

POST-FIRE REGENERATION OF A FOREST-STEPPE: VEGETATION STATUS 20 YEARS AFTER THE FIRE EVENT

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Erdős, L. (2014): Post-fire regeneration of a forest-steppe: vegetation status 20 years after the fire event. — Tiscia 40,11-15

Abstract. Fires played an important role in the natural dynamics of the forest-steppes, but human activity has modified the regeneration capacity of the vegetation: for example, post-fire immigration of the native species is less efficient, due to habitat fragmentation. On the other hand, alien species (including invasives) are positively affected by fires. During the past few decades, several human-induced fires happened in the sandy forest-steppes of the Danube-Tisza Interfluvium. Unfortunately, little is known about the regeneration processes. My aim was to compare two neighbouring forest-steppe segments, one of which burned down in 1996, the other remained intact. I prepared coenological relevés in both segments, and compared them, based on PCoA-ordination, differential species, species number, social behaviour types, species' coenological preferences and species' light requirement. The ordination and the social behaviour type spectra suggested that, almost two decades after the fire event, differences are not very pronounced any more. However, there were more light-demanding species in the burned section. The explanation for this may be that the canopy layer became more open due to the fire. The fire increased the species number of the forest patches, but this was partly due to the alien species. It can be concluded that, although fires had an important role in the natural dynamics of forest-steppes, and the regeneration may be fast, fires are hazardous at present. If invasives occur in the region, there is a high risk that they become more abundant.

Key words: dynamics, resilience, alien species, Emlékerdő.

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Introduction

In the northern temperate zone of Eurasia, there is a transitional belt, the forest-steppe zone between the closed forests and the grasslands (Walter and Breckle 2002). This zone reaches its western limits in the Carpathian Basin (Kovács-Láng et al. 2000). The forest-steppes of the Carpathian Basin are characterized by small forest patches separated by grasslands (Wendelberger 1989). In several mixed woody-herbaceous ecosystems worldwide, wildfires play an important role in the vegetation dynamics (e.g. Burkhardt et al. 1976, Archer et al. 1988, Vera 2000, Roques et al. 2001). Similarly, there is strong evidence that fires were part of the natural dynamical processes in the forest-steppes of the Carpathian

Basin (Magyari et al. 2010). However, little is known about the frequency and intensity of the fire events. Moreover, it is largely unknown how human activity modified the pattern and the effect of fires. For example, fires are often suppressed in natural areas. However, if they do occur, regeneration is modified due to several factors. For example, natural and semi-natural areas are limited in size, and they are isolated, hindering the re-establishment of several plants. On the other hand, invasive species are often positively affected by fires (Máté 2014). It has been observed that the major woody species react differently to fires, possessing different resistance and resilience properties (Molnár 2009). Unfortunately, there is a lack of detailed studies concerning the effects of fires on vegetation

properties and recovery processes, except for a few sporadic observations (e.g. Molnár 2009, Bölöni et al. 2011, Erdős et al. 2013). Detailed analyses have been carried out on the post-fire regeneration of extrazonal forest-steppes on dolomite bedrock (e.g. Tamás and Csontos 1998).

During the past few decades, some human-induced fires occurred in Hungarian forest-steppes (e.g. Bölöni et al. 2011, Erdős et al. 2013). From a nature conservation point of view, it would be desirable to gain a better understanding on their regeneration processes, so that it could be decided what kind of conservation measures are necessary to support regeneration and prevent the loss of natural values.

In this study, my aim was to observe post-fire vegetation development in a protected forest-steppe area. I compared a forest-steppe segment that burned twenty years ago with an intact segment. I wanted to find out whether the burned segment proceeds towards the original state, or a modified direction emerges, e.g. due to invasive species. My goal was also to evaluate how vegetation structure and composition differs between the two sections. I hope that my results will support efficient conservation measures.

Material and methods

The study was carried out in the protected forest-steppe area near the village Ásotthalom (south-eastern part of the Danube-Tisza Interfluve, Hungary, N 46°12', E 19°47'). The climate of this region is semiarid with mean annual temperature of 10.6°C (Ambrózy and Kozma 1990) and mean annual precipitation of 572 mm (Fröhlich in Gaskó 2009). In the study area, there are small sand dunes. Soils are humus-poor sandy soils, except for the forest stands, which have soils of slightly higher humus content and a buried layer of brown forest soil (Bodrogközy 1982). The vegetation is built up by forest patches (*Populo canescenti-Quercetum roboris*, *Populus alba* variant), fescue steppes (*Festucetum vaginatae*), annual sandy grasslands (*Secali sylvestris-Brometum tectorum*) and dwarf shrubs (*Molinio-Salicetum rosmarinifoliae*) (Bodrogközy 1957). The northern section of the study area burned down in 1996 (Gaskó 2009), while the southern part remained intact. Since the northern section was dominated by large forest patches, with only very small grasslands, the comparison of the burned and intact sites was possible only for the forest patches. Canopy cover varies between 40-60%, dominated by up to 15-16 m tall silver poplar trees (*Populus alba*). In the shrub layer, *Crataegus*

monogyna is the single typical species, although *Berberis vulgaris*, *Ligustrum vulgare* and *Rhamnus cathartica* are also frequent. The herb layer is generally sparse, but its cover increases considerably in the openings and on the edges.

For the study, 20 plots were established in the nature reserve, 20 m × 20 m each. Ten plots were randomly located in the burned area, and ten plots in the intact segment. Coenological relevés were made in May 2014. Percentage cover of all vascular plant species was estimated visually.

A PCoA analysis was carried out on presence-absence data using the program package SYN-TAX 2000 (Podani 2001). Comparison of the plots was made with the Yule coefficient.

Differential species between the two groups (burned vs. intact) were identified with the software JUICE 7.0 (Tichý 2002), by computing phi-values as indicators of species concentration in one of the relevé groups (Tichý and Chytrý 2006). Nonsignificant diagnostic species were excluded with Fisher's exact test.

For each relevé, total species number, the number of native species as well as the number of non-native species were calculated, and values were compared between the burned and intact sites, using Mann-Whitney U-test. Data were visualized with box-plots. For this analysis, I used the program Past 2.15 (Hammer et al. 2001).

The spectra of the social behaviour types and of the species' coenological preferences were used to compare the state of the burned area with the intact one; categorization was based on the work of Borhidi (1995). To assess the light conditions of the relevés, the spectra of the relative ecological indicator values for light demand were calculated, applying the indicator values of Borhidi (1995). In all cases, calculations were based on the frequency of the species.

Results

In the 20 relevés, a total of 113 plant taxa were identified. In the ordination scattergram, the groups of the intact and the burned relevés showed a moderate overlap (Fig. 1).

I found the following 14 significant differential species: *Silene otites* ($p < 0.001$); *Acer negundo*, *Dianthus giganteiformis* ssp. *pontederacae*, *Thymus pannonicus* ($p < 0.01$); *Dactylis glomerata* agg., *Medicago minima*, *Pimpinella saxifraga*, *Ranunculus polyanthemus*, *Silene latifolia* ssp. *alba*, *Solidago virga-aurea*, *Thesium linophyllum*, *Verbascum lychnitis*, *Vicia angustifolia*, *Vicia hirsuta* ($p < 0.05$). All of them were diagnostic for the burned section,

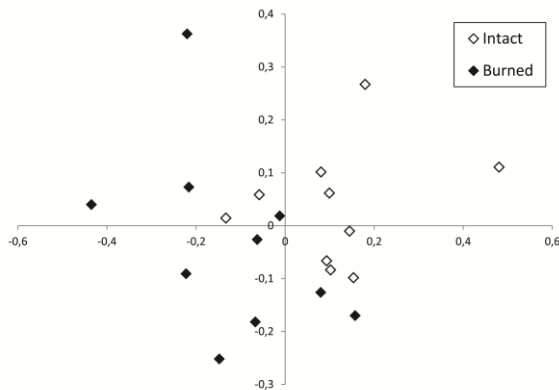


Fig. 1. Ordination scattergram of the 20 coenological relevés. Percentage variances explained by the first two axes were 30.71% and 16.65%, respectively.

while the intact section did not have any diagnostic species.

Species number was significantly ($U=3.5$, $p<0.001$) higher in the burned relevés than in the intact ones (Fig. 2a). The difference was also significant if only the native species were considered ($U=5$, $p<0.001$) (Fig. 2b). The number of non-native species was also slightly higher in the burned relevés, but the difference was not significant ($U=33$, $p<0.196$) (Fig. 2c).

Regarding the social behaviour types, no great differences could be seen between the burned and the intact sections (Fig. 3): it could not be concluded that species indicating disturbance were more frequent in either of the two groups.

If the light indicator values were considered, differences were not great, but the trend was obvious (Fig. 4). Species preferring shaded areas (categories L3 and L4) were more frequent in the intact section. In contrast, plants with a higher light requirement (categories L7, L8 and L9) were more frequent in the burned section, although the difference was minor in the case of category L7.

Species' coenological preferences differed considerably among the two groups. The greatest differences were found regarding species of natural and semi-natural grasslands and those of forests, the first group being more typical in the burned relevés, the second group in the intact ones (Fig. 5).

Discussion

Fires played an important role in the natural dynamics of the forest-steppes of the Carpathian Basin (Magyari et al. 2010). During the last few decades, several human-made wildfires have occurred in the forest-steppes of the Danube-Tisza

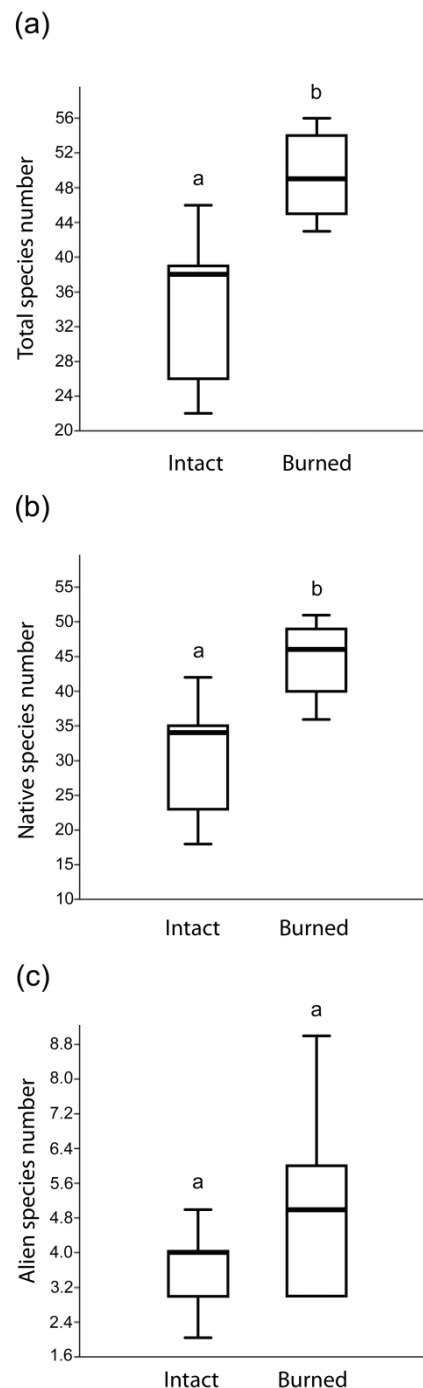


Fig. 2. Species number of the intact and the burned forest-steppes. (a) all species, (b) native species, (c) non-native species.

Interfluve (Bölöni et al. 2011), yet little is known about their effect and about the post-fire regeneration of the vegetation. The aim of this study was to contribute to the understanding of the role of fires, by comparing a burned and a neighbouring intact forest-steppe segment, almost 20 years after the fire.

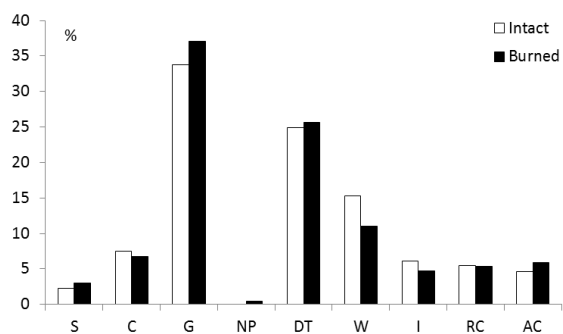


Fig. 3. Spectra of the social behaviour types in the intact and the burned sections. S: specialists, C: competitors, G: generalists, NP: natural pioneers, DT: disturbance-tolerants, W: weeds, I: introduced species, RC: ruderal competitors, AC: aggressive alien competitors (invasives).

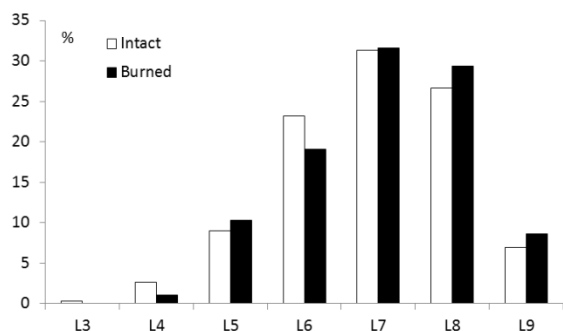


Fig. 4. Spectra of the relative indicator values for light in the intact and the burned sections.

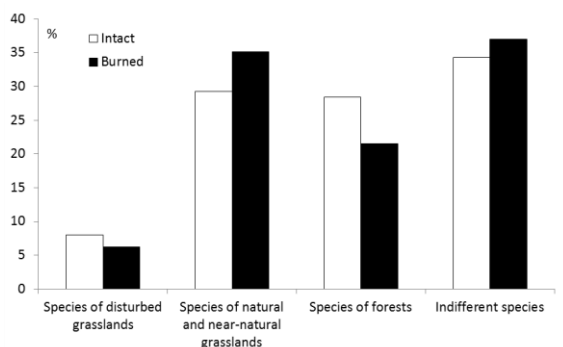


Fig. 5. Spectra of the species' coenological preferences in the intact and the burned sections.

The burned and the intact forest-steppe sections were moderately different, with a slight overlap in the ordination space (Fig. 1). Also, social behaviour type spectra did not show marked differences (Fig. 3). This probably indicates that twenty years of regeneration was not enough to reach the pre-fire conditions, but differences are not very pronounced any more. Although conclusions must be drawn with caution when using space for time substitution, it seems likely that regeneration proceeds towards the original (i.e. pre-fire) state, and not on an entirely different pathway. It has been observed that regeneration processes after the fire event may be relatively rapid, especially for the *Populus* individuals, although *Juniperus communis* regenerates slowly (Bölöni et al. 2011). The results of the present study reinforce these earlier observations. Moreover, since *Juniperus communis* does not occur in the study area, its slow regeneration does not hinder the regeneration processes of the habitat.

The differential species of the burned section were mostly plants with a high light demand (e.g. *Dianthus giganteiformis* ssp. *pontederiae*, *Medicago minima*, *Silene otites*), typical of open grasslands. The spectra of the indicator values for light demand showed a similar pattern: plants preferring shaded areas were more frequent in the intact section, while light-demanding plants were more typical in the burned relevés (Fig. 4). Similar conclusions could be drawn from the coenological preference spectra: forest-related species were more frequent in the intact relevés, and grassland-related plants were more typical in the burned section (Fig. 5). It seems that the canopy became more open due to the fire, favouring the establishment of plants of grasslands. Although *Populus alba* grows very quickly, two decades were obviously not enough for the canopy layer to close. As more and more trees reach the canopy, the light-demanding species will probably be adversely affected, although some of them may survive in the forest patches for a long period.

I found that the fire event increased the species number of the forest patches (Fig. 2). This supports the idea that fires may have been important natural disturbance events in the forest-steppes, increasing the diversity of the forest patches. However, my study has shown that the higher species number in the burned segment was partly due to the alien species. At present a high number of alien species can be found in the regional species-pool. Some of them have a competitive advantage after the fire. This has been well-known for *Robinia pseudo-acacia* (Bartha et al. 2006), but the present study has revealed that it is true for other non-native species as

well. Thus, although fires had an important role in the natural dynamics of forest-steppes, they are hazardous at present. Although post-fire regeneration may be relatively fast, the alien plants pose a considerable threat to the integrity of the forest-steppes. This is especially true for areas where alien species have higher cover values than in the study area; in those cases, they may out-compete native species (personal observation).

Given the present conditions, wildfires in the forest-steppes should be prevented in the Carpathian Basin. If they do occur, chance for the vegetation to regenerate relatively quickly becomes high when no invasive species are present. If, however invasives are present (which is the case for most regions in the Carpathian Basin), there is a high risk that they become more abundant, hindering or completely inhibiting regeneration processes. In such cases, active management is necessary to combat the invasive plants.

Acknowledgement

This research was supported by the European Union and the State of Hungary, co-financed by the European Social Fund in the framework of TÁMOP 4.2.4. A/2-11-1-2012-0001 'National Excellence Program'.

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