4. Climate change and other threats in the Australian Alps

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Abstract

The importance of protected areas will increase with the impact of climate change, with climate change adversely affecting natural ecosystems in Australia and globally. Unfortunately, climate change is also likely to show negative synergies with many existing threats to protected areas.

For the Australian Alps National Parks, which conserve most of mainland Australia's snow country, predicted increases in temperatures and changes in precipitation will result in a dramatic loss of snow cover. These changes will increase existing threats associated with loss of biodiversity, intensive fires, diversity and abundance of feral animals and plants, human demands on ecosystem services and tourism uses.

By recognising the range of possible negative synergies, managers in these and other protected areas will be able to prioritise control and amelioration measures. They will also need to reduce their own contribution to greenhouse gas production, and assist in increasing public awareness of just how great the threats are from climatic change.

Threats to protected areas in Australia

Globally and in Australia the priority for protected areas is conservation of the natural values (Lockwood *et al.* 2006). Threats to these natural values such as those from fire, weeds, pest animals, urban encroachment and climate change are all core issues for the effective management of protected areas (Worboys 2007).

Global temperatures have risen by approximately 0.74°C in the past 100 years with the Fourth Intergovernmental Panel on Climate Change (IPCC) reports predicting that without intervention this trend will continue (IPCC 2007a). By the end of this century global temperatures are predicted to increase by 1.8°C to 4°C with higher latitudes having the greatest warming (IPCC 2007a). It is predicted that climate change will cause major environmental and economic impacts particularly from increases in the frequency of extreme weather events such as bushfire, droughts, floods and heatwaves in Australia (Hughes 2003; Pittock 2003; IPCC 2007a,b).

In addition to global increases in surface temperatures, climate change is already affecting the alpine environments including: increase in the size of glacial lakes, reduction in the size and number of glaciers, increase erosion events in mountains and areas that had permafrost and changes in snow fall patterns (IPCC 2007a,b). Biological response include changes in the timing of event such as arrival of birds, butterflies, flowering of plants, changes in the distribution of species and resulting changes in biodiversity (Hughes 2003; Parmesan & Yohe 2003; Root *et al.* 2003; IPCC 2007b).

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Synergies between climate change and current threats to protected areas

Climate change will interact with many existing threats to protected areas, unfortunately usually resulting in even greater negative impacts on the environment. This includes increasing the threat from:

- Loss of biodiversity from increasing fragmentation of habitat, disturbances to ecosystem processes and/or alteration to the timing of events critical for species survival (migration patterns etc, Hughes 2003; Pittock 2003; Parmesan & Yohe 2003; Root *et al.* 2003; IPCC 2007b).
- Increase in risk of intense fires: Extreme fire events are predicted to increase in Australia as a result of climate change (Williams *et al.* 2001; Hughes 2003; Pittock 2003). In Australia the management of fires is a critical issue for protected areas. Fire directly affects ecosystems, with some impacts needing management responses. Fire control also diverts resources away from other management activities. This includes resources used for fighting fires, and also for replacing burnt park infrastructure and rehabilitating fire trials. There will also be an increased potential for fire to spread from protected areas into urban areas in high risk periods, with resulting political and economic repercussions for protected area managers.
- Increase in pests and weeds: Climate change will benefit species best adapted to disturbance (Hughes 2003). Weeds and feral animals already benefit from disturbance, with their spread in protected areas directly related to past and current human disturbance (Williams & West 2000). Climate change will directly alter the areas suitable for exotic species by altering climatic patterns. It will also result in increase in disturbances that benefit weeds and feral animals (fires and extreme weather events). Ecosystems will experience increased stress from climate change increasing their suitability to invasions by exotics.
- Increase in human demands on protected area ecosystem services: Protected areas worldwide and in Australia provide a wide range of ecosystem services for local and wider communities (Worboys *et al.* 2001; Lockwood *et al.* 2007). In Australia this includes acting as water catchments with the water then used for generating hydroelectricity as well as for drinking and irrigation (ISC 2004). They are important sources of soil conservation, preserving existing soils, and reducing erosion and risks of landslides (ISC 2004). They also act as CO_2 sinks. All these services will be put under additional stress by climate change.
- Change in demand for tourism activities: Current visitation to tourism destinations including protected areas is weather/climate dependent (Maddison 2001). Changes in climate including increased risk of extreme weather related events will alter the patterns of visitation (Maddison 2001). In some places this may result in reduced usage, or changes in the types of activities that occur, while in others it may result in increased usage — a “see the Great Barrier Reef while its still there” reaction (Maddison 2001).

Direct and indirect impacts of climate change on the Australian Alps National Parks illustrate many of these issues that apply broadly to protected areas in Australia and around the world.

Mountains and Climate Change

Mountains are recognized worldwide for their important economic, cultural and ecological values (Harmon & Worboys 2004; ISC 2004). For example, they are important water catchments receiving precipitation and channelling it to lowland areas where it can be used in agriculture, for domestic services and for industries (UNEP-WCMC 2002). Mountains are also popular tourist destinations valued for their pristine wilderness, dramatic landscapes and natural beauty. The flora and fauna of mountains are often rich in endemic species and act as important biodiversity reserves (Harmon & Worboys 2004).

Predicted climatic changes may threaten the values of mountain environments (UNEP-WCMC 2002; IPCC 2007a). Increased temperatures and changes in precipitation have already been documented in many mountain areas around the world. These are already changing the distributions of animal and plant species in some protected areas (Nagy *et al.* 2003; Pauli *et al.* 2006; IPCC 2007b).

Significance of the Australian Alps

Snow country in mainland Australia occurs in the southern section of the Great Dividing Range in the southeast of the continent. Known as the Australian Alps, this area is almost entirely conserved in a series of linked national parks and nature reserves that are cooperatively managed by authorities in Victoria, New South Wales and the Australian Capital Territory. The region is considered to be of world heritage standard (Kirkpatrick 1994), although a proposal for nomination has not yet been made. The largest of the national parks, Kosciusko National Park (KNP, 690 411 ha), has been classified as a UNESCO Biosphere Reserve based on the international significance of its natural values (ISC 2004).

As with many mountain regions around the world, there are economic values associated with the natural assets of the Australian Alps (Good 1992; ISC 2004; Mules *et al.* 2005). The region is a highly valued tourist destination, worth the order of $40 billion, with varying estimates of visitor numbers including over a million visitors to just one park, Kosciuszko National Park. Visitors generate considerable spill over revenue, supporting local businesses and communities (ISC 2004; Mules *et al.* 2005). Catchments also provide much of southeastern Australia with clean water, some of which is channelled into the Murray-Darling Basin (Good 1992b; ISC 2004). The hydroelectricity generated by water from the region is also a critical resource (ISC 2004).

Predictions of climate change in the Australian Alps

The Australian Greenhouse Office has identified the Australia Alps as particularly vulnerable to climate change impacts (Green 1998; Hughes 2003; Pittock 2003; Pickering *et al.* 2004). Snow is spatially and temporally limited in Australia, compared to Europe, north and south America (Costin *et al.* 2000). Approximately 0.15% of the continent receives regular winter snow falls (Costin *et al.* 2000). The most extensive snow covered areas are in the southeast of the continent in the Snowy Mountains in NSW, (around 2500 km^2). Of this only 1200 km^2 receives 60 or more days of snow cover and only 250 km^2 (or 0.0001% of Australia) is truly alpine (Green & Osborne 1994; Costin *et al.* 2000).

The latest climate change scenarios for the Australian Alps are based on the CSIRO temperature and prediction models for 2001 (Table 1). Based on these values, changes in temperature of +0.6°C under a low impact scenario and +2.9°C under a high impact scenario by 2050 are predicted (Hennessey *et al.* 2002). Consequent reductions in snow cover resulting from changes in temperature and precipitation in both scenarios will be dramatic. In the worst case scenario there will be a 96% reduction in the area that experiences more than two months snow cover a year.

These predictions have important implications for ski resorts with reductions of 30-40 days in the average season length by 2020 in the worst case scenarios. By 2050 under worst case scenarios, there are even more dramatic reductions in season duration by around 100 days, with only the highest ski resorts having season durations of more than ten days.

For the highest peak in Australia, the predicted changes in climate include a change in the duration of snow cover from around 183 days to 96-169 days by 2050. But even more dramatic is the change in the peak snow depth from over 2 m to under 50 cm under the worst case scenario by 2050 (Hennessy *et al.* 2002). Another way of viewing the change is to consider that +2.9°C is approximately the equivalent of a 377 m upward shift in the snowline (using a 0.77°C lapse rate: Brown & Millner 1989). Therefore under the worst case scenario in 43 years, conditions equivalent to the current tree line at around 1850 m altitude in the Snowy Mountains would be found a meter above the top of continental Australia's highest mountain, Mt Kosciuszko (2228 m).

Table 1. Best and worst case climate change scenarios for the Australian Alps as predicted change from conditions in 1990 (Hennessy *et al.* 2002)

	Best Case		Worst Case	
Change in	2020	2050	2020	2050
Temperature	+0.2^{o}C	+0.6 ^{o}C	+1.0 ^{o}C	+2.9^{o}C
Precipitation	+0.9%	+2.3%	-8.3%	-24%
Reduction in area with snow cover				
At least 30 days	14%	30%	54%	93%
At least 60 days	18%	38%	60%	96%

These predicted changes in climate are clearly likely to have dramatic affects on the natural values of the Australian Alps.

Synergies between climate change and threats in the Australian Alps

It has been predicted that a temperature increase of just 3^{o}C could alter the climate of the area that is currently alpine, to that of the subalpine (Green *et al.* 1992). This would result in the loss of the rare endemic communities such as the groundwater communities (fens, bogs and peatlands: Good 1992) and the endemic snowbank, feldmark and short alpine herbfield communities (Pickering *et al.* 2004). These latter two communities are the only known locations for four plant species endemic to the Kosciuszko alpine area (Costin *et al.* 2000). Conversely, higher temperatures are expected to increase the distribution of the dominant alpine and subalpine plant communities (tall alpine herbfield, heath and sod-tussock grassland) (Pickering & Armstrong 2003; Pickering *et al.* 2004).

Climate change in the subalpine or montane areas of the Australian Alps is expected to benefit exotic species and weeds which may be currently excluded from the alpine zone due to the severe environmental conditions at higher altitudes (Johnston & Pickering 2001; Pickering *et al.* 2004; Bear *et al.* 2006). With warmer and drier conditions associated with climate change the altitudinal ranges of some weed species are likely to increase. This invasion process may be facilitated by the predicted increase in frequency of natural disturbances (bushfire and drought) which reduce the cover of native vegetation.

The alpine region around Mount Kosciuszko is expected to be particularly vulnerable as it is small (100 km^2) with a limited altitudinal range (400 m from the treeline to the summit of Mount Kosciuszko at 2228 m) (Pickering *et al.* 2004). The lack of a permanent nival zone in the Australian Alps, a region perpetually covered in snow, to act as a refuge for altitudinal succession may limit the ability of many endemic alpine species to survive (Green *et al.* 1992; Pickering & Armstrong 2003; Pickering *et al.* 2004).

Three examples are used to illustrate the potential synergies between existing threats to the Australian Alps and climate change.

Direct affects on flora and fauna

Increasing temperatures and decreasing snow cover is likely to result in changes in species richness in the Australian Alps. Species richness of plants and animals is related to altitude in mountain regions world wide (Körner 2002; Nagy *et al.* 2003). In mountains there is a general trend of a decline in native and exotic plant diversity, and an increase in the proportion of the biota that is endemic with increasing altitude (Körner 2002; Nagy *et al.* 2003; Pauli *et al.* 2006). For example in the Australian Alps, the distribution of many mammal and bird species is strongly effected by snow cover (Green & Osborne 1994; Green & Pickering 2002). There is already some evidence that there have been changes in the altitudinal extent and timing of migration into the mountains from the lowlands with reduced duration of snow cover in the Australian Alps (Green & Pickering 2002; Pickering *et al.* 2004). For many species there will be gradual changes in distribution. For others, however, there is a real risk, particularly for some mammal populations, that this process might be rapid and dramatic. This is particularly likely where climate change results in a disassociation in the timing between key events for species.

For the endangered broad-toothed rat, it appears to be the timing of the thaw, and the increased risk of cold conditions post snow melt. For the endangered Pygmy possums it may be that early thaws result in the possums emerging from torpor before the arrival of their main food supply, Bogong moths in spring (Green pers. comm.).

There are also likely to be changes in the distribution of vegetation communities. This may involve changes in the tree line, both in frost hollows and between the alpine and subalpine zones. There is also likely to be changes in the distribution of specialist communities adapted to long periods of snow cover such as those under late-lying snowbanks, but also other communities dependent on snowmelt such as bogs and fens (Pickering & Armstrong 2003; Pickering *et al.* 2004). For plants some changes in distribution may be apparent in the short term, while for others it might be masked. Many alpine species are long lived perennials. Therefore there may be dramatic reductions in the size of populations and the cessation of recruitment for many populations, but a few long-lived individuals may survive for longer, masking the functional loss of the species.

Fires

Fires are likely to be more frequent, more intense and cover greater areas. Fires in the snow country of the Australian Alps are infrequent with decades or even centuries between fires in some areas prior to European arrival (Williams & Costin 1994; ISC 2004). The alpine zone can act as a large fire break, restricting the spread of large scale fires (ISC 2004). However, the intensity, area burnt and the frequency of fires are all likely to increase with climatic warming of the region (Hughes 2003; ISC 2004; Pickering *et al.* 2004). Although some of the flora will recover showing many of the adaptations seen in lower altitude flora for surviving fire, the capacity to survive fires that are more frequent and more intense is low (Wahren *et al.* 2001; ISC 2004; Bear & Pickering 2006). For example Snowgums can regenerate from lignotubers, and over 95% survived the extensive 2006 fires (Pickering & Barry 2005). However, the regenerating tissue is highly susceptible to damage from fires during the following 20 years. As a result, an increased frequency of fires may result in dramatic increases in tree death.

Weeds and feral animals

The Australian Alps like most of Australia has already been invaded by a diverse range of weeds and feral animals. Many of the species are general pests including foxes, rabbits, pigs, horses and hares (Green & Osborne 1994). Among the plants are some common weeds such as Sheep's sorrel, Catsears, Yarrow, White clover, Sweet vernal grass, Dandelion, Cocksfoot and Brown top bent which are also found in many protected areas including overseas (Bear *et al.* 2006; Pickering & Hill in press). Currently the distribution of many exotic plants and animals is limited by climate factors in the Australian Alps, particularly the duration of snow cover. Therefore, they are likely to directly benefit from reduced snow cover, resulting in an increase in the diversity and abundance of exotics at any given altitude (Bear *et al.* 2006; Green & Pickering 2003, Pickering *et al.* 2004). They are also likely to benefit from disturbances associated with climate change including changes in patterns of human use of the region. This could be changes in visitor use and activities, with an increase in summer tourism use of walking trails. It could also be due to changes in the ecosystem services of the region such as a greater priority on harvesting water in the region.

Recommendations

Clearly there is a need for protected area managers to find ways to deal with the impacts of climate change. This includes recognising how climate change will interact with many current threats to protected areas. Just some of the things that could be done include:

- Even greater emphasis on the control of weeds and feral animals, particularly those likely to benefit from climate change.
- Evaluate risk of increased risk of fires on biota and what can be done, which may not be much for intense fires in extreme fire conditions.
- Manage changes in tourism use and demand. This includes identifying what types of visitor use are, and will be appropriate in a particularly park. In the Australian Alps this will involve managing changes in ski tourism as it becomes economically less viable and more dependent on snow making. However, snow making itself may become less economically, socially and environmentally feasible with increasing demands on limited water and hydroelectricity supplies in the region.
- Reducing the management organisations' own contributions to production of greenhouse gases. We too must be eco-friendly and contribute to international reductions in greenhouse gas production.
- Making the community even more aware of the threats and likely impacts some of which are already occurring from climate change. For the Australian Alps this unique environment is particularly at risk, and this needs to be part of Australia's knowledge of what is and will be happening in a warmer world.
- Research and monitoring of changes in climate, temperature and snow cover and its effects on the natural environment of the Australian Alps. Currently several long-term monitoring projects have been established by researchers, several of which are part of international programs.

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