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AZ ÖKOLÓGIAI HÁLÓZAT HASZNÁLATI ÉS KITERJEDÉSI KÉRDÉSEI MAGYARORSZÁGON

DILEMMAS IN THE USE AND LAYOUT OF THE ECOLOGICAL NETWORK IN HUNGARY

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ABSZTRAKT

2022 nyarán Magyarországon szélsőséges aszályt tapasztalhattunk, amely különösen az Alföldet sújtotta. Sok helyi gazdálkodó változást szorgalmazott, ám a változáshoz mindannyiukra egységesen szükség van, és a jelenlegi földhasználati módok újragondolására elengedhetetlen. A kutatásunkban az ökológiai hálózat eredeti keleti európai koncepcióját használjuk a kulcsterületek feltárására, biodiverzitás, konnektivitás és vízgazdálkodás szempontjából, meghatározva azokat a területeket, ahol a tájhasználat-váltások bekövetkezhetnek. Megvizsgáltuk a területet regionális léptékben konnektivitás-analízissel, és helyi léptékben, a területhasználatot és élőhelyeket figyelembe véve, valamint a víz természetes körforgását a tájban is beépítettük a módszertanba. Megállapítottuk, hogy a regionális léptékű modell eredményei enyhén más képet mutattak a helyi eredményekhez képest a mintaterületen, ez pedig nagyban kötődik a terület nem megfelelő műveléséhez a potenciális ártéri területeken. ⦿

ABSTRACT

Hungary faced an extreme drought in the summer of 2022, especially in the Great Hungarian Plain. Many local farmers called for change – only to find that change requires all of them to rethink the way they use their land. Our research aims to use the original Eastern European Ecological Network concept to locate key areas of biodiversity, connectivity and water management – where the necessary changes in land use can be implemented. We examined the area on a regional scale, using connectivity analyses, and on a local scale, analysing land use, habitats and aspects of the landscape's natural water cycle. We found that the regional-scale model gave slightly different results to the local-scale research, and the difference is strongly related to the inadequate use of potential flood plain areas.

Keywords: ecological network, sustainable land use, biodiversity, nature conservation

INTRODUCTION

The ecological network (EN) consists of natural and semi-natural habitats [1]. Its main function is to maintain biodiversity with increasing connectivity and to help perpetuate natural processes, such as the circulation of matter and energy [2]. The EN is a coherent, graph-like spatial system where nodes (the core habitats or source areas) are connected through corridors (links) in a network system [3]. The ecological network usually consists of four types of areas: core areas, ecological corridors, buffer zones and restoration areas. Ecological corridors can be 3 different types: linear corridors (usually alongside waterways or roads), landscape corridors (consisting of multiple patches), and stepping stones (where the habitat patches are not contiguous) [1, 4, 5, 6].

The concept originated in the Baltic countries in the 1970s and spread to Western Europe where it became a tool for biodiversity conservation. Though it has proven to be an effective system for improving species diversity, the original theory was to create a sustainably-used environment, balancing intensive and extensive land use according to the landscape's attributes and valuable natural habitats [7]. The EN also provides recreational, socio-economic and visual benefits for the community alongside ecological benefits [5] and can also help moderate the effects of climate change as part of green infrastructure.

The EN can be interpreted according to many different spatial scales [8], from entire continents, to countries and regions, to a single municipality. Studies have shown that the most effective way to map ENs is on the "mesoscale" or "landscape scale" [5, 9, 10, 11] which equates to the regional/national mapping size with core areas of 10-1,000 km^2 [5]. Although this scale has proven to be effective, research shows that it is beneficial to investigate more than one scale (especially zooming into the local scale) to complement and revise the mapping method or add details to the network [11].

The EN is often evaluated by measuring and modelling connectivity. Functional and structural connectivity can be determined, former with monitoring the actual routes of species movement, the latter can be designated with GIS modelling. For example, the least-cost-path analysis, used in this study, is a widely accepted GIS method regarding the evaluation of structural connectivity [12].

In our opinion, by combining the original Eastern and Western European concepts (sustainable land use and species conservation), an efficient and feasible network can be created that is more resilient and integrates both conservation concerns and the interests of local stakeholders. This requires two different perspectives and methodologies, which we aim to present in this paper. The main goal of our research was to combine these two concepts, experimenting with the scale of the EN and identifying the advantages and limitations of both. This resulted in two approaches: the larger-scale network for species conservation and the smaller-scale network for land use that takes into account the natural characteristics of the area.

DATA AND METHODS

The Hungarian National Ecological Network (NECONET) was planned in 2000 within the framework of the Pan European Ecological Network (PEEN) [13]. It was enacted into law by OTrT (National Spatial Plan) in 2002, and although it is revised every six years when a new National Spatial Plan is prepared, the scope of NECONET has not changed much since it was first established. It was last amended by legislation in 2018 in the MaTrT (Spatial Plan of Hungary) [14]. The NECONET comprises three categories: core areas, ecological corridors and buffer zones, while the concept of restoration areas is completely absent from the network. The NECONET was planned by the National Parks on a regional scale, using different approaches and methods, and then merged into a country-sized network.

As mentioned before, we conducted our research on two different scales, regional and local, using two different areas to test our methods (Fig. 1). The **"regional-scale"** study area contained the catchment area of the River Tisza, located in Eastern Hungary. To specify the area, we used the Hungarian National River Basin Management Plan with smaller modifications. The research area is 32,275 km² along the 597 km river. The Tisza was heavily regulated in the 19th century, resulting in a simpler riverbed and creating backwaters all along the river, while also heavily modifying the flooding system and natural floodplains. The consequences of the intervention are highly sensitive right now because of climate change. In the summer of 2022, Hungary experienced an extreme lack of water and drought on the Great Hungarian Plain, which caused serious problems for local farmers.

The **"local-scale"** research area was located in Nagykörű, which is a smaller settlement along the river, between Szolnok and Lake Tisza. The study area contains parts of the administrative areas of the Nagykörű, Csataszög, Hunyadfalva and Kőtelek municipalities, and extends just under 90 km². The shoreline of the river is part of the Middle-Tisza Protected Area, which belongs to Hortobágy National Park. The main reason for choosing this area was to include the land use of floodplains (and potential floodplain areas) in the research to help create the network that fits into the Eastern EN approach. During our site visit, we discussed problematic land use and landscape conflicts with a local professional and farmer, Péter Balogh, who has long spoken out in favour of sustainable land use along the river. He helped us understand the river's natural water cycle, and we are also grateful for his advice.

For GIS calculations, we used the Linkage Pathways tool (Linkage Mapper 2.0.0.) in Arcmap 10.4.1. In addition, QGIS 3.0. Landsat DEM data was downloaded from the EarthExplorer's site [15]. For land cover data, we used CORINE 2018 and NÖSZTÉP (National Ecosystem Map [16].

METHOD 1 – REGIONAL EN

For the river-scale EN, we focused on biodiversity conservation and improving connectivity. The regional-scale network of the River Tisza was determined by using the least cost path method, which models the paths of the chosen indicator species or species groups between core habitats. This method is often used to model ENs because it models species movement and migration [3, 11], and the results can help identify missing links, key patches and stepping stones.

For indicator species, we wanted to take a horizontal approach, so we chose to use three indicator groups based on the most common natural habitats in the area: 1) forest-preferring species, 2) grassland-preferring species and 3) water- or wetland-preferring species. When determining the ecological preferences of these species groups, we had mainly bird species in mind, because their movement is less directly affected by the road network, and the scale of the research area is also suitable for migrating birds.

As mentioned before, to model the EN, we used the least cost path method, which requires three input layers: 1) core areas, 2) the Euclidean distances between the cores and 3) resistance rasters. For the **core areas,** we chose to use the same layer for all three indicator groups, which contained the cores from the already established NECONET. These areas have proven to be valuable natural or semi-natural habitats, containing key or endangered species by definition [14]. To reduce the number of cores and to get a more accurate result in this scale, we merged cores that were closer than 50 metres and then eliminated patches under 5 km², resulting in 85 core areas. According to the literature [5], the meso-scale network has cores of at least 10km², but this way, only 20 patches would be large enough to consider, which is why we chose to lower the minimum area to 5 km².

The Conefor plugin was used to calculate the **Euclidean distances** between the 85 cores. We set a threshold of 50 km between patches, because above this distance, it is unlikely that these patches would have a direct connection for any kind of species.

We used CORINE land cover as a base map for our **resistance rasters.** The three species groups each had different resistance rasters, where each set of land cover data had a specific resistance value for the group from 1-100 (with 1 the most suitable habitat for our indicator group). Then, the vector layer was converted into a raster with a pixel resolution of 50x50 metres, which is estimated to be accurate enough for our research area.

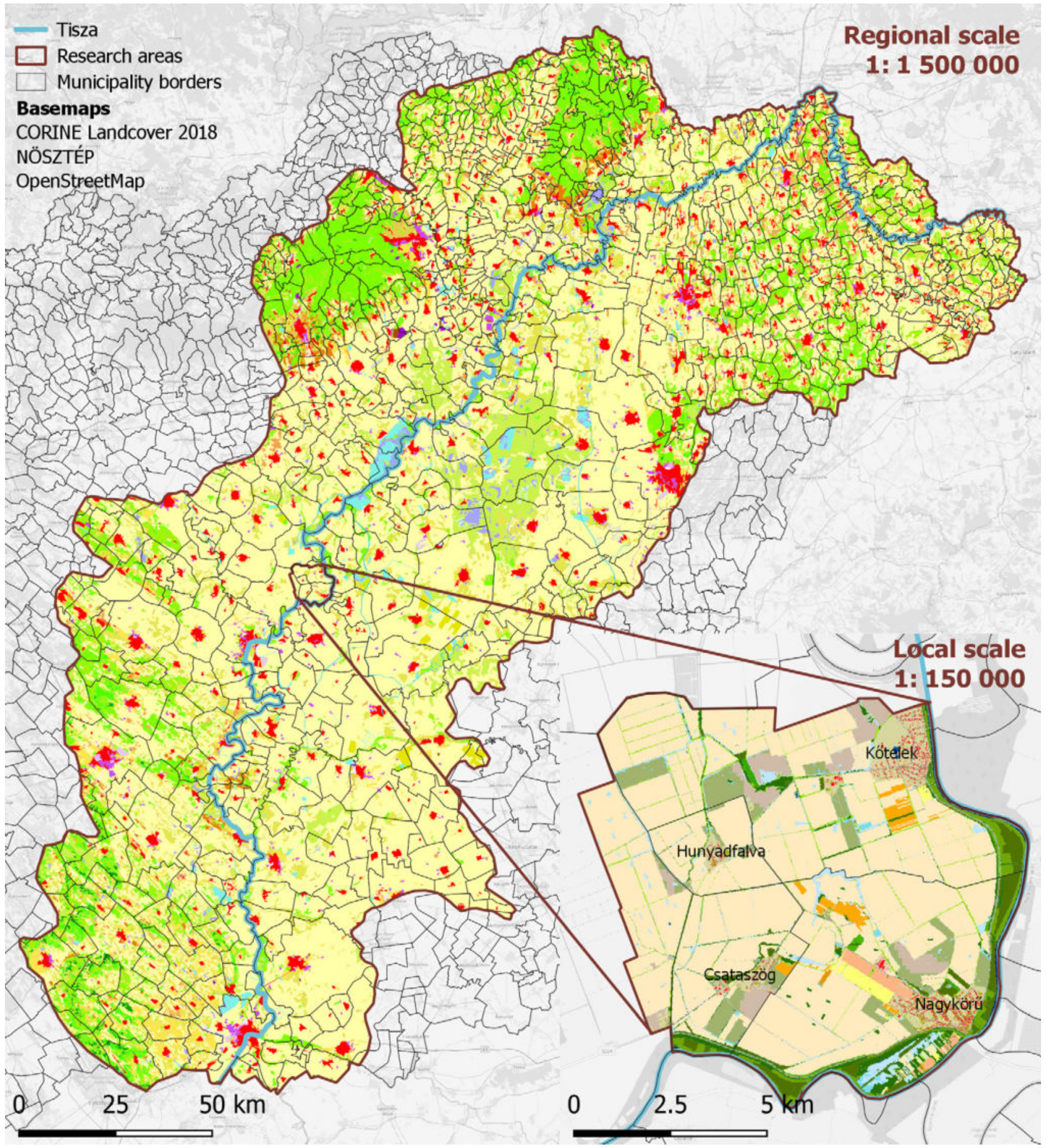
After we produced the input files, the Linkage Pathways tool was used to identify the **links** between the cores, and to generate the **cost-weighted corridors** for the three indicator groups. The corridor layers were truncated by 50,000 values to obtain narrower and specified corridors of the species along the links. These three output layers were then merged and evaluated to determine the most important habitats and connections of the EN.

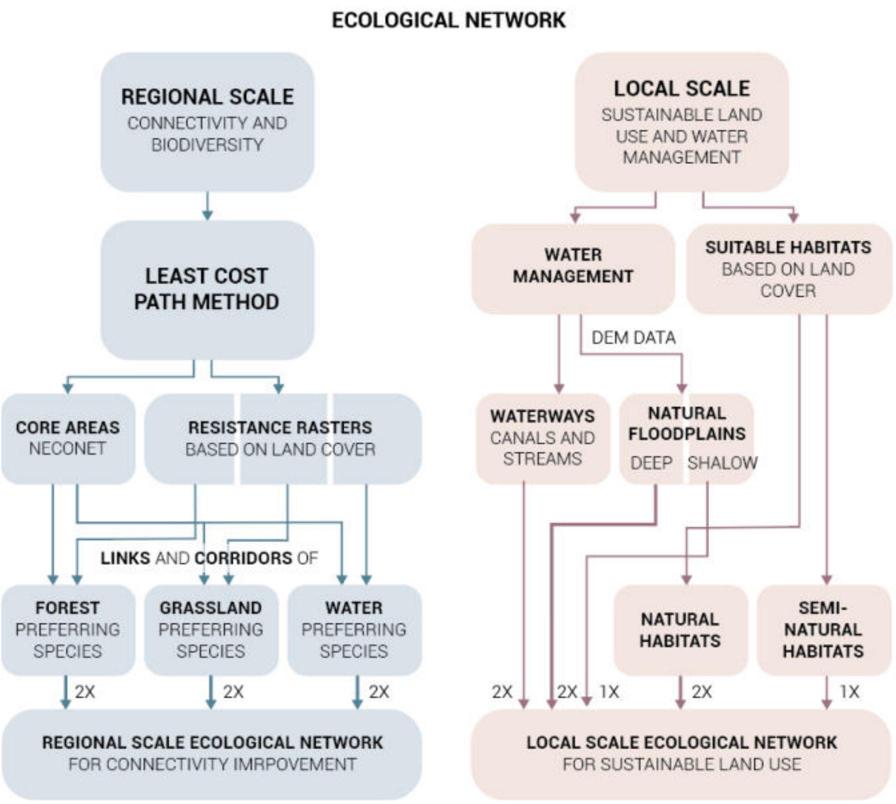
METHOD 2 – LOCAL EN

When modelling the EN on a local scale, our main goal was to include the landscape's natural water cycle and the possibilities that small, sometimes temporary, waterways (stream and canals) provide, alongside already existing habitats.

To determine the natural and semi-natural habitats, we used land cover data from NÖSZTÉP [15], which is a raster-based data source available for the whole of

Fig. 1: Regional- and local-scale research areas





Hungary. The resolution is 20x20 metres per pixel, which provides a more detailed source on this scale than CLC data, in which the MMU (minimal mapping unit) is only 25 hectares. In addition, NÖSZTÉP includes more land use categories, resulting in more actual habitat descriptions. We divided the land cover categories into three types: **natural habitats** (forests, meadows, wetlands and water surfaces), **semi-natural habitats** (orchards, gardens, forest plantations, extensive farmland and parks) and non-habitat areas (built-up areas, industrial areas and intensive farmland).

After identifying the habitats that could potentially be part of the EN, we also examined the river's natural flood system. In the 19th century, it was drastically modified, and the dam currently lies approximately 500-1,000 m distance from the riverbed. The floodplain is currently part of the NECONET in its full extent, as an ecological corridor. We used a DEM model to identify potential floodplains. Under 83 metres elevation, the area was considered to be a **deep floodplain,** and between 84 and 83 metres elevation, the area was considered a **shallow floodplain.** These thresholds were identified by consulting water management professionals and local farmers. According to their observations, above 85 metres (where most of the settlements are built), the land is completely safe from flooding.

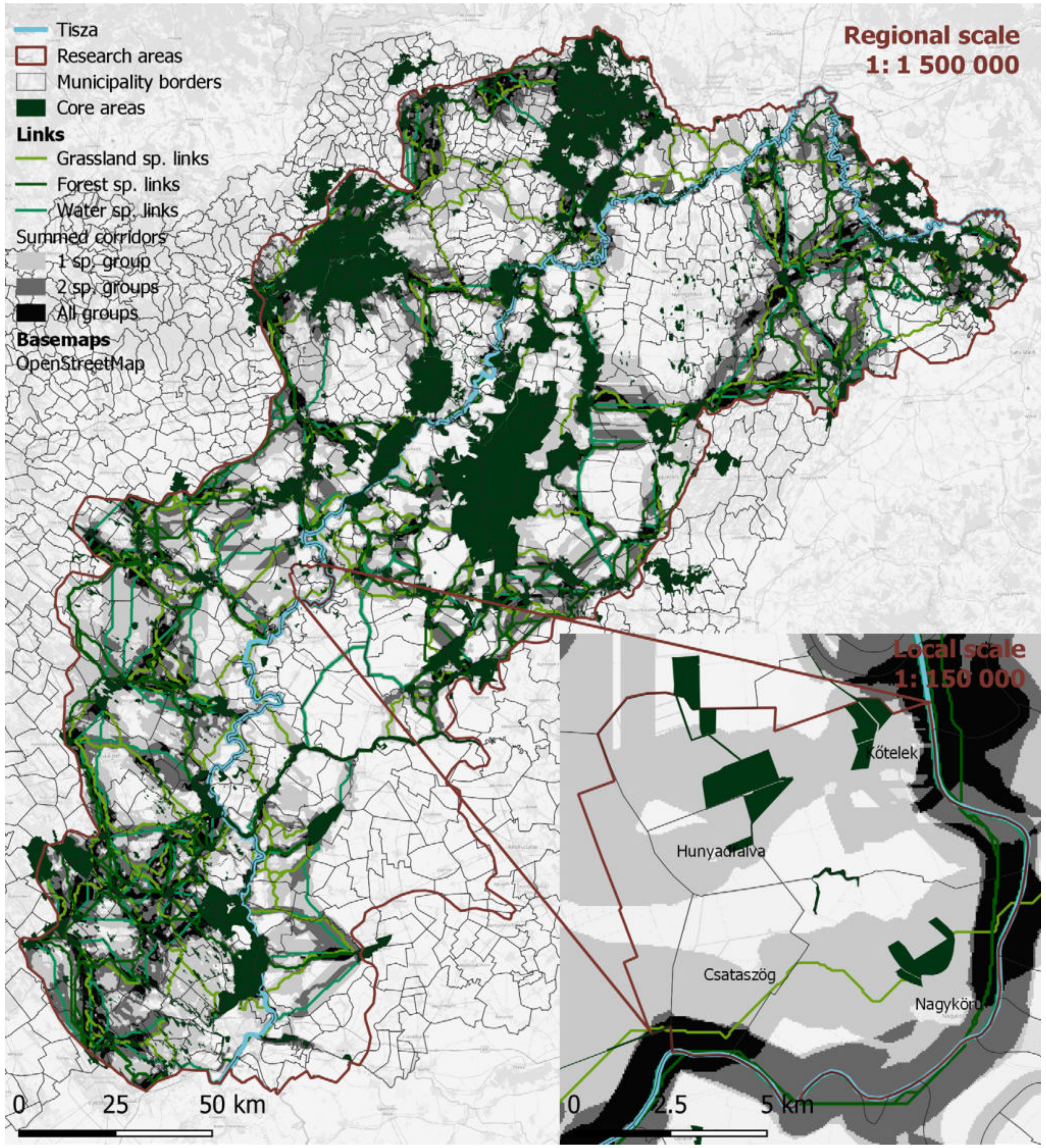
We also considered the smaller elements of the water system: the **streams and canals.** We calculated a 20-metre buffer zone around the shores for them to be effective ecotones and water retention tools. These waterways can be used to manage flooding and maintain water afterwards to help biodiversity conservation and address the lack of water on farmlands. Some of these waterways are only temporary, and especially in the summer drought, they become dry ditches, something we can also confirm after our observations made on site at the beginning of September. We acquired the spatial data of these elements from OVF (General Directorate of Water Management) for our research.

After identifying all the potential aspects of the EN, we summarised the ecological values in both scales. The methodology and the weighting of each category (indicator groups networks, natural and semi-natural areas, deep and shallow floodplains, waterways) are presented in Fig 2. The regional- and local-scaled results were then evaluated and compared to each other to identify the advantages and disadvantages of each method.

RESULTS

Evaluating **regional network** suitability based on the connectivity analyses (Fig. 3), we could establish the river's role as an ecological corridor: for all three species groups, the Tisza was an important link along its whole length. It provides an important connection for the different kind of species, because of the chain-like habitats along its shores. While the Tisza is part of the NECONET along its whole length, our results show that a buffer of at least 1,500-2,500 metres wide is needed,

◂◂**Fig. 2:** Methodology
Fig. 3: Regional-scale results



while today, protection is between 300-1,500 metres on average.

We could also observe key patches that are crucial habitats for preserving wildlife. Not only was the importance of already protected areas (like Hortobágy or other nature reserves) supported, but the importance of smaller, stepping-stone patches was also revealed. The Forest of Baktalórántháza Nature Reserve plays an important role in the ecological network, despite its size. Similarly, the forest in Fülöpjakab and the forest next to Nagykőrös also serve as key ecological stepping stones between larger protected areas.

We could also find the missing regional links when evaluating our results. We found that there is a lack of connectivity between the Nyékládházi and Ónodi lakes, and between some habitats in the Bükk National Park and the Kesznyéten Protected Landscape Area. Between the protected area of Pusztaszer and Bócsa-Bugac, the NECONET includes smaller, stepping stone-like patches, while according to our results, the area is severely lacking in buffer zones.

We found conflicting results within the **local-scale network** (Fig 4). Habitat suitability and floodplain analyses showed contrasting pictures. While according to both calculations, the river and its shore represent an ecologically important area, the floodplains are located in the middle of the area, and are mainly used for intensive farming, while suitable habitats are concentrated in the northern and southern sections of the research area.

The shores of the canals and streams proved to be the most valuable areas because of the linear vegetation and lower elevation. Other outstanding results can be found around the wetland areas, such as those along the border of Csataszög and Kőtelek, or that east of the built-up area of Csataszög.

When **comparing the two results,** we found that the regional-scale analyses completely miss the importance of smaller-scale wetlands and canals, as expected, especially that on the administrative border of the two settlements. Two regional links are outlined along the natural habitats for the grassland-preferring species group, and the intensively-farmed floodplains proved to be unsuitable for EN development on the regional scale. The reason for this difference is that when calculating the least cost paths, we used land cover data as the base of the resistance rasters, only from different sources, and this way we obtained a similar result, which was expected. The valuable areas and connecting links for the forest- and water-preferring groups concentrate along the river.

Both the connectivity-based and the land use and water management-based methods found the river outstandingly important regarding the EN. This proves that the Tisza is an important corridor on a regional scale, and a valuable source habitat when examining the local scale. Additionally, it would be beneficial for both of these roles to extend and create buffer zones along the shoreline.

DISCUSSION

Only the local-scale network showed the significant importance of streams and the vegetation along them, which means that these areas are an important part of the EN on the local scale, for local connections, and can be used both as links between valuable habitats and for water retention. These areas will be used mostly by grassland-preferring species, but when new wetland areas appear, water-preferring species could also be observed.

We found that both the regional- and local-scale results were useful for modelling the EN, but by evaluating them together, we could specify the role of our local area in the regional context. The area of Nagykörű lies along the Middle-Tisza Protected Area, just under the important core habitats of Lake Tisza, and the suggested EN could serve as a link between this natural protected area and the Tápió-Hajta Regional Protected Area. When developing the EN and the habitats on a local scale, we can also consider the needs of species that are native to these protected sites.

We would suggest that the next step of this research should be to focus on feasibility and to designate more areas to sustainable land use and water management, especially along canals, making them part of the EN as restoration areas. This way, the local development of the EN could begin, serving as an example for other projects, while also showing the advantages of water retention. In discussions with local farmers, we found that some of them are open to change; we hope that they will take the next steps in sustainability, and our research could help them locate possible areas. ⦿

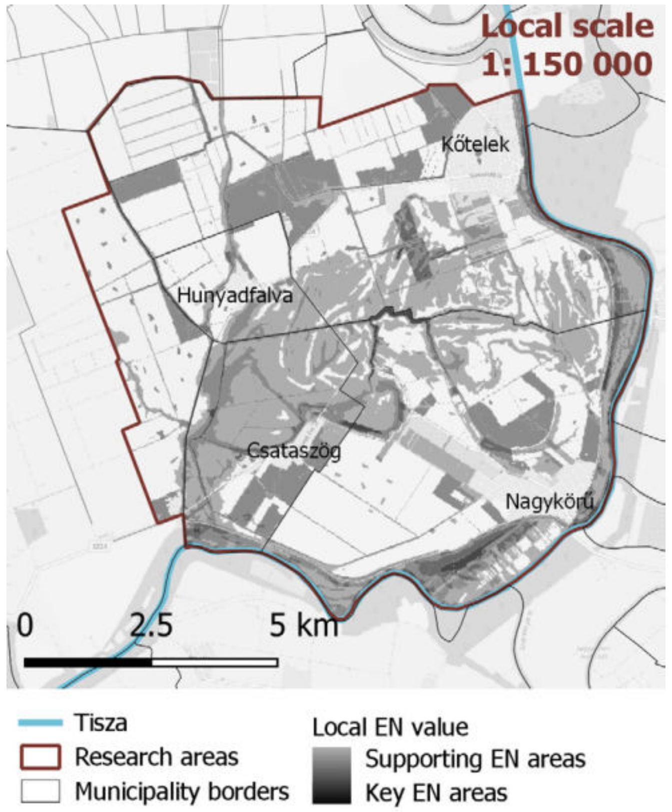


Fig. 4: Local-scale results

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