Extensive grassland management promotes greater above- and belowground community richness in two contrasting agroclimatic regions in Switzerland

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Abstract

This study investigated whether extensive management of permanent grasslands promoted greater aboveground (plant) and belowground (fungal) biodiversity. Three grassland management types, i.e. high intensity (INT), low intensity (LI) and extensive (EXT) were sampled in two contrasting agroclimatic regions in Switzerland, the Lowlands and the Alps. The latter two grassland management types are supported through the 'Ecological Compensation Areas' (ECAs) payment scheme. The number of distinct plant species were counted at each site and soil samples were taken, from which fungal operational taxonomic units (OTUs) were constructed. In both regions, EXT had significantly higher plant species and fungal OTU richness ($P<0.01$) compared to INT. Additionally, the correlation between plant and fungal community richness was stronger in the Lowlands ($R=0.59$, $P<0.001$) than in the Alps ($R=0.45$, $P=0.006$). These results underline the success of the ECA payment scheme at protecting above- and belowground biodiversity in Swiss grassland ecosystems.

Keywords: species richness, biodiversity, plants, fungi, permanent grassland

Introduction

Since 1993, Switzerland has implemented a scheme of 'Ecological Compensation Areas' (ECAs) aimed at promoting and protecting biodiversity in agronomic systems. Representing approximately 90,000 hectares, extensive (EXT) grasslands are the dominant ECA type (BLW, 2006). In the Alps, climatic and topographical limitations have restricted the agricultural intensification of grasslands and therefore these sites have largely maintained their compositionally complex plant communities (Peter *et al.,* 2008). There are no such limitations to agricultural intensification in the Lowlands, therefore the biodiversity promotion potential of EXT grasslands may be greater in this region. While their effectiveness at promoting aboveground biodiversity is known (Kampmann *et al.,* 2012), whether EXT grasslands promote belowground biodiversity demands attention. The present study addressed this and investigated their role in promoting both plant and fungal community richness (as well as the structural relationship between these) in the Lowlands and Alps, to see if ECAs are comparably effective in both regions.

Materials and methods

Three different management types were sampled in two agroclimatically contrasting regions in Switzerland, i.e. the Lowlands and the Alps. Management types represented were high intensity (INT) (conventional fertilisation rate, early and frequent utilisations), low intensity (LI, is a Swiss ECA category with strongly reduced fertilisation rate and infrequent utilisations) and EXT (is a Swiss ECA category with no fertilisation and infrequent utilisations). There were 72 plots in total (12 plots per management category in each region), with the sampling area comprising a standardised study unit with four subplots

of 4 m^2 each. The number of different plant species present was determined on each subplot. Plant species richness per plot was calculated as the total number of individual species present between the subplots. Four soil cores were also taken per subplot, and the resultant 16 cores were then combined and homogenized as a representative soil sample of the plot. Soil DNA was extracted from each sample, with the fungal internal transcribed spacer region (ITS2) being PCR amplified and an amplicon-based Illumina Miseq sequence analysis conducted (Frey *et al.*, 2016). The richness of the resultant fungal operational taxonomic units (OTUs, analogous to a fungal species) was then calculated (Jost, 2006). Statistical differences in both richness values between INT and the other management types was determined by analysis of variance. Pearson correlation was used to determine the relationship between plant species richness and fungal OTU richness.

Results and discussion

Compared to INT, there was a highly significant increase in fungal OTU richness in both LI and EXT in the Lowlands (P<0.001, Figure 1A). While there was also a significant increase in fungal OTU richness in EXT in the Alps (P<0.01), there was no significant increase in LI (P>0.05, Figure 1A). Such findings are in agreement with Barreiro *et al.* (2019) who found an increase in the biomass of saprophytic fungi in EXT grasslands in both of these regions (using the same sites used in this study), indicating that such grassland types represent favourable habitats for soil fungi. There was also a highly significant increase in plant species richness in EXT over INT in both the Lowlands and the Alps (P<0.001, Figure 1B). The increase associated with LI was stronger in the Lowlands (t value=5.38, P<0.001) than in the Alps (t value=2.94, P<0.01, Figure 1B).

In both regions, there was a significant correlation between plant species richness and fungal OTU richness, with the effect being stronger in the Lowlands (R=0.59, P<0.001; Figure 2A) than in the Alps (R=0.45, P=0.006; Figure 2B). This correlation would imply a relationship between the above- and belowground biodiversity (De Deyn, Quirk and Bardgett, 2011), highlighting additional advantages of implementing grassland management extensification strategies though ECA schemes. The more pronounced increases in plant and fungal community richness in both LI and EXT in the Lowlands would indicate that the biodiversity promotion potential is greater in this region. This is likely a consequence of the plant community richness of Lowland INT grasslands being so low, even being significantly lower than INT in the Alps (P=0.012, Figure 1B). To encourage increased implementation of EXT grasslands in the Swiss Lowlands, more targeted economic incentives for farmers in this region could be a potential strategy.

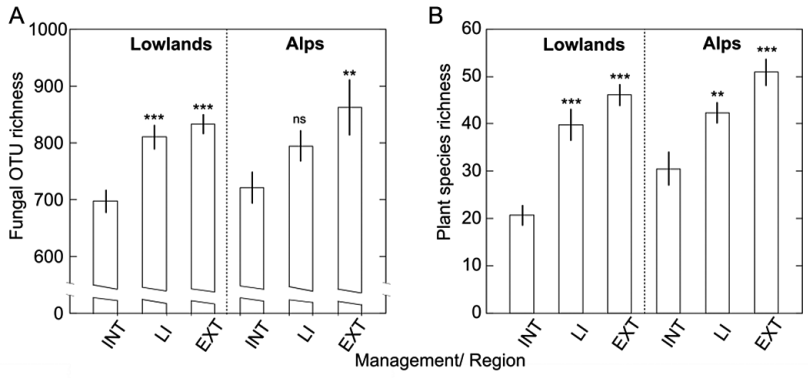

Figure 1. (A) Fungal OTU richness and (B) plant species richness in the three grassland management types; high intensity (INT), low intensity (LI) and extensive (EXT) in the two differing agroclimatic regions in Switzerland (Lowlands and the Alps). Asterisks denote a significant difference to INT. *** P<0.001, ** P<0.01, ns P>0.05.

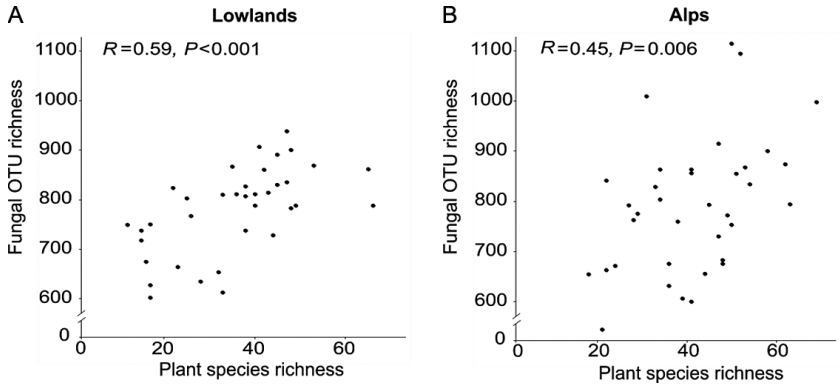

Figure 2. Correlation between fungal operational taxonomic units (OUT) richness and plant species richness in the two agroclimatic regions of Switzerland. (A) Lowlands and (B) Alps. Displayed is the Pearson *R* and its significance.

Conclusions

EXT grasslands supported by the Swiss ECA payment scheme significantly increased both plant and fungal community richness. This study highlights the success of this scheme for protecting above- and belowground biodiversity in Swiss grassland ecosystems. This is particularly apparent in the Swiss Lowlands, where grasslands tend to be more intensively managed.

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