# Effects of abandonment of montane grasslands on plant species composition and species richness - a case study in Styria, Austria

Bohner A.[1] and Starlinger F.[2]
[1] *Agricultural Research and Education Centre Raumberg-Gumpenstein (AREC), Department of Environmental Ecology, 8952 Irdning, Austria*
[2] *Federal Research and Training Centre for Forests, Natural Hazards and Landscape, Department of Forest Ecology and Soils, 1131 Wien, Austria*
Corresponding author: andreas.bohner@raumberg-gumpenstein.at

**Abstract**

Long-term abandonment of grassland generally causes a decrease in plant species richness. The questions, how long abandoned grassland may remain species-rich and whether the persistence varies between different sites, have been examined insufficiently so far. Thus, in this successional study we analysed over a period of 9 years the effects of abandonment on plant species composition and species richness in a montane grassland in Styria, Austria. We differentiated two topography-related habitat types: a pasture on a steep, south-facing slope with a nutrient-poor soil, and a meadow on a flat site below the slope with a more fertile soil. In spring 2001, one permanent plot (plot size: 50 m²) in each habitat type was established. Our results show that the long-term effects of abandonment on grassland vegetation depend largely on local site conditions, and nutrient availability in the soil seems to be an especially important factor. On the flat site, within 4 years of abandonment floristic composition changed dramatically, a high species turnover and a strong decrease in species richness could be observed. In contrast, on the steep, south-facing slope we found only minor effects, even after 9 years of abandonment.

Keywords: biodiversity, permanent plots, secondary succession, species turnover

## Introduction

In Austria and in many other European countries, two contrsting trends in grassland management can be observed. In climatically favoured areas, a further intensification of grassland management is to be expected. In mountain regions, however, abandonment of grassland will take place especially on sites with unfavourable climatic, pedological and/or topographical conditions. In general, the long-term abandonment of grassland causes a decrease in plant species richness (Prévosto *et al*., 2011). The questions, how long abandoned grassland may remain species-rich and whether the persistence varies between different sites, have been examined insufficiently so far. Thus, the primary aims of this successional study were: (i) to monitor the plant species composition and species richness of a montane grassland in Styria (Austria) after abandonment and (ii) to analyse the importance of local site conditions for vegetation changes during secondary succession.

## Materials and methods

This study on grassland succession was conducted at the Buchauer Sattel located near Admont in the northern part of Styria (Austria) at an altitude of 895 m a.s.l. The climate is relatively cool and humid, with a mean annual air temperature of 6.6°C and an annual precipitation of 1400 mm (ZAMG, 2002). During the growing season (April-September) 60% of the annual precipitation occurs. To study the effects of abandonment as a function of local site conditions, we differentiated two topography-related habitat types: a relatively low-productive, species-

rich pasture on a steep (30°), south-facing slope and a more productive and less species-rich meadow on a flat site below the slope. Before abandonment, the unfertilized pasture was extensively grazed by sheep and the meadow, which had two cuts every year, was fertilized with farmyard manure. In both habitat types, the soil represents a deep, base-rich Chromic Cambisol developed over a calcareous moraine. In the A horizon soil texture is loamy silt. Soil water regime is periodically moist in the topsoil. On the flat site wet periods are longer and dry periods are considerably shorter than on the slope. At the time of abandonment, the topsoils were in the cation exchange buffer range (Table 1). On the flat site $C_{org}$ to $N_{tot}$ ratio was narrower, whereas electrical conductivity, effective cation exchange capacity and lactate soluble phosphorus content were higher, indicating a better soil-nutrient availability on the flat site compared to the slope. In this habitat type, nutrient deficiency in the soil is the main limiting factor for plant growth. Dryness seems to be of minor importance due to the cool and humid climate in combination with a deep, humus-rich, fine-textured soil, indicating a high water-holding capacity. Originally, the flat site was covered by a *Trisetetum flavescentis* community and the slope by a *Festuco commutatae-Cynosuretum* community. Both vegetation types, especially the first-mentioned, are common and widely distributed in Austria. In spring 2001, one permanent plot in each habitat type was established. Both permanent plots had the same plot size of 50 m². They are representative for each habitat type and are largely homogenous from a soil science point of view. At each plot we recorded the individual cover of all vascular plant species according to the method of Braun-Blanquet. The experimental site is surrounded by a mixed forest of spruce, silver fir and beech (*Picea abies*, *Abies alba*, *Fagus sylvatica*).

Table 1. Soil chemical properties at the time of abandonment (A horizon, 0-10 cm).

| Site | % $C_{org}$ | % $N_{tot}$ | $C_{org}$:$N_{tot}$ | $CaCl_2$ pH | µS $cm^{-1}$ EC | $cmol_c$ $kg^{-1}$ $CEC_{eff}$ | % BS | mg $kg^{-1}$ $P_{CAL}$ | mg $kg^{-1}$ $K_{CAL}$ |
|---|---|---|---|---|---|---|---|---|---|
| Slope | 4.42 | 0.38 | 11.63 | 4.3 | 36 | 9.0 | 75 | 8 | 50 |
| Flat site | 4.52 | 0.41 | 11.02 | 4.8 | 57 | 11.6 | 93 | 15 | 48 |

EC = electrical conductivity; $CEC_{eff}$ = effective cation exchange capacity ($BaCl_2$-extract); BS = base saturation ($BaCl_2$-extract); $P_{CAL}$, $K_{CAL}$ = lactate soluble phosphorus and potassium content.

## Results and discussion

The investigated habitat types differed in their response to abandonment. On the flat site we observed relatively large vegetation changes during the first four years of secondary succession. From that time onwards, the successional changes in species composition and species richness were comparatively smaller, indicating a period of stagnation. During the investigation period herbs increased in cover from 40% in 2001 to 97% in 2009 at the expense of both grasses and legumes. The beta-turnover according to Shmida and Wilson (1985) shows a comparatively high species turnover (Table 2). Abandonment favoured mainly *Chaerophyllum hirsutum* and *Ficaria verna*. Their cover values increased considerably. During the first four years after abandonment, the tall herb *Chaerophyllum hirsutum* became dominant, resulting in a decline of the evenness value. Alpha-diversity (total number of vascular plant species within a plot size of 50 m²) decreased from initially 48 plant species in 2001 to 22 in 2009. During secondary succession only two new species appeared, whereas 28 species disappeared. Among the newly recorded species *Galeopsis tetrahit* increased in cover. This late-developing therophyte may benefit from the numerous gaps in the sward. Species with decreasing cover and species which disappeared were mainly characteristic grassland species, resulting in a change of the vegetation type. Up to now, we found no species of shrubs or trees. In contrast,

on the steep, south-facing slope vegetation changes were small, even after 9 years of abandonment. Alpha-diversity decreased from initially 73 plant species in 2001 to 70 in 2009. Obviously, the lack of disturbance did not result in a rapid decline in species richness. During secondary succession, we observed 8 newly appearing species, whereas 11 species disappeared. Among the 'newcomers' we found mainly plant species which are characteristic of forest margins (e.g. *Agrimonia eupatoria*, *Cuscuta epithymum*, *Hieracium laevigatum)*. Abandonment favoured particularly *Astrantia major* ssp. *major*, *Betonica officinalis*, *Clinopodium vulgare*, *Molinia caerulea*, *Prunus spinosa*, *Pteridium aquilinum* and *Trifolium medium*. Up to now, the cover value of woody plants is relatively low. Among the woody plants (tree seedlings of *Acer pseudoplatanus* and *Fraxinus excelsior*, shrubs such as *Crataegus monogyna* and *Prunus spinosa*), initially present, only *Prunus spinosa* increased. The early successional stage is characterized by a high species richness and evenness value (Table 2), indicating the absence of dominant species. The abandoned plant stand is rich in species of herbs, colourful when in bloom, resulting in a high aesthetic value. Until now, we found no rare and highly endangered vascular plant species in either of the habitat types. The observed smaller successional changes on the slope compared to the flat site are likely the result of a different nutrient availability in the soil. Also the small differences in soil water regime may have an influence primarily due to the fact that soil moisture affects nutrient availability in the soil. Because of the less-fertile soil on the slope, resulting in a comparatively lower above-ground plant biomass production and hence better light conditions at the soil surface, more light-demanding grassland species of short stature at maturity could survive after abandonment. In contrast, on the flat site many light-demanding grassland species were suppressed primarily by the dominant species *Chaerophyllum hirsutum* through shading. Thus, on nutrient-rich grassland soils abandonment favours the spread of a few highly competitive, tall plant species, resulting in rapid successional changes and a strong decrease in species richness.

Table 2. Vegetation changes after abandonment in the period 2001 to 2009.

| | Slope | Flat site |
|---|---|---|
| α-diversity 2001 | 73 | 48 |
| α-diversity 2009 | 70 | 22 |
| Change in α-diversity | -3 | -26 |
| Number of new species | 8 | 2 |
| Number of extinct species | 11 | 28 |
| Evenness value 2001 | 85 | 84 |
| Evenness value 2009 | 79 | 47 |
| Beta-turnover 2001-2009 | 0.13 | 0.41 |

## Conclusion

The results of our successional study suggest that the long-term effects of abandonment on grassland vegetation depend largely on local site conditions. Nutrient availability in the soil seems to be an important factor for vegetation changes during secondary succession. In order to prevent a considerable decrease in plant species richness, management operations have to be done in habitats with nutrient-rich soils in shorter intervals (approximately every three years) than in habitats with nutrient-poor soils (at least every five to ten years). Furthermore, our results suggest that abandoned grassland does not get lost immediately as agricultural area, because the appearance and/or spread of trees and shrubs are in most cases a slow process.

## References

Prévosto B., Kuiters L., Bernhardt-Römermann M., Dölle M., Schmidt W., Hoffmann M., Van Uytvanck J., Bohner A., Kreiner D., Stadler J., Klotz S. and Brandl R. (2011) Impacts of land abandonment on vegetation: successional pathways in european habitats. *Folia Geobotanica* 46, in press.

Shmida A. and Wilson M.V. (1985) Biological determinants of species diversity. *Journal of Biogeography* 12, 1-20.

ZAMG (Central Institute for Meteorology and Geodynamics) (2002) Klimadaten von Österreich 1971-2000. http://www.zamg.ac.at/fix/klima/oe71-00/klima2000/klimadaten_oesterreich_1971_frame1.htm.