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AUSTRALIAN MOUNTAIN RESEARCH FACILITY

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PROTECT OUR WINTERS

Our Changing Snowscapes:

Climate Change Impacts and Recommendations for the Australian Alps

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Acknowledgements

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Author contributions:

Ruby Olsson designed the report, compiled and analysed the literature review, developed key findings and recommendations, and wrote the report. Robert Steiger designed, performed, and analysed the SkiSim2 modelling. Adrienne B Nicotra and Jamie Pittock contributed to the literature review and helped to develop key findings and recommendations.

Thank you to the Australian National University (ANU) CartoGIS team, who prepared the maps (Figures 1.1 and 1.2) and the projection maps (Figures 2.6 and 2.7). Thanks to Zach Brown for his help in setting up this project between ANU, Protect Our Winters (POW), and the Australian Mountain Research Facility (AMRF).

Due to time and human research ethics approval constraints, formal interviews with stakeholders and knowledge holders in the Australian Alps were not possible. Thank you to the following people for productive conversations during the writing of this report: Ryan Backhouse, David Crea, Natasha Harvey, Andy Mudge, Tomas Remenyi and Richard Swain.

Finally, thank you to the team at POW. Thanks to Sam Beaver and Ana Ross for setting up the report and providing logistical support throughout. Designing and formatting the report was a mammoth task, so thank you to Owen Richards and Bianca Perusic for their time, effort, and expertise.

Finally, thank you to Natalia Simson for her science communication skills in designing the key graphs and charts throughout the report.

Cover image: Daygin Prescott

Executive Summary

Introduction

The Australian Alps region encompasses approximately 5,200 km^2 above the nominal seasonal snowline in south-eastern Australia[1]. The Australian Alps is one of Australia's most unique and fragile landscapes, with 31 endemic flora species[2] and further endemic fauna species, including the Mountain Pygmy Possum[3] and Southern Corroboree Frog[45]. Flora and fauna of the Australian Alps is particularly vulnerable to climate change, because unlike in many other countries, there are limited higher elevation areas which replicate their original habitats in a new climate[6]. The spectacular Australian Alps extend over 1.6 million hectares of public land contained in 11 national parks and nature reserves across New South Wales (NSW), Victoria (VIC), and the Australian Capital Territory (ACT)[7].

The impact of climate change on temperature, precipitation, and snow conditions in the Australian Alps is stark and has been heralded for more than three decades. In 1988, Galloway et al.[8] predicted that climate change will drastically impact the Australian Alps, and that even small temperature increases would have a catastrophic impact on the Australian winter tourism industry. The Australian snowpack is now at a 2,000-year low[9]. Snow cover between 1954 and 2012 has reduced by 30%[10] and the length of the ski season has already contracted by 17% - 28% across most Australian alpine resorts[11]. Businesses and regional communities at present are experiencing the impacts of climate change[12] and these impacts are projected to worsen rapidly without decisive climate mitigation[13].

Purpose

This report summarises a broad expanse of literature about current and projected climate change impacts on the Australian Alps and presents new modelling of climate change impacts on the Australian ski industry (SkiSim2 projections). The report highlights a cascading series of interconnected impacts across alpine tourism, regional communities, hydroelectricity, high country water flows to the Murray-Darling Basin, carbon sequestration, high country ecosystems, and First Nations and makes recommendations to respond to these impacts. The Australian Alps are likely to undergo significant transformation due to climate change. Managing this transformation is inherently normative[14], as adaptation will require trade-offs between social, economic, and ecosystem values. Key questions that need to be asked are "what does a desirable future look like, and for whom?", "how can adaptation be just?", and "what trade-offs should be made?". Answering these normative questions requires conversations between communities, First Nations, industry, natural resource managers, and governments. By summarising the impacts of climate change across social, economic, and ecological aspects of the Australian Alps this report seeks to inform these conversations about values, adaptation options, and trade-offs.

Scope

The scope of this report includes a domestic and international literature review of the current and projected impacts of climate change on the Australian Alps and presents findings and recommendations. This report also summarises the SkiSim2 model projections for the Australian ski industry and assesses what these projections mean for the interconnected social and ecological systems in the Alps.

The report analyses the overarching constraints for effective climate mitigation and adaptation action, including social and institutional barriers, such as short-termism, path dependency, and culture. The report then makes recommendations as to how some of these constraints could be overcome.

It was outside the scope of this report to make recommendations at an individual resort, town, or national park level. While the report makes specific local and regional recommendations for mitigation and emphasises the need for mitigation at state, national, and global levels, it is outside the scope to specify how mitigation should be achieved at these higher levels.

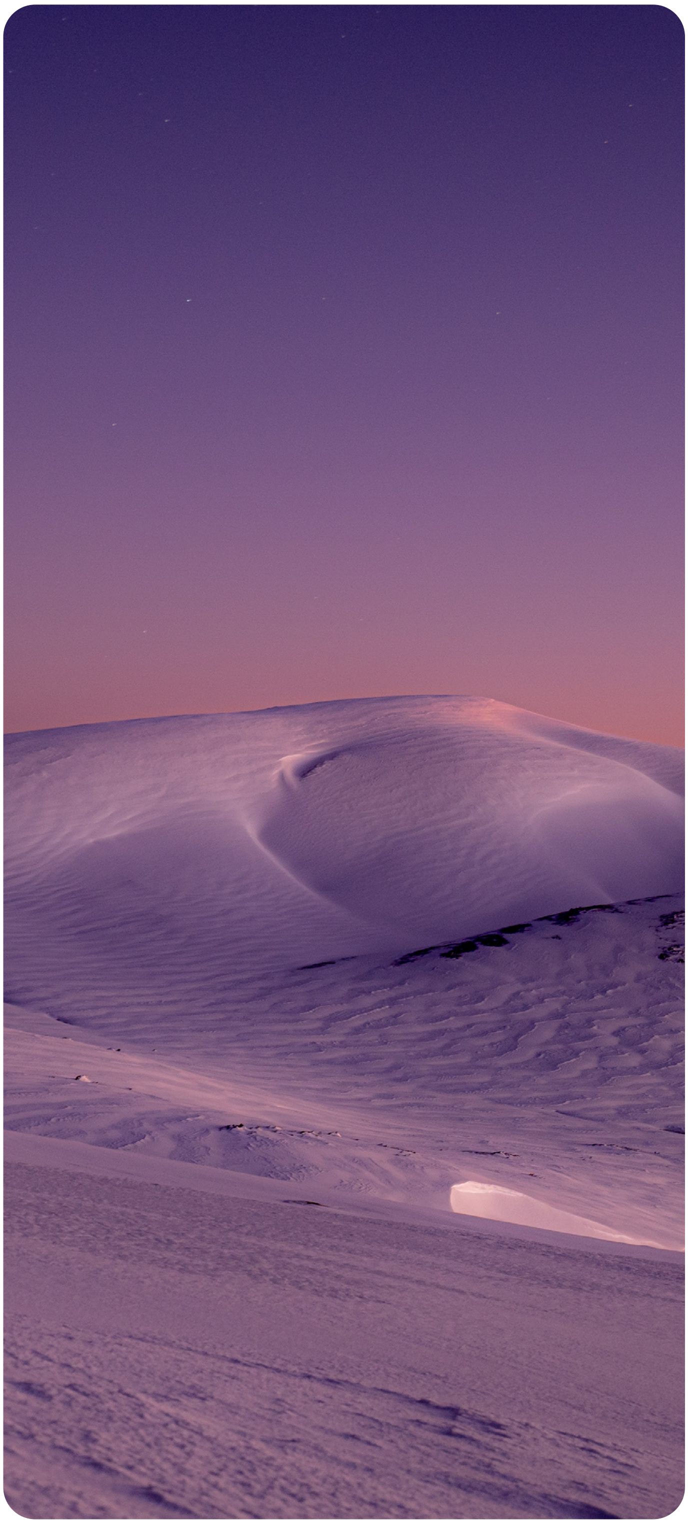


Image. Daygin Prescott

A snapshot of climate change impacts on the Australian Alps

Resort Ski Season

If the current trajectory of climate change continues, the Australian ski industry will change dramatically by 2050. The average ski season across all resorts will be 44 days shorter (-42%) under a mid emissions scenario and 55 days shorter (-52%) under a high emissions scenario. Snow reliability will substantially decrease in Australia. As a result, fewer resorts are expected to make up Australia's snow tourism industry, with some resorts at risk of closing without successful adaptation.

Regional communities

Climate change has the potential to cause financial pressure, mental health deterioration, loss of connection the environment, loss of houses and infrastructure to natural disaster, reduced regional development and services, and regional emigration. Effective adaptation can preserve a strong regional economy and community identity, wellbeing, and connection to landscape.

Hydroelectricity

Hydroelectricity production in the Australian Alps will face reduced inflows as a result of climate change, due to reduced precipitation and ecological change in the catchment. Increased frequency and severity of storms and bushfires as a result of climate change may damage hydroelectricity generation and transmission infrastructure.

The Murray-Darling Basin

The Australian Alps provide an average of 9,600 gigalitres of water per year into the Murray-darling Basin, which is around 29% of the Basin's total annual flows. Climate change will directly reduce precipitation in the Alps by 5-24% by 2050 and indirectly reduce catchment yield through ecological change.

High country ecosystems

Climate change is already significantly impacting high country ecosystems through changes to vegetation, soils, wetlands, snow cover, and fire regimes. These impacts are projected to worsen, threatening the extinction of unique species and causing ecological transformation.

First Nations

The Australian Alps have great significance to First Nations, particularly as a site for annual celebrations across many Nations. However, there is little research as to what the impacts of climate change will be for First Nations and their connection to Country.

Overarching Findings

There will be increasing competition for high ground in south-eastern Australia

The Alps represent a critical area for tourism operators (including ski resorts), regional towns, recreational users, hydroelectricity generation, the Murray-Darling Basin, and high country ecosystems. Climate change impacts, particularly snow line retreat and increasing temperatures, means many of these users are seeking increasingly higher areas and diversifying their activities (e.g. adding mountain bike facilities, pumped storage hydropower development). This exacerbates competition of increasingly scarce resources and means trade-offs between users are needed.

Decisive climate change mitigation and adaptation is needed to achieve positive outcomes for stakeholders, particularly alpine tourism and regional towns

Lack of leadership on climate change mitigation and adaptation will leave stakeholders to adapt incrementally and autonomously, without coordination or support. A planned and coordinated adaptation approach is more likely to seize opportunities for adaptation, avoid unintended consequences, and preserve values. Early, bold mitigation will require less adaptation at a lower cost, and enable a greater range of adaptation options.

Climate adaptation will require values conversations with all stakeholders to determine which trade-offs are acceptable

Even dramatic climate change mitigation will not eliminate future impacts of climate change, and some level of adaptation is needed. Trade-offs between users and between timeframes will be necessary. It is critical that these trade-off decisions are informed by conversations with all stakeholders, to ensure equitable outcomes that avoid favouring any one group.

Image. Matt Wiseman

Key findings and recommendations

Alpine Tourism

Key findings

If the current trajectory of climate change continues, the Australian ski industry will change dramatically by 2050:

- The SkiSim2 modelling shows that average ski seasons across all Australian resorts will be 44 days shorter (-42%) under a mid emissions scenario and 55 days shorter (-52%) in a high emissions scenario.
- Australia has much less reliable snow than overseas resorts. The SkiSim2 modelling indicates that Australian snow will become increasingly unreliable under all emission scenarios.
- The additional snowmaking infrastructure, water, and energy required will place significant ecological and economic costs on alpine resorts that may make their operation economically unviable.
- Fewer resorts are expected to make up Australia's snow tourism industry, with some resorts at risk of closing without successful adaptation.
- The SkiSim2 results highlight that long (and most likely economically viable) ski seasons are still possible with effective mitigation that keeps our global trajectory within a low emissions scenario, particularly for higher altitude resorts.
- Year-round tourism and diversification of winter tourism are the two adaptation options most likely to be successful long-term, but current offerings are ad-hoc, disjointed and have additional environmental impacts.

Recommendations

- Investments in year-round tourism and diversification of winter tourism should occur. These options need to be balanced with ecological values and the carrying capacity for each needs to be determined.
- Extensive collaboration about adaptation options needs to occur between natural resource managers, the alpine resorts, and the community to ensure that ecological trade-offs are acceptable and that adaptation options have the best chance of a sustainable and economically viable outcome.
- Further investment in renewable energy for snowmaking operations needs to occur, at a resort and/or state levels.

Regional Communities

Key findings

- Victorian alpine resorts contributed $1.22 billion in Gross State Product (GSP) 2019, an increase of 214% from 2011. The most recent data for NSW is from 2011, however, assuming a similar increase, NSW alpine resorts would have contributed $2.11 billion to NSW GSP in 2019. This would mean the total economic contribution of alpine resorts to the Australian economy was an estimated $3.33 billion in 2019.
- Climate change has the potential to cause financial pressure, mental health deterioration, loss of connection the environment, loss of houses and infrastructure to natural disaster, reduced regional development and services, and region emigration.
- Effective adaptation can preserve a strong regional economy and community identity, wellbeing, and connection to landscape.

Recommendations

Further research should be conducted into:

- The projected impacts of climate change on the health (including mental health) and wellbeing of communities in the Australian Alps.
- The health and wellbeing benefits provided by alpine resorts, particularly in NSW.
- Local alpine communities should be empowered to make their own climate adaptation decisions and take responsibility for those decisions.
- Governments and other decision-makers need to support community in this role, but also ensure accountability and legitimacy. This includes ensuring that decisions genuinely reflect the values of the broader community, and not just vocal stakeholders or already privileged voices.

Image. Matt Wiseman

Hydroelectricity

Key findings

- Hydroelectricity production in the Australian Alps will face reduced inflows as a result of climate change, due to reduced precipitation and ecological change in the catchment.
- Increased frequency and severity of storms and bushfires as a result of climate change may damage hydroelectricity generation and transmission infrastructure.
- There is pressure on hydroelectricity companies to transition from traditional hydroelectricity generation to pumped storage hydroelectricity, due to increased demand for energy storage technology as Australia transitions to a higher level of renewable energy. This will increase the resilience of hydroelectricity generation as it reduces reliance on inflows.
- Development of hydroelectricity in the Australian Alps has had devastating impacts on high country ecosystems. Further environmental degradation of the water catchment will have economic consequences for hydroelectricity generation, the Murray-Darling Basin, and alpine tourism.

Recommendations

- Future proposals for hydroelectricity expansion in the Australian Alps need to be closely scrutinised for ecological impacts. Biodiversity offsets must not be considered a blank cheque for development, particularly given the unique, fragile, and irreplaceable nature of high country ecosystems.
- Land management agencies (NPWS and Parks VIC) need to be involved in any hydroelectricity expansion proposals from the start.
- Loss of vegetation cover, wetlands, and Snow Gums is likely to reduce the quality and quantity of water in the Australian Alps. There is an opportunity for Snowy Hydro and AGL to enable critical ecological restoration work, removal of feral animals, and possible Snow Gum dieback responses.

The Murray-Darling Basin

Key findings

- The Australian Alps provide an average of 9,600 gigalitres of water per year into the Murray-darling Basin, which is around 29% of the Basin's total annual flows.
- Water from the Snowy Mountains NSW region is worth between $43.6 million and $1.974 billion annually (average $498.09 million) based on water allocation prices. These calculations are extremely conservative as they do not account for the social, environmental, or cultural values of water.
- Water from the Australian Alps is worth approximately $15 billion annually in 2024 prices, when all social and production benefits are considered (noting that this figure was originally calculated in 2009 using 2005 water prices and has been adjusted for inflation).
- Climate change will directly reduce precipitation in the Australia Alps by 5 - 24% by 2050. Increased temperatures, droughts, and bushfires will alter alpine vegetation and soils, and dry out peatbogs, further decreasing the catchment yield.
- There is already water conflict in the Murray-Darling Basin between agricultural production, domestic drinking water, regional communities, tourism, cultural flows for First Nations, and the environment. Reduced inflows from the Australian Alps will exacerbate this conflict, make trade-offs between water uses more difficult, and are likely to exacerbate a decline in community mental health and wellbeing.

Recommendations

- Ecosystem functions need to be maintained where possible, such as through maintaining canopy cover, soils, and healthy wetlands to maximise the quality and quantity of inflows from the Australian Alps.
- Trade-offs that result in ecosystem function decline (such as tourism or hydroelectricity expansion), should only be made with full consideration of impacts to the Murray-Darling Basin.

Carbon Sequestration

Key findings

- Soils in the Australian Alps have high organic material and carbon content, making them important national carbon sinks.
- Collaborative research is underway to appropriately classify soils in the Australian Alps and accurately calculate their carbon storage.
- Increased temperatures and reduced precipitation will exacerbate organic soil loss by changing decomposition rates. This will reduce carbon storage and increase bushfire risk in the Alps.
- "Climate fires" or "megafires" threaten to unbalance the relationship between the carbon emitted during bushfires and the carbon reabsorbed during post-bushfire regrowth. If this occurs, it will create a negative reinforcing loop of climate change impacts and increased greenhouse gas emissions.

Recommendations

- Enhance carbon storage in the Australian Alps' organic soils by reducing disturbances and promoting water retention. There is a suite of management actions that may be appropriate (particularly peat bog restoration), but any action should include the removal of hoofed animals from the high country region.
- Conduct further research to determine carbon storage amounts and how much carbon high country flora sequesters, as this will inform what the impact of increased bushfires or dieback might be on global carbon levels.

High Country Ecosystems

Key findings

- Climate change is already impacting high country ecosystems by increasing the presence of weeds and invasive animals, changing the composition of vegetation communities, altering the timing of flowering and migration events, and changing soil and hydrology.
- Climate change impacts are projected to worsen, threatening the extinction of unique species and causing ecological transformation.
- Bushfires will become more frequent and severe due to increased temperatures, reduced precipitation, and changes in vegetation. Bindoff et al. (2016) projected that under a high emission scenario by 2100 'Total Fire Ban' conditions will have increased by at least 75% and four times as much fire suppression work will be required.
- Changes to high country ecosystems have implications for the entire Australian Alps social-ecological system, impacting, regional communities, hydroelectricity production, inflows to the Murray-Darling Basin, carbon sequestration, and First Nations.

Recommendations

Implement all "no regrets" actions, with long-term, stable funding.
These include:

- Weed removal programs
- Invasive species removal and pest management
- Restoring peat bogs by reducing disturbances and promoting water retention
- Adapting fire management practices
- Replanting Snow Gum communities that were previously removed by grazing or fire
- Conduct further research into the feasibility and desirability of novel adaptation responses.

First Nations

Key findings

- The Australian Alps have great significance to Indigenous Australians, particularly as a site for annual celebrations across many nations. First Nations have a spiritual connection to the unique flora, fauna, water, and land of the Australian Alps.
- Despite recognition of the significance of the alps, there is little research as to what the possible impacts of climate change will be for First Nations and their connection to Country.
- First Nations in the Australian Alps have been extensively dispossessed. It is only recently that First Nations voices have been included in decision-making and management of the Australian Alps.

Recommendations

- Further empower First Nations in the decision-making and management of the Australian Alps. Expanding Indigenous ranger programs is a key opportunity.
- Researchers, natural resource managers, and governments need to work with First Nations to determine what the impacts of climate change will be for Indigenous Australians in the Alps and what the best adaptation responses might be to conserve First Nations values.

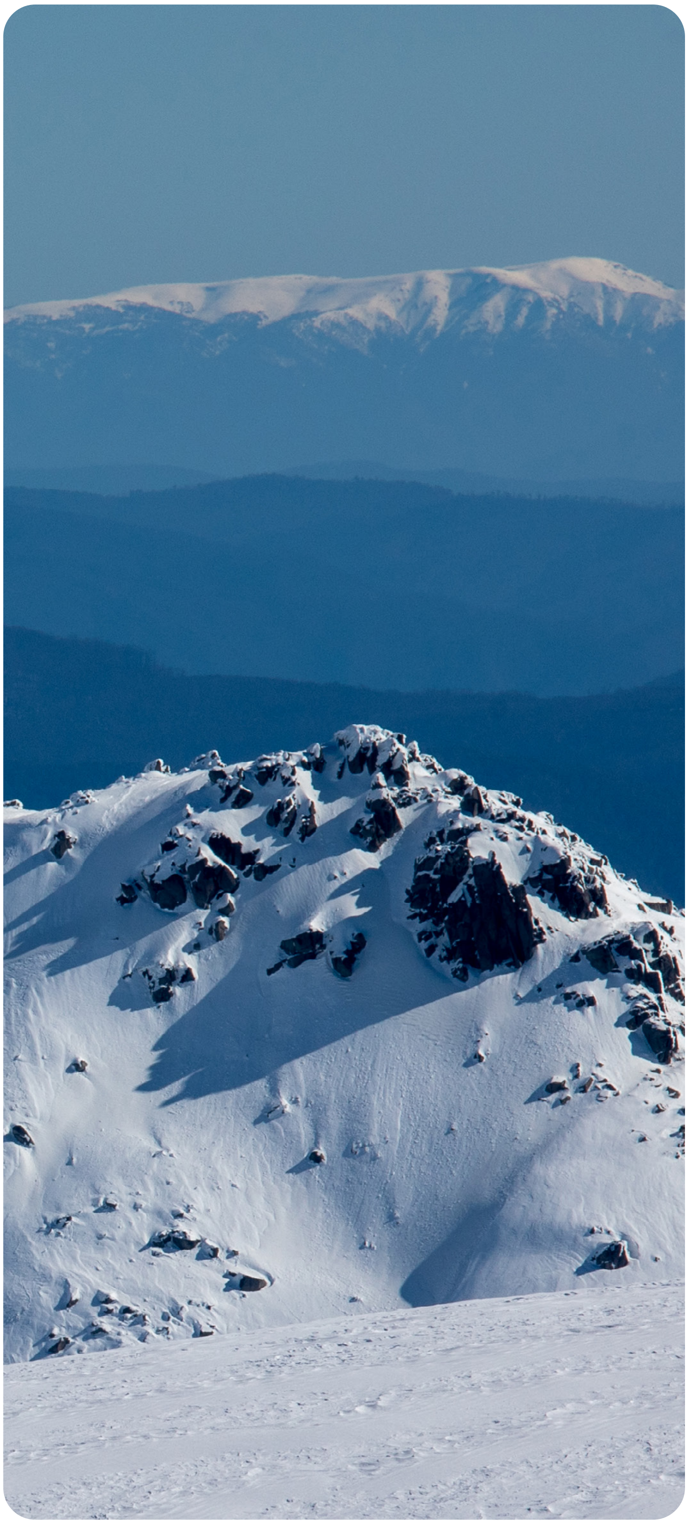


Image. Matt Wiseman

Decision-making and governance

Key findings

- The greater climate mitigation action that can be achieved, the greater the range of possible adaptation options is and the more likely adaptation action will generate desirable outcomes.
- The number and diversity of people who are passionate about the alps represents a huge opportunity for collaborative, decisive, and substantial climate mitigation and adaptation action.
- There are social and institutional barriers that hinder climate mitigation and adaptation.

Recommendations

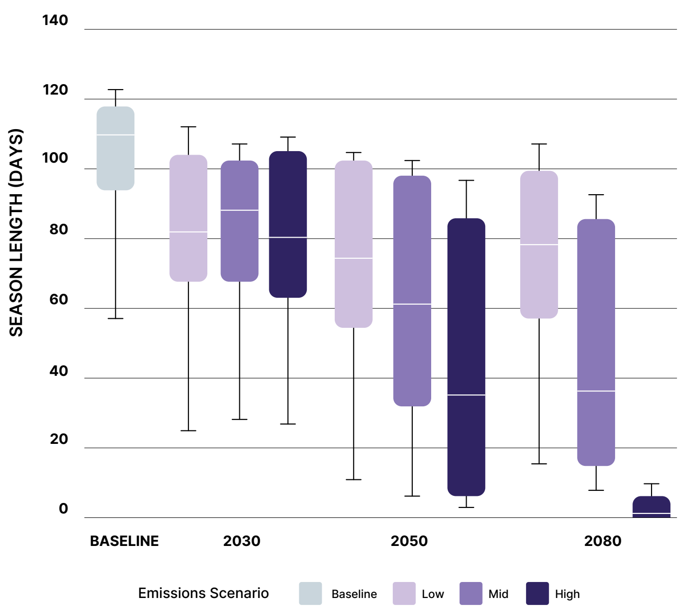
- Deliberative spaces and an implementation mechanism for such spaces need to be integrated into the Australian Alps governance system. The Australian Alps Liaison Committee (AALC), catchment management authorities, and regional organisations of councils have a critical role as these deliberative spaces due to their capacity to build local relationships with communities, First Nations, and businesses.
- The scope and resourcing of the Australian Alps Liaison Committee (AALC) should be expanded to include a whole-of-alps approach focused on climate adaptation and community engagement.
- Further adaptation strategies specific to the Australian Alps should be developed that explicitly address future trade-offs, just adaptation, and collaboration with stakeholders and knowledge holders. These strategies should consider employing a climate adaptation framework as a useful policy implementation tool, the Resist-Accept-Direct (RAD) framework being one potential example.

Image. Daygin Prescott

SkiSim2
Ski industry projections

The "SkiSim2" model has been applied to ski markets around the world, including North America[15], Europe[16], Scandinavia[17], and China[18]. The modelling undertaken specifically for this report applied the SkiSim2 model to the Australian ski industry, including alpine resorts and Nordic (cross-country) resorts, for a low emissions (RCP 2.6), mid emissions (RCP 4.5, SSP 2-4.5) and high emissions scenarios (RCP 8.5, SSP 5-8.5). Importantly, the model specifies the minimum snow depth required for skiing and accounts for resorts' capacity to make artificial snow, making it more realistic than studies which measure any level of snow cover or which do not account for snowmaking.

Further detail on the methods and the projected temperature and precipitation changes for the SkiSim2 model are included in the body of the report.



Results

Season length and snow reliability

Average resort season length, including snowmaking, will decline by 16-18 days (-15% to -17%) by the 2030s across all scenarios. In the 2050s, ski seasons will be 28 days shorter (27%) in the low emissions scenario, 44 days shorter (-42%) in the mid emissions scenario, and 55 days shorter (-52%) in the high emissions scenario. In the 2080s, the ski season will be 25 (-24%) days shorter in a low emissions scenario, 61 days shorter (-58%) in a mid emissions scenario and completely vanish (1 remainng skiable day) in a high emissions scenario. Figure 1 depicts the season length projections for all Australian ski resorts (including Nordic/cross country resorts), and Figure 2 depicts the season length projections for Australian downhill ski resorts (excluding Nordic/cross country resorts).

Snow reliability is defined as at least 100-days with a snow depth of at least 30cm in 70% of all winter seasons[19]. Snow reliability was originally used as a metric of economic viability for overseas ski resorts, however it is generally no longer considered a robust economic indicator, particularly for Australia. The SkiSim2 results include this international metric as a way to compare the Australian Ski industry to overseas ski resorts, especially those where the SkiSim2 model has been applied[20]. In the reference period (1981-2020), six out of nine analysed ski areas are snow-reliable. By the 2030s, only two to three ski areas will remain snow-reliable and no ski area will be snow-reliable from the 2050s in any emissions scenario.

Figure 1: Projected season lengths for all Australian ski resorts (including Nordic/cross country resorts) using RCP 2.6, 4.5, and 8.5. The figure depicts the median (solid horizontal line), the lower (25%) quartile, and the higher (75%) quartile of results in all analyzed ski areas. The vertical lines represent ski areas with the shortest and longest ski seasons.

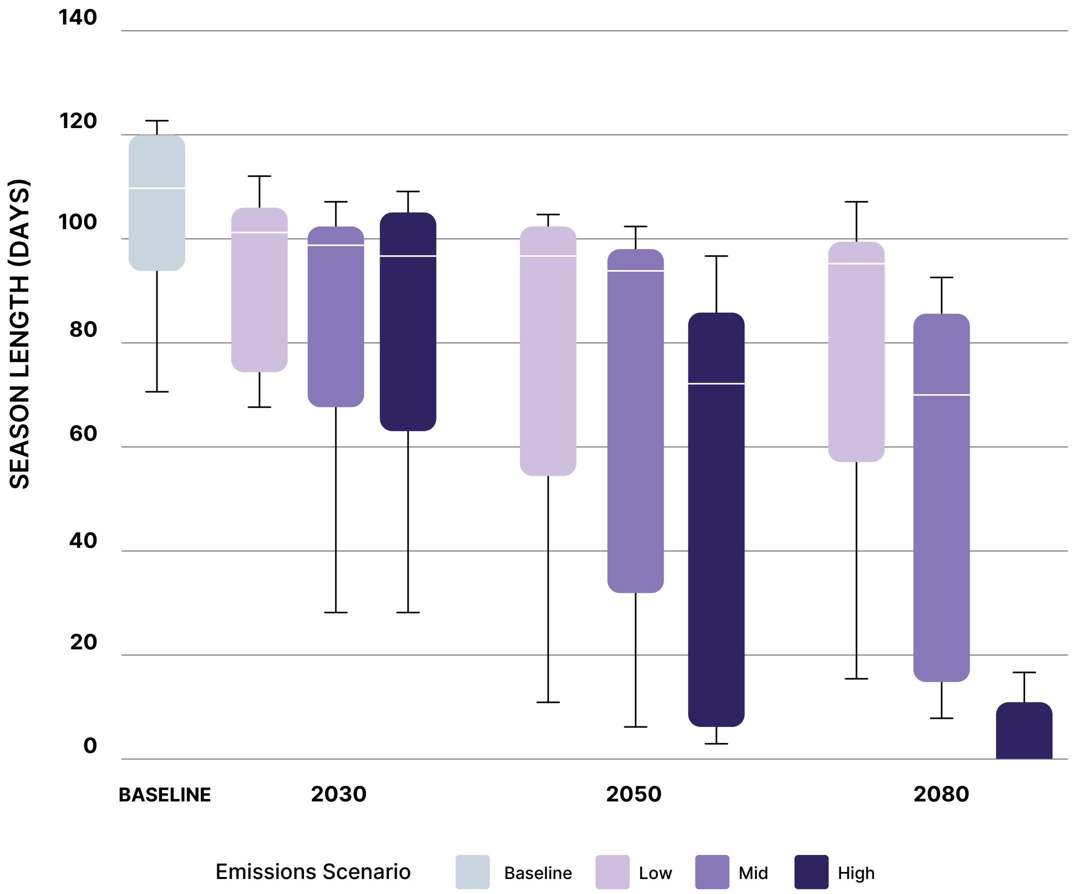


Figure 2: Projected season lengths for Australian downhill ski resorts (excluding Nordic/cross country resorts) using RCP 2.6, 4.5, and 8.5.

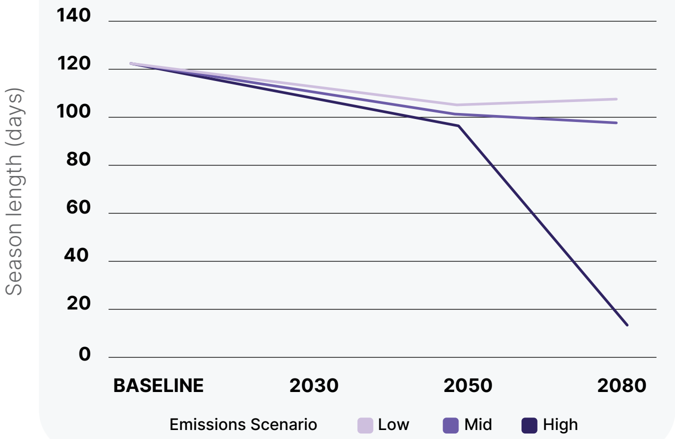
The projected ski season length for each individual ski resort under different climate change scenarios is summarised in table 3 and figures 1-2. Ski season length (days), including snowmaking, is provided for the baseline (average season length from 1981-2010), under a low emissions scenario (RCP 2.6), mid emissions scenario (RCP 4.5 and SSP 2-4.5) and a high emissions scenario (RCP 4.5 and SSP 5-8.5).

Importantly, the above season lengths are calculated using the critical altitude for each ski resort, meaning that to achieve the projected number of days, some resorts will have to only partially open for some of the season. This means that for part of the season some resorts may only have 1-2 lifts and 1-2 T-bars opening.

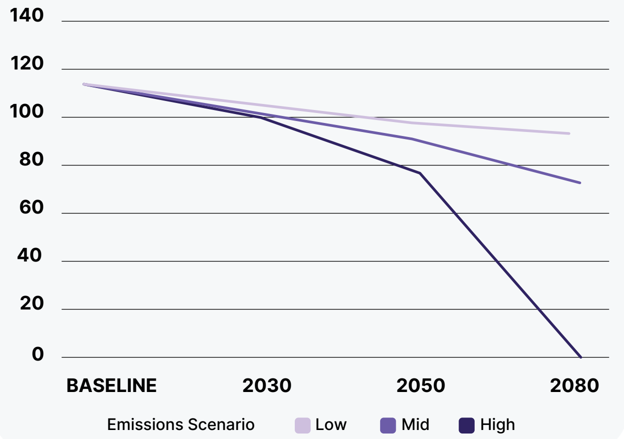
This modelling assumes that ski resorts (except for Nordic/cross country resorts) already have snowmaking infrastructure in place over all the groomed slopes at or above the critical altitude. While most resorts now have extensive snowmaking infrastructure (see Section 2: Alpine tourism), this is not the case for all resorts, meaning further investment in snowmaking infrastructure would be required. Snowmaking also requires significant water and electricity. For example, Thredbo already uses an average of 243,000 cubic metres of water and Mt Buller uses 210,000 - 250,000 cubic metres of water per year for snowmaking". The additional snowmaking infrastructure, water, and energy required to meet these projections will place significant ecological and economic costs on alpine resorts that may make their operation economically unviable.

Victorian alpine resorts

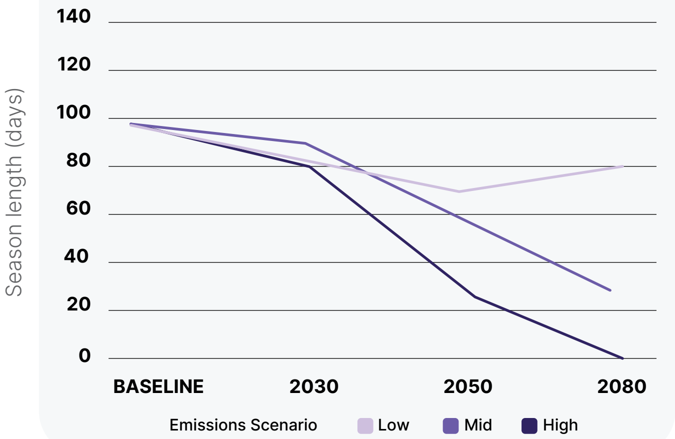
MT HOTHAM



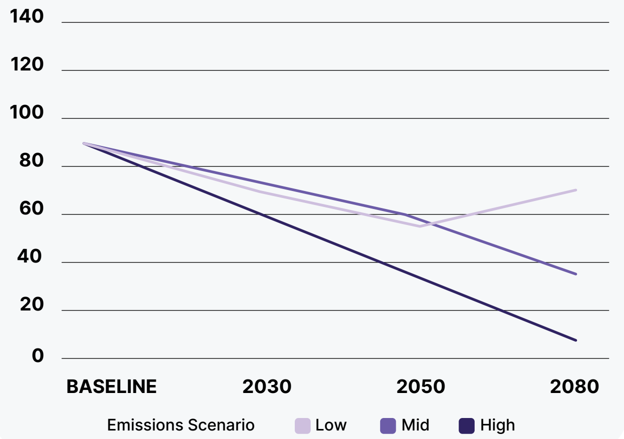
FALLS CREEK



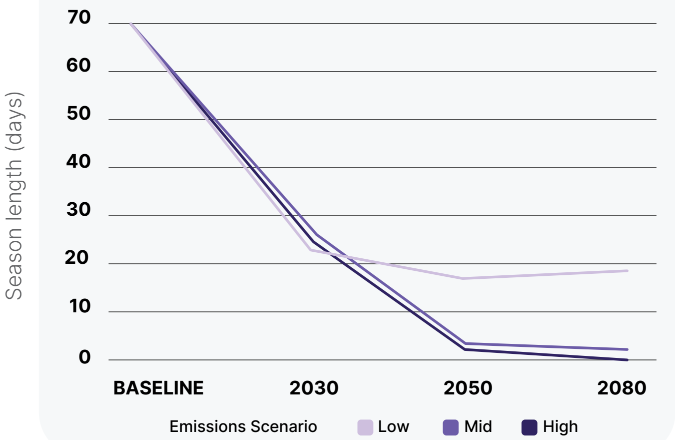
MT BULLER



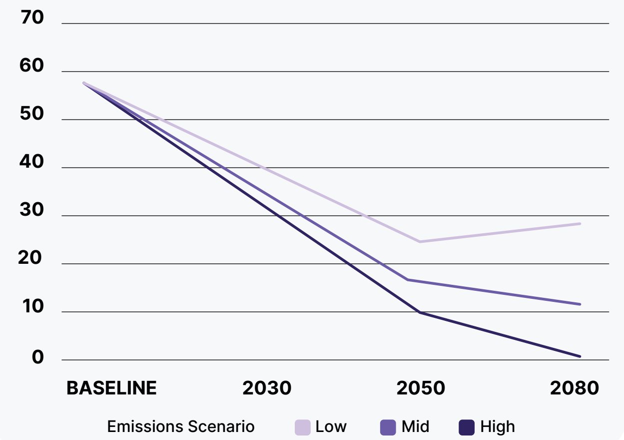
MT STIRLING



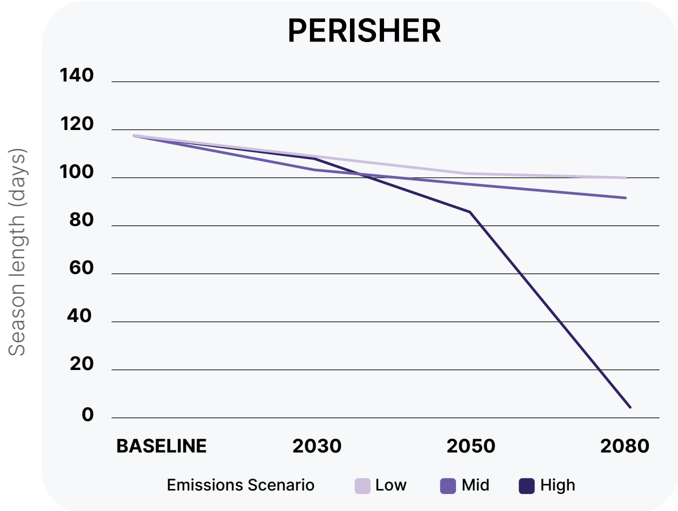
MT BAW BAW

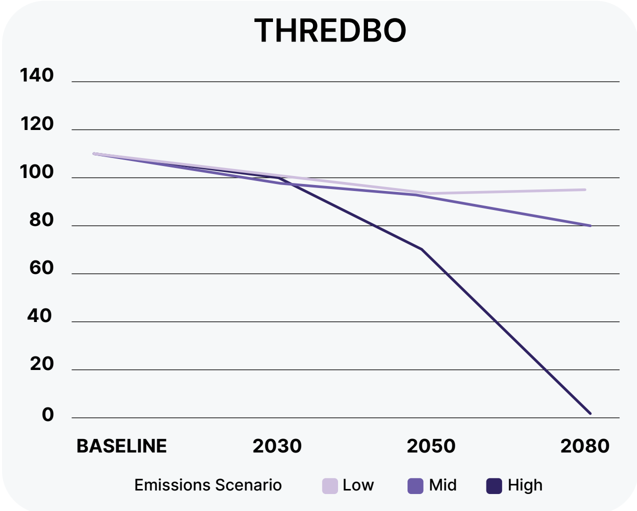


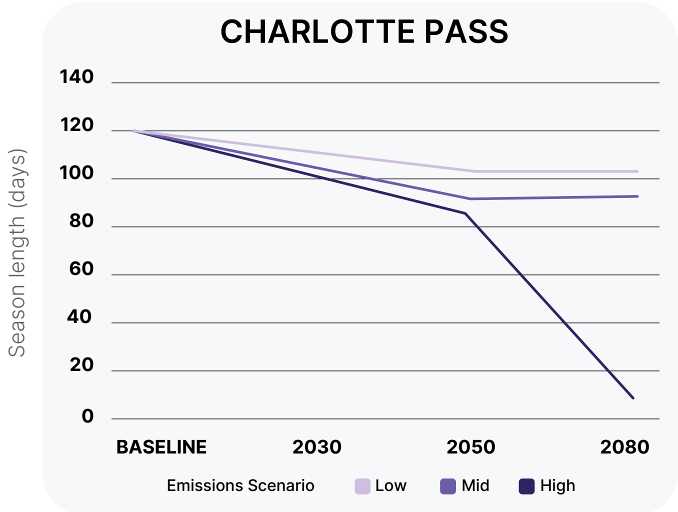
LAKE MOUNTAIN

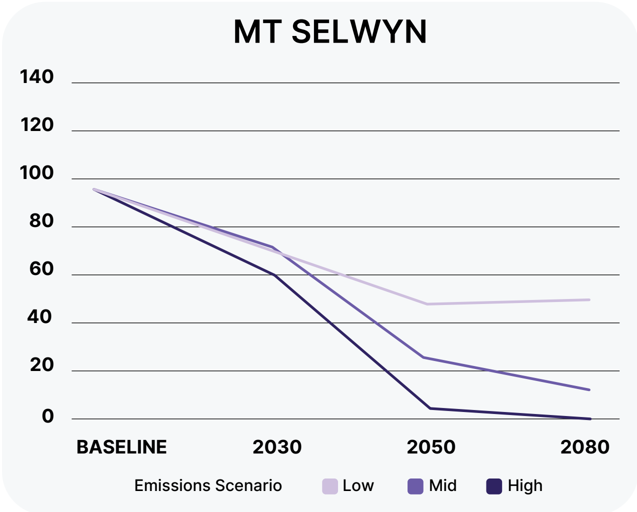


NSW & Tasmanian alpine resorts









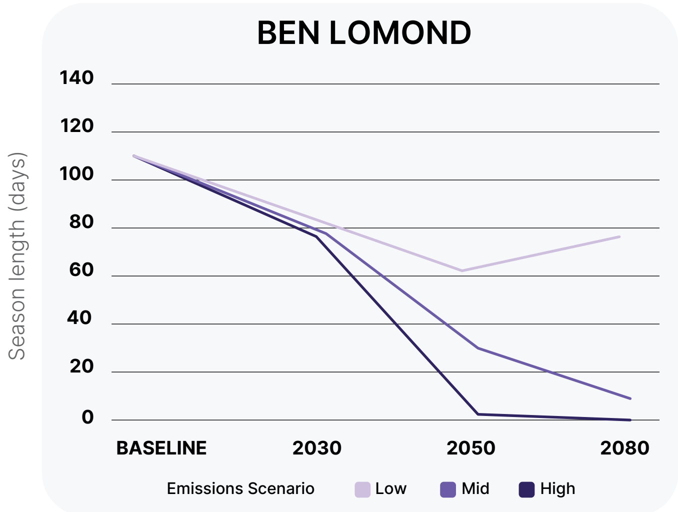


Table 3: Projected season length (days) for each Australian alpine resort using RCP 2.6, 4.5, and 8.5

	Baseline	Low Emissions Scenario			Mid Emissions Scenario			High Emissions Scenario		
RESORT	1981-2010	2030	2050	2080	2030	2050	2080	2030	2050	2080
VIC ALPINE RESORTS - SEASON LENGTH (DAYS)										
Mt Hotham	123	113	105	107	109-113	102-99	96-94	110	96-95	18-7
Falls Creek	109	101	95	96	99-102	91-87	75-58	98-101	74	0
Mt Buller	93	83	70	79	89	58-47	29-17	80-85	28-26	0
Mt Stirling*	92	70	57	67	76-74	60-44	33-25	65-76	35-29	5-2
Mt Baw Baw	70	23	11	16	28-29	5	2-0	28-32	3-1	0
Lake Mountain*	59	36	24	27	34-32	17-14	11-6	35-38	11-8	1
Average	91	71	60	65	73	56-49	41-33	69-74	41-39	4-2
NSW ALPINE RESORTS - SEASON LENGTH (DAYS)										
Perisher	117	105	101	99	103-104	96-91	87-77	106	84-86	5-0
Thredbo	111	101	96	95	99-103	92-85	81-63	101-102	70-73	1-0
Charlotte Pass	122	108	103	102	107-111	97-92	93-85	108-111	89-88	12-4
Mt Selwyn	97	68	51	53	68-74	28-25	8-3	64-74	3-8	0
Average	112	96	88	87	94-98	78-73	67-57	95-98	62-63	5-1
TAS ALPINE RESORTS SEASON LENGTH (DAYS)										
Ben Lomond	109	82	62	74	79-83	33-19	11-1	76-85	2	0
NATIONAL SEASON LENGTH (DAYS)										
Average	105	81	70	74	87-90	67-61	54-44	86-89	50	4-1

Table 3: Projected season length (days) for Australian ski resorts. The range shown indicates the slight difference between RCP scenarios and SSP scenarios (RCP first number; SSP second number; where there is only one number RCP and SSP are the same). The low emissions scenario uses only RCP. Averages have been rounded to the nearest whole day.
* Nordic (cross country) resorts, with no or limited snowmaking capacity but a minimum snow-depth requirement of only 15cm

SkiSim2 Projections Summary

Skiing in Australia is already relatively short compared to many other markets globally and the number of ski areas with a substantial ski season will decline rapidly in the coming decades. The SkiSim2 results indicate that Mt Buller, Mt Baw Baw, Mt Stirling (Nordic), Lake Mountain (Nordic), Mt Selwyn, and Ben Lomond are Australia's ski resorts most vulnerable to climate change. If these resorts continue to rely predominantly on winter skiing, they are unlikely to be economically viable past the next few decades.

These ski resorts play an important part of the region's economy, culture, and identity. VIC resorts contributed $1.22 billion in Gross State Product (GSP) in 2019[23] and NSW resorts contributed an estimated $2.11 billion[24], as well as health and wellbeing benefits for Australians[25]. These resorts need to invest in adaptation measures, such as summer tourism and winter diversification, to preserve Australian values of outdoor-based recreation in the alps, health and wellbeing, and to continue supporting regional towns. There are opportunities to be seized when adapting to climate change; for example, as Australia warms, the Alps will provide a haven of cool temperatures in summer. Seizing these opportunities requires proactive decision-making and collaboration across governments, communities, businesses, and recreational users.

The SkiSim2 results highlight that long (and most likely economically viable) ski seasons are still possible with effective mitigation that keeps our global trajectory within a low emissions scenario, particularly for higher altitude resorts. It is therefore critical that governments take drastic action to mitigate climate change. For resorts particularly vulnerable to climate change, planned adaptation needs to occur soon, so that Australian government and communities can support a transition that preserves jobs, economic activity, regional towns, and other values.

Conclusion

The Australian Alps is significantly transforming due to climate change. The extent of this transformation depends on the success of Australian and global climate mitigation efforts. What the Australian Alps transforms to is partly dependent on how communities, industries, and high-country ecosystems adapt. Lack of leadership on climate change mitigation and adaptation will leave stakeholders to adapt incrementally and autonomously, without coordination or support, and will miss opportunities to direct the transformation of social and ecological systems. The United Nations World Meteorological Organization (WMO) State of the Climate report[26] emphasizes that globally the cost of climate inaction is higher than the cost of climate action, and this is the case in the Australian Alps.

We conclude that:

a) Climate change impacts are already driving autonomous adaptation measures in the environment and by industries across the Australian Alps;

b) Some impacts can be mitigated by restoring environmental health of high country ecosystems, including by enhanced programs for control of weeds and feral animals, and peat bog restoration;

c) Many high country species of flora and fauna are at risk of extinction and require consideration of translocation and ex-situ conservation;

d) Climate change is driving expansion of new adaptions in industries, such as development of more mountain biking and pumped storage hydropower facilities, and informed discussion is required to manage environmental and other trade-offs.

The Australian Alps is rapidly changing. Governments, industries, and community groups need to proactively consider a range of adaptation options to understand the risks, minimise the costs, and maximise the benefits from this unwanted transition.

Image. Matt Wiseman

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