# VEGETATION DYNAMICS OF ABANDONED CALCAREOUS GRASSLANDS ON RIVER TERRACE SLOPES WITH DIFFERENT ASPECT


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## INTRODUCTION

The rate of plant species diversity decrease in semi-natural grasslands after abandonment is very variable. For example, studies of calcareous grasslands in western Europe have shown that 40 to 70 % of plant species disappeared during 10 year abandonment (Willems 1990; 2001), but there was no significant decrease in species richness after 5-10 year abandonment of grasslands in Sweden (Öckinger et al. 2006). Such a great difference is due to a huge number of factors influencing the course of succession. Important factors are management history, edaphic and topographic variables, as well as disturbances, fragmentation etc. (e.g. Ellenberg 1996; Löbel et al. 2006; Enyedi et al. 2008).

Calcareous grasslands are diminishing continuously in Latvia mainly because of land abandonment. However, there is no date about the rate of plant species diversity decrease, but central and western Europe experience is not applicable to Latvian situation in most cases because fragmentation and the impact of intensive agriculture is not so pronounced in Latvia (Rusina 2007).

The aim of the present research was to assess how rapid is the vegetation change and decrease of plant species diversity over seven year period in two calcareous grasslands (dry and mesic) abandoned for nearly 20 years, and to evaluate the impact of topographic and edaphic factors on the rate of changes.

## METHODS

Investigations were carried out in two calcareous grasslands (referred in text as Drubazas and Priednieki, respectively) located in the Abava River valley – the most spectacular calcareous grassland territory in Latvia. Both sites differed in position in relief – Priednieki site was located on the north-east facing slope, but Drubazas site – on the south-west facing slope (Fig.1), but the vegetation history was the same – grasslands were mowed and grazed for decades and abandoned about 20 years ago with occasional management (grazing in Priednieki and cutting of pines in Drubazas) for two years in late 1990ies.

Vascular plant species and their cover in percentage were recorded each year in July and August from 2001 to 2007 in permanent plots (size of a plot was 1m$^2$) established along transects (parallel to the river) located on the terrace slopes (Fig.1). Both sites included grassland patches with typical structure and species composition and patches overgrown by expansive grasses and tall herbs (Fig.1,2,3, Table 2). In total, 20 plots were monitored in Priednieki (10 plots in the most diverse part of the grassland in the *Carex flacca-Helictotrichon pratense* community (*CfHp*), 6 plots in a part overgrowing by *Aegopodium podagraria (Aegpod*), and 4 plots in a transition from *CfHp* to *Aegpod* community *(Tc)*. 15 plots were monitored in Drubazas (10 plots in the most diverse part of the grassland in the *Filipendula vulgaris-Helictotrichon pratense* (*FvHp*) community, and 5 plots in a part overgrown by *Calamagrostis epigeios* (*Calepi*) (Fig.2,3).

Soil samples were taken in 2006. One upper soil layer sample was taken in each community.

## RESULTS

Unexpectedly, no one community experienced decrease neither in total species number recorded per community nor in average species number per plot. Vascular plant species richness changed significantly over the research period only in Drubazas site (SW slope) – species number increased in seven years by 4 species per plot in *Calepi* com. and by 3 species in *FvHp* com. (Table 1, Fig.4). The decrease in species diversity (Shannon index) was significant in *Aegpod* community in Priednieki site (Table 1).

Only some species experienced significant changes in abundance. The major increase in abundance was observed for *Aegopodium podagraria* and *Chaerophyllum aromaticum*, but the major decrease in abundance experienced *Briza media, Ononis arvensis*, and *Prunella vulgaris*. In total, there were more species with increasing than with decreasing abundance (Table 3).

DCA ordination of data collected in 2001 and 2007 revealed that vegetation has changed differently in different communities (Ellenberg indicator values were used to explain environmental gradients). In Drubazas, the *Calepi* plots have moved slightly along axis 1 (nutrient, light and species diversity gradient), but *FvHp* plots have moved along axis 2 (year and species diversity gradient). In Priednieki site *Aegpod* and *Tc* plots have moved along axis 1 (increase of moisture and nutrients and decrease of species diversity), and *CfHp* plots have moved along axis 2 (in direction of decrease in moisture and increase of soil reaction) and 3 (year, increase of litter and decrease of herb layer) Table 5, Fig.7).

Soil physical properties were quite similar for all communities except of *CfHp* community where the proportion of sand was higher (Fig.5,6). Soil chemical properties are shown in Table 4.

## DISCUSSION AND CONCLUSIONS

Calcareous grassland vegetation succession after abandonment in the Abava River valley was slower than reported in many cases in central and western Europe. Even after nearly 20 year abandonment large parts of grasslands still possessed typical species composition and diversity, and during the last seven years increase of aggressive grasses and herbs were observed only in mesic but not in dry grassland.

Grassland on the south-west facing slope was more stable (species number even increased) than NE-facing slope grassland, where encroachment of *Aegopodium podagraria* and *Chaerophyllum aromaticum* in *CfHp* and especially in *Tc* community was obvious (*CfHp* and *Tc* vegetation gradually turns into *Aegpod* vegetation). Although significant decrease in species diversity was not observed it will take place in future on the north-east facing slope grassland.

Topographic and edaphic factors are of main importance to explain differences in vegetation dynamics in both sites. Grassland on the north-east facing slope had soils richer in nutrients and moister promoting the expansion of nitrophilous herbs. Extreme dryness of the south-west facing slope grassland hindered biomass production and nutrient enrichment of soils in the course of overgrowing.

It is reported that species diversity decreases continuously in abandoned grasslands (e.g. Willems 2001; Luoto et al. 2003; Baur et al. 2006). The current research showed that dry calcareous grasslands can be resistant to deterioration for a long period of time. Several explanations for increase in species diversity on SW-slope grassland for seven years could be put forward:

- research started only 13 years after abandonment, so the main decrease in species numbers could happen before monitoring was launched (unfortunately, the average number of plant species per 1 m$^2$ is not known for these communities in Latvia, there are in average 32 species per 9m$^2$ in managed *FvHp* grasslands (Rusina 2007);
- occasional disturbances are very important to keep dry grassland plant communities in dynamic equilibrium: drought periods were natural disturbance and tree cutting and occasional mowing in winter were anthropogenic disturbance in Drubazas site;
- differences in soil properties could explain the fact that there was a slight increase in species number in *Calepi* community and the increase of aggressive grass species (*Calamagrostis epigeios* and *Brachypodium pinnatum*) was not observed in *FvHp* community. Both species are reported as very aggressively encroaching in grasslands shortly after abandonment (Bobbink, Willems, 1987; Rebele, Lehmann 2001; Somodi et al. 2008). The invasion process could be hindered because *FvHp* community had sick layer of partly weathered dolomites (Fig.6.) and was located higher on the slope promoting more rapid drying out than the soil of *Calepi* community.

### Literature


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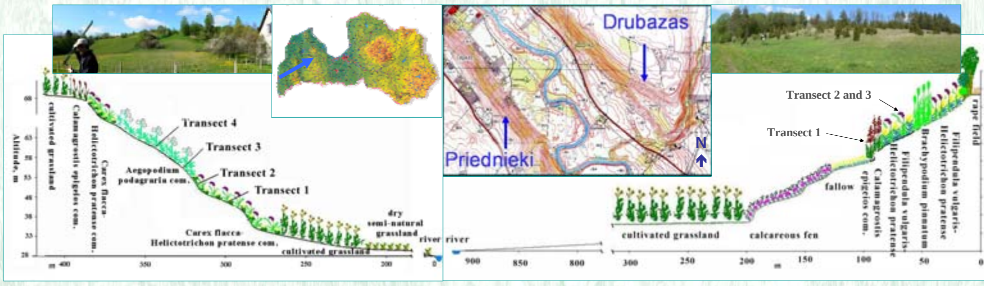


Fig. 1. Location of the transects in a relief profile

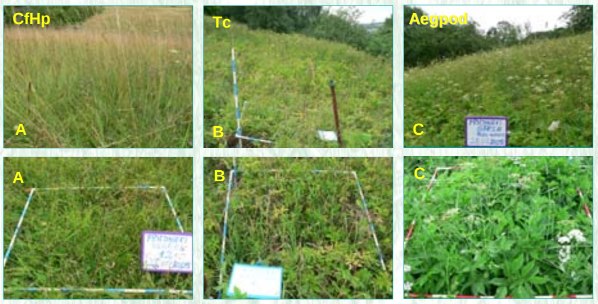


Fig. 2. *Carex flacca-Helictotrichon pratense* com.: *CfHp* (A), transitional community: *Tc* (B), and *Aegopodium podagraria* com.: *Aegpod* (C).

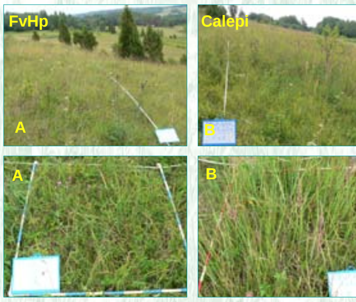


Fig. 3. *Filipendula vulgaris-Helictotrichon pratense* com.: *FvHp* (A) and *Calamagrostis epigeios* com.: *Calepi* (B).

Table 1. Correlation coefficients for seven year observations for species diversity parameters (* p = 0.05; ** p = 0.01).

| Parameter | Priednieki | | | Drubazas | |
|---|---|---|---|---|---|
| | CfHp (n = 10) | Tc (n = 4) | Aegpod (n = 6) | Calepi (n=5) | FvHp (n=10) |
| Year / total species number per year | 0.87* | 0.30 | 0.03 | 0.94* | 0.64 |
| Year / species number per plot | 0.64 | 0.29 | -0.12 | 0.99** | 0.79* |
| Year / Evenness | -0.53 | -0.79* | -0.95** | 0.83* | 0.60 |
| Year / Shannon-Wiener index | -0.16 | -0.65 | -0.90** | 0.90** | 0.64 |

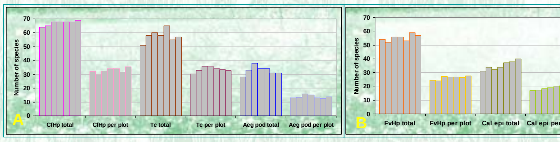


Fig.4. Changes in species richness from 2001 to 2007 in Priednieki (A) and Drubazas (B).

Table 2. Vegetation table (reduced) with TWINSPAN divisions (2001)

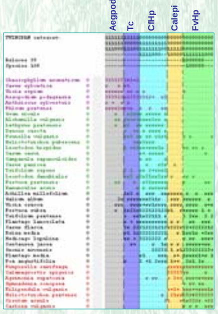


Table 4. Soil chemical properties

| Parameter | Priednieki | | Drubazas | |
|---|---|---|---|---|
| | CfHp | Aegpod | FvHp | Calepi |
| $pH_{KCl}$ (0-10 cm) | 7.1 | 7.1 | 6.9 | 7.1 |
| $pH_{KCl}$ (50 cm) | 7.6 | 7.5 | 7.5 | 6.9 |
| Exch.bases, mgekv./100g | 49.6 | 52.8 | 43.3 | 49.7 |
| Organic C, % | 5.0 | 5.0 | 4.1 | 4.5 |
| N, g/kg | 2.5 | 3.2 | 2.1 | 2.2 |
| $P_2O_5$ mg/100g | 2.6 | 3.8 | 1.9 | 2.5 |
| $K_2O$, mg/100g | 31.1 | 37.0 | 5.6 | 8.4 |
| CaO, mg/100g | 346.9 | 213.3 | 145.5 | 128.7 |
| MgO, mg/100g | 49.0 | 142.2 | 107.5 | 71.9 |

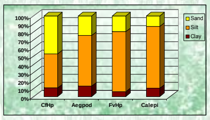


Fig.5. Soil fractions

Table 3. Correlation coefficient between species constancy/cover and observation year (figures in superscript – increase or decrease of cover and constancy from 2001 to 2007 in %). A – cover, C – constancy. * p = 0.05, ** p = 0.01

| Species | CfHp_C | CfHp_A | Tc_C | Tc_A | Aegpod_ | Aegpod_ | Calepi_C | Calepi_A | FvHp_C | FvHp_A |
|---|---|---|---|---|---|---|---|---|---|---|
| ***Decreasing species*** | | | | | | | | | | |
| *Agrostis tenuis* | -0.83*$^{30}$ | -0.89**$^{0.3}$ | -0.1 | -0.6 | -0.86*$^{17}$ | -0.86*$^{0.2}$ | a | a | -0.40 | -0.40 |
| *Briza media* | -0.1 | -0.82*$^{8.3}$ | -0.11 | -0.03 | n | n | -0.17 | -0.38 | 0.61 | 0.81*$^{14}$ |
| *Calamagrostis epigeios* | n | n | n | n | n | n | a | -0.79*$^{20}$ | -0.88**$^{20}$ | 0.05 |
| *Cerastium holosteoides* | -0.79*$^{20}$ | -0.79*$^{0.2}$ | -0.31 | -0.27 | 0 | -0.41 | 0 | 0 | a | a |
| *Dactylis glomerata* | 0.20 | -0.76 | 0.40 | -0.46 | 0 | -0.98**$^{28}$ | 0.6 | 0.73 | 0 | 0.02 |
| *Daucus carota* | -0.78*$^{60}$ | -0.2 | -0.82*$^{50}$ | -0.76*$^{0.5}$ | n | n | a | a | -0.47 | -0.47 |
| *Gymnadenia conopsea* | n | n | n | n | n | n | -0.40 | -0.40 | -0.75*$^{20}$ | -0.58 |
| *Linum catharticum* | -0.61 | -0.61 | -0.79*$^{25}$ | -0.79*0.3 | n | n | -0.40 | -0.40 | -0.30 | -0.30 |
| *Potentilla reptans* | 0 | 0.75*$^{3}$ | -0.61 | 0.60 | -0.90**$^{50}$ | -0.72 | -0.15 | 0 | 0.50 | 0.50 |
| *Prunella vulgaris* | -0.85*$^{40}$ | -0.94**$^{0.8}$ | -0.89**$^{75}$ | -0.87**$^{4.2}$ | n | n | 0.62 | 0.62 | -0.17 | -0.17 |
| *Trifolium pratense* | -0.84*$^{60}$ | -0.78*$^{2.5}$ | -0.94**$^{50}$ | -0.88**$^{0.5}$ | 0 | -0.43 | -0.40 | -0.40 | 0 | -0.50 |
| *Trifolium repens* | -0.87*$^{80}$ | -0.80*$^{3.2}$ | -0.87*$^{50}$ | -0.88**$^{2}$ | -00.2 | -00.2 | a | a | -0.29 | -0.29 |
| *Vicia cracca* | -0.34 | -0.42 | 0.47 | 0.61 | -0.80*$^{50}$ | -0.85*$^{5}$ | 0.61 | 0.78*$^{1}$ | 0.58 | 0.48 |
| ***Increasing species*** | | | | | | | | | | |
| *Aegopodium podagraria* | 0.78*$^{20}$ | 0.87*$^{28}$ | -0.61 | -0.06 | -0.61 | -0.82*$^{14}$ | 0.94**$^{40}$ | 0.92**$^{4}$ | a | a |
| *Alopecurus pratensis* | n | n | n | n | 0.89**$^{50}$ | 0.88**$^{1}$ | n | n | n | n |
| *Carex ornithopoda* | 0.89**$^{70}$ | 0.89**$^{1}$ | 0.14 | 0.14 | n | n | -0.47 | -0.47 | 0.72 | 0.89**$^{2.3}$ |
| *Campanula rapunculoides* | 0.61 | 0.52 | n | n | n | -0.11 | 0.92**$^{80}$ | 0.92**$^{1}$ | 0.58 | 0.58 |
| *Carex caryophyllea* | -0.04 | -0.04 | -0.62 | -0.62 | n | n | 0.85*$^{40}$ | 0.94**$^{0.4}$ | 0.87**$^{90}$ | 0.84*$^{0.9}$ |
| *Carlina vulgaris* | 0.61 | 0.61 | n | n | n | n | 0.78*$^{20}$ | 0.78*$^{0.2}$ | -0.21 | -0.22 |
| *Centaurea jacea* | 0.82*$^{50}$ | 0.80*$^{1}$ | 0.14 | 0.36 | n | n | -0.41 | -0.22 | 0.00 | 0.08 |
| *Chaerophyllum aromaticum* | 0.76*$^{20}$ | 0.83*$^{2}$ | 0.41 | 0.75*$^{27}$ | 0.00 | 0.95**$^{60}$ | n | n | n | n |
| *Deschampsia cespitosa* | 0.72 | 0.72 | 0.00 | -0.89**$^{2.2}$ | 0.79*$^{17}$ | 0.79*$^{0.2}$ | n | n | n | n |
| *Equisetum arvense* | 0.55 | 0.55 | 0.94**$^{75}$ | 0.93**$^{0.8}$ | 0.14 | 0.14 | 0.41 | 0.41 | 0.00 | 0.00 |
| *Festuca arundinacea* | 0.39 | 0.32 | 0.89**$^{50}$ | 0.81*$^{1.5}$ | n | n | -0.61 | -0.78*$^{0.8}$ | 0.72 | 0.41 |
| *Festuca ovina* | -0.41 | -0.41 | n | n | n | n | a | a | 0.84*$^{30}$ | 0.42 |
| *Fragaria viridis* | 0.36 | 0.47 | 0.69 | 0.61 | n | n | 0.78*$^{20}$ | 0.78*$^{0.2}$ | 0.41 | 0.21 |
| *Geranium sylvaticum* | 0.82*$^{50}$ | 0.56 | 0.63 | 0.55 | 0.55 | -0.26 | n | n | n | n |
| *Glechoma hederacea* | n | n | 0.43 | 0.43 | 0.88**$^{33}$ | 0.83*$^{0.5}$ | n | n | n | n |
| *Knautia arvensis* | 0.77*$^{30}$ | 0.91**$^{0.6}$ | -0.14 | -0.14 | n | n | 0.41 | 0.42 | 0.75 | 0.75 |
| *Lysimachia numullaria* | 0.64 | 0.66 | -0.61 | -0.32 | 0.11 | 0.87**$^{3.7}$ | n | n | n | n |
| *Picris hieracioides* | 0.81*$^{20}$ | 0.66 | 0.81*$^{25}$ | 0.80*$^{0.3}$ | n | n | n | n | n | n |
| *Ranunculus acris* | 0.56 | 0.56 | 0.78*$^{50}$ | 0.79*$^{0.5}$ | -0.41 | -0.41 | 0.00 | 0.00 | 0.62 | 0.62 |
| *Ranunculus cassubicus* | n | n | -0.14 | -0.14 | 0.86*$^{17}$ | 0.86*$^{0.2}$ | n | n | n | n |

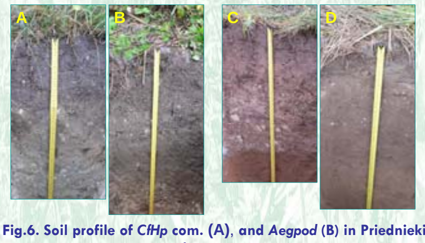


Fig.6. Soil profile of *CfHp* com. (A), and *Aegpod* (B) in Priednieki; and *FvHp* com. (C) , and *Calepi* com. (D) in Drubazas.

Table 5. Correlation coefficients between DCA axes and vegetation and environmental (after Ellenberg indicator values) parameters.

| Parameter | Priednieki | | | Drubazas | | |
|---|---|---|---|---|---|---|
| | Axis 1 | Axis 2 | Axis 3 | Axis 1 | Axis 2 | Axis 3 |
| Year | 0.31 | -0.21 | 0.43 | 0.13 | 0.44 | -0.12 |
| Herb layer | 0.31 | 0.43 | -0.43 | -0.50 | -0.48 | 0.12 |
| Moss layer | -0.05 | -0.16 | 0.28 | -0.38 | 0.27 | 0.28 |
| Litter layer | 0.00 | -0.47 | 0.59 | 0.67 | 0.13 | -0.13 |
| Species richness | -0.74 | -0.33 | 0.06 | -0.59 | 0.37 | 0.05 |
| Shannon index | -0.87 | -0.23 | 0.02 | -0.30 | 0.46 | -0.09 |
| Evenness | -0.84 | -0.19 | 0.02 | -0.09 | 0.43 | -0.14 |
| Light | -0.81 | -0.29 | 0.13 | -0.61 | -0.22 | 0.08 |
| Temperature | -0.46 | -0.21 | 0.35 | 0.10 | -0.03 | 0.01 |
| Continentality | 0.69 | 0.17 | 0.13 | 0.50 | -0.06 | -0.08 |
| Moisture | 0.71 | 0.63 | -0.11 | 0.18 | 0.14 | -0.16 |
| Reaction | -0.56 | -0.68 | 0.37 | 0.19 | 0.07 | -0.08 |
| Nutrients | 0.80 | 0.40 | -0.13 | 0.80 | 0.04 | -0.21 |

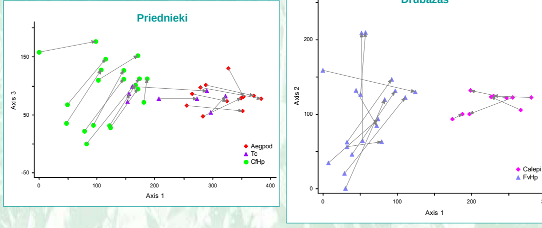


Fig.7. DCA ordination of plots. Successional vectors join the same plot in 2001 and 2007.


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