Long-term vegetation degradation in Hungarian rock grassland communities

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Abstract

We demonstrate a possible application of large historical vegetation data sets as reference to detect trends in natural state of the vegetation. Phytosociological relevés re-sampled after 3-6 decades were used to detect and interpret long-term plant compositional changes of seven rock grassland associations in Hungary. Data analyses were designed to minimise the negative effects arising from the application of historical information.
Detrended correspondence analysis shows a uniform displacement of plot averages in the ordination space in six communities. Occurrences of species typical to rock grassland associations decreased significantly. Natural pioneers, disturbance-tolerant and weed species increased in number. Nevertheless, their amount is relatively low and natural constituents of the communities still dominate, therefore the detected changes can be described as a minor degradation.

Introduction

In Europe, large phytosociological data sets were gathered from the early 20th century on (DENGLER et al. 2011). The difficulty in using these data for assessing the change in the natural state is that these were not gathered with the intention to serve as state references (BOTTA-DUKÁT et al. 2007). Their use is often criticised because of inconsistency in sampling methodologies, imprecise localization of the plots (WILLIAMS et al. 2005), differences in species abundance estimates (WILD et al. 2004). These problems can be minimised if the 'corresponding quadrat' concept (PERSSON 1980) is applied.
Rock grassland communities are considered to have a rather stable species composition (TÖRÖK and ZÓLYOMI 1998, RÉDEI et al. 2003) and thus are suitable for testing the sensitivity of the approach (**Figure 1**). Historical phytosociological relevés of seven rock grassland communities of European importance were resampled after 30-60 years in Hungary. The aim of the study was to detect and interpret long-term vascular plant composition changes of rock grassland associations.

Methods

Seven associations of rock grasslands were included in the present analysis representing the diversity of Hungarian rock grasslands on three main substrate types: dolomite, limestone and silicate. **Table 1**. shows details of the phytosociological relevés of Tibor Simon, András Horánszky, Bálint Zólyomi, and Júlia Szujkó-Lacza, recorded between 1931 and 1961 and served as historical references for resampling.

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Figure 1 *(**a**) Species rich stand of Minuartio-Festucetum pseudodalmaticae on the Castle Hill of Füzér, Zempléni Mts. (**b**) Strictly protected* ***Primula auricula*** *in dolomite rock grassland.*

Association	Abbrev.	Time	Mountains	Rock type	Number of plots	Author and reference
Minuartio-Festucetum pseudodalmaticae (/Mikyška 1933/ Klika 1938)	MF	1958-61	Zempléni Mts.	silicate	5	SIMON (1977)
Poetum scabrae (Zólyomi 1936)	PP	1954-60	Börzsöny Mts.	silicate	11	SZUJKÓ-LACZA (1961)
Potentillo-Festucetum pseudodalmaticae (Majovsky 1955)	PF	1953-56	Visegrádi Mts.	silicate	12	Horánszky (TÖRÖK et al. 1994)
Campanulo divergentiformis-Festucetum pallentis (Zólyomi 1958)	CF	1931-32	Bükk Mts.	limestone	9	Zólyomi (TÖRÖK and ZÓLYOMI 1998)
Seslerietum sadlerianae (Soó ex Zólyomi 1936)	SS	1933-35	Budai Mts.	dolomite	5	Zólyomi (TÖRÖK and ZÓLYOMI 1998)
Festuco pallentis-Brometum pannonici (Zólyomi 1958)	FB	1932-41	Budai, Keszthelyi, Bakony and Vértes Mts.	dolomite	14	Zólyomi (TÖRÖK and ZÓLYOMI 1998)
Seselio leucospermi-Festucetum pallentis (Zólyomi /1936/ 1958)	SF	1933-41	Budai, Keszthelyi and Bakony Mts.	dolomite	15	Zólyomi (TÖRÖK and ZÓLYOMI 1998)

Table 1. *Historical phytosociological relevé data: association type, abbreviation, time and place of sampling, substrate type, number of plots, and author of historic samples used in the study.*

Altogether 151 plots at 71 sites have been resampled in the Hungarian Northern- and the Trans-Danubian Mountains between 1990 and 1994 (**Figure 2**). Since no permanent plots were marked during the first sampling period, plots were reinvestigated carefully according to the historical description of locality, aspect, slope, elevation, vegetation period, plot size (either 16 or 25 m^2) and earlier species lists. Re-investigated plot data are unpublished, except for the *Potentillo-Festucetum pseudodalmaticae* (PF) from the Visegrád Mts. (TÖRÖK et al. 1994).

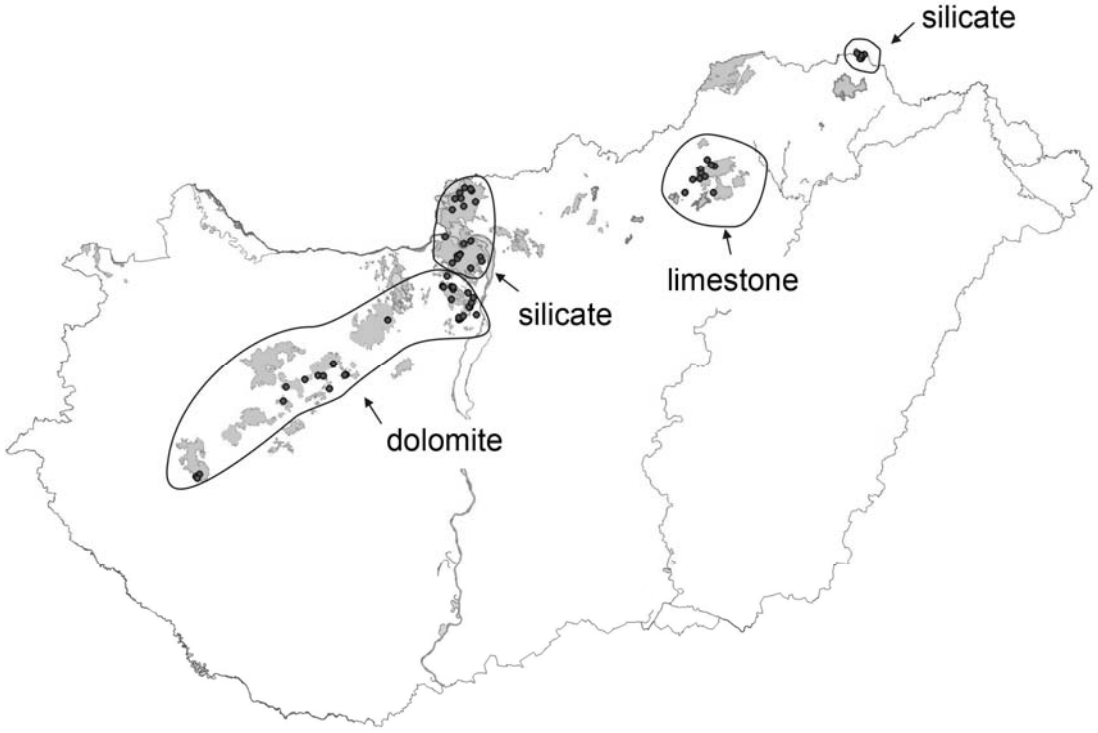

Figure 2. *Map of Hungary with the sampled rock grassland sites (black dots). Natura 2000 sites of the 'Rupicolous pannonic grasslands (Stipo-Festucetalia pallentis)' habitat (code 6190) are indicated by grey polygons.*

During the first sampling period cover estimation underwent a methodological development, therefore only binary data were used for this study. Jaccard similarity index was used as a measure of compositional similarity to compare plots from the two time periods (JACCARD 1912). The most similar plot pairs were selected for each site to avoid the overestimation of changes and used for further analyses (71 plot pairs with altogether 444 species).
General compositional changes were examined by detrended correspondence analysis (DCA) using CANOCO 4.5 (TER BRAAK and ŠMILAUER 2002). The results of vegetation change were interpreted with different species attributes. Ecological indicator values of Borhidi express ecological preferences of plant species for soil reaction (RB), nitrogen (NB) and soil moisture (WB) in ordinal scales, running from 1 to 9 (12 for moisture). They correspond to Ellenberg's respective indicator values (ELLENBERG et al. 1992) adapted to the Hungarian flora. The mean indicator values (calculated as a mean value of those species present in the plot) were used as supplementary variables to estimate changes in site conditions. The significance of changes in absolute frequency of Raunkiaer life form categories (RAUNKIAER 1934) and social behaviour types (SBT) of BORHIDI (1995) was tested by paired t-test. SBT categories were used to estimate the naturalness of communities: competitors (C; dominant perennial species of natural communities), specialists (S; stenotolerant species of low competitiveness) and generalists (G; species of wide ecological tolerance) represent the natural constituents of

communities. Natural pioneers (NP; species of initial stages of succession series) and disturbance tolerants (DT; pioneer elements of secondary succession) indicate natural disturbances, whereas weeds, alien species and ruderal competitors (W) indicate degradation processes. As changes in species attributes were consistent among associations, we present the results averaged across association types.

Results and Discussion

The investigated seven rock grassland associations underwent vascular plant species composition changes according to the uniform displacement of plot averages for six associations along the first axis in the ordination diagram (**Figure 3**). Considering the wide geographical distribution of the plots (maximum distance about 300 km), this change seems to indicate similar trends of vegetation change and can be attributed to general pressures operating at the large scale rather than to diverse local impacts (TÖRÖK and SZITÁR 2010).

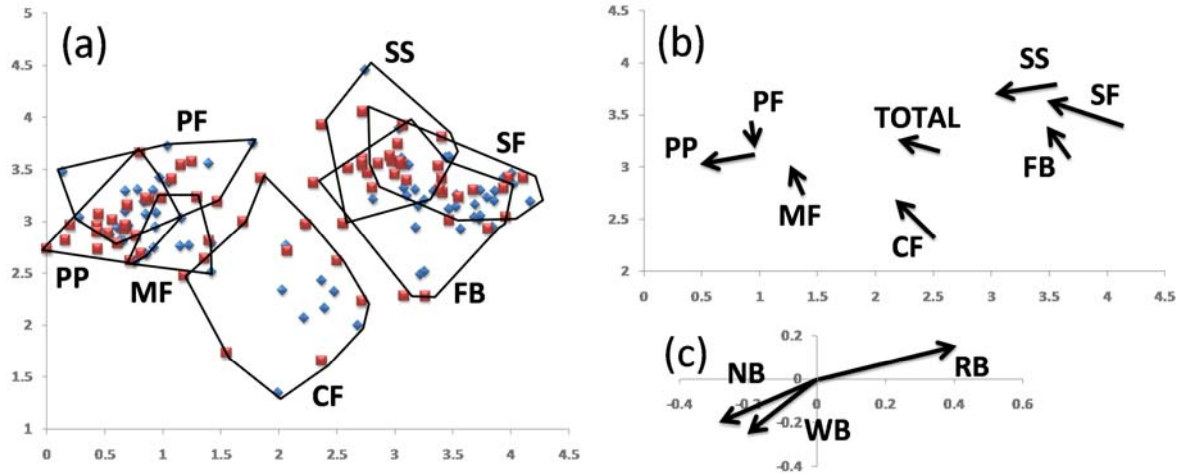

Figure 3. *DCA diagram based on the presence/absence data (total inertia: 15.86; Axis 1 eigenvalue: 0.56, axis length: 4.212, Axis 2 eigenvalue: 0.37, axis length: 4.461). (a) Polygons enclose plots of different community types for both sampling periods. Blue symbols represent historic, red symbols represent recent plots. (b) Arrows illustrates the displacement of the associations in the ordination space between the two time periods based on the average scores of plots on the first and second ordination axes. (c) Arrows represents biplot scores of mean indicator values of Borhidi, as supplementary environmental variables on the first and second DCA axes. Abbreviations see in Table 1 and in the text. Total – total average.*

The first and the second axes are negatively correlated with mean NB (r = -0.49 and -0.60 respectively) and WB indicator values (r = -0.44 and -0.50) and positively correlated with RB values (r = 0.85 and 0.45). The changes of WB indicator values show that the share of species of less extreme dry habitat decreased in time. The shift of mean NB values may suggest that nitrogen deposition occurred in the last 60 years (national average N deposition was 6-10 kg ha^{-1} yr^{-1} in 2000 according to BOZÓ 2004). The effects of dung of overpopulated mouflon herds can be another reason for the changes towards mesotrophic conditions indicated by vegetation changes (CHYTRÝ and DANIHELKA 1993, HOBBS 1996).

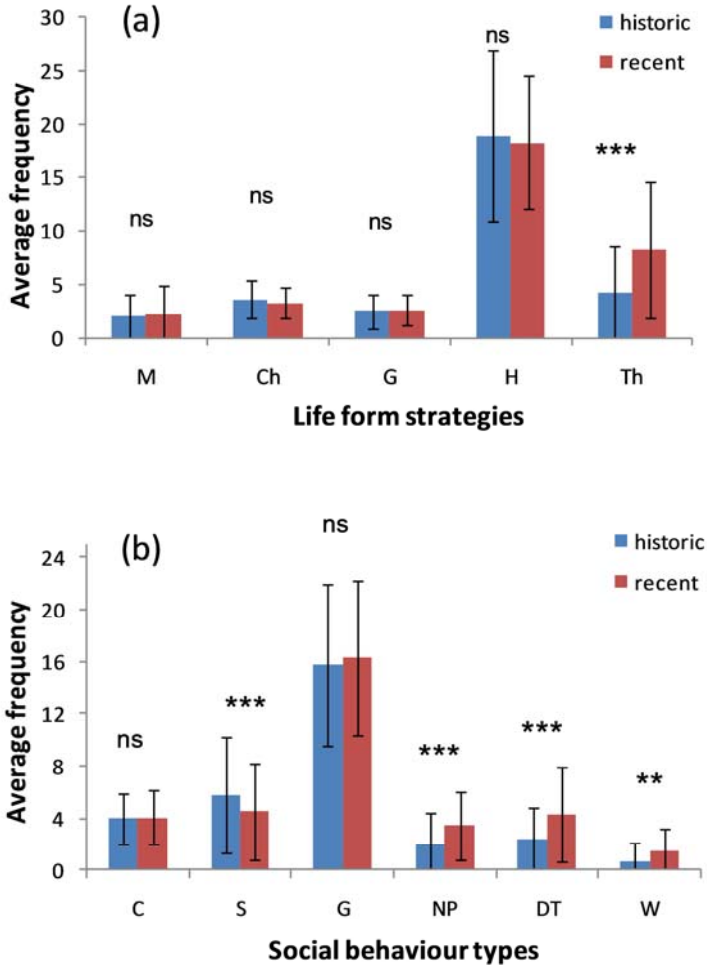

Figure 4. ***(a)*** *Frequency changes in Raunkiaer life forms (+/- SD) between the two sampling periods. Abbreviations: M: trees and shrubs; Ch: dwarf shrubs; G: geophytes; H: hemicryptophytes; Th: annuals and biannuals.*
(b) *Change in the occurrence (+/- SD) of the Social Behaviour Types between 1931-61 and 1991-94. Abbreviations see in the text. Significant differences based on t-tests between historical / recent data are indicated by * ($p<0.05$), ** ($0.001<p<0.05$) and *** ($p<0.001$), ns = non significant.*

The study of life forms revealed the loss of dwarf shrub species and the arrival of annuals (**Figure 4a**), which is considered a sign of degradation in several perennial grassland communities (RUPRECHT and BOTTA-DUKÁT 2000, PODANI et al. 2005). It is assumed that physical soil disturbance and trampling by grazing animals induce the establishment of annuals at temporarily open soil surfaces. A 7.5 fold increase in mouflon stock and a 5 fold increase in red deer and roe deer stocks between 1960 and 2000 according to the National Game Database (CSÁNYI 2001) support this hypothesis. SBT values reflect the different functional role of species in the grassland. The distribution of behaviour types has changed significantly during the last 30-60 years in favour of pioneers, disturbance-tolerants and weeds (**Figure 4b**). Nevertheless, their amount is relatively low and natural constituents of the communities still dominate, therefore the detected changes can be described as a minor degradation.

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