Perceptions of Climate Change Impacts, Adaptation and Limits to Adaption in the Australian Alps: the Ski-tourism Industry and Key Stakeholders.

Abstract

This paper explores perceptions of ski-tourism representatives and other regional stakeholders about climate change impacts, limits to tourism development and adaptation strategies in the Australian Alps. This area faces rising temperatures, declining rain and snow falls, and shorter skiing seasons. Open-ended interviews examined the perceptions, plans and attitudes of the ski industry and those of conservation managers, local government officials, and Australian researchers into tourism and/or climate change effects in the Australian Alps. All interviewees accepted climate change was a reality; several, however, questioned the worst case scenarios. The major tourism related adaptation strategies were snowmaking and diversifying to year round tourism; the success of these strategies will vary according to individual resorts’ snow making capacity and potential summer tourism revenue. Currently non-snow based tourism revenue is worth only c. 30% of winter revenue. Social resistance to increased water and electricity use for snowmaking emerged as an important issue. Competition for water including the needs of ecosystems, agriculture and fire protection in this summer fire prone region: fire management issues are a key concern. Current conflicts between the ski industry and other stakeholders over climate change adaptation call for a collaboration adaptation and change policy within the Australian Alps.

Keywords: snowmaking, year round tourism, fire management, adaptation capacity, sustainable tourism
Introduction

Globally, tourism is the fourth largest export industry with around 940 million international tourists in 2010 generating more than US$1 trillion and contributing an average of 5% to GDP (United Nations World Tourism Organisation [UNWTO], 2011). It is a diverse industry that includes food and hospitality, transportation, accommodation, visitor attractions, retail and other services. Although there are large international and national tourism companies, the industry is dominated by small and medium sized business (Tourism Research Australia [TRA], 2009), a feature contributing to its capacity to rapidly adapt to demand for new destinations, activities and markets. It is also a volatile industry that is sensitive to economic, social, ecological and technological change including climate change (Amelung, Nicholls & Viner, 2007; Buckley, 2008; Gössling & Hall, 2006a; Weaver, 2011).

The tourism industry is especially sensitive to climate conditions, as climate affects when, why and where tourists travel (Hamilton & Lau, 2006; Maddison, 2001). It determines the nature/location of many tourism attractions, including sun and surf tourism, snow based tourism and ecotourism (Gössling & Hall, 2006b; Perch-Nielsen, 2010). It is important for marketing many destinations as tourists escape a local unpleasant climate for more favourable climes. It shapes tourists’ expectations, experiences and memories, affecting where people return to and where they go next.

Due to this sensitivity, predicted changes in a wide range of climatic variables will have significant implications. Despite climate change being identified as the major threat to tourism in the 21st century (UNWTO-UNEP-WMO, 2008), there is limited research on how climate change will affect the tourism industry, and how the tourism industry is responding (Gössling & Hall, 2006b; Scott, 2011; Scott & Becken, 2010; Wolfsegger, Gössling & Scott, 2008). Only around 2% of tourism academic research examines any aspects of climate change be it impacts, mitigation and/or adaptation (Scott, 2011; Weaver, 2011). As a result,
the tourism sector is at least 5-7 years behind other industries actively involved in climate change research (Wolfsegger et al., 2008).

One segment of the tourism industry that has started to address climate change impacts and adaptation is snow based tourism (Scott, 2011). Research including in Europe (e.g. Elsasser & Messerli, 2001; Moen & Fredman, 2007; Wolfsegger et al., 2008; Soboll & Dingeldey, 2012), North America (e.g. Dawson, Scott & McBoyle, 2009; Hamilton, Brown & Keim, 2007; Scott, Dawson & Jones, 2008), and Australasia (e.g. Fukushima, Kureha, Ozaki, Fujimori, & Harasawa, 2002; Hennessey et al., 2008; Heo & Lee, 2008; Konig, 1998; Pickering, 2011; Pickering & Buckley, 2010) has modelled direct and indirect biophysical impacts of climate change for ski resorts. In many destinations natural snow cover is already declining, jeopardising destinations unless they adapt. The most common adaptations include snowmaking, amalgamation of resorts and the development of year round tourism, which often involve considerable investment of resources by industry and government (Pickering & Buckley, 2010; Wolfsegger et al., 2008). But are these strategies likely to be successful or are there limits to such adaptations and what are those limits?

Limits to climate change adaptations are commonly categorized as: (i) biophysical, (ii) economic, (iii) technological, and (iv) social (Adger et al., 2009). Understanding these limits is essential for determining which climate change adaptation strategies are feasible and over which time scales, understanding how people may respond to the impacts of climate change, and prioritizing adaptation strategies. This applies not only to the strategies of the ski industry, but also to responses of the tourism industry more generally to climate change.

To examine this issue, we need to understand the perceptions, plans and attitudes of the ski industry to climate change, its impacts, their adaption strategies, and what they think may limit these strategies. We also need to know what other people in a region are likely to do and how that will influence the tourism industry.
This study assesses the perceptions of climate change, its likely impacts, the ski resorts adaptation strategies and limits to those strategies using open-end interviews with representatives from ski resorts, conservation organisations, local government and researchers in the Australian Alps. The Australian Alps were selected as the geographic focus of this study into limits to adaptation by the ski industry as there is information on (i) climate change predictions and impacts, (ii) adaptation strategies including the potential for snowmaking under current and future climatic conditions, (iii) visitor attitudes including the intentions of skiers and actual visitation patterns with low snow, (iv) past attitudes of the ski industry and, (v) potential limits to adaptation strategies based on published documents.

Methods

The Australian Alps

Study Area

The Australian Alps are located in the southeastern corner of mainland Australia and extend over 500 km between the major cities of Melbourne and Sydney (Fig. 1). They occupy a total area of about 25,000 km² or 0.3% of Australia (Crabb, 2003). The highest peak, Mount Kosciuszko, stands at 2228 m. The Australian Alps contain nearly all the area within mainland Australia that has snow on the ground for one or more months a year, (2350 km², Green & Osborne, 1994). Within the Australian Alps are 11 national parks/reserves that occupy 16,640 km², extending across the majority of the Alps Bioregion which is recognized as a National Landscape in Australia’s National Heritage List (Department of the Environment, Water, Heritage and the Arts [DEWHA], 2010). In or adjacent to the protected areas there are currently 10 ski resorts (Table 1), which are serviced by lower altitude population centres whose economies are largely dependent on tourism, making them
particularly vulnerable to changes in the industry, including those from climate change (Lynch, Roman & Tyhorn, 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, while much of southeastern Australia utilizes hydroelectric power generated within the Australian Alps (Worboys, Good & Spate, 2010).

Tourism in the Australian Alps

The majority of visitation to the Australian Alps occurs in winter. The most recent available data for the region shows around 2.5 million skier days during the relatively short official ski season in 2009 (113-120 days) with 900,000 skier days in Victoria in 2010 (Alpine Resorts Co-ordinating Council [ARCC], 2011). The snow based tourism industry in the Australian Alps was worth roughly 0.1% of national GDP in 2005 (AU$906 million in 2005; National Institute of Economic and Industry Research [NIEIR], 2006) with the ski resorts the major industry players.

During the snow free period the area is extensively used for a wide range of nature based tourism activities. The most popular activities in summer are bushwalking/hiking including summiting Mt Kosciuszko (2228 m). Other popular activities include camping, fishing, rafting, canoeing, kayaking, rock climbing, mountain biking, orientation and horseback riding (Mules, Faulks, Stoeckl & Cegielski, 2005). Historical tourism and a range of music, food and art festivals are increasingly promoted by ski resorts and local towns. Non-snow based tourism to the region was estimated as worth one-third of winter tourism (AU$302 million in 2005, NIEIR, 2006).
Climate Change Predictions for the Australian Alps

The changes in climate predicted for the Australian Alps involve increased temperature and decreased precipitation resulting in less snow. For example, by 2020 under best and worst case scenarios, temperatures are predicted to increase by +0.2-1.0°C, rainfall decrease by 3-8.3%, the area with at least 60 days of snow on the around reduce by 17.5-60.3%, and the average length of the snow season to decline by 5-50 days compared to 1990 values (Hennessy et al., 2008). By 2050 under the best and worst case scenarios, temperatures are predicted to increase by +0.6-2.9°C, rainfall decrease by 2-24%, the area with at least 60 days of snow on the around reduce by 38-96.3%, and the average length of the snow season to decline by 15-110 days (Hennessy et al., 2008).

Significant declines in snow depth and duration have already been documented in the Australian Alps including a 30% reduction in overall snow cover, and a 40% reduction in spring snow for the highest snow course in Australia (Hennessy et al., 2008; Green, 2010). In addition to these direct changes, there are associated secondary biophysical effects predicted including more cloud free days, lower humidity and increased total solar radiation (Howden, Hughes, Dunlop & Zethoven, 2003). More variable and extreme climatic regimes and erratic weather events such as high intensity rainfall and storms are also predicted (Garnaut, 2008; Hennessy et al., 2008). Average summer temperatures are expected to rise, resulting in increased frequency and intensity of bushfires (Lucas, Hennessy & Bathols, 2007). By 2020, the number of extreme fire danger days (where fire suppression is virtually impossible) in southeastern Australia is predicted to increase by 6-25% and 20-70% by 2050.

Perceptions of the Ski Tourism Industry and Other Stakeholders
While this study focuses on the ski resorts, the adaptation strategies of other stakeholder groups in the region will affect the winter tourism industry. As the resorts are located in or adjacent to national parks, representatives of the parks agencies (conservation managers) were invited to participate. Decisions by resorts and parks directly affect each other, including their response to climate change and tourism. The resorts are also in or adjacent to local government areas. Local government is responsible for promoting and managing tourism in the towns adjacent to the Australian Alps where many tourists transit on their way to the resorts, the towns where most permanent resort staff live, and where there is increasing amenity migration. As such, it was also important to assess and compare strategies and limitations of the local government and the ski resorts. Finally, researchers who have published on tourism and/or climate change effects in the Australian Alps were also invited to participate. This group provides a different knowledge set and motivation to the other stakeholders and potentially were able to evaluate the likely strategies and limits without concern for the commercial or political implications.

For the ski resorts, all nine management organisations were contacted and asked to participate in the research. Only four resorts were willing or available to participate: however, these resorts represent a good geographical spread, range of resort sizes and altitudes and represent 60-65% of all visitors to the Australian Alps. The tourism participants were all nominated by their organisations as the best person to be interviewed and included an environmental services manager, a natural resource management officer, an environmental officer and an environmental services manager. They had between 2 and 18 years experience in their current positions (18, 4, 4 and 2), which was similar or less than representatives from other groups (average 7 years for local government, 18.5 years for conservation managers, and 28.5 years for researchers).
In the other stakeholder groups most of the people contacted who did not participate were unavailable (conservation managers and researchers) or did not respond (local government). Our final sample consisted of 16 people representing: (i) ski resorts (4 people, T quotes), (ii) conservation managers (4, C quotes), (iii) local government (2, L quotes) and, (iv) researchers (6, R quotes) from a potential pool of 32 people originally approached (7-9 people approached per stakeholder group).

Although only 16 people representing the different stakeholders were interviewed, due to small size of the Australian ski industry (compared to other regions, e.g. North America and Europe), they represent the majority of stakeholders involved in ski tourism in the Australian Alps and include a greater range of inputs than previous similar studies (e.g. Bicknell and McManus 2006). The participants were interviewed via Skype (voice only) or telephone between November 2 and November 26, 2010. To maximise the information collected from each interview, 23 in-depth open ended questions were asked about: (i) participant background, expertise, and experience, (ii) climate change in general, (iii) climate change predictions for the Australian Alps region, (iv) actual/potential impacts of climate change in the region, (v) current and proposed climate change adaptation strategies being used, (vi) actual/potential limits to climate change adaptation strategies, (vii) actual/potential collaborations and conflicts between stakeholder groups, and (viii) future research directions. Over 11 hours of interviews were conducted, with interviews averaging 42 minutes (shortest 27 minutes, longest 81 minutes).

Results

Climate Change and Impacts
In response to the question “What do you think about climate change in general?” all 16 participants expressed a general belief in climate change. All but one of the 16 participants were convinced by general current climate change predictions and data although three tourism representatives along with three researchers expressed dissatisfaction with the level of error involved with these predictions.

“Given the uncertainty associated with it I agree, but I generally have issues with the upper end of the scale, the worst-case scenarios.” (T1)

“Definitely happening. How big the impact is going to be a really big question. So many variables involved so it’s difficult to know for sure. Given that there is so much variability, particularly for the tourism industry like ours that is very reliant on certain weather conditions, it is very difficult to predict where we are going to be in 15-20 years even with the scientific data behind it. It’s definitely happening but with what impact we don’t know.” (T2)

“I do think that it is occurring and we can see various effects of it in our resort. I also believe there is a lot of hype surrounding climate change when it comes to political buzzwords – that’s just personal.” (T3)

“Every indication that there are changes in our climate. Whether it’s in degrees of temperature or in other ways. There’s a whole myriad of predicted changes, some I agree with, some I don’t.” (R2)

These same six participants also had questions about the range and uncertainty of values associated with specific climate change predictions for the Australian Alps region.

“Overall they are good, some specific locations in the Alps a little off but otherwise okay.” (R1)

“Personally I think the debate is far too global or broad scale and gets too general – for example, what happens in Canberra [city 200 km from resorts] doesn’t necessarily happen in the Alps…..seasonal conditions change but whether that’s associated with global warming and the subsequent climate change remains to be seen as far as I am concerned.” (R2)
All four tourism participants stated that they had had firsthand experience with climate change in the Alps region itself and stated that climate change was currently, or was likely, to become one of the most important issues in the region.

“Climate change will determine what the alpine resorts turn into.” (T2)

“Being around the snow for most of my life anyway I think you can see a change as it is.” (T3)

The tourism participants identified nine impacts when asked “What are the likely impacts of climate change in the region?” These were loss of snow cover (all), decreased winter visitors (all), loss of endemic species (2) and communities (2), decreased water availability (1), increased invasive species (1), increased cost of skiing (1), decreased ecosystem resilience (1) and increased storms (1).

“Alpine areas are one of the barometers of climate change…we acknowledge that in the medium to long term there may be potential impacts on the quantity of water available and snow cover. We think that on the large scale there will be impacts but on a microscale, on our little plots of land that is our little resorts, they may not necessarily have as great an impact as in the greater scheme of things” (T1)

“If climate change is really bad and the ski seasons do start really regressing and we get less money coming into the region, socially it’s going to have a big local impact. Worst case scenario it will have a big regional socio-economic impact.” (T2)

“Definitely increased temperatures, but also threat of increased storms which can be very damaging.” (T2)

“With the rising temperatures there is also increasing risk of fire.” (T3)
All but one of the 12 other participants felt that climate change would result in snow loss. Drier summers (5) and increased fire intensity/frequency (4) were other common impacts highlighted by non-tourism participants.

“Obviously going to get much less snow and much shorter snow seasons.” (R1)

“Climate change is a risk management issue. Overwhelming evidence points to an increase in risk overall and in the alpine area that will be related to loss of snow cover.” (R4)

“Most obvious impact will be the loss of snow.” (L1)

“Have seen real drying of areas that normally were quite moist...normally quite wet, bog areas generally be drier.” (C1)

“Fire regime intensity and frequency will increase.” (C3)

When asked “Which do you think will be the greatest impact(s)?” all four tourism participants identified loss of snow cover as the most important. Two of them also identified decreased winter visitors while decreased snow duration, increased fire intensity/frequency, increased storm frequency/magnitude and revenue loss by the industry were each identified by one tourism representative.

“The key point is obviously the loss of the ski industry or the decline of that at least. With that you’ve got loss of income or a shift in sources of revenue for different people.” (T3)

“Impact on snow cover will be the biggest. If there’s no snow there won’t be any visitors.” (T4)

The loss of snow cover and its flow on impacts (5) and increased fire intensity/frequency (4) were identified as the most significant impacts of climate change by the 12 non-tourism participants. They also highlighted loss of revenue by the ski industry and the loss of infrastructure due to fire.
“Fire regime changes and asset loss and tourism disruption will probably be in there.” (C3)

“For council more about social, most of our economies around here are based on park tourism, snow tourism so any impact on that will have an impact on the economy of the township as well.” (L1)

“Bushfires both frequency and intensity will have major impacts as they can influence social and economic factors more so than others.” (L1)

“We are facing a drier future which means more fire. In the Alps we have to be aware of the areas surrounding them which will become more fire prone. As the Alps are essentially islands, we are looking at a fire regime which may affect the Alps.” (R6)

When asked “What influence do you think these impacts will have on other stakeholders?” the most commonly identified influence was the impacts of less snow on the tourism industry (8 of the 12 non-tourism participants). Three of the non-tourism participants also identified decreases in visitor satisfaction/visitor numbers in having a negative impact on the tourism industry. Other perceived impacts of climate change on the tourism industry included the complete loss of the snow industry (2), increased fires in the summer tourism season (2), water shortages for snowmaking (2), and increased competition from other tourism destinations in winter (1).

“Lack of snow will have a big impact on tourism. The whole thing is all about perception. Come the beginning of the season if there is a lot of snow people book for September, if not they don’t book for September…it’s not about what happens in September, it’s about what happens in June.” (R1)

“Socially on the tourism side it can have a pretty significant impact, obviously with snow conditions. That will be a major impact for the tourism industry based around snow levels, with less days, less area of snow cover.” (L1)

“Snowline moving up makes the recreational activities more difficult.” (C4)
“The cool wet nature of the alpine region and its visual amenities, if that alters then the tourism industry will have to move with that change.” (C3)

“A lot more bushfires in summer will keep tourists away.” (C1)

**Climate Change Adaptation Strategies**

When asked “What climate change adaptation strategies are you currently implementing?” the tourism participants identified 10 strategies focussing primarily on snowmaking (4), improving technology (2) and water recycling (2). Fire management, invasive species management, diversification to year round tourism and initiatives to reduce carbon footprints were also identified.

“All the ski lift companies around Australia are investing heavily in snowmaking. That’s their entire investment at the moment because it is really expensive to put in. If you don’t have the snow on the ground people aren’t going to come and spend money.” (T2)

“Key adaptation strategy is the snowmaking system. We originally installed it because we were lower down anyway not because of climate change. We did it in response to what the ski customer wanted with quality snow cover for as long a part of the season as we can.” (T1)

“We’ve been using snowmaking for the past 10 years now. We’ve also got new groomers to shift the snow around, that’s more energy efficient.” (T4)

“Another adaptation strategy is moving or creating new infrastructure to suit the shifting snow levels. There is a resort master plan that is under way that looks at shifting the village assets around like the playgrounds and the beginners ski areas.” (T3)

“Our bread and butter is the skiing, obviously if there is less snow there is less opportunity for people to come and pay us for the privilege so if we reach a point where we can’t provide that, it will obviously impact on that part of the operation and then we have to start looking at other opportunities. Summer business is an obvious one.” (T1)

“Another strategy is considering all year round resorts so marketing is full steam ahead for summer activities – marketing the mountain as a year round resort involves a lot of mountain bike trail creation, a lot of money being put into creation of new tracks and trails. Has been a
huge part of our summer development for the past three years now and that will be ongoing.” (T3)

“Fire mitigation procedures that we have been adapting are following the fires we have had in the past few years. It also provides a back up for future as we can see them being more common in future.” (T3)

All other participants identified snowmaking as the tourism industry’s main adaptation strategy while some (5) identified diversification to year round tourism.

“Obviously what the ski industry is using to manage year to year variability is snowmaking. Also they move the snow around to where it’s needed. Beyond the winter based tourism there is a lot of diversification across all four seasons and we know that they have moved to things like mountain biking, horse riding and conferences and that sort of thing…trying to diversity to spread the risk.” (R4)

“Pushing a move to more year round tourism and not just reliance on winter tourism. Has worked in some areas like Thredbo [large resort in New South Wales] but at the other end of the spectrum it hasn’t worked for Perisher [another large resort that is close to Thredbo].” (C4)

“Major thing I think or major issues are we have to manage an exit of the ski industry. However on the other hand I think the Alps will become a highly desirable area for summer tourism.” (R6)

When asked “Which strategies are you planning to implement?” the tourism industry mainly planned to continue with current strategies (2) and develop year round tourism (2). They also identified super grooming, landscaping, and the creation of new infrastructure in higher slopes. One person specifically stated that due to the high altitude nature of their location they were not currently or planning in the near future to diversify to year round tourism but they thought that other lower lying resorts would have to.

**Limits to Climate Change Adaptation**
When asked “Will current and planned adaptation strategies address all the climate risks that concern you? Are there limits to these adaptations?” the tourism industry identified seven limits primarily concerned with social perceptions and visitor satisfaction (3) and the general lack of knowledge in relation to climate change impacts (2). They also identified biophysical limits associated with snowmaking, namely warmer temperatures (1) and required water volumes (2), along with the costs of infrastructure development (2) and water licence limits (1) for summer tourism.

“I think if we get to that stage it will be physical water volume will be the key driver. If we quadrupled the size of the system we could make an incredible amount of snow but it is a pretty finite equation: the volume of water makes a volume of snow. Water is likely to be the limiting factor rather than energy or technology.” (T1)

“Snowmaking is really important for all alpine resorts. But it also uses a lot of energy. Snowmaking is a double edged sword as it uses a massive amount of energy to compress the air through the pipes to pump everything and blow it out.” (T2)

“It’s not cheap to invest in alpine resorts, whether it’s building, whether it’s commercial operations and now people are starting to look at climate predictions before investing. If the data keeps showing worst-case scenario, worst case scenario it’s really going to limit how much people will invest in alpine resorts across Australia.” (T2)

“One of the biggest things is the perceived income we have in alpine resorts. We are not a statutory body and entirely self-funded so putting an extra $10,000 on our electricity bill which is already $300,000 is really difficult, we can’t snap our fingers and make the extra money appear. So one of the biggest limits to changing and adapting is the financial resources to be able to put into it.” (T2)

“Tourism market is very competitive particularly given that skiing is relatively expensive in Australia in relation to other activities you can do as well as skiing overseas. Not a particularly environmentally friendly activity either. If you look at the amount of heat generated lost through buildings and the amount of energy used for snowmaking in particular, plus peoples transport to get here. With more environmentally conscious tourists, unless the ski resorts can adapt to being more environmentally friendly places then they can be seen as a bad tourism destination. Some people won’t care but some people will start making decisions on that.” (T2)
“Summer tourism isn’t growing in leaps and bounds, its growth still lags far behind that of winter growth but we think there is potential.” (T1)

“Probably temperature will be the limit. If ski lift companies can’t make snow and there is no snow product to be able to generate skiing during winter then based on what we are seeing at the moment then the alpine resorts would collapse in Victoria [state, see Figure 1], there is no doubt about it. Data we have suggests that snowmaking will bolster the industry until 2050, if that’s the case that gives the alpine resorts the time to develop different seasonal products and not just the winter product. If we can do that we can still remain viable. If we can’t the alpine resorts will become ghost towns.” (T2)

“Another limit is culture. I believe that Australia is a beach culture so as much as you can work on summer visitation, the majority of the public is attracted to rivers, lakes and beaches.” (T3)

Non-tourism participants identified perceived and actual limits to the adaptation strategies favoured by the tourism industry including snowmaking technology (economic and technical limits, 5 participants), snowmaking water volume (physical and social limits, 3), snowmaking electricity (economic and social limits; 3), snowmaking temperatures (physical limits, 3), year round tourism (social and economic limits, 3), and fire management (physical, economic and social limits, 4).

“Snowmaking not a huge issue at the moment but it will be into the future when less water is available.” (L1)

“Skiing will be a non-viable activity unless they create a whole lot of artificial snow and to do that you require not only the water and the sub zero temperatures at night which you might not get.” (R5)

“In terms of summer tourism there is an opportunity for summer tourism to grow – I don’t know if it will grow significantly though.” (C2)

“Snowmaking has its limits – the amount of water it currently uses which will increase in future as they need to use it more, the electricity it consumes and how much it all costs. People will only pay so much to ski so eventually you’ll end up losing money.” (R6)
“Have to evacuate an area like Thredbo [large resort in New South Wales] in summer…relatively quick to get them out but takes a long time to get them back after the fire threat is gone…” (C1)

Conflicts and Collaborations between Stakeholders

When asked “Do you see any potential conflicts arising between the different stakeholder groups in relation to their climate change adaptation strategies?” the most common conflicts described were social objections (current and future) to the large amounts of water used for snowmaking (5 non-tourism participants). Restricted access to the national parks by the conservation managers was also important (2 tourism, 2 non-tourism participants) along with the general environmental impacts of the resorts (3 non-tourism participants). Interestingly, two participants (one conservation manager and one tourism participant) did not recognise any real conflict between stakeholders.

“More about conflicting ideas rather than collaborations. For example, the ski resorts are the main source of cats in the mountains which prey on native species…..so it’s more that they (the resorts) are a problem rather than part of the solution.” (R1)

“Collaboration in general, climate change aside, is very difficult as everyone has a polarised view of the mountains. You notice that with national parks there are users who think it should be open for everyone, more conservation minded people who think the best thing for conservation is to keep everyone out, in a way everyone is right but we need to find a balance. That is why national parks agencies are not well liked because they’re trying to keep everyone happy.” (C2)

“No I don’t see any real conflict between groups, although sometimes the lodges complain about the things we do because things are harder for them.” (T4)

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 general public perceptions of the negative environmental impacts of resorts (legacy of past management styles and social restrictions) as being the important conflicts faced by their group.

“Obvious one is the bed limit. We have a defined bed number available to us in the resort – we will probably at some stage reach that limit and as a commercial enterprise we will want to go over it.” (T1)

“There is a lot of research that gets done from a biodiversity point of view that says alpine resorts are detracting from the environment. But that information from that research is not fed back to us so we can actually act on it. We usually find out about it when it hits the press which is disappointing from a management point of view. The lack of collaboration with researchers and the unwillingness to share information and research before it’s released to everyone is really quite difficult to stomach. Especially since some of these papers can be quite influential.” (T2)

There was little consensus between the conflicts identified by the tourism industry and those identified by other groups with the exception of access to national parks.

Researchers highlighted social conflicts between the use of water (4 researchers) and electricity (2) for snowmaking and general public demand for the same resources. They also indentified conflicts between resorts and conservation managers regarding access to protected areas. The differences between effective long-term management strategies and goals for successful conservation and short-term decision making by the tourism industry and political decision-makers was also mentioned as a source of conflict.

“Local government shires around the park see the park as a tourism resource first and foremost. Therefore that brings money to the shire and more and more development of the support industry for the ski industry….so no real incentives for parks and local governments to work together either.” (R2)

“The secondary impacts of half a million more tourists hiking through the Alps in summer and winter instead of skiing when there is little snow could be as devastating as climate change
itself….climate change in that case will become a secondary effect. Parks agencies need to work with resorts in the future to ensure that doesn’t happen.” (R2)

“Historically cattle grazing had a significant impact on the landscape. Tourism will probably become the next big destructive use of the region.” (R6)

“High altitude endemic species and ski resorts are chasing exactly the same resource which is high altitude areas.” (R6).

The conservation managers primarily highlighted conflicts between themselves and other users in relation to park management e.g. resort impacts, increased recreation impacts in summer, fire management and tourist safety in summer as well changing government priorities.

The local government identified social conflicts between the use of water for snowmaking and 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.

When asked “Do you see any potential collaborations arising between the different stakeholder groups in relation to their climate change adaptation strategies?” the most common responses included collaborations between conservation managers and the tourism industry in invasive species management (identified by 2 tourism participants, 2 conservation managers), fire management (2 tourism participants, 1 conservation manager) and ecosystem rehabilitation (2 tourism participants).

There was collaboration between researchers and government and between 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).
“You’d be surprised at how much collaboration there is throughout the Australian Alps….park managers and scientists come together to disseminate information.” (C1)

“A strong industry is more than just one resort, so our resort marketing board works with others within limitations to make sure that the industry is strong rather than just one resort strong.” (T2)

“Social and tourism marketing for all year market will benefit us all, managing bushfire and bushfire risk is needed in order for it to work.” (L1)

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.

“In the Park there is always pressure for more and more development within the ski resort areas or expansion of the areas. That’s because their business is commercial…on the other hand and I’ve said this bluntly at many meetings when the industry cries that they need to build another $10 million structure to make themselves viable, my response is always your economic viability and our conservation are poles apart, your viability is your issue…therefore never really going to pull together even under climate change. There is very little incentive or reason for conservation agencies and the resorts to come together, it’s more of a friendly feel good thing.” (R2)

**Future Research Needs**

When asked “What information not currently available would help you/your stakeholder group better adapt to climate change in the Australian Alps?” two participants from the tourism industry identified more accurate climate change predictions and one identified information on extreme events. 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 snowmaking technology advances and better ways to determine their carbon footprint.
Discussion

Representatives from the tourism industry along with conservation managers, local government and researchers surveyed recognise that climate change is occurring and is a critical issue for the Australian Alps. They are also aware of the climate change predictions for the region and generally accepted the predictions (albeit sometimes with reservations due to the uncertainty of values). This differs from some previous studies looking at the perceptions of the snow-tourism industry where some level of denial was evident by resort managers as recently as 2002 (e.g. Bicknell & McManus, 2006). This increased awareness may be because several important climate change reports have been published (e.g. the Stern Review in 2007, Garnaut Climate Change Review in 2008) and climate change summits (e.g. Copenhagen Climate Conference in 2009) held in the intervening eight years. All those surveyed here, 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/intensity identified as the largest impacts.

A recent review of the publicly available literature of climate change impacts and adaptation in the Australian Alps found that snowmaking (and snow-manipulation) and diversification to year round tourism were the two primary adaptation strategies favoured by the tourism industry (Morrison & Pickering, 2011, Figure 2). Our interviews here demonstrate that snowmaking is still the most important current and future climate change adaptation strategy by the industry. In the Australian Alps, snowmaking is used principally to provide snow cover at the start of the season, to maintain cover on high use areas at lower altitudes, and to extend the season (Australia Ski Areas Association [ASAA], 2008; Pickering & Buckley, 2010). Most ski resorts in the Australian Alps use snow guns with a range of 1-15 guns per run depending on the location of the resort (Pickering & Buckley, 2010). Over the past 15 years, areas serviced by snowmaking infrastructure within the larger Australian ski
resorts have more than tripled from 120 to 370 ha. Pickering and Buckley (2010) estimated that six major Australian ski resorts had invested AU$104 million on snowmaking infrastructure alone (snow guns, piping, water storage facilities, pumps and control systems) with a further AU$123 million planned over the next decade to 2020 (water and energy costs not included).

This study, however, highlights important economic, physical, and social limits to snowmaking as an adaptation strategy (Figure 2) that will restrict the effectiveness of this strategy in the medium to long term. While the tourism industry believes that they will recoup the economic costs of snowmaking through visitor expenditure, the social and physical limits are less easily (if at all) ameliorated. As temperature rises, snowmaking will also increase. However, there will come a stage when overnight temperatures will be too warm for snowmaking to be cost-effective and/or physically possible (Hennessey et al., 2008; Pickering & Buckley, 2010). In addition, while most resorts state that they are sustainably using water for snowmaking (e.g. own storage facilities, recycling, etc.), the increasing demand for snowmaking as temperature rises will see resort water demands outstrip their supply capacity. Consequently, more water will be removed from the catchment/system resulting in decreased water availability and/or increased costs for other users in the region e.g. local communities, agriculture industry. Given the already increasing price of water in many parts of Australia (Australian Bureau of Statistics [ABS], 2010), social objections to the amount of water used by the resorts for snowmaking have been identified as a significant limit.

Insert Figure 2 near here
Diversification to year round tourism has been highlighted in the literature as a primary potential adaptation strategy, particularly for lower altitude resorts including in Australia (Fukushima et al., 2002; Konig, 1998; Moen and Fredman, 2007; Scherrer & Pickering, 2010; Sievanen et al., 2005; Unbehaun, Probstl & Haider, 2008). Our results suggest that this strategy may not be as widely adopted or favoured by the Australian industry as previously thought. Only one resort stated that they were currently promoting year round tourism while two others stated that this was a future strategy. The fourth resort specifically stated that they were not investing in year round tourism due to their geographic location i.e. due to their high levels of winter snow, they had many more visitors than the other resorts during the lucrative winter season and would continue to benefit from this strategy in the future as snow levels at the other resorts continued to decline. Given that summer visitors spend only one-third per person of the amount that winter visitors spend (NIEIR, 2006), resorts may see the lower financial returns per person from summer not worth the investment in new infrastructure costs (e.g. mountain bike trails), the cost of increased water licence limits in summer to meet visitor demand, and the costs associated with opening and running their resorts year round. In addition, there are social and economic limits associated with fire management in summer with increased visitors (visitor safety issues) and predicted increased fire risk.

While snowmaking and year round tourism have been previously identified as the primary climate change adaptation strategies by the tourism industry in the Australian Alps, the results of this study highlight a third strategy, fire management, that is now viewed as important by the industry (Figure 2). The adoption of fire management as a primary adaptation strategy has arisen a result of the extreme summer bushfires that burned through the Australian Alps in 2003 and parts of the Victoria Alps again in 2006. In 2003 the Australian Alps experienced their largest bushfires in 60 years with an estimated 1.73 million hectares burned (Worboys, 2003). Despite attempts at containment and control by up to 4000
personnel, the fires lasted 60 days resulting in the loss of four lives, property, power, gas reticulation, sewage treatment, and water supplies, and livestock (Sanders, Laing & Houghton, 2008; Walsh & McDougal, 2004). Three years later, the 2006/07 Victoria fires lasted for 69 days, and burning over 1.1 million hectares, c. 15% of the state’s public land (Cioccio & Michael, 2007; Department of Sustainability and Environment [DSE], 2008).

During the period of direct threat, tourists were evacuated from the parks in the Australian Alps and parks closed. After the fires large areas of the parks remained closed to allow regeneration. A wide range of tourism infrastructure within the parks was lost including toilets, sewage treatment plants, signs, campgrounds, walking tracks, historic huts and picnic areas (Worboys, 2003). The financial losses to the local tourism industry as a result of the fires was significant with the 2003 fires alone estimated to have cost AU$121 million in one state (Worboys, 2003). This in conjunction with the costs to park agencies of fighting fires, replacing damaged infrastructure (including tourism facilities), controlling erosion and facilitating vegetation regeneration highlights the massive financial costs of these extreme fire events. Consequently, the tourism industry and other stakeholders in the region are acutely aware of the negative economic, biophysical, and social impacts of fire and seek to minimize future impacts through improved fire management strategies.

The second key result to come out this study is the importance of social limits to climate change adaptation strategies. In the review by Morrison and Pickering (2011), most of the published limits to climate change adaptation for the tourism industry and other stakeholders in the Australian Alps were associated with the economic and physical limits of snowmaking and the low financial returns associated with diversifying to year round tourism (Figure 2). As previously discussed, our interviews with stakeholders highlight social limits to snowmaking in the form of less public acceptance of water and electricity consumption for snowmaking. Social limits were also associated with the diversification to year round
tourism in the form of decreased visitor satisfaction. Local community objections to fire management practices and decreased visitor satisfaction were social limits associated with fire management in the region. In many cases, participants in this study believed that social limits to adaptation strategies could become more important than economic or physical limits due to the ability of the public to influence government agendas and strategies.

In most cases, the limits to climate change strategies of a particular group as identified by other stakeholder groups were also identified by the stakeholder group concerned. For example, the economic limits to diversifying to year round tourism (e.g. low returns) were identified by the tourism industry and the local government participants who represent communities heavily reliant on the tourism industry. The most obvious difference between the limits of one group and the perceptions of other groups relates to the limits associated with snowmaking by the tourism industry. All other stakeholders believed that the tourism industry will soon (if not already) experience significant economic limits in terms of snowmaking costs (electricity, water, infrastructure) 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 snowmaking could be an issue in the future. In this case, it may be that the perception that climate change will have a serious impact on tourism (through decreasing snow levels) and that tourism adaptation strategies will not work in the longer term (social, economic and physical limits), is more detrimental to tourism than the actual impacts of climate change. This is seen throughout the tourism industry where companies do not broadcast their vulnerability to guests, insurers or investors, but discretely adapt or sell-off high-risk assets (Scott, 2011). Alternatively, it may be the result of shorter term thinking and planning by the tourism industry (more focussed on immediate business survival) compared to longer term planning by other stakeholders (see Brouder & Lundmark 2011).
Conclusions

The responses of the tourism industry regarding climate change adaptation and limits to adaptation in the Australian Alps provide key insights into how the industry is likely to respond to climate change in the future, and how complex those responses are. Responses by the resorts suggest that while snowmaking is still the main industry adaptation strategy, the adoption of other strategies will differ based on the physical characteristics, geographic location, management style, and business model of the resort concerned. Improved and more focused fire management has emerged as a new primary strategy for the industry to combat the threats of increased summer fire intensity and magnitude for infrastructure (winter and summer facilities), visitor safety and park access.

While the tourism industry is able to identify economic and physical limits to their strategies, the other stakeholders’ responses identify whether these strategies are socially acceptable and likely to cause conflict within the region. Our results suggest that regardless of the individual resort concerned, the winter tourism industry as a whole is acutely aware that perceptions of their vulnerability to climate change are far more damaging than the actual impacts, a result similar to that described by Bicknell and McManus in 2006. Consequently, the resorts understandably seek to downplay limits to their capacity to adapt primarily through strategic marketing highlighting their use of snowmaking technology and the improved and extended snow conditions this can provide visitors irrespective of natural snow levels. They also try to minimise social objections to their high water and electricity consumption through advertising their use of green energy, increasingly more energy and water efficient snowmaking technology and their environmental conservation strategies.

While there will be winners and losers in terms of the different climate change adaptation strategies used by the different stakeholders, there is great potential for
collaboration on a number of strategies that will benefit the ski tourism industry, the communities dependent on the industry, and conservation managers of the protected areas. These collaborations should be encouraged, supported and financed where possible to improve their success and sustainability. Research focusing on the combined needs of all stakeholders, particularly in improving climate change predictions and social aspects of climate change impacts and adaptation strategies by the tourism industry, should be developed and supported both financially and institutionally.

“If we get it wrong, the consequences are really going to be big for the ski industry.” (T1)

Acknowledgments
We thank the interview participants for taking the time to share their information and ideas in relation to climate change in the Australian Alps. This work was supported financially by the Australian Government and the partners in the National Climate Change Adaptation Research Facility (NCCARF) consortium. The views expressed herein are not necessarily the views of the Commonwealth of Australia, and the Commonwealth does not accept responsibility for any information or advice contained herein. Ethics approval was granted by Griffith University (GU Ref No. ENV/24/10/HREC). Jon Barnett and three anonymous reviewers provided valuable comments on an earlier draft of this manuscript.

References


Worboys, G.L., Good, R.B., & Spate, A. (2010). *Caring for Our Australian Alps Catchments, A climate change action strategy for the Australian Alps to conserve the natural condition of the catchments and to help minimise threats to high quality water yields*. Canberra: Australian Alps Liaison Committee and Australian Department of Climate Change.
Figure 1. Location of the ski resorts in the Australian Alps on mainland Australia.

Figure 2. Primary ski tourism climate change adaptation strategies and their associated limits in the Australian Alps. White (clear) boxes and arrows represent strategies and limits published in the literature. Grey (shaded) boxes and arrows represent new strategies and limits identified in stakeholder interviews in this study. The follow-on effects of the identified limits on socio-economic climate change impacts and the adaptation strategies utilised by the ski industry are highlighted by the circular feedback loop.
Table 1. Characteristics of ski resorts on mainland Australia operating in 2011. ARMB = Alpine Resort Management Board, KNP = Kosciuszko National Park, NP = National Park.

<table>
<thead>
<tr>
<th>Resort</th>
<th>Altitude (max. in m)</th>
<th>Skiable area (ha)&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Snow making area (ha)&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Resort management</th>
<th>National park in or near</th>
<th>Visitation in 2009 (skier days)&lt;sup&gt;c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>New South Wales</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perisher Blue</td>
<td>2034</td>
<td>1245</td>
<td>53.4</td>
<td>Perisher Blue Pty Ltd</td>
<td>in KNP</td>
<td>-</td>
</tr>
<tr>
<td>Thredbo</td>
<td>2037</td>
<td>480</td>
<td>66</td>
<td>Kosciuszko Thredbo Pty Ltd</td>
<td>in KNP</td>
<td>-</td>
</tr>
<tr>
<td>Charlotte Pass&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1954</td>
<td>50</td>
<td>Yes</td>
<td>Charlotte Pass Village Pty Ltd</td>
<td>in KNP</td>
<td>-</td>
</tr>
<tr>
<td>Selwyn Snowfields</td>
<td>1614</td>
<td>45</td>
<td>36</td>
<td>Mount Selwyn Snowfields Pty Ltd</td>
<td>in KNP</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total NSW</strong></td>
<td><strong>1820</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>1,149,000</strong>&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Victoria</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mt Buller</td>
<td>1805</td>
<td>300</td>
<td>79</td>
<td>Mt Buller and Mt Stirling ARMB</td>
<td>near Alpine NP</td>
<td>508,360</td>
</tr>
<tr>
<td>Falls Creek</td>
<td>1780</td>
<td>450</td>
<td>110</td>
<td>Falls Creek ARMB</td>
<td>in Alpine NP</td>
<td>377,405</td>
</tr>
<tr>
<td>Mt Hotham</td>
<td>1845</td>
<td>320</td>
<td>22</td>
<td>Mt Hotham ARMB</td>
<td>in Alpine NP</td>
<td>384,390</td>
</tr>
<tr>
<td>Mt Baw Baw</td>
<td>1563</td>
<td>30</td>
<td>-</td>
<td>Mt Baw Baw ARMB</td>
<td>near Baw Baw NP</td>
<td>52,952</td>
</tr>
<tr>
<td>Lake Mountain</td>
<td>1520</td>
<td>4</td>
<td>3</td>
<td>Lake Mountain ARMB</td>
<td>near Yarra Ranges NP</td>
<td>61,312</td>
</tr>
<tr>
<td>Mount Stirling</td>
<td>1747</td>
<td>0</td>
<td>3</td>
<td>Mt Buller and Mt Stirling ARMB</td>
<td>near Alpine NP</td>
<td>5472</td>
</tr>
<tr>
<td><strong>Total Victoria</strong></td>
<td><strong>1104</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>1,389,891</strong></td>
</tr>
<tr>
<td><strong>Total for all resorts</strong></td>
<td><strong>2924</strong></td>
<td></td>
<td><strong>369.4</strong></td>
<td></td>
<td></td>
<td><strong>2,538,891</strong>&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup> From Australian Resort Statistics for the Australia Ski Areas Association website accessed February 2011.

<sup>b</sup> Alpine Resorts Co-ordinating Council website accessed February 2011

<sup>c</sup> Actual area not specified

<sup>d</sup> Data not available for individual New South Wales resorts
Primary Tourism Adaptation Strategies

Climate Change Predictions
- Increased temperature
- Decreased precipitation
- Decreased natural snow

Climate Change Impacts
- Decreased snow cover and duration
- Drier summers
- Decreased water availability
- Increased fire frequency and intensity

Biophysical
- Snowmaking and snow manipulation

Socio-economic
- Decreased winter visitors
- Increased skiing costs
- Direct and indirect economic impacts on local communities

Economic
- Infrastructure costs (e.g., snow guns)
- Water costs
- Electricity costs

Physical
- Less acceptable use of water and electricity
- Insufficient water soon
- Number of cold nights to make snow decreases

Social
- Financial return too low
- Water licence limits
- Summer tourism infrastructure costs

Physical
- Uncertainty/competition
- Visitor satisfaction
- Increased fire risk

Economic
- Costs of implementing plan
- Loss of revenue through Park closure

Social
- Visitor satisfaction
- Local community objections

Physical
- Capacity to manage due to fire magnitude/intensity/frequency