Final report

OTKA PD 116114

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The planned studies were performed during the three years of the project. The study design of the precipitation manipulation experiment was slightly modified because the number of available oak acorns was limited. A total of 432 acorns was used in the experiment (3 habitats × 16 replicates × 3 treatments × 3 acorns). Watering treatments and environmental measurements were carried out as planned.

For the coenological studies, the number of study plots was slightly reduced, due to the low availability of appropriate patches (mainly the number of large forest patches was limited). 440 phytocoenological relevés were prepared. Environmental measurements were carried out in these plots. DBH measurements were carried out in 1054 plots.

From the project results, four scientific articles have been published (three of them in international journals with impact factors, one of them in a Hungarian journal). Two conference abstracts have also been published (both of them in English). Two publications are currently under review. Two publications are in preparation and to be submitted in the near future.

MAIN RESULTS

1.)
A new review and synthesis on Eurasian forest-steppes

Publication:
Erdős L., Ambarlı D., Anenkhonov O. A., Bátori Z., Cserhalmi D., Kiss M., Kröel-Dulay Gy., Liu H., Magnes M., Molnár Zs., Naqinezhad A., Semenishchenkov Y. A., Tölgyesi Cs., Török P. (2018): The edge of two worlds: A new review and synthesis on Eurasian forest-steppes. *Applied Vegetation Science* 21: 345-362. IF_{2017}: 2.331

A new definition of forest-steppes was proposed: forest-steppes are natural or near-natural vegetation complexes of arboreal and herbaceous components (typically distributed in a mosaic pattern) in the temperatezone (excluding the Mediterranean), where the co-existence of forest and grassland is enabled primarily by the semi-humid to semi-arid climate, complemented by complex interactions of biotic (e.g. grazing, land use) and abiotic (e.g. soil, topography) factors operating at multiple scales. The arboreal cover (with a minimum height of 2 m) is 10%–70% across the entire landscape mosaic. The vascular vegetation cover within the grassland is at least 10%.

We gave a comprehensive overview of all forest-steppes in Eurasia, with a discussion of their biodiversoty patterns, conservation status, and prospects under ongoing climate change.

We prepared a map of the total Eurasian forest-steppe zone (Fig. 1). Also, we provided the first delineation of the main forest-steppe regions based on floristic and physiognomic characteristics as well as relief and climate features. We defined nine regions, and gave a short description for each of them.

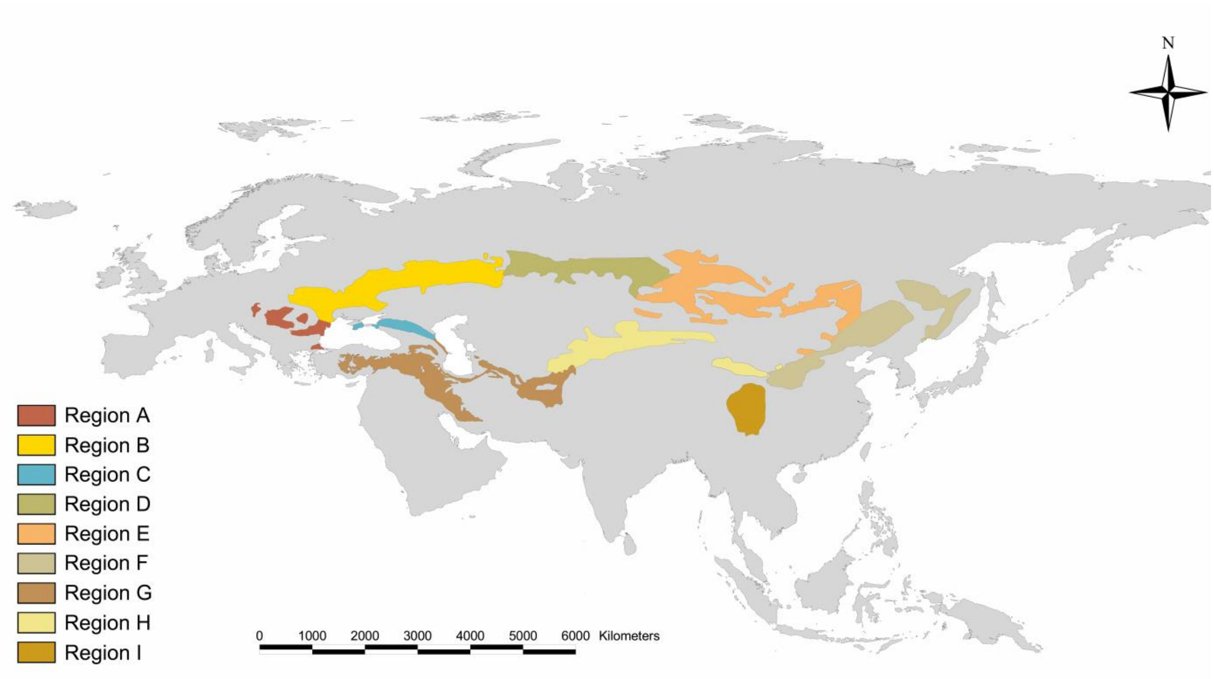

Figure 1. The distribution of Eurasian forest-steppes and the main forest-steppe regions. Region A: Southeast Europe, Region B: East Europe, Region C: North Caucasus and Crimea, Region D: west Siberia and north Kazakhstan, Region E: Inner Asia, Region F: Far East, Region G: Middle East, Region H: Central Asia and southwestern Inner Asia, Region I: eastern Tibetan Plateau.

2.)

Forest-steppe heterogeneity and its conservation implications

Publication:
Erdős L., Kröel-Dulay Gy., Bátori Z., Kovács B., Németh Cs., Kiss P. J., Tölgyesi Cs. (2018): Habitat heterogeneity as a key to high conservation value in forest-grassland mosaics. *Biological Conservation* 226: 72-80. IF_{2017}: 4.660

This study analyzed six main habitat types of the sandy forest-steppe mosaic: large forest patches (>0.5 ha), medium forest patches (0.2-0.4 ha), small forest patches (<0.1 ha), north-facing forest edges, south-facing forest edges, and grasslands. The results showed that each studied habitat contributes differently to the overall conservation value of the whole forest-steppe mosaic. The low redundancy among the individual habitats of the mosaic ecosystem emphasizes that each habitat type deserves specific conservation consideration. Thus, each habitat is important for a different reason.

Each habitat has its characteristic species composition, at least some species that are absent or rare elsewhere, and specific microclimatic conditions. In addition, the following characteristics were found for the studied habitats:

grasslands

- had the highest per plot number of species with special conservation relevance (protected, endemic, red-listed, and specialist species),
- had the highest naturalness values (i.e. grasslands were the most intact and showed almost no signs of degradation),
- were the least invaded (i.e. grasslands had the largest resistance agains invasion);

north-facing forest edges

- had the highest per plot pecies richness,
- had the highest total (i.e. pooled) species number;

south-facing edges

- had the second highest per plot species richness,
- had the highest number of native tree seedlings and saplings;

small forest patches

- had relatively high per plot species richness values,
- had considerable number of species with special conservation interest,
- were the least degraded among the forest habitats;

medium and large forest patches

- were the most invaded by non-native trees,
- but were important for structural reasons (contained large trees and many native shrus that were rare in other habitats).

Table 1 and Figs. 2-3 show some of the studied characteristics in the six habitat types of the forest-steppe mosaic.

Table 1. Stand characteristics of the six habitats in the forest-steppe mosaic. DBH: diameter at breast height. LF: large forest patches, MF: medium forest patches, SF: small forest patches, NE: north-facing edges, SE: south-facing edges, G: grasslands.

	LF	MF	SF	NE	SE	G
DBH < 5 cm						
N/ha native trees	1200.0	346.7	1146.7	2560.0	6080.0	2106.7
N/ha adventive trees	4373.3	5440.0	3040.0	3280.0	453.3	-
DBH > 5 cm						
N/ha native trees	1440.0	1360.0	1520.0	53.3	240.0	-
N/ha adventive trees	26.7	-	-	-	-	-
mean DBH (cm)	30.3	33.9	22.0	8.3	7.9	-
DBH > 50 cm						
N/ha native trees	240.0	133.3	53.3	-	-	-
N/ha adventive trees	-	-	-	-	-	-
max. DBH (cm)	68.4	70.0	62.7	10.5	16.9	-

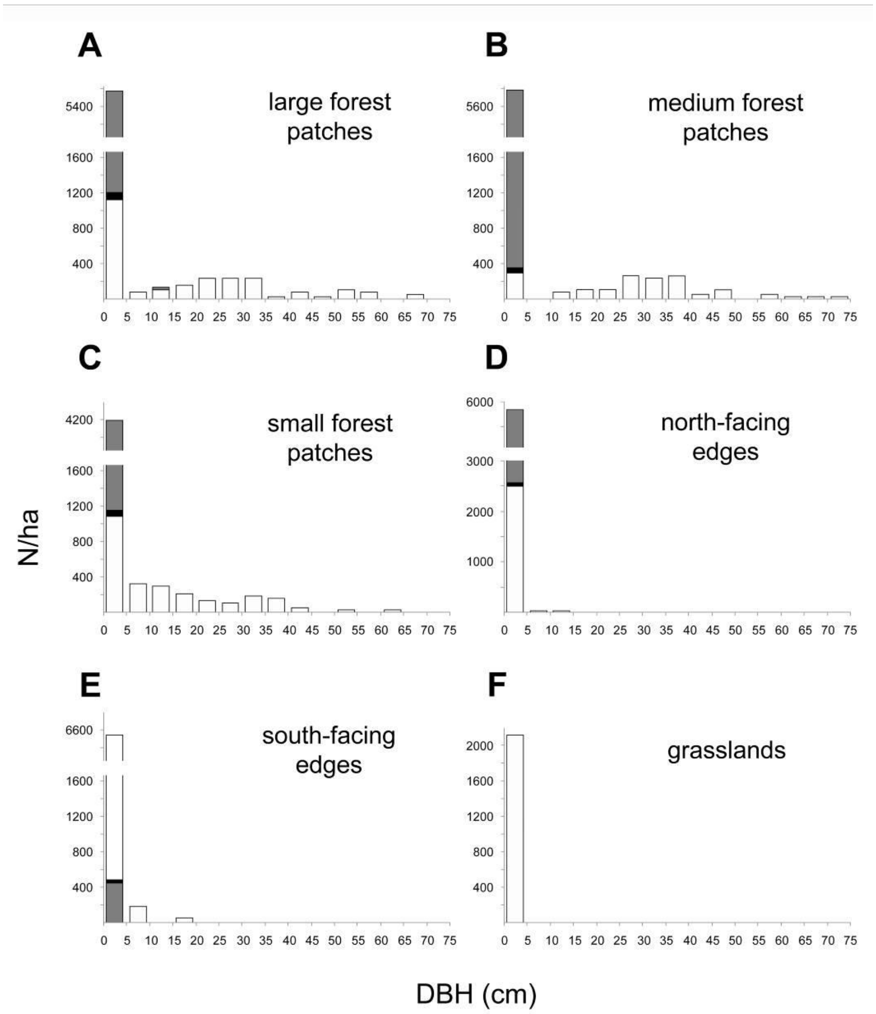

Figure 2. DBH class distribution of Populus alba + P. × canescens (white), other native trees (black), and adventve trees (grey) in large forest patches (A), medium forest patches (B), small forest patches (C), north-facing edges (D), south-facing edges (E), and grasslands (F).

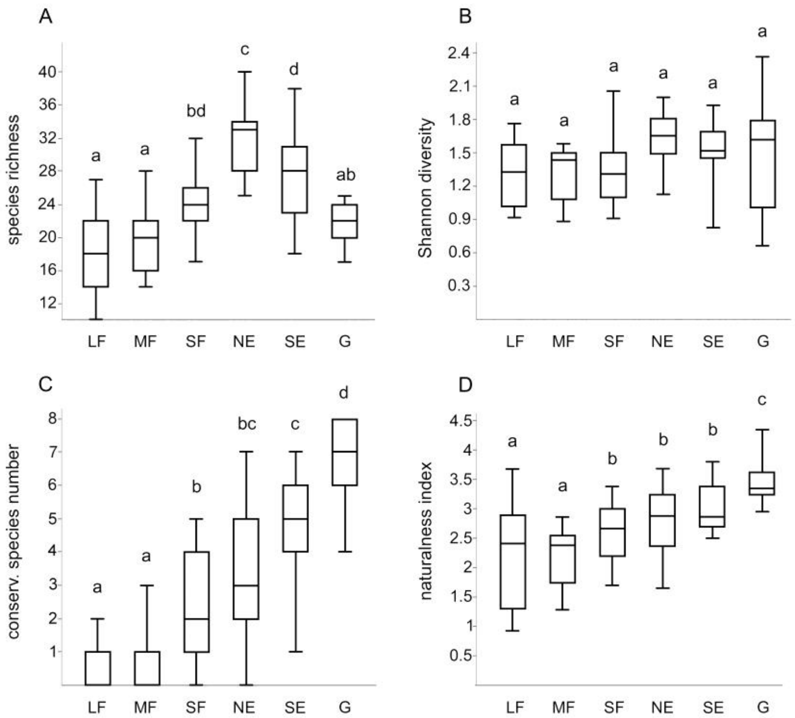

Figure 3. Species richness (A), Shannon diversity (B), the number of species with special conservation importance (C), and mean naturalness values (D) of the six habitats. Boxes not sharing a letter are significantly different. LF: large forest, MF: medium forest, SF: small forest, NE: north-facing edge, SE: south-facing edge, G: grassland. Boxes not sharing a letter are significantly (P < 0.05) different.

3.)

Gradient-like organization of forest-steppe habitats.

(Publication:
Erdős L., Szitár K., Bátori Z., Tölgyesi Cs., Török P., Kiss P. J., Kröel-Dulay Gy. Beyond the forest-grassland dichotomy: the gradient-like organization of habitats in forest-steppes. 90% ready, submission planned for December 2018.)

We found that forest-steppe habitats show a gradient-like organization regarding many characteristics, including species composition, functional species groups, and environmental parameters. This implies that the widely used dichotomic categorization of forest-steppe habitats into forest and grassland patches is inadequate and does not fit the conservation goals. Forest-steppe patterns better fit the gradient-based paradigm of landscape structure.

4.)

A comparison of vegetation patterns in two distant sandy forest-steppes

Publication:

Bátori Z., Erdős L., Kelemen A., Deák B., Valkó O., Gallé R., Bragina T. M., Kiss P. J., Kröel-Dulay Gy., Tölgyesi Cs. (2018): Diversity patterns in sandy forest-steppes: a comparative study from the western and central Palaearctic. *Biodiversity and Conservation* 27: 1011-1030. IF_{2017}: 2,828

We compared the vegetation patterns of two distant sandy forest-steppe regions: the Kiskunság (Carpathian Basin, Western Palaearctic) and the Naurzum (Kazakhstan, Central Palaearctic). Major vegetation patterns were remarkably similar in the two regions. Edges have increased per plot species richness and thus should be considered local biodiversity hotspots in both regions. Also, edges have considerable number of edge-related species. The comparative study pointed out that all components of the mosaic have outstanding conservation importance.

5.)

Centre-to-periphery gradient in the forest-steppes of the Carpathian Basin

Publication:

(Erdős L., Bátori Z., Bede-Fazekas Á., Biró M., Darányi N., Magnes M., Pásztor L., Sengl P., Szitár K., Tölgyesi Cs., Kröel-Dulay Gy. Compositional and species richness changes along a centre-to-periphery gradient in the forest-steppes of the Carpathian Basin. under review)

We examined the compositional and species richness trends along a centre-to-periphery gradient in the Carpathian Basin. Studies were performed at five sites. At each site, six habitat types were investigated. In addition, we also examined abiotic environmental factors, such as climate, soil, and land-use history, which potentially underlie the observed vegetation phenomena.

There was an apparent increase in the richness of native species in some habitats (Fig. 4). although different species groups reacted differently to the gradient. We also studied the trend for different phytocoenological species groups separately. We found that the different species groups and the different habitats reacted differently to the gradient: there was an increasing species richness trend towardy the periphery for some, but not all species groups, and for ome, but not all habitat types.

In addition to the species richness trends, we found a well-defined compositional change along the gradient, which was associated with climatic, soil, and land-use variables. Aridity seemed to play a major role in forming the above species richness trends.

The studied gradient may be used for tentative predictions regarding vegetation responses to continuing aridification (space-for-time substitution). A significant decrease in species richness may be expected with ongoing global warming. However, the conspicuous differences among the studied habitats and the different phytosociological preference groups suggest that the negative effects of climate change may be mitigated by protecting the highest possible diversity of both habitats and phytosociological groups, as some of them will be less affected by increasing temperature and decreasing precipitation. Preserving forest-steppe diversity and heterogeneity may thus be understood as an insurance policy against the effects of global environmental changes.

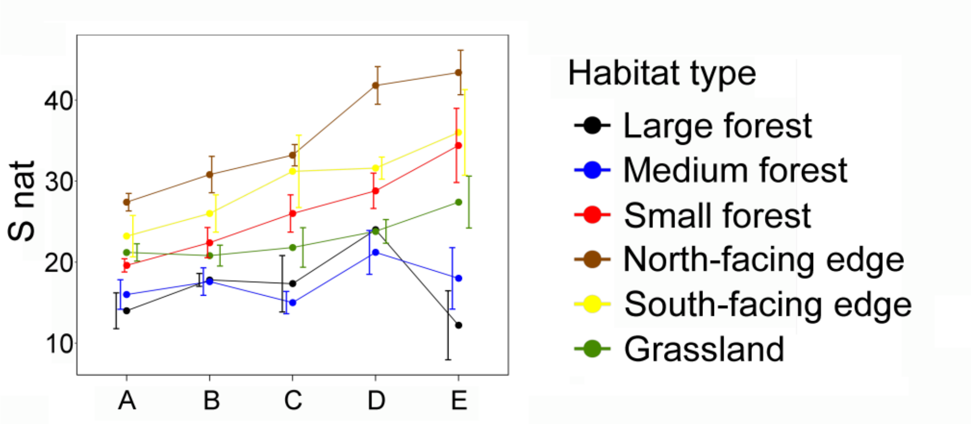

Figure 4. Per plot species richness (mean ±SE) of native species in the different habitats along the studied gradient. For clarity, error bars are shifted horizontally within each category. The sites are from north to south as follows: A: Fülöpháza, B: Bócsa, C: Pirtó, D: Kéleshalom, E: Négyestelep.

6.)

The effects of habitat type and precipitation on oak seedling emergence and survival

Publications:

Erdős L., Ónodi G., Kröel-Dulay Gy. (2017): The effects of habitat type and precipitation on Quercus robur seedling emergence and survival. In: 1st International Conference on Community Ecology, Book of Abstracts. Akadémiai Kiadó, Budapest, pp. 44-45.

(Erdős L., Baráth K., Ónodi G., Kertész M., Tölgyesi Cs., Bátori Z., Orbán I., Somay L., Kröel-Dulay Gy.: The effects of habitat type and precipitation on Quercus robur seedling emergence and survival. 60% ready, submission planned for 2019.)

In the frame of the precipitation manipulation experiment, artificial watering was applied and the emergence and survival of oak seedlings was checked regularly during the growing season. Generally, both abiotic and biotic backround factors (canopy closure, soil moisture, bare sand cover, lichen cover, leaf litter cover, moss cover) differed significantly between forest interiors and grasslands. Edges were intermediate in some cases, but in other cases they were similar either to the forest or the grassland. Seedling emergence and survival was similar in forests and edges. In both habitats, emergence occurred a bit earlier in the watered plots, but the differences disappeared later (in summer). Emergence and survival was very poor in grasslands. This was the only habitat where considerable differences were observable between the watered and unwatered plots. Seedling performance at the end of the growing season (measured as: number of live seedlings, number of leaves, leaf area, seedling height) was similar in forests and edges, but was significantly weaker in grasslands. Generally, treatment (watered vs. non-watered) had no effect on performance in most cases. There was a marginally significant effect on live seedling number and seedling height in the case of grasslands.

7.)
Floristic results

Publications:
Aradi E., Erdős L., Cseh V., Tölgyesi Cs., Bátori Z. (2017): Adatok Magyarország flórájához és vegetációjához II. *Kitaibelia* 22: 104-113.

(Erdős L., Aradi E., Bátori Z., Tölgyesi Cs.: Adatok Magyarország flórájához és vegetációjához III., under review)

As a by-product of my researches I found new localities of the following species (exact locations with flora mapping quadrates):

Botrychium lunaria in Imrehegy [9582.1],
Tephroseris integrifolia in Imrehegy [9582.1],
Jurinea mollis in Táborfalva, lőtér [8882.3],
Polygonatum latifolium in Kéleshalom, Kéleshalmi homokbuckák TT [9682.1],
Luzula campestris in Kisszállás, Jánosteleki-erdő [9783.2],
Carex humilis in Kisszállás, Jánosteleki-erdő [9783.2],
Epipactis atrorubens in Táborfalva, lőtér [8882.3],
Cephalanthera longifolia in Ásotthalom, Emlékerdő [9784.4].