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Shifting composition and functioning in alpine plant communities – Evidence of climate warming effects from 14 years biodiversity observation in the Northeastern Alps

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Abstract

Climate-driven vegetation shifts are expected to occur globally and were detected on mountains across Europe. Due to low growth rates and the long-lived nature of alpine plants, changes occur slowly, but continuously. Here we attempt to identify sensitive functional traits, such as leaf traits, plant height and ecological indicator values of alpine plant species to assess climate-driven community shifts in two GLORIA regions (National Park Gesäuse, Hochschwab). Changes in community trait weighted means are used to discern impacts of changes in temperature, snow cover duration and water availability.

Keywords

climate change, high mountain plants, alpine zone, vegetation change, plant functional traits, ecological indicator values, long-term monitoring, thermophilisation, GLORIA

Introduction

European alpine vegetation experienced pronounced thermophilisation during the past decades, i.e. an increase of warmth-demanding species with a synchronous decrease of cold-adapted species (GOTTFRIED et al. 2012). Plant functional traits (PFTs) are key to a species' ability to cope with the alpine climate on the one side and competition on the other side (KUNSTLER et al. 2016). Therefore climate-related directional changes in alpine plant biodiversity are expected to coincide with compositional changes of plant functional traits within alpine plant communities (VENN et al. 2014). Specific Leaf Area (SLA), Leaf Dry Matter Content (LDMC) and Plant Height (PH) will be used here to show recent vegetation changes in the Northeastern Austrian Alps. SLA is related to potential growth rate and provides information about a plant's water strategy (PÉREZ-HARGUINDEGUY et al. 2013). LDMC is roughly negatively correlated to SLA. It is a proxy of water availability and resistance to physical hazards. PH is related to a species' competitive ability for light and is further connected with biomass as well as moisture (COUSINS & LINDBORG 2004) and temperature gradients (SIEFERT et al. 2015; GUITTAR et al. 2016).

Methods

The two study regions in the Northeastern Alps, Hochschwab (established 2001) and National Park Gesäuse (established 2009), are part of the GLORIA network (www.gloria.ac.at), which uses the same internationally standardised monitoring method. Hochschwab includes four summit sites, located between 1910 to 2255m a.s.l. and Gesäuse three summit sites between 1856 to 2116m. Hochschwab was resurveyed in 2008 and 2015, Gesäuse in 2015. Hochschwab has restrictions in pastoralism due to water protection status (water protection area) and Gesäuse is a national park in the IUCN category II.

GLORIA 1m x 1m permanent plot data from all cardinal aspects of each summit was used to calculate community weighted mean trait values (CWMTs) of the following PFTs: SLA, LDMC and PH. PFTs of all species, comprising 90% cover in a 1m x 1m permanent plot were used for calculations of CWMTs. PFTs were measured, following the protocol of PÉREZ-HARGUINDEGUY et al. (2013).

Additionally, the thermic vegetation indicator, based on the altitudinal distribution of all species present in a plot (GOTTFRIED et al. 2012) as well as Landolt indicator values for soil moisture and continentality (LANDOLT et al. 2010) were used to show community based changes in both regions.

Results

Preliminary results show that CWMTs of SLA tended to decrease in both regions. This was more pronounced on Hochschwab, where LDMC showed an inverse pattern. Changes in CWMTs of PH, of the thermic vegetation indicator and of ecological indicator values were less consistent or indifferent.

Discussion

Decreasing SLA would indicate a transformation of plant communities adapted to conditions of lower water availability. Specifically, it means that species with more xeromorphic leaves were either increasing in cover or were newly entering the study plots, as previously reported from other alpine regions (SOUDZILOVSKAIA et al. 2013). LDMC is usually negatively related to SLA (PÉREZ-HARGUINDEGUY et al. 2013), which was indicated by our data from Hochschwab. Directional changes in leaf traits can be interpreted as response to trends of decreasing

precipitation, especially during the growing season, or result from a combined effect with rising temperatures. Atmospheric warming alone, however, may already cause changes in leaf traits, due to higher rates of evapotranspiration. At least over a longer term, leaf trait responses should be consistent with the thermic vegetation indicator. The latter showed an increase across Europe's GLORIA sites already after a period of seven years (GOTTFRIED et al. 2012), which is a rather short time-span in the context of slow growth rates of alpine plants. The much smaller subset from the Northeastern Alps, did not yet show significant thermophilisation, being most likely an effect of the limited number of data from permanent plots and/or a too short time span of observation, respectively.
Data of PFTs were not yet available for all species involved. Therefore, the preliminary results cannot be discussed in more detail at the current stage of analysis.

Conclusion

- Preliminary results suggest that PFTs, combined with permanent plot monitoring data, can build powerful indicators of climate change-induced vegetation changes.
- Especially directional shifts in the species composition and abundance proportions are expected to be detectable by using sets of PFTs and ecological indicator values (CWMT-approach) even in sub-decadal time spans.
- The significance of the CWMT-approach, especially over shorter periods, however, requires both trait data of all species that build the plant communities as well as a sufficient number of permanent plots. Although GLORIA long-term monitoring sites are already established in over 130 mountain regions, of them 12 in the Alps, new sites are still a priority matter, particularly in the Central Eastern Alps, Southeastern Alps and in the French Alps.
- Also it is of very high importance to secure the long-term operation of vegetation monitoring in permanent plots. Effective long-term commitments through national and international funding institutions as well as cooperation with and support from protected area authorities are needed.
- High resolution regional climate data can further improve the CWMT-approach, as regional climate, especially precipitation, can diverge from large scale patterns substantially (BARRY 2008).

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