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Alpine Plants Cope with Extreme Temperatures In a Mosaic of Diverse Microclimates

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With increasing average temperatures (and associated extreme events), climate change threatens fragile ecosystems worldwide. One of these fragile ecosystems, the Australian Alps Bioregion, is particularly at risk, only covering < 0.2 percent of the continental land mass and narrow elevation ranges, with only 10 percent of this area as true alpine (i.e., above the tree line). Despite its restricted range, the Australian Alps have highly endemic species of plants and animals found only in this region.

As primary producers in a fragile environment, plants are the foundation of alpine ecosystems. Concerningly, Australian alpine plants have limited capacity to retreat to higher elevations, where temperatures are cooler, to escape the warmer world below. Instead, they rely on pockets of refuge where climatic conditions differ from the surrounding area. If these climatic changes happen on a fine scale, we call them microclimates.

Microclimates occur across many ecosystems. In alpine systems, microclimates are often associated with differences in snowmelt timing. When walking along the Main Range in Kosciuszko National Park, New South Wales, in summer, have you ever wondered why snow hangs around in some areas but not others? A complex interaction between wind, topography, aspect, and elevation drives snowmelt patterns. Plants, especially small ones in alpine regions, are also experiencing these delicate variations in climate, which may lead to greater resilience to extreme conditions.

Studying ecologically important species routinely used in restoration, such as Alpine grevillea (*Grevillea australis*) and Alpine mint bush (*Prostanthera cuneata*), I get the opportunity to unravel some big questions about the fate of Australia's alpine plants, which will lead to enhanced management and conservation of alpine landscapes.

Searching for Resilient Alpine Plant Populations Through History

One aspect of this research is understanding where alpine plants are found now, where they were thousands of years ago and how that has changed over time.

The geographical area where individuals of a species occur is shaped by historical processes and

Main Range in Kosciuszko National Park, New South Wales. Image: Lisa Danzey.

selection pressures within that range. In alpine landscapes, historical glacial and interglacial shifts have seen populations of species contract during cool-dry glacial periods and expand into uninhabited areas when glaciers retreat in warmer periods. The first step in locating resilient alpine plants is understanding how past climates shaped current distributions.

How do we know where species are found across the landscape?

Occurrence records kept by museums, herbariums, experts, and citizen scientists document known observations of species. Modelling algorithms can find associations between occurrence records and environmental variables such as temperature and rainfall to identify suitable conditions for a species to survive. This information can be used to estimate the probability of a species occurring in a place depending on the environmental variables of that specific place.

Once the model is built, the predicted species distribution can be projected geographically onto a map. Better still, these predictions can be projected thousands of years backwards using Earth's natural records in rings of trees, frozen in glaciers, trapped in ocean sediments, and even forward into the distant future.

Another way to unravel the evolutionary history of alpine plants is through genetic studies. Like any other living organism, plant genetic makeup provides evidence of traits passed down through generations. If a trait is beneficial for an individual in survival and reproduction, the genetic signature of that trait is more likely to be passed down to the next generation. Genetic studies explore the evolutionary factors that explain differences within and among species populations that could lead to the resilience of some populations to extreme temperatures.

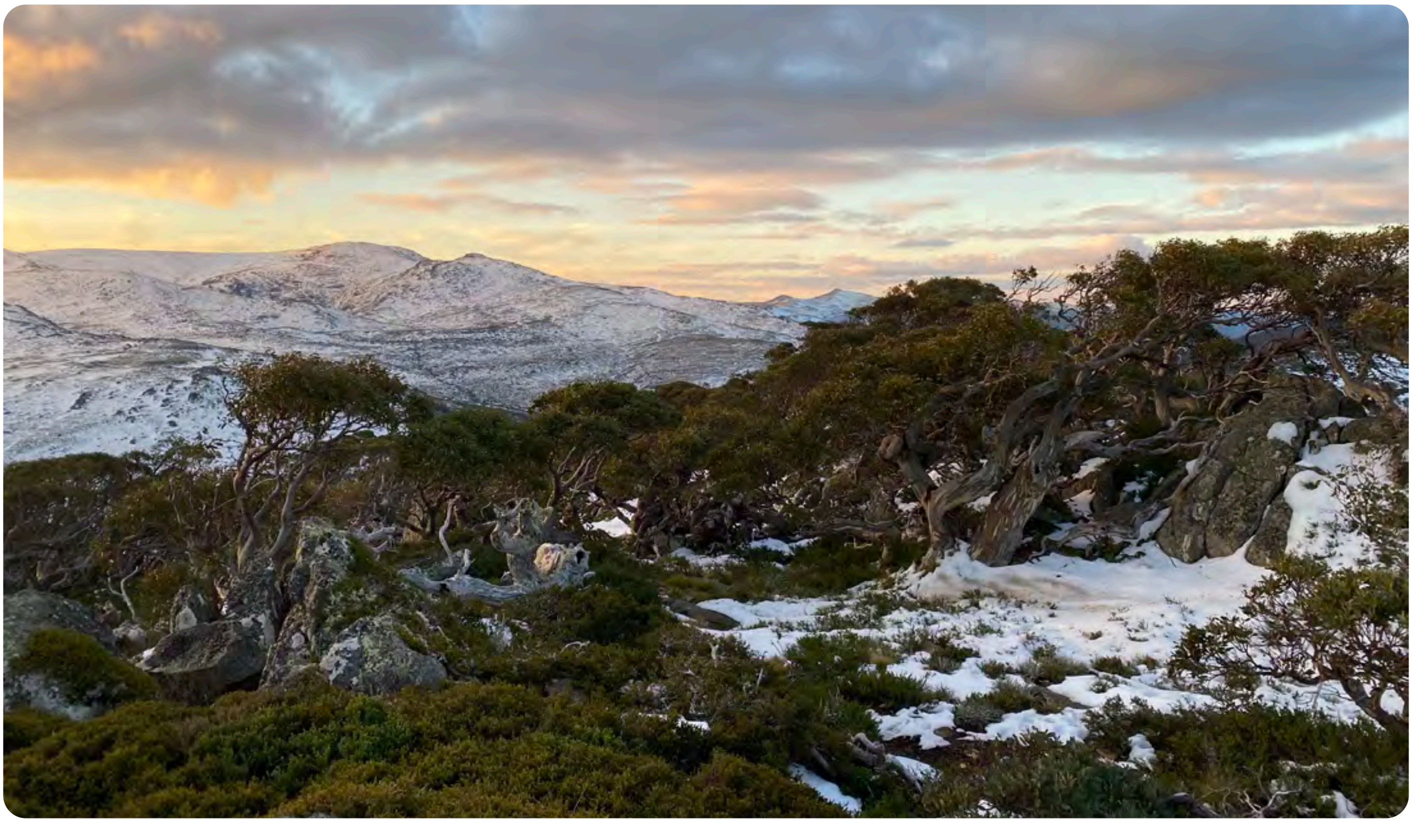
Alpine grevillea (*Grevillea australis*) on Porcupine Rocks walking track in Perisher Valley, New South Wales. Image: Lisa Danzey.

Alpine mint bush (*Prostanthera cuneata*) in Charlotte Pass, Kosciuszko National Park, New South Wales. Image: Lisa Danzey.

Once we know where resilient plants could be, what next?

Measuring the Thermal Tolerance of Alpine Plants

Photosynthesis, converting solar radiation to carbohydrates, operates within an optimum temperature range. This process occurs in chloroplasts, an organ-like structure within leaves.



Sunset over the Main Range in Kosciuszko National Park, New South Wales. Image: Lisa Danzey.

Bespoke heatwave chambers were installed over native vegetation near Mount Hotham summit in the Victorian Alps, Victoria. Image: Sabina Aitken.

Collecting data from microclimate weather stations near Schlink Pass, Kosciuszko National Park, New South Wales. Image: John Hurley.

When sunlight hits chloroplasts, one of three things can happen: 1. It can be used for photosynthesis, 2. It can be dispersed as heat, or 3. It can rebound.

The rebounded light indicates leaf health and thermal tolerance to extreme temperatures. If more light rebounds, less photosynthesis occurs, and the leaf becomes more stressed because of the increasing or decreasing temperature.

When potentially resilient plants are located, we can evaluate their resilience by measuring the photosynthetic thermal tolerance of leaves. This step involves an extensive field campaign across the mountains bordering Victoria and New South Wales. After a morning of hiking and collecting leaf samples, we ran some temperature stress experiments in our makeshift lab, where the rebounding light from the leaf is measured.

Coping with Future Climate Extremes

The final step in the journey is to determine how alpine plants will respond to and recover from future climate extremes such as heatwaves. Heatwaves are expected to intensify further and become more frequent under climate change. Plants will not only have to withstand extremely high temperatures during heatwaves but recover quickly before the next event.

Glasshouse studies, where plants are grown in pots under controlled conditions, have attempted to understand plant responses to heatwaves. But there is also a need to examine how plants respond in nature, where environmental conditions, such as humidity and light, fluctuate across time and space. To address this critical knowledge gap, this research uses bespoke chambers to simulate a realistic heatwave under natural conditions in a sub-alpine grassland of Kosciuszko National Park.

A Journey Through Time and Space

The overarching goal of the research is to understand how alpine plants are coping with current, historical, and future extremes. In combining diverse fields of plant ecophysiology, genetics, and biogeography, these insights will better predict and conserve the future of Australian alpine plants in the face of global environmental change.