SPONTANEOUS GRASSLAND RECOVERY IN EXTENSIVELY MANAGED ALFALFA FIELDS

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Abstract: Spontaneous succession is often underappreciated in restoration after the cessation of intensive agricultural management. However, it is an effective way of restoration and offers a cost-effective option with little intervention. We studied the spontaneous recovery of loess grasslands in extensively managed lucerne fields mown twice a year using space-for-time substitution to highlight the importance of spontaneous processes in grassland restoration. As the age of fields increased, a gradual replacement of lucerne by native perennial grasses and forbs and increase of mean species richness was detected. With increasing field age, lucerne decreased from 75% to 2% of total vegetation cover, whereas perennial graminoids increased from 0.5 to 50% cover. Mean total cover showed no significant differences between the age groups and weed cover was less than 10% in each age group. The biomass of lucerne was negatively correlated with graminoid biomass. As the age of the fields increased, lucerne biomass decreased and graminoid biomass increased. We found a negative correlation between litter and forb biomass but there was no relationship with the age of the field. There was no increase of mean total biomass and litter accumulation as the age of fields increased. Characteristic native grasses of loess grasslands recovered within 10 years, but target native forbs remained rare. In case of lucerne fields, the advantages of spontaneous succession compared to technical reclamation include: (i) no weed dominated stages, (ii) no considerable litter accumulation, (iii) a spontaneous decrease in lucerne over time, and (iv) negligible cost. In addition, farmers can be more involved in mowing management in the first years of grassland restoration because of the high forage quality of lucerne. To encourage the return of native forbs, the restoration of species-rich grasslands require more active management such as propagule transfer by hay and/or moderate grazing.

Keywords: 6250 * Pannonic loess steppic grasslands, land use change, spontaneous succession, reclamation of former agricultural land

Introduction

The aim of grassland restoration is to improve and/or recover grassland biodiversity and ecosystem functions. Grassland recovery can be accelerated by technical reclamation methods, which usually means the addition of seeds of target species by hay transfer or seed sowing. An alternative approach is spontaneous succession, where the system is left to recover naturally (Prach & Pyšek 2001). Technical reclamation measures are preferred worldwide despite of the several promising examples of spontaneous recovery of grasslands. Most studies reporting spontaneous succession have focused on abandoned fields formerly cultivated with annual crops, there are just a few papers studying the course of secondary succession after perennial crop cultivation. Alfalfa (*Medicago sativa*) is one of the most important perennial crops worldwide. We studied the recovery of loess grasslands in extensively managed (mown twice a year) alfalfa fields using space for time substitutions. The following questions were asked: (i) How effective is alfalfa in weed control? (ii) How quickly does alfalfa disappear? (iii) How fast does grassland recover in extensively managed alfalfa fields? We aimed at to examine the conservation value of spontaneous succession in the restoration of grasslands in former alfalfa fields as a cost-effective strategy for grassland restoration.


Picture 1 and 2. A 3-year-old (left) and a 10-year-old (right) extensive alfalfa field. Photos of A. Kelemen.

Materials and methods

The study area is located in the Great Hungarian Plain (Hortobágy), in East-Hungary. In the study region alfalfa (*Medicago sativa*) is generally sown at plateaux covered by loess grasslands. Alfalfa fields are managed extensively or intensively. Extensive management means only regular mowing twice a year, while intensive management inculdes also the regular use of fertilisers and pesticides and the re-sowing of alfalfa after three-four years. Every year 10-50 hectares of intensively managed alfalfa fields were replaced by extensively managed ones in the region.

The vegetation of 1-, 3-, 5- and 10-year-old extensively managed alfalfa fields (three fields in each age group) was studied. The study fields were situated on loess plateaux between 87-94 m a.s.l., within a 50 km radius and none of the study fields were directly connected to loess grasslands (Török et al. 2010). In each field three 5×5-m-sized sample blocks were chosen randomly. Within each block, the cover of vascular plants was recorded in four 1×1-m-sized plots in early June, before the first mowing. In addition, within each block and near to the plots, ten 20×20-cm-sized aboveground biomass samples were collected. For base-line vegetation reference we recorded the vegetation of three variously degraded stands of loess grasslands (*Festucion rupicolae*): (i) a formerly heavily grazed *Cynodonti-Poëtum angustifoliae* stand, (ii) a species-rich loess balk stand with *Bromus inermis* dominance and (iii) a regularly mown species-rich stand of *Salvio nemorosae-Festucetum rupicolae* grassland using the same sampling design as described above. Biomass samples were dried (65 ^{o}C, 24 hours), then sorted to alfalfa, litter, other forb and graminoid (Poaceae and Cyperaceae) subsamples.

We classified the species into four functional groups, these were perennial graminoids, perennial forbs, short-lived graminoids and short-lived forbs. The cover, diversity and biomass data of the differently aged fields were compared using General Linear Mixed-Effect Models (GLMM) and Tukey test (Zuur et al. 2009). For the comparison of the vegetation of alfalfa fields and reference grasslands, we used DCA ordination with Bray-Curtis similarity. We used cover-based Shannon index of diversity to characterise vegetation diversity.

Results and discussion

With increasing field age the mean cover of alfalfa decreased from 75% to 2%.while the mean cover of perennial graminoids increased from 0.5% to 50%. The mean total cover of differently aged alfalfa fields varied between 77% and 86%. No significant differences were found between the total biomass of differently aged alfalfa fields. The biomass of graminoids was highest in the 5- and 10-year-old fields (Fig. 1). A decreasing alfalfa biomass and an increasing graminoid biomass were detected with increasing field age, which was caused by the gradual replacement of alfalfa by perennial grasses. This is in accordance with the common agricultural practice in the region, where alfalfa is re-sown after three-four years of cultivation.

Several weed species were present in the vegetation, but their mean cover was less than 5%, regardless of the age of the fields. Our results support the findings of Li et al. (2008), where legume species like alfalfa were found to be effective in weed suppression. Török et al. (2010) detected a high cover of short-lived weeds after ploughing and sowing of perennial graminoids in former alfalfa fields (1- to 3-year-old), which suggests high-density weed seed banks in the soil of alfalfa fields. The low cover of weeds detected in our study is most likely to be explained by the presence of alfalfa, than by the absence of weed seeds in the soil. We detected low amounts of litter in all alfalfa fields (Deák et al. 2011, and Fig. 1). Litter and forb biomass were negatively correlated, but no clear temporal trend was found. Accumulated litter affects vascular plant species richness negatively (Huhta et al. 2001; Enyedi et al. 2007); it reduces the micro-topographical heterogeneity and decreases the availability of colonisation sites (Facelli & Pickett 1991), which can stabilise the community in an undesirable state (Hobbs et al. 2006). High amounts of litter can also hamper the immigration and establishment of several target species by reducing microsite availability (Foster & Gross 1998).

Shannon diversity scores increased with field age, which is quite promising for grassland recovery. Characteristic grass species for reference grasslands (e.g. *Festuca rupicola* and *Bromus inermis*) were found at low cover scores in 5- and 10-year-old alfalfa fields. Conversely, some common grasses occured with high cover scores (e.g. *Festuca pseudovina*, *Poa angustifolia*, *Agropyron* spp., *Alopecurus pratensis*). Increasing similarity of species composition was detected with increasing field age. Characteristic forb species of native loess grasslands were only present in 5- and 10-year-old alfalfa fields (e.g. *Galium verum, Trifolium angulatum* and *T. retusum*). Species composition of the alfalfa fields showed a clear shift along the first axis in the DCA ordination (Fig. 2). Time is represented by the first axis, and the age groups are separated along it. We found that the recovery of species-poor loess grasslands dominated by perennial native species in former alfalfa fields was possible within 10 years. Other old-field studies found that 6-23 years after abandonment was sufficient time for the spontaneous succession of loess grasslands (Molnár & Botta-Dukát 1998; Ruprecht 2005; Csecserits et al. 2007; Feng et al. 2007).

Several perennial forbs found at high frequency in loess grasslands were not detected in the alfalfa fields. Previous studies have reported that the spontaneous immigration of target species is a propagule-limited process (Donath et al. 2007, Kiehl et al. 2010). There are two reasons for propagule limitation: (i) limited spatial dispersal (e.g. missing dispersal agents) reduces the movement of seeds into target sites (Simmering et al. 2006); (ii) long-term agricultural use often depletes local seed banks and increases the amount of weed seeds in the soil

(Coulson et al. 2001). Thus, spontaneous recovery will be more effective where native grassland sites are located nearby (Öster et al. 2009). A further explanation for the persistent differences in species composition between the old-fields and reference grasslands is that perennial forb species may require more time to establish in extensively managed fields (Prach et al. 2007).

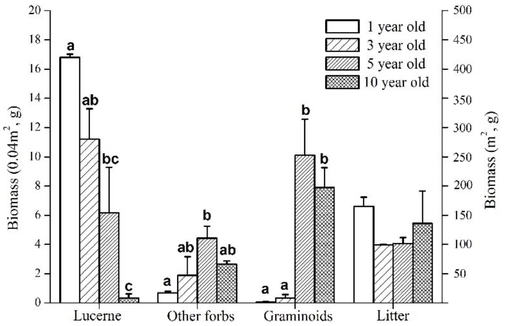

Figure 1. Biomass of differently aged alfalfa fields in 20×20 cm samples. Within-group differences between years are indicated by different letters.

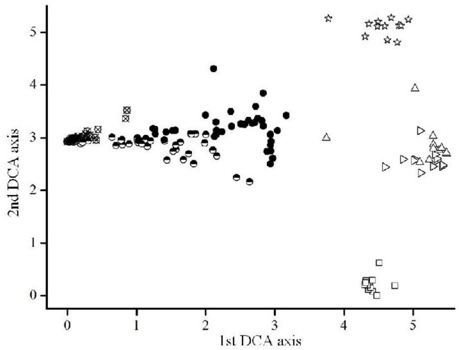

Figure 2. Vegetation composition of differently aged alfalfa fields and reference grasslands based on percentage cover data using DCA ordination and Bray-Curtis similarity.

Conclusions

We found the following advantages of spontaneous succesion on extensive alfalfa fields compared with tecnical reclamation: (i) there was no weed-dominated stage, (ii) no considerable litter accumulation, (iii) the formation of the „semi-natural grasslands characterised by grasses is possible within ten years, (iv) negligible costs and (v) the motivation of farmers supported by the fine-quality hay. There are also some limitations of the use of spontaneous succession to recover grasslands on former alfalfa fields: (i) the vicinity of natural grassland sites is necessary as they can provide propagule sources of target species (ii) the outcome of spontaneous succession is often difficult to predict and (iii) grassland recovery can be a quite long-term process. We can support the immigration and establishment of target species with grazing, hay-transfer or seed sowing in the course of spontaneous succession.

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