Limits to Adaptation

Climate change adaptation in Australia's Alps

NCCARF
National
Climate Change Adaptation
Research Facility

Synthesis and Integrative Research Program

NCCARF Synthesis and Integrative Research Program

Climate change adaptation in the Australian Alps: Impacts, strategies, limits and management

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Research Facility

Published by the National Climate Change Adaptation Research Facility 2012

ISBN: 978-1-921609-43-5 NCCARF Publication 03/12

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Please cite this report as:

Morrison, C & Pickering, CM 2012, *Climate change adaptation in the Australian Alps: Impacts, strategies, limits and management,* National Climate Change Adaptation Research Facility, Gold Coast, 78 pp.

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Acknowledgement

This work was carried out with financial support from the Australian Government (Department of Climate Change and Energy Efficiency) and the National Climate Change Adaptation Research Facility (NCCARF).

The role of NCCARF is to lead the research community in a national interdisciplinary effort to generate the information needed by decision makers in government, business and in vulnerable sectors and communities to manage the risk of climate change impacts.

Disclaimer

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Preface

The National Climate Change Research Facility (NCCARF) is undertaking a program of Synthesis and Integrative Research to synthesise existing and emerging national and international research on climate change impacts and adaptation. The purpose of this program is to provide decision-makers with information they need to manage the risks of climate change.

This report on "***Climate change adaptation in the Australian Alps: impacts, strategies, limits and management***" forms part of a series of studies/reports commissioned by NCCARF that look at the limits to adaptation. The notion of 'limits to adaptation' is fundamentally concerned with identifying the thresholds at which actions to adapt cease to reduce vulnerability. Much of the research on adaptation avoids the question of what adaptation cannot achieve. It is therefore implied by omission that adaptation can avoid all climate impacts. Yet this is clearly not going to be the case for many systems, sectors and places at even modest rates of warming, let alone at the more rapid rates of warming that now seem almost inevitable. Understanding the limits to adaptation is an emerging frontier of climate change research. It is important for decision making about adaptation for three reasons.

Firstly, it helps to determine which responses to climate change are both practicable and legitimate, and the time scales over which adaptation may be considered to be effective. Secondly, it helps to understand how people may respond to the damage to, or the loss of, things that are important to them, for which there may, in some cases, be substitutes or ameliorating policy measures. Thirdly, it can help prioritise adaptation strategies, refine their intentions, and identify communities that will be served by them.

This report assesses the ecological, physical, economic, technological and social thresholds that may limit the adaptation strategies of conservation organisations and the tourism industry in the Australian Alpine ecosystems. It should assist these organisations in better focusing their efforts to minimise the negative impact of climate change. This research provides a methodology, a case study and important insights into the conflicts that can arise between the objectives of different stakeholders such as conservation and tourism organisations in dealing with climate changes. This research establishes benchmarks for other regions about how to examine limits to adaptation and how social, economic, physical and environmental factors interact.

Other reports in the series are:

- *Limits to climate change adaptation in the Great Barrier Reef: scoping ecological and social limits;*
- *Climate change adaptation in the Coorong, Murray Mouth and Lakes Alexandrina and Albert;*
- *Limits to climate change adaptation in floodplain wetlands: the Macquarie Marshes;*
- *Limits to climate change adaptation for two low-lying communities in the Torres Strait;* and,
- *Limits and barriers to climate change adaptation for small inland communities affected by drought.*

To highlight common learnings from all the case studies, a brief synthesis has been produced which is a summary of responses and lessons learned.

All reports are available from the website at www.nccarf.edu.au.

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ACKNOWLEDGMENTS

We thank the following people and organisations for their help and support throughout this project:

- Graeme Worboys for his help with the development of the stakeholder questionnaire, identification of the interviewees, and feedback on earlier drafts of this report. Fernanda Pegas also provided help developing the questionnaire.
- Agustina Barros and Sebastian Rossi for their advice on the Griffith University Human Research Ethics approval process.
- Anthony Evans for his valuable comments and feedback at the end-user workshop for the project.
- All the interview participants who gave up their time to be interviewed and for their feedback comments on the interview section of the final report.
- The National Climate Change Adaptation Research Facility (NCCARF) for funding and supporting this project.
- Griffith University and the International Centre for Ecotourism Research for research support.

1. EXTENDED SUMMARY

The snow covered mountains of the Australian Alps are nationally and internationally important due to their conservation significance, ecosystem services and economic values. Predicted increases in temperature and decreasing precipitation due to climate change will result in dramatic changes in the region with snow cover already declining (approximately 30% since 1954). While the Australian Alps are of high conservation value with most subalpine and alpine areas conserved in a series of protected areas, the area is used by a number of different stakeholders. In or adjacent to, the protected areas there are currently 10 ski resorts, with winter visitation to the resorts worth AU$906 million in 2005. At lower altitude, there are population centres that depend to a large extent on jobs and incomes generated from snow based and summer tourism. Agricultural and other productive industries that occur in the lower lands surrounding the Australian Alps are dependent on water from the mountains including irrigation, while much of south eastern Australia utilizes water and hydroelectric power generated within the Australian Alps.

Using a desktop analysis of available literature and a series of semi-structured interviews with different local stakeholders, this project examined the impacts of climate change; current and potential climate change adaptation strategies; ecological, technological, physical, economic and social limits to these strategies; potential conflicts and collaborations between stakeholder groups in relation to climate change adaptation; and future research directions for the region. Understanding these climate change issues are critical for stakeholders as they adapt to less snow and warmer summers in the Australian Alps.

The results of the desktop review and the stakeholder interviews demonstrate that the region benefits from relatively long term data on climate and detailed modelling of climate change compared to many other locations in Australia. There is reasonably detailed existing long term ecological research for the region and modelling of climate change impacts on the flora and fauna. There has also been research on tourism in the region and the likely impacts of climate change on this industry. Because of the fairly direct link between increasing temperatures and decreasing precipitation and natural snow cover there is less debate that climate change will change this critical resource. Consequently, stakeholders within the region are more advanced than in many other regions in terms of recognising that climate change is occurring and identifying its impacts.

The stakeholders in the region are also fairly advanced in planning and utilising a range of climate change adaptation strategies and acknowledging a wide range of biophysical, economic and social limits to those strategies. These limits mean that major impacts of climate change will still occur despite climate change adaptation strategies. For example, while snow-making is the primary climate change adaptation response by the tourism industry, it will not be economically, physically or socially acceptable in the future. Current threats to ecosystems are also likely to continue, e.g. management strategies for feral animals and plants have only slowed the spread of some species under conditions so are unlikely to be adequate with climate change.

Our results highlight the fact that social, governance and knowledge issues currently play an important but largely under-recognised role in limiting climate change adaptation in the Australian Alps; a role that is likely to increase with time. Given that these limits are fairly flexible or dynamic in nature compared to ecological limits (currently the most recognised threshold), there is great potential for them to play a very significant role (both positive and detrimental) in future climate change adaptation. A major gap identified in current stakeholder assessment of climate change is the importance of the Alps catchment nationally, particularly the importance of its water for Australia's economy ($10 billion/annum for actual water and products from industries reliant on water supplies from the Alps

catchment). This is an important social limit that was not recognised by stakeholders who were more focussed on local or regional limits.

While several conflicts have arisen and/or are likely to arise among stakeholder groups in relation to the flow-on effects of various adaptation strategies, there is also a great potential for collaboration in relation to other adaptation strategies in the region.

Recommendations

Based on the results of this study we recommend:

1) Identifying a common goal or vision for the future of the Australian Alps in relation to the state of the environment that is acceptable to all stakeholders.
2) Due to increasing recognition of the need to adapt to future climate change regardless of mitigation actions and success, greater emphasis on research that specifically addresses the information needs of stakeholders is needed. This includes a detailed investigation of the information requirements of each stakeholder group and collaborative partnerships that can be generated to both collect data and use the information in feasible, successful management strategies and actions.
3) Identifying methods to best raise awareness of the regional and national significance of the Australian Alps in both the general public and stakeholders involved with the management of the region.
4) Increase mitigation of climate change to minimise the severity of the negative physical, ecological, social and economic impacts of climate change including in the Australian Alps. Adaptations strategies for the Australian Alps will only delay and/or have a minor effect on the severity of the impacts of climate change in the region.
5) Formally identify, promote and fund collaborative stakeholder partnerships.

2. PROJECT BACKGROUND

2.1 Summary of NCCARF Limits to Climate Change Adaptation program

The National Climate Change Adaptation Research Facility's (NCCARF) key role is to generate the knowledge required for Australia to adapt to the physical impacts of climate change. This is done primarily through:

i) developing National Adaptation Research Plans to identify critical gaps in the information available to decision-makers
ii) synthesising existing and emerging national and international research on climate change impacts and adaptation and developing targeted communication products
iii) undertaking a program of integrative research to address national priorities, and
iv) establishing and maintaining adaptation research networks to link together key researchers and assist them in focusing on national research priorities.

A core function of NCCARF is to conduct a program of research that synthesises and integrates existing and emerging national and international climate change adaptation knowledge. One mechanism for delivering this program is through modular Projects. In 2010, NCCARF developed a project on the limits to climate change adaptation in Australia. The rationale behind the project is that much of the research on adaptation avoids the question of what adaptation cannot achieve. It is therefore implied by omission that adaptation can avoid all climate impacts. Yet this is clearly not the case for many systems, sectors and places at even modest rates of warming, let alone at the more rapid rates of warming that now seem almost inevitable.

The notion of 'limits to adaptation' is fundamentally concerned with identifying the thresholds at which actions to adapt cease to reduce vulnerability. These thresholds exist in four domains:

i) ecological and physical thresholds beyond which unplanned or planned responses fail to avoid climate change impacts
ii) economic thresholds, which are where the costs of adaptation exceed the costs of impacts averted
iii) technological thresholds beyond which available technologies cannot avoid climate impacts
iv) subjective nature of the limits to adaptation based on perceptions and social values

Understanding the limits to adaptation is important for decision making about adaptation for three reasons. First, it helps to determine which responses to climate change are both practicable and legitimate, and the time scales over which adaptation may be considered to be effective. Second, it helps to understand how people may respond to the damage to, or the loss of, things that are important to them. Third, it can help prioritise adaptation strategies, refine their intentions, and identify communities that will be served by them.

In Australia there are places and sectors where the impacts of climate change will be unavoidable, even with adaptation measures. In these areas there is also ongoing or pre-existing research and expertise upon which to examine the limits of adaptation. Specifically, the project aims to answer the following:

i) Assuming there will be no planned adaptation, what are the likely impacts of climate change (in association with other known drivers of vulnerability)? For whom will these impacts be a problem?
ii) What adaptation strategies are available? Will (can) these strategies address all the climate risks that concern all potential stakeholders?

iii) Assuming climate stabilises at 2oC above pre-industrial levels, what seem to be the likely residual impacts of climate change after adaptation has taken place? For whom will these impacts be a problem?
iv) Assuming warming exceeds 4oC above pre-industrial levels, what seem to be the likely residual impacts of climate change after adaptation has taken place? For whom will these impacts be a problem?
v) Given anticipated losses, are there substitutes for things that are lost that would be acceptable to affected parties?

These questions will be answered using a combination of (i) Desktop reviews of available information, (ii) extensive workshopping to systematically identify climate change risks, adaptation options, and the limits to adaptation, (iii) engagement with key researchers and decision makers with knowledge of the ecological, technological, economic and social dimensions of adaptation, and (iv) some collection of primary data.

As the Australian Alps ecosystem is considered one of the three most at risk ecosystems from climate change in Australia, the area was identified by NCCARF as one of the key regions to include in this program. Following a competitive process, the authors were selected to conduct research on the limits to climate change adaptation in the Australian Alps. This document is the final reviewed report to NCCARF and contains an extensive summary of the research methods used, results of the desktop review and stakeholder interviews, a discussion of the implications of the results and recommendations for future work in this field. More detailed information is currently being produced in the form of refereed academic publications and will be available from the authors.

2.2 The Australian Alps

2.2.1 Study area

The Australian Alps are located in the south-eastern corner of mainland Australia and extend over 500 km between the Victorian and New South Wales capital cities of Melbourne and Sydney (Figure 2.1 insert). They occupy a total area of about 25,000 km^2 or 0.3 percent of Australia (Crabb 2003). The highest peak, Mount Kosciuszko stands at 2228 m. Within the Australian Alps are 11 national parks/reserves that occupy 1.644 million hectares and extend across the majority of the Alps Bioregion (Figure 2.1, Crabb 2003).

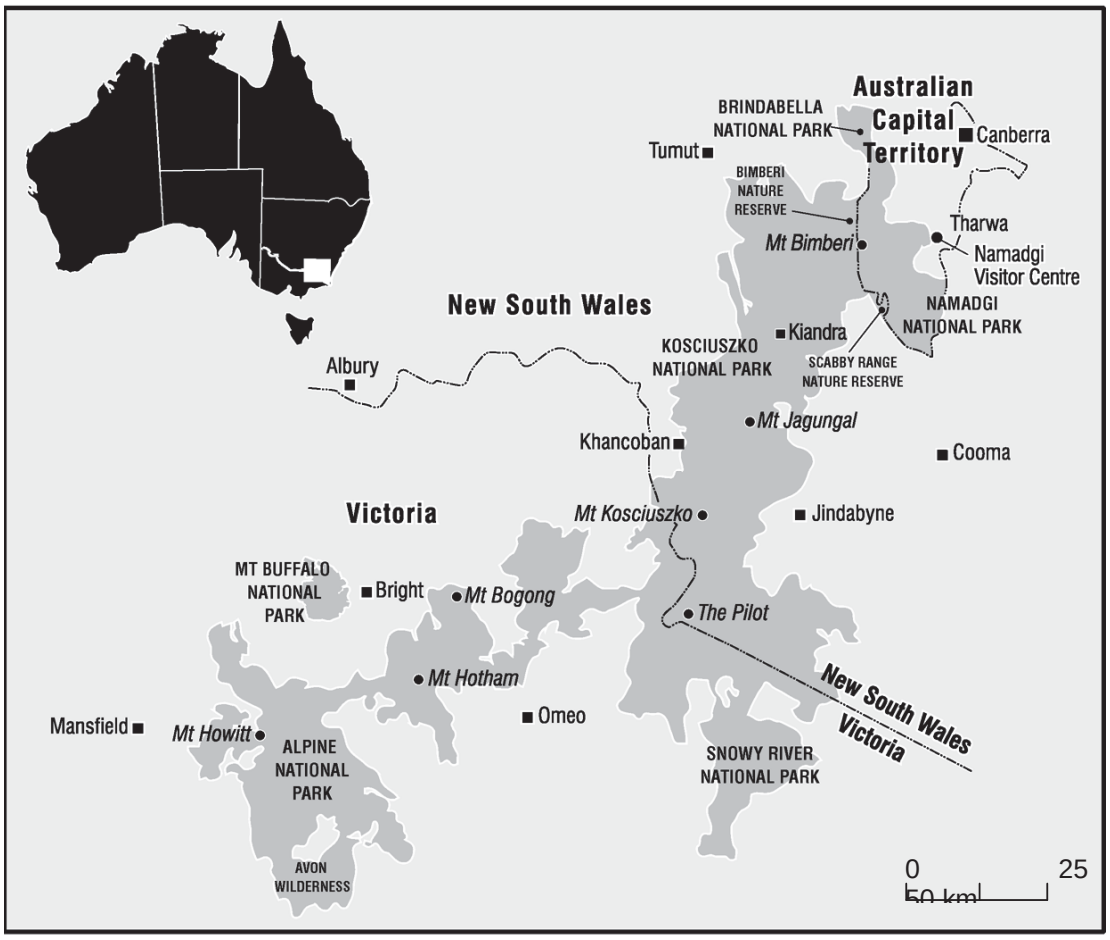

Figure 2.1. Location of the Australian Alps National Parks. Modified from AALC website.

The Australian Alps National Parks and Reserves have been recognized in Australia's prestigious National Heritage List as a National Landscape (DEWHA 2010). They include a United Nations Biosphere Reserve, contain International RAMSAR wetlands (ISC 2004) and are one of the 234 worldwide biodiversity "Centres of Plant Diversity and Endemism" (Boden and Given 1995).

The vegetation communities of the Australian Alps and their habitats are diverse. To date 852 species of vascular plants and 221 species of nonvascular plants have been recorded in the largest and highest of the parks; Kosciuszko National Park, with at least 380 of these species found in the alpine and subalpine areas (DEC NSW 2006). The subalpine and alpine areas also contain rare plant assemblages including those dependent on late lying snow

such as snow bank feldmark and short alpine herbfield with limited distributions and contain endemic species (Costin et al. 2000).

Rare and threatened animals are dependent on specialist plant communities. Examples include the periglacial boulder fields and their associated plum pine communities that are favored by the endangered and emblematic Mountain Pygmy Possum (Burramys parvus) (Green and Osborne 1994; Mansergh et al. 2004), and alpine wetlands that are critical habitats for many species including the Alpine Water Skink (Eulamprus kosciuskoi), Alpine Tree Frog (Litoria verreauxii alpina) and Corroboree Frogs (Psuedophryne corroboree and P. pengilleyi) (Mansergh et al. 2004). A total of 293 vertebrate species have been being recorded in Kosciuszko National Park which includes 61 species (or 21%) which are considered rare, vulnerable or threatened (Mansergh et al. 2004). Many common species are also found which are of critical importance for the health and resilience of the Australian Alps ecosystems (Green and Osborne 1994; Mansergh et al. 2004).

As well as being highly biodiverse, the Australian Alps have a rich cultural and social heritage. Aboriginal people have continuously lived and visited the Alps area from at least 21,000 years ago as evidenced by archaeological sites (Flood 1980). Their strong cultural links and continuing associations continue today (Worboys et al. 2010).

While the Australian Alps are of high conservation value with most subalpine and alpine areas conserved in a series of protected areas, the area is used by a number of different stakeholders. In or adjacent to the protected areas there are currently 10 ski resorts, with winter visitation to the resorts worth AU$906 million (0.1% of national GDP) in 2005 (NIEIR 2006; Pickering and Buckley 2010). At lower altitude, there are population centres that depend to a large extent on jobs and incomes generated from snow based and summer tourism (NIEIR 2006; TRA 2011) making their economies particularly vulnerable to any shocks that affect the tourism industry, including climate change (Lynch et al. 2009; TRA 2011). Agricultural and other productive industries that occur in the lower lands surrounding the Australian Alps are dependent on water from the mountains including irrigation, while much of south eastern Australia utilizes hydroelectric power generated within the Australian Alps (Worboys et al. 2010).

2.2.2 Governance of the Australian Alps

The three key issues in relation to climate change in the Australian Alps are conservation, tourism and water/power management. Governance of these issues involves all three levels government in Australia: Federal, State and local government. It also involves a range of statutory authorities and many private not-for profit and commercial organisations. Here we describe the key government and non-government organisations involved in the management and administration of conservation, tourism and water management for the Australian Alps.

Conservation

The Australian government Department of the Environment, Water, Heritage and the Arts (DEWHA) is the Australian Government agency responsible for biodiversity conservation including in the Australian Alps. The Australian Government is a signatory to a range of international conventions and agreements, including the international Convention on Biological Diversity. The Australian Government also has its own conservation legislation including the Environment Protection and Biodiversity Conservation Act. Much of the direct administration of the conservation of species under this act is undertaken by state and territory governments, including the establishment and management of most protected areas which are the major form of species conservation in Australia. However, the Australian Government does maintain and administer a national list of endangered species and communities and a national list of threatening processes. They also are directly responsible

for the management of some national protected areas with Parks Australia, the agency responsible for these parks.

In addition to the national responsibilities and roles of the Australia Government in relation to conservation, they are also one of the four signatories to the Australian Alps Memorandum of Understanding, which established the Australian Alps Liaison Committee. This Committee and its programs facilitate the cooperative management of the Australian Alps national parks which conserve most of the snow country on mainland Australia. The other members of the committee are parks representatives from the Australian Capital Territory (ACT), New South Wales (NSW) and Victorian governments.

Within the NSW state government, the Department of Environment, Climate Change and Water (DECCW) is primarily responsible for conservation, with a wide range of environment legislation including responsibility for conserving biodiversity involving threatened species inside and outside national parks within the State. This Department includes the NSW National Parks and Wildlife Service (NPWS) which is responsible for planning and the day to day management of the three parks in NSW that are part of the Australian Alps National Parks (Table 2.1).

In the State of Victoria, the Department of Sustainability and Environment (DSE) is responsible in part for services for management and governance of Victoria's parks. However, it is Parks Victoria (a statuary authority), that reports to the Minister for Environment and Climate Change, which is responsible for the four national parks in the Victorian section of the Australian Alps (Table 2.1).

In the Australian Capital Territory, the Parks, Conservation and Lands branch of Land Management and Planning Division of the ACT Government Department of Territory and Municipal Services is responsible for the day to day management of the two national parks in the Act and for the conservation of threatened species (Table 2.1).

Table 2.1. Details of the eleven protected areas that make up the Australian Alps National Parks. NSW NPWS = New South Wales National Parks and Wildlife Service, ACT PCL = Australian Capital Territory Parks, Conservation and Lands.

Protected area	Current size (ha)	Year established	Direct management agency	State/Territory
Kosciuszko NP	676 542	1944	NSW NPWS	NSW
Brindabella NP	18 472	1996	NSW NPWS	NSW
Scabby Range Nature Reserve	4 982	1982	NSW NPWS	NSW
Bimberi Nature Reserve	10 886	1985	NSW NPWS	NSW
Alpine NP	660 550	1989	Parks Victoria	Victoria
Snowy River NP	98 100	1979	Parks Victoria	Victoria
Avon Wilderness	39 650	1987	Parks Victoria	Victoria
Mount Buffalo NP	31 000	1898	Parks Victoria	Victoria
Baw Baw NP	13 300	1979	Parks Victoria	Victoria
Namadgi NP	105 900	1984	ACT - PLC	ACT
Tidbinbilla Nature Reserve	5 450	1962	ACT - PLC	ACT

Tourism

As for conservation, different departments and levels of government are involved in tourism in the Australian Alps. They include government departments such as the Federal Department of Tourism, State and Regional Development; the Tourism division of the Department of Industry and Investment in the NSW government; and the Department of Tourism and Major Events in the Victorian government. Each of these departments has established statutory bodies that are responsible for promoting tourism such as Tourism Victoria, Tourism NSW and Tourism Australia. There are also regional tourism organisations such as Tourism Snowy Mountains that include state and local governments and industry members in the different regions around the Australian Alps. There are industry tourism bodies including the Victorian Tourism Industry Council and the Tourism Industry Council. For example there is the Australian Ski Areas Association which is a not for profit organisation to develop and publish policies for the Australian ski resorts.

The 11 ski resorts in the region are the major agencies involved in tourism in the Australian Alps (Table 2.2). However, there are important differences in the ownership, and hence management, of the resorts between NSW and Victoria.

In Victoria the ski resorts are unincorporated authorities, i.e., they are not formally part of the local government areas. Instead, they are permanent Crown Land Reserves with individual management boards that are appointed by the Victorian Government Minister for Environment and Climate Change. These boards provide basic town services, but are also responsible for the management, marketing and promotion of the resorts with the aim to commercially manage the resorts for the benefit of the Victorian community (Falls Creek Management Board 2008). However, they consider themselves to be not-for-profit organizations as they do not have profit as their primary purpose. They are required to produce annual reports for the Victorian government that include income and expenditure statements. They obtain income from grants from various government organisations, visitor entry fees, site rentals, land sales and service charges. There is also an Alps Resorts Coordination Council established by the Victorian Government that facilitates planning, promotion and management of the Victorian Ski resorts.

Within the Victorian ski resorts private companies run the ski lifts and snow guns and pay fees to the management boards along with other private operators. In addition, there are not-for-profit ski club/lodges as well as commercial accommodation providers (hotels, commercial ski lodges, etc.), along with other commercial business such as restaurants, bars, ski hire facilities and shops. In effect, most of the Victorian ski resorts function as small towns with many of the same responsibilities as local government areas (shires in Victoria).

Outside of the Victorian ski resorts and parks, tourism is the responsibility of the local government. For example, tourism is an important industry in towns such as Mount Beauty, Marysville, Bright, Myrtleford and Beechworth with the promotion of tourism in part the responsibility of the Shire of Mansfield and Alpine shire which are the main local government areas adjacent the Australian Alps in Victoria. In addition to its conservation focus, Parks Victoria also sees itself as having an important role in tourism and has representation on some state tourism boards and involvement in the development of some tourism plans.

Table 2.2. Characteristics of ski resorts in mainland Australia operating in 2011. ARMB = Alpine Resort Management Board, KNP = Kosciuszko National Park, NP = National Park.

Resort	Altitude (max. in m)	Skiable area (ha)*	Resort management	National park in or near	Visitation in 2009 (skier days)
New South Wales					
Perisher Blue	2034	1245	Perisher Blue Pty Ltd	in KNP	-
Thredbo	2037	480	Kosciuszko Thredbo Pty Ltd	in KNP	-
Charlotte Pass	1954	50	Charlotte Pass Village Pty Ltd	in KNP	-
Selwyn Snowfields	1614	45	Mount Selwyn Snowfields Pty Ltd	in KNP	-
Total NSW		**1820**			**1,149,000***
Victoria					
Mt Buller	1805	300	Mt Buller and Mt Stirling ARMB	near Alpine NP	508,360
Falls Creek	1780	450	Falls Creek ARMB	in Alpine NP	377,405
Mt Hotham	1845	320	Mt Hotham ARMB	in Alpine NP	384,390
Mt Baw Baw	1563	30	Mt Baw Baw ARMB	near Baw Baw NP	52,952
Lake Mountain	1520	4	Lake Mountain ARMB	near Yarra Ranges NP	61,312
Mount Stirling	1747	0	Mt Buller and Mt Stirling ARMB	near Alpine NP	5472
Total Victoria		**1104**			
Total for all resorts		**2924**			**2,538,891****

* From Australian Resort Statistics for the Australia Ski Areas Association website accessed February 2011.

** Alpine Resorts Co-coordinating Council website accessed February 2011

In NSW the ski resorts are private organisations that have leased land in Kosciuszko National Park from the NSW Minister for the Environment. They are run for profit and provide different levels of facilities. All the resorts except for Selwyn provide accommodation on site including hotels, commercial and club (private) lodges. Thredbo and Perisher also have private apartments and include to varying extents a range of 'town' facilities including retail outlets, chemists, post offices, fire departments, medical centres, etc.

Planning and development of the ski resorts is the responsibility of the NSW Department of Planning, while more day to day responsibility for environmental aspects of the resorts is the responsibility of the NSW NPWS resorts section. They are responsible for aspects of environmental management, environmental health, municipal services, and waste and water management. Day to day management of some facilities however, such as sewage treatment plants, are often the responsibility of the ski resorts.

Outside of Kosciuszko National Park there are several NSW local towns with a strong involvement in tourism including ecotourism within the five local government areas of Snowy River (Jindabyne and Berridale), Monaro Shire (Cooma), Tumut (Tumut town), and Tumbarumba (Tumbarumba and Khancoban). The regional tourism organisation for this area is Tourism Snowy Mountains.

Water and power

The Australian Alps are a critical watershed for south-eastern Australia. The total volume of water from the Australian Alps is estimated at 9600 GL (Worboys et al. 2010). Its subsequent use in the west of the Great Dividing Range for agriculture, hydroelectricity and town water supplies is of national importance. Commercial electricity infrastructure in the region includes tunnels, pipes, powerlines, dams and hydroelectric power stations. This includes the massive Snowy Mountains Scheme in NSW and the Kiewa Hydroelectric Scheme in the Kiewa River valley in Victoria. These schemes have been privatised and the two main commercial operators involved in the generation of power in the Australian Alps now are Snowy Hydro and AGL-Hydro.

Management of water from the Australia Alps is complicated as it involves state and federal government departments, statutory authorities including parks agencies, commercial power generation companies, and local government agencies (Worboys et al. 2010). It also involves a wide range of government legislation ranging from conservation acts to the provision of water leases.

2.2.3 Climate change predictions for the Australian Alps

Climate change predictions for the Australian Alps have been discussed in detail in a number of publications and reports. Consequently, we will only summarize the predictions here (see Table 2.3). The changes in climate predicted for the Australian Alps involve increased temperature and decreased precipitation resulting in less snow (Whetton 1998; Nicholls 2005; Hennessy et al. 2008; Green and Pickering 2009, Figure 2.2). In addition to these direct changes, there are associated secondary biophysical effects including more cloud free days, lower humidity and increased total solar radiation (UVR) (Howden et al. 2003). More variable and extreme climatic regimes and erratic weather events such as high intensity rainfall area also predicted (Hennessy et al. 2008). Average summer temperatures are expected to rise resulting in increased frequency and intensity of bushfires (Lucas et al. 2007). By 2020, the number of extreme fire danger days in south eastern Australia is predicted to increases by 65% under the worst case scenario, and by 300% by 2050. There will also be an increase in climatic related events such as storms and landslides (Garnaut 2008).

Table 2.3 Summary of climate change predictions for Australian Alps under different climate change scenarios (from Hennessy et al. 2008).

Changes in:	Best case 2020	Worst case 2020	Best case 2050	Worst case 2050
Temperature	+0.2°C	+1.0°C	+0.6°C	+2.9°C
Rainfall	+0.9%	-8.3%	+2.3%	-24.0%
Reduction in area with snow cover				
At least 1 day	9.9%	39.3%	22.0%	84.7%
At least 30	14.4%	54.4%	29.6%	93.2%
At least 60	17.5%	60.3%	38.1%	96.3%
Average snow season length (ct 1990)	- 5 days	- 30-40 days	- 15-20 days	- 100 days

Unlike many other areas in Australia, the link between climate change and a range of ecological, economic and social impacts is fairly direct. This is because most of the benefits humans obtain from the Australian Alps are directly related to snow and the amount of snow is directly related to temperature and precipitation. Therefore, the major physical impact of climate change on natural snow cover directly affects ecological, social and economic

factors. This is in contrast to some other locations where the physical impacts of climate change are one of many variables affecting communities, and where social and economic decisions locally and more generally may have more effect on communities than the immediate physical impacts of climate change.

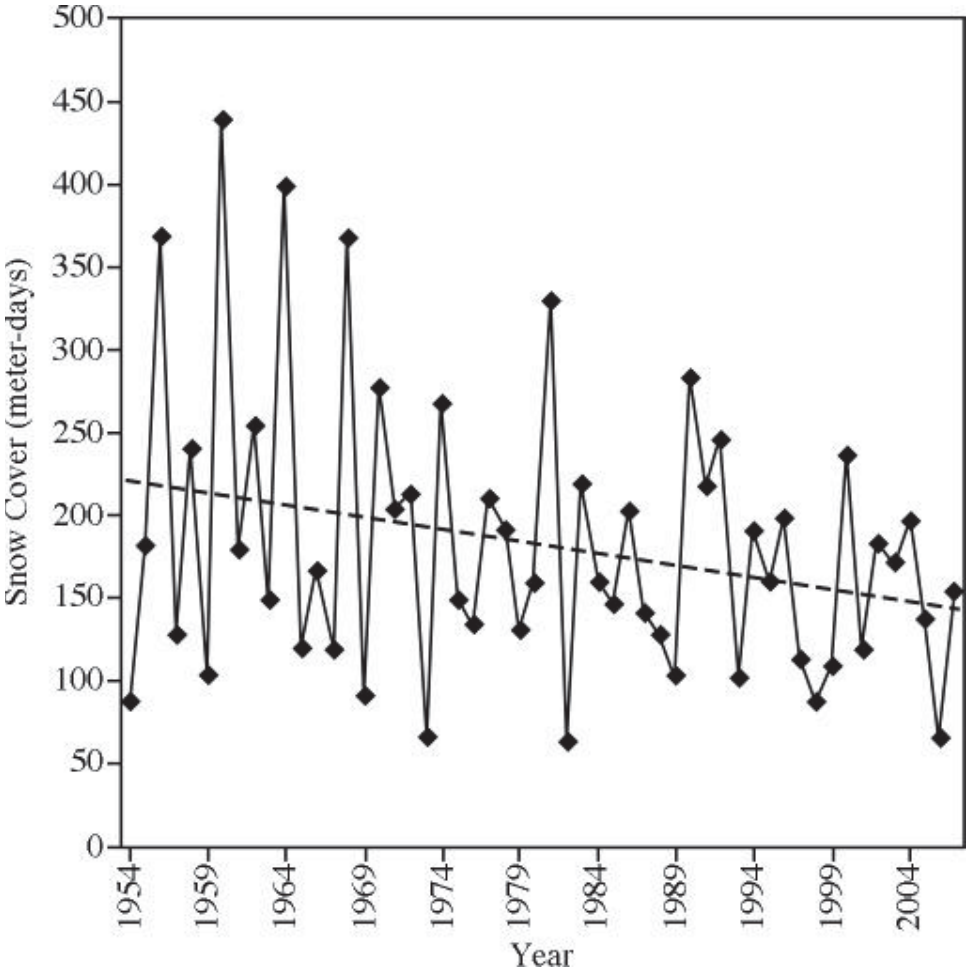

Figure 2.2. Five-year mean of annual snow cover in metre days at the highest regularly monitored snow course in Australia at Spencers Creek in the Snowy Mountains. Modified from Green and Pickering (2009).

3. DESKTOP REVIEW OF LIMITS TO CLIMATE CHANGE ADAPTATION IN THE AUSTRALIAN ALPS[1]

3.1 Rationale

The desktop review was conducted to assess available information about the Australian Alps region, the predicted impacts of climate change and proposed responses. More specifically this involved reviewing existing information available from database searches, from stakeholders and the PI's extensive published and unpublished data, internal and publicly available reports, and visitor and ecological data from parks agencies. The main aims of the review were to:

(a) produce a draft list of current and future climate change impacts for the region in the absence of planned adaptation
(b) identify current and proposed adaptation strategies
(c) evaluate the adaptation strategies in terms of ecological, physical, economic, technical and social thresholds

3.2 Methodology

3.2.1 Data collection

An extensive literature of peer-reviewed journal articles, books and book chapters, and unpublished reports was compiled and examined for information relating to; (i) impacts of climate change in the Australian Alps region, (ii) climate change adaptation strategies currently used or proposed in the region, (iii) limits to the climate change adaptation strategies, and (iv) potential stakeholder collaboration and conflict in regards to climate change. We divided the stakeholders involved with climate change impacts and adaptation in the region into four groups; conservation managers (e.g. NSW National Parks and Wildlife Service), tourism industry (primarily the snow-based ski industry), local council (representing the general public), and researchers. Where possible we also compared the results from the Australian Alps to alpine regions overseas, primarily North America, Canada, Europe and Asia. The final database consisted of 128 publications, including 68 peer-reviewed papers, 8 books, 15 book chapters, 6 published reports, 23 unpublished reports and 8 management plans (see Appendix 1).

3.2.2 Climate change predictions for the Australian Alps

The climate change predictions for the Australian Alps have already been summarised in section 2.2.3 (page 14 this report).

3.3 Main results

3.3.1 Impacts of climate change in Australian Alps

The actual and predicted impacts of climate change in the Australian Alps region are extensive and can be loosely grouped into four main categories: ecological, physical, economic and social. The majority of current observed impacts are of an ecological or physical nature with several having a subsequent direct or indirect economic impact. Predicted impacts focus more on ecosystem level issues and the economic impacts of decreased winter tourism. Similar impacts have been observed and/or predicted in alpine

[1] A detailed version of this desktop review including tables and references is currently under review by an academic journal. To avoid potential copyright issues we have included a general summary of the review here. Please contact the authors for the more detailed version.

regions overseas. The most common impacts highlighted in the literature are the loss of snow cover and/or duration, drier summers and the associated increases in fire danger, and the loss of endemic species and communities. Less common are references to changes in soil conditions, the increased closure of National Parks during fire events, and decreases in real estate investment in region.

3.3.2 Adaptations to climate change

Conservation managers favour strategies that promote ecosystem resilience and connectivity including: control of invasive species, restoring disturbed habitats, establishing better fire management plans, and the establishment of *ex-situ* seed banks and assurance populations of animal species. These ecological and physical strategies essentially reflect those being conducted in other alpine regions around the world.

The tourism industry favours strategies such as: artificial snow-making and associated snow-preservation activities, the development of non-snow related activities in winter and diversifying to year round tourism to maximise the benefits of extended warmer weather periods.

3.3.3 Limits to climate change adaptation

Despite a wide range of planned and current climate change adaptation strategies available for use by the different stakeholder groups, only a few have actually been implemented over a large-scale or seriously recommended for implementation. The remainder are usually considered as unsuitable or inappropriate due to the different limits associated with them. To date, the most obvious or important published limits to adaptation strategies are associated with economic costs and ecological constraints. Potential limits to climate change adaptation are primarily associated with large-scale conservation management issues including the control of invasive species, habitat restoration and rehabilitation, improvement of connectivity and resilience, and *ex-situ* populations of endangered alpine flora and fauna species. The most commonly reported limits to climate change adaptation in the tourism industry are related to technological and economic thresholds involved with snow-making and/or manipulation, and the social and economic costs associated with diversifying to year-round tourism.

3.3.4 Potential collaboration and conflict between stakeholder groups in relation to climate change adaptation

A number of actual and/or potential collaborations were identified between the different stakeholder groups, primarily between the conservation managers and the tourism industry. Examples include invasive species removal programs conducted in the National Parks by conservation managers in conjunction with those done on ski-resort land by the resorts. The conservation managers achieve their goal of minimising the spread or eradication of invasive species while the tourism industry increases their aesthetic appeal, green credentials and visitor satisfaction while fulfilling their obligations as land managers. Similar collaborative projects are run for endangered species protection in the National parks and on resort land. Water management by the two groups results in overall water conservation which is important to the conservation managers while decreasing costs and increasing green credentials benefits the tourism industry. Fire management is critical for both groups; species and habitat conservation and human safety in particular for the conservation mangers and human safety, infrastructure protection and maintaining aesthetic appeal for the tourism industry.

More commonly published are reports of conflicts between the climate change strategies favoured by the different groups. Again most of the issues arise between the conservation managers and the tourism industry. For example, while the use of snow-making primarily

benefits the tourism industry, it has negative impacts on a range of environmental factors (important to conservation managers) and water and electricity consumption (important to local governments and communities). Similarly, the diversification to year-round or two-season tourism primarily benefits the tourism industry and the local surrounding communities supporting the industry, but at the same time causes fairly significant additional environmental impacts and issues dealing with fire safety and management for the conservation managers. Conversely, habitat restoration and rehabilitation strategies used by conservation managers will result in restricting visitor access and activities in areas of the National Parks and therefore potentially have a negative impact on tourism through decreased visitor satisfaction.

4. STAKEHOLDER INTERVIEWS OF THE LIMITS TO CLIMATE CHANGE IN THE AUSTRALIAN ALPS

4.1 Rationale

Interviews with key members of four stakeholder groups in the Australian Alps were conducted to complement information from published material including research studies on climate change adaptations in the region. The interviews collected data on adaptations, actual and potential limits to these adaptation strategies and the values and opinions that may underlie strategies.

The desktop review of the limits to climate change adaptation in the Australian Alps examined information that has been published or is otherwise publicly available. Therefore it may not reflect the latest stages of adaption planning and thinking, particularly for strategies from groups that may not always publish in publicly available documents. Also, publicly available documents may not systematically include information on issues such as acceptance of climate change as a process, levels of awareness of other stakeholder's attitudes and adaptation strategies, and their perceptions regarding limits to their own and other stakeholder's adaption strategies.

4.2 Methodology

4.2.1 Interview format

While questionnaires are useful for obtaining very specific questions concerning quantifiable information (e.g. age, income) or for converting general information into a closed form, interviews allow a more thorough examination of experiences, feelings or opinions that cannot be captured through closed questions as well as providing more detailed information on the topic. As we were primarily interested in the beliefs, values and perceptions of the stakeholders in relation to climate change, we elected to use an in-depth telephone interview process with key stakeholders.

4.2.2 Questionnaire development

The questionnaire was developed as a series of semi-structured, open-ended questions to allow participants to freely express their views without being prompted in a particular direction (see Appendix 2 for questionnaire). The content and specific questions involved were based on the results of the desktop review of the limits to climate change adaptation in the Australian Alps region and overseas alpine regions. The questionnaire was proofed by experienced social scientists who were not involved in this project for an independent opinion of suitability and feasibility. The final version of the questionnaire was approved by the Griffith University Human Research Ethics Committee (see Appendix 3 for GU Ethics clearance – GU Ref No: ENV/24/10/HREC). In total, there were 23 questions which were divided into different sections:

1) Participant information
2) Opinions on climate change in general
3) Opinions on climate change predictions for the Australian Alpine region
4) Actual/potential impacts of climate change in the region
5) Current and proposed climate change adaptation strategies being used
6) Actual and potential limits to climate change adaptation strategies
7) Potential collaborations and conflicts between stakeholder groups
8) Future research directions

Summary tables were used to help record and transcribe material as it related to published information.

4.2.3 Interviewees

Interviewees were initially selected based on the prior knowledge of one of the authors (Pickering) and then using the snowballing method. Potential interviewees were initially contacted by email to gauge interest in participation. Most people approached agreed to be interviewed. Those who did not, usually declined on the basis that they were no longer involved in the region/area of responsibility and recommended someone else (Table 4.1). We endeavoured to get as many participants as possible in each stakeholder group as well as a geographical spread and hence include people from NSW, Victoria and the ACT. We classified the participants into four stakeholder groups:

1. Conservation managers e.g. National Parks and Wildlife Service, Department of Environment, Climate Change and Water, Australian Alps Liaison Committee, etc.
2. Tourism industry e.g. ski resorts, Tourism Snowy Mountains.
3. Local government e.g. Environmental Officers and Managers from local councils in the region.
4. Researchers e.g. CSIRO climate change modellers, research scientists within conservation organisations, university academics, and government environment personnel. Although tourism researchers were approached, none were interviewed as they indicated they were now working in different areas.

Before the start of the interviews we confirmed with the interviewee their stakeholder group allocation to ensure it reflected their current position and interests. Four weeks prior to the interview, participants were sent an information sheet relating to the project, ethics approval and a summary of publically available climate change predictions for the area (see Appendix 4). A few people requested further information prior to participating and this was either done by email or telephone.

4.2.4 Actual interviews

Interviews were conducted between November 2 and November 26, 2010. At the beginning of the interview all participants were provided with additional background to the project focussing on the role of NCCARF, its overall limits to climate change program, and how our project fit into that program. They were then read a list of statements relating to ethics and voluntary participation and asked if they consented to their interview being recorded (see Appendix 5). All participants agreed to the interview being recorded and gave their verbal consent to being interviewed. All interviews were done using Skype which allowed recording of the calls.

All participants were asked the same questions in the same order and in the same manner. Participants were free to ask questions at any time during the interview and were specifically asked if they had any final questions before the end of the interview.

Early on in the interview process (i.e. after the first two interviews), it became apparent that questions in one section of the questionnaire were redundant and potentially confusing for the participants. These questions were numbers 15-20 in the questionnaire (Appendix 2) and related to the residual impacts of climate change under best and worst case scenario predictions after adaptation strategies had been used. Consequently, we did not include them in the rest of the interviews. The information we had hoped to gather using these questions was better collected using question 13 “Will your current and planned adaptation strategies address all the climate risks that concern you? Are there limits to these adaptations?” This was primarily because many respondents stated that they did not base their strategies on best or worst case scenarios and were just adapting to climate change in general.

4.2.5 Analyses

4.2.5.1 Stage 1

The first stage of the analysis of the interviews was to summarise the main responses to the key questions in relation to the topics generated from the desktop review. This was done based on notes that were taken during the interviews and listening to each interview again to make sure that the written notes were comprehensive and accurate. This was done to highlight:

1. The key impacts of climate change in the region
2. Climate change strategies currently being used and proposed for future use
3. Identified limits to these climate change strategies
4. Potential conflicts and collaborations between stakeholder groups
5. Future research directions

4.2.5.2 Stage 2

The second stage involved in-depth analysis of similarities and differences within and between the stakeholder groups. This included information relating to stakeholder perceptions and opinions of other stakeholder groups, their adaptation strategies and perceived limits to climate change adaptation strategies.

4.3 Results[2]

4.3.1 Interview specifics

A total of 32 people were invited to participate in the project with 16 interviews (50% participation rate) conducted between November 2 and November 26, 2010. Interview duration ranged from 27 to 81 minutes, depending on the participant, with an average time of 43 mins. In most cases participants answered questions directly. In cases where the discussion ended up related to a second question, the second question was asked specifically to confirm the answer. In some cases, participants expressed that they did not think they were knowledgeable enough to answer one or more questions. In these cases, a note was made of this and the questions passed over.

4.3.2 Stakeholder group profiles

A summary of the actual participants is provided in Table 4.2. The largest group was the researchers with six participants, followed by the tourism and conservation managers each with four. Only two participants from local government were interviewed due to the low response rate from the group. The longest average interview time was with the research group (53 ± 21 min).

The length of time that each participant had been working in his or her respective stakeholder group ranged from 2-45 years. The longest average time spent working in a particular stakeholder field was in the research group (28.5 years) followed by the conservation managers (18.5 years). Most participants had remained in the same stakeholder group (as categorised by this study) their entire careers. Those who had come from another field usually came from an unrelated area (outside the four stakeholder groups of this project). Roughly half the participants were from the Australian Alps region with several others having spent extended periods of time in the region. Almost all participants had tertiary qualifications in the field of expertise (one exception). Nearly all of the interviewees were male (14/16).

[2] Due to large size and number, result tables are presented at the end of this chapter rather than in text.

4.3.3 Attitudes to climate change

4.3.3.1 General climate change

When asked "What do you think about climate change in general?" all participants expressed a general belief in climate change (Table 4.3). All but one were convinced by general current climate change predictions and data although some (6/16) expressed dissatisfaction with the level of error involved with these predictions (Table 4.3). Most participants elaborated further and stated that they had had firsthand experience with climate change in the Alps region itself and almost all participants (14/16) stated that climate change was currently, or was likely, to become one of the most important issues in the region.

4.3.3.2 Climate change predictions for Australian Alps

When asked "Do you agree with the climate change predictions for the Alpine region?" all participants (16/16) generally agreed with the current climate change predictions for the Alps (Table 4.4). Several stated that in their line of work, they tended to focus on either the best-case scenarios (3/16) or the worst-case scenarios (2/16). Several (6/16), while agreeing with the general predictions had questions about the range and uncertainty of values.

4.3.4 Impacts of climate change in the Australian Alps

4.3.4.1 General impacts of climate change in the region

When asked "What are the likely impacts of climate change in the region?" 17 potential/actual climate change impacts were identified (Table 4.5). The majority of identified impacts (12/17) were ecological/physical in nature. Economic impacts such as increased cost of skiing (3/17), and ecological/physical/social impacts including decreased water availability (1/17) were much less common.

There was general agreement among nearly all participants, that climate change will result in the loss of snow, with only one of the local government participants not listing this as an impact (Table 4.3). There was less uniformity among the other 16 impacts, with the next most commonly listed impacts, the loss of endemic species (identified by 8/16 participants) and communities (7/16), drier summers (5/16) and decreased water availability (5/16). Increased fire intensity and frequency, increased invasive species, decreased winter visitors, decreased rainfall and decreased soil moisture were all identified by 4 participants. The other seven impacts were identified by only one or two participants (Table 4.3).

Researchers listed the largest number of different impacts (11) and generally had greater consistency among themselves in impacts. They primarily identified ecological/physical impacts of climate change (10/11 of their observations). The most commonly mentioned impacts were the loss of snow cover (5/6 participants), loss of endemic species (4/6) and communities (4/6) and increased fire intensity/frequency (4/6). They did not list several of the tourism related impacts including decreased winter visitors, loss of snow based industry, increased costs of skiing however, this is likely to be due to the fact that none were tourism researchers.

Conservation managers identified nine different impacts, and there were fewer consistencies internally in this group compared to researchers. Conservation managers primarily identified ecological/physical impacts such as loss of snow cover (4/4 participants), drier summers (2/4) and increased invasive species (2/4). Interestingly, no conservation manager mentioned the loss of endemic communities while only one mentioned the loss of endemic species. They also did not list increased fire intensity and frequency as a likely impact despite this being a major responsibility for conservation managers as the largest land holders in the region, and two recent large scale bushfires. However, when later asked to identify the largest or most significant impact (see next section) increased fire intensity and frequency was identified by this group. They made no mention of the economic impacts of climate change in the region.

The tourism industry also identified nine different impacts, but they often listed different impacts to the researchers and the conservation managers. The two most common impacts identified were loss of snow cover (4/4 participants) and decreased winter visitors (4/4). Surprisingly, more tourism participants mentioned the loss of endemic species (2/4) and communities (2/4) than the conservation managers.

The two local government participants listed six different impacts in total, but never the same impacts. One or other listed loss of snow cover, loss endemic species, and communities, decreased soil moisture, loss of snow based industry and other impacts.

4.3.4.2 Most significant impact of climate change in the region

Twelve different impacts were identified when participants were asked "Which do you think will have the greatest impacts?" (Table 4.6). The loss of snow cover and its flow on impacts was identified as the largest impact of climate change in the region (9/16 participants), closely followed by increased fire intensity and frequency (8/16). The remaining 10 impacts were identified by four or less of all participants.

Researchers again listed the largest number of impacts (8), concerned with either loss of snow cover and its flow on effects (3/6 participants) and/or increased fire risk (3/6). Other weather related impacts such as changes in snow duration (2/6), increased storms (1/6), and decreased rainfall (1/6) were also identified.

The conservation managers were primarily concerned with the loss of snow cover and general flow on impacts (2/4 participants) and increasing fire risks (2/4). The loss of infrastructure due to fire (1/4), decreased winter visitors (1/4) and decreased snow duration (1/4) were also mentioned. No conservation manager specifically mentioned the loss of endemic species or communities as the biggest impact of climate change.

The loss of snow cover was the major impact identified by the tourism industry (4/4 participants). Decreased winter visitors were also seen as important (2/4). Fire risk (1/4), increased storms (1/4), revenue loss by the industry (1/4) and loss of endemic species (1/4) were also identified by this group.

The local government were primarily concerned with increased fire intensity and frequency (2/2 participants) and drier summers (1/2). They also mentioned revenue loss by the tourism industry as a major impact of climate change.

When asked "What kind of influence will these impacts have on you or your industry? (Positive, negative, short-term, long-term)?" all participants said that the effects of climate change would be negative (Table 4.7). Three participants (two from tourism industry and one from local government) also mentioned that there may be one positive effect of climate change in the region in that there was potential for increased summer tourism with extended warmer weather. Many participants thought that climate change would produce short-term effects (9/16) while nearly all (14/16) thought that there would be long-term effects.

Researchers did not think there were any positive effects of climate change and all thought that there would be long-term effects. Four researchers thought that there would be definite short-term effects of climate change while the other two did not mention short-term effects.

Conservation managers also did not think there would be any positive effects of climate change. Three managers thought that there would be definite long-term effects while the other three did not mention them specifically. Two managers highlighted definite short-term

effects and another stated that there were no definite short-term effects specifically attributable to climate change.

Three tourism participants mentioned the short-term effects of climate change with one stating that there were short-term effects and the other two stating that there were no definite short-term effects. Three of the tourism participants stated that there would be long-term effects while the other did not know (attributed to error with climate change predictions).

Both the local government participants thought that there would be short-term and long-term effects of climate change in the region.

4.3.4.3 Impacts of climate change on other stakeholder groups

When asked “What influence do you think these impacts will have on other stakeholders?” the most often identified industry was tourism (6/12 impacts identified, Table 4.8).

The most commonly identified was the impacts of less snow on the tourism industry (identified by 8/12 non tourism participants, Table 4.8). The non tourism participants also specifically identified decreases in visitor satisfaction/visitor numbers in having a negative impact on the tourism industry (3/12). Other perceived impacts on the tourism industry included the loss of the snow industry (2/12), increased fires in the summer season (2/12), water shortages for snowmaking (2/12), and increased competition from other tourism destinations in winter (1/12).

The conservation managers were perceived to face impacts relating to endangered species management (3/12 non conservation participants), fire management (2/12) and ecosystem dynamics (1/12).

The local government were perceived to face impacts relating to loss of income related to the tourism industry (2/14 non local government participants) and water shortages (2/14). The Australia Government was predicted to lose tax income from the tourism industry (1/16 total participants).

4.3.5 Climate change adaptation strategies

4.3.5.1 Current climate change adaptation strategies

When asked “Are you familiar with climate change adaptation strategies?” all participants stated that they were familiar with the concept of climate change adaptation (16/16) and different climate change adaptation strategies.

When asked “What climate change adaptation strategies are available to your industry?” and then asked “Which of these are you currently implementing?” 15 strategies were listed (Table 4.9). The answers to these two questions were combined as all participants included current strategies in their available strategies lists and none identified additional available but unused strategies. The conservation managers and the tourism industry both identified 10 adaptation strategies while the researchers identified 3 and the local government only 2.

The most commonly identified strategies were invasive species management (5/16 participants) and snow-making (5/16). Fire management and restoration of disturbed habitats were both identified by 3/16 participants. Interestingly, research or long-term monitoring was named as a current climate change adaptation strategy by 4/16 participants.

Current climate change adaptation strategies identified by the researchers involved research and long-term modelling of the impacts of climate change (2/6 participants), which would provide information for developing/modifying future climate change adaptation strategies.

They also mentioned invasive species management (1/6) and the restoration of disturbed habitats (1/6).

Conservation managers listed 10 different strategies, primarily relating to species management (both invasive and endemic), fire management, risk assessments and long-term monitoring. One conservation manager stated that currently he was unaware of any climate change adaptation strategies being used by his group. However, this was primarily due to his belief that most of the identified climate change adaptation strategies were in fact already in place to deal with other factors (e.g. fire management, invasive species management) that were now being exacerbated by climate change rather than being developed for climate change adaptation per se.

The tourism industry also listed 10 current adaptation strategies, although only five were the same as conservation managers. For the tourism industry, snow-making was the most common current climate change adaptation strategy (4/4 participants). They also identified water recycling (for snow-making), recycling/treatment of sewage and improved technology as important strategies. The current promotion of year round or two-season tourism as a strategy was only identified by one participant.

For the two participants from local government, only one stated any adaption strategy and that was the restoration of disturbed habitat. Like one of the conservation managers, the other local government participant thought that many of the identified climate change adaptation strategies were already being carried out for different reasons and was unaware of any specific current climate change adaptation strategies.

4.3.5.2 Future climate change adaptation strategies

When asked “Which strategies are you planning to implement?” a wide range (15) of future climate change climate change adaptation strategies were identified (Table 4.10). There were no single common climate change adaptation strategies favoured by participants. The continuation of current strategies and increased invasive species management were the two most common strategies identified (3/16 participants). A shift to increased year round/two season tourism was identified (2/4 tourism), along with the need to conduct risk assessments (2/16 participants).

There was little consensus in the research group as to individual future adaptation strategies however, they primarily mentioned ecological/physical adaptations including fire management, increasing resilience, developing ex situ flora and fauna populations and artificial bog shading to reduce drying.

Half the conservation managers had not yet identified their future adaptation strategies and were awaiting the results of vulnerability assessments to prioritise their future actions. The others highlighted invasive species management (2/4), increased fire management (1/4) and continuing with current strategies (1/4) as their future adaptation strategies.

The tourism industry mainly planned to continue with current strategies (2/4 participants) and develop year round or two-season tourism (2/4). They also identified additional winter tourism strategies including super grooming, landscaping, and the creation of new infrastructure in higher slopes.

The local government mentioned water management and the potential development of “last chance to see” tourism. Both local government participants mentioned that their future adaptation strategies would also depend on higher level government directives.

4.3.5.3 Impacts of current/planned climate change adaptation strategies on other groups

When asked "Will your current or planned climate change adaptation strategies affect other stakeholders?" all groups thought that there would be some benefits for others (Table 4.11). Year round tourism was thought to benefit the local economy (4/16 participants). Fire management (3/16) and invasive species management (2/16) by the conservation managers was thought to benefit the tourism industry, while invasive species management by the resorts was thought to benefit the conservation managers (2/16). Two respondents had no idea whether their adaptation strategies would benefit other groups.

4.3.6 Limits to climate change adaptation

When asked "Will your current and planned adaptation strategies address all the climate risks that concern you? Are there limits to these adaptations?" 28 limits were identified by the respondents (Table 4.12). Nearly all were ecological/physical thresholds (10/28 limits), social thresholds (8/28) or economic thresholds (6/28). Technological thresholds were only identified once and were associated with limits to snow-making technology. Lack of knowledge in relation to different strategies was identified as a limit in three cases – general lack of knowledge of climate change, lack of knowledge on invasive species, and lack of knowledge about assurance populations.

The research group identified 17 limits to climate change adaptation in the region, with the majority (8/17 limits) being ecological/physical thresholds. These involved the complexity and uncertainty involved with climate change impacts and fire management (3/8 ecological limits) and limits to snow-making (3/8). They also recognised social (3/17 limits), economic (3/17) and knowledge limits (3/17) to climate change adaptation strategies, particularly in relation to snow-making, assurance flora and fauna populations and fire management. There was little consensus (2/6 or fewer researchers nominating) on the individual limits identified.

The conservation managers identified 18 limits to climate change adaptation, the majority of which were ecological/physical (7/18 limits) and related primarily to fire and invasive species management. They also identified social thresholds associated with fire and invasive species management (4/18), economic barriers to different adaptation strategies (3/18) and knowledge gaps (3/18). Again there was little consensus on the individual limits identified with the exception of general economic constraints (2/4 participants) and the costs associated with assurance flora and fauna populations (2/4).

The tourism industry identified seven limits to climate change adaptation and was primarily concerned with social perceptions and visitor satisfaction (2/7 limits) and the general lack of knowledge in relation to climate change impacts (2/7). They also identified ecological/physical limits associated with snow-making, namely warmer temperatures and required water volumes, along with the costs of infrastructure development and water licence limits for summer tourism.

The local government participants were primarily concerned with social limits to climate change adaptation (3/5 identified by the group). These included general social constraints and public opinion of water and fire management strategies. They also identified general economic constraints and a general lack of knowledge to implementing different adaptation strategies. There was no consensus between the two participants on any specific limit.

4.3.7 Conflicts and collaborations between the stakeholder groups

4.3.7.1 Conflicts

When asked “Do you see any potential conflicts arising between the different stakeholder groups in relation to their climate change adaptation strategies?” 19 different current or potential areas of conflict were identified by the participants (Table 4.13). The most common were the social objections (current and future) to the large amounts of water used by the tourism industry for snow-making (5/16 participants). Restricted access to the National Park by the conservation managers was also important (4/16 – identified by one member of each group) along with the general impacts of the resorts on the biodiversity and conservation of the area (3/16). Interestingly, two participants (one conservation manager and one tourism) did not recognise any real conflict between stakeholders.

Researchers highlighted social conflicts between water (4/6 researchers) and electricity use (2/6) for snow-making by the tourism industry and general public demand as well as social objections to some invasive species management practices by the conservation managers (2/6). They identified conflicts between resorts and conservation management of protected areas, and the impacts of surrounding landowner land management practices e.g. grazing, on conservation. They also highlighted conflicts between themselves and conservation managers in two areas (i) conservation managers want scientific information but are not willing to fund the research, and (ii) the conservation management options recommended by the researchers are often not carried out by conservation managers. The differences between effective long-term management strategies and goals for successful conservation and short-term decision making by the tourism industry or political decision-makers was also mentioned as a source of conflict.

The conservation managers primarily highlighted conflicts between themselves and other users in relation to the management of the protected areas e.g. resort impacts, increased recreation impacts in summer, and invasive animals and sporting shooters. One manager also agreed with the researchers and mentioned the activities of surrounding land owners e.g. cattle grazing, on their ability to control fire and invasive species within the protected areas.

The tourism industry identified access to the National Parks (restricted by conservation managers), bed limits (restricted by government), research information not being passed back to resorts (restricted by researchers) and the general public perception of the negative impacts the resorts are having on the environment (legacy of past management styles and social restrictions) as being the important conflicts faced by their group. There was little consensus between their identified conflicts and those identified by other groups with the exception of access to National Parks.

The local government identified social conflicts between the use of water for snow-making by the tourism industry and competition for water by other groups e.g. residential, agricultural and industry, access to National Parks (restricted by conservation managers) and social objections to bushfire prevention and management strategies planned by the local government and conservation managers.

4.3.7.2 Collaboration between stakeholder groups

When asked “Do you see any potential collaborations arising between the different stakeholder groups in relation to their climate change adaptation strategies?” 12 different activities were identified (Table 4.14). The most common included collaborations between conservation managers and tourism industry in relation to invasive species (identified by 4/16 participants), fire management (3/16) and ecosystem rehabilitation (2/16).

There was collaboration between researchers and government and researchers and conservation managers in relation to data collection.
The tourism industry (specifically the resorts) also collaborated amongst themselves (collective marketing), with local government (recycling) and with lift companies (for year round tourism).

Two participants (1 local government and 1 researcher) could not identify any collaboration between stakeholders and one (researcher) stated that there was the capacity for collaboration but that it was very limited in reality due to the different agendas and goals of the groups.

4.3.8 Future research needs of stakeholders

When asked "What information not currently available would help you/your stakeholder group better adapt to climate change in the Australian Alps?" 19 different suggestions were made by the participants (Table 4.15). With the exception of the need for long-term ecological monitoring to provide better or more accurate data on the impacts of climate change in the region and to feed into management plans (7/16 participants) and the need for more accurate climate change predictions (4/16) there was little consensus between and within the groups. Other research directions included: (i) better information on social perceptions of the general public and skiers to climate change and the ski industry in the region as well as the community response to climate change; (ii) better information on impacts of climate change on water (surface and groundwater); (iii) better data on fire risk and invasive species management; (iv) conceptual and path models to demonstrate the impacts of climate change to government and the general public; and (v) cost-benefit analysis research for different adaptation strategies.

Researchers were primarily interested in long-term monitoring (4/6 participants), more accurate climate change predictions including variability and extreme events (2/6), better data on fire risk (1/6) and the impacts of human disturbance in protected areas (1/6). With the exception of long-term monitoring, there was little consensus between members of the group on individual research programs.

The conservation managers were primarily interested in long-term monitoring research (3/4 participants). While they also mentioned research on the social aspects of climate change (perceptions of skiers and general public) and the ability to separate the impacts of climate change from other factors, there was little consensus in the group as to the remaining research directions.

The tourism industry mainly wanted more accurate climate change predictions (2/4 participants) and information on extreme events (1/4). While there was little agreement on specific research projects they were generally interested in more information on the social perceptions of skiers and the general public, information on snow-making technology advances and better ways to determine their carbon footprint.

The local government were primarily interested in management issues such as the impacts of climate change on water, more information on weeds and their removal and a way to develop better collaborative networks for regional councils. One participant the made comment that they were very isolated and generally doing their own thing with little collaboration between neighbouring councils in strategies and regard for flow-on impacts for other councils.

4.4 Discussion

4.4.1 Summary of results

Climate change is recognised by all stakeholders as a very important issue for the region and that it is occurring. They were also all aware to varying extents of the climate change predictions for the region and generally accept these predictions (albeit sometimes with reservations due to associated ranges). This differs from some previous work looking at the perceptions of stakeholders (primarily the snow-tourism industry) where some level of denial was evident by resort managers as recently as 2002 (e.g. Bicknell and McManus 2006). All stakeholders were aware of, or had firsthand experience, of the impacts of climate change in the region with the loss of snow cover and its associated flow on effects and changes in fire frequency and intensity identified as the largest impacts. Most stakeholders were involved in some form of climate change adaptation and some had several strategies in place. Where they were not currently implementing adaptation strategies, they were generally waiting for more information (e.g. risk or vulnerability assessments) to determine the most appropriate and feasible strategies rather than just not acting. In addition to their own climate change adaptation strategies, they also seemed to be aware to a certain extent of the strategies being used by other stakeholder groups and, in some cases, had collaborated in these strategies. Most stakeholders were aware of the limits to their strategies and in large part, those of other stakeholders. They were also generally aware that some of their strategies would be in conflict with the needs and actions of other groups while collaboration was possible in other areas. Long-term monitoring and more accurate climate change predictions were identified as key information needed by all stakeholder groups to help them better adapt to climate change. The results generally agreed with those from the desktop review however, there were a number of new issues arising from the interviews in relation to (i) the perceptions of climate change adaptation strategies used by the different stakeholder groups and their associated limits by other stakeholders, (ii) collaborations and conflicts between stakeholder groups, and (iii) future research needs of stakeholders.

4.4.2 Stakeholder groups

In general, the 16 interviewees provided a wide range of responses to most of the interview questions however, there was generally limited consensus after the first 1-2 responses. This limited consensus was not restricted to just among groups but also within each stakeholder group. As expected, the results generally reflected the stakeholders own issues in relation to climate change. They were most familiar with issues and stakeholder groups that directly affected them, less familiar with groups that they occasionally collaborated/conflicted with, and least familiar with those groups where there was little contact or interaction.

The accuracy of one stakeholder group's perceptions of other group's activities and limits was a direct reflection of their level of involvement with the other groups. In most cases, the activities and limits to climate change strategies of a particular group as identified by other stakeholder groups were also identified by the stakeholder group concerned. The most obvious difference between the perceptions of other groups and activities/limits of one group relates to the limits associated with snow-making by the tourism industry. All other stakeholders believed that the tourism industry will soon (if not already) experience significant economic limits in terms of snow-making costs (electricity, water, technology) and social constraints (public opinion and competition for water and electricity). No tourism participant identified any of these limits with the exception of one who thought that the physical volume of water needed for snow-making could be an issue in the future.

4.4.2.1 Researchers

In general, the research group identified the largest number of individual impacts, limits to climate change adaptation strategies, and conflicts and collaborations between stakeholder groups. Their perceptions of the impacts of climate change on other stakeholder groups and current adaptation strategies were by comparison relatively limited. Researchers were primarily concerned with ecological/physical aspects of climate change impacts, adaptation strategies, limits to adaptation and conflicts. There was little emphasis on social or economic aspects of these issues although this may be due to the fact that there were no tourism or social scientists included in this group with fewer researchers focusing on tourism than have examined climatic modelling and the ecology of this region.

In terms of the impacts of climate change there was general consensus within the group that the loss of snow cover, loss of endemic species and communities, increased fire threats, drier summers and decreased water availability were key issues. All researchers agreed that the loss of snow cover and/or increased fire risk were the biggest impacts of climate change in the region. There was limited consensus within the group as to individual impacts of climate change on other stakeholder groups but all identified the tourism group as the ones likely to experience the biggest impacts.

Researchers identified few climate change adaptation strategies (usually involved some form of species management and monitoring), and also had limited ideas as to whether these strategies would benefit other stakeholder groups. There was very limited consensus within the group as to the limits of individual climate change strategies but those identified generally were ecological/physical in nature with some economic limits also identified.

Researchers identified the largest number of actual or potential conflicts in relation to the climate change strategies used by the different groups however, with the exception of social limits to water use for snow-making, there was no consensus within the group. Researchers also highlighted new conflict areas that had not been previously found in the literature namely (i) conflicts between researchers and conservation managers and (ii) conflicts between researchers, the tourism industry and political decision makers. The conflicts between researchers and conservation managers generally involved two issues. The first issue highlighted was that the best conservation management options recommended by the researchers were not being implemented by the conservation managers for social or economic reasons, e.g. culling brumbies/feral horses. The second involved the conservation manager's demands for long-term data on the impacts of climate change on biodiversity but their general unwillingness (or inability) to pay for the research programs. The second general area of conflict involved differences between the time frames needed for effective long-term conservation management goals and actions (usually 10+ years), and the short-term decision making by the tourism industry and political decisions makers (usually < 5 years).

The researchers also identified the largest number of potential collaborations between the stakeholder groups but again there was little consensus as to the actual collaborations. They did however agree that the most potential for collaboration existed between the conservation managers and the tourism industry. With the exception of long-term monitoring, there was no consensus within the group on the key research directions for the region.

4.4.2.2 Conservation Managers

The conservation managers identified the largest number of climate change impacts on other stakeholder groups, conflicts between groups and future research areas. They also identified a wide range of individual climate change impacts, climate change adaptation strategies, and limits to climate change adaptation strategies. They were primarily concerned with the ecological/physical aspects of each key area with some emphasis on economic and social limits of climate change adaptation strategies and conflicts.

In terms of the impacts of climate change there was general consensus within the group that the loss of snow cover, drier summers and an increase in invasive species were key issues. The loss of snow cover and increased fire intensity and/or frequency were identified as the biggest impacts of climate change in the region but there was no consensus by all group members. It was interesting to note that no conservation manager specifically highlighted the loss of endemic species or communities as a major impact of climate change. All group members agreed that the tourism industry would be the stakeholder group most affected by climate change, particularly in relation to the lack of snow.

The conservation managers identified the largest number of current climate change adaptation strategies which focussed primarily on ecological/physical activities. With the exception of invasive species management and assurance populations of flora and fauna, there was little consensus within the group. In relation to future climate change adaptation there was also little consensus however, in two cases, no future strategies had been planned as managers were waiting for the results of vulnerability/risk assessments before committing resources and staff to various strategies. There was little consensus as to specific strategies that would benefit other stakeholders but all agreed that the tourism stakeholder group would be the one to benefit the most.

The group identified the largest number of actual or potential limits to climate change adaptation strategies used/proposed for the region. There was very little to no consensus as to individual limits but the group identified the widest range including ecological/physical, social, economic and knowledge limits.

The conservation managers identified several conflicts between the stakeholder groups but there was no consensus. Most of the identified conflicts were social or ecological/physical in nature and primarily involved the tourism industry and surrounding land owners. Unlike the researchers, no conservation manager recognised the conflicts associated with the transfer and use of knowledge from the researchers.

The collaborations identified between stakeholder groups were primarily between their own group and the tourism industry. One conservation manager also identified ecological and climate data collection by conservation managers and researchers as another collaborative strategy.

Finally, the conservation managers identified the largest number of research gaps but there was no consensus as to actual research programs with the exception of the need for long-term ecological modelling. They also identified a general need for data on the social perceptions of climate change and adaptation strategies by skiers and the general public.

4.4.2.3 Tourism

The tourism group was primarily concerned with economic and social aspects of climate change impacts, adaptations, limits and research. They were also concerned to a slightly lesser extent with ecological/physical aspects of the same issues. In general, for this stakeholder group, the prospect of climate change as a threat was more damaging than the impact of climate change itself. As such many tourism participants needed to demonstrate that they have a viable future. They were also identified by all other stakeholder groups as the ones that would be most impacted by climate change in the region.

In terms of the impacts of climate change there was general consensus within the group that the loss of snow cover and decreased winter visitors were key issues and all agreed that the loss of snow cover and the flow on impacts was the biggest impact of climate change in the region. Most group members identified the conservation management group to be the one most impacted by climate change although the local and federal governments were also thought to experience economic impacts through the follow on effects of decreased winter visitor numbers.

Most of the climate change adaptation strategies identified by the tourism industry involved snow-making and water recycling for snow-making. There was little consensus within the group in relation to other strategies. Interestingly, only one participant identified the development and promotion of year-round tourism as a current strategy. There was little consensus as to future adaptation strategies with the exception of continued snow-making and related activities (e.g. grooming, landscaping). Two tourism participants identified the promotion of year-round tourism in their short-term plans (bringing the total to 3 out of 4). The last tourism participant when asked specifically about year-round tourism stated that due to their geographical location, they would continue to benefit from good snow levels and were not considering promoting year-round tourism in the near future. The local community/government was thought to be the primary beneficiary of the tourism climate change adaptation strategies through revenue generated during future year-round tourism.

The tourism group only identified 7 limits to their climate change adaptation strategies (compared to 17 by conservation managers and 18 by researchers) and focussed primarily on a general lack of knowledge of climate change and visitor satisfaction and social perceptions. Interestingly, no tourism participant identified limits to snow-making in relation to electricity consumption, technology or costs and only one identified water limits.

The tourism group also identified a small number of potential or actual conflicts with one participant stating that there were no real conflicts between tourism and the other stakeholders. There was no consensus within the group as to individual conflicts but these generally involved the conservation managers (restrictions on park use and access). One participant highlighted the lack of communication between the researchers and the tourism group as an area of conflict.

Most of the actual or potential collaborations identified by the group were between themselves and the conservation managers in relation to species and fire management. They also highlighted collaborations within their group in relation to information sharing and collaborative marketing. They were in fact the only group to highlight collaborations within their own group.

There was limited consensus within the tourism group as to future research needs with the exception of more accurate information on climate change predictions on a relevant time scale. They were also interested in information on social perceptions of climate change and skiing both by skiers and the general public.

4.4.2.4 Local government

There was very little consensus within this group in any area and they identified the fewest issues in relation to all aspects of climate change and adaptation in the region. This however, may be an artefact of sample size as there were only two group members.

The impacts of climate change identified were either ecological/physical or economic in nature. Both participants agreed that increased fire frequency and intensity was the largest impact of climate change in the region. They also both thought that the tourism industry would be the most severely impacted due to loss of snow and decreased winter visitors.

The restoration of disturbed habitats was the only current climate change adaptation strategy identified by one participant with the other participant stating that their local government did not have any current strategies in place. Water management was the only future adaptation strategy identified. The group had no idea as to whether their limited climate change adaptation strategies would benefit any other stakeholder group.

The biggest limits to climate change adaptation by the local government were social constraints associated with fire and water management and general climate change adaptation. They also identified general knowledge gaps and economic limits to their activities.

There was no consensus between the two participants as to individual conflicts arising from climate change adaptation but both agreed that they would be or were mainly social in nature. There was also no consensus in collaborations between stakeholders but identified fire management as a potential area for conservation managers, tourism and the local government. One participant mentioned that local governments were constrained by higher level directives that often made it difficult for them to collaborate with different groups and between local council areas.

There was again no consensus on future research directions but both agreed that more information was needed to help councils better adapt, particularly in relation to climate change impacts on water management and invasive species.

4.5 Conclusions

In general, the results of the interviews demonstrate that those locally responsible for making decisions about climate change in the region accept climate change as a process and have knowledge of many of its current and potential impacts. While many climate change impacts are recognised, there is great diversity in those identified both within and between stakeholder groups. Although all stakeholders have climate change adaptation strategies and recognise the limits of their strategies, there is again great diversity within and between groups as to the strategies used and their acknowledged limits. There are current and potential collaborations and conflicts between stakeholder groups in relation to climate change adaptation in the region which are heavily influenced by stakeholder needs and values. All stakeholders identified the need for more research to be conducted and results made available to the different groups but again there is diversity in the actual research directions.

Table 4.1. Summary of the potential interviewees from each stakeholder group approached to participate in project interviews.

Stakeholder group	Position	Response
Conservation Managers	Regional Manager	Yes
	Regional Manager	Agreed but not interviewed no suitable time
	Chief Ranger	No – on leave
	Assistant Director	No longer in key position – made referral
	Working Group Convenor	No longer in key position – made referral
	Program Manager	No longer in key position – made referral
	Program Manager	Yes
	Management Co-ordinator	Yes
	Manager Visitors	Yes
Tourism Industry	Environmental Officer	No – did not want to participate
	Environmental Services Manager	Yes
	Natural Resources Management Officer	Yes
	Environmental Officer	Yes
	Environmental Services Manager	Yes
	General Manager	No – responded after interviews ended
	Environmental Officer	Did not respond
	Executive Officer	Agreed but not interviewed as no suitable time
Local Government	Chief Environmental Officer	No – referral to co-worker
	Environmental Officer	Yes
	Environmental Health Officer	Yes
	Environmental Officer	Did not respond
	Environmental Officer	Did not respond
	Environmental Officer	Did not respond
	Environmental Officer	Did not respond
Researchers	Ecologist	Yes
	Ecologist	Yes
	Senior Principle Research Scientist	Yes
	Principle Research Scientist	Yes
	Academic Professor	Yes
	Senior Policy Analyst	Yes
	Researcher - tourism	No - no longer in key position
	Senior academic – climate change	No – no longer in key position

Table 4.2. Summary of the 16 participants from different stakeholder groups who participated in open-ended interviews. C = Conservation Managers, T = Tourism, L = Local government, R = Researchers. * Only refers to the four stakeholder groups in this project.

Code	Interview time (min)	Position	Time in current position	Time in stakeholder group	Previous member of another stakeholder group*	From alpine region
C1	35	Regional Manager	6 months	10 years	No	Yes
C2	32	Program Manager	5 months	15 years	No	Yes
C3	42	Management Co-ordinator	2 years	25 years	No	No
C4	32	Manager Visitors	1 month	24 years	No	No
Group average	***35.3***			***18.5 years***		
T1	27	Environmental Services Manager	18 years	18 years	No	No
T2	62	Natural Resources Management Officer	4 years	4 years	No	Yes
T3	31	Environmental Officer	4 years	4 years	No	No
T4	32	Environmental Services Manager	2 years	2 years	No	Yes
Group average	***38***			***7 years***		
L1	32	Environmental Officer	8 years	8 years	Yes (Conservation)	Yes
L2	29	Environmental Health Officer	6 years	6 years	No	Yes
Group average	***30.5***			***7 years***		
R1	32	Ecologist	15 years	15 years	No	No
R2	75	Ecologist	45 years	45 years	No	Yes
R3	42	Senior Principle Research Scientist	new position	20 years	No	No
R4	42	Principle Research Scientist	23 years	23 years	No	No
R5	45	Academic Professor	22 years	38 years	No	No
R6	81	Senior Policy Analyst	5 years	30 years	No	Yes
Group average	***52.8***			***28.5 years***		

Table 4.3. Participant responses when asked "What do you think of climate change in general?" The three sub-sections are summarised from individual responses.

	Total/16	Researchers/6	Conservation/4	Tourism/4	Local government/2
Believe in climate change in general					
Yes	16	6	4	4	2
No					
Don't know					
Convinced by data					
Yes	15	6	4	3	2
No					
Don't know	1			1	
Too much error in the predictions					
Yes	6	3		3	
No	9	3	4		2
Don't know	1			1	

Table 4.4. Participant responses when asked "Do you agree with the climate change predictions for the Australian Alps?" Relates to the climate change predictions sent to participants as part of the information sheet (Appendix 4). Sub-sections are summarised from individual responses.

	Total/16	Researchers/6	Conservation/4	Tourism/4	Local government/2
Agree with predictions for Australian Alps?					
Yes	16	6	4	4	2
No					
Don't know					
Best case or worst case scenarios					
Best case	3		1	1	1
Worst case	2	1	1		
Neither	13	5	2	3	1
Too much error in the predictions					
Yes	6	3		3	
No	10	3	4	1	2

Table 4.5. The impacts identified and the number of participants who identified them when asked "What are the likely impacts of climate change in the region?" *Additional impacts identified when we include the answers to the question "What are/will be the largest or most significant impacts of climate change in the region?" (see Table 4.6 for details on number of participants who identified these additional impacts). * E = Ecological, Ec = Economic, P = Physical, S = Social.

Impacts identified	Category*	Total/16	Researchers/6	Conservation/4	Tourism/4	Local government/2
Loss snow cover	E/P	14	5	4	4	1
Loss endemic species	E/P	8	4	1	2	1
Loss endemic communities	E/P	7	4		2	1
Drier summers	E/P	5	3	2		
Decreased water availability	E/P/S	5	3	1	1	
Increased fire intensity and/or frequency	E/P	4	4			
Increase invasive species	E/P	4	1	2	1	
Decreased winter visitors	Ec	4			4	
Decreased or altered rainfall	E/P	4	3	1		
Decreased soil moisture	E/P	4	2	1		1
Snow duration	E/P	2	2			
Changes to species phenology	E/P	2	1	1		
Loss of snow-based industry	Ec	2		1		1
Decreased resilience	E/P	1			1	
Increased soil erosion	E/P	1	1			
Increased cost of skiing	Ec	1			1	
Other (carbon, farmer productivity)		2			1	1
Increased storms*	E/P					
Revenue loss by ski industry*	Ec					
Loss of infrastructure due to fire*	P/Ec					

Table 4.6. The impacts identified and the number of participants who identified them when asked "What are/will be the largest or most significant impacts of climate change in the region?" * E = Ecological, Ec = Economic, P = Physical.

Impacts identified	Category*	Total/16	Researchers/6	Conservation/4	Tourism/4	Local government/2
Loss snow cover and flow on impacts	E/P	9	3	2	4	
Increased fire intensity and/or frequency	E/P	8	3	2	1	2
Snow duration and flow on impacts	E/P	4	2	1	1	
Decreased winter visitors	Ec	3		1	2	
Loss endemic species	E/P	2	1		1	
Increased storms	E/P	2	1		1	
Revenue loss by ski industry	Ec	2			1	1
Increase invasive species	E/P	1	1			

Decreased soil moisture	E/P	1	1			
Drier summers	E/P	1				1
Decreased or altered rainfall	E/P	1	1			
Loss of infrastructure due to fire	P/Ec	1		1		

Table 4.7. Participant responses when asked "What kind of influence will these impacts have on you or your industry? Positive, negative, short-term, long-term?" Sub-sections summarised from individual responses.

Question	Total/16	Researchers/6	Conservation/4	Tourism/4	Local government/2
Positive effects of climate change?					
Yes	3			2	1
No	13	6	4	2	1
Don't know					
Not mentioned					
Negative effects of climate change?					
Yes	16	6	4	4	2
No					
Don't know					
Not mentioned					
Short-term effects?					
Yes	9	4	2	1	2
No	3		1	2	
Don't know					
Not mentioned	4	2	1	1	
Long-term effects?					
Yes	14	6	3	3	2
No					
Don't know	1			1	
Not mentioned	1		1		

Table 4.8. Stakeholder groups and impacts identified by participants when asked "What influence do you think these impacts will have on other stakeholders?" N/A = not applicable.

Group and impact identified	Total/16	Researchers/6	Conservation/4	Tourism/4	Local government/2
Tourism - impacted by a lack of snow	8	2	4	N/A	2
Tourism - loss of visitors/visitor satisfaction	3		2	N/A	1
Tourism - loss of snow industry	2	1	1	N/A	
Tourism - increased fires in summer	2	1	1	N/A	
Tourism industry - water shortages for snow-making	2	1	1	N/A	
Tourism - increased competition	1		1	N/A	
Conservation managers - endangered species management	3		N/A	3	
Conservation managers - fire management	2	1	N/A	1	
Conservation managers - ecosystem dynamics	1		N/A	1	
Local government - water shortages	2		1	1	N/A
Local government - loss of income related to tourism	2		1	1	N/A
Australia Government - loss of tax income from tourism	1			1	

Table 4.9. Climate change adaptation strategies identified by participants when asked "What climate change adaptation strategies are available to your industry?" and "Which of these are you currently implementing?" These answers have been combined as all participants included current strategies in their available strategy lists and did not identify additional available but unused strategies.

Strategies identified	Total/16	Researchers/6	Conservation/4	Tourism/4	Local government/2
Invasive species management	5	1	3	1	
Snow making	5		1	4	
Research/long term monitoring	4	2	1	1	
Fire management	3		2	1	
Restoration disturbed habitats	3	1	1		1
Assurance *ex situ* fauna populations	2		2		
Assurance *ex situ* flora	2		2		
Risk assessments etc.	2		2		
Year round tourism	2		1	1	
Recycling water	2			2	
Recycling/treating sewage	2			2	
Improved technology	2			2	
None implemented	2		1		1
Reduce carbon footprint initiatives	1			1	
Using water for snowmaking from local rivers	1			1	

Table 4.10. Climate change adaptation strategies identified by participants when asked "Which strategies are you planning to implement?"

Strategies identified	Total/16	Researchers/6	Conservation/4	Tourism/4	Local government/2
Invasive species management	3		2	1	
Continue with current	3		1	2	
Increased fire management	2	1	1		
Not identified yet - waiting for vulnerability assessments	2		2		
Year round tourism	2			2	
Risk assessments	2		2		
Ex situ flora and fauna	1	1			
Supergrooming	1			1	
Landscaping	1			1	
Create new infrastructure/shift assets to higher slopes	1			1	
Track creation for summer biking	1			1	
Develop "last chance to see" tourism	1				1
Increasing resilience	1	1			
Artificial bog shading (reduce drying)	1	1			
Water management	1				1
No idea	1	1			

Table 4.11. Climate change adaptation strategies and stakeholder groups identified by participants when asked "Will your current or planned climate change adaptation strategies affect other stakeholders?"

Strategies identified	Total/16	Researchers/6	Conservation/4	Tourism/4	Local government/2
Year round tourism - benefit local economy	4		1	2	1
Fire management - benefit tourism	3	1	2		
No idea	3	1		1	1
Invasive management - benefit tourism	2	1	1		
Invasive species management - benefit conservation managers	2			2	

Table 4.12. Current or potential limits to climate change adaptation strategies identified by participants when asked "Will your current and planned adaptation strategies address all the climate risks that concern you? Are there limits to these adaptations?" * E = Ecological, Ec = Economic, K = Knowledge, P = Physical, S = Social, T= Technical.

Limits identified	Category*	Total/16	Researchers/6	Conservation/4	Tourism/4	Local government/2
General economic constraints	Ec	5	2	2		1
General lack of knowledge	K	5	1	1	2	1
Assurance populations cost	Ec	3	1	2		
Complexity of climate change impacts	E/P	3	2	1		
Invasive species social constraints (esp. Fauna)	S	3	2	1		
Snow making warmer temperatures	T/P	3	2		1	
Visitor satisfaction/social perceptions	S	3		1	2	
Snow making technology	T/P	3	2	1		
Snow making electricity	Ec/S	3	2	1		
Snow making physical water volume	E/P/S	3	2		1	
Snow making costs	Ec	2	2			
Assurance populations lack of natural habitat	E/P	2	1	1		
Fire management unpredictability of future fires	E/P	2	1	1		
General social constraints	S	2		1		1
Invasive species knowledge	K	2	1	1		
Fire management social constraints (e.g. Locals don't want to evacuate/surrounding landowners)	S	2		1		1
Water management social constraints (don't like being regulated by council)	S	2	1			1
Unpredictable/unseasonal climate change impacts	E/P	2	1	1		
Lack of more specific climate data and impacts	E/P/T	2	1	1		
General politics	S	2	1	1		
Assurance populations knowledge	K	1		1		
Fire management magnitude of future fires	E/P	1		1		
Invasive species funding	Ec	1		1		
Summer tourism infrastructure costs	Ec	1			1	
Summer tourism water licence limits	Ec/P	1			1	
Green energy costs	Ec	1			1	
Summer tourism social perceptions (Summer = beach)	S	1			1	
Conservation management social (behaviour of surrounding landowners/users)	S	1	1			

Table 4.13. Actual or potential conflicts in relation to climate change adaptation identified by participants when asked "Do you see any potential conflicts arising between the different stakeholder groups in relation to their climate change adaptation strategies?"

Conflict	Total/16	Researchers/6	Conservation/4	Tourism/4	Local government/2
Snowmaking and water (social)	5	4			1
Access to National Parks	4	1	1	1	1
General resort impacts on conservation management of area	3	1	1		1
Snowmaking and electricity (social)	3	2	1		
No real conflict	2		1	1	
Cattle/sheep grazing in surrounding areas	2	1	1		
Recreation impacts on NP (summer)	2	1	1		
Control of invasive species (especially fauna) by conservation managers not favoured by public	2	1	1		
Best conservation management options recommended by researchers not done by conservation managers (social)	2	2			
Surrounding land owners/users activities and conservation management - especially fire and invasive species	2	1	1		
Sporting shooters and invasive animals	1		1		
Bed limit (tourism and government) restricts expansion	1			1	
Research information not passed back to resorts for implementation	1			1	
Green fringe critical of resorts (previous management style)	1			1	
Bushfire prevention and preparation by conservation managers and local government (social objections)	1				1
Competition for water - industry, residential, agricultural	1				1
Ski resorts main source feral cats preying on native fauna	1	1			
Conservation managers want scientific information but not fund research	1	1			
Differences between long-term management strategies and goals need for conservation and short-term decision making by tourism or politics	1	1			

Table 4.14. Actual or potential collaborations in relation to climate change adaptation identified by participants when asked "Do you see any potential collaborations arising between the different stakeholder groups in relation to their climate change adaptation strategies?"

Collaborations	Total/16	Researchers/6	Conservation/4	Tourism/4	Local government/2
Resort operators and conservation managers - invasive species control	4	1	1	2	
Resort operators and conservation managers - fire management	3	1	1		1
Collaboration between resorts - share information, collaborative marketing	3		1	2	
Conservation managers and researchers - data collection	2	1	1		
Resort operators and conservation managers - ecosystem rehabilitation	2			2	
Researchers and government - climate change data collection	2	1	1		
Resort and local government - recycling	2			1	1
None	2	1			1
Resort operators work with lift company - year round tourism	1			1	
Capacity but limited in reality	1	1			
Collaboration between researchers – comparative climate change research with New Zealand counterparts	1	1			
Conservation managers and government - invasive species management	1	1			

Table 4.15. Future research needs identified by participants when asked "What information not currently available would help you/your stakeholder group better adapt to climate change in the Australian Alps?"

Information needed	Total/16	Researchers/6	Conservation/4	Tourism/4	Local government/2
Long-term ecological monitoring	7	4	3		
More accurate climate change predictions	4	1		2	1
Identification of trends (ecological and climatic)	2	1	1		
Understand limits for human disturbance (numbers, activities)	2	1	1		
Social perceptions (skiers)	2		1	1	
Social perceptions (general public)	2		1	1	
Better data on climate variability and frequency of extreme events	2	1		1	
Separate impacts of climate change and other factors	1		1		
Conceptual models to demonstrate impacts of climate change to government or public	1		1		
Path models to demonstrate flow on impacts	1		1		
Cost-benefit analysis research for adaptation strategies	1		1		
Environmental impacts of cloud seeding and feasibility in natural settings	1		1		
Snowmaking technology advances	1			1	
Better ways to determine carbon footprint	1			1	
Better data on impacts of climate change on water - surface and groundwater	1				1
More information on major weeds and removal	1				1
Community response to climate change	1				1
Better collaborative networks for regional councils	1				1
Better data on fire risk	1	1			

5. COMPARISON OF THE DESKTOP REVIEW OF PUBLISHED MATERIAL AND STAKEHOLDER INTERVIEWS

5.1 Impacts of climate change

Both the desktop review and the stakeholder interviews identified a large number of climate change impacts in the Australian Alps. Twenty impacts were identified in the desktop review with the majority being ecological/physical (70%) and economic impacts (10%). The most common impacts identified were the loss of snow cover, loss of endemic species and communities, increases in invasive species, increases in the intensity and frequency of fires and decreased winter visitors. Of these, the loss of snow cover and the follow-on effects and the loss of endemic species and communities were identified as the most significant.

Seventeen impacts were identified by the stakeholders and like the desktop review, most were ecological/physical (70%) or economic impacts (18%). The most common impacts were the loss of snow, the loss of endemic species and communities, increased frequency and intensity of fires, and decreased water availability. The biggest impacts of climate change as identified by the stakeholders were the loss of snow and the follow-on effects and increases in fire frequency and intensity.

5.2 Adaptations to climate change

A large number of climate change adaptation strategies were also identified by both the desktop review (20 strategies) and the stakeholder interviews (15 strategies). In both cases the majority were ecological/physical or technical/physical in nature. Economic and social adaptations were much less common.

Snow-making, control of invasive species, rehabilitation of disturbed sites and fire management were the most common strategies identified from the literature. The stakeholders identified snow-making, invasive species management, fire management and long-term monitoring as their current or future adaptation strategies. Despite the wide range of adaptation strategies identified and available, some stakeholders stated that they were not currently implementing any climate change specific adaptation strategies. This is in contrast to the literature where it is stated/assumed that all stakeholders will be involved in adapting to climate change.

5.3 Limits to climate change adaptation

Thirty-one and 28 limits to climate change adaptation strategies were identified in the desktop review and stakeholder interviews, respectively. In both cases most limits were ecological/physical in nature (50% desktop, 36% interviews). Economic limits (26%) and socio-economic limits (13%) were also common in the literature. Economic limits (22%) were also common in the stakeholder interviews. The biggest difference between the two data sets involved many more social limits (29% vs. 4%) and knowledge limits (11% vs. 0%) identified by the stakeholders than those reported in the literature.

Specifically, limits to climate change adaptation identified in the literature were primarily associated with snow-making (technical and economic), invasive species management (ecological/physcial and economic), diversifying to year round tourism (ecological/physical) and assurance populations of flora and fauna (economic). Those identified in the stakeholder interviews were associated with snow-making (social, technical and economic), assurance populations (knowledge and economic), and general economic and knowledge constraints

relating to different strategies. The primary limits to year round tourism identified by stakeholders related to economic costs of new infrastructure and legal requirements relating to water licences and increasing bed limits (compared to ecological/physical limits identified in literature).

5.4 Collaborations and conflicts

5.4.1 Collaborations

Most of the actual or potential collaborations for climate change adaptation between the different stakeholder groups described in the literature related to the management of invasive species, fire, endangered species and water. These collaborations usually involved the conservation managers and the tourism industry.

Stakeholder interviews highlighted collaborations between invasive species management, fire management, habitat rehabilitation (conservation managers and tourism industry), data collection (conservation managers, tourism industry and researchers) and information sharing and collaborative marketing (within the tourism industry).

5.4.2 Conflicts

Nine climate change adaptation strategies by different stakeholder groups resulting in conflict were identified in the literature. Most were associated with snow-making (conservation managers and tourism, local government and tourism) and the diversification to year-round tourism (conservation managers and tourism).

Thirteen conflict-causing strategies were identified by stakeholders and primarily involved snow-making (conservation managers and tourism, general public and tourism) restricted access to parks in summer (conservation managers and tourism), and conservation management strategies for invasive species, fire management and water management (conservation managers and public). New conflicts between conservation managers and researchers were also identified.

5.5 Conclusions

Overall, the desktop review and the stakeholder interviews provided similar information regarding climate change impacts, adaptation strategies, limits to strategies and conflicts within the Australian Alps. The interviews however, provided much more information on social, governance and knowledge issues relating to adaptation limits and conflicts, highlighting the importance of these values and perceptions when considering climate change adaptation strategies and identifying management priorities.

6. FINAL CONCLUSIONS AND IMPLICATIONS OF RESEARCH

Based on the desktop review and the stakeholder interviews we find:

1. The Australian Alps are experiencing climate change and are among the most at risk regions in Australia from climate change.

2. The region benefits from relatively long term data on climate and detailed modelling of climate change compared to many other locations. There is reasonably detailed existing long term ecological research for the region and modelling of climate change impacts on the flora and fauna. There has also been research on tourism in the region and the likely impacts of climate change on this industry.

3. Data shows changes have already occurred in the region including reduced natural snow cover, changes in fire frequency and intensity, changes in the timing of biological events such as flowering, animal migration/movement, and in plant and animal distributions. These include both long-term changes (up to 60 years data) and short (< 10 years) term variability.

4. Social changes have also been documented including a greater recognition of climate change by skiers and stakeholder groups such as the tourism industry and local government.

5. Economic issues such as reduced winter visitation to lower altitude resorts with low natural snow and costs associated with snow-making and species management have also been documented.

6. Because of the fairly direct link between increasing temperatures and decreasing precipitation and natural snow cover there is less debate now that climate change will change this critical resource. Consequently, stakeholders within the region are more advanced than in many other regions in terms of recognising that climate change is occurring and identifying its impacts.

7. The stakeholders in the region are fairly advanced in planning and utilising a range of climate change adaptation strategies and acknowledging a wide range of biophysical, economic and social limits to those strategies. However, the lack of general understanding of the context of the Alps and the importance of its water for Australia's economy is an important social limit that was not recognised by stakeholders who were more focussed on local or regional limits.

8. These limits mean that major impacts of climate change will still occur despite climate change adaptation strategies. For example, while snow-making is the primary climate change adaptation response by the tourism industry, it will not be economically, physically or socially acceptable for very long. Current threats to ecosystems are also likely to continue, e.g. management strategies for feral animals and plants have only slowed the spread of some species under conditions so are unlikely to be adequate with climate change.

9. Stakeholder interviews provided additional information to that in published documents, particularly in relation to social values, opinions and perceptions. For example, the tourism group did not see itself as most at risk from climate change while other stakeholders all agreed that the snow-based tourism industry would be the most at risk. In this case, it may be that the perception that climate change will have a serious impact on tourism (through decreasing snow levels), is more detrimental to tourism than the actual impacts of climate change. Alternatively, it may be the result of shorter term thinking and planning by the tourism industry vs. the longer term planning by other stakeholders or positive spin by the tourism industry.

10. The results and conclusions of this report are very similar to the conclusions reached for the European Alps and other mid-latitude regions where snow and ice are a major component of both the physical and socio-economic environments (e.g. Beniston et al. 2011; Agrawala et al. 2007). This highlights the importance of research on the limits of climate change adaptation in Australia to the global knowledge base of climate change science and impacts.

11. There is a need to move from descriptive problem-based discussion towards a more positive, action-oriented discourse on how different sectors can work together to achieve climate goals and enable communities and stakeholders to better adapt to future climate change.

12. Future research must build multi-disciplinary collaborations to produce new ideas and research techniques to address knowledge gaps and ensure that possible effects of climate change are factored into relevant policies and development and management plans.

13. As management of the environment becomes increasingly complex, there is a clear need to introduce adaptive management, integrate scientists and managers in management decision making (including personal and corporate accountability for management decisions) and clearly defining management goals and visions for the region that involve all stakeholders.

In conclusion, climate change adaptation in the Australian Alps illustrates general issues that need to be addressed when dealing with limits to climate change adaptation and how we can more successfully adapt to climate change. While primarily dealing with the loss of snow cover and the numerous ecological, economic, technological and societal flow-on impacts for different stakeholders, the results of this study can be applied to other obvious climate change issues including fires, cyclones, coastal flooding and coral bleaching among others. This information can help determine which climate change adaptation strategies are feasible and over what time scales, how society will respond to climate change and various adaptation strategies, and help prioritize adaptation strategies for groups where personnel and finances are limited. Consequently, this will permit the development of collaborative and comprehensive approaches to deal with climate change that benefit the environment and all stakeholders.

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APPENDIX 2. LIMITS TO CLIMATE CHANGE ADAPTATION INTERVIEW SHEET

PART A: INTERVIEWEE INFORMATION

Interviewee code:_____

Name:_____

Organisation:_____

Date and time of interview:_____

Interview type: Phone Skype

Introduction to project: Complete Incomplete

Verbal consent: Yes No

Recorded with permission: Yes No

PART B: PERSONAL DATA

What is your employment position:_____

What are your primary responsibilities in this position?_____

_____

_____

How long have you been in this position?_____

Were you employed in a similar position prior to your current employment: Yes No

If yes, where? _____

Are you from the Australian Alpine region? Yes No

If not, where? _____

What is your educational background?_____

PART C: CLIMATE CHANGE

1) What do you think about climate change in general? _____

_____

_____

_____

_____

_____

Climate change	Yes	No
Believe in CC		
Data convincing		
Too much error		
Too early to tell		
No consensus		

***REMIND ABOUT CC PREDICTIONS FOR THE AREA – BASED ON INFORMATION PACKAGE

2) Do you agree with the climate change predictions for the Alpine region? Yes No

3) If not, why not?_____

_____

_____

_____

PART D: LIKELY IMPACTS OF CLIMATE CHANGE IN THE AUSTRALIAN ALPS

Potential impacts	Likely	Influence your industry	Greatest impact	Influence others	Not concern you but others
Loss of snow cover					
Loss endemic species					
Loss endemic communities					
Increased diversity invasive species					
Decreased connectivity					
Decreased resilience					
Changes to species phenology					
Increased extreme fires/frequency					
Decreased soil moisture					
Increased soil erosion					
Increased landslides					
Increase intensive storms					
Drier summers					
Decreased water availability					
Increased loss of infrastructure (fire)					
Loss of snow -based tourism industries					
Increased cost of skiiing					
Decreased visitors (winter)					
Decrease in real estate investment					
Decrease in amenity migration					
Increased closure of NP					

4) What are the likely impacts of climate change in the region?_____

_____

_____

5) What kind of influence will these impacts have on you or your industry?(+ve, -ve, short-term, long-term)_____

_____

_____

6) Which do you think will have the greatest impacts?_____

_____

_____

7) What influence do you think these impacts will have on other stakeholders?_____

_____

_____

8) Are there other impacts that may not concern you or your industry but may be important for others? _____

_____

_____

_____

PART E: CLIMATE CHANGE ADAPTATION STRATEGIES

Adaptation	Familiar with	Available	Currently, when	Planning, when	Address all CC risks	Others
Fire suppression/control						
Control/limit invasive species						
Restore wetlands, snowgum woodlands						
Reduce soil erosion						
Restore connectivity						
Restoration disturbed sites						
Assurance populations of key native animals						
Seed banks for plants						
Post-fire control of weeds						
Tourism change to other industries e.g. Agriculture, forestry						
Increase capacity to deal with fire						
Increase real-estate sales						
Change to year-round tourism						
Non-snow related tourism in winter						
Snow-making						
Supergrooming						
Development of higher terrain						
Snow farming/harvesting						

9) Are you familiar with any climate change adaptation strategies?_____

_____

10) What climate change adaptation strategies are available to your industry?_____ _____

_____

11) Which of these are you currently implementing? Why? How long have you been using them?_____

_____

_____

12) Which of these are you planning to implement? Why? When?_____

_____

_____

13) Will your current and planned strategies address all the climate risks that concern you? Are there limits to these adaptations?_____

_____

_____

_____

14) Will these strategies address all the climate risks that may concern other members of your industry or other stakeholder groups?_____

_____

_____

_____

PART F: LIMITS TO ADAPTATION

Adaptation	Limit	Identified
Snow-making	Cost exceeds guest willingness to pay/prohibitive	
	Low natural snow	
	Fewer cold nights	
	Excessive consumption of water	
	Excessive consumption of electricity	
Snow manipulation/supergrooming etc.	Costs	
	Inefficient	
Resorts move into higher areas	Not physically/legally possible	
Change to year-round tourism	Closure of resorts in summer due to fires	
	Additional impacts on environment	
	Insufficient to meet economic demands	
Control/limit invasive species	Cost becomes prohibitive	
	Fire frequency/intensity limit control capacity	
	Loss of specialist snow-communities	
Restore wetlands, snowgum woodlands	Cost becomes prohibitive	
	Fire frequency/intensity limit recovery capacity	
Reduce soil erosion	Cost becomes prohibitive	
	Fire frequency/intensity limit recovery capacity	
Restore connectivity	Cost becomes prohibitive	
	Fire frequency/intensity limit recovery capacity	
Restoration disturbed sites	Cost becomes prohibitive	
	Fire frequency/intensity limit recovery capacity	
Assurance populations of key native animals	Loss of suitable apline habitat	
Seed banks for plants	In situ conservation impossible if habitat lost	
	Cost	
Fire suppression/control	Fire frequency/intensity limit control capacity	
Increase capacity to deal with fire	Fire frequency/intensity limit control capacity	
Post-fire control of weeds	Fire frequency/intensity limit recovery capacity	
Water conservation-recycling	Insufficient to meet demands	

PART F: LIMITS TO ADAPTATION - RESIDUAL IMPACTS UNDER BEST CASE SCENARIOS

15) Assuming that climate change stabilises under the best case scenarios discussed earlier, what do you think will be the residual impacts of climate change after adaptation has taken place?_____

_____

_____

_____

_____

_____

16) What influence will these residual impacts have on you or your industry?_____ _____

_____

_____

_____

_____

_____

17) What influence do you think they will have on other stakeholder groups?_____

_____

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PART G: LIMITS TO ADAPTATION - RESIDUAL IMPACTS UNDER WORST CASE SCENARIOS

18) Assuming that climate change stabilises under the worst case scenarios discussed earlier, what do you think will be the residual impacts of climate change after adaptation has taken place?_____ _____

19) What influence will these residual impacts have on you or your industry?_____

20) What influence do you think they will have on other stakeholder groups?____ _____

PART H: COLLABORATIONS OR CONFLICTS BETWEEN STAKEHOLDER GROUPS

21) Do you see any potential collaborations arising between the adaptation strategies favoured by different stakeholder groups?_____

_____

_____

_____

_____

_____

22) Do you see any potential conflicts arising?_____

_____

_____

_____

_____

_____

Adaptation	Potential negative impacts/conflict	Identified
Diversify to year round tourism	Greater impact physical environment - e.g. Soil erosion, trampling effects	
	Greater weed dispersal	
	Increased clearing native vegetation for walking tracks	
	Increased pressure on NP resources - e.g. Fire response	
Development of higher terrain	Greater impact physical environment - e.g. Soil erosion, trampling effects	
	Greater weed dispersal	
	Increased clearing native vegetation for ski infrastructure	
Snow making	Impacts on vegetation	
	Impacts on soil	
	Impacts on hydrology	
	Competiton for water - drive up costs	
	Impacts on fauna	
	Competition for electrcity	
Snow-manipulation	Impacts on vegetation	
	Impacts on soil	
	Impacts on hydrology	
	Impacts on fauna	
	Increase weed dispersal	
Control/limit invasive species	Limit visitor numbers/access	
	Restrict visitor activities	
Reduce erosion	Limit visitor numbers/access	
	Restrict visitor activities	
Restore connectivity	Limit visitor numbers/access	
	Restrict visitor activities	
Restore disturbed sites	Limit visitor numbers/access	
	Restrict visitor activities	
Increased real estate sales	Drive up prices for locals	
Cloud seeding	Increased rain impact snow dependent species	

PART I: FURTHER RESEARCH

23) What information not currently available would help your /your stakeholder group better adapt to climate change in the Australian Alps?___

_____

_____

_____

_____

_____

_____

_____

APPENDIX 3. GRIFFITH UNIVERSITY HUMAN RESEARCH ETHICS APPROVAL

GRIFFITH UNIVERSITY HUMAN RESEARCH ETHICS COMMITTEE

08-Oct-2010

Dear Dr Morrison

I write further to your application for ethical clearance for your project "NR: Limits to Climate Change Adaptation in the Australian Alps" (GU Ref No: ENV/24/10/HREC). This project has been considered by Human expedited review 1.

The Chair resolved to grant this project provisional ethical clearance, subject to your response to the following matters:

This application has been reviewed administratively by the Office for Research via a new mechanism for research that has been assessed as involving no more than negligible risk.

Provision of an amended information sheet that includes a legal privacy statement. Please note that the Commonwealth Privacy Commissioner has classified opinions as personal information. Please refer to section 7.10 of Booklet 23 of the Griffith University Research Ethics Manual for guidance. (http://www.griffith.edu.au/or/ethics/humans/)

The applicants are congratulated on a thoughtful and excellent application.

This decision was made on 08-Oct-10. Your response to these matters will be considered by Office for Research.

The ethical clearance for this protocol runs from 08-Oct-10 to 30-Jun-11.

Please forward your response to Karen Moorehead, , Office for Research as per the details below.

Please refer to the attached sheet for the standard conditions of ethical clearance at Griffith University, as well as responses to questions commonly posed by researchers.

It would be appreciated if you could give your urgent attention to the issues raised by the Committee so that we can finalise the ethical clearance for your protocol promptly.

Regards

Karen Moorehead

Office for Research
N54 2.39 Nathan Campus
Griffith University
fax: 07 5552 9058
email: k.moorehead@griffith.edu.au

GRIFFITH UNIVERSITY HUMAN RESEARCH ETHICS COMMITTEE

12-Oct-2010

Dear Dr Morrison

I write further to the additional information provided in relation to the provisional approval granted to your application for ethical clearance for your project "NR: Limits to Climate Change Adaptation in the Australian Alps" (GU Ref No: ENV/24/10/HREC). The additional information was considered by Office for Research.

This is to confirm that this response has addressed the comments and concerns of the HREC. Consequently, you are authorised to immediately commence this research on this basis.

The standard conditions of approval attached to our previous correspondence about this protocol continue to apply.

Regards

Karen Moorehead
Office for Research
N54 2.39 Nathan Campus
Griffith University
ph:
fax: 07 5552 9058
email: k.moorehead@griffith.edu.au
web:

APPENDIX 4. INFORMATION PACKAGE SENT TO PARTICIPANTS

Limits to Climate Change Adaptation in the Australian Alps

Dr Clare Morrison International Centre for Ecotourism Research School of Environment Griffith University Ph: +61 7 55527338 Email: c.morrison@griffith.edu.au	Ass. Prof. Catherine Pickering International Centre for Ecotourism Research School of Environment Griffith University Ph: +61 7 55528059 Email: c.pickering@griffith.edu.au

Purpose of the research:

Climate change challenges both the conservation values and the social matrix in alpine areas that occur in the highest mountains of the Australian Alps and the higher peaks in Tasmania. These areas are of high conservation value, with most subalpine and alpine areas conserved in a series of protected areas. In or adjacent to these protected areas are ski resorts, and at lower altitude, there are population centres that depend to a large extent on jobs and incomes generated from snow based tourism. Snow cover is already declining in Australia in response to climate change. The consequence is changes in the distribution of native and introduced animals and plants, and fewer big snow years for ski tourism. For the conservation stakeholders proposed adaptations to climate change include increasing the resilience of ecosystems to threats from weeds and feral animals, soil erosion and increased fire risk, as well as ex situ conservation and enhanced connectivity. For the tourism industry, adaptation is focused around snow making and diversification into year round activities. There are ecological, physical, economic, technological and social thresholds that will limit these strategies. Using extensive published and unpublished data and a series of semi-structured interviews with different stakeholders, this project aims to examine thresholds under different scenarios- no planned adaptations; residual effects at 2^{o}C after planned adaptations used; residual effects for >4^{o}C after planned adaptations; and substitutes for losses. Understanding these and other limits will be critical for conservation and tourism stakeholders as they adapt for less snow and warmer summers in Australia's alpine areas.

Benefits of the research:

Alpine ecosystems are considered one of the four most at risk ecosystems from climate change in Australia. Assessing ecological, physical, economic, technological and social thresholds that may limit adaptation strategies of conservation organisations and the tourism industry in the region will assist these stakeholders in better focusing their efforts to minimise the negative impact of climate change. This research will provide important insights into the objectives of four different stakeholder groups dealing with climate changes change such as conservation and tourism organisations, local government and researchers. This research will also establish benchmarks for other regions about how to examine limits to adaptations and how social, economic, physical and environmental factors interact.

What does participation in this project involve?

While there have been several reports and published articles looking at the influence and impacts of climate change in the Australian Alps, there is often a lag between work that is done and the time it takes to become publicly available. As such, important information on adaptation strategies currently being employed is often out of date. As a key member of your stakeholder group, we would like to conduct a 30-60 minute telephone interview regarding your views on; (i) potential climate change impacts in the Australian Alps, (ii) climate change adaptation strategies you/your organisation are currently using or planning to use, and (iii) potential limits to these adaptation strategies. Questions will be open-ended allowing for discussion of climate change issues that you feel are important to your stakeholder group/industry and the Australian alpine region in general. We would like to conduct the interviews during the first two weeks of November, 2010 and will interview you at any time suitable to you during that period. There will be roughly 20 interviewees from different stakeholder groups involved in this project.

Confidentiality:

During the interview we will take written notes and with your permission, make a recording. If you do not wish the interview to be recorded, that will not preclude you from participating. We will not use your name or your company's name in any of our public reports or presentations other than to identify the stakeholder group to which you belong. All of the information that we obtain from you during this interview will be kept confidential and only general results will be published. If given permission to record the interview, we will destroy the recording after it has been transcribed.

Privacy statement:

The conduct of this research involves the collection, access and / or use of your identified personal information. The information collected is confidential and will not be disclosed to third parties without your consent, except to meet government, legal or other regulatory authority requirements. A de-identified copy of this data may be used for other research purposes. However, your anonymity will at all times be safeguarded. For further information consult the University's Privacy Plan at http://www.griffith.edu.au/about-griffith/plans-publications/griffith-university-privacy-plan" or telephone (07) 3735 5585.

Voluntary participation:

Your participation will be entirely voluntary and you will be free to withdraw from the project and/or interview at any time.

Feedback:

Once the research is completed, a summary report highlighting the results of the interviews with all stakeholders and the project in general will be prepared and sent to you via email or post depending on your preference.

Ethical conduct of this research:

Griffith University conducts research in accordance with the National Statement on Ethical Conduct in Human Research. You are free to contact Griffith University regarding the ethical clearance of this project ENV/24/10/HREC.

Griffith University Human Research Ethics Committee

Ph: +61 7 37355585

Email: research-ethics@griffith.edu.au

Further information or to confirm willingness to participate:

If you would like more information about the project before making a decision to participate or to confirm your willingness to participate, please contact Dr Clare Morrison by either email (c.morrison@griffith.edu.au) or phone (07 55527338).

Climate change predictions for the Australian alpine region

Table 1: Summary of climate change predictions for Australian Alps (from Hennessy *et al.* 2005, Hennessy *et al.* 2008, Garnaut 2008)

Changes in:	Best case 2020	Worst case 2020	Best case 2050	Worst case 2050
Temperature	+0.2°C	+1.0°C	+0.6°C	+2.6°C
Rainfall	+3%	-8%	+8%	-23%
Reduction in area with snow cover				
At least 1 day	9%	37%	19%	87%
At least 30 days	13%	55%	27%	93%
At least 60 days	15%	60%	34%	97%
Average snow season length (ct 1990)	- 5 days	- 30-40 days	- 15-20 days	- 100 days
Very high/ extreme FFDI (Forest Fire Danger Index)	+~2%	+~10%	+~5%	+~25%

Snow cover, duration, depths

The predictions from Table 1 are estimated for 2020 and 2050 based on CSIRO climate change projections in a climate-driven snow model. Ranges of change are based on uncertainty in projections and variations in snow responses between sites.

By 2020:

- The total area with an average of >1 day snow cover decreases 10-39%
- Average snow season length decreases by 5-50 days (10-60% sites above 1600 m, 5-30% sites above 1600 m)
- Peak snow depths decline by 15-80% (below 1600 m) or 5-50% (above 1600 m).
- Maximum snow depth occurs earlier in the season.

By 2050:

- The total area with an average of >1 day snow cover decreases 22-85%
- Average snow season length decreases by 15-110 days (30-99% sites above 1600 m, 15-95% sites above 1600 m)
- Peak snow depths reduce by 10-100%.

The small area of true alpine habitat will probably disappear under the worst-case scenario 2050. The snowline is expected to rise e.g. Mt Kosciuszko snowline elevation now = 1460 m, may rise to 1490-1625 m by 2020.

Other climatic events

Average summer temperatures are expected to rise with an increase in the length of the warmer seasons. This increasing warmer weather and season length will have an impact on the frequency and intensity of bushfires during this time. There will also be an increase in climatic related events such as storms and landslides.

References

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APPENDIX 5. VERBAL CONSENT FORM FOR INTERVIEWS

Verbal Consent Form – Limits to climate change adaptation in the Australian Alps

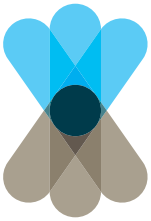
We are conducting research on the impacts of climate change in the Australian Alps and potential adaptations that can be made by different stakeholder groups. This work is being conducted by Dr Clare Morrison and Associate Professor Catherine Pickering of the International Centre for Ecotourism Research (ICER) and is funded by the National Climate Change Adaptation Research Facility.

As part of this research we would like to interview you regarding your views on the potential impacts of climate change in the Australian Alps, adaptations to climate change and potential limits to these adaptations. The interview will consist of a number of open-ended questions on the topic and will take approximately 60 minutes. We will take written notes during the course of the interview and would like to record the interview but will only do so with your permission. Once the research is completed, a summary report highlighting the results of the interviews with all stakeholders and the project in general will be prepared and sent to all participants via email or post.

Before you agree to participate, we would like to make clear the following points:

- This interview is entirely voluntary and you are free to stop at any time
- You do not have to give permission for this interview to be recorded. Any recordings made with your permission will be destroyed after being transcribed.
- We will not use your name or your company's name in any of our public reports or presentations other than to identify the stakeholder group to which you belong. All of the information that we obtain from you during this interview will be kept confidential and only general results will be published.
- You are free to ask questions at any time regarding the project
- Griffith University conducts research in accordance with the National Statement on Ethical Conduct in Human Research. You are free to contact Griffith University regarding the ethical clearance of this project.

Do you have any questions regarding the project or what is expected of you in this interview?
Do you consent to be interviewed as part of this project?
Do you consent to a recording being made of this interview?



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Department of Climate Change
and Energy Efficiency

Queensland
Government

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OF SOUTHERN
QUEENSLAND

QUT

University of the
Sunshine Coast

MACQUARIE
UNIVERSITY

THE UNIVERSITY OF
NEWCASTLE
AUSTRALIA