Habitat-specific threats to degraded Arnica montana populations

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Introduction

Arnica montana L. is a characteristic species of nutrient-poor grasslands in Central Europe with its main distribution range in Germany. Although protected by law, populations have been declining strongly over the last few decades, especially in lowland regions (<500 m a.s.l.) while populations in montane areas seem to remain stable4,6. Several studies have focused on the topic5,6, but due to varying results and experimental setup the cause for the decline is still not clear.

The aim of this study is to identify the habitat-specific reasons for the decline of A. montana in the lowlands of Hesse and to determine environmental variables that indicate the risk potential for populations.

Fig. 1: Flowering A. montana near Ober-Moos, Hesse (picture: Verena Lauströer).

Methods

We compared habitat characteristics of sites with and without A. montana, creating four categories. We grouped sites with existing populations in three classes (<200, 201-500 and >500 rosettes). Sites without the species were picked according to reports of A. montana having vanished from them during the last 15 years. 32 sites across Hesse, Germany were studied using 37 variables and focusing on soil parameters (e.g. soil C:N ratio, pH) and vegetation characteristics (e.g. species composition, Ellenberg indicator values, nutrient contents).

Fig. 2: Large A. montana population, Hesse (picture: Claudia Hering).

Results

The population size of A. montana increased with decreasing nitrogen indicator values (Fig. 3a) and by trend with increasing C:N ratios (Fig. 3b). Population size increased with declining reaction indicator values (Fig. 3c) indicating a shift to acidic environments.

Detrended correspondence analysis supports the strong influence of soil nitrogen and reaction (Fig. 4) as well as C:N ratio on habitat quality for A. montana. Figure 5a shows that there is a change in species composition over the population size categories.

Indicator species analysis supports this change in species composition due to soil nitrogen concentrations with nitrophilous species (Poa pratensis, Lathyrus pratensis, p<0.05) on sites without A. montana compared to less nitrophilous species (Carex pilulifera, Betonica officinalis, p<0.05) on sites with large populations.

Fig. 3a-c: Effect of mean nitrogen indicator value (a), soil C:N ratio (b) and mean reaction indicator value (c) on size of A. montana populations (means ± S.E., n=15). Different letters indicate significant differences among categories (ANOVA: (a) F1,14=5.53, p=0.01; (b) F1,14=7.08, p=0.03; (c) F1,14=3.79, p=0.05).

Fig. 4: Ordination diagram of detrended correspondence analysis. (a) shows sample sites with the distance between sample scores reflecting their dissimilarity regarding species composition. Symbols indicate the corresponding population size category. (b) depicts the supplementary, environmental variables and their relation to the sample scores pattern of (a) (axis 2/3, gradient 3.0;0.2, eigenvalue 0.37/0.15).

Conclusions

Our study strongly indicates that nitrogen input is the most relevant factor for declining populations in Hessian lowlands due to nitrophilous plant species suppressing and replacing A. montana. Reducing the nutrient input via air pollution and enhancing soil depletion of nutrients is vital to maintain and restore A. montana populations.

Most existing A. montana lie in nature reserves which are being preserved, but not intensively managed. The lack of proliferating A. montana populations shows the need for a new kind of land-use in those habitats to sufficiently strip the soil of nutrients. As the next step therefore, we will search for the optimal management procedure for A. montana habitats using a long-term land-use experiment in Hesse.

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References


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