# Submitted Abstract

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## Abstract

Explaining why a species does exist where it does, is the number one issue in ecology. However, the actual range limits of alpine plant species are still largely unexplored and unexplained. We aim at identifying the low temperature range limits of two highly abundant graminoid species that intermingle in mosaics of high-elevation habitats across the European Alps: the sedge Carex curvula and the grass Nardus stricta. We assessed the year-round temperature 3 cm below ground, close to the plant meristems as well as snow cover duration, soil chemistry and vegetation characteristics (composition, Landolt indicator values) in 115 well-characterized microsites, and combined the field data with freezing resistance using different approaches such as electrolyte leakage for leaves, tetrazolium vital staining for shoots, and regrowth capability for entire tussocks.Carex and Nardus clearly segregated across different microsites. Season length, growing degree hours and soil chemistry (pH, C/N-ratio, phosphorus) did not demarcate the two species' ranges, while their distribution was strongly affected by soil temperature minima in winter. Carex occurred at sites with and without protecting snow cover and resisted low soil temperatures (-13 °C). Nardus was absent at microsites with short snow cover duration (less than 5 months) and soil minimum temperatures below -5 °C. During the growing season, leaves of Carex had a higher freezing resistance with LT50 of -16.1 °C than those of Nardus with LT50 of -13.3 °C (LT50: lethal temperature for 50% of the tissue). Tetrazolium vital staining in young shoots also revealed a higher freezing resistance in Carex compared to Nardus, and shoot apices tolerated lowest temperatures in both species: Carex -30 °C, Nardus -24 °C. However, a vital shoot apex alone did not ensure regrowth after winter. Regrowth after severe frost events requires intact vessels and roots, all less freezing tolerant than apical meristems and young leaves.

The cold range limits of widespread alpine graminoid species are evidently set by thermal extremes in winter and not by gradual thermal constraints in growth and development. Microtopography, thus snow distribution pattern, combined with the species' freezing resistance explains the cold edge of the fundamental niche of these two prominent species. To our knowledge, this is the first mechanistic explanation of species range limits in cold environments. Previous attempts have mainly employed mapping approaches and correlative analysis.