RESTORATION OF ARABLE LANDS IN EGYEK-PUSZTAKÓCS LIFE PROJECT AREA

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Abstract

Restoration of grasslands in former arable lands is in the focus of interest for decades but only a few studies were able to discuss the results of a multiple plot study. We studied the vegetation development during a grassland restoration in Egyek-Pusztakócs, Hortobágy National Park. In former arable lands alkali and loess grasslands (altogether 480 ha between 2005 and 2007) were created by sowing low density seed mixtures. Seed mixtures of dominant alkali and loess grass species (*Festuca pseudovina*, *F. rupicola*, *Poa angustifolia*, *Bromus inermis*) were sown in density of 25 kg/ha. Percentage cover and the number of individuals of vascular species were recorded from the first year onwards in early June (2006 -2007). Aboveground phytomass samples (10 per site, 20 cm by 20 cm) were collected in June in both years. Our results show that sowing seed mixtures is a fast and effective tool to restore the former grasslands. The sown grasses became dominant in the second year, they composed a closed grassland. Total and mean species number per plot decreased for the second year. The number of species and the biomass of weeds decreased considerably, as well as the coverage of the therophyta group. The amount of herbaceous phytomass decreased in both treatments. The phytomass of graminoids, however showed a significant increase in the fields restored with the loess seed mixture. In spite of management (grazing and mowing) dead phytomass accumulation was detected in the fields. To increase the species' richness of the restored fields sowing seeds of herbaceous species, hay transfer and/or moderate grazing are requred.

Keywords: Succession, alkali, loess, alfalfa, phytomass

Introduction

Agricultural intensification together with large-scale changes in land-use and reclamation of wetlands led to the loss of formerly characteristic habitat systems across Europe (Bradshaw, 1983; Bakker, 1989). The intensification of land-use, especially the creation of agricultural ecosystems resulted in a change of species composition and a decrease of the diversity of natural habitats (Burel et al., 1998; Schläpfer et al., 1999). Habitat restoration and reconstruction are the most widespread tools to create natural habitats considering the present possibilities (Clewell, 2000). In our work we briefly discuss the results of a grassland restoration project which is a part of the landscape-scale rehabilitation program in Egyek-Pusztakócs marshland (HNP) supported by the European Union (LIFE).

Description of studied sites

The study site is located in the ca. 4000 ha Egyek-Pusztakócs marshland (EOV 790600; 249800) near to Tiszafüred and Egyek villages, on the Eastern boundary of Nagykunság. The site belongs to the Hortobágy National Park since 1973, and it is also a part of the Ramsar Convention and NATURA 2000 network and is an Important Bird Area and a part of the World Heritage. The study area is located 88-92 m above the sea level. The soil of the higher elevations characterised by loess sediment is mainly chernozemic while in the lower elevations between loess plateaus alkali and alkali clay soils can be found. Mean annual temperature is 9.5ºC; the average annual precipitation is 550 mm, with a monthly precipitation maximum in June (80 mm) (Pécsi, 1989).

The lower elevated sites are mostly covered by extent alkali marshes including various associations (such as *Bolboschoeno-Phragmitetum*, *Schoenoplectetum taubernaemontani*, *Typhaetum latifoliae*, *Typhaetum angustifoliae*, *Bolboschoenetum maritimi*, *Glycerietum maximae*, *Galio palustris-Caricetum ripariae*). The marshes are surrounded by alkali meadows (*Agrostio stoloniferae-Alopecuretum pratensis*, *Agrostio stoloniferae-Glycerietum pedicellatae*, *Agrostio stoloniferae-Beckmannietum eruciformis*, *Eleochari-Alopecuretum geniculati*), followed by extent alkali grasslands (*Achilleo setaceae-Festucetum pseudovinae*, *Artemisio santonici-Festucetum pseudovinae*). There are some remnants of loess steppe vegetation (*Salvio nemorosae-Festucetum rupicolae*, *Cynodonti-Poetum angustifoliae*) which are situated at higher levels and at plateau top position (Deák et al., 2007).

According to the military mapping surveys, the marshland was a floodplain which was rich in wetlands separated by a few arable lands located in the loess plateaus till the 19th century. The area received regular floods from river Tisza that time. After river regulations however the area was hardly ever reached by floods which resulted in the loss of direct water supply of the marshes. After agricultural cultivation became more widespread the majority of suitable grassland areas were ploughed. This process mainly concentrated to loess steppes at plateau top position and to alkali short grasslands which had humus rich topsoil and had a salt accumulation layer in the deep.

The rehabilitation of the region began in the 70's straight after it had become protected. At first the rehabilitation projects focused on construction of a water supply system for the marshes which ended at the end of the 80's. Even the water supply of the marshes (Fekete-rét, Kis-Jusztus, Csattag, Meggyes-mocsár, Hagymás-mocsár) was ensured, a landscape-scale restoration of the area was required, because the marshes were separated from each other by extent arable lands. Since these arable lands were formed on former grasslands, which were the catchment basins of the marshes, the restoration of them has a considerable impact on the success of the whole landscape restoration. Beside that forming grasslands establishes new habitats, the restored grasslands in the catchment basins prevent the infiltration of various chemicals (fertilizers, herbicides) into the marshes, which accelerated eutrophication and the extinction of certain species. Considering the most important aim of this LIFE project is to transform these arable lands into grasslands.

Materials and methods

Sampling

In the project area altogether 109.5 ha arable land (former alfalfa fields) was restored by sowing seed mixtures in 2005. Two types of low diversity seed mixtures, which contained the seeds of dominant grass species of alkali and loess grasslands, were used (Vida et al., 2008). Higher elevations (higher than 90 m above see level) were sowed with loess (*Festuca rupicola*, *Poa angustifolia*, *Bromus inermis*), while lower elevations were sowed with alkali (*Festuca pseudovina*, *Poa angustifolia*) seed mixture in density of 25 kg/ha in October 2005. The sites are managed either by mowing or by extensive grazing with moderate intensity (cattle, sheep) after sowing seed mixtures.

In each restored field there were chosen 2 or 4 sites for study (depending on the size of the field) in May 2006. Four 1 m^2 permanent plots per site were sampled. Percentage cover of vascular plants was estimated in May 2006 and 2007. Ten 20 cm by 20 cm above ground phytomass samples per site were taken. Phytomass samples were dried (65 ºC, 24 h), and the dried samples were sorted into 3 categories: dead material, graminoid (*Poaceae*, *Cyperaceae*, *Juncaceae*) and herbaceous groups. Each group was weighed with the accuracy of 0.01 g after selection.

Data processing

Life form categories (therophyta group = annual and biannual species: therophyta and hemitheropyhta; hemichryptophyta group = perennials: chamaephyta, hemichryptophyta and chryptophyta), indicator values for nitrogen (NB) and naturalness value weighed by the percentage cover were determined (Borhidi, 1993). Normality was tested using Kolmogorov-Smirnov test, while the equality of variances were tested using F-test. By comparing the means of two samples depending on the results of the normality tests a paired t-test or a Wilcoxon signed-rank test was applied.

Results

Vegetation

The vegetation was dominated by annual tall-growing weedy species in the first year after restoration. Weedy assemblages were replaced by shorter growing clonal grass dominated communities in the following vegetation period. Altogether 104 vascular species (78 herbaceous and 26 graminoid) were recorded over the 2 years. Mean species numbers per plot were significantly lower ($p<0.001$) in 2007 than in 2006 either on sites sowed with the alkali or loess seed mixtures. The proportion of species requiring natural habitats (specialists, competitors, generalists) was significantly higher ($p<0.001$), while the proportion of the therophyta group and species having a greater NB value was significantly lower ($p<0.001$) in 2007 on sites in case of each seed mixtures (Table 1).

Phytomass

The amount of dead phytomass was significantly higher ($p<0.001$) in 2007 independent by of seed mixture. Increasing values of graminoid phytomass were recorded in 2007, but significant difference ($p<0.001$) was only detected in sites sowed with loess seed mixture. Contrarily the amount of herbaceous phytomass significantly decreased ($p<0.001$). The total phytomass decreased to ca one third in 2007 independent by of seed mixture types (Table 1).

Table 1. Characteristics of vegetation samples of sites sown with loess and alkali seed mixtures (mean±SE). Different superscripted letters indicate significant differences between years (paired t-test or Wilcoxon signed-rank test, $p<0.001$). Statistical testing of phytomass data are based on quadrats of 20 cm by 20 cm.

	Alkali seed mixture		Loess seed mixture	
	2006	2007	2006	2007
Vegetation height (cm)	64.2 ± 2.1^a	43.4 ± 0.8^b	60.3 ± 1.6^a	41.4 ± 1.1^b
Total species number	65	44	74	51
Mean species number (m^{-2})	16.6 ± 0.7^a	8.4 ± 0.7^b	17.0 ± 0.7^a	8.6 ± 0.7^b
Herbaceous species number (m^{-2})	11.3 ± 0.7^a	3.6 ± 0.5^b	12.1 ± 0.5^a	3.4 ± 0.4^b
Proportion of the therophyta group (%)	65.2 ± 4.5^a	17.4 ± 5.2^b	83.4 ± 3.4^a	7.2 ± 1.3^b
Proportion of plants requiring natural habitats (%)	9.0 ± 2.2^a	33.9 ± 5.3^b	11.2 ± 3.2^a	19.0 ± 4.1^b
Mean NB value	5.1 ± 0.1^a	4.0 ± 0.2^b	6.3 ± 0.2^a	3.9 ± 0.1^b
Graminoid phytomass ($g*m^{-2}$)	545.4^a	482.5^a	388.9^a	445.7^b
Herbaceous phytomass ($g*m^{-2}$)	1020.2^a	54.2^b	989.0^a	6.4^b
Dead phytomass ($g*m^{-2}$)	20.0^a	262.4^b	37.8^a	288.3^b

Discussion

Species richness and phytomass

The amount of dead phytomass increased significantly in each site. Our results parallel with other studies found that herbaceous species richness is decreasing with the increasing amount of litter (Wheeler et al., 1991; Jensen et al., 2001; Török et al., 2007). Species richness decreased considerably independent of seed mixture types in the second year after sowing mainly due to the disappearance of short-lived, mainly therophyta and hemitherophyta species. Closed graminoid perennial dominated vegetation was formed by the sown species in the second year after sowing, where the weaker competitor annual weedy species requiring open and disturbed surfaces were not able to regenerate (Rees et al., 1992). The initial species rich communities dominated by weedy species were replaced by perennial dominated vegetation with less species but approximating the natural vegetation more. Weedy species requiring high light intensity will find worse circumstances for germination and seedling survival due to the shadowing effect of litter accumulation and the closing of the grassland (Bobbink et al., 1989; Tilman, 1993; Eriksson, 1995; Deák, 2007). Sustaining management by mowing or extensive grazing is essential as it efficiently reduces litter accumulation and by that increases the diversity of herbaceous plants (Török et al., 2007).

Was the grassland restoration in arable lands successful?

In general the spontaneous regeneration of arable lands is relatively slow and its outcome is often unpredictable while the diversity of aboveground vegetation and soil seed bank considerably decreased due to long-term agricultural land use (Bakker, 1997). Our findings underline the effectiveness of restoration by sowing seed mixtures. Closed vegetation dominated by perennial grasses was formed in only two years. However, in such closed, highly graminoid dominated communities the establishment of perennial herbaceous subordinate species is very slow as mentioned in previous studies as well (Matus, 2003; Matus et al., 2005; Török et al., 2008). It can be attributed to the following reasons. The majority of these species does not have persistent seed bank, their dispersion is limited and their absence can be caused by competitive exclusion as well (Odum, 1969; Van der Valk et al., 1989; Bekker et al., 1997; Zobel et al., 1998). Having regard to this other techniques should be used in order to restore species rich grassland communities in the absence of local diaspore resources. The spread of seeds of natural subdominant species can be facilitated by application of hay or topsoil or using biotic vectors, e.g. grazing animals (Bakker et al., 1996; Stroh et al., 2002; Donath et al., 2003; Hölzel et al., 2003).

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