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ASSESSMENT OF ECOLOGICAL VALUES OF GREENING LANDSCAPE ELEMENTS IN THE GREAT HUNGARIAN PLAIN

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Abstract

The research examines the effects of agricultural subsidies on the landscape structure. According to the hypothesis, greening – which has been introduced as part of the European Union's Common Agriculture Policy (EU CAP) reform –, if it is properly controlled and applied, can be a suitable tool for habitat network development. Landscape elements eligible for greening can function as significant landscape structural elements, and can promote the achievement of goals e.g. in the preservation of biodiversity. As part of this research, field surveys were performed in 2016 and 2017 in the Great Hungarian Plain, where significant landscape elements were assessed and documented in the sample area. During the research, Shape Index and Fractal Dimension Index values for polygonal elements were calculated based on their current extensions in 2016 and in 2017. In line with my basic hypothesis, eligible landscape elements (such as hedgerows, stonewalls, shadoofs and infield trees) do not possess extraordinary ecological values, nor can their persistence be guaranteed solely with greening subsidies. Therefore, they may also not be able to fill their role in the protection of landscape structure and biodiversity in the long term.

Keywords: greening, landscape element, EFA, landscape structure, landscape indicator, Shape Index, Fractal Dimension Index

INTRODUCTION

According to the 2013 CAP reform, EU member states are obliged to use 30 percent of their agricultural subsidies for environmental goals, collectively called as greening. In the greening starting in Hungary in 2015, farmers have to fulfil criteria in three areas in order to receive subsidies: (1) maintaining permanent grasslands, (2) crop diversification and (3) designation of ecological focus areas (EFAs) (Greening regulation, 2015). Landscape planners could be especially involved in the designation of EFAs, as these can mostly be identical to landscape elements which are to be protected or have ecological values (Allen et al. 2012). The main goal of the new agricultural subsidies is the protection of water and soil quality, and the preservation of biodiversity and rural agrarian landscapes (EU regulations 1307/2013 (44)). A long-term goal is the adaptation and mitigation of climate change. The experiences of the first year are worrying in terms of whether opportunities in landscape development provided by these subsidies can be exploited, and whether the measures serve the protection of truly valuable conservation areas (Matthews, 2015; Máté, 2017). This study attempts to answer a question if among greening landscape elements, those elements are really subsidised which are justifiably more stable ecologically. Thus, it is examined whether the selection of eligible landscape elements is a result of consequent, professional decisions or they may have been selected without proper consideration, rather accidentally – which would constitute a long-term threat. The subsidies may have drawn the attention of not only the farmers but also landscape planners, ecologists, conservationist and other nature-related professionals, as they could effectively contribute to the improvement of landscape structure connectivity, to the increase of biotope network stability and even to halting the decrease of biodiversity (Máté and Kollányi, 2016).

The delivery of obligations and undertakings of Hungarian farmers is supported by the Hungarian Land Parcel Identification System (MePAR). MePAR is the exclusive, country-level system used in the subsidy processes (MePAR regulation, 2015). On the online interface, every farmer and interested parties can search for their own parcel, of which they can learn further information thanks to the rich GIS background database.

At the end of 2015, the database has been extended with greening landscape elements, thus farmers can see which of them are EFA eligible. According to the regulation, EFAs can be: fallow lands, terraces, landscape elements, buffer strips, eligible forest edges, agroforestry, short-rotation coppice, catch and cover crops, and nitrogen fixing crops (Kovács et al., 2015). Landscape elements can be the following habitats: field margins with trees, single trees, tree lines, tree and shrub groups, field margins, ponds, and ditches. The preservation of permanent grasslands and crop diversification are important for landscape structure mosaics. In addition, the conservation and creation of EFAs may bring significant changes in the ecological and biotope network.

The protection of the ecological networks is especially important as nowadays, fragmentation – the break-up of natural habitats – is one of the most significant threats to communities (Didham, 2010). The role of landscape ecology is examining correlations in patterns, i.e. landscape structure, and various ecological processes (Turner, 1989). Human activities have a large impact on patterns which also has an effect on biodiversity (Moser et al., 2002). During land use, natural mosaics and man-made patches form a fragmented landscape, where interconnection of natural habitats is not ensured in all cases (Turner et al., 2001). Bigger interconnected natural or semi-natural areas have become very rare by today. Fragmentation negatively affects the survival of communities and does not only result in a shrinking habitat, it can also have negative consequences regarding biodiversity and species distribution (Mairota et al., 2013). The widely known island biogeographical theory of MacArthur and Wilson (1967) can be applied with slight adjustments also to mainland habitat islands. According to the theory, larger islands have more species, and the larger the distances of the islands, the lower the number of species is. Wilson and Willis (1975) recognised that laws of island biogeography have important consequences for planning in protected areas. Thus, it is preferable that the protected area be in a single block; have a rounded shape, i.e. a low perimeter-area ratio; and – if fragmented – have its fragments close to each other and have corridors between them. It is important however to mention a debate in conservation biology still current today: the so-called SLOSS debate. It raises the question whether a fewer but larger, or more but smaller patches make the planning of protected areas more effective regarding biodiversity and connectivity.

Landscape indicators have proven to be very popular and efficient in the quantification of landscape patterns (Gustafson, 1998). Most landscape indicators are based on the perimeter-area ratio. One of the most basic patch-level indicator is the Perimeter-Area Ratio (PARA) itself. Most landscape ecology indicators examining patch shapes are based on this ratio. The most common criticism of the PARA indicator is that its value may change with the size of the patch. This error is fixed by the Shape Index (SHAPE) indicator which compares the shape of a patch with a square of the same size, and which is widely used in landscape ecology researches (Forman and Godron, 1986). Another patch-level index based on the perimeter-area ratio is the Fractal Dimension Index (FRAC). It is well known that the more compact shape a patch has, the more stable habitat it can provide for – as it is less affected by the so-called edge effect (Helzer and Jelinski, 1999). Shape Index has an interval of 1 to +∞, while Fractal Dimension Index has an interval of 1 to 2 (Szabó, 2009). Both indices indicate a regular patch shape with 1, and higher values mark a higher irregularity.

In this study, greening elements surveyed in a Hungarian sample area are examined using the demonstrated landscape indices, in order to have a clearer picture on what ecological values do those greening landscape elements have which are supposed to meet the goals of biodiversity protection and landscape structure.

STUDY AREA

The sample area is an about 120 km^2 large on the Dévaványa-Ecseg fluvial plains, in the operational area of Körös–Maros National Park, on the south-western edge of the former Great Sárrét region (Fig. 1). An important characteristic of the area are the mosaics of saline plain remnants in the vicinity of the settlements Ecsegfalva and Dévaványa. These saline plains had been formed by secondary salinisation following the regulation of river Tisza (from 1846). The floodplain grasslands, once rich in grass, had dried out, become salinated, and been placed under cultivation by local inhabitants (Sallai, 1999). However, even the ploughing of grasslands had not caused the complete extinction of native species, thus certain species of the former plain grasslands have been preserved in the secondary saline communities and weed communities with wild flowers peculiar to the Transtisza region (Dövényi, 2010). Some parts of the sample area are under various nature protections – there are local protected areas, highly protected areas, Natura 2000 and National Ecological Network core areas, buffer zones and corridors; also, the entire sample area is part of the "Dévaványa and surroundings high natural value area".

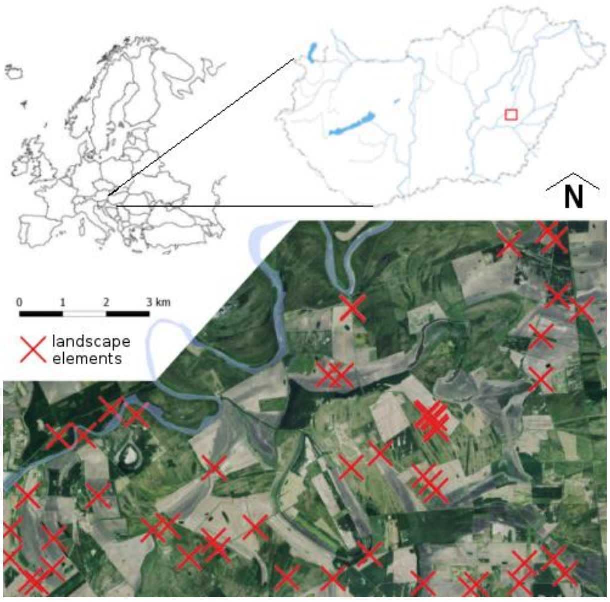

Fig. 1 Location of the sample area and assessed elements

The region belongs to the significant agricultural areas of Hungary. The islands of protected areas are surrounded by intensively cultivated arable lands. In the designation of the sample area, both natural and artificial landscape boundaries were taken into account. Thus, the sample area is bordered by the unregulated river bends of Hortobágy-Berettyó to the west, road 4205 connecting Ecsegfalva and Dévaványa to the north and to the east, and dirt roads with larger agricultural traffic to the south.

METHODS

Preparations for the field survey were made using QGIS 2.10.1 Pisa (QGIS, 2010). EFA eligible elements were displayed using MePAR symbols. The path of the field survey was planned in a way that it passes by all EFA elements in the sample area. The first field survey was performed between 12 July and 13 August 2016, and the second one between 8 and 10 September 2017. Both EFA elements and other non-EFA elements – in total, 48 point, linear and polygonal elements – were assessed. Among the data assessed on the spot were: EFA type verification, general ecological and condition attributes, species composition, GPS coordinates for later display on map, and photo documentation of all elements.

As part of processing the field work, a GIS database was built which contained all the assessed elements. The shapes of the assessed patches were drawn based on their shapes in MePAR in case of EFA landscape elements, and as a result of merging field survey data with cartographic post-production in case of non-EFA elements. The Shape Index and the Fractal Dimension Index of these shapes was then calculated in ArcGIS 10, using the V-LATE extension. In the GIS database, Shape Index and Fractal Dimension Index values and photo ID numbers were registered, along with year, the fact of EFA eligibility, ecological condition and species composition, and in some cases an additional note (e.g. terminated EFA eligibility or disappeared element) (Table 1). The structure of the database allows for incorporating results of studies in the following years as well, and for comparison of the results.

In this study, only the Shape Index (SHAPE) and Fractal Dimension Index (FRAC) of patch-like EFA and non-EFA landscape elements were examined, as their values can be calculated only for this type of elements. 22 landscape elements were examined, which can be divided into two categories: tree and shrub groups, and ponds. First eligible and non-eligible elements were examined using Student's t-test, but as the conditions of normality and homogeneity of variance were not fully met, a simpler yet more reliable analysis was needed. After individually calculating both indices of each 22 patch-like elements, the averages of the values were calculated in each group for each year, differentiating EFA and non-EFA elements. For a preliminary overview, understanding and sanitisation of data, they have been displayed as bar graphs in Microsoft Excel software.

During the field surveys, pictures were taken of every element, which can be used not only for documenting year-to-year changes but also for visually comparing "protected" and "not protected" landscape elements. The collation of the photo documentation was an especially important step of the annual field survey, as it could also be regarded as an annual monitoring of landscape elements in the sample area. The photo documentation was performed for all surveyed elements both in 2016 and 2017. As for linear landscape elements, there was no basis for comparison, as tree lines defined in the greening starting in 2015 were still not visible in MePAR in summer 2016. It should also be noted that the EFA designation of tree lines are professionally objectionable. As

Table 1 Surveyed polygonal elements and their attributes

Nr	Landscape element type	Dominant species	EOV coordinates of centroids		2016			2017		
			X	Y	EFA	SHAPE	FRAC	EFA	SHAPE	FRAC
001	tree and shrub group	*Robinia sp.*	193585.88	780233.37		1.24	1.37		1.24	1.37
002	tree and shrub group	*Robinia sp.*	192963.25	780231.38	x	1.39	1.44	x	1.20	1.43
003	tree and shrub group	*Robinia sp.*	192453.76	780685.41	x	2.09	1.53	x	2.09	1.53
004	tree and shrub group	*Robinia sp., Fraxinus sp.*	192368.25	780867.80	x	1.68	1.47	x	1.37	1.43
006	tree and shrub group	*Robinia sp.*	193359.50	781262.40		5.61	1.64		5.61	1.64
014	tree and shrub group	*Robinia sp.*	197110.67	787860.39		1.12	1.30		1.12	1.30
016	tree and shrub group	*Robinia sp., Populus sp.*	196268.89	789875.49		1.15	1.50		1.15	1.50
019	pond	*Phragmites sp.*	196140.55	790019.94		1.35	1.38		1.35	1.38
020	tree and shrub group	*Populus sp.*	195972.77	790024.31		2.39	1.59		2.39	1.59
021	tree and shrub group	*Populus sp.*	195884.43	790061.47		1.20	1.49		1.20	1.49
024	tree and shrub group	*Robinia sp., Salix sp.*	194492.93	790048.27	x	1.25	1.50	x	1.25	1.50
025	tree and shrub group	*Robinia sp.*	195334.15	788756.92		1.25	1.36		1.25	1.36
031	tree and shrub group	*Robinia sp., Salix sp.*	198939.82	792832.33	x	1.58	1.42		1.58	1.42
033	tree and shrub group	*Robinia sp., Salix sp., Quercus sp., Fraxinus sp.*	197989.55	792549.66		2.25	1.42		2.25	1.42
034	tree and shrub group	*Fraxinus sp.*	197051.64	792482.59	x	1.81	1.48	x	1.79	1.48
035	tree and shrub group	*Robinia sp.*	192918.89	792775.08	x	1.41	1.38		1.41	1.38
036	tree and shrub group	*Robinia sp., Salix sp.*	192588.15	793034.73	x	1.27	1.37	x	1.27	1.37
038	tree and shrub group	*Salix sp., Robinia sp.*	192368.43	791992.98		3.60	1.67		3.60	1.67
039	tree and shrub group	*Robinia sp.*	192342.62	790979.08		1.42	1.53		1.42	1.53
040	pond	*Carex sp.*	192213.82	790846.07	x	1.19	1.35	x	1.19	1.35
044	tree and shrub group	*Robinia sp.*	193130.75	785019.50		3.10	1.58		3.10	1.58
047	pond	*Salix sp., Phragmites sp.*	193684.56	783867.91		1.16	1.37		1.16	1.37

of 2017, the MePAR layer for tree lines is available. Unfortunately however, on the 120 km^2 sample area there is not a single official EFA tree line.

RESULTS

Shape Index and Fractal Dimension Index values of the assessed elements

The averages of SHAPE values for each eligible and non-eligible EFA types in 2016 and 2017 can be seen on Figure 2. It can be stated that in general, EFA-eligible patch-like landscape elements have lower SHAPE values in the sample area in both years, thus they can be regarded as ecologically somewhat more stable than non-eligible elements. The figure shows that eligible landscape elements in 2016 have a higher SHAPE (1.52) value, thus are ecologically somewhat less stable than eligible elements assessed in 2017 (1.45).

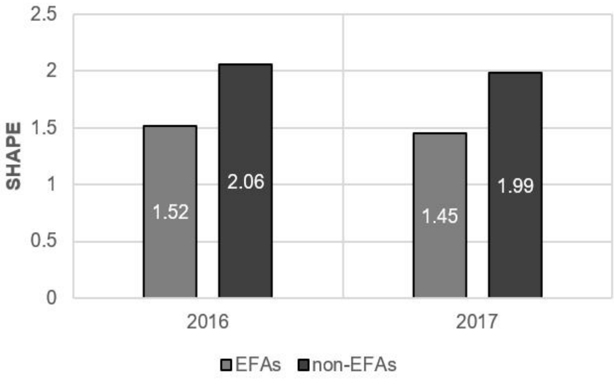

Fig. 2 Average SHAPE values of the assessed elements in 2016 and in 2017

No significant change can be demonstrated in FRAC values in the assessed EFA landscape elements from 2016 to 2017 (Fig. 3), and the change in FRAC values of non-EFA elements is also negligible from 2016 to 2017 (0.01).

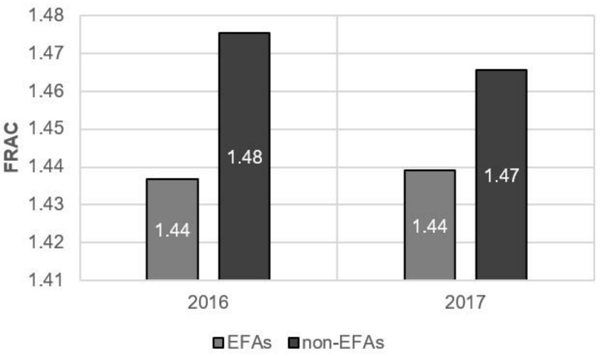

Fig. 3 Average FRAC values of the assessed elements in 2016 and in 2017

There is a similar tendency in the 2016 and 2017 SHAPE values of the assessed tree and shrub groups in the sample area to the overall values (Fig. 4). In 2016, the Shape Index value of EFA tree and shrub groups was 1.56, which decreased to 1.49 in 2017. This means that based on their SHAPE value, these groups are more stable. A similar change can be observed for non-EFA elements. In 2016, the SHAPE value was 2.21, while in 2017 it decreased to 2.10. As for ponds, there is no change over the two years.

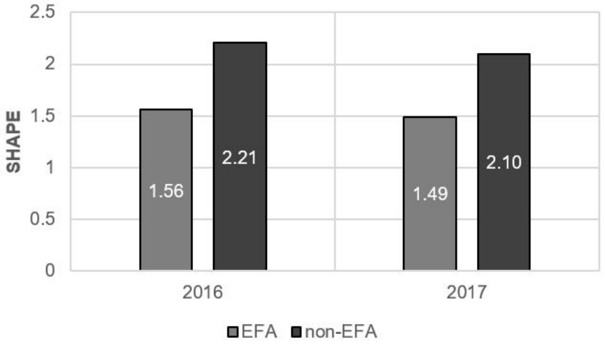

Fig. 4 Changes in the Shape Index of the assessed tree and shrub groups in 2016 and in 2017

Differences in the assessed elements

Although we could get a relatively relieving result when examining the Shape Index and Fractal Dimension Index of the assessed elements, as EFA elements have lower values, yet concerns for valuable landscape elements are not unfounded. The following examples demonstrate that for elements of each dimensional type (point, linear and polygonal), valuable elements have not been selected in all cases as EFA elements.

In the case of point landscape elements, the main groups are shadoofs, tumuli and individual trees. The comparison of the following two individual trees is an instructive example. The Populus in Figure 5a (2016) and 5b (2017) is not listed as an EFA element, despite meeting all prerequisites. The tree in Figure 5c (2016) and 5d (2017) is an individual tree EFA element in MePAR even though it barely fulfils the preconditions.

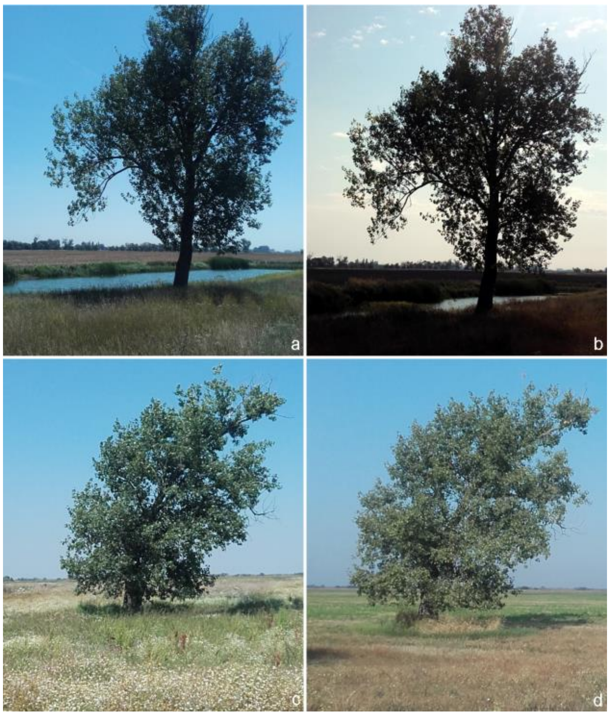

Fig. 5 Non-EFA individual tree (a and b) and EFA individual tree (c and d) in 2016 and 2017 (K. Máté)

Fig. 6 Officially non-eligible tree lines in 2016 and 2017 (K. Máté)

Tree lines in Figure 6a and 6b are officially not regarded as EFA elements, despite their very significant role in the landscape structure both as a habitat and as a protection for arable lands. They can be defined as significant landscape character elements in the intensively cultivated agricultural landscape.

Among polygonal elements, the greatest contrast was discovered regarding ponds. In Figure 7a (2016), the pond (a former borrow pit) fulfils all criteria, has clean water, is surrounded by arable lands but also by a lakeside margin. Its ecological value is outstanding in its area, a high diversity of species was observed during the field surveys, it is a favourable bird resting place. Still, it is not EFA eligible. However, the former borrow pit which dried up and became filled with soil (Fig. 7b (2016)) is eligible. The difference between the two landscape elements is obvious, the difference in their EFA eligibility is harder to grasp. No change was found in these two ponds during the 2017 field survey. The pond with a large open water surface is still not EFA eligible, while the EFA eligible pond still has low ecological value. The only change regarding the latter is that dry trees standing on the side of the lake bed have been removed by 2017.

Fig. 7 Non-EFA eligible (a) and EFA eligible (b) ponds in 2016 (K. Máté)

Changes in eligibility and conditions

During the 2017 survey, on numerous occasions, the decrease or complete cessation of the eligible area of a landscape element was observed. The field margin in Figure 8a (2016) and 8b (2017) was placed in the category of permanent, not sensitive grasslands in 2016. As for its species composition, it was mostly composed by agricultural weed species. By the 2017 field survey, the grassland field margin could not be found any more: it has been cultivated together with the field and was sowed with sunflowers.

Fig. 8 A disappeared permanent, not sensitive grassland field margin in 2016 (a) and in 2017 (b) (K. Máté)

DISCUSSION

Based on the results it can be stated that the concerns of experts regarding appropriate designation of greening elements is well-founded. No significant difference can be demonstrated between SHAPE and FRAC values of EFA-eligible and non-eligible elements, the year-to-year changes however show a rising trend in the ecological stability of patches. It has to be added though that no far-reaching conclusions can be drawn from a two-year set of data. The minimal change in SHAPE and FRAC values can be explained by the fact that two surveyed tree and shrub groups were EFA-eligible in 2016 but were removed from the MePAR layer for eligible elements in 2017 – thus, there was a difference in the number of elements in the EFA and non-EFA groups. Still, the experiences of the field survey imply that there are certain eligible elements which are ecologically insignificant, and there are “not protected” elements which represent significant ecological value and can contribute to the structural stability of the landscape. The shrinking of eligible areas on MePAR layers did not appear in the landscape in the range of one year, no significant felling took place from one year to the other in tree and shrub groups or in tree lines.

These hidden pitfalls however may have their effect on the landscape structure elements in the long term. The area shrinking of officially eligible tree group patches in MePAR may be followed by an actual shrinking in reality. The slow but gradual expansion of fields at the expense of dirt roads or grassland field margins is a commonplace issue, as it was shown. Similar problems can be expected regarding tree and shrub groups – the unified area-based subsidisation and the hectare-based support of greening may both be incentives for farmers to keep only those patches for which they can receive subsidies. Ecological values play no significant role in these cases.

The decrease of SHAPE values of the EFA elements from 2016 to 2017 can be seen in Figure 2. The 0.07 decrease does not allow for far-reaching conclusions, also because of the low number of elements; however, there are real changes in areas and shapes behind this figure which bring a demonstrable result based on the methodology. The changes of SHAPE values of tree and shrub groups seen in Figure 4 can be traced back to similar reasons. Of the surveyed elements, two EFA tree and shrub group elements have disappeared by 2017 (number 031 and 035), thus farmers could not receive subsidies for their preservation this year. The SHAPE and FRAC values of elements 002 and 004 have decreased, while in case of element 034 only the SHAPE value has changed. The decrease of the overall value shows a positive change in the patch shapes regarding ecological aspects.

In Figures 2, 3 and 4, a small change can be demonstrated for non-EFA elements. The reason behind this may be the reclassification of two formerly EFA tree and shrub groups to the non-EFA group in 2017. As for the SHAPE and FRAC values of individual non-EFA elements, no change can be demonstrated based on Table 1. This stagnation is due to the fact that unlike annually updated MePAR layers for EFA elements, there is no annually updated patch designation for non-EFA elements. Therefore, an annual change for non-EFA elements can be demonstrated only in case a significant change in area can be perceived during the field surveys which can be represented in a GIS system. Comparing the areas of EFA and non-EFA elements is thus recommended only with great caution.

As Table 1 shows, *Robinia pseudoacacia* is the dominant species in a major part of tree and shrub groups in the sample area. The composition of vegetation is a key in defining the ecological values. Unfortunately, the occurance of native woody plants is scattered, and they can be mostly found in the highly protected national park areas. Thus, greening landscape elements marked as protected and ecologically significant are in most cases actually patches consisting of the invasive *Robinia pseudoacacia*.

CONCLUSIONS

In the study, the shapes of 22 patch-like greening landscape elements and the landscape metrics analysis of their changes over two years is shown. Based on landscape indices, patches have become more compact from 2016 to 2017 according to both the Shape Index and the Fractal Dimension Index. However, the positive trend displayed by these patch indices are overshadowed by the findings of the field survey, namely that the dominant species of all patch-like element was the *Robinia pseudoacacia.*

The experiences of the research amplify concerned voices regarding the success of greening. It is important to emphasize that financial incentives do not lead farmers towards the goals that had been originally defined. The fundamental goal of greening is the protection of biodiversity – however, the inappropriate EFA designation renders its achievement impossible, if tree groups consisting of invasive species and dried-up lake beds are also eligible for support and protection. It is necessary to raise the awareness of farmers to the ecological values of elements like tree lines consisting of native species, tree groups hiding nests of birds of prey or lakes with permanent water surface.

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References

Allen, B., Buckwell, A., Baldock, D., Menadue, H. 2012. Maximising Environmental Benefits through Ecological Focus Areas. LUPG UK.

Didham, R. K. 2010. Ecological Consequences of Habitat Fragmentation. Encyclopedia of Life Sciences Published Online: 15 nov 2010

Dövényi, Z. 2010. Inventory of microregions in Hungary, Hungarian Academy of Sciences, Geographical Institute, Budapest. (In Hungarian)

European Parliament and Council, resolution No. 1307 of 2013 (XII. 17.) about establishing rules for direct payments to farmers under support schemes within the framework of the common agricultural policy and repealing Council Regulation (EC) No 637/2008 and Council Regulation (EC) No 73/2009

Forman, R. T. T., Godron, M. 1986. Landscape Ecology. Wiley.

Gustafson, E. J. 1998. Quantifying landscape spatial pattern: what is the state of the art? *Ecosystems* 1, 143–156. DOI: 10.1007/s100219900011

Helzer, C. J., Jelinski, D. E. 1999. The relative importance of patch area and perimeter–area ratio to grassland breeding birds. *Ecological Applications* 9(4), 1448–1458. DOI: 10.2307/2641409

Kovács, M., Kránitz, L., Madarász, I., Magyari, R., Palakovics, Sz., Pethő, J., Rezneki, R., Szabó, E., Szerletics, Á., Sztahura, E., Tengerdi, G., Zemle, V. 2015. Greening Handbook for Farmers. Nemzeti Agrárgazdasági Kamara, Budapest. (In Hungarian)

MacArthur, R. H., Wilson, E. O. 1967. The Theory of Island Biogeography. Princeton University Press

Máté, K. 2017. Examination of greening landscape elements. In: Blanka, V., Ladányi, Zs. (eds): Interdiszciplináris tájkutatás a XXI. században: a VII. Magyar Tájökológiai Konferencia tanulmánykötete, 417–424.

Máté, K., Kollányi, L. 2016. The potential impact of greening as a directed land use on the landscape structure. In Valánszki, I., Jombach, S., Filep-Kovács, K., Fábos, J. Gy., Ryan, R. L., Lindhult, M. S., Kollányi, L. (eds), Greenways and Landscapes in Change – Proceedings of 5th Fábos Conference on Landscape and Greenway Planning. Budapest, 30 June, 2016, 79–87.

Mairota, P., Cafarelli, B., Boccaccio, L., Leronni, V., Labadessa, R., Kosmidou, V., Nagendra, H. 2013. Using landscape structure to develop quantitative baselines for protected area monitoring. *Ecological indicators* 33, 82–95. DOI: 10.1016/j.ecolind.2012.08.017

Matthews, A. 2015. Delivering biodiversity through the common agricultural policy. In: Ó hUallacháin, D. Finn, J.A. (eds.) Farmland Conservation with 2020 Vision, Teagasc, Wexford, 10–11.

Ministry of Agriculture of Hungary, resolution No. 10 of 2015 (III. 13.) about greening (Greening regulation) (In Hungarian)

Ministry of Agriculture of Hungary, resolution No. 71 of 2015 (XI. 3.) about the Hungarian land parcel identification system (MePAR) (MePAR regulation) (In Hungarian)

Moser, D., Zechmeister, H.G., Plutzar, C., Sauberer, N., Wrbka, T., Grabherr, G., 2002. Landscape patch shape complexity as an effective measure for plant species richness in rural landscapes. *Landscape Ecol.* 17, 657–669. DOI: 10.1023/a:1021513729205

Quantum GIS Development Team (2010). Quantum GIS Geographic Information System. Open Source Geospatial Foundation Project. http://qgis.osgeo.org

Sallai, R. B. 1999. Field trips around Túrkeve, Herman Ottó Természetvédő Kör, Túrkeve. p.7.

Szabó, Sz. 2009. Examining potential applications of landscape metrics in landscape Analysis. Habilitation dissertation. University of Debrecen, Faculty of Science and Technology, department of Landscape Protection and Environmental Geography. Debrecen.

Turner, M. G., Gardner, R. H., O'Neill, R. V. 2001. Landscape ecology in theory and practice: pattern and process. Springer-Verlag, New York.

Turner, M.G., 1989. Landscape ecology: the effect of pattern on process. *Ann. Rev. Ecol. Syst*. 20, 171–197. DOI: 10.1146/annurev.es.20.110189.001131

Wilson, E. O., Willis, E. O. 1975. Applied biogeography. In M. L. Cody and J. M. Diamond (eds.) Ecology and evolution of communities. Harvard University Press, Cambridge, Massachusetts, USA, 522−534