Regeneration of sandy old-fields - a new method to assess recovery success

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Abstract

Abandoned agricultural fields are potential sites for the regeneration of semi-natural vegetation, and the newly developed vegetation can counteract biodiversity loss. We studied the vegetation of 161 old-fields in the Kiskunság, central Hungary. Old-fields were categorized into three age groups based on historical aerial photographs: fields abandoned 1-7, 8-20, and 21-57 years ago. The recovery success on old-fields was assessed by using potential target communities (open and closed grasslands and forest) as references. Species richness and cover of characteristic species of natural habitats were used as regeneration indicators. In our paper we present a new selection method for defining species groups and the results of the comparison based on these species groups.

Introduction

Regeneration success following land abandonment depends on various factors and the resulting communities may or may not resemble to potential natural vegetation. Biogeographic zone, vegetation type, biotic and abiotic site conditions, surrounding landscape, previous land use have all been shown to affect recovery (PRACH and REHOUNKOVA 2006, COUSINE and AGGEMYR 2008). Secondary vegetation often exhibits a dual character: having some features and components from the target community but also others, often alien species, that differentiate them. A recent concept of "novel ecosystems" suggests that such new – often stable – combinations of species are becoming more and more frequent due to mixture of floras, altered disturbance regime and environmental conditions including climate change that create "no-analog" site conditions (HOBBS et al. 2006, WILLIAMS et al. 2007, HOBBS et al. 2009).

The evaluation of vegetation developed on abandoned fields can be done by various methods. The use of chronosequences (stands abandoned at different times) is a widely used approach, even if its limitations are acknowledged (PICKETT 1989, WALKER et al. 2010). Another method frequently used in evaluating restoration projects is the comparison of secondary vegetation with target vegetation (ARONSON et al. 1995, BLOCK et al. 2001). The combination of these two approaches, however, is rarely done (e.g. RUPRECHT 2006, ÖSTER et al. 2009).

The choice of appropriate target is always an issue, since it may not always be clear what the potential vegetation of a particular site may be at present (BAKKER et al. 2000, SUDING & GROSS 2006). Thus, a comparison with multiple possible target communities would be a desirable approach, but is rarely done (e.g. FAGAN et al. 2008).

The comparison is made frequently on the basis of species richness, but it can be overly simplifying. We can use the spectra of environmental indicator values, however in case of not yet stabilized communities, it can be misleading. An other approach is the study of the presence and dominance of species groups characteristic to natural habitats. In our study, we defined these species groups on the basis of a regional field survey.

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The overall aim of our study was to investigate old-field succession at the regional scale in the Kiskunság along a chronosequence, and evaluate regeneration success by comparing old-field vegetation with multiple target communities including grassland and forest elements of the zonal forest steppe mosaic and agricultural fields as starting phase of recovery.

Methods

Data collection

We used the field site network of the KISKUN-LTER program representing the variability in regional land-use types (RÉDEI et al. 2008; **Figure 1**). Within each study site, we sampled 3 separate stands of 11 habitat types, if they were present. In a total of 507 plots, 20 m × 20 m in size, we estimated the aboveground percentage cover of vascular plant species. Vegetation surveys were carried out between 2006 and 2008.

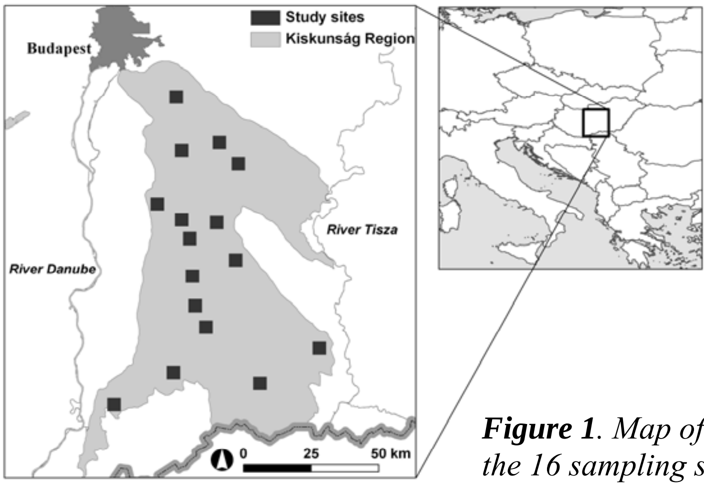

***Figure 1**. Map of the study area with the 16 sampling sites.*

Old-fields were categorized into three age groups based on historical aerial photographs: old-fields abandoned 1-7 years ago (O1), old-fields abandoned 8-20 years ago (O2), and old-fields abandoned 21-57 years ago (O3). Abandonment of old-fields was defined as the cessation of ploughing, though occasional grazing or mowing may occur. Nevertheless, we hypothesized that the impact of elapsed time since abandonment would greatly exceed the impact of random grazing and mowing.

To represent the starting point of the secondary succession, we used relevés made in different agricultural habitats (A). Our potential target communities were open grassland (GO), closed grassland (GC), open woodland (FO), closed woodland (FC). For forest plantations, we sampled black locust (PR), black and Scots pine (PP) and non-native poplar (PE) plantations (**Table 1**.). For more detail see CSECSERITS et al. (in press).

Data analysis

Characteristic species of natural habitats were selected by determining the fidelity of species to natural habitats with Fisher-exact test (CHYTRY et al. 2002) in the Juice programme (TICHY 2002) using the relevés of A, PR, PP, PE, GO, GC, FC habitats. Species faithful to natural habitats at p=0.01 level of significance were regarded as characteristic. Characteristic species of GO, GC and FC, FO were defined on the basis of the fidelity of species to GO, GC and FC, FO respectively by using the relevés of natural habitats only. Differences in species richness and cover of species groups (characteristic species of natural habitats, of GO, GC and FC and neophytes – species intruduced in Europe after the discovery of America (MIHÁLY and BOTTA-DUKÁT 2004) - among habitats were examined using Kruskal-Wallis test and Dunn post-hoc tests.

Name of habitat	Abb.	Number of relevés	Dominant species or description
Agricultural	A	75	Fields, vineyards and orchards
Old-field	O1	57	
Old-field	O2	53	
Old-field	O3	51	
Open grassland	GO	41	*Festuca vaginata, Stipa borysthenica*
Closed grassland	GC	46	*Festuca wagnerii, Stipa capillata, Bothriocloa ischaemum*
Open forest	FO	38	*Quercus robur, Populus alba, Juniperus communis*
Closed forest	FC	36	*Quercus robur, Populus alba*
Black locust plantation	PR	44	*Robinia pseudo-acacia*
Pinus plantation	PP	47	*Pinus nigra, Pinus sylvestris*
Non-native poplar plantation	PE	19	*Populus x euamericana*

***Table 1**. Number and description of the studied habitats. Abb.: abbreviation of the habitat.*

Results

We found 105 species significantly confined to natural habitats. Out of these species, 28 were characteristic to GO, 32 species to GC and 23 to FC. In old-field relevés we detected 85 characteristic species of natural habitats, 27 GO, 29 GC and 11 FC species (CSECSERITS et al. 2011 in press). As there were so few species faithful specifically to FO, we did not use this species group in the further analysis.
The species number of *characteristic species of natural habitats* was significantly higher in O2 and O3 than in O1. The number of such species found in O2 and O3 was not significantly different from the species number of open grasslands and closed forests, but it was lower than that of closed grasslands and open forests (**Figure 2**). The cover of *characteristic species of natural habitats* in O1 was significantly lower than in O2 and O3. In O2 and O3, the cover of these species achieved the level of that in open grasslands, but it was lower than in other natural habitats.

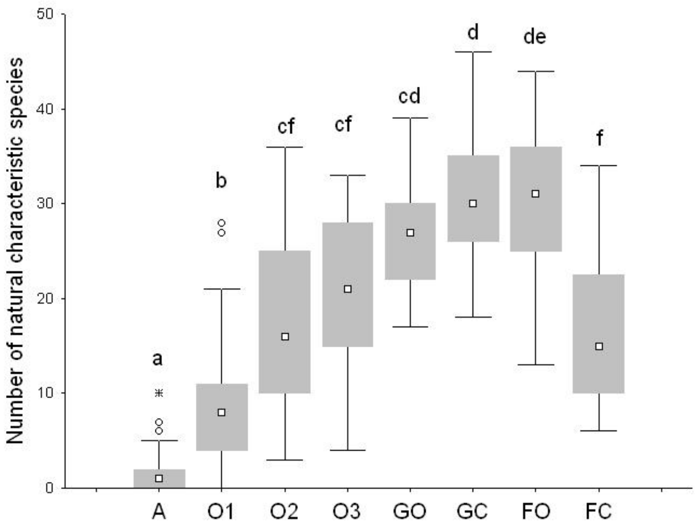

***Figure 2**. Species number of characteristic species of natural habitats. Habitat types with the same letter are not statistically different (p<0.05; Kruskal-Wallis test and Dunn post hoc test). Empty squares are medians, boxes are quartiles, whiskers are non-outlier minimum and maximum values, ○ outliers, *extreme values. For abbreviations see table 1.*

We found that O2 and O3 supported as many *open grassland species* as closed grasslands and open forests did, moreover in O3 it was as high as in open grasslands. Considering the cover of this species group, O2 and O3 did not differ significantly from closed grassland and open forests and in O3 it was as high as in open grasslands.
There were fewer *closed grassland species* in O1 than in O2 and O3. The species number of these species in O2 and O3 did not differ from that in open grasslands and open forests, but in closed grasslands it was significantly higher. The cover of *closed grassland species* showed a similar trend: it was significantly lower in O1 than in O2 and O3. The cover of this species group in O1 did not differ from what we found in open grasslands and in forests. In O2 and O3, this species group reached higher cover than in open grasslands, but was significantly lower than in closed grasslands. The number of *forest species* in O2 and O3 was as low as in open and closed grasslands.
The relevés of old-fields contained 34 neophyte species, while 21 neophyte species appeared in the relevés of natural habitats. In old-fields, the most frequent neophyte species were *Ambrosia artemisiifolia* (frequency: 80.7%, mean cover: 5%), *Conyza canadensis* (frequency: 80.1%, mean cover: 1.73 %) and *Asclepias syriaca* (frequency: 79.5 %, mean cover: 12.14 %). The number of neophyte species was significantly higher in O1 and O2 than in natural habitats. In O3 it was euqal to open grassland and forests. The cover of neophyte species was significantly higher in every age group of old-fields than in natural habitats (**Figure 3**.).

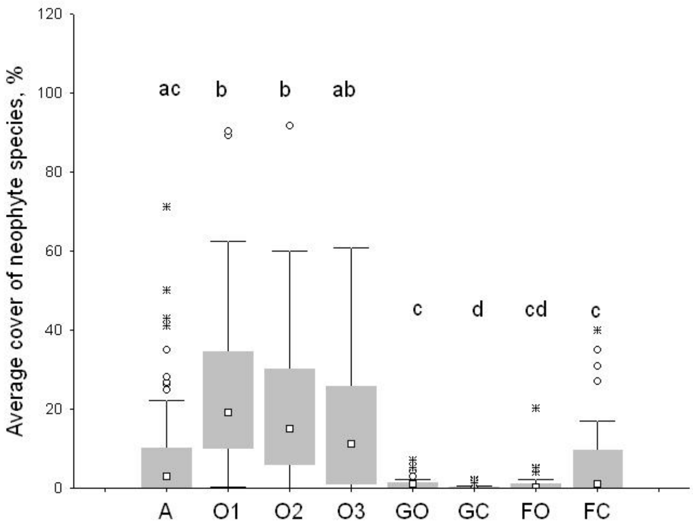

***Figure 3**. Average cover of neophyte species. Habitat types with the same letter are not statistically different (p<0.05; Kruskal-Wallis test and Dunn post hoc test). Empty squares are medians, boxes are quartiles, whiskers are non-outlier minimum and maximum values, ○ outliers, *extreme values. For abbreviations see table 1.*

Discussion

Species richness is a widely used but often criticised measure of regeneration success, because it does not take species identity into account. The richness of habitat specialist species is a more reliable indicator (BAKKER 2008). Determining fidelity of species characteristic to different semi-natural habitats on the basis of a regional survey enabled us to define species groups reflecting present habitat preference. This approach can be used in other regions and our species list can be used in other projects dealing with regeneration or restoration in the region.
In our case, 80% of species characteristic to semi-natural habitats were capable of colonizing old-fields in a few decades, which is compared with other studies a good result. Studies that reported less successful vegetation recovery on old-fields suggest that the main reason of failure is propagule limitation, which is due to either habitat fragmentation or the regional rarity of some species. The Kiskunság still exhibits significant quantities of semi-natural

grassland habitats which can serve as regeneration sources (MOLNÁR et al. 2007, CZÚCZ et al. 2011).

We found that open and closed grassland species are much more successful in establishing, as well as in spreading on old-fields compared to forest species. There may be several reasons for the poor establishment of forest species: the region is located in the forest-steppe zone; there are much fewer natural forest fragments left compared to grasslands (BÍRÓ et al. 2008, BÍRÓ & MOLNÁR 2009) suggesting a stronger propagule limitation for forest species and the regional decline of ground water table is more favourable for the drough-tolerant grassland species.

Figure 4*. A typical old-field in the Kiskunság with the dominant native grass: sandy federgrass (****Stipa borysthenica****) and with the non-native milkweed (****Asclepias syriaca****).*

The vegetation of the studied old-fields are similar to the grassland, however the cover of neophyte species is larger than in semi-natural habitats. This new and through the studied time-scale stabile combination of species can be considered as appearance of a new community (HOBBS et al. 2006) which can have nature conservation values.

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