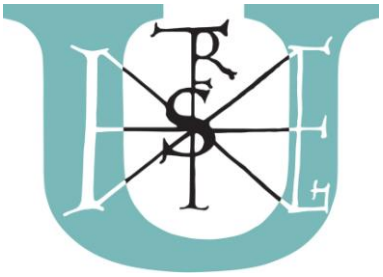

SZENT ISTVÁN UNIVERSITY

COMPARATIVE ANALYSIS OF LANDSCAPE-SCALE BIODIVERSITY INDICATORS BASED ON ORNITHOLOGICAL SURVEYS

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1. BACKGROUND, OBJECTIVES

The comparative analysis and assessment of certain landscapes and landscape units is an effective tool for decision makers to arrive at appropriate land use decisions. Most biodiversity indicators were developed for agricultural regions, primarily on a national and global scale. Most of the decisions on the use of land is made locally, therefore the need to support decision making is most intense on the local and regional level. In order to adapt to this demand, numerous international and regional indicators have been elaborated in recent years, and each of these indicators have a 'special approach' to landscape. Several ones are available to evaluate naturalness of different agricultural landscapes.

During my doctoral research I reviewed and evaluated the professional literature about the international and Hungarian biodiversity indicators and their underlying assessment principles, and studied simple and aggregated international biodiversity indicators. I investigated the role of plants and birds as bio-indicators in the assessment of ecosystem health, and summarized the Hungarian applications of biodiversity indicators.

During the doctoral research I compared biodiversity indicators based on plant and bird communities in eight mosaic landscapes in Hungary, dominated by a mixture of agro-ecosystems and grasslands. The assessed indices characterize the landscape from the point of view of the sessile plants and the vagile birds. Bird communities were described using several assemblage-level (number of species, total abundance and Shannon diversity), as well as species-level (the presence of 18 farmland bird species) indicators, which were checked against a synthetic naturalness indicator describing the degradation of the local plant communities with respect to an ideal baseline (vegetation-based natural capital index, NCI). The NCI value of an area equals the product of the quality and quantity of the remaining natural and semi-natural areas, it summarizes the

extent to which a landscape has preserved its original natural capital. Our main issue was to explore the relationship between the vegetation-based natural capital index and the main characteristics of the bird assemblages observed at the same sites.

The research had the following goals:

a) Identifying the most abundant breeding bird species in agricultural landscapes, as well as other bird species which use these areas for any purpose.
b) Comparative analysis of eight lowland agricultural landscapes based on bird assemblages.
c) Evaluation of naturalness of agricultural landscapes based on a vegetation-based natural capital index and the main characteristics of bird assemblages.
d) Determination of the relationship between the vegetation-based natural capital index and the main characteristics of bird assemblages.
e) Identification of indicator bird species which can be used to determine the naturalness of agricultural landscapes.

2. MATERIALS AND METHODS

I selected eight lowland agricultural landscapes with more or less the same geographic characteristics: Beregi-sík, Borsodi-Mezőség, Csepeli-sík, Gerje-Perje-sík, Hortobágy, Nagyberek, Sárvíz-völgy and Vác-Pesti-Duna-völgy. The common characteristics of these areas include the diversity of the mixed agricultural landscapes, where a mosaic of intensively managed farmlands and high nature value semi natural grasslands is still relatively prevalent. The designation criteria of the eight study areas were: at least 70% of the surface of each study area must be open areas such as arable lands and/or grasslands; both natural/semi-natural and degraded study areas had to be selected; when experiencing drastic vegetation difference within the study areas, I narrowed the selection only to those part of area which best characterized the lowland agricultural landscape, and from then on it was considered the study area. As a next step six "rosettes" were randomly identified within each study area, with each rosette consisting of seven adjacent hexagons of the MÉTA hexagonal grid (each hexagon is 35 ha, and the whole rosette is 245 hectares). I defined three designation criteria: the central point of the rosette could be accessed relatively easily; 80% of all the ground of the seven hexagons constituting the rosette should be accessible; there should be at least 70% open area within the rosette, cropland and/or grassland. Our data were derived from seven hexagons in each of the rosettes, i.e. 42 in each study sites and 336 survey units in total.

The determination of our vegetation data is based on MÉTA (GIS Database of the Hungarian Habitats), which was collected between 2003 and 2008. Vegetation-based natural capital index values for the study were derived from this MÉTA mapping, I examined the values in every MÉTA hexagon. The NCI value of an area equals the product of the quality and quantity (that is relative area and naturalness of the habitat) of the remaining natural and semi-

natural areas. It follows from this that the higher the NCI value is in a given landscape, on the larger area habitats can be found with natural conditions.

The ornithological surveys were carried out with the point count method at the level of hexagons, between late April and mid-June in 2011 and 2012. To minimize travel cost and survey time hexagons within the same study site were surveyed during a single morning between 5 am and 10 am. The point count method was adapted to the current study design so that the centre of each MÉTA hexagon was chosen as the survey point, where all bird species observed (seen and heard) within 100 m during a 10 min survey period were recorded. The recording included both breeding and feeding birds, but excluded flying ones just crossing over the 100 m circle. Furthermore, I added records of birds leaving the site on the surveyor's arrival in the case of few middle-sized or large birds which tend to take flight in the presence of humans.

The analysis was confined to farmland birds, defined according to the Pan-European Common Bird Monitoring Scheme (PECBMS). To characterize the diversity of bird assemblages, the number of species, the total abundance and the Shannon-index were used, whereas Jaccard index was used to describe the similarity of the bird asseblages. To evaluate the similarity and congruence of the various biodiversity metrics I performed a series of statistical analyses. I fitted a multivariate generalized linear model in a MANCOVA nested design framework: with number of species, total abundance and Shannon-index as dependent variables, study area and rosette as independent blocks, and vegetation-based natural capital index of the hexagons as the single covariate predictor of interest. In order to determine the relationship between NCI and the presence of individual bird species I discretized the NCI values into five categories. Then I cross-tabulated these values with the presence/absence of the bird species and calculated Somers' symmetric and asymmetric *d* values for each species determined. The analysis was carried out with the R statistical software package and Quantum GIS.

3. RESULTS (THESES)

1. **<u>The most abundant bird species using agricultural landscapes were determined.</u>**

   These were the following: common kestrel (*Falco tinnunculus*), northern lapwing (*Vanellus vanellus*), common skylark (*Alauda arvensis*), barn swallow (*Hirundo rustica*), crested lark (*Galerida cristata*), yellow wagtail (*Motacilla flava*), whinchat (*Saxicola rubetra*), common stonechat (*S. torquata*), common whitethroat (*Sylvia communis*), rook (*Corvus frugilegus*), european starling (*Sturnus vulgaris*), eurasian tree sparrow (*Passer montanus*) and corn bunting (*Miliaria calandra*).

   During the years 2011 and 2012 a total of 4476 observations of 112 bird species were observed in the eight lowland farmland areas. I used the farmland birds list of the Pan-European Common Bird Monitoring Scheme (PECBMS) containing 23 species recommended to Central and East European agricultural areas as an initial species list, which was then narrowed to 18 species. A total of 3074 observation records were made of bird species which are associated with farmlands according to the list, which accounts for 68.7% of the total abundance.

   Out of the non-discussed birds **I observed segde warbler (*Acrocephalus schoenobaenus*) and common quail (*Coturnix coturnix*) in great numbers**. The former species was mainly observed on those temporary habitats which often surrounded the agricultural areas (i.e. marshes, reed beds). The latter one prefered natural/semi-natural grasslands as well as croplands with tall vegetation.

2. **<u>Based on bird assemblages a comparative analysis of eight Hungarian lowland agricultural landscapes was made.</u> It was pointed out that a high degree of similarity was shown among the eight study areas not**

only in terms of plants, but in terms of the species composition of bird assemblages just as well.

The Jaccard index was used for comparing the similarity of the set of species. Each study area resembled to each other 66% in average. Most similar were Gerje-Perje-sík and Hortobágy (86%), while the least ones were Borsodi-Mezőség and Vác-Pesti-Duna-völgy (40%).

When the five most frequent species of the survey were considered, **the two character species could be determined: common skylark (*Alauda arvensis*) and yellow wagtail (*Motacilla flava*).** In addition to them three other species occured in every eight study areas: common kestrel (*Falco tinnunculus*), barn swallow (*Hirundo rustica*) and common stonechat (*Saxicola torquata*).

3. **An order of naturalness of the eight lowland agricultural landscapes was determined.**

It was found that **the order of naturalness demonstrated by the ecological state-indicators vegetation-based natural capital index (NCI) and the total abundance/species number ratio also showed a high degree of similarity**.

The highest values on the basis of the order of naturalness were given to the vegetation-based natural capital index and the total abundance/species number ratio of Hortobágy and Borsodi-Mezőség. One of the weakest value was Nagyberek in both cases.

In contrast with these two rankings, **Shannon index showed a totally different sequence**. The landscape transformation activity of man and the large extent of mosaicity of some of the landscape units was found in the background of this phenomenon. Based on these facts **the application of the Shannon index of bird assemblages can not be recommended for the description for naturalness of landscapes**.

4. **It was pointed out that the total abundance of bird assemblages showed significant correlation to the condition of the vegetation (vegetation-based natural capital index).** This means that the more natural the vegetation in a given area is, the greater the total number of observed birds.

   Examining the relationship between NCI and the presence/absence of the individual bird species, **six species were found to show significant correlation with the NCI values, which means that the presence of these species suggest high NCI values, i.e. these species indicate a relatively natural vegetation: common kestrel (*Falco tinnunculus*), northern lapwing (*Vanellus vanellus*), black-tailed godwit (*Limosa limosa*), common skylark (*Alauda arvensis*), yellow wagtail (*Motacilla flava*) and corn bunting (*Miliaria calandra*).**

   There were three species (crested lark *Galerida cristata*, common whitethroat *Sylvia communis* and yellowhammer *Emberiza citrinella*) with negative correlation rates to the NCI, which means that the presence of these species suggest low NCI values, they indicate degraded habitats.

   Three farmland bird species, european turtle dove (*Streptopelia turtur*), common stonechat (*Saxicola torquata*) and common linnet (*Carduelis cannabina*) are slightly negatively correlated to NCI. The presence of these species suggest low NCI values, they indicate degraded habitats. In the case of three other species, white stork (*Ciconia ciconia*), Eurasian tree sparrow (*Passer montanus*) and whinchat (*Saxicola rubetra*), I did not find any correlation with NCI.

5. **It was demonstrated that the relationship between the vegetation-based natural capital index and the main characteristics of bird assemblages was directional.**

I found that **it is more possible to draw conclusions about the naturalness of the vegetation in an agricultural landscape based on the bird communities, than to predict the bird assemblages from vegetation condition**. So farmland bird species could be good indicators to determine the naturalness of these ecosystems.

6. **<u>The species which could be suitable indicators for naturalness of an agricultural landscape were defined.</u> It was demonstrated, that the following five farmland bird species were suitable to define the degree of naturalness of agricultural landscapes: common kestrel (*Falco tinnunculus*), northern lapwing (*Vanellus vanellus*), common skylark (*Alauda arvensis*), yellow wagtail (*Motacilla flava*) and corn bunting (*Miliaria calandra*).**

4. CONCLUSIONS AND PROPOSALS

My results can be seen as a preliminary study which could support the development of a regional farmland bird index (FBI) customized for South-East Europe, the Pannonian biogeographic region, or Hungary. It promotes the development of objective metrics serving the characterisation of landscape naturalness, and provides recommendations from some perspectives. The method used for the research and the indicator bird species specified are both suitable to characterise the naturalness of each landscape unit, and hence, their involvement in long term monitoring programmes has a practical benefit.

My research findings can also be used in practical landscape architecture. The assessment and evaluation method and the indicator bird species can be applied in certain parts of settlement and landscape plans. They may basically operate as a monitoring tool (such as evaluating areas within ecological networks), which is currently not or only incompletely represented in the set of tools. Indicator bird species are a suitable tool to determine the degree of naturalness or the status of a given area, and later on to monitor it and hence, to preserve its ecological values.

Recently, the concept, assessment and evaluation of ecosystem services has been put to the forefront both domestically and internationally. Indices fit for describing the degree of naturalness of a habitat may serve as a basis for assessing ecosystem condition, which is an integral part of ecosystem service assessments. But developing and testing potential ecosystem condition indicators in different social and environmental contexts is challenging. My work contributes to this important ongiong process. Birds, as a group of vagile organisms on the top of the food web, yet highly sensitive to environmental changes can potentially be very good indicators. The field testing of promising species should go on in further studies.

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