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Climate change and alpine tundra loss

The alpine tundra domain occurs at altitude in the high mountains in Europe. It is an important reservoir of freshwater and provides habitat to unique species. The treeline, which is below the domain, represents the forest limit. About 98% of Europe's alpine tundra domain is in the Pyrenees, Alps and Scandes. In a 3°C warming scenario, the natural climatic treeline is projected to move vertically upwards and the domain could shrink significantly over Europe. Adaptation is challenging because of the unique topographic, soil and climatic characteristics of high mountain systems.

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KEY MESSAGES

Significant shrinkage

84% shrink of domain in 3°C warming scenario

The Alpine tundra domain will shrink by 84% of its present size over Europe in a 3°C warming scenario and in the Pyrenees there will be a near total loss.

Limiting warming to 1.5°C will reduce the loss of alpine tundra to 48%.

Multiple implications

The projected changes have implications for vital ecosystem services, habitat for biodiversity, and recreational services such as skiing.

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Shrinkage of the alpine tundra domain

Alpine tundra currently covers around 87,000 km² in Europe, of which around 25,000 km² is in the Alps, 1,800 km² in the Pyrenees and 59,000 km² in the Scandes. This is close to the size of Austria or Portugal. However, the domain is projected to shrink significantly with global warming (Figure 1).

There are large differences in the losses projected for the three main regions that make up the domain: the most severe impact is projected for the Pyrenees, where the current domain virtually disappears with 3°C, compared to the Scandes and Alps, which would shrink by around 87% and 75% respectively.

The magnitude of loss is smaller at lower warming levels but it is still significant: with 1.5°C global warming the alpine tundra domain in the Pyrenees, Scandes and Alps reduces in area by around 74%, 50% and 36% respectively (Figure 1).

	1.5°C	2.0°C	3.0°C
Habitat loss in Pyrenees (%)	74	91	99
Habitat loss in Alps (%)	36	50	75
Habitat loss in Scandes (%)	50	61	87

Figure 1. Projected shrinkage of alpine tundra (%) compared to present.

About PESETA IV

The JRC PESETA IV project aims to better understand the biophysical and economic consequences of climate change. It does this by using projections of climate change for Europe from several climate models along with a set of climate change impact models. The project covers several sectors that are relevant to society and the natural environment, such as freshwater, agriculture, and coasts.

ec.europa.eu/jrc/en/peseta-iv

European Commission

Joint Research Centre

Losses of alpine tundra in Natura 2000 sites

Over 16,000 km² of current alpine tundra domain are Natura 2000 sites, a network of nature protection sites established under the EU Habitats Directive, approximately 20% of the total extent of the current alpine tundra domain.

	1.5°C	2.0°C	3.0°C
Habitat loss in Pyrenees (%)	73	91	99
Habitat loss in Alps (%)	36	50	74
Habitat loss in Scandes (%)	52	65	86

Figure 2. Projected shrinkage of alpine tundra within Natura 2000 sites (%) compared to present.

Of the 210 sites that contain alpine tundra, almost all of them are projected to see a shrinking of the domain: 207 and 208 in the 2°C and 3°C warming scenarios respectively. The magnitude of shrinkage is already significant under the 1.5°C warming scenario: the current domain within Natura 2000 sites shrinks by between 36% (Alps) and 73% (Pyrenees; Figure 2). The contraction increases gradually with warming, and in the 3°C warming scenario the current domain inside Natura 2000 sites shrinks by over 74% in all three of the mountain regions where most of Europe's alpine tundra is currently found.

With unmitigated climate change practically all alpine tundra Natura 2000 sites in the Pyrenees could be lost.

Vertical shifts in the treeline

The natural climatic treeline is projected to gradually advance vertically upward in mountain regions of Europe with global warming (Figure 3). The rate of treeline shift generally increases at lower latitudes, where climatic treelines are already higher.

In a 3°C warming scenario, the treeline in the Pyrenees could reach 2,317m compared to 1,675m now (+642m). In the Alps, the treeline could shift from 1,762m at present to 2,288m (+526m) with 3°C warming, while in the Scandes it could climb from 523m to 859m (+336m).

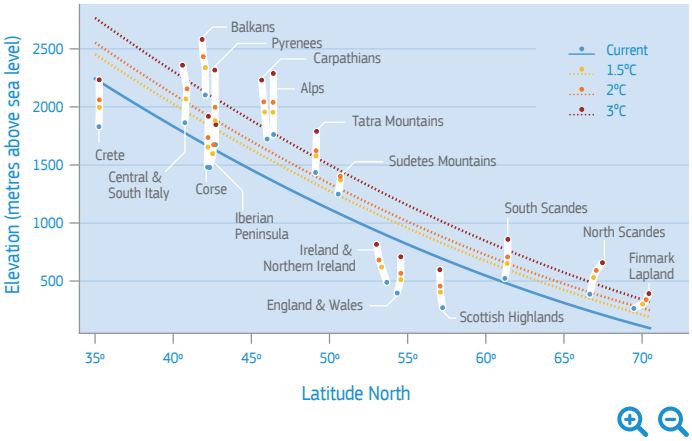

Figure 3. Climatic treeline elevation for 16 mountain regions in Europe, currently, and in 1.5, 2 and 3°C warming scenarios. White lines group impacts for each region. Solid and dotted lines show best regression fit for each scenario.

Implications and need for adaptation

Snow retains water above the treeline that is released during the summer months. Shrinkage of the alpine tundra domain could alter available water resources downstream in summer months. It is also associated with a shrinkage of alpine glaciers, causing debris flows and reductions in water quality due to an increase in the amount of sediments in rivers. Cold mountain habitats would decline, leading to local extinction of some alpine plant species. Warm-adapted species would increase at the expense of declining cold-adapted species. Shrinkage of the alpine tundra domain would likely restrict winter sports.

Ecosystem-based adaptation options include ecological restoration, increasing biological diversity, assisted migration of threatened species, ecological corridors, ex-situ conservation and seed banks. Several of these options face constraints arising from the unique topographic, soil and climatic characteristics of alpine tundra regions. Migration of species could be constrained by the lack of sufficient altitude to migrate vertically or due to limiting soil conditions for plant growth. The feasibility of the implementation of adaptation measures should therefore be assessed at local level. Potential trade-offs between adaptation for nature conservation and adaptation for winter tourism should also be considered.

Approach

PESETA IV assessed the effects of climate change on the spatial range of the alpine tundra zone in the high mountain ranges of the Pyrenees, Alps and Scandes, using climate simulations for the present (1981-2010) and global warming of 1.5, 2 and 3°C above preindustrial levels. Alpine tundra was mapped based upon climate characteristics and changes were defined as stable, contraction and expansion. Treelines were mapped based upon air temperature and elevation.

Natura 2000 sites projected to be affected by changes of the alpine tundra were identified by overlying areas that are projected to remain stable, contract or expand with the map of Natura 2000 sites.

Treeline shifts with global warming were assessed in 16 mountain regions in Europe, from the Mediterranean islands to the Boreal and from the Iberian Peninsula to the Carpathians, including the more prominent treeline ecotones of Europe.

The impacts of declines in the alpine tundra domain and vertical shifts in the treeline, as well as potential adaptation options, were considered by reviewing the available literature – it was not modelled specifically by PESETA IV.

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