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Landscape planning dilemmas and challenges in designation and management of the ecological network alongside the Tisza River in Hungary.

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Landscape planning dilemmas and challenges in designation and management of the ecological network alongside the Tisza River in Hungary.

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1. Abstract

In our research we focused on the flaws in designation and management of the ecological network alongside the Tisza River. For defining these deficiencies, we analyzed the available databases, evaluated the different territorial protected environmental resources and collected data about the protected areas along the river. Taking all this information into account we compared our results with the already existing National Ecological Network, assigning its deficiency. Our goal was to identify a manageable frame of regional scale of ecological network and to create a network that contains all the categories listed above while preserving its original purpose. To achieve this, we compared our GIS based results to the already existing network categories of the river.

2. Introduction

The main goal of our research was to determine, if the National Ecological Network (NECONET) and other protected networks (national protected areas and Natura2000 areas) are functioning appropriately alongside the river Tisza in Hungary. We wanted to determine the role of the river as an ecological corridor, as well as to identify the missing links and patches of these networks while drawing attention to the key habitat patches, that are already protected.

The Hungarian system of environmental databases and environmental information platforms regarding landscape ecology and nature conservation data holdings via web-based tools is highly fragmented. The different databases are often incompatible with each other, which makes the ecological based spatial planning processes quite difficult.

In our approach, a well-functioning ecological network could be the common territorial system for the landscape protection, the nature conservation, and the natural resource management, joining all the protected areas and environmental values such as national parks, nature reserves, elements of cultural heritage, valuable water surfaces and wetlands etc. in one layer, making the system of the value based territorial and spatial thinking clearer, focused and the planning process far easier.

3. Background and Literature Review

The concept of an ecological network is coherent spatial system, consisting of natural or semi-natural habitats (Jongman et. el. 2011). Its main purpose is to restore the proper ecological functions of nature, and to maintain biodiversity by battling fragmentation and increasing landscape connectivity (Jongman et. al. 2004). In another approach: "*The ecological network connects habitats within the landscape through the corridors, forming a network system which is closely connected in space*" (Shi et. Al. 2020). While mainly serving an ecological purpose, the ecological network also has recreational, socio-economical and visual benefits for the community (Mander Et. Al. 2003). The ecological network consists of 4 types of areas: core areas, ecological corridors, buffer zones and resoration areas (Konkolyné 2003, Jongman Et. Al. 2011, Mander Et. Al. 2003, Jongman et. al. 2007).

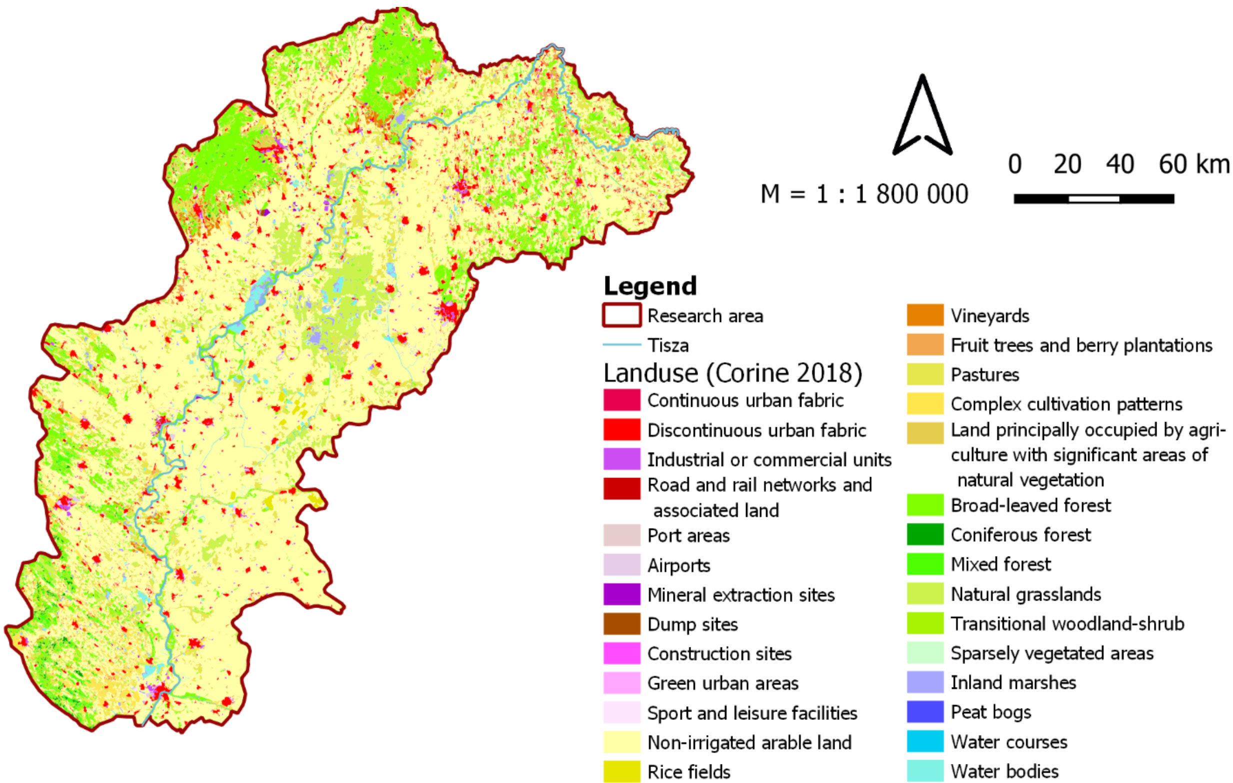
In Europe the concept of an ecological network is represented in the Natura2000 areas and the PEEN (Pan European Ecological Network). The PEEN consists of the countries national ecological networks (Jongman Et. Al. 2011), and every EU member took a different approach when defining these areas (Érdiné 2002). The Natura2000 system is the ecological network of the EU. The network consists of SPA (Special Protection Area) and SAC (Special Area of Conservation) areas, which were defined by a common method in each country. In Hungary the Natura2000 areas were specified by the National Parks based on the marker species and habitats occurrence.

In Hungary the ecological network is defined by law in MaTrT (2018) for the entire country. The Hungarian National Ecological Network (NECONET) is divided into 3 categories: core areas, ecological corridors and buffer zones. The concept of restoration areas is completely missing from the network. According to the MaTrT, the NECONET's core areas are those natural or semi-natural areas that can provide the survival and the living conditions of the natural wildlife and gives home for one or more protected or culturally significant species. The ecological corridors are mainly linear, continuous or intermittent habitats, that are natural or semi-natural and provide connectedness between the core areas. Buffer zones obstruct or moderate the negative effects that could unfavorably influence the state of the core areas and corridors. The NECONET was determined by the local National Parks based on the occurrence data of protected species.

The extent and the defined categories of the NECONET has not changed much since it was first established in 2000. Furthermore, the local and regional aspects and the changes in landscape was not considered when it was last modified in 2018. At some places, the ecological network is seriously insufficient (for example there are areas where buffer zones are less than 1% of the whole network) which makes its main purpose - helping the preservation of the biodiversity, moderating fragmentation and protecting the remaining natural habitats - impossible.

For our research we studied the network of the Tisza river, located in eastern Hungary. The Tisza is the largest river in Middle-Eastern Europe, it stems in Ukraine, where the Black and the White Tisza confluence. It crosses the borders of Hungary at Tiszabecs and leaves the country at Szeged. The length of the river in Hungary is 597 km. During the 19th century it was heavily regulated, a lot of meanders where cut off, resulting in a simpler riverbed and creating backwaters all along the river.

For our study area we chose to research the catchment area of the Tisza in Hungary. We used the Hungarian National River Basin Management Plan to determine the area, we included all the catchment areas around the river, with smaller modifications. The result is a 32 275 km^2 area, as shown on the map (Figure 1.), which is more than the third of Hungary (93 030 km^2).



1. Figure: The River Tisza and the landuse of our research area

4. Method and Data

We used the Linkage Pathways tool to analyze the network in our study area. The Linkage Mapper toolkit is a useful and broadly used method for creating networks for indicator species (Feng Et. Al. 2021), because it takes the species ecological requirements and preferences into account while calculating with its the dispersion distance. The Linkage Pathways tool needs 3 input layers: 1) a core area map, that shows the most suitable habitats for the species, 2) a text file containing the Euclidian distances between the core areas and 3) a resistance raster of the area, where each pixel reflects the species ecological preferences.

In our research we wanted to analyze the network more horizontally, and create a general method for evaluating the current networks functionality. This is why we did not chose indicator species, but we used 3 "hypothetical" indicator groups to take a broader spectrum of ecological preferences into account. The 3 groups were the following: 1) Grassland preferring species 2) Forest preferring species and 3) Water preferring species. When determining the ecological preferences, 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 too large for other species that are native in Hungary.

There are many grassland preferring bird species alongside the Tisza river, here we tried to collect the most iconic species, like the european roller (*Coracias garrulus*), the great bustard (*Otis tarda*) the northern lapwing (*Vanellus vanellus*) the red-footed falcon (*Falco vespertinus*) and the short-eared owl (*Asio flammeus*). Forest preferring key species in Eastern Hungary are less represented, because the natural vegetation of this area is grassland, but some valuable species can be mentioned, like the black stork (*Ciconia nigra*), the Eurasian golden oriole (*Oriolus oriolus*) the European honey buzzard (*Pernis apivorus*) and the short-toed snake eagle (*Circaetus gallicus*). From the waterland preferring group most of the species only feed on wetlands and near-water areas, like the European bee-eater (*Merops apiaster*) or the sand martin (*Riparia riparia*), who prefer shore areas, the Eurasian bittern (*Botaurus stellaris*) lives in areas habited by reed, or the common crane (*Grus grus*) and the little egret (*Egretta garzetta*) who prefers flooded grasslands and shores. Some species hunt on open watersurfaces, like the common tern (*Sterna hirundo*), the black tern (*Chlidonias niger*) or the white-winged tern (*Chlidonias leucopterus*). Geese, duck and grebe species are also quite common alongside the river, like the greater white-fronted goose (*Anser albifrons*), the tufted pochard (*Aythya fuligula*) ferruginous duck, the ferruginous pochard (*Aythya nyroca*), the black-necked grebe (*Podiceps nigricollis*) or the great crested grebe (*Podiceps cristatus*).

The three groups's **core areas** were the same: the NECONET's core areas. These are the areas, by definition, where the survival of species is assured. Because of the method that was used to specify these areas, we can assume that the NECONET's core areas are natural or close the natural habitats where key or endangered species live. To have a less fragmented database, we eliminated the areas smaller than 10 hectares, and merged the areas that were no more than 50 meters apart. This way we reduced the original 1839 polygons into only 830 patches, without major loss of data. Because of the size and scale of the research area, we further eliminated the patches under 500 hectares which resulted in 85 core area patches. According to the literature (Mander Et. Al. 2003), in a mezo-scale network (which is equal to the regional level) the core areas size range between 10-1000 km^2. Our research area had only 20 patches that were above 10 km^2, which we found it is not enough for the modelling, so we decided to include the polygons above 5 km^2 as well. In total we eliminated 1754 patches, which in area is only 13% of the original data.

When our layer containing the core areas was ready, we calculated the **Euclidian distances** between them in ArcMap, using the Conefor plugin. We restricted the program to calculate the distances only between patches that are closer than 50 kilometers. Above that distance it is not likely that those patches have a connection directly for any kind of species.

When determining the **resistance raster** values, our main database was the Corine 2018 Landcover data. Each category got a resistance value from 1 to 100 (where 1 was the most suitable habitat for our indicator group). This way every group had a different resistance raster. From the vector layer we created the resistance raster with 50 x 50 meters pixel resolution which estimated to be accurate enough for our research.

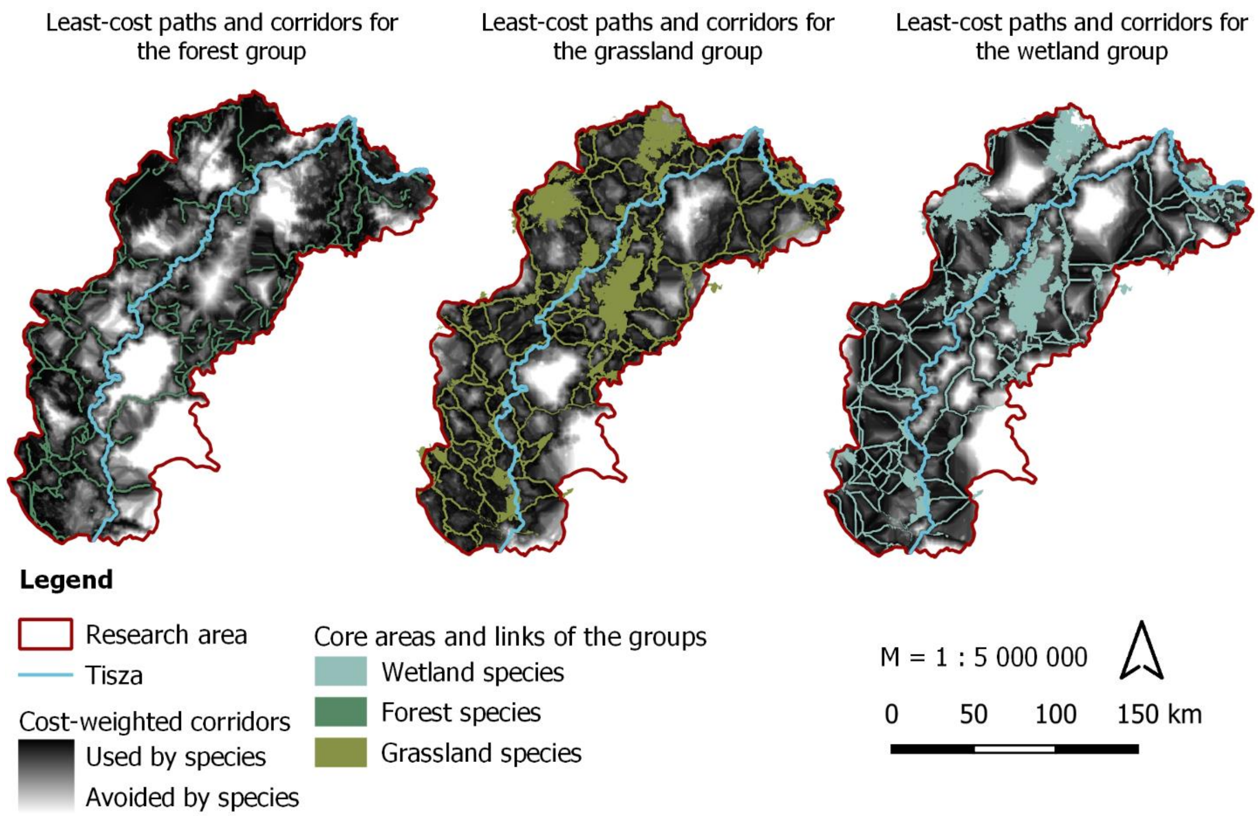
After we produced the input layers (a vector layer of the core areas, a text file with the Euclidian distances and three resistance rasters, one for each indicator group) we used the Linkage Pathways tool to generate the least cost paths and corridors. To determine the effectiveness of the NECONET and the Natura2000 network, we compared these networks to our modelled corridors. This way we could specify where the two legally protected networks have a deficiency and where further addition of habitats is necessary. We could also specify the key patches of the network, that are already part of the NECONET and which habitats preservation is crucial for maintaining wildlife along the Tisza river.

For the GIS calculations we used Arcmap 10.4.1. in conjunction with the Linkage Mapper 2.0.0.

and the Conefor plugins.

5. Results

After running the Linkage Pathways tool, we started analyzing our results. First, we visualized the raster that contained the cost-weighted corridors with the cost-weighted links and core areas for all three indicator groups (***Figure 2.***). That showed us the networks separated for the three groups with the different ecological preferences. We found that the white areas (the ones where there are no links)

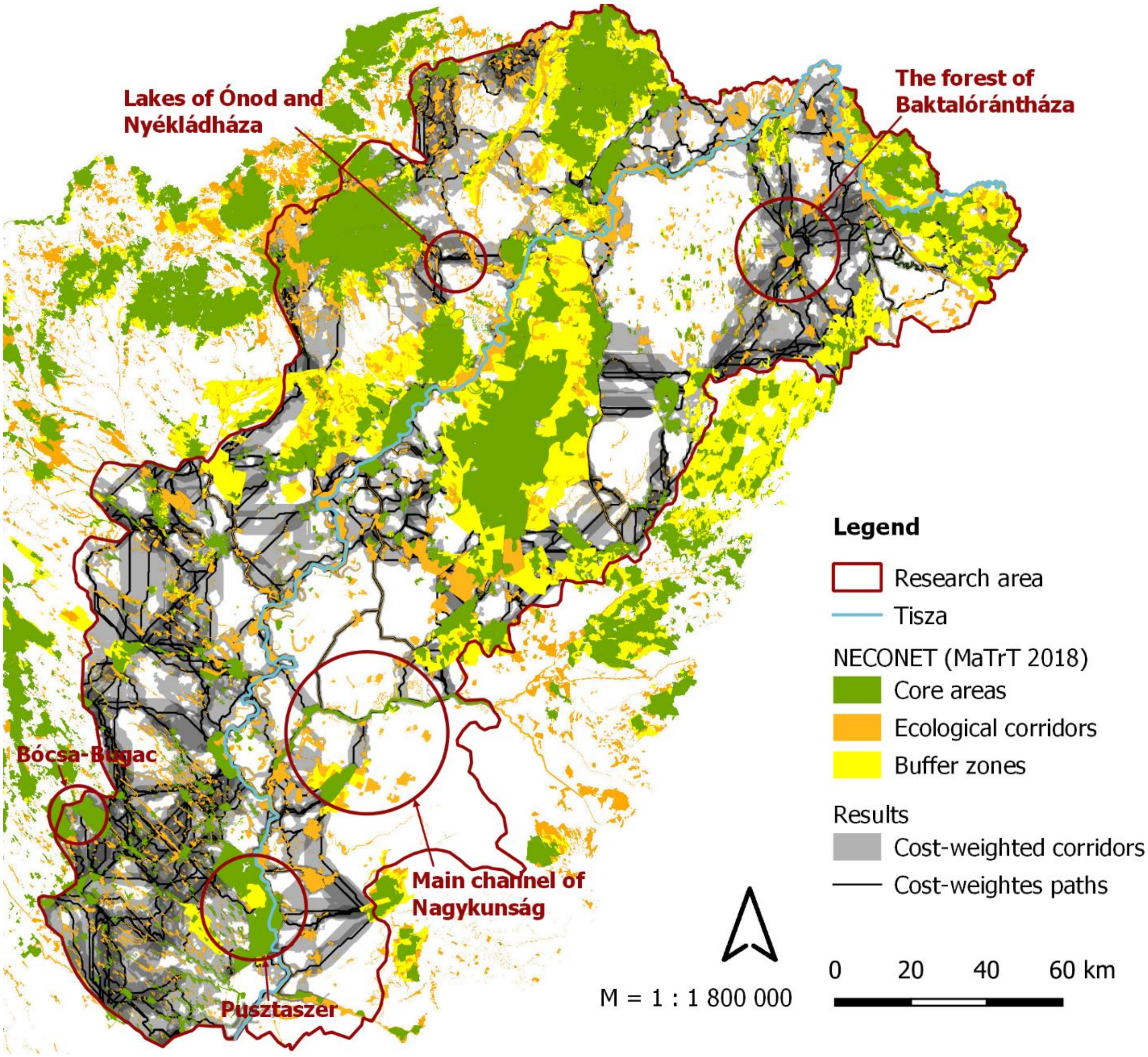


2. Figure: Least-cost paths and corridors for indicator groups

are looking quite similar for all three maps. These areas are dominated by intensive, contiguous agricultural land use, or bigger cites (such as Nyíregyháza and its agglomeration).

To compare the output with the NECONET and the Natura2000 areas we displayed the cost-weighted corridors truncated by 50 000 values to have narrower, more specified corridors. We visualized them on top of each other with 30% opacity, to see all three together. After that we displayed the NECONET layer at the top to determine the key patches and missing links of the network (***Figure 2.***).

Analyzing the comparison of the NECONET with our results we could conclude that the Tisza river is a strongly outstanding ecological corridor for all three groups. Although it's also part of the NECONET in full length, the NECONET protection is on average 300-1500 m wide (where there are no important key habitat patches, just only the river) while based on our measurements, a 1500-2500 m wide protection is needed. It could help to maintain the key habitats alongside the river while also decreasing the risk of floods.



3. Figure: Comparison between our results and the NECONET

We were also able to identify some patches that play a key role in the network. These polygons are smaller, but due to their spatial location they have a large number of connections with other habitats or serve as a stepping stone between larger protected areas. For example, the Forest of Baktalórántháza Nature Reserve has an important role in the ecological network, despite its smaller size. The forest is located close to Nyíregyháza where the ecological network is seriously defective, paths and connections are insufficient, if the Nature Reserve disappeared, the impenetrable area would be even bigger. Another key patch with a similar role is the forest in Fülöpjakab, or the forest next to Nagykőrös. These two areas do not belong to the National Park Directory, they are only the part of the NECONET, which is a weaker protection category.

Our results also showed the importance of watercourses in a land mainly dominated by agriculture.

Not only the river Tisza was highly valuable, but the main channel of Nagykunság proved to be a key corridor in the network. The channel links the Heaths of Ecseg, the floodplain of Körös and the southern areas of Hortobágy together. The watercourse is part of the NECONET, but the width of the protection is only 150 meters wide along the banks, while according to our results, its key role demands a far wider protection area.

The comparison allowed us to identify the missing links in the river network. 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.

In the analysis of our results, we found that the ecological network in the southern-western side of our area show an interesting pattern. There's a strong connection between the protected area of Pusztaszer and the Bócsa-Bugac which includes small, stepping-stone-like corridors that are not directly connected. These patches show a firm parallel pattern that goes from the Northwest to the Southeast, but there are no links between these habitats in the other directions. According to our results, taking the density of the NECONET's habitats into account, the whole area should be part of the ecological network. As shown on the map (Figure 2) the entire area proved to be valuable from a network perspective.

We have already mentioned that the “empty” areas showed a similar pattern between the three groups. These areas are mostly dominated by intensive agriculture or contain larger cities: The agglomeration of Nyíregyháza, and Törökszentmiklós, but also the areas around Csovács and Kondoros need network intervention. In these areas, there is a need for small-scale development of the ecological network and changes in agricultural practices that will help to preserve biodiversity.

Comparing the Natura2000 areas with our results, we observed similar deficiencies to the NECONET, but on a larger scale, which is rooted in the fact that NECONET contains all Natura2000 SAC sites, while the latter is a smaller network. The Natura2000 SPAs are larger contiguous areas due to the way they are designated but lack connectivity.

According to our study, the main shortcoming of Natura2000 sites is that they do not include the entire length of the Tisza, with several breaks in protection along the riverbed. As a result, the ecological corridor of the river is insufficient, while the protection of the watercourse becomes more difficult. In Hungary, Natura2000 sites are of a higher protection category than NECONET sites, so the legal protection of the river is not strong enough along its entire length.

6. Discussion and Conclusion

Our method has produced valuable results, demonstrated the ecological importance of the Tisza and identified key habitat patches in our study area, but further research, including fieldwork, is needed to verify these results. We have only considered one main factor – connectivity – and the use of landscape metrics and other GIS methods could refine our results, and the field experience from National Parks and other local stakeholders could help refine our research.

Although our results revealed valuable information about the riverine ecological network, we found that the methodology, namely the use of the Linkage Mapper toolkit, has some weaknesses and this has led to biased results in some cases. The program linked all patches within 50 km of each other and tried to find a path between them - even if there was none. Habitats separated by intensive agricultural land use are more likely to be isolated patches, as these areas are impassable for some species. This could be addressed by increasing the resistance values of agricultural land, but then its non-negligible importance for birds would be reduced.

These false links can be identified by their geometric, highly rectilinear shape, which is due to the fact that they are not affected by other land uses and habitats. It has been shown that in these cases, the links are missing and enhancing the naturalness of these habitats is highly recommended.

Another missing factor was the transport network. Highways and arterial roads are the main cause of fragmentation and are the strongest barriers for most species. In our research, we focused mainly on bird species, and for this group the road system is less of an issue. However, for further research purposes, taking the traffic system into account when calculating connectivity may lead to a different, more sophisticated result that more nuancedly reflects the ecological network of the area.

Our results also raise the question of areas that should be part of the ecological network, but land use or other factors prevent these patches from becoming protected. These areas are not natural or semi-natural habitats, but on the contrary, and can only form part of the buffer zones of the network. Riverbanks cannot be fully protected under current legislation, as they are partly built-up municipal areas, and these patches cannot be reverted to natural habitats again. On the other hand, this will show the ecological importance of our settlements and perhaps help to spread and enforce ecological thinking in the settlements. The same applies to the larger continuous agricultural lands or to the industrial areas.

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