Ecological Connectivity in the Danube River Basin

Future Perspectives and Guiding Principles

Interreg
Danube Transnational Programme
DANUBEparksCONNECTED

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DANUBEPARKS
network of protected areas

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Dear Readers,

The Danube River is a symbol and a lifeline for several countries which needs to be safeguarded and restored. In the beginning of this century 75% of the Lower Danube's floodplains were cut off by dykes as a result of land conversion for farming and development causing increased pollution and flood risks, threats which are expected to be exacerbated by climate change. The EU environment and biodiversity policy including the EU Birds, Habitats and Water Framework Directives aim to support Member States to reverse that trend. The "Lower Danube Green Corridor", a 1,000 km long corridor with many Natura 2000 sites has made significant improvements to water quality, increased biodiversity, lowered risks from flooding and improved local livelihoods.

Green and Blue Infrastructure is an efficient tool to conserve and enhance the multiple benefits that nature provides. The science is clear: in order to stem interlinked and interdependent challenges such as biodiversity loss and climate change we need to work with nature rather than against it. The present poly-crisis cannot be solved by dealing with each issue in isolation or in a consecutive manner. It needs partnerships, solidarity and swift implementation of integrated approaches such as nature-based solutions to climate change adaptation and mitigation and disaster risk reduction. We need strategically planned networks with natural and semi-natural areas including healthy ecosystems with a rich diversity of species that provide multiple ecosystem services and benefits.

The European Commission is working towards a European Green Deal which aims, inter alia, to make the protection and restoration of ecosystems a Leitmotif for decision makers, including cohesion policy. DANUBEparksCONNECTED, which is supported by the European Territorial Cooperation Interreg programme, is one of the examples included in the 'Guidance on a strategic framework for further supporting the deployment of EU-level green and blue infrastructure (SWD(2019) 193 final) published by the European Commission in 2019. The guidance lays out the definition and criteria for EU-level green and blue infrastructure projects. It shows what can be achieved, if countries decide to join forces behind a common objective. I hope that this important and ambitious initiative will be continued, scaled up and replicated also in other regions.

Stefan Leiner

Head of Biodiversity Unit
European Commission
Directorate
General Environment

Dear Readers,

Understanding the conservation values of ecological corridors is one of the basic foundations to understand how life on the planet can survive in the face of human overpopulation trends and competing demands for land use.

Conservation importance of such corridors is sometimes difficult to recognise at a first glance, especially when comparing corridors with emblematic patches of habitats in protected and conserved areas, and if looking at the corridors only over a short period. It might come as a surprise, but the number of song-bird species determined in one scenic wetland area, known for its birds, can be very similar to the number of species detected in the longer observation period in the floodplains up- and downstream of the river, passing that wetland.

It is important to understand that organisms need to move from one habitat to another and that their survival is not dependent only on safeguarding their reproduction areas. The term „organisms“ also includes humans; in times when the amount of time people in the western world spend indoors exceeds 90% and our children play within a 90% smaller area than their parents when they were the same age and the BlackBerry is more familiar to the majority of the youth than the blackberry, the social values of the “green infrastructure” are as important as their biodiversity values in order to reconnect people with nature.

Discussions on the importance of connectivity have gained adequate attention in the global biodiversity conservation agenda. New global targets for the post 2020 period clearly indicate the importance of connected protected and conserved areas. Although the publication “Ecological Connectivity in the Danube River Basin” explores the connectivity between the various habitats in the Danube River Basin, its findings and guidance go beyond regional importance.

Andrej Sovinc

IUCN World Commision on
Protected Areas
Regional Vice-Chair
Europe

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Summary

The improvement or rehabilitation of ecological connectivity is considered a fundamental aspect in order to reduce the loss of biodiversity and to preserve various ecosystem services for the benefit of humans in the long term. Sectoral policies and a dynamic economic development of the Danube River Basin (DRB) therefore represent a major challenge for the remaining green spaces in the area. Within the framework of the implementation of the European Strategy for the Danube Region (EUSDR) the discussion gains momentum. Activities are numerous and spread over the entire DRB, often driven by local or national actors as well as NGOs. Ecological connectivity and joint transnational strategies on this topic are not yet fully on the political agenda.

The three-year Interreg project DANUBEparksCONNECTED (2017-2019) co-funded by the Interreg Danube Transnational Programme pursues the further development of a Danube-wide corridor through the implementation of best practice examples in the elements of air, water and land. The present guiding principles were developed as part of this project and are a guideline for future activities related to ecological connectivity.

The first step was an analysis of the theory of ecological connectivity, the current situation in the DRB with regard to corridors, barriers, existing strategies, the current projects in the DRB and their lessons learnt and the results of the DANUBEparksCONNECTED project. Based on the output, general recommendations were formulated and put up for discussion which is intended to provide orientation for further measures, projects and strategies in the DRB.

The guiding principles advocate long-term continuity, cross-sectoral and cross-border cooperation and the use of different protected areas categories and emphasise the increasing importance of capacity building, the use of new technologies and new research approaches and the right choice of funding pools.

I. Ecological Connectivity – An Introduction

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Ecological connectivity is becoming increasingly important in a world shaped by human use. However, prior to the document focusing on ecological connectivity along the Danube, this chapter clarifies the principles. It deals with definitions, types and functions of ecological corridors and networks, their political anchoring and the spatial reference of this document, the Danube River Basin (DRB).

Conceptualising Ecological Connectivity

All organisms need a certain type of place to live, i.e. a habitat. For some species this habitat is very large, for others it is rather small, depending on their ecological characteristics and territory size. Many species, however, are not dependent on only one habitat, but on several, be it due to the different seasons (e.g. birds), the time of day (e.g. food habitats for bats) or the respective annual cycle (e.g. reproduction habitats for migratory fish species or large migratory movements of wildlife). The habitats and their connectivity must therefore each have very specific qualities.

The Upper DRB is intensively used by man, with the result that habitats are 'fragmented' and sometimes lost. Extensive natural areas are changed over time by human activities such as deforestation. The land surface is decreased or broken up into small habitat patches. Due to the fragmentation of their habitat (Figure 1), many species have already disappeared or may disappear from several regions in the future. As natural areas are fragmented, only small populations of species can survive in the small and isolated habitat patches. Whether species survive or

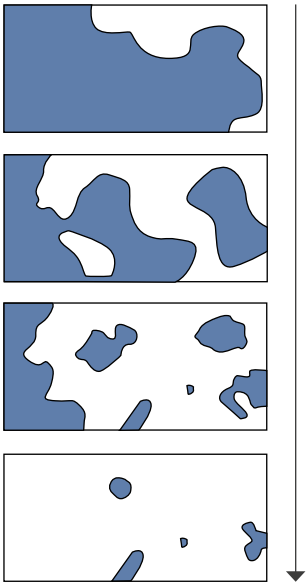


Figure 1: The process of fragmentation of natural areas (based on Van der Sluis et al. 2004)

not, often depends on a fragile balance. For example, a number of bad years, an epidemic disease or accidents may result in the extinction of a species.

Also, if the total population of a species is divided into several isolated subpopulations, each comprising only a few individuals, inbreeding depressions can lead to genetic impoverishment. In some cases, this can further result in the complete collapse of the individual subpopulations and thus to the extinction of a species, i.e. a so-called ***gene erosion***.

White-tailed Eagle (*Haliaeetus albicilla*) - flagship species for the Danube © Donau-Auen National Park/Hoyer

However, if the species does not die out and the overall population recovers, the now larger population is genetically much more uniform than the population of approximately the same size before the crisis as a result of the gene erosion that previously occurred. Such a „gene erosion event" without extinction is called a genetic bottleneck.

Good ***landscape connectivity*** will give species a better chance of survival in the long term. Moreover, the impact of climate change, which may result in species and habitats moving north in Europe, may be decreased if landscapes are well connected. The creation of an ecological network in Europe is crucial for achieving a global network of protected areas as envisaged in the Convention on Biological Diversity (CBD). Notwithstanding the necessity of connecting fragmented areas, those areas which were always isolated as a result of physical geographical barriers should not be connected, so as to preserve regional and genetical differences. However, if these isolated areas are linked by natural events, this should not be prevented either.

Together with so-called core areas, ***corridors*** form essential components of ecological networks. An ecolo-

gical network is a system of areas which are connected via ecological links or physical links. An ***ecological network*** usually consists of 'core areas' (protected or not), corridors, buffer zones and in some cases nature development or restoration areas. A central role in ensuring spatial cohesion of the network is therefore played by corridors. Currently much effort is put into the development of ecological networks, e.g. by means of the construction of wildlife corridors and road crossings or underpasses.

Nevertheless, it must be said that corridors and networks are not in all cases an improvement in conservation. There are important ***limitations*** to the network concept:

- endemic species that have developed over thousands of years of isolation can be affected by new competitors, new predators or new genes.
- invasive species can easily pass through new corridors and damage natural habitats and species.
- many species may not be able to pass the corridors provided and for many species these corridors might not be beneficiary (Gutleb et al. 2010).


Kopački rit Nature Park © DANUBEPARKS/Kopački rit Nature Park

The improvement or rehabilitation of ecological connectivity is regarded as a fundamental aspect to reduce the loss of biodiversity and to preserve various ecosystem services for the benefit of humans in the long term. Sectoral policies and a dynamic economic development of the DRB therefore represent a major challenge

for the remaining green spaces in the area. Ecological connectivity and joint transnational strategies on this topic are not yet fully on the political agenda.

Political Framework for Ecological Connectivity

The development of ecological networks and corridors is recognised as a positive policy for promoting nature conservation both at European and global levels. The concept of ecological networks was officially recognised in Europe as an important approach for biodiversity conservation in the ***Pan-European Biological and Landscape Diversity Strategy (PEBLDS)***. The PEBLDS was endorsed in 1995 by 54 states in Europe and calls for the development of the Pan European Ecological Network (PEEN) in order to achieve the effective implementation of the ***Convention of Biological Diversity (CBD)*** at the European level. The PEEN wants to promote a Europe where nature is connected and where all European governments are actively engaged in establishing and maintaining a pan-European ecological network.

The ***Habitats Directive of the European Union*** (1992), which responds to the Berne Convention, acknowledges in Article 10 the importance of landscape elements that enhance connectivity ("corridors"). Whilst building the EU ecological network Natura 2000, the Directive encourages member states to include those landscape elements in their land-use planning and development policies which they consider appropriate. A more specialised agreement is the ***Convention on Migratory Species (CMS)***, also called Bonn Convention, that obliges contracting parties to take effective measures in conservation and management of the listed species in their migratory ranges. During the first years of the new millennium, political attention for the development of ecological networks on a global level has increased considerably.

At the World Summit on Sustainable Development in Johannesburg (2002) the importance of the development of regional and national ecological networks and corridors as a way to achieve sustainable development was confirmed in the Plan of Implementation. Finally, during the Seventh Conference of Parties of the Convention on Biological Diversity (2004) ecological networks were incorporated in the work programme on protected areas as a key conservation strategy.

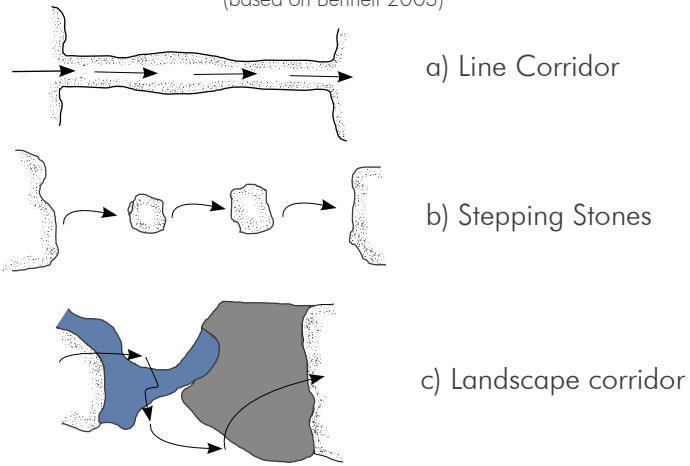
Functions and Types of Corridors

Corridors can be classified into three classes according to the functions that they fulfil. ***Commuting corridors*** are used for regular movements from resting/breeding sites to foraging areas. A commuting corridor links elements that have a different function within the home range of a species. It supports daily movements between these elements and acts beneficially because it reduces predation risk, offers guidance and facilitates movement through the landscape. Normally these movements are restricted to short distances (up to a few kilometres) for vertebrates, or to tens of kilometres for wider ranging species. Good examples of species using commuting corridors are badgers and bats. ***Migration corridors*** are used for annual migratory movements from one resource area to another (e.g. from breeding to wintering ground). The biological process of migration is a principal activity for any species groups. The most well-known are bird and fish migrations. In their journey from one resource area to another, some species will benefit from the use of

The Danube bend, connecting the the Danube corridor and the Carpathians © DANUBEPARKS/Duna-Ipoly National Park

corridors. This can be in the shape of a continuous linear pathway (e.g. riparian fish species). More often the pathway will consist of a set of areas used during migration as 'stopover' places (e.g. marshes for waterfowl and waders). ***Dispersal corridors*** are used for a one-way movement of an individual (usually a juvenile) or population from either its site of birth (for juveniles) or its former breeding area to a new breeding area. Dispersal is an essential process leading to the immigration of individuals into other populations or to (re)colonisation of suitable habitat patches. In order to differentiate between individuals and populations, dispersal corridors may be sub-divided into three types; one step dispersal corridors, reproduction corridors and range expansion corridors. In addition to the classification according to functionality, corridors can be classified into three classes according to the shape that they have: ***line, steppingstone and landscape corridors*** (Figure 2). Landscape connectivity may be achieved in two main ways: (a) by managing the entire landscape mosaic to facilitate movement; or (b) and (c) by maintaining specific habitats that assist movement through an inhospitable environment. These patterns of habitat may be in the form of (b) steppingstones of various sizes and spacing, or (c) habitat corridors that provide a continuous connection of favoured habitat.

Figure 2: Corridor types (based on Bennett 2003)



Terminology

Ecological connectivity, ecological networks, ecological corridors, green infrastructure (GI) and much more – all these terms are frequently used in publications, strategies and reports and also in this document, but do not mean exactly the same thing. Therefore, here is

a brief overview of the most important definitions of key terms in the context of ecological connectivity and GI.

Ecological connectivity refers to the spatial and temporal extent to which animals or plants and related ecosystem functions can move between different habitat patches. Ecological corridors, greenways or steppingstones facilitate connectivity (Chester and Hilty 2010). Ecological connectivity describes how well an ecological network functions. However, the concept is still controversially discussed as there is no consensus on a common definition, ranging from enabling the movement of specific species along linear elements to the establishment of large regional connections to facilitate ecological flows and the migration of species between different parts of the landscape (Walzer 2016).

Green Infrastructure refers to both the concept as such and to structures in the landscape. It is thus a strategically planned network of natural or semi-natural areas with different natural characteristics providing a wide range of ecosystem services to a wide range of beneficiaries (European Commission 2013).
Blue infrastructure is often used in an urban context and is a collective term for all water elements including rivers, streams, ponds and lakes. In combination with land spaces, it is often referred to as blue-green infrastructure.
Ecological corridors can be considered as part of an ecological network model that describes a functional zone linking several natural zones for a group of species dependent on a single environment. This corridor therefore connects different populations and allows the migration of species between them. These corridors are also sometimes named "eco-corridors", "landscape corridors" or "greenways". Ecological corridors usually have a clear conservation and species focus and are the backbone of all ecological networks.
A widely accepted and cited definition for ***ecological networks*** is proposed by Bennett (2006): *"An ecological network is regarded as a coherent system of natural and/or semi-natural landscape elements that is confi-*


Human pressure by transport and energy infrastructure on the Danube corridor in Bavaria
© DANUBEPARKS/Stadt Ingolstadt/Bäuerlein

gured and managed with the objective of maintaining or restoring ecological functions as a means to conserve biodiversity while also providing appropriate opportunities for the sustainable use of natural resources".

This definition is widely used and although slightly modified, all definitions emphasise the need for a "system", to have a "coherent" network and "maintenance of ecological functions" and an interaction or link between individual patches (Zhang 2012). These networks require structural models or concepts on how to describe, analyse, plan or implement them including GI models, ecological corridor concepts or greenways.

The Danube River Basin

For this document, the Danube River Basin (DRB, Map 1) as used by the International Commission for the Protection for the Danube River (ICPDR) will serve as the reference area.The boundaries go hand in hand with the catchment area of the Danube river and comprise the following countries or parts thereof: Germany, Czech Republic, Austria, Slovakia, Hungary, Romania, Bulgaria, Ukraine, Moldova, Servia, Bosnia and Herzegovina, Montenegro, Croatia, Slovenia as well as a valley of Switzerland (Engadin) and a very small part of Italy (the source of the Drava river). With a total area of 801,463 km^2, the DRB is Europe's second largest river basin and the world's most international river basin. More than 81 million people of different cultures and languages call the Danube Basin their home, for centuries they have been interconnected through the widely ramified water system of the Danube. All countries sharing over 2,000 km^2 of the DRB and the European Union are contracting parties of the ICPDR.

Map 2: The Danube River Basin, data source: eurostat, ESRI

Data source: eurostat, ESRI

II. Ecological Corridors in the Danube River Basin

II. Ecological Corridors in the Danube River Basin

This chapter first identifies the existing elements of green infrastructure (GI) in the Danube River Basin (DRB) on land, water and air. Based on these elements, the four main ecological corridors are then described. The document itself focuses on the Danube River and its main tributaries, however, it is crucial to understand the connectivity to other habitats and to other main corridors and to always see the Danube as an element in a more or less interconnected environment.

Main Elements of Green Infrastructure on Land

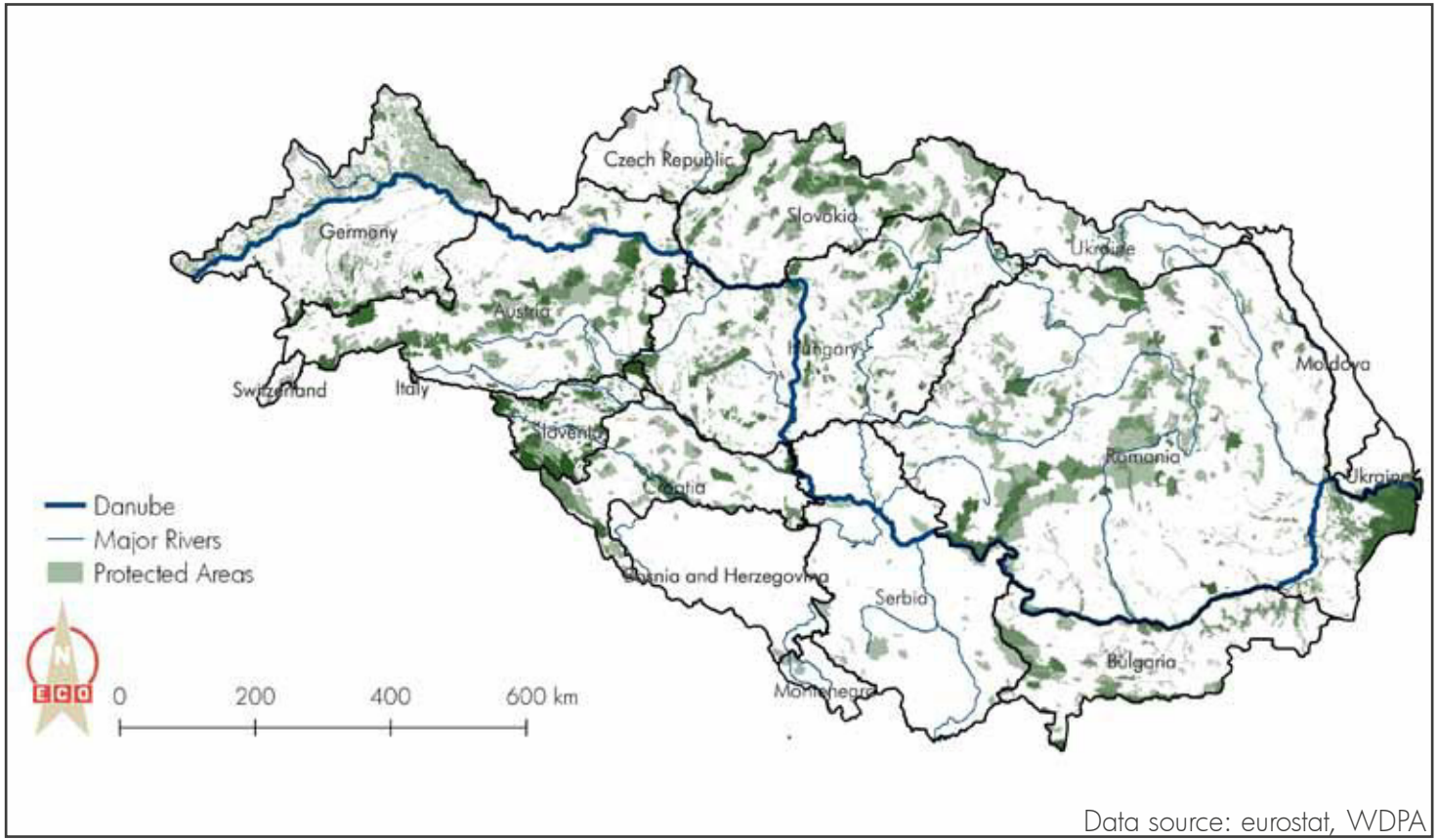
Protected Area Network

The backbone of GI on land (as well as on water) is the ***network of protected areas*** within the DRB. According to the World Database of Protected Areas, there is a large number of more than 12,395 protected areas within the DRB (Map 3). Most of the protected areas, especially the larger ones, are located on higher mountains such as the Alps, the Dinaric Alps, the Carpathians and the Balkan Mountains. At lower altitudes, forest areas such as the Bavarian Forest and Šumava constitute huge protected areas. The Danube Delta includes a large area, most of which is IUCN Category V. In addition, several ***Natura 2000 sites*** have been established along the major rivers such as the Danube itself, the Drava, the Prut, the Sava and the Tisza. However, protected areas are often not sufficient to fully cover all relevant ecosystems and habitat types necessary for connectivity, as, with the exception of Natura 2000, protected areas are often selected not for ecological representativeness but for other (e.g. political) reasons (Broggi et al. 2017). Nevertheless, this network forms the core of any GI network. The Natura 2000 sites

Box 1: IUCN Protected Area Categories

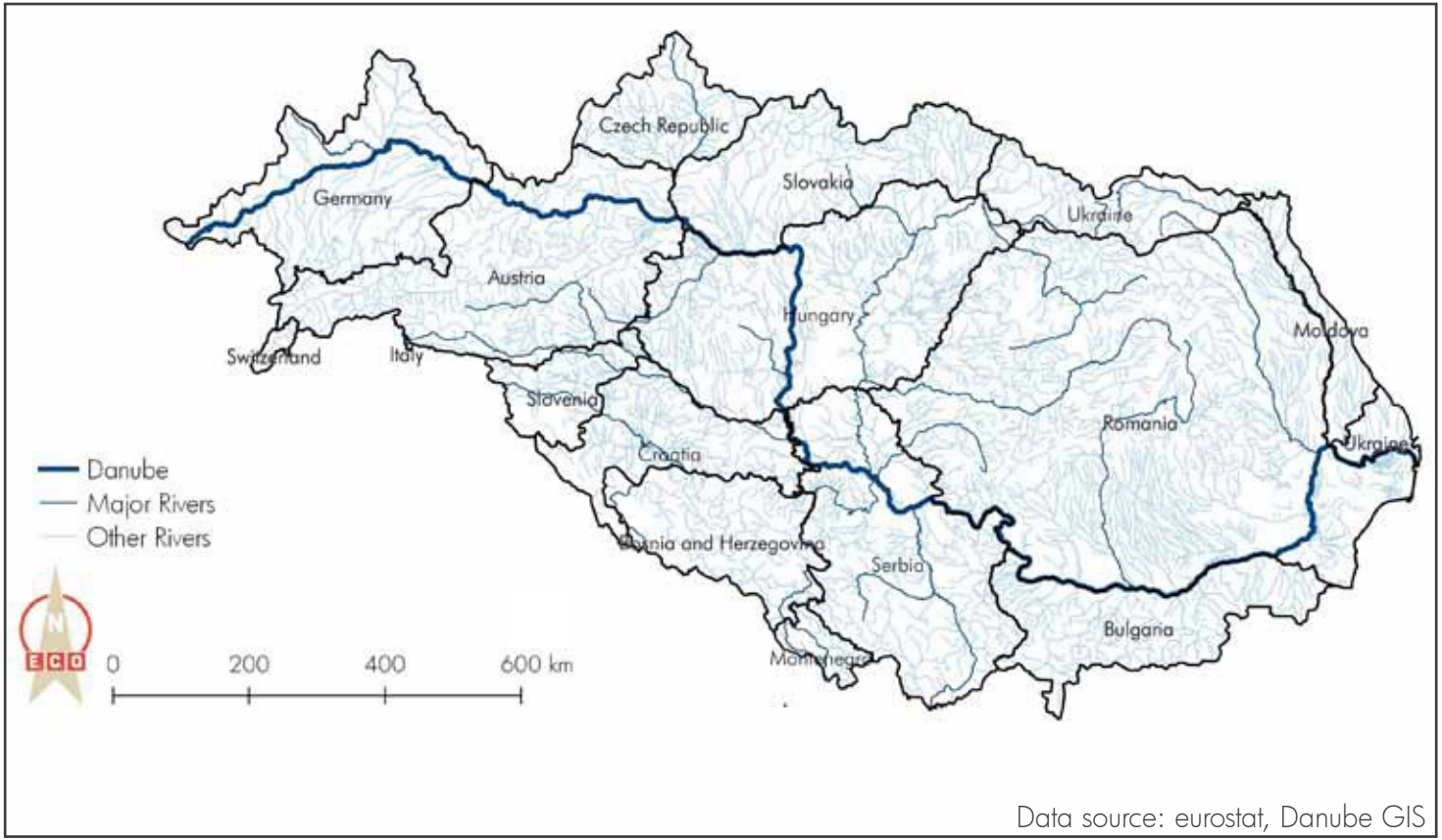
Category Ia – Strict Nature Reserve
Category Ib – Wilderness Area
Category II – National Park
Category III – Natural Monument or Feature
Category IV – Habitat/Species ManagementArea
Category V – Protected Landscape/Seascape/Area
Category VI – PA with sustainable use of natural resources

Map 3: Protected Area Network of the Danube River Basin.



Data source: eurostat, WDPA

Map 4: River System of the Danube River Basin



Data source: eurostat, Danube GIS

are considered as the contribution from the EU Member States to the Berne Convention. Therefore, this protected area category is not present in Bosnia and Herzegovina, Moldova and Serbia. However, these countries still have great potential for establishing new protected areas due to their large natural areas.

Large Forest Areas and Extensively Managed Land

Outside protected areas, ***large forest areas*** play an important role as GI, if forest use is not too intensive. Areas with spruce monoculture or intensive deforestation with clear cuts are regarded as ecological barriers. Apart from large forest areas – some of them adjacent to alluvial forest to the Danube and its tributaries – areas with rather ***extensive agriculture***, characterised by small patches of meadows, fields and hedges, play a big role. On land, there are some major key infrastructures or ecological corridors of transnational importance. The global land cover analysis shows rather few extensively cultivated areas, mainly in mountainous areas. This reflects good agricultural production capacities in the lowlands from the east of Vienna to the Carpathians. Intensive agricultural land is regarded as a barrier.

Main Elements of Green Infrastructure: Water

With regard to water connectivity, the ***Danube*** itself and its most important ***tributaries*** (Map 4, Table 1) are considered key elements of GI. In addition, larger lakes complement the Blue Infrastructure of the Danube. Given the detailed and extensive mapping and activities of ICPDR, this section only indicates the main river system and the main lakes in the area. The ***main lakes*** (surface area > 100 km²) in the DRB are Lake Neusiedl, Lake Balaton, Lake Sinoe, Lake Golovita, Lake Zemeica, Lake Razelm, and Ozero Ialpug. Of these lakes, Lake Balaton with an average depth of 3,60 m, is the deepest one. In addition, the ***Danube Delta*** is the most important blue-green infrastructure of this system. Since rivers also form transnational borders, these blue infrastructures are often of transnational importance. Management issues cannot only be dealt with at national level. This has already led to the creation of interesting initiatives such as the Green Belt connecting 24 countries, the planned 5-country Biosphere Reserve Mura-Drava-Danube or the trilateral Donau-March-Thaya-Auen Ramsar Site.

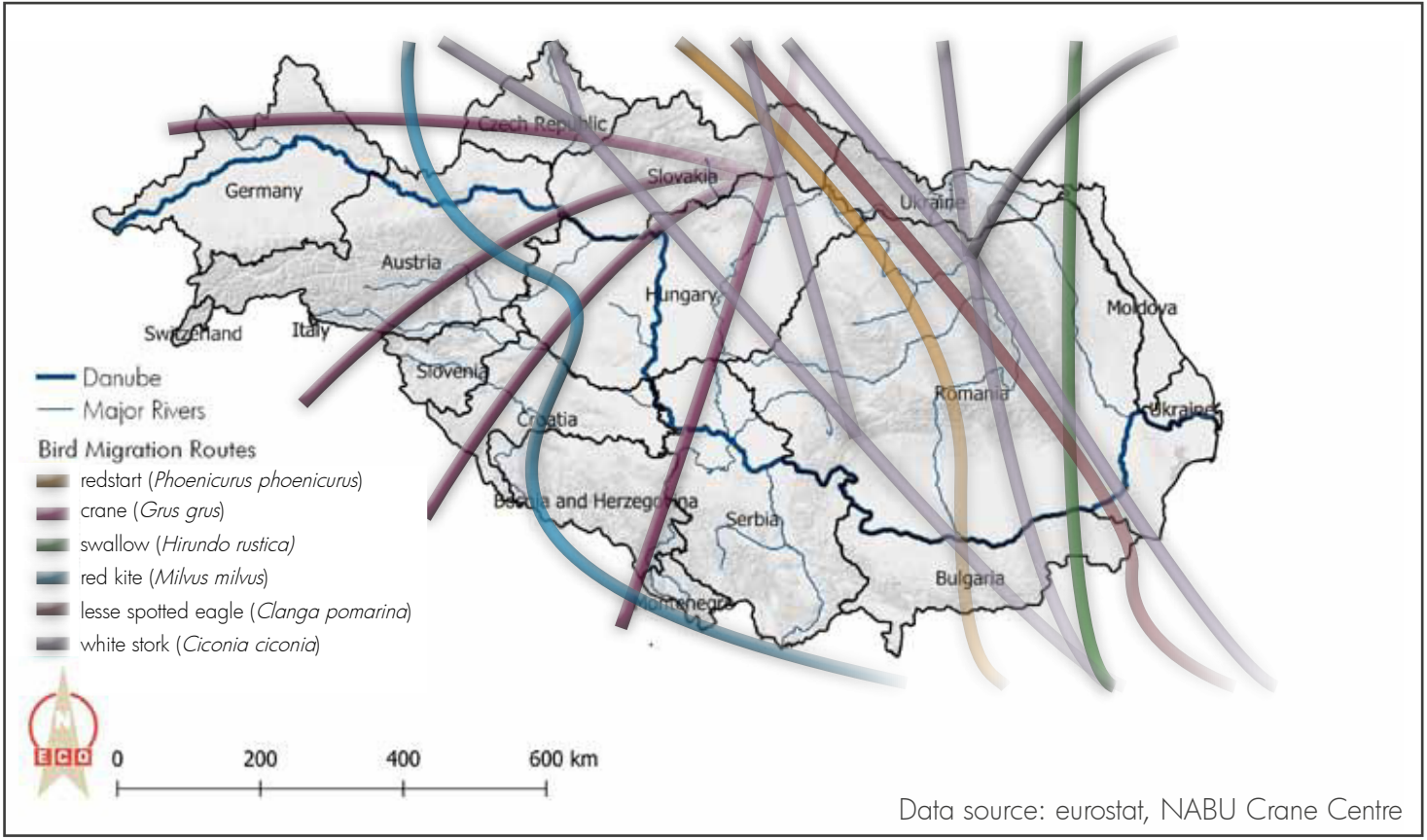
Table 1: Danube and major rivers in the Danube River Basin

Rivers	Mouth at Danube [rkm]	Length [km]	Size of catchment [km^2]	Average discharge [m^3/s]
Danube	0	2,78	801,463	6,46
Lech	2,497	254	4,125	115
Naab	2,385	191	5,53	49
Isar	2,282	283	8,964	174
Inn	2,225	515	26,13	735
Traun	2,125	153	4,257	150
Enns	2,112	254	6,185	200
Morava (March)	1,88	329	26,658	119
Rába	–	311	10,113	88
Vah	1,766	398	18,296	161
Hron	1,716	278	5,463	55
Ipoly	1,708	197	5,108	22
Sió	1,498	121	9,216	39
Drava	1,382	893	41,238	577
Tisza	1,214	966	157,186	794
Sava	1,17	861	95,719	1,564
Timis	1,154	359	10,147	47
Morava (Serbia)	1,103	430	37,444	232
Timok	846	180	4,63	31
Jiu	694	339	10,08	86
Iskar	636	368	8,684	54
Olt	604	615	24,05	174
Yantra	537	285	7,879	47
Arges	432	350	12,55	71
Ialomita	244	417	10,35	45
Siret	155	559	47,61	240
Prut	132	950	27,54	110

Main Elements of Green Infrastructure: Air

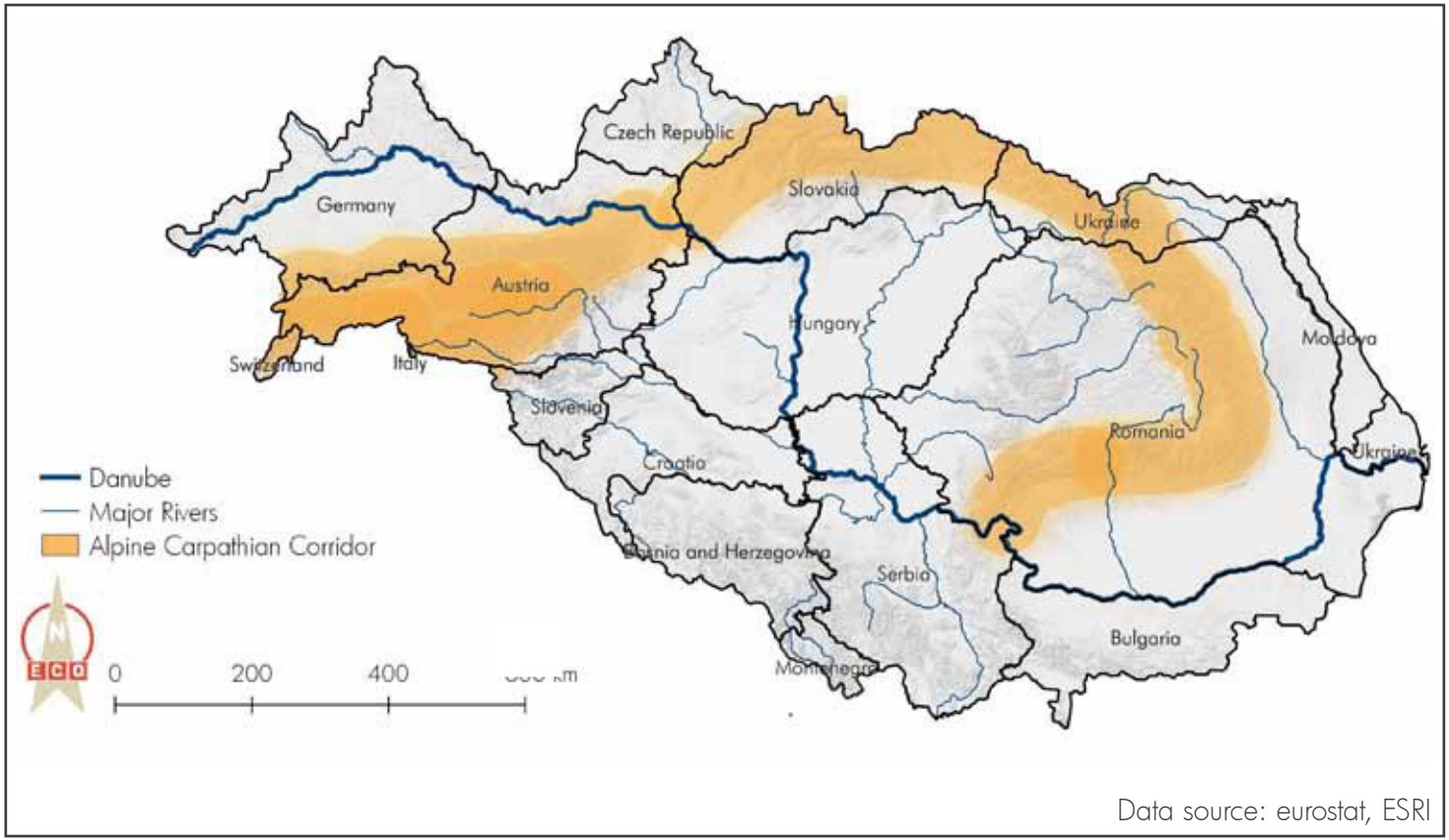
Ecological connectivity from an aerial perspective is a challenging topic. Key elements for ecological connectivity in the air are the migratory routes of birds and the associated main resting spots of migratory birds, which are mostly wetlands. In addition, the Danube itself is also a major flyway for certain species. Map 5 shows the main ***bird migration routes*** for selected species in the DRB. Hortobagy in Hungary is an important stop-

Map 5: Bird Migration in the Danube River Basin



Data source: eurostat, NABU Crane Centre

Map 6: Alpine Carpathian Corridor



Data source: eurostat, ESRI

over for cranes. Other important sites are the Danube Delta, Lake Balaton and Lake Neusiedl.

Although these corridors are quite flexible and may shift due to habitat changes, climate or wind direction changes, further investigation of these routes appear essential. The ***Convention on Migratory Species*** (CMS) aims to protect migratory species throughout their range, which is particularly important for birds and a key issue for transboundary or international cooperation (e.g. the CMS Agreement on the Conservation of African-Eurasian Migratory Waterbirds) (Jongman et al. 2011). Flyways of birds include the routes (and their man-made barriers such as power lines), stopovers and feeding places as well as the respective final destinations (Boere et al. 2006). The DRB plays an important role as it has core resting and feeding places.

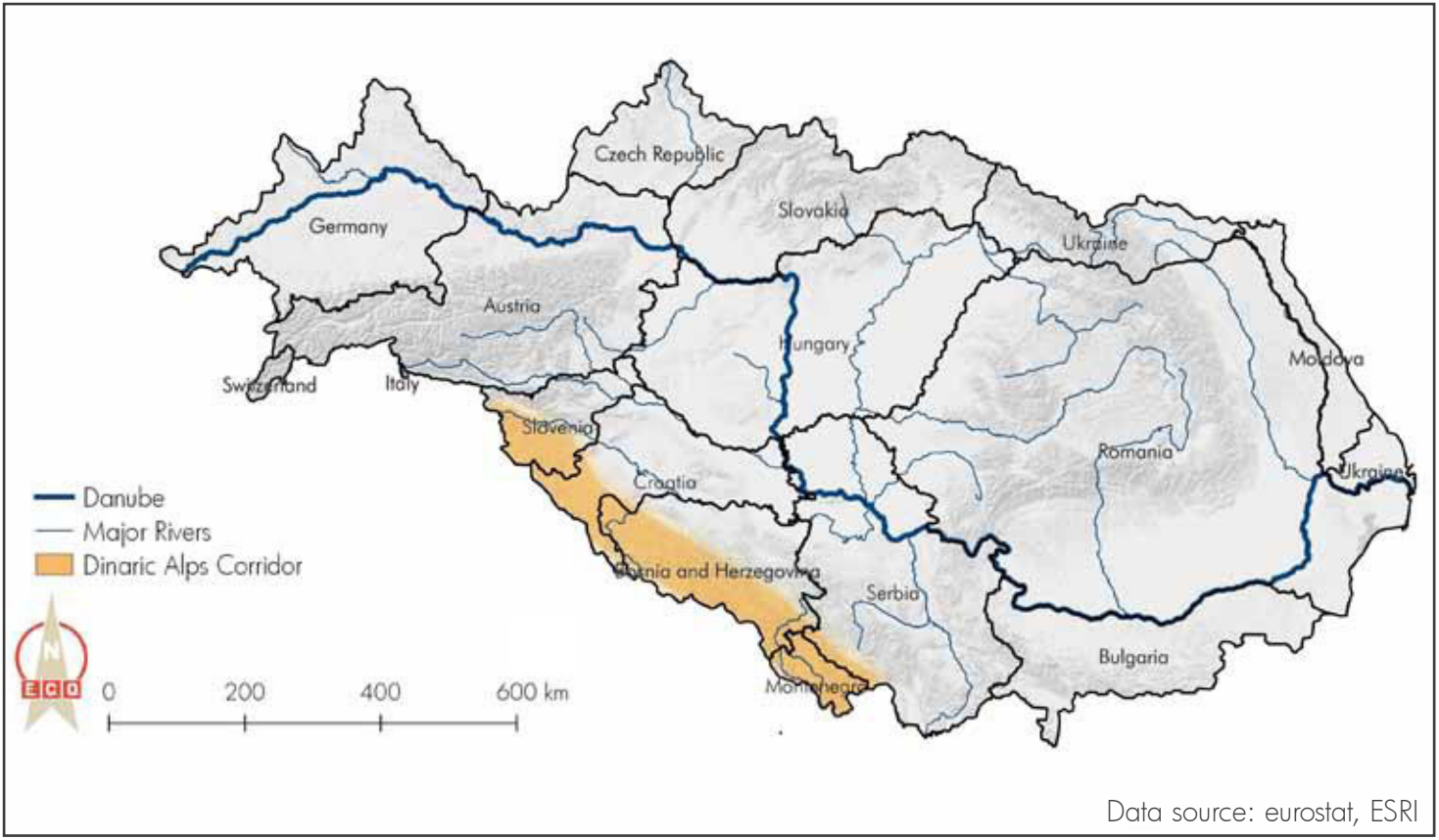
However, the level of knowledge is still quite limited, and the question of flyways has been largely neglected in the discussion about GI and ecological connectivity.

Main Corridors in the Danube River Basin

Based on the analysis of the GI elements in the DRB, four main corridors were identified:

One of the key transnational infrastructures and an important ecological network is the ***Alpine Carpathian Corridor*** (Map 6). It follows the Alps and the Carpathians, and many species of higher altitudes occur in both mountain areas. The Alps and Carpathians are home to a variety of large wild animals such as deer, lynx, wolves and bears – species that today are highly dependent on humans for their natural habitat. The corridor between the Alps and the Carpathians is a traditional migration route for wildlife. This corridor not only connects the eastern border of the Alps with the Little Carpathians of Slovakia, but also crosses a highly dynamic European region between the cities of Bratislava, Sopron and Vienna. This provides a good knowledge base for ecological connectivity in the Carpathians (e.g. Kutal 2013; Maanen et al. 2006, CEEB 2011; Deodatus et al. 2013; Andel et al. 2010). The European Beech Forest Network, which was recently established as a result of the approval of the international World Heritage Site, also addresses the need to ensure permeability and improve corridors for typical and rare beech forest species with high demands on ecological habitats. Examples of important species in Central Europe are the barbastelle

Map 7: Dinaric Alps Corridor



Data source: eurostat, ESRI

bat, the Alpine longhorn beetle and the white-backed woodpecker (Kirchmeir & Kovarovics 2016).

In addition to the above, the ***Dinaric Alps Corridor*** (Map 7) is an important north-south connection for large mammals (Proschek 2005). The corridor is reflected in the network of protected areas of Slovenia and Croatia, but not yet in Bosnia-Herzegovina and Serbia. Currently, many Balkan countries (Montenegro, Macedonia, Croatia, Serbia) are concentrating on expanding and consolidating the network of protected areas (Natura 2000 and Emerald Sites). The area is an important refuge for large carnivores (lynx, bear, wolf) and other migratory species. Through the Alps and the Danube with its tributaries, the Dinaric Arc ecoregion has many points of contact with other European macro-regions.

The ***European Green Belt*** follows the route of the former Iron Curtain and connects national parks, nature parks, biosphere reserves and transboundary protected areas as well as unprotected valuable habitats along or across the (former) borders. This border strip, which is more than 12,500 km long and between 50 and 200 m wide, has become a refuge for endangered species, as nature was able to develop here, undisturbed, during the Cold War. Conservationists aim to create a continuous, pan-European nature reserve stretching from northern Finland to the Black Sea along the route of the former Iron Curtain.

The ***Danube Corridor*** is one of the most valuable water and earth corridors in the DRB, as it is the lifeline of the DRB, which runs through the centre of the microregion and also crosses more developed and industrialised parts. Floodplain forests, (semi-wild) islands, dry habitats and wetlands are valuable GI elements along the Danube and its major tributary rivers, not only fulfilling ecological functions but also providing several ecosystem services such as flood protection or recreation. Urbanisation and economic development pose the greatest challenges, especially in the lower watercourses (Filipovic & Petrovic 2015).


Iron Gate Dam © DANUBEPARKS/Frank

III. Barriers and Gaps in the Danube River Basin

III. Barriers and Gaps in the Danube River Basin

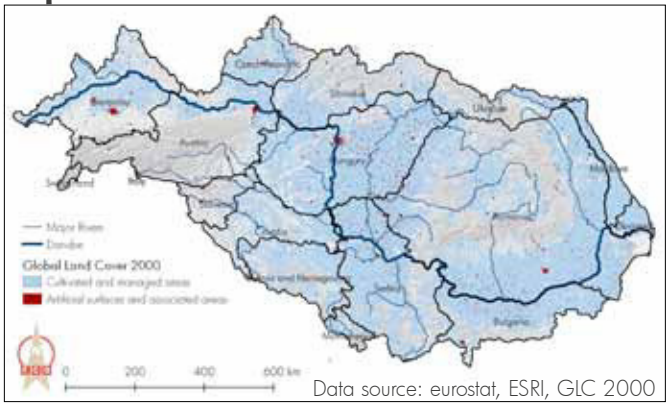
In this chapter, barriers and gaps in the Danube River Basin (DRB) on land, water and air as well as knowledge gaps are pointed out. Furthermore, the fragmentation and connectivity between the main corridors is analysed. The result is a map marking priority areas for pilot projects in the field of ecological connectivity.

Barriers and Gaps on Land

The natural relief of a landscape, especially mountain areas, can become a barrier for many species. The main mountain ranges in the DRB are the Alps, the Tatras, the Dinaric Alps, the Balkan Mountains and the Carpathians. Apart from the peaks of these mountain ranges, however, these are mostly core areas for GI and together with the Danube and the network of protected areas form the backbone of GI.

In addition to natural barriers, there are several anthropogenic barriers such as airports, highways, hydropower plants and dense populated areas (Maps 8 and 9). Favilli et al. (2014) provide a good analysis of the barriers to ecological connectivity in the Carpathians and Marschall et al. (2012) of the barriers and gaps of the Green Belt.

Map 8: Cultivated and artifical land cover

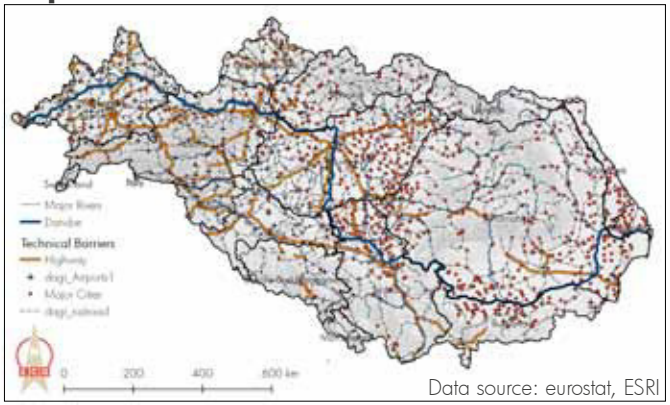


Barriers and Gaps in the Water

In addition to hydropower plants, the river system is also negatively influenced by artificial canal structures

and anthropogenic negative effects on the hydraulic properties. In the DRB, there are over 700 dams and weirs only at the main tributaries. The ICPDR has been continuously working on water connectivity for many years through the EU Water Framework Directive. Protected areas themselves have contributed to the revitalisation of lateral connectivity. The restoration potential and status are known at macro-regional level. However, so far, the main river has been in the foreground, while tributaries are only gradually receiving more attention.

Map 9: Technical barriers in the Danube River Basin



Barriers and Gaps in the Air

In the air, the main barriers are connected to high voltage power lines and wind farms, leading to significant mortality of migratory birds.

Barriers and Gaps in Knowledge

Information concerning the current status of ecological connectivity is very dispersed and varies a lot between the different DRB countries (Kostyanzski 2013). Similar challenges were also reported from the EUSALP area (Plassmann et al. 2016) and other studies that wanted to give an overview of ecological connectivity or GI (Sinnett et al. 2016).

Table 2 gives an overview of the available information on ecological connectivity in the individual DRB countries and about the degree of integration into national planning.

Austria and Germany have carried out numerous studies and projects to identify corridors and barriers for different habitats and species. In certain sectors, the results are integrated into specific spatial plans, e.g. ***Waldfachplan (Forest Management Plan***) in Austria, which are

drawn up on a voluntary basis, mostly on the initiative of forest owners (BMNT 2019), or considerations of wildlife corridors in transportation infrastructure planning in Germany (Rudolph et al. 2010).

In addition, the Czech Republic, Slovakia and Hungary have good concepts for ***national ecological corridors systems (TSES***), which need to be considered in spatial planning. This also provides a national legal basis for ecological corridors. However, no detailed information on the quality of these corridors or the final degree of implementation could be obtained during the research.

Most countries have at least an overview of their main ecological corridors at national level and detailed studies for specific areas (e.g. locally relevant corridors) or species (e.g. regional lynx corridors). However, ecological connectivity and corridors are rarely legally implemented or integrated into spatial planning. In most cases, ecological connectivity is only considered as a cross-cutting issue. The quality of the corridors in many countries remains unclear, either because no data have been collected, data are not publicly available or were only published in the national language. This underlines the need to identify common standards and methodologies if the issue of connectivity is to be addressed at transnational or macroregional level. As a result of this heterogeneity, transnational information is scarcely

Table 2: Information available in the Danube River Basin

	Trans-boundary activity	Corridors known	Quality of corridors known	Barriers mapped	Legally integrated	Integration into spatial planning
AUT						
CZE						
DEU						
HUN						
SVK						
MDA						
SRB						
SVN						
ROU						
UKR						
BGR						
HRV						

Available information and activities regarding ecological connectivity in individual countries of the DRB (green: good information/frequent activities, yellow: medium information level/some activities, orange: no information available/no activities)

available and can only be generated through the use of global data sets and local or national information, which is often lacking. Information on TSES in Slovakia and the Czech Republic could also be of high relevance for other countries. When it comes to the issues covered, it is very clear that water-related connectivity issues are mostly dealt with at a transnational level, providing comprehensive information on connectivity and barriers. As far as the country is concerned, the information usually remains at national level, with corridors sometimes even ending at the national border. Most connectivity projects, laws or actions are strongly related to terrestrial connectivity, while air connectivity is an issue that is not yet mentioned anywhere.

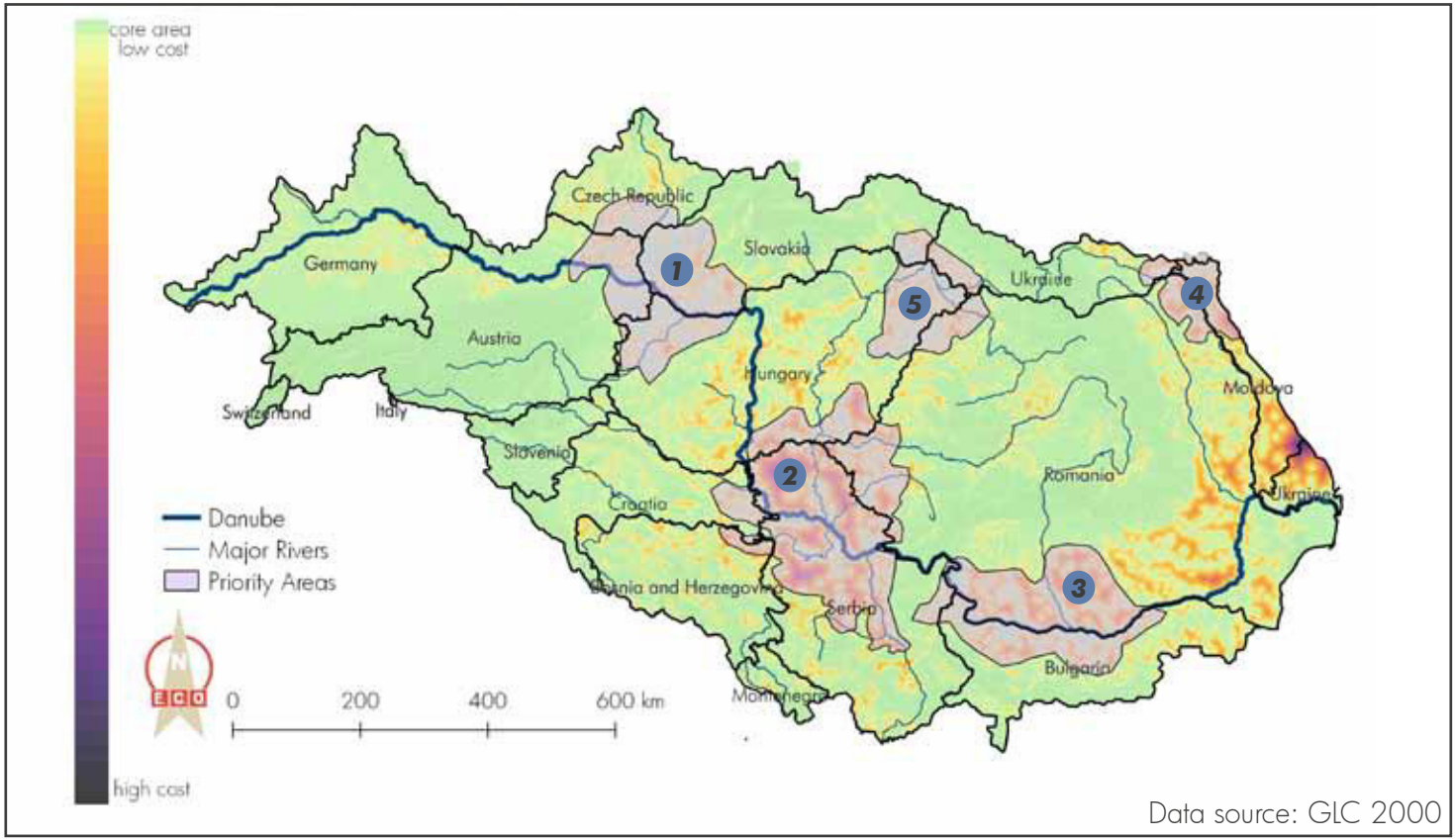
One way of generating transnational knowledge and making it accessible is shown by the European project „ECONNECT – Restore the Web of Life", funded by the European transnational cooperation (ETC) Alpine Space Programme. The vision was to analyse the capability of the Alpine range to serve as an ecological continuum and to identify and visualise areas in which the ecological network can be improved. For this purpose, the web application ***JECAMI*** was developed. The „Joint Ecological Continuum Analyzing and Mapping Initiative" allows the combined visualisation of animal needs and landscape realities in different scales and offers an insight into the matrix of connectivity potential in the Alps.

Connectivity of Main Corridors in the DRB

In a ***study on ecological connectivity*** in the DRB, commissioned by the ***Bavarian State Ministry*** of the Environment and Consumer Protection ***PA 6*** Leader of EUSDR, ArcGIS was used to produce a map showing the degree of fragmentation and the spatial distribution of step stones (Map 10). Data from the Global Land Cover 2000 database was divided into three categories: natural (extensively used and natural vegetation), intensive (cultivated and managed areas) and anthropogenic (artificial and associated areas). Natural areas and protected areas were grouped together as core areas (green). The lowest "cumulative cost difference" is shown in light green. The changing colour gradient from light green to dark violet shows an increasing effort to get to the next core area.

While ***greenish*** areas have a small distance from each other, ***yellowish to violet*** areas indicate areas in which no or only very isolated patches of (semi-)natural areas

Map 10: Priority areas for actions on ecological connectivitiy in the Danube River Basin



Data source: GLC 2000

can be found. In the analysis, no linear barriers (roads, railroads) were considered.

The results show only a broad overview at macro-regional level. It is important to note that this analysis does not replace concrete local assessment and modelling for specific species and local barriers. However, the results can be used at a strategic level when deciding on the selection of pilot regions, the allocation of budgets for connectivity projects or the definition of transnational corridor systems.

Isolated areas in more intensive/fragmented areas are most likely to have a higher significance in terms of loss of the area. While areas with cost values (green) offer many different possibilities for wildlife migration (alternative routes), a loss of natural elements in isolated areas (yellow-violet) can trigger complete isolation. Nevertheless, the analysis clearly shows where the existing main corridors are and gives a broad indication of areas with low connectivity, especially in these ***5 priority areas*** (3 of which are along the Danube, 2 in the mountains):

1. The area along the border of Slovakia and Austria is a major barrier for the connection of the Alps and the Carpathians.
2. The Pannonian Lowlands in the border region of Croatia, Serbia and Hungary are areas that are dominated by large intensive agricultural areas. The Green Belt and the Danube are amongst the few key GI in the area.
3. The lowland areas between the Danube and the Carpathians in Romania and Bulgaria are also dominated by important agricultural areas. The tributaries to the Danube main river represent important local elements for connectivity between the Danube and the Carpathians.
4. The area where Ukraine, Romania and Moldova share the border has some major barriers and is located along the main Alps-Carpathians Corridor.
5. The area along the borders of Slovakia, Ukraine, Hungary and Romania has some major barriers located directly along the main corridor within the Carpathians.

These areas have also been selected as priority areas for possible pilot projects in the field of ecological connectivity. The criteria degree of isolation, transboundary aspects (at least 2 countries), location along one of the identified main corridors and data availability were characteristic for the selection of the areas.

IV. Enhancing Ecological Connectivity – Strategies & Projects

IV. Enhancing Ecological Connectivity – Strategies & Projects

Studies, initiatives and projects on green infrastructures (GI) or ecological connectivity are abundant. This section provides a general overview of strategies, funding instruments and best practice projects on ecological connectivity in the Danube River Basin (DRB).

Relevant Strategies and Policies

The following section lists the relevant strategies and conventions at macro-regional and European level and gives a brief overview of their link to ecological connectivity.

Target 2 of the ***EU 2020 Biodiversity Strategy*** requires that by 2020 "ecosystems and their services are maintained and enhanced by establishing GI and restoring at least 15% of degraded ecosystems". To support this process across Europe, the European Commission adopted the strategy in 2013.

The ***EU Strategy for the Danube Region (EUSDR)*** aims to strengthen EU policies in the Danube region. The Priority Area 06 of EUSDR "To preserve biodiversity, landscapes and the quality of air and soils" comprises the development and implementation of a GI at macro-regional level. The topics range from restoring degraded ecosystems to eradicating invasive species and securing viable populations of migratory fish species.

The ***Danube River Protection Convention (DRPC)*** is the major legal instrument for cooperation in transboundary water management in the DRB. The Convention was signed in Sofia (Bulgaria) on June 29, 1994 and came into force in 1998. The main objective of the Danube River Protection Convention is to ensure the sustainable and equitable management and use of surface and groundwater in the DRB.

The ***International Commission for the Protection of the Danube River (ICPDR)*** was established to implement the DRPC. The ICPDR is formally comprised of the Delegations of all Contracting Parties to the Danube River Protection Convention but has also established a framework for other organisations to join. Since 2009,

the Danube River Management Plan (DRMP) has provided a roadmap for this. It contains a Joint Programme of Measures and aims to fulfil the EU Water Framework Directive (WFD). The ICPDR is currently working on an updated version of the DRMP. The ICPDR also implements the EU Flood Directive (EFD).

The ***Habitats and Birds Directives*** and their implementation through the Natura 2000 network are key instruments for the implementation of the ecological connectivity at European level. These directives emphasise the coherence and connectivity of the network and require member states to comply with the requirements. The Natura 2000 network is therefore seen as the backbone of a European GI network.

The ***White Paper*** on Integrated Sustainable Development of the DRB (Winiwarter & Haidvogel 2015) identifies important gaps in knowledge, principles and topics of inter- and transdisciplinary long-term research for the sustainable development of the DRB. It contains recommendations for political decision-makers on important prerequisites and organisational measures at national and European level.

Best Practice Projects

Several projects have already been initiated in the DRB to promote ecological connectivity. The following pages describe four successful projects selected for their practice-oriented measures and their direct influence on connectivity. ***MEASURES*** deals with a migratory flagship species whose survival depends on connectivity, whereas ***COOP MDD*** is an example for a transnational protected area network. ***DaRe to Connect*** shows a successful project that tries to close the last gaps of the historically grown green belt and ***Sava TIES*** identifies the negative aspects of connectivity, such as the rapid dispersal of invasive species.

Box 2: Audience Polling at the DPC conference, Part I

These best practice projects were presented at the final DANUBEparksCONNECTED conference in Novi Sad in June 2019. The audience was asked whether the selection of the projects was justified. 60% found that these projects have a major impact on ecological connectivity in the DRB. 25% already knew about the projects and 70% had at least heard about them. 76% of the audience thought that these projects represent key aspects of the activities that have been implemented to enhance ecological connectivity in the DRB.


Sturgeon hatchery © Daniel Trauner

FACTS & FIGURES

Interreg Danube Transnational Programme
Term: Jun 2018 – May 2021
Budget: 2,513,000€
Partners: 12 (Lead Partner: BOKU Vienna)
AUT|BGR|HUN|HRV|ROU|SLV|SRB|SVK

MEASURES

Managing and Restoring Aquatic Ecological Corridors for Migratory Fish in the Danube River Basin

The Danube is home to some of the most important sturgeon and other ***migratory fish populations*** (e.g. shads, barbel, nose etc.). The largest and possibly most iconic among these species are the ***sturgeons***, a key element of life within the river basin. Bulgaria and Romania hold the only – still – viable populations of wild sturgeons in the European Union which have faced a dramatic decline in the past decades due to man-made barriers that prevent their migration and their ability to spawn, such as dams or hydropower plants. Only a coordinated approach can prevent the further decline or the total disappearance of these species, whose health reflects the overall well-being of the entire Danube ecosystem itself. MEASURES aims to create ***safe corridors*** on the entire Danube and its major tributaries for the native fish, which migrate along the river as an essential part of their reproductive life-cycles. By working to protect and increase their numbers, MEASURES will be

contributing a key piece to the complex puzzle to restore and assure river vitality and sustainability. This is particularly important in regard to the development of future infrastructure projects, which would put additional pressure on the last remaining habitats of the endangered species. Migratory fish are excellent bioindicators of the effectiveness of ecological corridors due to their specific needs during their life cycles. This is especially true for sturgeons, which typically migrate over long distances and are an important part of the natural heritage of the entire Danube region. By focusing on one flagship species and trying to ensure ecological connectivity for it, many other migratory fish species benefit from this.

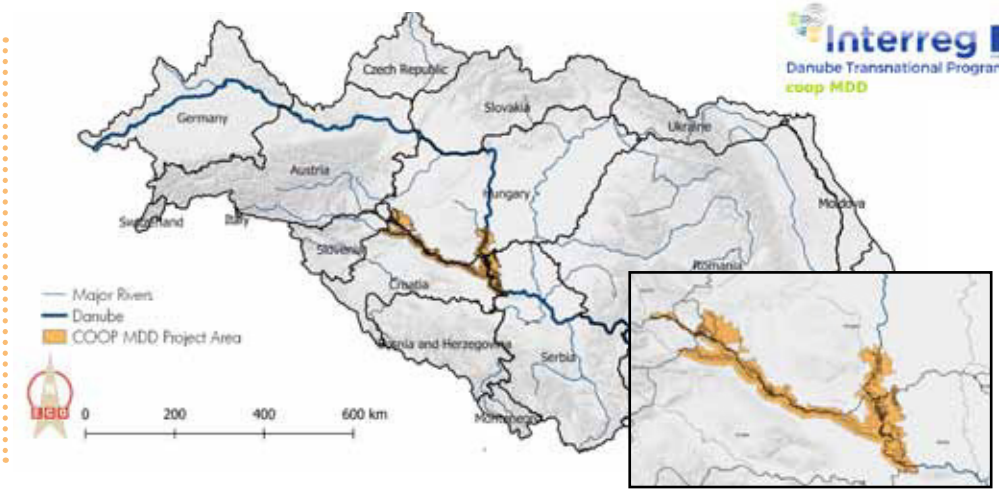
Activities to pursue this objective include the development and verification of a ***mapping method*** to identify habitats for migratory fish species. This will lead to a ***standardised manual*** of mapping approaches and a ***basin-wide map*** of suitable habitats and migration corridors. Another vital approach consists of manually ***restocking*** two native sturgeon species in Hungary (*Acipenser ruthenus*) and Romania (*Acipenser gueldenstaedtii*). The fish were tagged prior to release in order to identify them if they are caught during later in-river surveys, providing valuable insights into their survival rates for larger future restocking plans. Finally, an ***information system*** will be set up to allow experts, decision-makers and the general public access to the collected data. The results should help to develop a transboundary strategy for the restoration and protection of ecosystem corridors for future management plans in the Danube countries. In addition to MEASURES, the Danube Sturgeon Task Force coordinates Danube-wide conservation and restoration actions, and the ICPDR is active to promote technical solutions to make the Iron Gate Dams passable for sturgeons.

> “The Danube is a key lifeline in Europe connecting important bioregions, economics and cultures. Securing biodiversity is fundamental to human development and rivers are one of the most threatened ecosystems on our globe. Our project contributes to these challenges specifically for the Danube River in its role as an important ecological corridor connecting natural heritage sites and an organism group key to a sustainable future of the river, migratory fish including sturgeon species.”
>
> Thomas Hein, University of Natural Resources and Life Sciences (BOKU) Vienna


Drava-Mura confluence in Croatia / Hungary © Goran Safarek

FACTS & FIGURES

Interreg Danube Transnational Programme
Term: Jan 2017 – Jun 2019
Budget: 2,154,000€
Partners: 11 (Lead Partner: WWF Austria)
AUT|HRV|HUN|SRB|SVN|



Coop MDD

Transboundary Management Programme for the Planned 5-Country Biosphere Reserve "Mura-Drava-Danube"

The Mura, Drava and Danube rivers form a highly valuable and free-flowing river corridor 700 kilometres in length, connecting almost 1,000,000 hectares across Austria, Slovenia, Croatia, Hungary and Serbia – the "Amazon of Europe". Their waters transport sediments disregarding man-made boundaries, animal species regularly cross national borders on their daily search for food, and the people on these rivers are exposed to up- and downstream developments, which is why river management must also take place at a transboundary level. The cooperation Mura-Drava-Danube (coop MDD) project worked on harmonising protected area management and developing a joint management programme for the future 5-country UNESCO Biosphere Reserve ***Mura-Drava-Danube*** (TBR MDD). The core goals of coop MDD are coherent management practices, support for the local population and political agreements that should ultimately lead to the preservation and resto-

ration of a dynamic river system. The main outcome of the project is the document ***Guidelines for a Dynamic River Corridor***. These guidelines show what objectives need to be achieved in order to protect and restore the dynamic river corridor for the Mura, Drava and Danube rivers. The topics range from species and habitat conservation to visitor management to spatial planning and address obstacles, visions and objectives from all partner countries.

Ecological connectivity is covered in two thematic areas: In the chapter "Habitat and Species Conservation", one of the main objectives is: "The corridor function of the TBR MDD river corridor and the connectivity with surrounding natural areas is well-preserved". It includes water, forest and meadow habitats as well as the connection with the surrounding natural areas through tributaries or steppingstones. In the chapter "River Management and Engineering", one of the objectives is as follows: "Mura, Drava and Danube within the TBR are free-flowing rivers within a well-connected active floodplain". This sub goal focuses on restoring longitudinal connectivity, ensuring that no hydroelectric power plants interrupt the free flow and that rivers can move freely between dikes or within natural terraces.

> "With coop MDD, a coherent strategic approach was developed for the first time across all five countries for the successful management and restoration of the Mura-Drava-Danube river corridor. Following harmonised objectives, the measures implemented by the project partners to conserve this important eco-corridor will be much more effective in the future."
>
> Magdalena Wagner, WWF Austria

In order to monitor the success of the implementation of the guidelines, the 12 protected areas within the transboundary river system agree to discuss together regularly the state of implementation, to continuously exchange experiences on challenges and successes and to support each other in the implementation of the guidelines for a dynamic river corridor. A follow-up project, aimed at assessing the status of the river corridor on a scientific basis and developing a river restoration strategy together with water managers, is currently being developed and proposed to continue work and define the next steps for the implementation of the joint management strategy.


Laksar Uplands in the Zahorie Region © Tomas Olsovsky

FACTS & FIGURES

Interreg Danube Transnational Programme
Term: Jun 2018 – May 2021
Budget: 2,087,000€
Partners: 11 (Lead Partner: BUND Bavaria)
AUT|CZE|DEU|HRV|HUN|ROU|SRB|SVK

D2C – DaRe to Connect

Supporting Danube Region's Ecological Connectivity by Linking Natura 2000 Areas along the Green Belt

The ***Iron Curtain*** refers to the 7,000 km long physical barrier of fences, walls, minefields and watchtowers that divided Europe into "East" and "West" from the end of the Second World War in 1945 to the end of the Cold War in 1991. The creation of these highly militarised no-man's-lands led to de facto nature reserves and created a ***wildlife corridor from Finland to Greece***, allowing several species to spread into new areas. Since the fall of the Iron Curtain, several initiatives have pursued the creation of a European nature reserve for the Green Belt along the former Iron Curtain Route.

The Green Belt now covers 12,500 km, crosses 8 biogeographical regions in 24 countries and partly follows the riverbed of the Danube. In the Danube Transnational Programme, the corridor connects 10 countries. The area includes not only wilderness areas, but also cultural landscapes, water ecosystems and coasts, making

it home to many endangered species. However, the Green Belt still suffers from a certain degree of inadequately connected habitats and valuable landscapes.

The main objective of the DaRe to Connect Project is therefore the implementation of the ***EU Danube Strategy*** through the further transnational development of the Green Belt as the backbone of the Pan-European Ecological Network and EU GI through the conservation and improvement of ecosystems and their services.
The project defines feasible ecological corridors between Natura 2000 sites at transnational and macro-regional level through innovative GIs and remote sensing approaches, partly based on newly available EU Copernicus (Sentinel) data. The focus is on the identification of suitable ecological corridors between protected areas and the analysis in terms of connectivity. For suitable corridors, an ***analysis*** of the implementation potential will be carried out, covering the legal and financial requirements as well as the ecosystem services provided.

On the basis of the pilot actions, the project will then provide concrete guidelines and recommendations for the planning and establishment of transnational ecological corridors linking Natura 2000 sites at local and regional level.

The results will be disseminated through a transnational strategic vision ***Green Belt in the Danube Region 2030*** supported by national policy actors. The measures along the Green Belt are also relevant for the Danube, as their courses overlap and cross, especially in the Balkan section.

> “Working on transnational, cross-border projects such as DaRe to Connect is a major key to preservation and development of the European Green Belt. We strengthen this initiative as a network of partners and stakeholders and as an ecological network. All of us involved in the project want to bring nature closer together and by this grow together as Europeans.”
>
> Martin Kuba, BUND Department Green Belt


Sava gravel bars © Mario Zilec

FACTS & FIGURES

Interreg Danube Transnational Programme
Term: Jun 2018 – May 2021
Budget: 1,604,000€
Partners: 9 (Lead Partner: EuroNatur Foundation)
BIH|DEU|HRV|SLV|SRB

Sava TIES

Preserving Sava River Basin Habitats through Transnational Management of Invasive Alien Species

With a catchment area of 97,800 km^2 and a length of 926 km and passing through 4 countries, the Sava River is the largest tributary of the Danube by discharge. It is an important ecological corridor for natural movements of many species. In total, 64% of the Sava River is designated in various categories of protected areas and is also one of the focal areas of biodiversity in Europe. Recently, it has been proven that, apart from the fact that it is a natural corridor for native species, it is also a pathway of invasive alien species expansion.

Invasive alien species (IAS) are species which have established a stable population in areas where they have not been distributed historically and have a tendency to spread to a degree believed to cause damage to the biodiversity, human health and/or economy. They can be introduced intentionally or unintentionally into new areas. IAS are identified as one of the most

significant threats to the Sava River basin (SRB) biodiversity. Prevention is one of the most important instruments when dealing with invasive species. To do this, however, knowledge about the occurrence of all the different alien species that can cause problems is key.

The Sava TIES project which is carried out in all four countries of the SRB, Slovenia, Croatia, Bosnia and Herzegovina and Serbia, focuses on the species that are already causing severe damage in the SRB. The following IAS are being tackled in 7 pilot areas: Japanese knotweed (*Reynoutria japonica*), false indigo (*Amorpha fruticosa*) and tree of heaven (*Ailanthus altissima*). Furthermore, research on other IAS posing a threat on biodiversity is conducted. The main project objective is to ***reduce habitat fragmentation*** and to improve the connectivity of the transnational Sava River corridor by developing cross-sectoral measures for monitoring, controlling and eradicating invasive alien species in the protected areas network of the Sava River Basin.

The activities will result in a ***guidebook*** on existing best management practices for eradication techniques, a protocol for IAS mapping and monitoring, a map of IAS in the Sava river basin and policy recommendations to be included in strategic documents.

In the Sava TIES project, ecological connectivity becomes visible in the sense that one can see how (rapidly) some invasive species are spreading towards downstream areas, and that measures to prevent the spread of the species only make sense if all countries along the river work together. This is why a transnational and cross-sectoral strategy is indispensable.

> “The focus of Sava TIES is on cross-sectoral cooperation, as we can only achieve the desired results through cooperation between different stakeholders, national and local governments and the local population. This will be the first attempt within the region to address the challenging issue of invasive alien species at the transnational corridor level, with the lessons learned benefiting the entire Danube region and beyond.”
>
> Ivana Vasić, Vojvodinašume, Serbia

V. DANUBEparksCONNECTED

V. DANUBEparksCONNECTED

Bridging the Danube Protected Areas towards a Danube Habitat Corridor

The guiding principles on ecological connectivity were developed as part of the DANUBEparksCONNECTED project. The results of this three-year project are reflected in the recommendations of this document, therefore the following pages are dedicated to the most important outputs and experiences of DANUBEparksCONNECTED. As within the project, the individual measures are divided into the sections land, water and air.

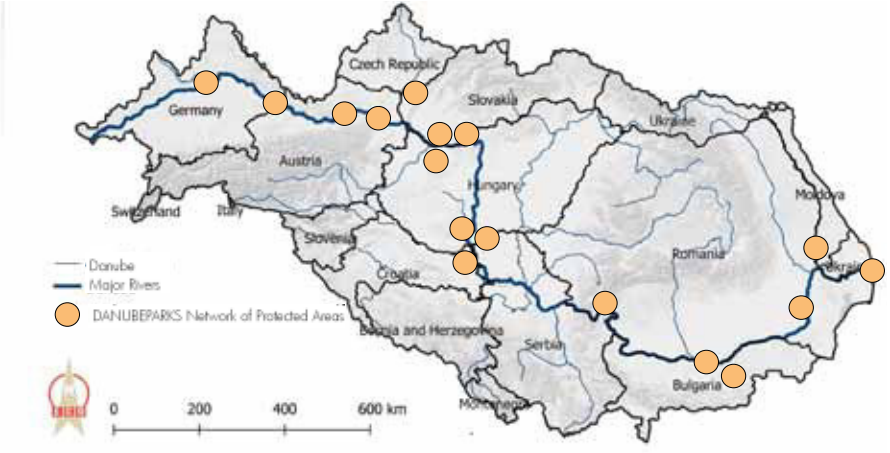

Danube floodplains © DANUBEPARKS/ Duna-Dráva National Park Directorate

FACTS & FIGURES

Interreg Danube Transnational Programme
Term: Jan 2017 – Nov 2019
Budget: 3,085,000€
Partners: 15 (Lead Partner: Donau-Auen National Park)
AUT|BGR|DEU|HRV|HUN|ROU|SRB|SVK

DANUBEPARKS Association

In terms of ecological connectivity along the Danube, protected areas preserve the most important natural areas. Cross-border conservation is of crucial importance, and transnational cooperation the tool to restore and preserve the connectivity of habitats along the world's most international river. The coherence of



management has improved significantly as a result of two earlier projects that were jointly implemented by the protected areas along the Danube. The partnership focused on the protection of flagship species, habitat management, the preservation and restoration of river dynamics and the strengthening of nature tourism and environmental education programmes. The successful cooperations led to the foundation of the network of Danube protected areas in 2007 and finally to the development of the DANUBEPARKS Association in 2014, which consists of 17 protected areas in 9 countries. The aim is to bring together all protected area administrations along the Danube, and to cooperate closely with protected sites along the larger tributaries.

Development and Structure of the Project

While the network of Danube protected areas preserves the most valuable sites, the fragmentation of habitats limits efforts to preserve a coherent ecosystem. DANUBEparksCONNECTED launched the ***Danube Habitat Corridor campaign*** to counteract this ecological fragmentation. The three-year Interreg Project (2017-2019) is the third of its kind and comprises 15 project partners, Donau-Auen National Park being lead partner. The project is divided into four areas:

In the ***water*** category, the cross-sectoral Danube WILDisland corridor programme has been established to protect islands, which are among the most important habitats for intact river dynamics and the home of characteristic species.

The ***land*** category refers to the dry habitats and the riparian forests that are part of natural river systems and are today often fragmented into individual sections. Measures such as the Danube Dry Habitat Corridor, the DANUBEPARKS Canyons Network and the Danube Riparian Forest Corridor attempt to counter the fragmentation of these habitats.

Under the name DANUBE FREE SKY, technical solutions are searched for in the ***air*** corridor to ensure a collision-free and electrocution-free bird migration along the Danube flyway.

Fire is the fourth element and stands for communication. It includes measures to communicate the activities to the outside world, to involve people in nature conservation and to raise awareness for connectivity.

Water – Danube WILDisland Corridor

Islands are threatened hotspots of biodiversity, providing habitats which various species depend on for survival. They are excellent indicators of dynamic river morphology and ecological backbones for the development of GI. Since the many small, large and sometimes even dynamically growing or shrinking islands are steppingstones along the Danube, DANUBEparksCONNECTED aims to emphasise their importance for other sectors as well and to preserve these vital river sites and strengthen the Danube-wide water corridor.


The Danube Wild Island Habitat Corridor © DANUBEPARKS/ DANUBEPARKS/Stadt Ingolstadt/Bäuerlein

The WILDisland initiative, launched within the DANUBEparksCONNECTED project, wants to strengthen ecological connectivity and the preservation of natural wilderness in the heart of Europe. In several meetings and cross-sector conferences, the DANUBEPARKS partners and external experts have agreed on a common understanding and formulated the ***WILDisland guidelines***. Based on these guidelines, a dynamic database has been created, visualising an eco-corridor of 912 Danube islands.

The selected islands were categorised according to their natural character, from islands with completely natural wilderness (category A) to valuable islands with restoration potential (category B) to islands that are heavily exposed to human use (category C). The inventory provides an important overview of the status of the Danube WILDisland Corridor. After site visits, non-intervention management agreements were developed, as the WILDisland label aims to protect natural processes and characteristic riverine habitat structures.

The inventory of the Danube islands is shared via ***WILDisland Online***, the very first interactive map-based database of islands along the entire Danube.

It covers 3,000 river kilometres, 912 islands, 147 untouched or completely natural islands, 138,000 ha of dynamic island habitats and 14,000 ha of wilderness.

During the project, the communication with the navigation sector was very important. Several workshops and coordination meetings took place to set up WILDisland as a ***joint pilot initiative***. The pilot actions included river restoration and rewilding islands. Together, the nature conservation and navigation sector came up with an environmentally sound waterway maintenance document and a management concept. In 2018, the WILDisland initiative already received recognition from the EU-Forum of Nature and Biodiversity Directors, stressing "WILDisland along the Danube can serve as a good example for the establishment of EU level GI projects" and contributes "for further developing and strengthening the coherence of the Natura 2000 network". A Danube-wide commitment signed by all DANUBEPARKS directors anchors the WILDisland initiative and has triggered already first national declarations for the protection and non-intervention management of Danube islands at policy level.

Land – Danube Riparian Forest Corridor

Riparian forest habitats are an essential component of the river ecosystem. However, about 90% of the forests have been lost in the last century due to human intervention. DANUBEparksCONNECTED aimed to restore riparian forests by detecting gaps in the riparian forest corridor for conservation or restoration measures. Such activities might significantly mitigate climate change by increasing the carbon storage capacity of the Danube riparian zones.

To determine the current condition of the riparian forests as habitat corridors along the Danube, a Riparian Forest Fitness Check was carried out. Based on satellite data from Copernicus Land Monitoring Services, fac-

Valuable old growth forests in the Danube floodplains © Donau-Auen National Park/Kovacs

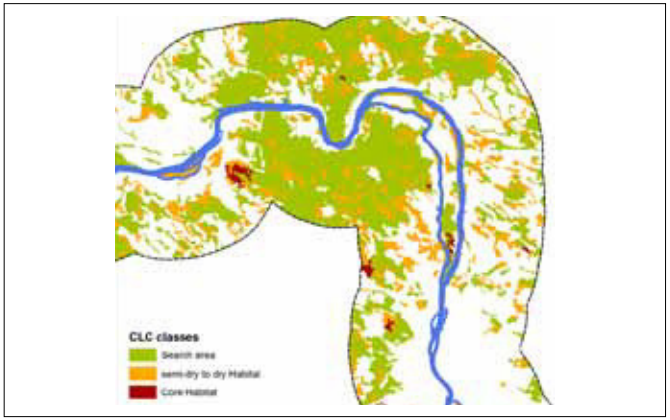
tors such as the size of forest complexes and fragmentation and habitat typology were analysed. The results led to a jointly developed ***roadmap*** towards a Riparian Forest corridor.

Additional activites in the corridor included the reforestation of areas between intact forest complexes with native species, the transformation of plantations used by intensive forestry into native stands, and the management of invasive alien tree species.

Land – Danube Dry Habitat Corridor

An intact river ecosystem includes not only water and riparian forests, but also dry habitats, which play a crucial role in sustaining biodiversity as they are home to many rare and endangered species. These dry habitat patches are very often reduced to small remnants in the floodplain areas, resulting in isolation and habitat fragmentation. The focus of the Danube Dry Habitat Corridor is therefore the protection, restoration, conservation, and appropriate management. For the first time, local expertise on the management of dry habitats has been incorporated into a Danube-wide perspective.

Map 11: Visualisation of the Danube Dry Habitat Corridor



The issue of dry habitats has been addressed by focusing on any habitat dominated by species, both flora and fauna, that prefer dry habitat conditions (xerophilic species). Additionally, semi-dry habitats with species that tolerate a wide amplitude of habitat conditions (mesophilic-xerophilic species), are considered as an important puzzle piece for the dry habitat corridor. These dry and semi-dry areas are all low in nutrients, open or semi-open, extensively or not managed, influenced of or evolved by the dynamics of the Danube, have a shallow topsoil layer and provide relatively little water

for plants and animals

In various GIS analyses, data from CORINE Land Cover (CLC), Copernicus Riparian Zones and Natura 2000 Protected Areas were used to derive information of how probable it is that a plot hosts a dry habitat. Within a corridor of 10 km on both sides of the Danube, three habitat types were identified:

Core Habitat: area dominated by species preferring dry habitats (xerophilic species)

Orchids (*Ophrys holoserica*) on Danube dry habitats © Donau-Auen National Park/Baumgartner

Semi-dry to dry habitat: area occupied by species tolerating a wide amplitude of habitat conditions, from dry to fresh and sometimes wet (mesophilic-xerophilic species)

Search area: area containing few habitats occupied by species preferring dry habitats.
The results led to a ***strategy paper*** on dry habitats that provides information on existing dry habitats, on the interaction between the Danube and dry habitats as well as on threats to these habitats. The main parts of the strategy paper are the geoinformation analyses and the 45 maps that were created in a grid system and show the distribution of valuable dry habitats (Map 11).

Air – DANUBE FREE SKY

The Danube River is a ***flyway*** of European importance providing an important breeding, resting and wintering place for millions of birds that use the Danube as their migration route every year. Although the protected areas along the corridor are a refuge, the hundreds of ***power lines*** crossing natural areas are dangerous barriers, as ***avian collisions*** with power lines result in mortality for several bird species along the Danube. Electrocution can play a major role too. More than 200 high and extra-high voltage lines cross the river, as well as numerous medium and low voltage lines.

DANUBE FREE SKY aims to ensure the conservation of Europe's main biodiversity hotspots by creating and strengthening the platform between nature conservation and the energy sector and developing a Danube-

wide best practice approach. The implemented pilot activities of ***marking power lines*** demonstrate the feasibility of the measures and increase the efficiency of adopted measures on a transnational level.

Installation of diverters to counteract bird collission at powerlines crossing the Danube © DANUBEPARKS/Frank

With the help of power line operators, a Danube-wide inventory was prepared, displaying all powerlines crossing the Danube, highlighting the most dangerous areas and indicating power line stretches for marking. To further identify the highest risk areas that urgently need mitigation measures, partners organised ***monitoring*** activities for collecting valuable field data. The research and studies led to a position paper summarising current knowledge, defining risk categories for each power line in the Danube corridor, describing power line marking standards and introducing innovative and effective marking methods.

Studies have shown that using the right marking techniques can reduce the risk of bird collisions by 70-90%. DANUBE FREE SKY therefore promoted the installation of approx. 1,000 bird diverters along about 8 km of the most dangerous powerlines in 5 Danube countries.

Fire – Involving People in Nature Conservation

Communication is the fourth pillar of the project and connects all other topics. While *land, water* and *air* try to close gaps in knowledge and take action, *fire* tries in the next step to bring this knowledge to the outside world and raise ***awareness*** of the importance of ecological connectivity in the DRB. Various activities took place, such as ***Cycling the Danube*** which invites stakeholders and interested participants from the public to cycle along the Danube corridor on the dikes and to visit the project results. Helping hands for corridor management were welcome at the ***Danube Volunteer Days*** with over 30 events along the Danube. The continuous exchange of experience and knowledge between the project partners from 10 Danube countries and the cross-sectoral approach between water management, energy, forestry, nature conservation and politics stands for a long-term use of the Danube Corridor.

VI. Strategic Perspectives – Guiding Principles

VI. Strategic Perspectives – Guiding Principles

The cross-over capitalisation strategy of the Interreg Danube Transnational Programme has been an efficient platform for the cooperation of projects and initiatives on ecological connectivity in the Danube region. The guiding principles compile some of the results and experiences of this process.

Ecological connectivity is a dynamic issue that is gaining momentum with the EU GI Strategy, the EU Biodiversity Strategy and the increasing attention towards climate change and adaptation. Now it is important to push forward and to use the opportunity of public awareness and the numerous existing starting points to enhance ecological connectivity in the Danube River Basin (DRB).

In view of the dynamic development of the Eastern European countries and the continuous soil sealing in Europe, the continuation of the work on ecological corridors in the DRB seems to be urgent.

Guiding Principle 1: Promoting Ecological Connectivity across Bio-Geographic Regions

The Danube is a hub of biodiversity and an essential lifeline of Europe. Rivers and their riparian zones form ecological networks and often build the backbone for bio-corridors. This is true of the Danube in particular, due to its important role as a link between more bio-regions than other corridors in Europe.

This document aims to boost the key role of the Danube River as an ecological corridor and to establish green infrastructure (GI) on a European scale, considering the major tributary rivers to form a net of blue infrastructure of European relevance.

The richness in bio-geographic regions qualifies Central and South-East Europe and the Danube as model regions for habitat connectivity and corridor functionality. Together with the main mountain ranges in the region (the Carpathians, the Balkans, part of the Alps) it defines a hotspot of Biodiversity for Europe.

Facing, for example, an increasing future impact of climate change, intact corridors for migration and dispersal of species between the Black Sea Region, the Steppic Region, the Pannonian Region, the Continental and, finally, the Alpine Region, will gain relevance, as such a corridor function could be ensured by a vital Danube river ecosystem.

Map 12: The Danube corridor, connecting five bio-geographic regions (Environment Agency (EEA), adapted)

Guiding Principle 2: Fostering Permeability among Macro-Regions

The Danube River floodplain, as well as the mountain regions in the Alps and the Carpathians, represent the most important natural and semi-natural areas in Central and South-East Europe. Economic pressure is increasing constantly in the Alps, Carpathians and in the DRB regions, resulting in growing pressure on its natural treasures.

Therefore, in the EU macro-regions, big efforts are being taken to strengthen ecological connectivity. Both, the EU Strategy for the Danube Region (EUSDR) Priority Area 6 and the Action Group 7 of the EU Strategy for the Alpine Region consider ecological corridors and GI as key elements in their respective action plans.

Hydrological and geological phenomena are linked between the regions (e.g. the water from mountains flowing to the Danube, gravel and sediments from the Alps and Carpathians are transported to the Danube), large carnivores migrate from the Carpathians towards the Alps, and various species exist in respective regions whose population maintenance require joint efforts.

Consequently, the interface of the EU macro-regions in the Danube and in the Alps can act as good practice for ecological connectivity and cooperation among these two EU macro-regional strategies, to trigger good practice initiatives and pilot projects (such as the ADC Net and the Alpine Carpathian (River) Corridor).

Possible synergies need to be identified and concerted efforts are required with other neighbouring macro-regions, with the Danube as an important link.

Guiding Principle 3: Implementing Lighthouse Projects in Priority Areas within the Danube Region

GIS analyses were carried out within a study on ecological connectivity in the DRB for the EUSDR PA6 (Huber et al. 2017). Considering the degree of fragmentation, the naturalness of areas, stepping stones, location of transboundary main corridors, a map of the "cumulative cost difference" was prepared. The study identified five priority areas for possible pilot projects in the field of ecological connectivity, three of which are along the Danube, two in mountain areas.

Along the Danube, the cross-border region between Austria and Slovakia is crucial to maintaining and restoring the Alpine Carpathian Corridor. In the Pannonian Lowlands (Croatia, Serbia, Hungary) ecological corridors are needed to overcome large intensive agricultural areas and in the lowland area between the Danube and the Carpathians in Romania and Bulgaria the tributary rivers represent important local elements for connectivity between the Danube and the Carpathians.

In addition, the inclusion of further pilot sites such as the cross-border region along the Prut River (Romania and Moldova) as pilot site for ecological connectivity in lowlands between the Danube and the Carpathians and the the tributary rivers in the Upper Danube (Germany and Austria) as a "hot spot" for ecological connectivity from the Alpine Space to the Danube should be considered in the future.

A concrete local assessment and modelling for specific species and local barriers is greatly needed (see guiding principle 7). However, this study is an appeal for the consequent implementation of pilot projects on ecological connectivity in the priority areas.

Guiding principle 4: Strengthening Protected Areas and their Coherence as key for Ecological Connectivity

The large number of Natura 2000 sites and protected areas impressively shows Europe's commitment to preserve the Danube natural heritage. Protected Area Networks represent core areas within ecological networks and are in a leading role to foster coherence and habitat connectivity.

Table 3: Protected area categories and GI

Protected Area Category	Core	Buffer	Connection
IUCN I	■		
IUCN II	■		
IUCN III	■		
IUCN IV		■	■
IUCN V	■	■	
IUCN VI		■	■
Natura 2000	■	■	■
Ramsar	■	■	■
World Heritage	■		
Biosphere Reserve	■	■	■

Natura 2000 is a coherent network of protected areas within the European Union that has been established since 1992 in accordance with the Fauna-Flora-Habitat Directive. Its purpose is the transnational protection of endangered wild native plant and animal species and their natural habitats. Inclusion in the Natura 2000 network is therefore not yet an ad hoc status of protection, but a presentation of the community importance of the site.

Large GI mainly consist of protected areas which can be complemented and combined by other protected area categories.

Furthermore, protected areas are proven players for lighthouse projects in the field of ecological connectivity and excellent multipliers towards stakeholders as well as to the public. The capacities of protected area administrations need to be further developed, toward competence centres for ecological connectivity on a local, regional and transnational level.

The revised Action Plan of the EUSDR (in prep.) calls for transnational cooperation and harmonization of the strategic documents to ensure consistency and sus-

tainability in implementation of conservation measures and, in the end, contribute to better nature protection of these areas. Transnational Networks of Protected Areas (e.g. DANUBEPARKS; ALPARC; CNPA) contribute significantly to strengthen each single protected area for its crucial conservation tasks on the spot, to improve coherence, to share new knowledge and to initiate cross-border and transnational initiatives in the field of ecological connectivity (Table 3).

Guiding Principle 5: Establishing Green Infrastructure to improve Ecosystem Services

While protected areas preserve some of the most valuable natural sites, habitat fragmentation limits efforts to preserve a cohesive ecosystem. Human infrastructure, extensions of urban areas, the establishment of new transport routes and energy infrastructure as well as the ongoing intensification of land-use put increasing pressure on the natural treasures. Often, protected areas are too small to cover home-ranges of certain organisms and to host sustainable populations of species. Flagship species, such as the Danube Sturgeon, the White-tailed Eagle along the Danube or large carnivores in mountain areas, impressively demonstrate the need for coherent habitat networks and transnational cooperation.

As the world´s most international river, and due to its richness in bio-geographic regions (see guiding principle 1) and its diversity in habitats and species, the Danube may act as a model region for local, cross-border as well as transnational initiatives to implement GI. The implementation of GI requires the involvement of a wide range of stakeholders and cross-sectoral cooperations. This applies in particular to the Danube due to its multifunctionality.

The implementation of GI, e.g. by restoring riverine habitats, counteracts fragmentation and helps to improve the provision of the Danube´s ecosystem services, relevant for over 80 million people living in the Danube catchment area.

Guiding Principle 6: Creating New Mechanisms for Cooperation, Dialogue and Participation towards a Danube Ecological Corridor

The overview of the projects shows that long-term connectivity can only be achieved through cooperation

across borders, sectors and interest groups. Often, the lack of awareness is the limiting factor when it comes to habitat connectivity and implementation of GI. Considering the multi-functionality of the Danube river, the dialogue has to involve a wide range of stakeholders such as water managers and the waterway sector as well as hydropower, transport, forestry, energy and tourism and many more.

This requires innovative and further developed institutions and networks as well as formats for dialogue and participation. For the capitalization of existing networks and partnerships built within projects, sustainability is needed and the achievements have to be reflected, considered and anchored at policy level.


Danube Volunteeres active for dry habitats © (DANUBEPARKS/Welterbegemeinfen Wachau/Hohla)

Finally, the involvement of the interested public gains increasing relevance. The touristic potential of GI needs to be stressed and used economically, for communication and for raising awareness.

Several initiatives show the increasing interest of the public in conservation efforts crossing all borders, often protected areas and international NGOs acting as multipliers. Bringing together people from different countries to be involved in nature conservation contributes significantly to understanding the cohesion of regions, their interrelated ecosystems and the local populations.

Guiding Principle 7: Consolidating Basic Knowledge

In order to understand ecological connectivity in the DRB, regular surveys and monitoring play a crucial role. However, "traditional research" is often unable to address such a large area and complex topic in an appropriate way. New research approaches must be strengthened and brought into the development of GI. Furthermore, the rapid development of a wide range of modern technologies (such as the use of laser scan-

ning or latest satellite imagery technology from the Sentinel-2) that are used must be taken into accoutn, explored and integrated into ongoing efforts.
The use of new technologies requires a more systematic approach. Common standards and guidelines are appropriate ways to ensure an optimal and transnational use of these technologies. Good practice exists at local, regional and national level. Concerted efforts will raise the efficiency (e.g. extension of the JECAMI tool as a joint tool for the Alpine Space and the Danube Region) and could help to improve the understanding on a transnational scale. This document includes a first analysis for priority areas on ecological connectivity. However, more profound analyses need to follow in order to elaborate on common macro-regional connectivity maps as a comprehensive working basis.

As ecological connectivity in the DRB encompasses many sectors and stakeholders, it is highly recommended to foster transdisciplinary research. Finally, key findings of research need to be processed and presented to the policy makers in an accessible form.

Such a large area requires the support from many people, here, enabling the participation of interested or qualified members of the public can open new perspectives. There is already a large network of scientifically active members of the public who can be used for citizen science.

Guiding Principle 8: Closing the Gap to Policy Makers

For the implementation of GI on EU-level and good practice projects on ecological connectivity on transnational scale, concerted efforts of the policy level, competent partners on site as well as professional communication and participation of the public is required.

For the Danube region, an obvious gap between the EU macro-regional strategy and the interested public can be identified, respectively a gap between bottom-up initiatives and the policy makers.

Good practice initiatives for habitat networks, biocorridors for species and co-operation between different stakeholders haven taken place and are ongoing. Transnational and cross-border EU funding instruments are of fundamental importance. Despite intense efforts by these initiatives and projects, key findings at project

level often do not find their way into strategies, plans and guidelines at policy level. Thus, capacities have to be built on stakeholder level to improve the professional policy work and ensure the consideration of project results in corresponding strategic documents.

Additionally, raising awareness amongst policy makers may contribute to close the gap between strategically relevant outcomes on project level and policies, and may also contribute to implementing existing and upcoming policies on the ground. Often, transnational networks and projects act as excellent catalysts and communicators towards the interested public, and therefore, are able to significantly improve the standing of different policies e.g. on nature conservation and GI. Existing platforms such as the EUSDR PA6 need to be strengthened in their efforts to bridge good practice projects and task forces to policy level.

Guiding Principle 9: Building Capacities on Ecological Connectivity

Capacity building is becoming increasingly important when dealing with ecological connectivity in a European perspective. This concerns institutions as well as the people involved and responsible at the level of personal competencies. The required competencies range from personal skills such as knowledge of different countries, cultures, languages and laws to soft skills such as conflict management and mediation between different sectors. In the technical field, knowledge of hydrology, biology, geomorphology and animal and plant species is essential.

Currently, ecological connectivity has few mandates at international level. It is mainly addressed and promoted through projects. Long-term transnational networks of NGOs (e.g. WWF Danube Carpathian Programme) and Protected Area Networks (such as DANUBEPARKS) are good examples of how organisation, networks and transnational platforms give innovative impulses. The ICPDR and the EUSDR can be excellent platforms to further increase these capacities across sectors.

Guiding Principle 10: Fostering Continuity towards Green Infrastructure

The development and maintenance of GI are long-term investments. Consequently, it is important to continuously develop successful approaches and initiatives

Table 4: Suitability of funding categories and instruments for each guiding principle

Funding Category	GP1	GP2	GP3	GP4	GP5	GP6	GP7	GP8	GP9	GP10
European funding: cohesion (Interreg, EuropeAid)										
European funding: environment (Life)										
European funding: research (Horizon 2020, Coin, Espon)										
European funding: education (ERASMUS)										
National funding										
Private investment (technologies, CSR)										
Private donors										

Legend: dark blue: very suitable, blue: suitable, light blue: conditionally suitable, white: not suitable

over years and decades, and over programme periods. The developed guidelines need to be continued, completed, made available and as binding as possible.

Often, EU funding instruments are the only available tools for the implementation of cross-border and transnational efforts on GI. Therefore, the role of GI, also as one of the important tools of climate change mitigation, has to be stressed in upcoming EU funding programmes. Here, concerted efforts at national level are also needed. Beside adequate funding for ecological connectivity at national level, also raised awareness and capacities building is required in public institutions, protected area administrations, NGOs and the public also at national and local scale. However, at national level, only few countries follow a strategic approach to strengthen ecological connectivity, even though this is the best opportunity to achieve Natura 2000 coherence, preserve the full range of ecosystem services and to halt biodiversity loss in the context of climate change.

Annex 1: References and Further Reading

ANDĚL P., MINÁRIKOVÁ T. & ANDREAS M. (EDS.) (2010): Protection of Landscape Connectivity for Large Mammals. Evernia, Liberec,134pp. | **BENNETT A.F. (2003):** Linkages in the Landscape. The Role of Corridors and Connectivity in Wildlife Conservation. IUCN, Gland. 254pp. |**BENNETT G., MULONGOY K.J. (2006):** Review of experience with ecological networks, corridors and buffer zones. Montreal, Canada: Technical Series Number 23 Secretariat of the Convention of Biological Diversity. Benedict, Mark A. and McMahon, Edward T. | **BOERE G.C., GALBRAITH C.A. & STROUD D.A. (EDS). (2006):** Waterbirds around the world. The Stationery Office, Edinburgh, UK. 960 pp. | **BROGGI M. F., JUNGMEIER M., PLASSMANN G., SOLAR, M. & SCHERFOSE V. (2017):** Die Schutzgebiete im Alpenbogen und ihre Lücken. In: Natur und Landschaft. Stuttgart, 432-439 pp. | **CEEWEB FOR BIODIVERSITY (2011):** Assessing Green Infrastructure Elements in the Visegrad Countries – Analysing Green Infrastructure elements and connectivity at national level in the Czech Republic, Hungary, Poland and Slovakia. Budapest, 15pp. | **CHESTER C. & HILTY J. (2010):** Connectivity Science. In: Worboys, G. L., Francis, W. L., Lockwood, M. (2010): Connectivity Conservation Management: A Global Guide (with particular reference to mountain connectivity conservation). Earthscan: London. | **DEODATUS F., KRUHLOV I., PROTSENKO L., BASHTA T.A. KORZHYK V., TATUH S., BILOKON M., SHKITAK M., MOVCHAN I. CATANOIU S., DEJU R. & PERZANOWSKI K. (2013):** Creation of Ecological Corridors in the Ukrainian Carpathians. The Carpathians: Integrating Nature and Society Towards Sustainability, Environmental Science and Engineering, 701-717 | **EUROPEAN COMMISSION (2013):** Communication from the commission to the European parliament, the council, the European economic and social committee and the committee of the regions. Green Infrastructure (GI) — Enhancing Europe's Natural Capital. Brussels, 11pp. | **FAVILLI F., HOFFMANN C., ALBERTON M., & ELMI M. (2014):** Report on identified barriers to ecological connectivity in the Carpathians. Institute for Regional Development and Location Management. Bolzano, 113 pp. | **FILIPOVIĆ D. & PETROVIĆ L. (2015):** The Significance of The Danube Ecological Corridor in The Proceedings of Implementing Ecological Networks in Serbia. Bulletin of The Serbian Geographical Society, 109-124pp. | **GUTLEB B., JUNGMEIER M., KRASSNITZER S., WAGNER J., WAGENLEITNER S., ZOLLNER D., (2008):** PANet – Protected Area Networks. A handbook. Klagenfurt. 116pp. | **WALZER C. (2016):** The science of connectivity measures. In: PLASSMANN, G., KOHLER, Y., BADURA, M., WALZER (2016): Alpine Nature 2030 – Creating (ecological) connectivity for generations to come. Published by Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB): 37-45pp. | **HUBER M., JUNGMEIER M., GLATZ-JORDE S., HÖFFERLE P., BERGER V. (2018):** Ecological Connectivity in the Danube River Basin. Final Report. Study commissioned by Bayrisches Staatsministerium für Umwelt und Verbraucherschutz. E.C.O. Institut für Ökologie, Klagenfurt, 76 pp. | **JONGMAN, R.H.G., BOUWMA I., JONES-WALTERS L., VAN DOORN A.M. (2011):** The pan European ecological network: PEEN. Landscape Ecology. DOI 10.1007/s10980-010-9567-x | **KIRCHMEIR H. & KOVAROVICS A. (EDS) (2016):** Nomination Dossier „Primeval Beech Forests of the Carpathians and Other Regions of Europe" as extension to the existing Natural World Heritage Site "Primeval Beech Forests of the Carpathians and the Ancient Beech Forests of Germany" (1133bis). Klagenfurt, 409 pp. | **KOSTYANZSKI T. (2013):** Analysis of National Institutional Frameworks and Legislations Affecting biodiversity and Ecological Connectivity in The Carpathian Countries. National Report Hungary. Budapest, 48 pp. | **KUTAL M. (ED.) (2013):** Migration corridors in the Western Carpathians: Malá Fatra – Kysucké Beskydy – Moravskoslezské Beskydy – Javorníky. Friends of the Earth Czech Republic – Olomouc branch. Olomouc, 26 pp. | **VAN MAANEN E., PREDOIU G., LAVER K., SOULÉ M. , POPA M., IONESCU O., JURJ R., NEGUS S., IONESCU G., ALTENBURG W. (2006):** Safeguarding the Romanian Carpathian Ecological Network. A vision for large carnivores and biodiversity in Eastern Europe. A&W ecological consultants, Veenwouden, The Netherlands. Icas Wildlife Unit, Brasov, Romania, 131pp. | **MARSCHALL I., MÜLLER M., GATHER M. (2012):** Proceedings of the 1st GreenNet Conference, 31st of Jan. 2012: "The Green Belt as a European Ecological Network – strengths and gaps". Berichte des Instituts für Verkehr und Raum Band 10 | **PLASSMANN G., KOHLER Y., BADURA M., WALZER C. (EDS.) (2016):** Alpine Nature 2030 – Creating (ecological) connectivity for generations to come. Published by Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB). | **PROSCHEK M. (2005):** Strategische Planung für die Lebensraumvernetzung in Österreich Prioritätensetzung für Nachrüstungsvorschläge für Grünbrücken über Autobahnen und Schnellstraßen Wildökologische Bedeutung und raumplanerische Sinnhaftigkeit untersucht anhand der Tierarten Bär (Ursus arctos), Luchs (Lynx lynx), Wolf (Canis lupus), Elch (Alces alces) und Rothirsch (Cervus elaphus) | **RUDOLPH B-U., FETZ R., WÖLFL M. (2010):** Wildtierkorridore in Bayern. Von der Zerschneidung durch Barrieren hin zu einer Durchlässigkeit der Landschaft. LWF aktuell 79/2010: 9-12 pp. | **SINNETT D., CALVERT T., MARTYN N., WILLIAMS K., BURGESS S., SMITH N. AND KING L. (2016):** Green Infrastructure. Research into Practice. Centre for Sustainable Planning and Environments, University of the West of England, Bristol. Report | **VAN DER SLUIS T., BLOEMMEN M. & BOUWMA I.M. (2004):** European corridors: Strategies for corridor development for target species. Groels, 32p | **WALZER C. (2016):** The science of connectivity measures. In: PLASSMANN, G., KOHLER, Y., BADURA, M., WALZER (2016): Alpine Nature 2030 – Creating (ecological) connectivity for generations to come. Published by Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB): 37-45 pp. | **WINIWARTER V., HAIDVOGL G. (2015):** Danube: Future White Paper on Integrated Sustainable Development of the Danube River Basin. Vienna. 47pp. | **ZHANG K. (2012):** Review and Gaps: European Ecological Networks in the past 40 years. In: Marschall, I., Müller, M., Gather, M. (2012): Proceedings of the 1st GreenNet Conference, 31st of Jan. 2012: "The Green Belt as a European Ecological Network – strengths and gaps". Berichte des Instituts für Verkehr und Raum Band 10.