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Unique and highly threatened - endemic plants at the cold edge of southern Europe

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Abstract

The Spanish Sierra Nevada National Park hosts an extraordinarily rich flora of endemic plant species – many being restricted to high elevations above 2800m. Given their limited distribution area and adaptation to low-temperature conditions, these species are at extremely high risk of losing their habitat through amplifying climate change. We show recent changes in endemic species occurrences and abundances in GLORIA permanent monitoring plots and discuss the risk of biodiversity losses through climate change and land use impacts.

Keywords

alpine vegetation, climate change, endemic flora, long-term monitoring, land use

Introduction

The Mediterranean Basin is Europe's only and one of 35 global biodiversity hot spots, which comprise the Planet's biologically richest and most endangered terrestrial ecoregions (MYERS et al. 2000). Sierra Nevada is Europe's highest Mediterranean mountain range, extending from the thermo-Mediterranean belt at sea level to the cryoromediterranean belt with alpine climate. Sierra Nevada's outstanding richness of endemic plants has long been recognised (e.g. QUÉZEL 1953, RIVAS GODAY & MAYOR LÓPEZ 1966). Most of its endemic species occur at high elevations (MOLERO MESA et al. 1996) and many are restricted to the uppermost zone, covering only ca. 40 km² (FERNÁNDEZ CALZADO 2007); these cryophilic species could be considered among the continent's most vulnerable due to the rapidly progressing climate change. Given this critical situation, the Spanish Sierra Nevada was one of the first GLORIA sites established, aiming at assessing magnitude and velocity of biodiversity losses through long-term monitoring. On the background of the unique situation of Sierra Nevada, this presentation focuses on three objectives:

1. GLORIA data series recorded during the period 2001 to 2015, specifically on the proportions of endemic species along the elevation gradient and their change in abundance and species numbers during the observation period;
2. the potential risk of habitat loss for endemic species through changing thermal and precipitation regimes;
3. the main land use practices causing pressure on mountain endemics.

Methods

Sierra Nevada is a small Mediterranean mountain range near the Andalucian coast in southern Spain, stretching over 90 km (and ca. 40 km of its part with alpine climate) in E-W direction. Due to its high elevations, with 3479 m a.s.l. Mulhacen is the highest point on the Iberian Peninsula, it represents an isolated 'island' of cold climate, ca. 700 km away from similar environments in the Atlas range and the Pyrenees. Climate is typically Mediterranean with winter rain/snow fall and arid summers, and bedrock of the high parts is siliceous (MOLERO MESA 1998). The eight GLORIA summit observatories (four in each study region ES-SNE and ES-SNN) are located between the upper oro-Mediterranean and the cryoro-Mediterranean zone, i.e. between 2600 and 3300m.

Sampling design and vegetation sampling followed the international standard GLORIA protocol (PAULI et al. 2015). On each summit biodiversity observatory, four 1-m² permanent plots in each cardinal direction and the entire summit area down to the 10-m isoline, divided into eight sections, constitute a monitoring site. All vascular plants and their abundances were recorded in each plot and summit area section.

For anthropogenic land use influences, a reconnaissance was conducted throughout the alpine life zone of Sierra Nevada by using standardised field sheets. In addition, qualitative semi-structured, guideline-aided interviews on land-use history and development plans were carried out with key-informants to assess types of anthropogenic activities as well as spatial and temporal dimension of land-use and anthropogenic influences at the target sites.

Results

The fraction of endemic species of the entire summit flora was 23% on the lowest and increased linearily to over 90 % on the highest summit. During the past 14 years, the proportion of endemic species decreased from 2001 through 2008 to 2015. High-elevation vegetation experienced thermophilisation, i.e. an increase in more warm-demanding species from lower-elevations and/or decline of high-elevation species. The following land use activities in high elevations of Sierra Nevada were identified, ranked by the estimated magnitude of impact on endemic vegetation:

1. skiing with artificial snowmaking infrastructure,
2. livestock pasturing (cattle, sheep),
3. tourist horse riding,
4. hiking along high-elevation summit trails,
5. growth of ibex (Capra pyrenaica) populations.

Discussion

The observed thermophilisation in the high-elevation vegetation of Sierra Nevada is a Europe-wide trend (GOTTFRIED et al. 2012), but Mediterranean mountains differ from central to northern European mountains by the stagnation or even decrease in species numbers. Endemic species in Sierra Nevada are also affected by such climate-driven decreases and are the most vulnerable due to upward shifting vegetation, because they already sit at the spatially very limited cold edge (FERNÁNDEZ CALZADO 2007, PAULI et al. 2011). Projected warming and less spring and summer precipitation (NOGUES BRAVO et al. 2008, PÉREZ-LUQUE et al. 2016) are expected to lead to widespread habitat losses and extinction processes of endemic plant species in the Sierra Nevada (FERNÁNDEZ CALZADO 2007, PAULI et al. 2011). Given that the vegetation is mainly built by endemics (MOLERO MESA et al. 1996), high-elevation ecosystems are at high risk to be completely transformed. Intensive land use practices also contribute to the decline of habitats for endemics.

Through its outstanding low-temperature environment, surrounded by Mediterranean summer-hot land and urban areas, Sierra Nevada is much demanded by different user groups. The most detrimental is a giant skiing resort. Second, livestock grazing still extends into high-elevation areas, despite the protection status of a national park and UNESCO biodiversity reserve. Touristic horse riding and increasing hiking impacts ('Camino Integral de los Tresmiles') reach virtually all summits over 3000 m. Finally, the population size of the Iberian endemic *Capra pyrenaica* has reached over 30000 individuals.

Conclusions

- Sierra Nevada's high elevation vegetation is mostly built of endemic plant species whose numbers are declining.
- If climate-warming projections hold true, most if not all habitats of alpine endemic plants will become unsuitable within this century. The predicted decrease of precipitation and land use pressures will amplify the effects of warming.
- Monitoring activities and associated early-warning indicators of biodiversity losses need to be supported and intensified at the most vulnerable endemic species and communities.
- An extension of conservation strategies and strengthening of measures leading to targeted guidance of tourism and the creation of strictly protected cores zones is required.
- Measures that support the continued existence of Sierra Nevada's unique flora must be a priority concerns on the regional, national and international levels.

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