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THE EFFECT OF CURRENT DYNAMICAL STATE OF A LOESS STEPPE COMMUNITY ON ITS RESPONSES TO DISTURBANCES

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Abstract. The impact of site history and current dynamical state of a loess steppe grassland community on its coenological changes caused by different disturbances were studied in permanent plots. Disturbance agents applied were the enclosure by fence and the resumed grazing.

We investigated the coenological responses to grazing and lack of this management of 2 stands of a *Pulsatillo-Festucetum rupicolae* community with different structure, dynamical status and management history. One type of these stands was a species rich, well-organized "intact" stand, usually avoided by sheep. It was considered to be in a dynamically stable state. The other stand was a slightly degraded one, which was more frequented by the animals. This *Festuca pseudovina* type of the *Pulsatillo-Festucetum rupicolae* association had been used as a grazing land for a long time, but the regular grazing was stopped about 10 years before our experiments started.

Our results demonstrated that effects of enclosure were entirely different in a relatively intact semi-natural dense community and in a formerly grazed degraded community. We pointed out the great importance of site management history and current coenological and dynamical states of the community on its responses to fencing.

Drastic coenological changes (significant decrease in species richness, vegetation cover and living phytomass) were detected in a very short time-period (3 years) when sheep were excluded in the formerly regularly grazed stand, while only slight floristic and coenological changes could be measured in the relatively "intact" community even for several years (9 years) after fencing.

Our results of resuming grazing experiment in the degraded stand showed that the species richness, species diversity, average vegetation cover, as well as the living and dead parts of plant biomass were relatively unchanged in the slightly grazed plots. It was concluded that slight grazing management in a traditionally grazed old meadow was necessary for maintaining its floristic composition and coenological state. We emphasized that relative importance of grazing also differred between various types of a grassland community and depended on their current floristic and dynamical states and the past grazing pressures.

Keywords: sheep grazing, fencing, site history, coenological changes, diversity

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Introduction

The significant role of disturbances in forming, maintaining and altering floristic states and dynamics of plant communities is generally accepted. Various hypotheses and ecological theories have been developed to explain how local diversity is produced and maintained by disturbances (Sousa 1984, White and Pickett 1985, Collins 1987, Pickett *et al.* 1989, Chaneton and Facelli 1991). It was documented that the effect of disturbances on species diversity is strongly dependent not only on disturbance regime (type, frequency, intensity, duration of disturbance, site history) but also on the studied temporal and spatial scales (Collins and Glenn 1988, Matus and Tóthmérész 1990, Podani 1982, Wiens *et al.* 1986, Wiens 1989). It became obvious that plant communities show very high variations in their dynamic behaviour and the predictability of floristic changes and community responses after disturbances is often uncertain. Understanding the disturbance-induced community changes and revealing their mechanisms are difficult because of lack of information on past events. Relevance of site history has been emphasized (Drake 1990, Facelli and Pickett 1990) in several contexts, but our kowledge about the role of past history is rather insufficient. Our present work aimed to study the impact of site history and the current dynamical state of a loess steppe grassland community on its coenological changes caused by disturbances: grazing and lack of grazing.

Considerable empirical and theoretical work has been done on the effects of grazing on grassland structure and diversity (reviewed by Looman 1983, Milchunas *et al.* 1988, 1993). Many controlled grazing and enclosure experiments were established for investigating long-term effects of grazing or protection from grazing in different types of grasslands (Klippe and Costello 1960, McNaughton 1979, 1983, Collins and Barber 1985, Hill *et al.* 1992, Noy Meir 1995). These studies suggest that changes in species composition due to grazing were primarily a function of net primary production and the history of grazing of the site. It was also stated that community responses to grazing can be modified by soil and weather conditions (eg. soil moisture, and yearly rainfall). Chaneton and Facelli (1991) and Allen et al. (1995) emphasized the importance of site history, initial species composition and dominance hierarchy of species.

Most of the observations on the effects of grazing on grassland vegetation has accumulated over the last centuries, particularly in North America (reviewed by Ellison 1960, Stoddart *et al.* 1975, Noy Meir *et al.* 1989, Milchunas *et al.* 1988, Laurenroth *et al.* 1994). In parallel, some ecological hypotheses have also been developed that attempt to explain and predict grazing effects.

Majority of the enormous number of publications on this topic, however, is connected with typical grazing lands of long evolutionary grazing history and adaptation. Most of the studied grasslands has been grazed by domestic grazers for more than 5000 years (Noy Meir and Seligman 1979). It is not the same situation in our young loess grassland area. The study site was not covered originally by grasslands. The present vegetation was formed after the deforestation (ca. 400-500 years ago) (Military Survey Map I 1783) and shaped by past grazing disturbances in different degree, but only for some centuries, and without intensive use as a typical pasture neither in the past.

Our present study analyzes the effect of excluding sheep-grazing from a stabilized subclimax slope-steppe community (*Pulsatillo-Festucetum rupicolae*) formed after deforestation. We used enclosure to understand what will happen in the secondary steppe grasslands when sheep will be removed in the future, hereby giving useful information also from practical point of view. It is also important because there is no traditional nature conservation management practice in Hungary for maintaining diversity of this type of loess grasslands. The enclosure experiment may be a step towards understanding the importance of grazing and small localized disturbances in the maintenance of species-richness, compositional state and regeneration capability of a rarely or periodically grazed old loess steppe grassland community and of a formerly regularly grazed one. Furthermore, resuming grazing experiment will help to reveal the role of grazing in sustaining of current coenological states.

The aims of our investigation were:

1) to compare the floristic and coenological changes after grazing has been excluded from 2 stands of slope steppe meadows of different dynamic states and histories (enclosure experiments);

2) to study the effect of experimental sheep grazing on the coenological changes of a slightly degraded stand of *Pulsatillo-Festucetum rupicolae* community (resuming grazing experiment).

Material and method

Study area and field experiments

Our study was carried out on a dry, wind-exposed hill, at the southern foot of the Bükk Mountains (NE-Hungary), at an elevation of about 200-300 m. The subcontinental climate of this gentle hilly country represents an intermediate position between the Great Hungarian Plain and the mountainous region. The annual mean temperature is 9 ^{o}C, the total precipitation is about 600 mm. The soil is brown forest soil of chernozem character, formed on loess (Virágh 1982).

The climatic zonal forest before the deforestation was *Aceri tatarico-Quercetum* reaching far from the Great Hungarian Plain, as proved by relic species (*Quercus pubescens, Acer tataricum, Nepeta pannonica, Phlomis tuberosa* etc.) and remnant forest fragments existing even today. Nowadays different secondary steppe meadows (Virágh and Fekete 1984) and their degraded types due to intensive grazing cover almost the whole area and only small remnants of forest steppe meadow rich in *Festuca rupicola* can be found.

Controlled disturbance experiments were conducted for 10 years to study the secondary succession, as well as the regeneration capability (community resilience) of a loess steppe grassland community (Virágh 1982, 1989a,b). The internal coenodynamics of a grazed slope-steppe meadow was also investigated and the secondary xeroseries, e. g. : degradation stages created by past grazing in a hilly country were characterized (Virágh and Fekete 1984).

A slope-steppe meadow, *Pulsatillo-Festucetum rupicolae* (Máthé and Kovács 1962) was chosen for our detailed studies. This community can be considered as the final stage (subclimax community) in the successional series of grasslands in the given area. Detailed description of this community and the sources of richness of flora are presented in Virágh (1982) and Virágh and Fekete (1984). Two uniform stands of this community were selected for our experiments in order to eliminate the effects of spatial heterogeneity.

The first stand situated on the hill top. In spite of its mild slope it was relatively protected from grazing because the animals were usually driven on from this field. Moreover, probably due to the presence of great number of slightly poisonous *Pulsatilla nigricans*, the stand was mostly avoided by sheep. It was rich in plant species, consisted of 80-100 species. It was considered to be a relatively intact, natural or semi-natural typical stand of the *Pulsatillo-Festucetum rupi-colae* association (Virágh 1989a, b, Virágh 1992a, b).

The second stand, nearer the village, towards the bottom of the slope was slightly degraded one, which was more frequented by the animals. Decrease and disappearance of many codominant and rare species (*Pulsatilla nigricans, Genista tinctoria, Dianthus pontederae, Asperula cynanchica* and *Arenaria graminifolia, Asparagus officinalis, Stipa capillata*) and the increasing abundance of grazing tolerant species (*Hieracium pilosella, Plantago lanceolata, Euphorbia cyparissias*) was characteristic here. Owing to the selective grazing, the abundance of *Festuca rupicola*, a species preferred by animals, also decreased and replaced by the less preferred *Festuca pseudovina*. It can be classified as *Festuca pseudovina* type of the *Pulsatillo-Festucetum rupicolae* association, tainted also with several ruderals. This stand had been used as a "grazing land", but the regular grazing was stopped about 10 years before our experiments started.

The species list of the quadrats selected for our studies is presented in Table 1 with the indication of average cover. The flora of the studied area is rich both in the intact "ungrazed" plots and the slightly degraded ones. The total species number of the intact plots is 73, however, it is much smaller (53) in the degraded plots. It is remarkable that there is a large number of species with low cover and the total cover of the degraded quadrats is resulted mostly by a very few dominant species. Great differences in the species dominance hierarchy between the 2 stands are demonstrated in Table 2. It is indicated that several species are codominant and many species of intermediate importance values occur in the intact quadrats but only 2 grasses are predominant having a 50 % share of the total cover in the slightly degraded (grazed) quadrats.

Experiments

1) Enclosure experiments:

a) The area of 40 × 30 m in the intact, "ungrazed" community (stand A) was fenced in 1979 to study major floristic changes in permanent quadrats over 9 years.

b) Enclosure by fence was also applied in the degraded, formerly intensively grazed stand in the area of 5 × 5 m (stand B) to study the effect of protection from grazing after 3 years.

Extent of the 2 fenced areas was dissimilar, because some other experiments (Virágh 1982, 1992) were also carried out in the stand A, but the comparable data were both originated from the area of 5 m^2 that proved to be representative for the whole stand (Virágh 1992, 1994).

2) Experiment of resuming grazing:

The slightly degraded "grazed" stand (stand B) was experimentally grazed at a low stocking rate (grazed by a flock of four sheep; Gibson 1988, Gibson *et al.* 1987) from 1987. It was continued for 3 years and then the influences on floristic and coenological changes were analysed.

Sampling

The experiments were followed in permanent plots of 1 m^2 with 5 replications per treatments. The detailed investigations were made in 1 × 1 m quadrats covered with a grid of 20 × 20 cm. Presence — absence and percentage cover of each species, visually estimated, were recorded in a set of contagious subquadrats (125 in total per treatments). The values detected at 400 cm^2 were summed or averaged for 1 m^2 and 5 m^2 quadrats in each experiment.

Remarks on the relevant plot sizes

Our previous studies (Virágh 1992, 1994) indicated that:

— Maximum value of the cover-based significant interspecific correlation (ISC) appeared at 400

cm^2 plot size on the study-site (Bartha 1983). The number of species combination was also the highest and the stand proved to be the most heterogeneous at this characteristic area for the most abundant species. The floristic changes at this spatial microscale were indicated very sensitively (Virágh 1994).

— At 1 m^2 plot size summation of the smaller scale dynamics was manifested. Variability among these plots, resulted from the plots differed in species composition and abundance, reflected the local spatial heterogeneity, characteristic for the whole stand of small extent.

— Considering all of the species, the 5 m^2 size of plots contained a portion of the stand large enough to be floristically homogeneous and characteristic for the stand.

Floristic composition was recorded in June from 1979 to 1983 and then in 1987 in the case of experiment 1a. Presence — absence and cover data for each species in the other experiments (1b, 2) were assessed before the treatments and 3 years later, at the end of May in 1987 and 1990.

In the 2 latter experiments (1b, 2) simultaneously with the recordings, samples were taken for production investigations (by monolith sampler of 20 × 20 × 10 cm). The samples were separated into monocots and dicots. Weight measurements of above-ground living plant parts and above-ground dead plant parts were carried out after a drying on 105 ^{o}C.

Methods used

1) Community responses to disturbances were assessed with respect to major floristic changes and some community attributes, mainly based on the cover of every species. These were the following:

a) total cover of vegetation, species richness, species diversity and evenness
b) plant production (living and dead plant biomass).

Species richness is the total number of species for each date of sampling in each experiment. Species diversity was calculated as:

$$H = -\sum p_i \ln p_i$$

(Shannon 1948), where p_i is the relative cover of species "i" . The evenness measure used here is based on this diversity index and is defined as:

$$E = \frac{H}{H_{\max}}$$

where $H_{\max}$ = ln S, S is the species number

2) Dissimilarity indices were used to analyse the effect of treatments on the rate of change. The changes referring to the first sampling date, namely the trend of changes during the investigated period were calculated by Sørensen (1948) and Czekanowski (1909) indices.

Percentage dissimilarity index and principal coordinates ordinations based on Czekanowski index were also applied (Podani 1991) to estimate the degree of floristic change induced by disturbances and to reveal trends in temporal variation of species composition over years.

Results and discussion

Effect of enclosure by fence (excluding sheep grazing)

1a) Floristic and structural changes after fencing in the "intact", ungrazed stand of a semi-natural community for 9 years

In the closed, very dense intact community a large number of species coexisted (Table 1).

Total percentage cover of vegetation (Fig. 2a) showed some significant changes during the 9 years, indicating mainly the effect of climatic differences between years. When the total precipitation of the growing season (Fig. 1) was high above the 50 years average in 1980 and 1981, the vegetation cover was the highest. There was a significant decrease in vegetation cover from 1982 to 1987 in response to the dry summer periods, but the vegetation still remained closed with relatively high cover values (>80 %) 9 years after the fencing in this stand.

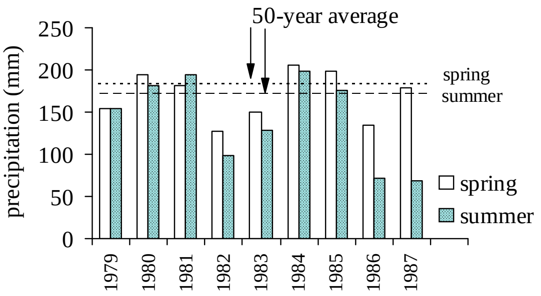
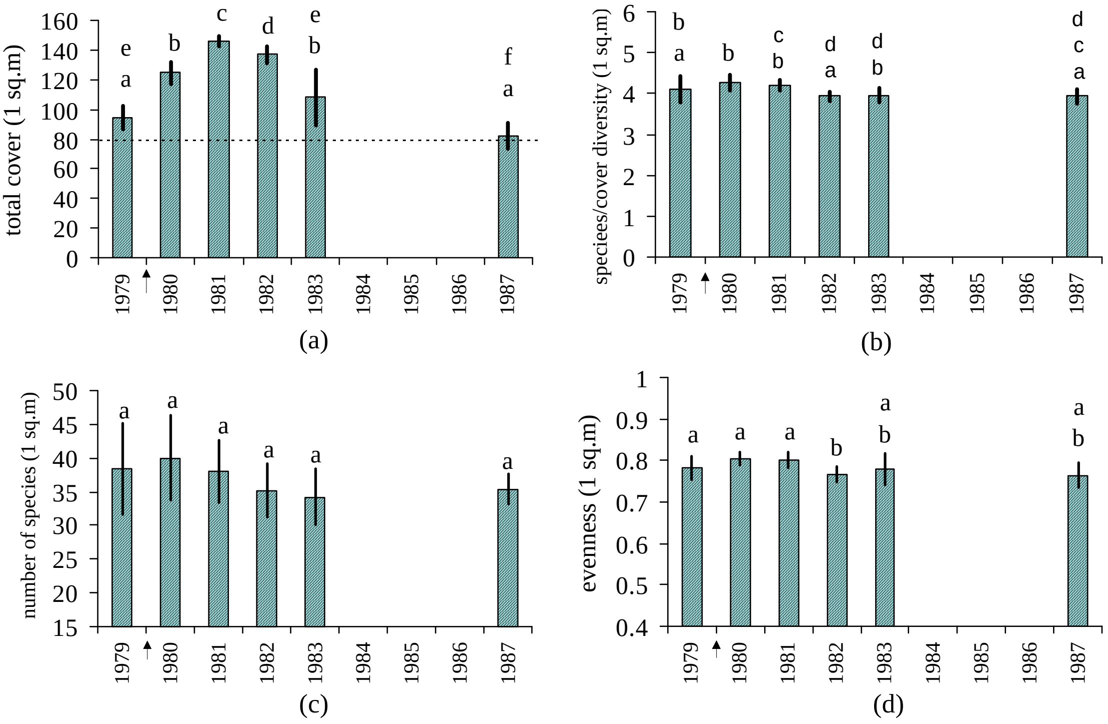


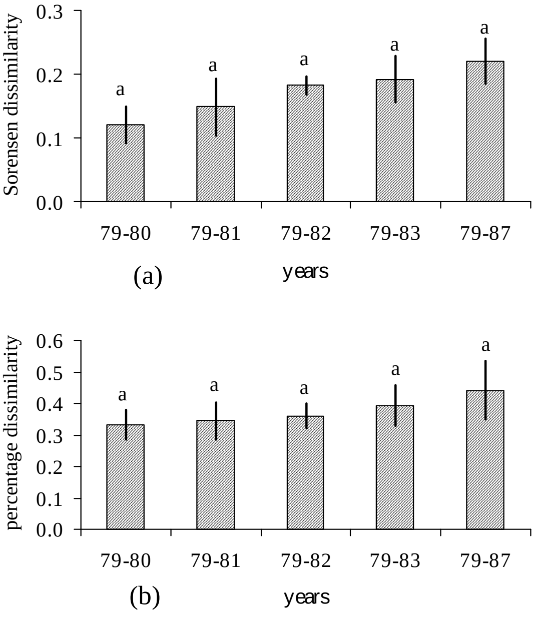
Fig. 1. Spring and summer precipitation from 1979 to 1987.

Species diversity (H) (Fig. 2b), species richness (S) (Fig. 2c) and evenness (E) (Fig. 2d) were very similar during the investigated period. Changes of species richness were insignificant from 1979 to 1987, indicating that this community was able to preserve its species number for several years. Species diversity and evenness values changed within a



(a) (b) (c) (d)

Fig. 2. Changes of total cover (a), species diversity(b), number of species (c) and evenness (d) in the intact stand over 9 years. (Arrow indicates date of fencing. Data marked with the same letters had no significant differences (t-test, p<0. 05))



(a) (b)

Fig. 3. Trends of floristic change (a) and cover-based change (b) in the intact stand over 9 years. (Non-significant differences marked in the same way as in Fig. 2).

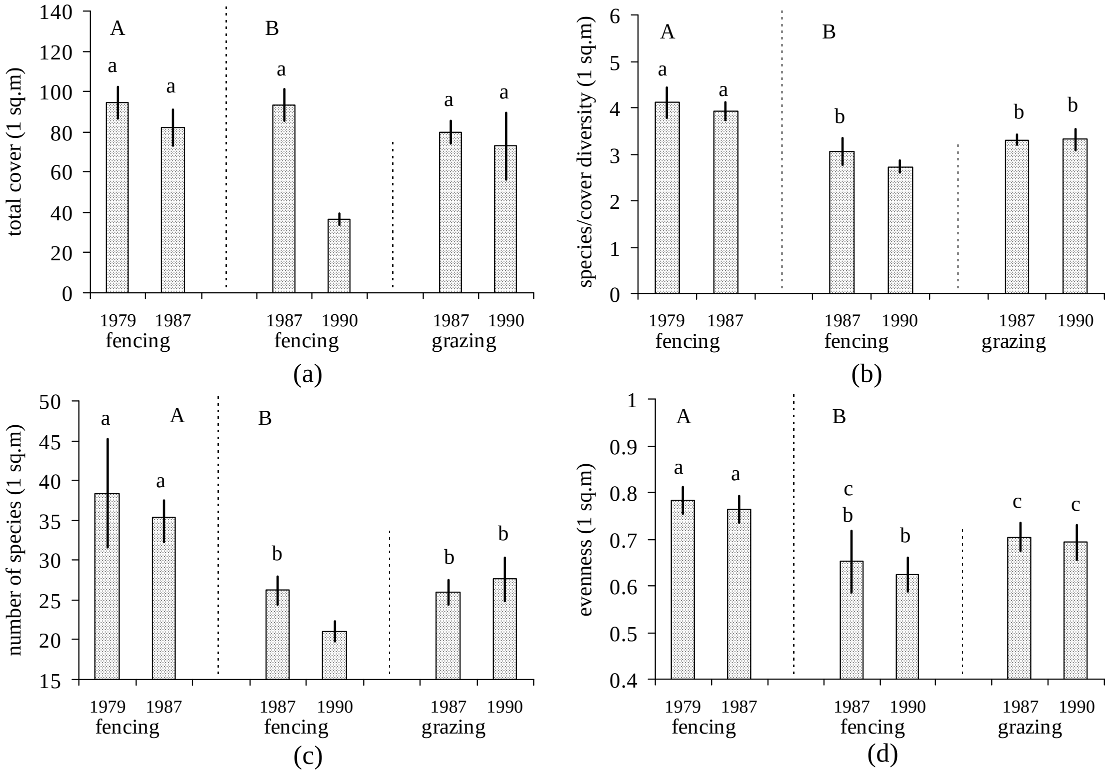
relatively narrow range from 3.9 to 4.3 and 0.76 to 0.80, respectively. The lowest values of these community attributes were measured in the dry years. According to the climatic differences between years the t-test showed some significant differences between the average diversity and evenness values, however these statistically significant changes could be considered rather "fluctuation" than ecologically significant changes referring to the whole period, because in 1987 both the diversity and eveness values were almost the same as 9 years before, in 1979.

The results of dissimilarity analyses (Figs 3a and b) demostrated the differences in the temporal variation of floristic composition. Sørensen dissimilarity values referring to the first year changed between 12-22 %. Because of the high species number and many rare species these dissimilarities could be considered relatively low. The Czekanowski dissimilarities based on species cover always showed higher dissimilatities than the Sørensen values. During the 9 years the changes were between 33-44%. Both dissimilarity indices increased by about 10 % probably induced by the variation in weather, but significant changes could not be detected among the average values of the dissimilarity indices over the study-period.

Table 1. Species list of the intact stand (A) and the slightly degraded stand (B) before the treatments. Nomenclature follows Soó (1980). Average cover of each species was calculated for 1 m^2 quadrats.

Name of species	Average cover %		Name of species	Average cover %	
	stand A	stand B		stand A	stand B
Gramineae					
			Hieracium bauhinii	2.12 ± 0.32	0.39 ± 0.19
Agrostis canina	10.85 ± 0.99	13.96 ± 2.10	*Hieracium pilosella*	2.74 ± 0.71	0.52 ± 0.12
Anthoxanthum odoratum	3.56 ± 0.33	4.18 ± 0.77	*Hypericum perforatum*	0.92 ± 0.16	-
Bothriochloa ischaemum	8.18 ± 1.05	-	*Inula britannica*	0.20 ± 0.11	< 0.10
Briza media	0.20 ± 0.11	-	*Leontodon hispidus*	13.18 ± 1.49	4.52 ± 0.87
Bromus mollis	< 0.10	-	*Linum catharticum*	-	< 0.10
Chrysopogon gryllus	< 0.10	< 0.10	*Lotus corniculatus*	-	1.46 ± 0.36
Danthonia alpina	2.93 ± 0.78	3.05 ± 0.94	*Myosotis stricta*	< 0.10	-
Danthonia decumbens	0.85 ± 0.24	-	*Ononis spinosa*	-	0.17 ± 0.05
Festuca rupicola et	23.13 ± 2.01	21.92 ± 1.94	*Orchis morio*	< 0.10	< 0.10
Festuca pseudovina			*Pimpinella saxifraga*	0.70 ± 0.19	0.55 ± 0.15
Koeleria cristata	0.48 ± 0.17	0.86 ± 0.16	*Plantago lanceolata*	1.04 ± 0.18	1.15 ± 0.34
Stipa capillata	< 0.10	< 0.10	*Plantago media*	0.76 ± 0.25	0.21 ± 0.11
			Polygala comosa	0.25 ± 0.08	< 0.10
Other Monocotyledons			*Potentilla arenaria*	3.24 ± 0.40	< 0.10
			Potentilla argentea	0.33 ± 0.14	-
Anthericum ramosum	0.16 ± 0.03	-	*Pulsatilla nigricans*	1.84 ± 0.46	< 0.10
Asparagus officinalis	0.40 ± 0.01	-	*Prunella laciniata*	< 0.10	< 0.10
Carex caryophyllea	8.95 ± 1.07	1.86 ± 0.27	*Prunus spinosa*	< 0.10	-
Luzula campestris	7.92 ± 0.51	1.47 ± 0.43	*Ranunculus repens*	-	< 0.10
			Rumex acetosella	0.57 ± 0.14	< 0.10
Dicotyledons			*Rumex thyrsiflorus*	0.23 ± 0.13	-
			Salvia pratensis	< 0.10	< 0.10
Achillea collina	6.64 ± 0.35	2.88 ± 0.47	*Saxifraga bulbifera*	< 0.10	< 0.10
Ajuga genevensis	0.16 ± 0.01	< 0.10	*Scabiosa ochroleuca*	1.09 ± 0.27	0.126 ± 0.05
Arenaria graminifolia	< 0.10	-	*Senecio jacobaea*	< 0.10	-
Arenaria serpyllifolia	< 0.10	< 0.10	*Seseli annuum*	2.56 ± 0.30	2.58 ± 0.44
Asperula cynanchica	1.41 ± 0.25	< 0.10	*Silene otites*	0.25 ± 0.10	< 0.10
Campanula rotundifolia	< 0.10	-	*Stellaria graminea*	< 0.10	-
Carlina vulgaris	1.91 ± 0.34	< 0.10	*Taraxacum officinalis*	0.39 ± 0.15	-
Centaurea pannonica	0.27 ± 0.17	0.53 ± 0.33	*Teucrium chamaedrys*	0.58 ± 0.31	-
Centaurium erythraea	< 0.10	-	*Thesium ramosum*	0.20 ± 0.07	-
Cerastium brachypetalum	< 0.10	< 0.10	*Thlaspi jankae*	< 0.10	-
Crataegus monogyna	< 0.10	< 0.10	*Thymus marschallianus*	12.11 ± 1.06	3.51 ± 0.44
Dianthus pontederae	2.16 ± 0.32	-	*Trifolium alpestre*	0.57 ± 0.21	-
Dorycnium herbaceum	< 0.10	-	*Trifolium campestre*	0.11 ± 0.01	0.40 ± 0.01
Echium vulgare	< 0.10	-	*Trifolium montanum*	< 0.10	< 0.10
Eryngium campestre	1.21 ± 0.55	< 0.10	*Trifolium repens*	-	< 0.10
Euphorbia cyparissias	2.40 ± 0.27	0.36 ± 0.07	*Verbascum phoeniceum*	1.44 ± 0.35	-
Euphrasia tatarica	0.79 ± 0.10	0.11 ± 0.02	*Veronica prostrata*	-	< 0.10
Filipendula vulgaris	2.33 ± 0.77	1.93 ± 0.25	*Veronica spicata*	1.09 ± 0.21	0.96 ± 0.19
Fragaria viridis	1.15 ± 0.23	0.33 ± 0.14	*Vicia cracca*	-	< 0.10
Galium verum	< 0.10	< 0.10	*Viola arenaria*	5.60 ± 0.17	0.13 ± 0.03
Genista tinctoria	2.88 ± 0.39	-	*Viscaria vulgaris*	3.79 ± 0.82	-

Our results suggested that the most important influential factor in the intact grassland community dynamics may be the climatic-year heterogeneity (cf. Virágh 1986, 1987). Vegetation cover changed as a result of year to year changes in species abundances also influenced by climatic differences between years. Fencing did not change significantly species richness, diversity and evenness, as well as the degree of floristic composition changes within 9 years. All community attributes except the total cover of vegetation and dissimilarity indices changed within a narrow range during the study period, showing the intact community in a dynamically stable state. In spite of the protection of the stand from the large animal disturbances, as well as the great annual climatic changes and fluctuation in species abundances (Virágh 1989a, b), the community was able to maintain its floristic composition. It was also found that



(a) (b) (c) (d)

Fig. 4. Effect of treatments on the total cover changes (a), changes of species diversity (b), number of species (c) and species evenness (d) in the intact stand (A) and the slightly degraded stand (B), (non-significant differences marked in the same way as in Fig. 2).

the relative importance of most of the species remained fairly constant and a relatively fixed abundance-dominance hierarchy of the species was revealed for 9 years, as had already been discussed in Virágh (1989a).

1b) Floristic and structural changes in the slightly degraded stand after fencing over 3 years

The enclosure experiment in the degraded stand led to significant decreases in the average vegetation cover (<40%) (Fig. 4a), indicating that the stand seriously opened up. Monocots accounted for 71% of the total cover in 1990 which proportion was 15% higher than in 1987. This considerable increase of proportion between monocots and dicots after excluding grazing was not surprising because sheep prefer graminoids over other types of forage. The significant cover decrease was probably also due to a build-up in dead biomass, which was 4.5 times higher as compared to the living biomass.

Fencing did not change evenness but it significantly reduced species richness and diversity during 3 years (Fig. 4). One of the most significant changes in the formerly grazed stand after the enclosure was the considerable decrease of species number (Fig. 4c), primarily as a result of disappearence of many subordinate dicots *(Asperula cynanchica, Linum catharticum, Pimpinella saxifraga, Polygala comosa*) and more increasing dominance (predominance) of *Festuca pseudovina et rupicola*.

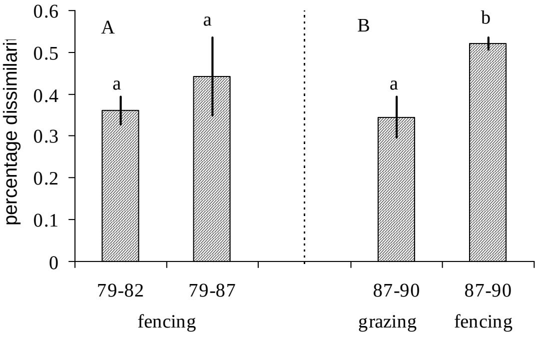


Fig. 5. Coenological changes induced by the treatments in the intact stand (A) and the slightly degraded stand (B) over 3 years (see Fig. 2 for explanation of symbols).

Drastic coenological changes (Fig. 5) within a 3-year period were also detected by the percentage dissimilarity index which showed the degree of community changes with a rather high dissimilarity value (>50%).

Our results indicated that fencing differentially affected species composition and community structure in the dynamically stable intact stand and in the degraded, formerly regularly grazed stand.

Table 2. Dominance hierarchy of the species in the intact stand (A) and the slightly degraded stand (B) before the treatments.

A	**Name of species**	**Rel. dom. %**	**Cum. rel. dom. %**
1	*Festuca rupicola*	15.82	15.82
2	*Leontodon hispidus*	9.01	24.84
3	*Thymus marschallianus*	8.28	33.12
4	*Agrostis canina*	7.42	40.55
5	*Carex caryophyllea*	6.12	46.67
6	*Bothriochloa ischaemum*	5.59	52.27
7	*Luzula campestris*	5.41	57.69
8	*Achillea collina*	4.54	62.23
9	*Viscaria vulgaris*	2.59	64.82
10	*Anthoxanthum odoratum*	2.43	67.26
11	*Filipendula vulgaris*	2.27	69.53
12	*Potentilla arenaria*	2.22	71.75
13	*Danthonia alpina*	2.00	73.76
14	*Genista tinctoria*	1.97	75.74
15	*Hieracium pilosella*	1.87	77.61
16	*Seseli annuum*	1.75	79.37
17	*Euphorbia cyparissias*	1.64	81.02
18	*Eryngium campestre*	1.51	82.53
19	*Dianthus pontederae*	1.47	84.01
20	*Hieracium bauhinii*	1.45	85.47
21	*Carlina vulgaris*	1.30	86.77
22	*Pulsatilla nigricans*	1.25	88.03
23	*Verbascum phoeniceum*	0.99	89.02
24	*Asperula cynanchica*	0.96	89.99
25	*Fragaria viridis*	0.78	90.78
26	*Scabiosa ochroleuca*	0.74	91.53
27	*Plantago lanceolata*	0.71	92.24
28	*Veronica spicata*	0.65	92.89
29	*Hypericum perforatum*	0.63	93.50

B	**Name of species**	**Rel. dom. %**	**Cum. rel. dom. %**
1	*Festuca rupicola*	31.06	31.06
2	*Agrostis canina*	19.79	50.86
3	*Leontodon hispidus*	6.38	57.25
4	*Anthoxanthum odoratum*	5.92	63.17
5	*Thymus marschallianus*	4.97	68.15
6	*Danthonia alpina*	4.32	72.47
7	*Achillea collina*	4.08	76.55
8	*Seseli annuum*	3.66	80.22
9	*Filipendula vulgaris*	2.73	82.95
10	*Carex caryophyllea*	2.64	85.60
11	*Luzula campestris*	2.08	87.69
12	*Lotus corniculatus*	2.06	89.75
13	*Plantago lanceolata*	1.63	91.38
14	*Veronica spicata*	1.36	92.74
15	*Koeleria cristata*	1.23	93.97

Fencing had significant effects on species diversity and species richness only in the degraded stand, while the intact dense stand kept its composition practically unchanged for 9 years. Proportion of monocots, accounting for 40-50 % of the total cover, remained about the same in the intact stand over 9 years (Virágh, 1989a), but the proportion of monocots and dominance structure in the degraded stand had considerably changed (from 56% to 71%) in a very short time period (3 years). The degree of coenological changes had already been rather high over 3 years (50%) when sheep were excluded in the degraded stand while in the intact stand it was not so high after 9 years, either.

The effect of protection from large animals on the vegetation cover changes was entirely different on the 2 stands. However, our evaluation in this comparision could be only limited, because we had no data for both stands during the same years, so the year to year climatic variability might be considerably masked our differences obtained on the 2 stands.

Effect of resuming grazing at low stocking rate on the floristic and structural changes over 3 years

Resuming grazing experiment demonstrated that the species richness, species diversity and evenness, as well as the average vegetation cover were unchanged in the moderately grazed plots during the investigated 3 years (Fig. 4). Proportion of monocots of the total vegetation cover was also similar (64-65%) from 1987 to 1990. Percentage dissimilarity value, which expressed the degree of coenological changes over 3 years, was almost the same as in the case of the intact, hardly grazed stand (Fig. 5).

Moderately grazed and ungrazed-fenced plots in the degraded stand were compared to determine the effect of grazing and protection from grazing on floristic state and biomass production, as well.

The ordination based on cover data (Fig. 6) showed great compositional similarities among the initial pre-disturbed states (1987). Separation of the fenced plots in 1990 from both the initial states and the moderately grazed states after 3 years was also well-demostrated, indicating larger floristic changes caused by exclusion of grazing than grazing.

The results, that species richness and diversity remained very similar in grazed plots for 3 years but these attributes decreased in the fenced plots, were also obtained by Belsky (1992) in Mediterranean grasslands. Singh and Misra (1969) also reported a decline in species diversity in exclosures for an alluvial grassland and McNaughton (1979, 1983) and Belsky (1986, 1992) for several Serengeti communities. However, many reverse situation had also been observed (Noy-Meir *et al.* 1989, Allen *et al.* 1995) in various grasslands. We suggest that these results are strongly dependent on the current dynamical state of community, its species composition, as well as the climatic condition and intensity and duration of former grazing impact (site manangement history).

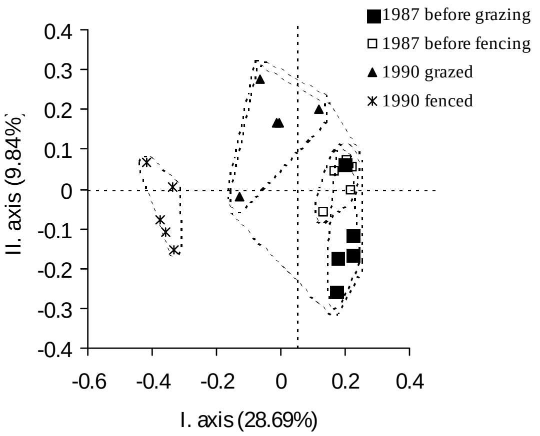


Fig. 6. Principal coordinates ordination (based on Czekanowski index) of 1 m^2 sampling plots in the degraded stand.

It is surprising that in our grazing experiment the total vegetation cover (Fig. 4a) was unchanged in grazed quadrats within 3 years but during the same time significant changes were induced by fencing in ungrazed quadrats. Belsky (1992) experienced that 1 year after the enclosure the total live cover was higher in ungrazed than in grazed plots, however over the next 4 years live cover declined in the ungrazed plots.

It is likely that in our case the greater accumulation of litter on fenced plots compared to grazed ones (Fig. 7) can be responsible for this difference. Litter in the fenced plots was 4. 5 times higher than the living biomass while this ratio was only 2 in the grazed plots. Greater accumulation of litter on ungrazed sites compared to grazed ones is commonly reported for several grassland types (Belsky 1992, Kelly and Walker 1976, Knapp and Seastedt 1986, Cid *et al.* 1991). Three years after our treatments drastic changes in the biomass fractions was well-detected. We suggest that the great number of litter fraction could inhibit the normal regeneration grassland dynamics and the process of establishment of new species. It may also be the reason for the great decrease of species number due to lack of grazing, too.

In the comparison of 3 treatments (Fig. 8) the relative importance of site effects was well-demostrated. The ordination revealed the similarity relationships among the treatments and showed the impact of fencing and grazing in the intact, hardly grazed and the slightly degraded stands. The result presented that the most influential factor was the difference between the 2 sites. Separation of the intact quadrats from the degraded ones was rather strong on the principal coordinates axis 1 accounting for 36 % of the total variance, while compared to this, the effect of treatments was only slight.

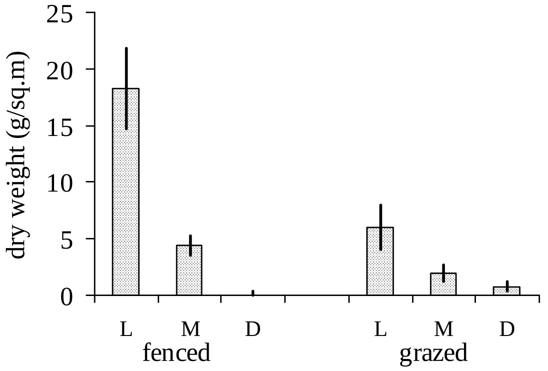


Fig. 7. Biomass fractions in the slightly degraded stand in the 3rd year of the treatments (L: litter; M: monocots; D: dicots).

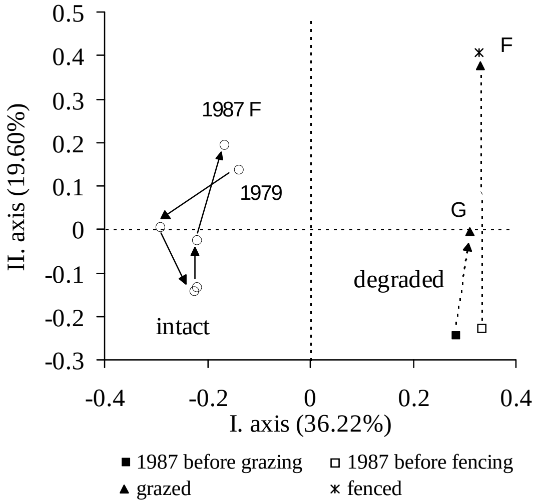


Fig. 8. Effect of treatments in the intact and degraded stands. Principal coordinates ordination (based on Czekanowski index) of 5 m^2 sampling plots.

Concluding remarks

Our investigations demostrated the differences in the coenological changes of a formerly grazed and an ungrazed community after fencing, and the differences inside of enclosure and in the area subjected to resuming slight grazing. Great importance of site management history was emphasized in the community responses to disturbances.

The effect of enclosure was entirely different in a relatively intact, semi-natural community and in a formerly often grazed degraded community. Significant coenological changes were only found in the degraded stand, where drastic changes took place already within a very short time period (3 years). Considerable decrease in species richness, diversity and vegetation cover was observed here. Protection led to the predominance of a few species and a very high litter fraction of biomass. On the contrary, the intact dense community kept its floristic composition and coenological structure practically unchanged for several years (9 years).

In the degraded community resuming grazing promoted maintenance of species richness, diversity, vegetation cover and living and dead parts of plant biomass on similar level.

The results of present study also suggested that in order to preserve the current compositional state of the regularly grazed communities slight grazing has to be used. Relative importance of grazing strongly differed between the various types of a grassland community and depended on their current compositional and dynamic state and the past grazing pressure. It was apparent that slight grazing management is necessary for maintaining the coenological state of the formerly grazed community. However, high species diversity and coenological structure of the relatively intact, formerly hardly grazed community can only be reserved by exclusion of regular sheep grazing in our study site. Strong protection by fencing is not proposed, because small natural animal activities are probably needed for persistence of plant species and normal grassland dynamics for a long time period.

This work focussed on the community changes after disturbances with only emphasis on some aspects of compositional changes without studies on particular population. It is a preliminary experiment because of the limitation of few years of exclosure and grazing treatments. Long term study of the impact of slight grazing and lack of grazing management (fencing) on the loess grassland area is needed. Our results can be useful for nature conservation practice which has to aim at both preserving the ancient loess steppe fragments and sustaining existing floristic diversity and maintaining all successional stages influenced by very variable past grazing intensity on the study area.

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