ALPINES CAN'T STAND THE HEAT

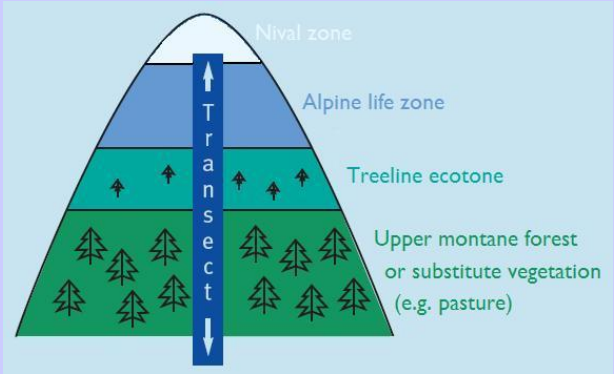
New findings show that high mountain plant species in the European Alps are threatened with extinction as a result of climate change.

by Victoria Butler

The European Alps are now experiencing the highest temperatures since 1500, according to a study carried out by the Organisation for Economic Co-operation and Development (OECD) [1]. Climate model projections show further changes in the coming decades, with receding glaciers at high altitudes and reduced snowfall on lower slopes. While most people's biggest concern is the future of the skiing industry, we should not forget that there is also a struggle for survival being faced by many alpine plant species.

A survey of plants in the Italian Alps led by the European Native Seed Conservation Network (ENSCONET) last year found that many had migrated up to 430 metres higher in the last 50 years as a response to an average temperature increase of 1.5°C. Gilberto Parolo and Graziano Rossi, who carried out the study observed that some of these had almost reached the highest parts of the mountains and subsequently have nowhere else to go to escape the rising temperatures. [2] Species such as the blue gentian (*Gentiana bavarica*), coltsfoot (*Tussilargo farfara*) and the alpine hawkweed (*Hieracium intybacuem*) may be threatened with extinction if temperatures continue to rise, according to ENSCONET [3].

Mountain vegetation zones



The Alps are an interzonal mountain system (orobiome) with an area of nearly 150,000 square kilometres, stretching over parts of France, Italy, Germany, Austria, Slovenia, Switzerland, and Liechtenstein. Over 4,500 vascular plant species

are found here, of which around 400 species are endemic to this region, such as *Draba sauteri* and *Potentilla saxifraga.* Within the European Alps 17% of plants are restricted to the alpine zone. [4] This comprises the high mountain area above the treeline and is often subdivided into an alpine zone and the higher nival or snow-covered belt. Plants growing in these zones are highly specialised in order to cope with extreme conditions, including low temperature and reduced air pressure [5]. Water is often scarce for much of the year, either the soil is dried by evaporation or the water is locked away from plant roots in the form of ice, but in spring, the ice melts and plants make use of the moisture while it remains available.

Many species are specialised to a particular microscale region, with precise conditions of sunlight, humidity and exposure. For this reason, alpines are particularly sensitive to changes in climate, however, some would argue that these isolated microclimates are less vulnerable to the effects of wider climate change and will continue to support endemic populations.

This is the over-riding feature of mountain slopes: the compression of climatic zones along elevational gradients causing flora to represent hotspots of biological richness. The terrain is highly fragmented and topographically diverse, leading to great habitat diversity and mosaics of plant communities [6]. If these conditions change, specialised plants may be driven out by more competitive generalised species, leading to an increasingly homogeneous plant community.

Climate change in the Alps

The European Environment Agency reported that in 2004 the concentration of carbon dioxide (CO_2) in the lower atmosphere had increased from its pre-industrial concentration of 280 ppm to 375 ppm, which is the highest level in the last 500,000 years. As a result, average temperatures in Europe have risen by an average 1°C over the last century (Figure 1) [7]. Within the Alps, it appears that the temperature rise has been even greater than the European average. This may be due to the positive feedback effect caused by retreating glaciers – whereas the snow and ice reflects solar radiation, the areas of rock and soil revealed when a glacier melts absorb heat, thus accelerating the rate of warming.

The Intergovernmental Panel on Climate Change (IPCC) predicts that the global average surface warming by 2100 will be between 1.4 and 5.8 °C above 1990 levels (Figure 2), using a broad range of scenarios of potential socio-economic developments and related greenhouse gas emissions [8]. An increase in the annual temperature of 1–2 °C, might be within the range of tolerance of many high mountain species and will therefore only result in a limited composition change. However, some with some scenarios the projected warming is more than 3°C within the next 100 years, which will most likely be outside the tolerance range of most plant species, and would lead to extensive loss of species [9].

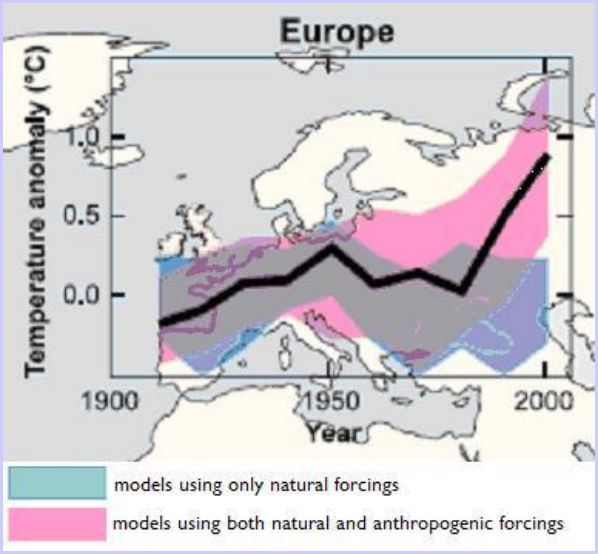


Figure 1. **Comparison of observed changes in surface temperature in Europe with results of simulations by climate models using either natural or both natural and anthropogenic forcings. Decadal averages of observations are shown for the period 1906-2005 (black line) plotted against the centre of the decade and relative to the corresponding average for the 1901-1950.** *[Figure from IPCC 2007]*

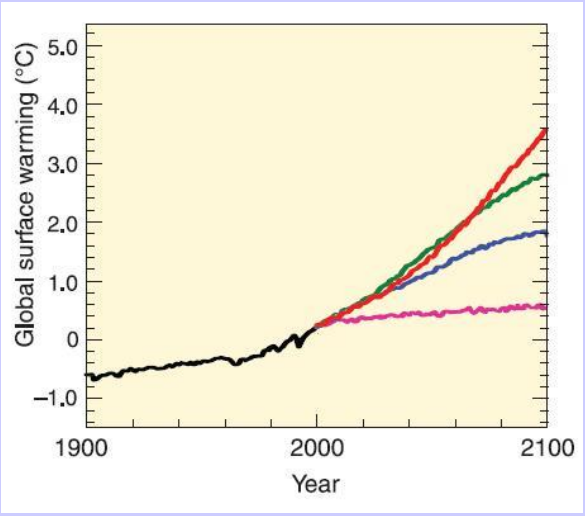


Figure 2. **Multi-model global averages of surface warming (relative to 1980-1999) for a range of scenarios.** *[Figure from IPCC 2007]*

How has this affected the alpine flora?

In the study carried out for ENSCONET, Parolo and Rossi compared historical records from the 1950s with recent surveys of vascular plants in the alpine-nival zone of the North Italian Alps. They found that at an altitude of 730 metres, species richness had increased from 153 to 166. This may sound like a good thing, but these figures indicate the development of a transition zone where cold-tolerant alpines are equally represented with grasses and shrubs that have moved up from lower altitudes. These species are more competitive in warmer conditions and will eventually dominate, pushing the more specialized plants upwards.

This appears to be happening already – 52 species were recorded 30-430 metres higher than their 1950s limits. This equates to a median migration

rate of nearly 24 metres per decade [2], although rates varied drastically between species. Both fast and slow migrants face potential future problems: the latter will not be able to keep up with the speed of warming and will be out-competed by species better suited to a warmer climate and the former may be forced into increasingly smaller areas until the population dies out altogether.

These findings have been supported by other studies. Harald Pauli and his team carried out two floral surveys, the first in 1994 and the second ten years later, on Mount Schrankogel in the central Tyrolean Alps in Austria. Their results showed a slight increase in species richness overall, but a contraction of the range of subnival to nival species related to an spread of alpine pioneer species. Species cover changed depending on altitudinal preferences of species, showing significant declines of all subnival to nival plants [10]. In addition, analyses of data collected in the Bernina region of the Swiss Alps, show a growing trend towards uniformity of plant communities on alpine summits [11]. The projected acceleration of climate warming raises concerns that this phenomenon could become the major threat to biodiversity in high mountains.

Future projections – the survival lottery

Survival of high mountain plant species may depend on two things: firstly, how effectively the population is able to relocate; secondly, whether there are any suitable sites remaining within its seed distribution area. Parolo found that the fastest migrants were those species with the lightest seeds, which are easily wind-dispersed [2]. These were most successful at colonising bare ground, however, establishment in a new area is restricted by the availability of sites. Plants growing on Southern slopes may have a better probability of relocating due to the greater abundance of microclimates [12].

The EEA report on the impacts of Europe's changing climate predicts that overall, future climate change will affect species distribution in the Alps substantially, resulting in decreased abundance and possibly even the extinction of some endemic species. These species will become threatened as they are unable to adapt to environmental changes, cannot migrate to more suitable places and cannot compete with invading shrub and tree species. [13]

Plants in danger

According to projections by Michel Bakkenes of RIVM (the National Institute for Public Health and the Environment in the Netherlands), the mountain bladder fern (*Crystopteris montana*), snow dock (*Rumex nivalis*) and mountain buttercup (*Ranunculus montana*) will disappear from many of its current locations including parts of the Alps if temperatures rise by 3°C by 2100. In the worst-case scenario examined by the IPCC, which assumes a temperature rise of more than 3°C along with the supposition that no species would be able to migrate, 2% of Europe's flora would become extinct by 2080 and 22% would be critically endangered. [8]

Alpine plants under threat

Clockwise from top left: *Leucojum nicaeense*, *Nigritella corneliana*, *Fritillaria tubaeformis*, *Primula allionii*

Although these figures are alarming, the response to climate change of high mountain plant species in the Alps is still relatively uncertain, because monitoring sites have been in operation for only a few years. Many projections are based on global trends due to absence of local-scale climate information, and as climatic conditions vary from one mountain range to another, these may not be representative of the European Alps. Results based on local-scale modelling in the Swiss and Austrian Alps, suggest there are divergences between local and broad scale projections. Also, the accuracy of climate projections is limited in simulating small-scale plant communities and mountain plant species

are only modestly represented in the simulation models. Furthermore, the threat from the migration of many tree species might be exaggerated since the development of appropriate growing conditions comprises more than just climate. This may limit the projected extinction of species. Finally, the adaptive capacity of mountain plant species is often unclear and might change in the future. [13]

Looking to the future

Even if a substantial reduction in greenhouse emissions is achieved within the next few decades, temperatures will continue to rise through this century. If temperatures increase by as much as 3°C, the future for many high mountain plants looks bleak. As a consequence of the difficulties of projecting future species loss, the Global Observation Research Initiative in Alpine Environments (GLORIA) was set up. Its intention is to function as an early warning system for the growing threat to high mountain biodiversity. It began originally in European mountain regions including the Alps, but is now active in mountain regions across the world. Ecologists plan to conduct resurveys at intervals of 5 to 10 years to enable the comparison of actual changes across mountain regions. [14]

Climate warming: the end for alpines?

'Ongoing warming and reduced snow cover will exert strong pressure on nival plants by competition from alpine species. In the long term, nival plants will lose habitats. Plant species of very limited distribution area, e.g. summit endemics, are threatened even in the short term.' Dr Michael Gottfried, University of Vienna

'Species from alpine plant communities are usually long-lived and strongly rely on reproduction by vegetative or clonal growth. Nevertheless, genetic diversity in populations of such plants is usually surprisingly high. Seed dispersal, seedling establishment and the colonization of new sites are probably much more frequent in alpine plant life than previously thought. For the response of alpine plant species to global warming and associate changes this is good news.' Prof. Jürg Stöcklin, University of Basel [6]

In 2006, the EUROMONT workshop was held at the University of Lausanne in Switzerland, its objective being to assess the overall sensitivity of mountain plants to climate change by comparing global and European predictions with local scale trends and decide which projections are most relevant for deriving reliable conservation plans. [15]

Many areas within the Alps are now conservation sites and numerous plant species are protected by law. Last year, UNESCO inscribed an extension to the Jungfrau-Aletsch-Bietschhorn World Heritage site in the Swiss Alps, which has increased the area by 53% to 82,400 hectares. A diverse range of plants is represented in the site and plant colonization in the wake of retreating glaciers provides an excellent example of plant succession [16]. This may help with obtaining funding for future research and protecting habitat at least from dangers such as tourism and recreation, but sadly, cannot prevent the threat posed by climate change.

With this in mind, seeds of threatened species are now being harvested and stored in seed banks. Dr. Jonas Müller, ENSCONET coordinator explained: "For many plants that have their habitats threatened by climate change, seed banking is the only alternative, without these measures they will become extinct. The idea behind long-term seed storage is simply to insure that species survive and can be returned to nature for future generations to enjoy".

"ENSCONET enables vital knowledge of threatened plants, harvesting seed and subsequent storage to be pooled from across Europe. Kew, Pavia and 25 other institutes from 17 countries in Europe have joined forces to protect the continent's most endangered species many of which face extinction" [3]. Unfortunately, current lack of funding has meant that progress is being restricted.

Sara Oldfield, from Botanic Gardens Conservation International said: "The need for plant conservation has never been greater, it is imperative that we take action now. The early signs that high mountain plants are migrating to cooler areas should serve as a wake-up call to us all" [3]. The changes observed in the Alps are just one of the numerous indications that our climate is warming dramatically and that the consequences reach far beyond a ruined skiing trip.

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