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ORIGINAL ARTICLE

Topographically controlled thermal-habitat differentiation buffers alpine plant diversity against climate warming

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ABSTRACT

Aim We aim to: (1) explore thermal habitat preferences in alpine plant species across mosaics of topographically controlled micro-habitats; (2) test the predictive value of so-called 'indicator values'; and (3) quantify the shift in micro-habitat conditions under the influence of climate warming.

Location Alpine vegetation 2200–2800 m a.s.l., Swiss central Alps.

Methods High-resolution infra-red thermometry and large numbers of small data loggers were used to assess the spatial and temporal variation of plant-surface and ground temperatures as well as snow-melt patterns for 889 plots distributed across three alpine slopes of contrasting exposure. These environmental data were then correlated with Landolt indicator values for temperature preferences of different plant species and vegetation units. By simulating a uniform 2 K warming we estimated the changes in abundance of micro-habitat temperatures within the study area.

Results Within the study area we observed a substantial variation between micro-habitats in seasonal mean soil temperature ($\Delta T = 7.2$ K), surface temperature ($\Delta T = 10.5$ K) and season length (>32 days). Plant species with low indicator values for temperature (plants commonly found in cool habitats) grew in significantly colder micro-habitats than plants with higher indicator values found on the same slope. A 2 K warming will lead to the loss of the coldest habitats (3% of current area), 75% of the current thermal micro-habitats will be reduced in abundance (crowding effect) and 22% will become more abundant.

Main conclusions Our results demonstrate that the topographically induced mosaics of micro-climatic conditions in an alpine landscape are associated with local plant species distribution. Semi-quantitative plant species indicator values based on expert knowledge and aggregated to community means match measured thermal habitat conditions. Metre-scale thermal contrasts significantly exceed IPCC warming projections for the next 100 years. The data presented here thus indicate a great risk of overestimating alpine habitat losses in isotherm-based model scenarios. While all but the species depending on the very coldest micro-habitats will find thermally suitable 'escape' habitats within short distances, there will be enhanced competition for those cooler places on a given slope in an alpine climate that is 2 K warmer. Yet, due to their topographic variability, alpine landscapes are likely to be safer places for most species than lowland terrain in a warming world.

Keywords

Climate change, indicator values, micro-habitat, snow distribution, soil temperature, species diversity, surface temperature, Switzerland, thermometry.

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