National Park. Only those at Cooleman and Yarrangobilly have been examined for aquatic taxa — and not all systems in those areas have been surveyed even at a reconnaissance level (Eberhard and Spate 1995, Thurgate et al 2001). Cooleman, in common with a number of the other major karst systems within New South Wales, has an aquatic fauna that includes a number of undescribed crustaceans, including isopods, amphipods, copepods and, very significantly, a syncarid (Eberhard and Spate 1995, Thurgate et al 2001). Cooleman ranks third, behind Wombeyan and Jenolan, in terms of aquatic invertebrate richness, and there are probable endemics. Surprisingly, the same cannot be said of Yarrangobilly in spite of greater survey effort there (A Spate, Optimal Karst Management, pers comm, September 2002). Taxonomic knowledge of this fauna is incomplete, but it seems likely that endemic species with restricted distributions are present and that these species are essentially confined to subterranean habitats.

Pressures

Very low concentrations of ions and nutrients have been recorded in these lakes. Disturbance in their catchments may cause nutrient release, which in turn may cause changes in the composition of aquatic biota. Apparently, there has been some release of septic tank effluent into Lake Albina (Timms 1980a), and both this lake and Blue Lake have fairly large amounts of decomposed leaves and twigs in bottom sediments. It does not appear that such inputs of organic material have caused major changes in the benthic invertebrate fauna compared with that found in the other two lakes.

Two of the lakes also contain native fish, whose presence has apparently resulted in changes to the dominant invertebrate taxa. If trout were introduced to any of the lakes, substantial changes to invertebrate species composition could be expected based on what has happened to such fauna in Tasmanian highland lakes (Williams 1974, Knott et al 1978). It is also possible that trout may eliminate the native galaxiids in the lakes, much as they have done in rivers (Campbell et al 1986).

Knowledge gaps

As emphasised above, little seasonal and no long-term data on species composition is available for the benthic fauna. Sampling of at least the littoral zone of the four lakes once every few years in summer would be feasible, would indicate how stable these assemblages are (data that are sorely lacking from most freshwater habitats in Australia), and might give some idea whether climate change is affecting lakes in Kosciuszko National Park.

Opportunities

Trout in the lakes may cause large changes to benthic species composition. There should be regular checks for the presence of trout, and they should be removed if found. Regular water quality measurements (as indicated below), particularly of nutrients, would indicate whether changes to the catchments of the lakes are occurring.

Indicators and monitoring

The benthic invertebrate fauna is the obvious biotic indicator for the lakes. It would also be useful to monitor aspects of water quality such as conductivity, pH and nutrients, which may provide early warning of problems, as noted above.

Dams

A number of reservoirs or large dams (constructed by the Snowy Mountains Hydro-Electric Authority) occur within Kosciuszko National Park. Information on the water quality of some of these dams is available (Bowling 1995) but it seems that no data on their biota have been obtained. In fact, the limnology of very few of the many human-made lakes in Australia has been examined. Those few that have been studied are quite different from each other in size, depth, location and many other features; it would be pointless trying to generalise. About all that can be said is that the benthic diversity of dams is poor, and certainly lower than found in natural lakes (Timms 1980b).

Given this lack of knowledge, there is little that can be said under any of the headings used above for lakes. The dams could not be considered as significant habitats under any of the scales of measurement. There are more than 450 large dams in Australia. Recent work in south-eastern Australia (Marchant and Hehir 2002) has shown that large dams inevitably cause disruption to downstream invertebrate communities, probably because they act as barriers to recolonisation of river reaches that have been disrupted by the associated engineering works. It is also well known (Boulton and Brock 1999) that water quality problems (eg low water temperatures, low oxygen concentrations and high levels of toxins such as hydrogen sulfide) can occur below deep dams that release bottom water. As the Kosciuszko National Park dams probably release bottom water, the quality of their discharges should be monitored.

Streams and rivers

Introduction

An expert panel was commissioned in 1998 to assess the environmental flows of various rivers affected by the Snowy Mountains Scheme (Bevitt et al 1998). They concluded that:

- The Snowy Mountains Scheme has affected the hydrological, geomorphological and ecological condition of many streams in the Snowy Mountains. These impacts are particularly severe in the Tumut, Eucumbene, Snowy and Gungarlin Rivers and some of the reaches of the Tooma and Geehi Rivers.

The impacts of the scheme on stream flow in most of these rivers are:

- reduced flood frequency and magnitude;
- reduced volumes of flows at all times;
- reduced seasonal flow variability; and
- in some cases, unnaturally rapid and aseasonal changes in water levels from power station releases.

The geomorphological outcomes of these changes to stream hydrology have been:

- channel contraction due to reduced discharge;
- lack of channel adjustment to reduced flows in some reaches, resulting in isolation of the channel from riparian vegetation;
- loss of rapids, chutes and riffles in many reaches; and
- lateral isolation of pools and sedimentation.

The impacts of the hydrologic changes on water quality are greatest in the pool sections of streams, and include:

- warmer summer water temperatures and freezing over winter because of the reduced flows;
  lower dissolved oxygen;
- nutrient concentration due to low flows;
- high algal productivity; and
- anoxia and stratification in the Tumut and Eucumbene Rivers.

Ecological integrity has been greatly affected by the Scheme, both directly (through the changes to the natural flow regime) and indirectly (through the impacts of changes to hydrology, geomorphology and water quality). Macroinvertebrate communities have changed from lotic to lentic in many areas where flow, habitat and water quality have changed those typical of a mountain stream to those typical of a lake or lowland stream. This indicates that important ecological processes have been disrupted, and ecological integrity is low. This is clearly not conducive to the conservation of native fauna in a National Park. (Bevitt et al, 1998, p92).

The assessment that follows assumes that these effects will continue as prescribed by the Snowy Corporatisation process (Heads of Agreement, 6/12/200).

Basis for management

As with lakes, the streams and rivers in Kosciuszko National Park fit the definition of objects in the *National Parks and Wildlife Act* that require conservation and management. They are discrete aquatic habitats that are easily recognised. In spite of this, river managers today generally acknowledge that the whole of the catchment is the unit of management rather than just the river itself. This approach recognises that activities anywhere in a catchment can ultimately affect the quality of running water habitats.

Significance

The alpine rivers in Kosciuszko National Park are not obviously significant at state or national levels, given that alpine running waters are found elsewhere in New South Wales (NSW) and in Victoria and Tasmania. At an international level, all Australian alpine rivers are significant because they form only a very small percentage of running waters nationally and they harbour a number of endemic species of aquatic insect and other invertebrates. On a world scale, alpine rivers are not scarce; they are common, for example, in Europe (Alps, Pyrenees, Norway) and North America (Rocky Mountains), where many are fed by glaciers.

All the large rivers in Kosciuszko National Park (Snowy, Murrumbidgee, Tumut, Swampy Plain) are dammed either within the park or just outside the park boundary. In some cases extensive reaches of riverine habitat have been inundated (for example, 50 km of the Tumut River are submerged by Blowering and Talbingo dams). Thus Campbell et al (1986) concluded that large rivers above altitudes of 900 m could be considered an endangered habitat in the Snowy Mountains region. Small streams are still common in Kosciuszko National Park and surrounding regions.

Dependence

As noted above, rivers are an integral part of their catchment. Thus, to maintain a river in an undisturbed state requires that its catchment is also undisturbed. In this sense rivers in Kosciuszko National Park are dependent on the state of their catchments within the park.

Condition and trend in condition

Measurements of water quality and biological condition have been taken in the Thredbo River for over 20 years (Norris et al 2002). Similar measurements have been made on various tributaries of the upper Snowy River since the early 1990s (Cunningham and Norris 2001). In all cases, the aim has been to detect whether the ski resorts in these areas and their attendant infrastructure such as car parks and sewage treatment plants (STPs) are having an impact on riverine ecosystems. Biological condition has been assessed by examining the composition of the stream invertebrate community, although observations have also been made on algal populations. Water quality has been assessed by measuring nutrient (phosphorus and nitrogen) levels and turbidity, electrical conductivity, pH and dissolved oxygen; all these variables are widely used as indicators of water quality. Since the mid-1990s it has also been possible to use the AUSRIVAS predictive models for assessing invertebrate composition. These models enable the macroinvertebrate fauna expected at a site to be predicted from measurements of a small number of environmental factors that are unaffected by human activities, such as longitude, altitude, distance of site from source, percentage of river bed composed of various sized stones and sediment. Predictions are based on the relationship between these factors and the macroinvertebrate fauna at a set of reference or minimally disturbed sites.

At least one site on each of the four tributaries of the upper Snowy River (Spencers Creek, Perisher Creek, Pipers Creek and Sawpit Creek) was assessed as impaired on a number of occasions. The first three creeks were more frequently contaminated than the last one (Cunningham and Norris 2001). Discharge from two STPs, plus run-off from resorts, roads and car parks, all contributed to this pattern. Road de-icing salt may also have been a factor, particularly at sites receiving run-off. At Sawpit Creek, the main source of contamination was a campground, but impairment was relatively less frequent. A site on the Thredbo River directly downstream of the Thredbo resort was also shown to be quite frequently impaired (Norris et al 2002), but two sites further downstream (and downstream of an STP) were usually in better condition. Water quality values at all sites were usually within recommended guidelines, but nutrient levels were elevated at sites below STPs on at least one occasion. Further details on water quality at these sites are given by Davies and Norris (1999).

The Kosciuszko National Park AUSRIVAS model used for assessing biological quality was more sensitive than water quality variables in detecting impairment, detecting about twice as many instances of impairment (Norris et al 2002). The model indicated that impairment was present if the ratio of the observed (O) number of taxa (in this case, families of aquatic insects such as mayflies, caddis flies, stoneflies, various beetles and dipterans, plus other invertebrates) to the expected (E) number of taxa (O/E score) was less than 0.86. At reference sites where there was no impairment, O/E averaged 1.0. Thus, impaired sites had lost at least 15% of the 11–15 families expected to occur at a site. Some of these families are known to be intolerant of sewage effluent. The O/E scores from the Thredbo AUSRIVAS model could be placed in four bands of progressively increased impairment. On most occasions, when impairment was detected it was considered mild; that is, O/E was in the first band (0.57–0.85) below the unimpaired band.

A single broad-scale survey of invertebrates in rivers throughout Kosciuszko National Park and in alpine parks in the Australian Capital Territory and Victoria has also been undertaken (Cooperative Research Centre for Freshwater Ecology 2000). In summer 2000, 79 reference sites and 16 test sites were sampled once; 59 of these sites were in Kosciuszko National Park. An alpine AUSRIVAS model (at the family level) for use throughout the high country of south-eastern Australia was developed, and enables the sites on the Thredbo and upper Snowy rivers to be put into a broader perspective. The expected number of families (16–19) at a site was somewhat higher than predicted by the Thredbo AUSRIVAS model, and impairment was evident when the O/E ratio was less than 0.85. The assessments for the Thredbo and upper Snowy sites were much the same as before. Sites below the three STPs and the ski resorts in Kosciuszko National Park were again judged to be mildly impaired, as was the site below a campground on Sawpit Creek; O/E ratios varied from 0.70 to 0.83. The model also demonstrated that sites in the Victorian Alps affected by cattle grazing had lower O/E ratios (0.50–0.71). A single site in Kosciuszko National Park used by brumbies as a watering hole had an O/E greater than the reference value (1.16), possibly due to mild nutrient enrichment leading to higher family diversity. Thus, deviations from the reference condition at sites on the Thredbo and upper Snowy rivers were not the most extreme encountered. Further work by a student using the alpine model (L Simpson and R Norris, Cooperative Research Centre for Freshwater Ecology, pers comm, September 2002) has demonstrated that stream modification from past grazing continues to disturb invertebrate communities, but not to the same extent as current grazing; and that the presence of brumbies also affects these communities.

Both the Kosciuszko National Park and the alpine AUSRIVAS models provide suitable standards against which to compare family composition at sites where some disturbance is suspected. The O/E scores also provide a measure that can be used to detect trends in disturbance. The evidence so far suggests that STPs on Spencers Creek and Perisher Creek create chronic sewage pollution, which has changed little in severity since monitoring began in the early 1990s. Effluent from the STP on the Thredbo River appears less damaging. The fact that more nutrients are removed at the Thredbo plant probably explains this difference (Norris et al 2002).

Both AUSRIVAS models are constructed for family level data and thus do not indicate what the genus or species level reactions to disturbance might be. As far as is known, there are no aquatic invertebrate species that are confined to rivers in Kosciuszko National Park (Campbell et al 1986), but it must be admitted that taxonomic knowledge of these groups is by no means complete, and species endemic to Kosciuszko National Park may yet be discovered. The mayfly mentioned above (in the section on lakes) is an example of an aquatic insect that may exist only in the rivers and lakes of the park.

Freshwater fish are the other obvious component of the riverine fauna in Kosciuszko National Park. Unfortunately no systematic distribution studies have been made either of fish in rivers near the resorts or on a wider scale throughout the park. However, during 1994–96 NSW Fisheries undertook a survey of freshwater fish at 80 sites in NSW (Harris and Gehrke 1997). Two of these sites were in Kosciuszko National Park. Five species of native fish (Short and Long-finned Eels, Climbing Galaxias, Australian Smelt and Congolli) and three species of introduced fish (Brown Trout, Rainbow Trout and Goldfish) were found at these two sites. Records from the Museum of Victoria and the Australian Museum, and from other sources (Tilzey 1976, Koehn 1990, Lintermans 1998), indicate that at least two other native species (Mountain Galaxias and Two-spined Blackfish) and two more introduced species (Mosquito fish and Redfin) occur in the park. None of the seven species of native fish is confined to Kosciuszko National Park and none appears endangered, each having an extensive distribution in southern Australia. Given the lack of systematic sampling for native species through time anywhere in Kosciuszko National

Park, it is not possible to discuss trends. However, Brown and Rainbow Trout, which were introduced to the Monaro region in 1888 and 1895 respectively (Tilzey 1976), are known to prey on various galaxiid species and probably compete with Two-spined Blackfish for benthic food, mostly invertebrates (McDowell 1996). Tilzey (1976) has produced compelling evidence that the distribution and abundance of both species of galaxiids in Kosciuszko National Park has been greatly altered since the arrival of trout.

Finally, it is worth noting that Platypus (Grant 1995) and Freshwater Crayfish (R Norris, Cooperative Research Centre for Freshwater Ecology, pers comm, September 2002) are known to occur in the Thredbo River; and probably occur throughout Kosciuszko National Park. Unfortunately nothing can be said about how or whether their distribution within the park has been affected by past and present disturbances within the park.

Pressures

As detailed above, effluent from STPs and run-off from ski resort areas are causing chronic, but generally mild, pollution of various streams within the park. Nutrients released in the effluent are the most likely culprit. As many alpine streams in south-eastern Australia, including those in Kosciuszko National Park, are not heavily shaded, increased growth of benthic algae is a very probable result of nutrient input into an ecosystem poor in nutrients. Run-off of road de-icing salt is also a potential problem for stream communities and has been shown in North America to cause increased drift of stream invertebrates (Crowther and Hynes 1977). Given the very low salinities recorded in rivers in Kosciuszko National Park (Cunningham and Norris 2001), saline inputs could impose additional stress on the stream biota.

The presence of two species of trout, probably throughout Kosciuszko National Park, may well threaten populations of native fish, especially galaxiids. Much of the damage was probably done when trout were first introduced over a century ago. Whether they are continuing to have a deleterious effect on native fish can only be determined by further investigation.

Annual burning and livestock grazing no longer occur within Kosciuszko National Park, although both wildfire and, at lower altitudes, hazard reduction burning do occur. However, the hydrological after-effects may continue to affect various rivers in the park. Wimbush and Costin (1983) have shown that creeks in Kosciuszko National Park continued to erode over a 20-year period after grazing and burning in the region ceased. However, there is no evidence that directly links such erosion with changes in lotic communities in Kosciuszko National Park. The input of sediment to streams (by erosion or other means) is widespread in many parts of the world, and excessive amounts impair benthic habitats that are vital for both invertebrate and fish life cycles (Waters 1995). Thus the potential for damage to these communities by sediment is present in Kosciuszko National Park even if actual damage has not yet been noted.

Highway construction at Yarrangobilly in the 1970s contributed enormous loads of fine sediments to the various cave systems, and the Yarrangobilly fauna may be depauperate as a result, because there are fewer molluscs and crustaceans in Yarrangobilly cave streams than would be expected (A Spate, Optimal Karst Management, pers comm, September 2002). Rainbow (1907) reported very large numbers of a collembolan in an unnamed cave (almost certainly River Cave) that are no longer present (A Spate, Optimal Karst Management, pers comm, September 2002).

Other hydrological and riparian changes have occurred as a result of European settlement of the region. The Snowy Mountains scheme has diverted water from the large rivers in the park, but much of this diversion actually takes place outside the park boundaries. Tributaries of these large rivers within Kosciuszko National Park have also been affected by this scheme. For example, the upper Snowy River, upstream of Lake Jindabyne, has had essentially all of its discharge diverted: flow below the Island Bend dam on this river has ceased completely except when the dam spills (Wimbush 1998, Bevitt et al 1998). Similar removal of flow has occurred in a number of rivers within the park, resulting in exposure of the riverbed for prolonged periods, invasion of the riverbed by riparian vegetation and consequent destruction of lotic habitat and organisms.

Riparian changes have occurred with the introduction of willows to many of the rivers of the park. The Tumut and Snowy Rrivers (especially downstream of Lake Jindabyne) have well established willows along many kilometres of bank (Wimbush 1998, Bevitt et al 1998). Along the Thredbo River, work to remove willows has recently begun. These exotic trees displace native riparian vegetation. Whether they have important effects on the aquatic habitat itself is less clear. Willow roots are known to encroach onto riverbeds, especially where flow has been reduced. However, studies in Tasmania (Read and Barmuta 1999) comparing benthic invertebrate communities in reaches lined with either willows or native vegetation have shown few differences.

Knowledge gaps

Streams and rivers have been examined only in small sections of Kosciuszko National Park. Park-wide surveys of freshwater invertebrates should be made, especially of groups such as mayflies, stoneflies and caddis flies, which are thought to be most sensitive to human disturbance. Such surveys should emphasise taxonomic aspects, as there may well be undescribed species in these groups that could be endemic to Kosciuszko National Park. Preliminary surveys of these taxa in small areas (around the Thredbo and upper Snowy rivers) have been made recently (Suter, La Trobe University, pers comm, July 2002), but more comprehensive collecting throughout Kosciuszko National Park is needed.

The broad-scale sampling of reference sites for the alpine AUSRIVAS model should also continue. The current model is based on collections from a single summer period. Additional sampling will increase the reference site database, which should improve the reliability of model predictions; and continued sampling may indicate the extent of any secular changes in benthic fauna due, for instance, to climate change.

Opportunities

If removal of nutrients from the effluent of the STPs at Charlotte Pass and Perisher can be achieved, this should noticeably reduce the degree of pollution in Spencers and Perisher creeks. Restrictions on, or banning of, the use of road de-icing salt should also be considered, or at least attempts should be made to demonstrate that current use is not causing unacceptably large increases in the salinity or conductivity of the rivers.

As there is good evidence that the introduction of trout has damaged native fish communities, stocking of streams with trout within Kosciuszko National Park should not be countenanced. Stocking of waters outside the park — such as Lake Eucumbene — that are fed by rivers from within (and that provide breeding habitat for trout from the lake) should at the very least be reduced. Stocking streams that contain populations of wild trout is ineffective and costly, and has been known to be so for at least 50 years (Pollard et al 1980, Davies et al 1988). Stocking trout in lakes can also cause problems: the trout fishery in Lake Eucumbene has suffered from a variety of management difficulties stemming from overpopulation of Brown Trout (Pollard et al 1980).

Currently, management of fish populations within Kosciuszko National Park (and probably other aquatic biota) rests with the NSW Department of Agriculture and Fisheries rather than NSW National Parks and Wildlife Service (NPWS). This institutional arrangement simply subverts any efforts to conserve freshwater ecosystems and their biota in Kosciuszko National Park, as noted by Cullen and Norris (1989); however, 13 years later, the arrangement is still in place (M Adams, NSW NPWS, pers comm, October 2002). Both the aquatic and terrestrial components of Kosciuszko National Park must be managed together by a single authority (in this case, obviously, the NSW NPWS), because, as has been noted above, activities anywhere in a catchment can ultimately affect aquatic ecosystems.

One outcome from the Snowy Mountains Corporatisation and Water Inquiry, is that there are 150 gigawatt/hours of water to be allocated to the montane streams of the Snowy Mountains (Heads of Agreement, 6/12/2000). More research and monitoring will be required to specify how and where this water should be allocated.

Indicators and monitoring

Water quality and benthic invertebrates are obvious indicators, and monitoring as described above should continue. The distribution of native fish within the park is poorly known. Knowledge of their distribution may enable some assessment of the degree to which this section of the fauna has been disrupted by introduced trout.

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