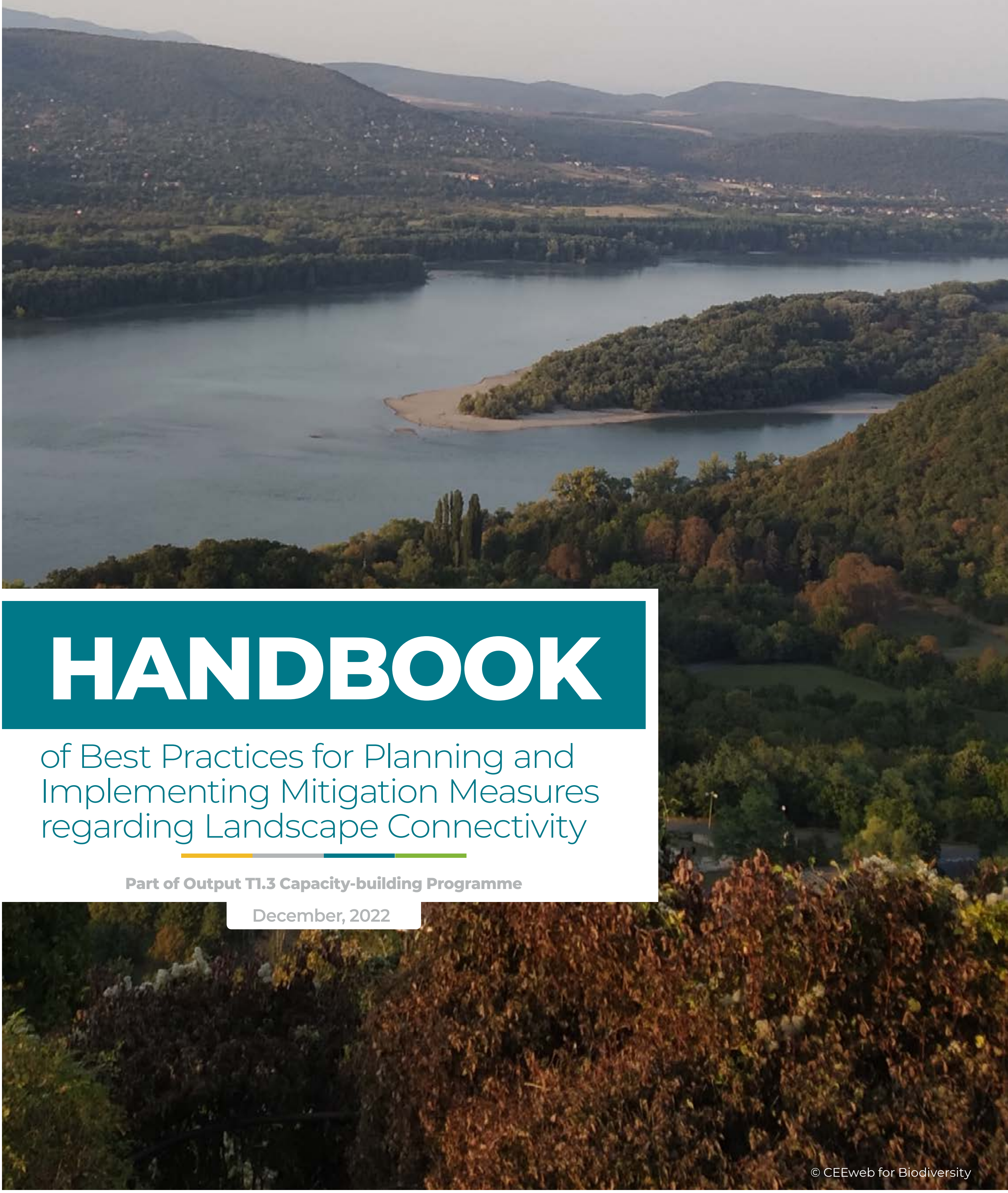

HANDBOOK

of Best Practices for Planning and Implementing Mitigation Measures regarding Landscape Connectivity

Part of Output T1.3 Capacity-building Programme

December, 2022

Interreg
EUROPEAN UNION
Danube Transnational Programme
SaveGREEN

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www.interreg-danube.eu/SaveGREEN

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Handbook of Best Practices for Planning and Implementing Mitigation Measures regarding Landscape Connectivity

Part of Output T1.3 Capacity-building Programme

SaveGREEN Project "Safeguarding the functionality of transnationally important ecological corridors in the Danube basin"

Danube Transnational Programme, DTP3-314-2.3

December 2022

The Capacity Building Programme consists of the following parts:
>> Toolkit >> Handbook >> Training Package

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About SaveGREEN

The SaveGREEN project, funded by the Interreg Danube Transnational Programme is focused on the identification, collection, and promotion of the best solutions for safeguarding ecological corridors in the Carpathians and further mountain ranges in the Danube region. Currently, ecological corridors in the region are under threat due to the lack of adequate planning of economic development initiatives. Therefore, basing its work on integrated planning, SaveGREEN will monitor the impact of mitigation measures in 8 pilot areas and derive proper recommendations for follow-up actions and policy design.

www.interreg-danube.eu/savegreen

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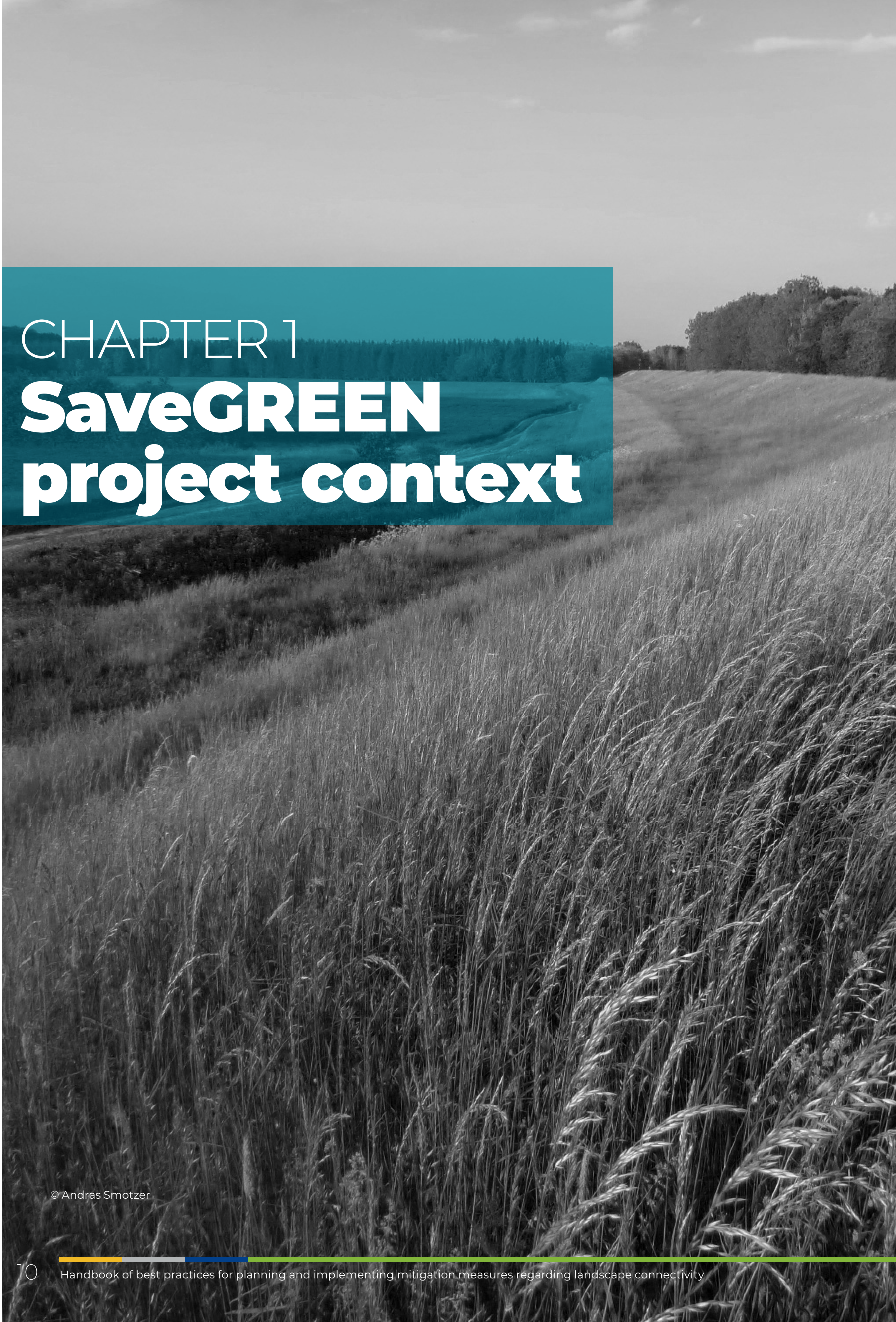
ASP	Associated Strategic Partner
CBD	Convention on Biological Diversity
CCIBIS	Carpathian Countries Integrated Biodiversity Information System
CICES	Common International Classification of Ecosystem Services
CLC	Corine Land Cover
CSOP	Cross Sectoral Operational Plans
CZ	Czech Republic
DST	The Decision Support Tool
EAA	Environment Agency Austria
EC	European Commission
EIA	Environmental Impact Assessments
ERDF	European Regional Development Fund
EU	European Union
EUNIS	European University Information Systems organisation
FAO	Food and Agriculture Organization
FoE	Friends of the Earth Czech Republic
GI	Green Infrastructure
GIS	Geographic Information System
HNPI	Hortobágy National Park
IENE	Infrastructure & Ecology Network Europe
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IUCN	International Union for Conservation of Nature
KvVM	The Hungarian Ministry of the Environment and Water Management
LAU	Local Administrative Units
LC	Large Carnivores
LCP	Least Cost Path
MME	The Hungarian Ornithological and Nature Conservation Association
MoE	Ministry of Environment
MoUs	Memorandums of Understanding

MSPA	Morphological Spatial Pattern Analysis
NEN	The National Ecological Network
NGO	Non-governmental organizations
NNL	No net loss
NTS	National Landscape Strategy for the period 2017-2026
NWRM	The Natural Water Retention Measures
OBWIC	Open Borders for Wildlife in the Carpathians
OSM	OpenStreetMap
PEEN	Pan-European Ecological Network
PUG	General Urban Development Plan
PUZ	Urban Spatial Planning
RO	Romania
R-TSES	Regional space management plans
SAC	Special Areas of Conservation
SCI	Site of Community Importance
SEA	Strategic Environmental Assessments
SPA	Special Protection Area
SR	Slovak Republic
SSC	Slovak Road Administration (Slovenská správa ciest)
TEN-T network	Trans-European Transport Network
TSES	The Territorial System of Ecological Stability of the Landscape
UA	Ukraine
UNESCO	The United Nations Educational, Scientific and Cultural Organization
WEP	The Forest Development Plan
WWF	World Wildlife Fund for Nature



CHAPTER 1

SaveGREEN project context

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The main objective of the SaveGREEN project was to develop specific solutions to preserve, improve or restore the functionality of key ecological corridors in the Carpathian, Alpine and Balkan Mountains and valleys, where human activities as well as critical points for wildlife migration concentrate and thus conflicts are the highest.

The SaveGREEN project aims to demonstrate ways of designing appropriate mitigation measures, strengthening the structural connectivity and maintaining or improving the functionality of ecological corridors through integrated planning. The above-mentioned activity involves capacity building for the relevant stakeholders in the context of ecological corridors and their integration in planning, especially in the Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA).

The project activities are mostly focused on Austria, the Czech Republic, the Slovak Republic, Hungary, Romania, Bulgaria and Ukraine, in 8 pilot areas.

One of the most important components of the SaveGREEN project is the capacity building, to be completed under Work Package 1. This capacity building component involves important stakeholder engagement, with potential direct consequences on the maintenance of ecological connectivity in the participant countries.

The present deliverable was elaborated within activity *A.T1.3 Develop capacity building programme* of the SaveGREEN project. The SaveGREEN project aims to show ways of designing appropriate mitigation measures and maintaining or improving


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the functionality of ecological corridors through integrated planning. As ecological connectivity is above transport and other linear infrastructure considered as the main barrier to landscapes and ecosystems, the main purpose of SaveGREEN is to ensure connectivity at the landscape level through an integrated, cross-sectoral approach including critical sectors such as agriculture, forestry, tourism, and water management.

The A.T1.3 activity includes the development of a Handbook, showcasing best practices for planning and implementation of mitigation measures through the use of examples and case studies. It is of particular importance to showcase examples that approach connectivity in an integrated manner at the landscape level.

The **scope** of the Handbook is to provide support for the capacity building programme

and represent a basis for policy work for advocating the improvement of management practices in corridor areas.

The **objectives** which have been established for this Handbook include:

Obj. 1 To showcase a general presentation on the best practices for planning and implementing mitigation measures in the context of areas of ecological corridors.

Obj. 2 To analyse positive and negative case studies and identify the best solutions implemented in the positive examples and the unfavourable solutions from the negative ones.

Obj. 3 To identify and present the most effective measures for maintaining or restoring ecological connectivity in relation to linear infrastructure and other important domains.

This Handbook will be used for the capacity building programme and will be widely disseminated to the relevant stakeholders. It will represent an important component to be further used in the policy work for improving management practices in corridor areas.

The Handbook can be used in combination with the rest of deliverables of the SaveGREEN project, such as the following:

1. The Methodology for Standardised Monitoring of Ecological Connectivity (Guidelines for the analysis of structural and functional connectivity);

2. The Toolkit for Ensuring Sustainable Use and Management of Green Infrastructure in Strategic Environmental Assessments (SEA) and Environmental Impact Assessments (EIA);

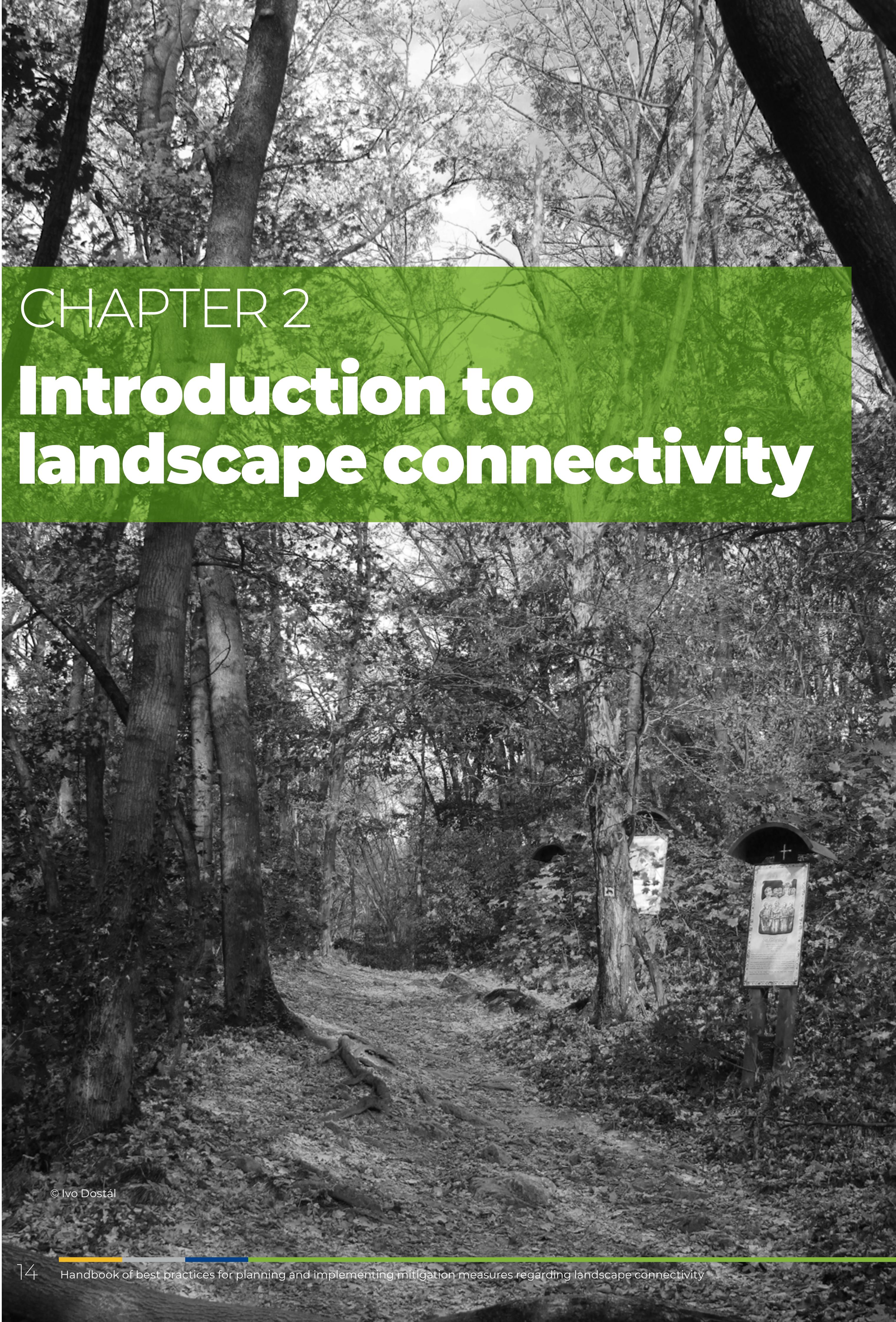
3. The Cross Sectoral Operational Plans, elaborated for the Pilot Areas included in the project;

4. The Declaration of Carpathian Convention on Achieving functional biodiversity in the Danube-Carpathian Region by mainstreaming ecological connectivity;

5. Other deliverables elaborated within the SaveGREEN project.

CHAPTER 2

Introduction to landscape connectivity



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2.1. Definition

Ecological connectivity is one of the most important components for the conservation of flora and fauna species. It is defined as the *“binding or interconnection of eco-landscape elements (semi-natural, natural habitats or buffer zones) and biological corridors between them from the viewpoint of an individual, a species, a population or an association of these entities, for whole or part of their developmental stage, at a given time or for a period given to improve the accessibility of the fields and resources for fauna and flora.”* (Hlaváč et al., 2019).

Ecological connectivity is ensured through the existence of ecological corridors, defined as *“landscape structures of various size, shape and vegetation cover that mutually interconnect core areas and allow migration of species between them.”* (Hlaváč et al., 2019). For more definitions on ecology and transportation terms, an updated glossary of the IENE Wildlife and Traffic Handbook can be used[1].

One of the main causes for the interruption of ecological connectivity is the construction of transport infrastructure (roads, railways, etc.). The interruption of ecological connectivity has multiple effects, such as:

» A loss of wildlife habitat;

» Fragmentation of habitat areas (creation of a barrier effect);

» Mortality of fauna due to collisions with traffic. This is also important in regards to human road safety as accidents with wildlife are a threat to human lives;

» Disturbance and pollution;

1 https://handbookwildlifetraffic.info/annex-1-glossary/

- Changes in the roadside vegetation, with a tendency to favour the spread of alien invasive plant species.

Additionally, negative perspectives on landscape ecology in broader geographical scales and over extended periods through permanent transport and other linear infrastructure interventions, especially in sensitive natural landscapes, can determine an overall future framework of irreversible impacts (Georgiadis et al., 2020).

2.2. IUCN

A key issue facing the conservation of biological diversity that has been recognized throughout the world is represented by habitat loss and fragmentation (IUCN, 1980). Major consequences for wildlife are a loss of species from fragments and entire landscapes, changes to the composition of faunal assemblages, and changes to ecological processes involving animal species.

Isolation of habitats, a fundamental consequence of the process of fragmentation, also influences the status of animal populations and communities in developed landscapes. Minimising the effects of isolation by enhancing landscape connectivity is one way to counter the adverse effects of fragmentation. Pragmatic and theoretical approaches that address the status and conservation of wildlife in heterogeneous environments each implicitly recognize the importance of maintaining habitat patterns that allow animals to move through modified landscapes.

Landscape patterns that promote connectivity for species, biological communities and ecological processes are a key element in nature conservation in environments modified by human impacts.

IUCN created guidelines[2] in order to clarify and standardise a shift in conservation practice from a narrow focus on individual protected areas to considering them as essential parts of large landscape conservation networks. A key component of this is ecological connectivity across land, freshwater and marine regions and among and between sites through 'ecological networks for conservation'. These networks are specifically designed, implemented and managed to ensure that ecological connectivity is maintained and enhanced where it is present, or restored where it has been lost.

Even though it is well understood that ecological connectivity is critical to the conservation of biodiversity, IUCN affirms that the approaches to identify, retain and enhance ecological connectivity have been scattered and inconsistent. Also, countries on every continent, along with the regional and local governments, have advanced various forms of corridor legislation and policy to enhance connectivity. It is imperative that the world move toward a coherent global approach for ecological connectivity conservation, and begins to measure and monitor the effectiveness of efforts to protect connectivity and thereby achieve functional ecological networks.

Landscape connectivity can be achieved for wildlife species and communities by managing the entire landscape mosaic, or by managing specific patterns of suitable habitat such as stepping stones, linkage zones, or habitat corridors.

Organisms move at a range of spatial scales, from metres to hundreds of kilometres. Conservation of biodiversity in developed environments requires measures that will maintain connectivity for species, communities and ecological processes at multiple scales.

The proposed benefits of enhanced connectivity result from an increased capacity of animals to move through disturbed landscapes, greater opportunities for dispersal to isolated habitats and populations,

2 https://portals.iucn.org/library/node/49061

and greater likelihood of the continuity of ecological processes in patchy environments. Linkages that promote landscape connectivity may have substantial value as habitats for plants and animals, and also make an important contribution to other ecological processes in the landscape.

Proposed disadvantages of linkages include their potential to spread pest species, disease or abiotic disturbance; the increased exposure of animals to predators, competitors or parasites; and the risk that assigning resources to maintenance of linkages will be less cost-effective than undertaking other conservation measures (IUCN, 2003; IUCN, 2020).

2.3. Importance

Considering the effects on ecological connectivity, it is particularly important to ensure the permeability of the landscape. Permeability is defined as "the ability to let animals safely pass through" (Hlaváč, 2019). The concept can be applied to the linear infrastructure itself (e.g. a "permeable" motorway can allow for the movement of fauna), but it is more important to be applied to the landscape in which the infrastructure is set. A permeable landscape is an area in which all of the landscape elements (e.g. agricultural, urbanised areas, forested areas, etc.) are permeable for wildlife. The importance of landscape connectivity is related to the maintenance of a good conservation status for species dependent on movement and to the maintenance of the integrity of ecological networks at national or international level.

2.4. Green Deal requirements

The European Green Deal aims to preserve and restore ecosystems and biodiversity through a biodiversity strategy that identifies specific measures to meet these objectives. These include quantified objectives, such as increasing the coverage of protected biodiversity-rich land and sea areas building on the Natura 2000 network.

It is also mentioned that Member States should reinforce cross-border cooperation to protect and restore more effectively the areas covered by the Natura 2000 network. The biodiversity strategy also includes proposals to green European cities and increase biodiversity in urban spaces.

All EU policies should contribute to preserving and restoring Europe's natural capital.

The Commission will also support more connected and well-managed marine protected areas (European Commission, 2019).

2.5. The CBD COP15 Kunming-Montreal Post 2020 Global Bio-diversity Framework

The Kunming-Montreal Post 2020 Global biodiversity Framework[3] as a result of the CBD 15th Conference of the Parties in Montreal, Canada (7-19 Dec 2022) within the framework of 2050 Vision and 2030 mission includes as first of the four general Goals "The integrity, connectivity and resilience of all ecosystems are maintained, enhanced, or restored, substantially increasing the area of natural ecosystems by 2050".

Additionally, among the 23 action-oriented global targets for urgent action over the decade until 2030, three targets address the need to secure ecological connectivity:

TARGET 1:
Ensure that all areas are under participatory integrated biodiversity inclusive spatial

3 https://www.cbd.int/doc/c/abb5/591f/2e46096d3f0330b08ce87a45/wg2020-03-03-en.pdf

planning and/or effective management processes addressing land and sea use change, in order to bring the loss of areas of high biodiversity importance, including the ecosystems of high ecological integrity, close to zero by 2030, while respecting the rights of indigenous peoples and local communities.

TARGET 2:
Ensure that by 2030, at least 30% of areas of degraded terrestrial, inland water, and coastal and marine ecosystems are under effective restoration, in order to enhance biodiversity and ecosystem functions and services, ecological integrity and connectivity.

TARGET 12:
Significantly increase the area and quality and connectivity of, access to, and benefits from green and blue spaces in urban and densely populated areas in a sustainable way, by mainstreaming the conservation and sustainable use of biodiversity, and ensure biodiversity-inclusive urban planning, while enhancing native biodiversity, ecological connectivity and integrity, and improving human health and well-being and connection to nature and contributing to inclusive and sustainable urbanisation and the provision of ecosystem functions and services.

2.6. On the way to avoiding the fragmentation of the European landscapes and ecosystems

Expressing the experience and the updated scientific knowledge presented in the IENE 2022 International Conference in Cluj-Napoca, Romania (September 2022), and supported by the SaveGREEN project, the Declaration[4] of the Conference with the title "Connecting people, connecting landscapes" proposes an urgent framework of priority actions from policy to practical implementation fundamental actions and addresses, and among the other challenges, the need to:

a) Recognize the safeguarding of ecological connectivity as a key aim and a major challenge for the transport sector which needs to be addressed in spatial planning in collaboration with other sectors (i.e., other infrastructure, agriculture, forestry, tourism, hunting, water management, protected areas, etc.)

b) Include as a key objective for sustainability the avoidance of fragmentation of nature and landscapes in all developing activities, in accordance with the relevant strategic policy documents and technical recommendations.

4 https://www.iene.info/news/iene-2022-final-declaration/


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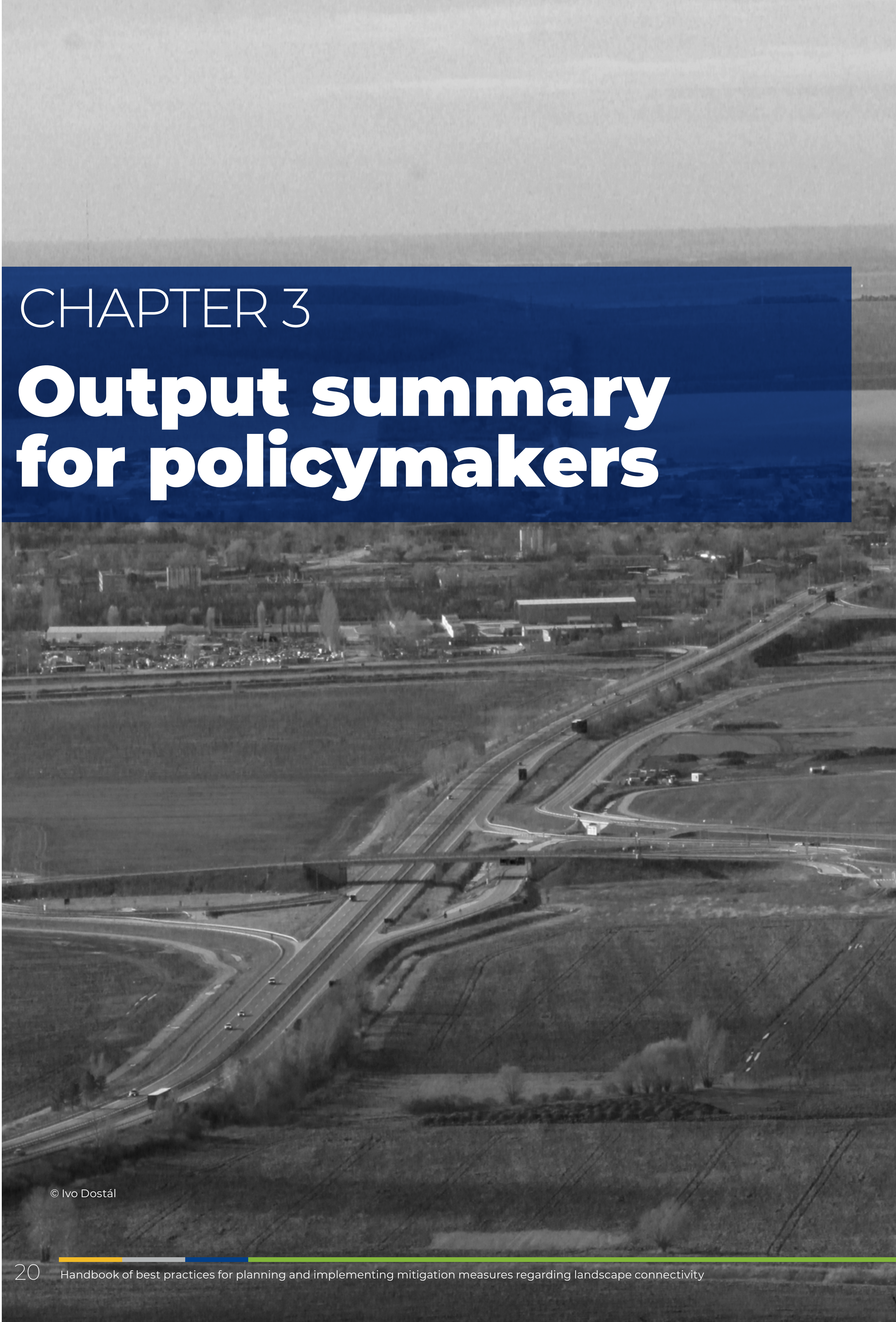

CHAPTER 3

Output summary for policymakers

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This output represents a collection of information at different levels of detail, related to ecological connectivity at landscape level. It highlights the most important requirements related to ecological connectivity in different strategic documents elaborated at international and European levels, the importance of ecological connectivity at landscape level, the main component domains relevant to this type of connectivity, as well as examples and recommendations for best practices to implement in each of the relevant domains in order to ensure the maintenance of permeability.

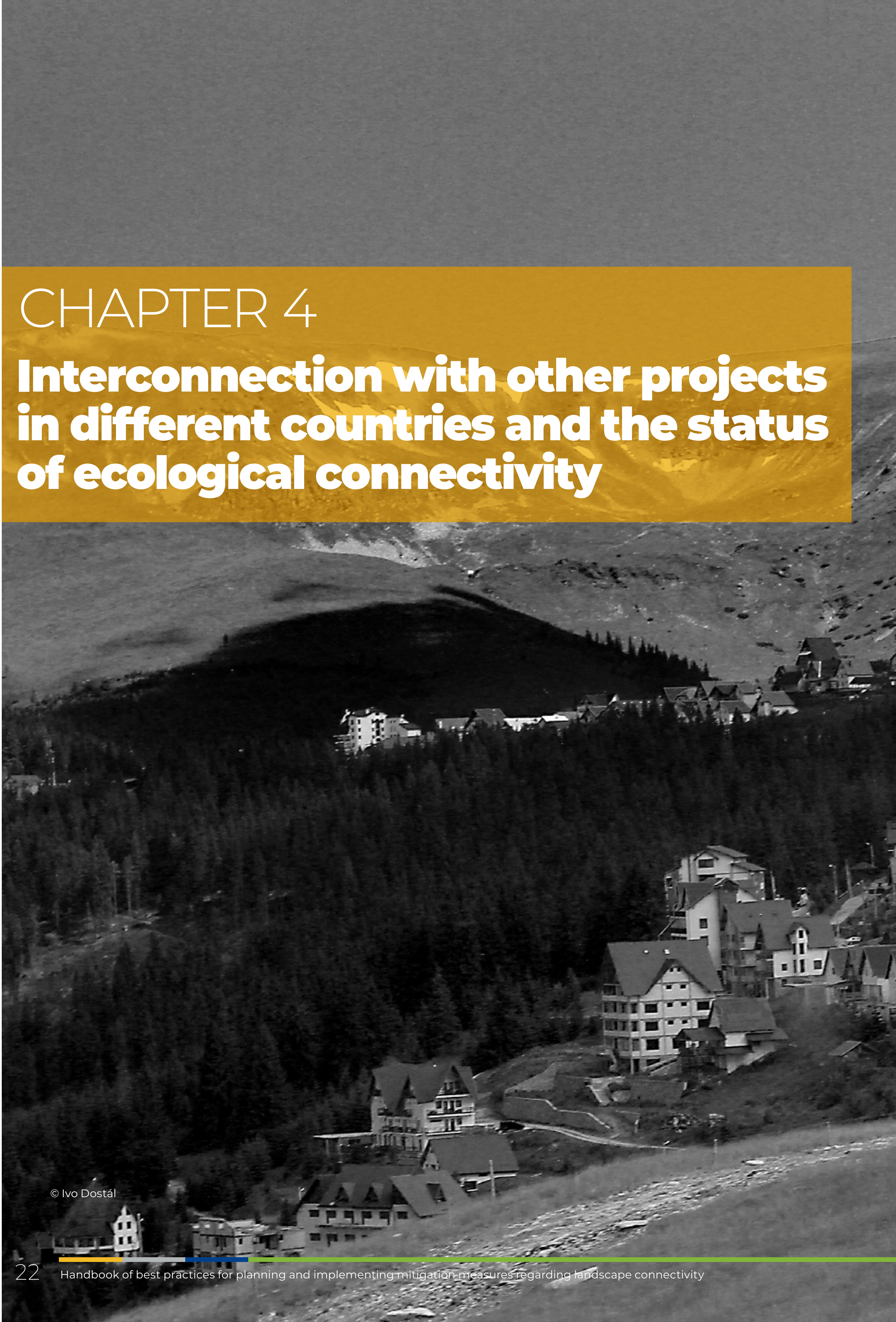
At policy level, one of the most important recent documents is represented by the Declaration of the IENE 2022 International Conference from Cluj Napoca, Romania. This Declaration highlights the main changes to policy necessary to ensure the harmonisation of infrastructure with ecological connectivity at landscape level. The present deliverable comes as a direct response to the 5th issue highlighted in this Declaration: "Develop an urgent common framework of priority actions from policy to practical implementation of evidence-based solutions in order to mainstream biodiversity into a sustainable transport sector".

This Handbook can be used in multiple ways. Firstly, it can represent an overview of the main issues and proposals for each of the domains or sectors relevant to landscape level connectivity, their role and the main challenges associated with each one in turn. Secondly, it can be used by representatives from each domain, in order to understand and implement the relevant practices and measures applicable to them, for ensuring ecological connectivity. The Handbook has a significant section that presents a large number of case studies, which can be used to analyse previous experience, as well as relevant measures and their associated effectiveness. Another important section of the Handbook is represented by the General Recommendations chapter, which shows the most important measures that can be taken for ecological connectivity at different stages, for each relevant sector. The description of these for each relevant sector, in turn, allows practitioners from different domains to more easily identify the aspects that are relevant to them.

Stakeholder involvement is key to ensuring the improvement of ecological connectivity at landscape level, taking into consideration that the necessary measures require their direct input, at different levels of implementation (policy, planning, management, etc.). Considering the interconnectedness necessary to ensure ecological connectivity at landscape level, it is of particular importance to involve stakeholders starting with the policy level. Stakeholders should understand the importance of ecological connectivity, as well as their domains' relevance to achieving this objective and should adapt the policy relevant to their domain to be in line with the requirements necessary to ensure the functional connectivity at landscape level.

CHAPTER 4

Interconnection with other projects in different countries and the status of ecological connectivity



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The SaveGREEN project is a continuation of the TRANSGREEN and ConnectGREEN projects, also funded by the Interreg Danube Transnational Programme, from 2017 and 2019, respectively. The results of these projects were integrated in the deliverables elaborated during the SaveGREEN project, allowing for further development of the concepts presented in them.

Connectivity is an important topic in many European countries, especially in areas which harbour important fauna species, large mammals in particular. In certain countries, connectivity is included in the legislation, and is at times based on research from independent projects.

As resulted from the research of the ConnectGREEN project framework, the ecological networks and corridors are acknowledged by law in most of the participating countries (such as the Czech Republic), and integrated into the spatial planning system. In the other SaveGREEN participating countries, the recognition and designation of ecological corridors and the establishment of ecological networks are integrated in different ways or at different levels. Below the status of establishing ecological networks, designation of ecological corridors and integration of ecological connectivity in spatial planning is described below for the Czech Republic, Hungary, Slovakia, and Romania.

Ecological networks and connectivity in the Czech Republic

In the Czech Republic, establishing and managing ecological networks across various spatial scales have been included in the nature conservation and landscape management legislation. The Territorial System of Ecological Stability of the Landscape (TSES) is the only nature conservation tool constituting an ecological network in the landscape in the Czech Republic. This nature conservation tool is integrated in the spatial planning system. Act No. 114/1992 Gaz., as amended later, defines the TSES as an interconnected system of both natural and altered, but still semi-natural ecosystems. The TSES consists of three basic elements - biocentre, bio-corridors and interactive elements:

a) A biocentre is a habitat or a system of habitats which by its state and size enables a permanent existence of a natural or modified, but semi-natural ecosystem. Bio-centres are divided into existing and planned.

b) A biocorridor (biotic dispersal & migration corridor) is an area which does not enable a long-term existence of organisms, but facilitates their migration and/or dispersal between biocentres: thus, interconnecting isolated biocentres through a network structure.

c) The third component of TSES is represented by interactive elements, which are small areas/patches/plots (often spatially isolated) that provide favourable conditions for specific plants and animals, significantly affecting ecosystem functioning in the cultural landscape.

The TSES is defined at three interconnected levels: supra-regional, regional and local. There is a dense network of local corridors (of approx. 1 km) linking local biocentres (1 to 3 hectares). The function of regional biocentres is to preserve the sub-national biodiversity. At regional level, corridors have a width ranging from 20 to 50 metres, and a length ranging from 300 to 1,000 metres. The supra-regional level includes biocentres with an area of more than 1,000 hectares (Görner, Kosejk, 2011).

Ecological networks and connectivity in Hungary

In Hungary, the ecological network is integrated into the spatial plans. The National Land Use Plan, the County Land Use Framework Plans, and the Land Use Plans for so-called priority regions (e.g. Lake Balaton Recreational Area and the Budapest Metropolitan Region) contain regional tasks to protect the environment, landscape and nature. The Regulation Plans (zoning of regulation packages on a map) of the Spatial Plans contain the exact location of the National Ecological Network. The national ecological network zone includes the core areas, the buffer zones and the ecological corridors as well. The spatial plans are arranged in a hierarchical structure; each plan must be in accordance with the higher-level plans. Guidelines for landscape types of particular importance can also be found within the development plans. For example, in core areas and ecological corridor zones, rules restrict the designation of areas for the development and placement of transport infrastructure, new surface mines, and utility lines within the landscape. New urban areas can be designated for construction when following an official land-use regulation framework; however, this is prohibited in core areas and ecological corridors. The zone of the National Ecological Network is identified in the municipal planning of settlements. The National Development Concept of 2011 sets out guidelines for the development and protection of landscape areas of national importance such as Lake Balaton, Danube region, and Lake Tisza. The land use plans (master plans) of the settlements follow the structure of the higher (spatial) level land use plans.

Ecological networks and connectivity in Slovakia

In Slovakia, ecological plans exist at the regional and municipal level. Landscape-level ecological plans are provided when developing land-use plans at the regional and municipal level, with a focus on analyses and assessments of the potentials and limitations for development at landscape level. The plans of the Territorial Systems of Ecological Stability are in accordance with the Law on land-use planning supportive documents. As defined in the Act No. 543/2002 on Nature and Landscape protection: The Territorial System of Ecological Stability is a spatial structure of interconnected ecosystems and the components determining their diversity in terms of environmental conditions and the species present. This system, similar to the one in the Czech Republic, consists of biocentres, bio-corridors and interacting elements of supra-regional, regional or local importance. Biocentres are defined as ecosystems or groups of ecosystems providing stable conditions for reproduction, shelter and food acquisition, ensuring population viability of the species present. Bio-corridors are spatially interconnected sets of ecosystems that connect biocentres and enable the migration and exchange of genetic information of living organisms and their communities. They can be terrestrial or aquatic. Bio-corridors and interaction elements enable overcoming barriers that isolate ecosystems from one another, ensuring that migration and the exchange of genetic information across ecosystems can persist, thus improving their resilience to stressors. The General of the Super-regional Territorial System of Ecological Stability of the Slovak Republic (SR) (scale of 1:200,000 – 1:500,000), is an overarching document concerned with the strategy to protect the diversity of ecological conditions and species at national level. It is developed by a group of national experts and approved by the Government of SR. The Regional TSES (scale of 1:50,000) represents a document for the protection of the diversity of conditions and species in a particular region; detailed at a district level – LAU1 level according to Eurostat. R-TSES documents are procured and approved by the relevant district bureaus of environment management. Currently, there is an ongoing process of updating and creating new ones. The Local level (1:10,000) TSES documents serve to protect the diversity of conditions and species at municipal level – LAU2 level according to Eurostat. These are procured and approved by the relevant municipality bureaus. There is an ongoing process of updating and creating new ones, within the municipal level of territorial planning.

Ecological networks and connectivity in Romania

In Romania, Law 350/2001 on Spatial and Urban Planning specifies that territorial management aims, among other targets, to ensure the protection of natural and artificial landscapes, biodiversity conservation and the creation of ecological connectivity.
The basic purpose of spatial planning is to unify the economic, social, ecological and cultural policies at national and local levels. Achieving sustainable management of the landscape, which is a basic component of natural and cultural heritage and natural resources, is the main aim among other objectives. The National Plan for spatial planning indicates core areas and corridors of international and national importance and includes international nature conservation priorities: Natura 2000, Emerald, and PEEN. The County/Regional plans determine the core areas (10-100 sq. km) and connecting corridors between these areas (e.g. natural river valleys or semi-natural recreation areas for local settlements). The Comprehensive Urban Plans determine the function of small habitats, woodlots, wetlands, grassland, patches, ponds (<10 sq. km) and connecting corridors (stream banks, hedgerows, field verges and ditches). As for urban planning, one of its main objectives includes the protection and enhancement of natural heritage.

Ecological corridors are regulated under the Emergency Ordinance No. 57/2007 on the regime of natural protected areas and the conservation of natural habitats, wild flora and fauna, with its subsequent modifications and alterations, which states that it is mandatory for protected natural areas and ecological corridors to be addressed in planning of frameworks. This includes requirements for national, zonal and local urban and spatial plans, in cadastral plans and land books developed by the national Agency for Cadastre and in Real Estate advertising, as well as by the central public authority for agriculture. The constitution of the protected natural areas has also taken into account the provisions of general urban plans, which cannot be modified until the upgrading period stipulated by the existing legislation on spatial and urban planning.

Order No. 1964/2007 on establishing the regime of natural protected areas for the sites of community importance as an integral part of the European Ecological Network Natura 2000 in Romania also reflects the link between these protected areas and the territorial planning. National, zonal and local urban and spatial plans must highlight natural reserves and protection areas. The Urban Planning Regulations must contain rules on preserving the integrity of the environment and protecting the natural heritage (Decree No. 525/1996 for the approval of the General Regulation of Urban Planning). According to the Methodology for the Elaboration of General Urban Plans, inserting the elements of ecological networks is mandatory in all the chapters (the Content Framework, the General Memo and the Urbanistic Regulations of each locality). In Zonal Urban Plans, which also provide specific regulations for a particular area in a locality, natural heritage values that require protection are highlighted, and their Local Urban Regulations establish basic rules for preserving environmental integrity and protecting natural heritage. The methodologies for the elaboration of Urban Plans of various types (General, Zonal, and Detail) stipulate that they must also include the Natural Protected Areas in different territorial scales, mentioned in both the written and graphic part.

In terms of defining ecological corridors in Romania, multiple attempts have been documented, but none of them led to an official designation of corridors at national level. Thus, while projects such as ConnectGREEN and COREHABS have identified ecological corridors, they remain undesignated officially, and, thus, unprotected.

Ecological networks and connectivity in Bulgaria

In Bulgaria, according to the Law on Biological Diversity, to ensure the connections between the Natura 2000 sites in the development plans, regional plans for the development of forest territories, forestry plans and programmes, national and regional programmes, it is intended to include measures and activities for the protection of landscape features that, by virtue of their linear and continuous structure or connectivity function, are significant for migration, geographic distribution and genetic exchange in plant and animal populations and species. The principal features of the landscape are rivers and river banks and water-logged old river beds, natural marshes, lakes, wet meadows and other wetlands, caves, rock edges, faces and dunes, cols and other natural landforms linking separate mountains, field boundary markings, forest shelter belts, dry meadows and pastures, flood plains and riverside vegetation, and forests located at an altitude not exceeding 500 m above sea level.

Despite the existence of such a wishful provision, there are no officially mapped and approved/recognized ecological corridors in Bulgaria. Without such approval, they are not included in the cadastre and are not considered when carrying out the Environmental Impact Assessment, the Strategic Environmental Assessment and the Appropriate Assessment. The possibility to introduce areas for environmental connectivity in large-scale projects is missing. For example, when building a linear transport infrastructure, the area occupied by a highway does not include the neighbouring territories, which are essential for ensuring a functional bio-corridor or passage of wild animals.

There is a lack of any engineering requirements and formal by-law standards for the construction and planning of defragmentation facilities to ensure the passage of wild animals. Without such standards, the construction of such facilities occurs very rarely, but in most cases it does not occur at all.

Thanks to the well-developed Natura 2000 network in Bulgaria, some ecological corridors or parts of them have been included and declared as SPAs&SACs/SCIs and protected areas and they are protected with the mechanisms for conservation of the Natura 2000 sites and protected areas according to the Law on Biological Diversity and the Protected Areas Act.

Bulgaria has made some provisions for the development of ecological networks in the overall framework of policy setting of the EU Natura 2000 network and the National Ecological Network. **Natura 2000** is at the core of the EU's green infrastructure. Bulgaria has designated 233 Natura 2000 sites under the Habitats Directive (Special Areas of Conservation SACs/Sites of Community Importance SCIs) and 120 Natura 2000 sites under the Birds Directive (Special Protection Areas SPAs), in total 340*[5] Natura 2000 sites. In total, the SACs/SCIs and SPAs cover a total area of 41,558.4 sq km, e.g. terrestrial and marine areas of which 38,737.05 sq km of terrestrial areas (34.9% of the land) and 2,821 sq km of marine areas (8% of the sea waters) (Bulgarian MoEW, 2021 The National Ecological Network (NEN) concept was set up with the adoption of the Biological Diversity Act 2002 in response to the requirements for establishing the Natura 2000 network in Bulgaria. The National Ecological Network covers all designated Protected Areas and Natura 2000 sites in Bulgaria and represents around 37% of the country's territory, thus ensuring effective in situ conservation of biodiversity; however, the management plans of many of the protected areas and Natura 2000 sites must be elaborated or updated (The Ministry of Environment and Water of the Republic of Bulgaria, n.d.).

The Spatial Development Act (Jan 2001, amend. SG. 49/13 Jun 2014) contains some small provisions for the protection of the green system on the territory of municipalities.

Ecological networks and connectivity in Austria

In Austria, the designation of ecological connectivity already has a long history. In 2015, the Environment Agency Austria (EAA) started collecting all the existing ecological corridor designations resulting from various projects of the public sector and scientific community. These designations were compiled into a so-called integral data set on habitat connectivity in Austria and published via the platform (www.lebensraumvernetzung.at). This integral data set on habitat connectivity in Austria represents the most important remaining habitat corridors in Austria.

These designated habitat corridors are considered an expert base (and considered within developed studies); however, they are not legally binding. There is neither strategic and systematic approach nor a legally binding instrument for the implementation of habitat corridors and their proper protection and management. Habitat corridors are defined as landscape elements with a high degree of interconnectedness of natural areas, including protected areas for animal migration, dispersion of plants and valuable habitats for small-sized mammals, insects, amphibians and reptiles. These landscape elements have a low amount of constructions and are equipped with landscape components that connect forests and grasslands. There are three different categories of habitat corridors depending on their importance and function at the local (150 m), regional (300 m) and supra-regional level (800 m) with minimum requirements for their equipment. Corridors are assessed as for their permeability for animals on structural features, and are approved by experts.

The Austrian Biodiversity Strategy 2030+ foresees effective protection and proper designation of biotope connectivity, a reduction of land consumption and habitat fragmentation, and keeping free from

5 13 Natura 2000 sites completely overlap and has got joint borders under both Directives.

constructions. The implementation is due to the nine different provinces that have nine different nature conservation laws.

Since there is no legally binding spatial planning instrument covering the entire area of Austria, the experts changed their original strategy from legally binding designation of corridors in spatial planning instruments to making the corridors visible in various non-legally binding but nationwide development plans, such as the Forest Development Plan Austria.

Additionally, there is a guideline from the Ministry of Climate for the implementation of green bridges along the existing highways that were built long before defragmentation measures became important.

With the establishment of the coordination Platform Ecological Connectivity (Plattform Lebenrausmvernetzung) and its visualisation of ecological corridors, it is hoped to raise awareness and respective action among the policy-makers and decision-takers.

Ecological networks and connectivity in Ukraine

In the case of **Ukraine**, as a European state, Ukraine is a party to many international environmental conventions and agreements, and also actively participates in the formation of the Pan-European eco-network, along with the definition of wetlands of international importance (International Wetlands), within the framework of the Convention on Wetlands of International Importance mainly as wetland habitats (Ramsar, 1971); areas of special conservation interest of the Emerald Network of Europe, in compliance with the Convention on the Protection of Wild Flora and Fauna and Natural Habitats in Europe (Bern, 1979); biosphere reserves of the UNESCO World Network of Biosphere Reserves in accordance with the provisions of the Seville Strategy for the Development of Biosphere Reserves (1995), etc. Ukraine, like all other participants in the process, has an obligation to integrate the national econetwork into the Pan-European one.

The main legal acts that regulate the process of forming the National Ecological Network of Ukraine are the Law of Ukraine "On the Ecological Network of Ukraine" (N1864-IV of June 24, 2004) and the Law of Ukraine "On the Nationwide Programme for the Formation of the National Ecological Network of Ukraine for 2000-2015" (N1989 dated from September 21, 2000). The Laws of Ukraine are also closely related to the formation, management, preservation and monitoring of the National Ecological Network of Ukraine: "On Environmental Protection"; "On the basis of urban planning"; "On land protection"; "About land management"; "On local self-government in Ukraine"; Water, Forest and Land Codes of Ukraine, and other regulatory legal acts of Ukraine.

According to the Law of Ukraine "On the Ecological Network", the structural elements of the econetwork include key, connecting, buffer and renewable territories. Key territories ensure the preservation of the most valuable and typical of this region's landscape and biodiversity components. Connecting territories (eco-corridors) connect key territories, ensure animal migration and the exchange of genetic material. Buffer territories provide protection of key and connecting territories from external influences. The restored territories ensure the formation of the spatial integrity of the ecosystem, for which priority measures must be taken to restore the primary natural state.

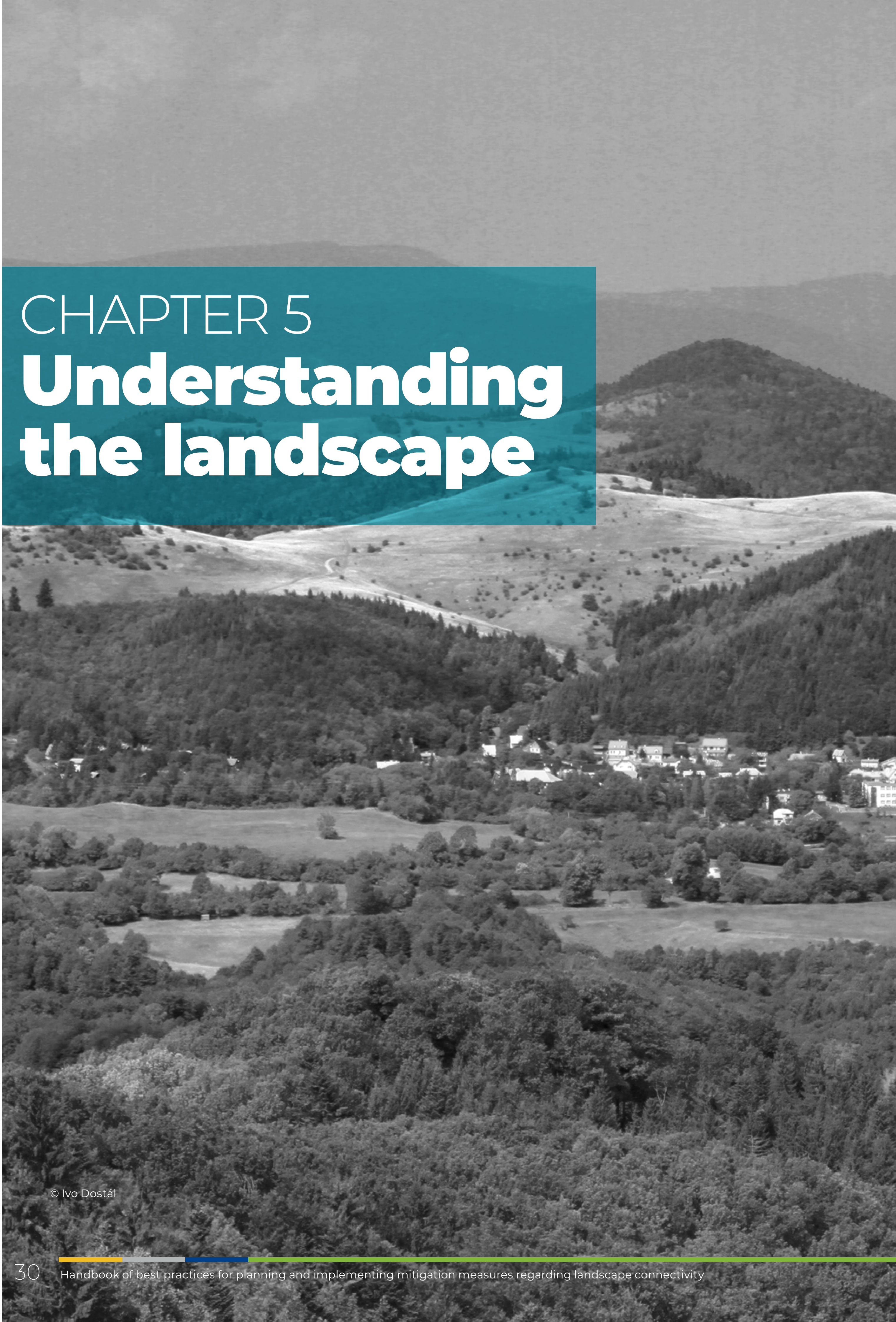
The list of key territories of the ecological network includes territories and objects of the nature reserve fund, wetlands of international importance, and other territories within which the most valuable natural complexes have been preserved. First of all, these are the regions of the Carpathians, the Crimean Mountains, the Donetsk Ridge, the Azov Highlands, the Podilsk Highlands, the Polissia, sources of small rivers, separate estuaries of large rivers, the coastal strip, the continental shelf, etc.

The list of econetwork buffer zones includes territories around the key areas of the econetwork, which prevent the negative impact of economic activities on adjacent territories. These can be not only natural territories of extensive use (pastures, hayfields, exploitation forests, ponds, etc.), but also arable territories with fairly safe (in particular, without the use of mineral fertilisers) agricultural management.

The list of connecting territories of the ecosystem includes territories that provide connections between key territories and the integrity of the ecosystem. These are 3 latitudinal natural corridors that provide natural connections of a zonal nature. Also, the connecting territories of the eco-network include meridional eco-corridors, spatially limited by the valleys of large rivers - the Dnipro, Danube, Dnister, Western Bug, Southern Bug, Seversky Dinets, which unite water and floodplain landscapes - the migration routes of numerous species of plants and animals.

During the time that has passed since the adoption of the Programme, real measures to ensure its implementation in terms of planning and use of specific territories were carried out in separate and distinct directions. On the one hand, they had definitely positive consequences; on the other hand, they did not lead to significant changes in achieving the main goal - the formation of an ecological network as a complete system, the feature of which is the maximum possible continuity and interconnection of its constituent elements. One of the main reasons for this was the lack of specific mechanisms and the uncertainty of the procedures for the design of the ecological network, the formation of lists of territories and objects of the ecological network, and their monitoring.

A positive attitude and promotion of the concept of ecological network for the public sector is the only way to create, preserve and rationally use the ecological network in Ukraine. Civil society institutions should play a significant role in the processes of forming the ecological network, which consists, first of all, in ensuring high-quality interaction between the society and the government.



CHAPTER 5
Understanding the landscape

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5.1. Complexity - elements and inter-dependency

Ecological connectivity can be analysed either from a structural or a functional viewpoint. Structural connectivity is considered to be "anything that links separate populations" (Doerr et al., 2014). Examples include ecological corridors, vegetated verges, tree alignments, etc. Functional connectivity is considered to be the desired outcome of these features, namely the degree to which wildlife movement and dispersal actually occur (Doerr et al., 2014).

5.2. Functions and roles

The landscape level functions of ecological corridors are:

- prevent fragmentation of habitats, hence sustain the wildlife species, populations, habitats, and overall biodiversity;
- provide space for population resilience, hence prevent species extinction;
- create the connection between protected areas and semi-natural habitats;
- provide buffer zones to protected areas;
- mitigate barriers thereby preventing human-wildlife conflicts;
- support regenerative function of nature to biotic and abiotic factors;
- provide the basis of resilience to agriculture, forestry, water and wildlife management.

The most important species-level roles of ecological corridors include:

- Migration – many species migrate for several reasons, such as breeding, feeding, or territory needs. Corridors enable these species to move back and forth safely through the landscape and overcome human development barriers.

» Interbreeding – Most species have the need to find new mates out of their home range, promoting genetic exchange and diversity across populations.

» Colonisation – eco-corridors enable animals to relocate through natural dispersal behaviour and occupy new areas when food, space or other natural resources are lacking in their core habitat.

5.3. Ecosystem approach - species, processes, green infrastructure

Connectivity of the landscape for a species requires mobility, which is dependent on the type of available habitat and its configuration in the landscape. Likewise, for habitats, connectivity depends on the landscape matrix, the natural configuration of habitats, and inherent properties of the particular habitat. Corridors are very important for certain species. Connectivity is very much defined by species characteristics: range, habitat choice, dispersal distance, carrying capacity. These species-specific characteristics cannot be modified; however, the landscape itself can be adjusted to promote connectivity to a certain extent (van der Sluis, 2022).

Connectivity represents an emergent property of landscapes with respect to species dispersal and ecological processes. As such, it is becoming increasingly recognized as a fundamental feature for enhancing biodiversity conservation and ecosystem service capacity against fragmentation, in both ecological networks and Green Infrastructure planning (Honech et al., 2020). Pragmatically, ecological connectivity analyses the focus on structural, functional, and dynamic individual characteristics and mutual relationships between patches, matrices, and corridors in order to assess landscape permeability to species movement (Zeller et al., 2020).

In habitat connectivity, small and large forests, natural grasslands and water bodies are widely regarded as "keystone structures" in human-dominated landscapes: they provide foraging sites and shelter for many species (Carruthers et al., 2004; Le Roux et al., 2018; Barth et al., 2020), habitat for insectivores and pollinators (Lumsden and Bennett, 2005; Prevedello et al., 2018), focal points for tree regeneration (Dorrough and Moxham, 2005; Derroire et al., 2016), soil nutrient retention (Wilson, 2008) and connectivity for a wide range of biota (Manning et al., 2006). Forests act as a stepping-stone, connecting fragmented habitat patches and providing protection from predation for many woodland and forest species travelling through the open matrix, effectively making fragmented landscapes "usable" (Tiang et al., 2021).

Green Infrastructure has a wider set of aims, or ambitions than ecological networks. Green Infrastructure (GI) is a concept, not a set of rules, with many interpretations. GI is a spatial and functional structure delivering nature benefits to people. The focus is on multifunctional use, whereby natural areas can contribute to biodiversity conservation and other environmental functions. Green Infrastructure is an approach that brings together both the need for strategic planning of green and open spaces and the science of ecosystem services. It promotes the multifunctional nature of space and the benefits that appropriate management approaches can deliver. It recognises the need to plan land use for specific purposes such as farming, nature protection, and development, but also provides the tools and methods to identify the needs and opportunities to enhance the environment and its functions (John et al., 2019). The three key GI principles are connectivity, multifunctionality and spatial planning.

GI mapping has been demonstrated to enhance nature protection and biodiversity beyond protected areas, deliver ecosystem services such as climate change mitigation and recreation, prioritise measures for defragmentation and restoration in the agri-environment and regional development context, and find land allocation trade-offs and possible scenarios involving all sectors (Estreguil et al., 2019).

5.4. Irreversible changes to the landscape

Landscape modification and habitat fragmentation are key drivers of global species loss. Their effects may be understood by focusing on: (1) individual species and the processes threatening them, and (2) human-perceived landscape patterns and their correlation with species and assemblages. Individual species may decline as a result of interacting exogenous and endogenous threats, including habitat loss, habitat degradation, habitat isolation, changes in the biology, behaviour, and interactions of species, as well as additional, stochastic threats. Human-perceived landscape patterns that are frequently correlated with species assemblages include the amount and structure of native vegetation, the prevalence of anthropogenic edges, the degree of landscape connectivity, and the structure and heterogeneity of modified areas. Extinction cascades are particularly likely to occur in landscapes with low native vegetation cover, low landscape connectivity, degraded native vegetation and intensive land use in modified areas, especially if keystone species or entire functional groups of species are lost (Joern Fischer et al., 2007).

For many species of plants and animals, habitat conditions are ideal in large areas of unmodified native vegetation. Hence, the loss of native vegetation at landscape and regional scales has been linked to the loss of native species around the world (e.g. Andrén, 1994; Kerr & Deguise, 2004). Similarly, the loss of native vegetation at the local scale tends to reduce native species richness. Other things being equal, small patches of native vegetation support fewer native species than large patches (e.g. Bellamy et al., 1996; Rosenblatt et al., 1999). Such species–area relationships have long been known (Arrhenius, 1921). Several mechanisms are likely to underlie species–area relationships (McGuinness, 1984). Larger patches may have a higher ratio of colonisations to extinctions (MacArthur & Wilson, 1967), are more likely to contain undisturbed areas which are required by some species (Harris, 1984), capture a range of environmental conditions which constitute habitat for different sets of species (Harner & Harper, 1976; Fox, 1983), and capture patchily distributed species by chance (Connor & McCoy, 1979).

Despite strong evidence of the importance of large areas of native vegetation, it is important to recognise that: (1) small areas of native vegetation can be important complements to large areas (Fischer & Lindenmayer, 2002; Tscharntke et al., 2002); (2) land management outside patches of native vegetation can have both positive and negative context effects on patches (Wethered & Lawes, 2005); and (3) different types of native vegetation will support different sets of species (Austin & Smith, 1989; Sabo et al., 2005). For these reasons, the exclusive focus on large patches of native vegetation is often overly restrictive and represents an out-dated conceptual model of landscape modification (Haila, 2002; Manning et al., 2004).

Landscape modification typically results in the loss of native vegetation and changes to its spatial distribution, altered disturbance regimes and deterioration of vegetation structure (see above). These processes can interact and cause cascading ecosystem changes and regime shifts in ecosystem functioning. Regime shifts occur when inter-relationships between key variables in an ecosystem change fundamentally — they can be thought of as transitions where an ecosystem 'flips' from one state to another (Scheffer et al., 2001; Folke et al., 2004; Groffman et al., 2006). Extinction cascades occur where the extinction of one species triggers the loss of one or more other species, which in turn leads to further species extinctions (e.g. Terborgh et al., 2001).

CHAPTER 6

Relevant sectors & stakeholders

6.1. Sectoral assessment

This chapter aims at identifying and presenting the relevant sectors and stakeholders in the area of landscape level connectivity. Because it occurs on a larger scale, it is necessary to consider not only the transport infrastructure itself, but also areas such as agriculture, forestry, urban development and water management, together with their associated practices and specific needs. A detailed analysis and identification of stakeholders has been done within Work Package 2, more specifically in the deliverables D.T2.1.1. Stakeholder Analysis Report and D.T2.2.4. Cross Sectoral Operational Plan. These deliverables were elaborated for each of the project pilot areas, and highlight the specific situation characteristic to each pilot area, as well as the experience of the project partners in their respective areas.

6.2. Transport infrastructure

Development of transportation has had extensive impacts on nature and the landscape. When it comes to collisions with vehicles, animal mortality is undoubtedly most obvious. However, transportation is associated with other issues as well, often less noticeable at first sight. Motorways and other intensively used arterial roads and major railways create impassable barriers for animals. These barriers separate the originally continuous distribution into smaller and mutually isolated islands that are no longer able to ensure conditions for long-term survival of populations. This process, called fragmentation of the environment, is becoming an increasingly serious threat.

Animal movement through the landscape is a basic condition for survival of populations, providing both local daily needs alongside long-term and seasonal demands.

Fragmentation of populations caused by transport infrastructure, therefore, becomes a key issue for survival of many species, particularly threatening large mammals and other species inhabiting large areas in relatively small numbers. The impact of fragmentation on populations significantly increases under the conditions of climate change, which modifies habitats and consequently results in range shifts or the relocation of both individuals and populations into new areas. Especially related to the previously mentioned reversibility, critical changes to habitats and landscapes are important for the assessment of the sustainability of transport projects. In transport projects, reversibility is included as the fourth pillar of sustainability along with economy, society and environment (Joumard and Nicolas., 2010).

The severity of fragmentation caused by infrastructure is also increased by the fact that it is an irreversible process, usually manifesting itself with a delay. Isolated populations can still survive for a certain period even after negative changes in their habitat have taken place[6].

The main goal in Green Infrastructure planning is to effectively avoid, mitigate and/or compensate the impacts of transport infrastructure on wildlife, and to ensure sufficient connectivity in landscape for relevant groups of species.

In order to achieve these, in the following phases of transport infrastructure planning, preparation and processes (SEA, EIA, Planning proceedings, Building permit, etc.), all of the tools available within these processes should be carefully used:

1. **Transport policies -** transport concepts, analysis of the above-regional conflicts with protected areas and main migration corridors;

   Tools available: Strategic migration study, map of protected areas, Natura 2000 (Special Protection Areas, Sites of Community Importance, Natura 2000 habitats), core areas and main migration corridors for target species, important and protected Species Action Plans and their distribution, etc.

2. **Delimiting a transport corridor -** delimiting and surveying a wider transport corridor, selecting basic conflicts with protected areas and main migration corridors, starting a biological survey

   Tools available: same as point 1.

3. **Route selection -** assessment of proposed variants, basic proposal for placement and type of fauna passages, detailed biological survey, monitoring programme

   Tools available: Biological survey, Framework migration study.

4. **Detailed project -** solving details in placement of fauna passages, technical parameters, surfaces of bridges and areas under them, connection to the surroundings, means of spatial protection of migration corridors

   Tools available: Monitoring programme, a detailed migration study, incorporation of migration corridor(s) near fauna passage(s)

6 Hlaváč, V., Anděl, P., Matoušová, J., Dostál, I., Strnad, M., Immerová, B., Kadlečík, J., Meyer, H., Moț, R., Pavelko, A., Hahn, E., Georgiadis, L. (2019): Wildlife and Traffic in the Carpathians. Guidelines how to minimize impact of transport infrastructure development on nature in the Carpathian countries. Danube Transnational Programme TRANSGREEN Project, The State Nature Conservancy of the Slovak Republic, Banská Bystrica, 2019, 228 pp.

into the spatial plan, monitoring before construction, Plan to protect biota during construction.

5. **Construction –** minimising the impacts on natural habitats, prevention of animals entering the construction site, building time schedule, protecting surrounding habitats of fauna from contamination and disturbance

   Tools available: Ecological supervision, monitoring during construction.

6. **Operation and maintenance –** assessing the effects of infrastructure operation and maintenance on fauna, functionality of mitigation measures (underpasses, overpasses), contamination and disturbance on habitats of fauna, animal mortality

   Tools available: Monitoring after construction, monitoring the impacts of operation (including maintenance) on fauna, post-project analysis.

6.3. Agriculture

The land area utilised for agriculture provides the largest potential for ecological corridors, and will be required to go through a fundamental transformation over the upcoming decade by the international agreements, but most importantly due to climate change.

There are many theories on how to transform agriculture into a more resilient sector, all of them admitting that it must be based on natural cycles in the ecosystems. In terms of ecosystem services, agriculture plays a vital role in providing food, forage, bioenergy and pharmaceuticals, and also in supporting the critical processes behind the provision of these benefits, including pollination, biological pest control, the maintenance of soil structure and fertility, nutrient cycling, carbon sequestration and hydrological services (Power, 2010). In order to achieve the maximum potential of agricultural land, space must be allocated for nature and interconnected through ecological corridors and stepping stones. The interrelatedness between the ecosystem services provided means that an integrated approach to their maintenance and conservation is also needed.

The concept of agroecology is based on a holistic approach considering all the identified and potential ecosystem services as a whole and inseparable system. Changes of land use in cultivated fields can determine the permeability of agricultural landscape for wildlife. To achieve an appropriate balance on wildlife permeability without a loss of benefit for the farmers requires a nature-based transformation of agricultural practices, which employs actions to achieve sustainable natural resource management, whilst maintaining the longstanding need to meet demands for food quality and quantity, alongside newer demands such as energy production and carbon sequestration.

The implementation of such agricultural practices requires:

- A sustainable land-use system, where the natural functions are close to the production-oriented functions. This will require a land-use change, which can be achieved through a range of agroforestry systems such as:

  - Agri-silvicultural systems, which combine forestry (tree plantation) and the cultivation of specific target crops through methods such as alley cropping, hedge systems or even using home gardens silvopastoral systems that combine forestry and grazing on pastures, rangelands or on-farm.

  - Agri-silvicultural and silvopastoral systems might be integrated into agro-sylvo-pastoral systems, which are illustrated by mixed farms delivering the production demands of local markets whilst running a sustainable nutrition cycle.

- New agrotechnologies that are more energy conscious, regenerative, support nutrient cycles and prevent ecological damage from fertiliser-, pesticide- and herbicide-overuse include:
  - No tillage or minimal tillage which will support soil formation and structure, soil fertility, nutrient cycling, a reduction of green-house gas emissions and a reduction in water demands for irrigation;
  - Diverse crop system/hedge system/temperate perennial orchards/strip crops/push-pull pest control methods which will provide protection against erosion of soil quality, whilst creating habitats for pollinators, natural predators of pests, and vertebrates maintaining a balanced predation cycle to control small mammals and herbivores. This also benefits farmers through providing genetic diversity for future agricultural use, water purification and flow regulation into agricultural systems, providing green manures and natural fertilisers and providing natural shading for sun-sensitive crop species
  - Precise agricultural techniques require less input use (energy, pesticide, herbicide, nutrition, water, seed, forage, human resource involvement etc.), due to more targeted and optimised management systems on all levels of farm management.
- A landscape level approach, considering all territorial elements and their current and potential connections, such as:
- Considering nearby land areas, and the need to separate grey infrastructure from production-oriented fields in order to minimise disturbance across sites. For example, protecting roads and railways against dust from tillage whilst also protecting crops from exhaust gases.
  - Grazing animals bordering crop fields usually requires fencing to protect the cereal crops from herbivores. Game-lands can support wild species to feed on instead of crop lands.

All of these agro-ecological and agro-technical solutions provide services to neighbouring land-use including supporting the biodiversity conservation of protected areas, providing habitats, supporting natural regeneration of the overall ecosystem and providing a non-fragmented, well-connected habitat system for migrating species.

Besides the above mentioned “technical” transition, a social transition is also needed given the climate change and natural resource-loss crises, resulting in overall imbalance across our ecosystems. According to the FAO, 5 main criteria must be considered to reach a sustainable food system:

- (i) Protection of ecosystem biodiversity; which is the main focus of this paper;
- (ii) A food system that is accessible and culturally acceptable;
- (iii) is economically fair and affordable;
- (iv) is safe, nutritionally adequate, and healthy; and
- (v) optimises natural and human resource use. (FAO, 2012 in Magrini M-B. et al., (2019)

The main actors of the agricultural transition are the farmers themselves, comprising the production side of agriculture. They are the greatest service-providers for this transition and bear the greatest risk of changing the current management system to a new system, which despite showing great promise at the farm-level, may result in unpredictable impacts at other levels.

The other most important stakeholder group of this transition are consumers, who benefit the most from sustainable agriculture. This will require a shift in attitudes and behaviours of society members towards their consumption and the transition of farmers to become financiers and risk-bearers, not only exploiters of the ecosystem.

Within both the production and consumption circles, efforts at a whole society-level are needed:

- From a production perspective:
  - Farmers need to understand the theory and practice of the potential solutions, requiring mass knowledge-exchange from scientists to farmers, but also among farmers. Therefore, more cooperation is needed within farmer associations such as the national chambers of agriculture, farm clusters and resource-sharing associations.
  - Food industry and food marketing systems should accept new standards embedding the investment of farmers into the protection of natural resources and support the shortening of supply chains to reduce energy consumption and waste.
- From a consumer perspective:
  - Increased individual demand for more sustainable and healthier foods
  - At government levels:
    - National governments: redefining the subsidy system of food production, sharing the costs among the other production systems and promoting the importance of the transition and its burden on the whole society.
    - International government bodies: providing support to national governments regarding knowledge-transfer and new financial schemes.
    - Global government bodies: calling on action and accelerating the transition, highlighting the global crisis can only be solved locally.

Identified recommendations to policy-making that support the agricultural transition:

- Support landscape-level corporations in providing access to ecosystem services across all sectors.
- Define costs and benefits of agricultural contribution to ecosystem degradation/regeneration
- Provide payment schemes for the ecosystem services provided by agronomy as “public use of a private property” as Just Compensation.
- Establish a whole society agreement on “Property Rights” as inalienable rights, as for agriculture and farm owners must not be deprived from the free use of property rights.
- Provide financial support for an agro-ecological transition. This requires:
  - Clear definitions on the regulation of agroecology and agroecological practices
  - Clear differentiation of the definition, regulation, land-use registration, subsidies, and evaluation compared to other land-use types
- Provide national/local best practices, particularly highlighting economic cost-benefit analyses to provide effective guidance to farmers and reduce risks on agro-ecological transitions
- Focus on local needs and possibilities
- Incorporate EU regulations and strategies into national-level administration
- Ease the bureaucratic burden of funding the agricultural transition
- Support knowledge transfer not only nationally, but also transnationally

- Providing a freely accessible database to support farmers in adopting specific agricultural practices, support collaborative solutions in order to accelerate landscape-level regeneration, improve the accessibility of new techniques for more farmers, and decrease costs.

6.4. Forestry

When considering the potential for implementing and restoring ecological corridors within forests, it is important to consider targets associated with both wood production and ecosystem protection.

Targets for wood production ensure that needs for fuel and construction materials are met, and like all other agricultural sectors are managed under a profit-oriented production system. However, forests provide a wide range of vital benefits to humans in the form of ecosystem services, and in order to continue receiving such benefits, both economic and ecological sustainability need to be an integral part of forest management. Management plans outlining protective measures to conserve forested areas and the key ecosystem services that they provide present an opportunity to engage local communities and a range of stakeholders to give input of their needs and interests. These management plans can foster knowledge-exchange on best-practices and also less-effective measures of conserving forest biodiversity and associated ecosystem services.

Despite forests being the first type of land area considered in relation to ecological corridors, the effectiveness of management plans developed for these areas and their capacity to support ecological corridors is often questioned and even criticised. This issue is rooted in a lack of understanding and agreement between the forestry sector and wider society on how to value the services provided by forests and how the forestry sector should be compensated for this.

Although there are many local solutions on ways to compensate land owners for giving up their rights on using their property for production, a general agreement or scheme has not yet been reached to conclude that "Property Rights" are inalienable rights in a democratic country.

This issue also applies in wildlife management, water management and also in some aspects of agriculture.

Habitat provision is the main ecosystem service provided by forests, and is also an indicator of how well the forest ecosystem is functioning and its resilience to environmental pressures and changes. Forest habitat diversity greatly depends on the main tree species present, and their ability to provide shade and protection against harsh climatic conditions to species living within the forest. In monoculture plantation forests, with a single dominating tree species, the actual species diversity can be very low. The number and type of tree species supported by the forest ecosystem depends on the forest management practice:

- Planting and/or regeneration method(s) of the main tree species. Where there is an opportunity to have a naturally-regenerating forest, employing a forestry practice that relies on natural processes is ideal, as defined in the Ecological Forestry Initiative. There are cases where natural forest regeneration is unachievable, for example, due to habitat destruction by natural processes such as windbreaks, avalanches or forest fires, or due to climate-driven abiotic changes preventing the re-establishment and survival of species that once inhabited the area. There are also cases where natural reforestation may be possible, but would take much longer than necessary to support the species there, for example in the case of steep slopes.

This problem might occur due to several reasons:

  - Invasive species establishing and outcompeting native species in the forest, which can have both ecological and economic impacts.

  - The most criticised reason for species loss and community changes are market requirements, which refers to the desire to cultivate and harvest trees with the highest demand and economic potential. From a forestry perspective this criticism is unfair as forestry is a profit-oriented production system, just as agriculture is. Both sectors were meant to provide primary production, based on the ownership of the plot of land (and the associated ecosystem services), which are effectively used free-of-charge. More recently a new approach is arising on ownership rights of natural assets, namely the mere fact that once a plot of land has been bought, this does not guarantee the free use of all natural resources (such as ecosystem services) in the land area, where a constant payment is required instead (based on Pay Polluter Principle). These sectors, therefore, depend upon receiving payments from the society to enable them to maintain and develop these natural assets. The debate concludes to one of the most basic principles of all democratic societies: questioning the free use of property.

- Cultivating a single tree species and implementing the appropriate maintenance methods are likely to result in biodiversity loss due to the specific set of environmental conditions that have been created. These include soil pH, root symbiosis with other species and shelter and nutrient provision. These conditions will only support a restricted range of species; this loss of functional diversity is a significant threat in maintained forests. Several initiatives have been introduced in the last 50 years to tackle this issue:

  - Evergreen forests and selective cutting techniques that require minimal input, and which support multi-story forest ecosystems that comprise a range of species of different ages and growth stages, are considered sustainable forestry management practices.

  - Natural regeneration practices support diversification of the species present in the forest, through measures such as leak cutting and “left-behind trees” on the clear cut area, providing the seeds for natural reforestation. However, these practices are only successful in certain climate conditions, which is a particular issue given the climate change.

- Finally, the harvesting method itself can cause degradation due to the heavy machinery and the required roads and transportation routes. Machinery compacts the soil and changes its structure, which results in water and air pollution. Lower impact machinery could be used to mitigate this, as well as the development of precise techniques informed by remote sensing to harvest specifically selected trees, whilst preserving the others to enable the long-term viability of a diverse forest ecosystem.

Identified recommendations to policy making supporting the forestry domain:

- Pay for the ecosystem services provided by forests as “public use of a private property”; Just Compensation;

- Provide compensation for non-use of forest resources;

- Support reforestation of ecological corridor areas;

- Support remote-sensing based monitoring systems in forest planning, monitoring and evaluation;

- Support precision-techniques and legal restrictions on harvesting methods that cause a potential damage to connectivity;

- Support knowledge transfer in sustainable forest management practices;

- Support foresters in joining forest endorsement certification systems and make it a requirement in government procurements.

6.5. Water management

Ecological connectivity within the context of water management is mostly related to aquatic connectivity, in particular the longitudinal connectivity of rivers. Interruption of this longitudinal connectivity represents a river fragmentation phenomenon. River fragmentation can also occur when the lateral connectivity of a river to its floodplain has been interrupted.

River fragmentation is one of the most important environmental concerns at European level. It occurs when anthropic obstacles (such as dams, levees, and other types of infrastructure) interrupt or block the natural flow of a river. This can have drastic effects on the river's ecosystem and can limit the ability of native fish and other aquatic species to migrate and reproduce. Fragmentation can occur on large and small rivers alike, the only difference lies in the obstacle sizes.

In relation to large terrestrial fauna (such as mammals), river fragmentation can act in several ways.

Firstly, it can directly affect ecological connectivity at the landscape level. For instance, the construction of a dam on a large river will create in its upstream portion a large lake, representing a barrier for terrestrial fauna (such as bears, wolves or lynx). In addition to bank protection and other hydrotechnical works, the created lake ecosystem can represent a complete barrier.

Secondly, the fragmentation of rivers can lead to an indirect effect through changes in the availability of food for mammals such as otters or even bears, due to a reduction in the population of fish upstream of the barrier. This can change habitat suitability as well as the distribution pattern of these species in the area.

Water management authorities can represent important stakeholders on this subject. Since continuity is viewed as key to achieving good ecological status for rivers, it is their responsibility to ensure that the existing barriers are equipped with adequate, functional structures for river connectivity. New barriers should be avoided, but if their creation is unavoidable, they should from the very beginning also be equipped with appropriate measures for maintaining longitudinal and lateral connectivity of rivers, adapted to the fish fauna of each individual case.

6.6. Urban development / Spatial planning

Urbanisation and urban growth is a major cause of land conversion, which often results in habitat loss, threatening the survival of species and the ecological processes sustaining them. Today, more than 50% of the world´s population lives in cities, moreover, in developed economies it is about 75%. Consequently, urban areas are expanding across many landscapes into the surrounding environment (Bierwagen, 2007).

On the one hand, urbanisation brings many opportunities due to the concentration of capital and other resources, contributing to sustainable growth. However, rapid transitions in urban development cause challenges for communities. Solutions shall be found to tackle these challenges and conflicts in order to provide affordable housing, viable infrastructure and transport systems, employment, public and private services for the locals. Spatial planning and well-thought-out urban development is necessary to avoid unsustainable land use patterns, which could have lock-in effects for generations resulting in a decreased quality of life (The World Bank, 2022). Hence, sound spatial planning is an important tool in promoting sustainable development and creating links between various uses of land. Spatial planning is often recognized as a public sector function mainly aiming to enhance the cooperation between different sectors and stakeholders to provide an even distribution of economic development, which would often be dominated by market forces. Its main purpose is to provide socio-economic development while also considering environmental protection endeavours (Takahiro et al., 2020).

Urbanisation and urban sprawl is also associated with land use change. Landscape connectivity is often negatively affected, resulting in ecological fragmentation, decreased connectivity, loss of habitat patches, hindered movement of species and decline of biodiversity (Tarabon et al., 2020). Negative consequences also might take shape in increased predation and decreasing livestock population sizes (Bierwagen, 2007). Land use change due to rapid urban transition poses an incredible pressure for ecological landscape. Increased pressure causes destruction of ecosystem structures and weakens the functions of the given ecosystem (Wang et al., 2021).

Urban areas are also dependent on several ecosystem services. Locally-produced ecosystems are contributing to quality of life, holding values for human well-being, positive health impacts, and resilience (Tan et al., 2020). However, many of the urban ecosystem services are not consumed by locals directly, while many others are generated by ecosystems outside of the cities (Gómez et al., 2013). These services are supported by urban ecological infrastructure. Urban landscape is mainly defined by natural and semi-natural elements such as forests, grasslands and water, whose components are essential for securing ecosystem services and maintaining the functionality of urban ecosystems (Wang et al., 2021). Therefore, both the urban landscape infrastructure and the surrounding ecosystems should be preserved and balanced for well-functioning urban and natural systems. Healthy ecosystems and its services are also supported by green infrastructure elements. As a strategically planned network of semi-natural and natural areas, GI is able to deliver ecosystem services, thus improving environmental conditions and providing increased quality of life. Traditionally-built grey infrastructure can be partially replaced by nature-based solutions since green infrastructure planning offers economic, social and environmental benefits without damaging the environment and biodiversity. Inclusion of green infrastructure elements in spatial planning and urban development is offering an alternative for cheaper, easy-to-maintain solutions in comparison with standard grey solutions. (European Commission).

Ecological connectivity in urban areas is even further affected by high traffic roads, railway, power lines, dams and dense development than the rural areas (Rozenau-Rybowicz et al., 2008). Therefore, it is crucial to implement mitigation measures for the already existing barriers, and also avoid the creation of new barriers. Sustainable development and spatial planning have the potential and responsibility to promote a comprehensive approach to resolve connectivity issues and ecological constraints along the planning processes. Adoption of the mitigation hierarchy helps to minimise, and ultimately reach the goal of no net loss (NNL) of biodiversity. Due to the three-step mitigation hierarchy, the main objective


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is to (1) avoid the impacts on biodiversity, secondly - if the first step is unsuccessful - the focus is on the (2) mitigation, as reducing the impacts and on the (3) compensation, as the loss of biodiversity should be minimised.

Although green infrastructure is recognised today for biodiversity conservation, there are no uniformed spatial planning tools and practices within the European Union. However, there are legal obligations for the member states to take ecological connectivity into consideration along with green infrastructure elements in spatial planning practices. Member states are obliged to integrate ecological networks into spatial planning, but currently, there is no uniform approach within the EU. Therefore, countries have the liberty to develop models tailored to their historical, geographical, political, legal and institutional backgrounds. For example, in countries with large carnivore populations, the mapping of ecological networks proved to be useful in spatial planning to identify the most important ecological corridors, limit development and

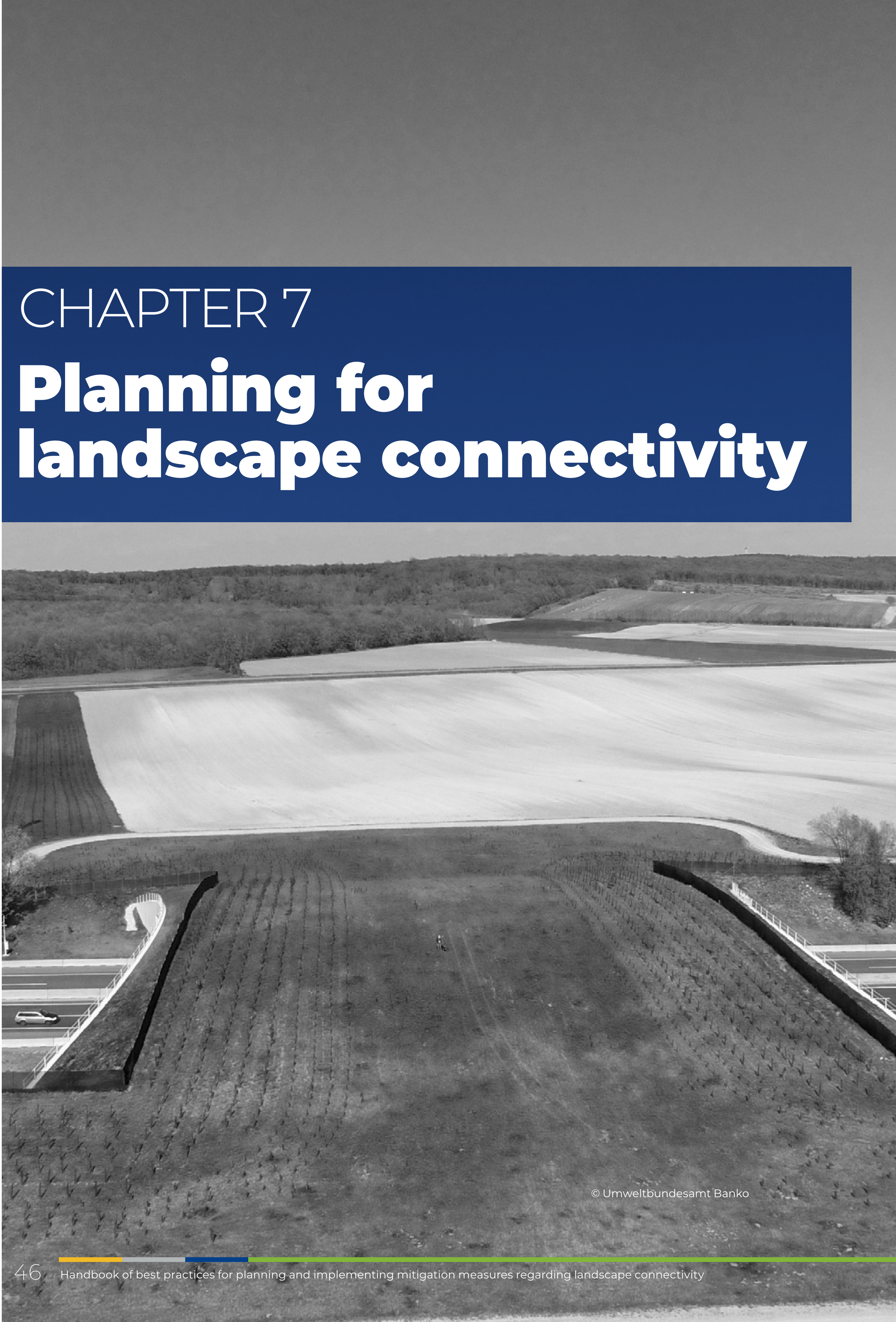
avoid further ecological fragmentation. Although current planning practices differ in each country, the implementation of ecological corridors in urban and spatial planning documents is recommended at all plans for the local, regional and national level (Popescu et al., 2022).

However, spatial planning is an effective tool+ it has no limitations in addressing ecological concerns since the developed strategies and plans are usually political documents. These documents usually express ideological positions which can be different from the ongoing practices. An ecosystem-based approach could complement these strategic plans for a better recognition of ecological issues. Also, an ecosystem service framework and its detailed mapping has the potential to provide a more comprehensive understanding of ecological matters in spatial planning (Wilkinson et al., 2013).

There are some recommendations to follow when planning for ecological connectivity. Ecological corridors should maintain links between the protected areas to provide a specific value complementing the already designated protected areas. Furthermore, ecological corridors should have specific ecological objectives and should consist of natural areas. Corridors could also support human activities; mainly the ones that represent forms of human habitation, farming, forestry, grazing, hunting, fishing and ecotourism. In order to achieve the connectivity objectives, management plans for ecological corridors can also be created. The documentation should have clear and measurable objectives based on specific indicators, while measuring the associated ecosystem service values of the ecological corridors. Social and economic benefits should also be focused on the ecological role of connectivity, as awareness of these benefits results in social acceptance. If relevant, conservation of cultural and spiritual elements can also be considered, along with social and economic benefits (Hilty et al., 2020).

Protection of ecological corridors can likewise be supported by the implementation of sustainable land use policies and measures, funding mechanisms, also planning regulation and policies. Ecological connectivity is also essential in order to boost the adaptation capacity and resilience of species. Human adaptability is also backed by improved connectivity through agroforestry, river and floodplain restoration and adaptive management of natural habitats (Climate Adapt).

CHAPTER 7
Planning for landscape connectivity



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7.1. Goal

Landscape fragmentation is the physical disintegration of continuous habitats into smaller units or patches, most often caused by urban or transport network expansion. This has a wide range of environmental, social, climate change adaptation and mitigation, and biodiversity implications.

In accordance with the EU Biodiversity Strategy for 2030, it is necessary to protect and restore nature, by tackling fragmentation as one of the mechanisms. Fragmentation also impacts the implementation of the EU strategy into green infrastructure and achieving the long-term objectives of the EU common agriculture policy, namely the sustainable management of natural resources, climate action and balanced territorial development[7].

The EU 2030 Biodiversity Strategy sets the following targets:

- Build a coherent **Trans-Europe Nature Network**.
- Legally protect a minimum of 30% of the EU's land areas and 30% of the EU sea area and **integrate ecological corridors**. (It means an extra of 4% of land and 19% for seas areas as compared to today).
- 10% of EU land and 10% of EU marine areas should be under Strictly Protected Areas. (Today, only 3% of land and less than 1% of marine areas are under strict protection).
- As part of this Strictly Protected Areas network, it highlighted the necessity of protecting all the EU's remaining primary and old-growth forests.

The main goal of landscape level connectivity is to ensure an integrated approach for the maintenance and restoration of connectivity on a regional, national and international scale. Thus, it aims to integrate connectivity in multiple domains, in order to ensure a continuous and coherent ecological network which allows for the free movement of fauna species. In order to achieve this aim, especially outside of the protected areas networks, mainstreaming of biodiversity in the energy and mining, infrastructure, manufacturing and processing sectors is essential according to the relevant Decision (14/3) of the CBD in 2018 (Convention on Biological Diversity, 2018).

7.2. Mapping the landscape & modelling scenarios

Based on the patch-corridor-matrix model, corridors are considered as more-or-less wide linear areas connecting the patches. In simplified terms, patches are usually understood as mosaic-like parts of the landscape that are essential for the persistence of populations of a group of organisms under study. In our case, patches correspond to core areas, or to linkage zones/stepping stone areas between core areas. These patches are embedded in the matrix that represents the dominant land use type for the study area, e.g. arable land in anthropogenically overformed landscapes. It should be emphasised, however, that the matrix is both context- and scale-dependent.

The methodology described here is presented in more detail in *A Methodology for Standardised Monitoring of Ecological Connectivity – Guidelines for the Analysis of Structural and Functional Connectivity*[8], elaborated within Output T1.1 of the SaveGREEN project.

7 EC, 2021, 'Biodiversity strategy for 2030', European Commission (https://ec.europa.eu/environment/strategy/biodiversity-strategy-2030_en) accessed December 22, 2021.

8 Deliverable is available here https://www.interreg-danube.eu/uploads/media/approved_project_output/0001/55/c77d06b226f6713e45a22497856ac10c45610e78.pdf

In **selecting the datasets**, the following minimum landscape description requirements should be identified as a basis for monitoring/modelling structural connectivity:

- Land cover/land use, setting the general framework that describes the potential for suitable habitats that can be part of a core area and also affects the resistance surface;
- Elevation/slope, influencing the suitability of a given area for species (groups);
- Rivers and streams, which can potentially have considerable barrier effects for many species (groups);
- Infrastructure (such as roads, railways, and buildings), which due to its technical characteristics can create a barrier effect for many species of mammals, reptiles, amphibians, etc. This barrier effect can be mitigated by underpasses/overpasses, green bridges, tunnels, etc.

The development of a possible connectivity network with bottlenecks highlighted can be carried out in two phases:

1. Creation of a habitat suitability model and designation of core areas, based on land cover and species occurrence using MAXENT software;

2. Creation of a least cost path (LCP) model based on surface resistance by land use category, infrastructure permeability, vegetation cover, rivers, using CIRCUITSCAPE software.

The modelling of the structural connectivity includes the following steps:

- Screening of potential data sources and selection of suitable input data in order to designate core areas and define resistance surfaces for umbrella species in the pilot areas;
- Gathering information on species distribution, and define target species (groups) for the pilot areas;
- Development of an appropriate model to define core areas and resistance surfaces for the selected species (groups) depending on data availability and quality;
- Creating a habitat suitability model and core areas designation;
- Calculation of species (group) specific corridors for each pilot area;
- Identification of bottleneck situations;

7.3. Objectives

In promoting biodiversity conservation and ecosystem service capacity, landscape connectivity is considered a critical feature to counteract the negative effects of fragmentation.

Overall objectives of approaching connectivity at the landscape level include: harmonising transport infrastructure planning with landscape and overall water body connectivity, maintaining and restoring connectivity in critical areas, involving stakeholders in infrastructure planning, and creating a set of best practice measures in agricultural, forestry and water body management areas.

One of the most important components of the SaveGREEN project has been the development of Cross-Sectoral Operational Plans; documents elaborated for each Pilot Area included in the project, which aim to identify the main problems related to connectivity from different domains, such as transportation, agriculture, etc.

The Cross Sectoral Operational Plans identify and address issues related to communication, stakeholder engagement, technical design, monitoring, etc.

The objective of the CSOPs was to create a framework for addressing all of the relevant stakeholders in the targeted pilot areas, and to ensure adequate identification of relevant problems, measures and actions related to landscape level connectivity within the analysed areas.

7.4. Problems/ measures/actions

The main problems identified within the Cross Sectoral Operational Plans were similar in most of the analysed project areas.

An analysis of the inputs from the CSOPs developed within the SaveGREEN project shows that the main problems identified were related to:

- An increased barrier effect from new transport & linear infrastructure projects;
- A barrier effect from the existing transport & linear infrastructure;
- Wildlife mortality due to linear transport infrastructure;
- Reduced landscape permeability, due to multiple reasons such as: changes in land use, fencing, land management, game management and human wildlife conflicts;
- Lack of coherent monitoring at landscape level and adaptation of solutions;
- Reduced support from stakeholders for an integrated ecosystemic approach at landscape level.

For these problems, certain measures and actions were proposed in each of the CSOP. These measures and actions were specifically adapted within each Plan to the situation in the project Pilot Areas, and were mostly related to:

- Data collection for both new and existing infrastructure;
- Improvement of the SEA/EIA/AA procedures and infrastructure design and an increase in the regulations for infrastructure;
- Improvement of functionality for underpasses and overpasses and their inclusion into the surrounding green infrastructure;
- Safeguarding (including improvements) permeability of the existing transport infrastructure;
- Maintenance of permeability for water courses (both lateral and longitudinal connectivity);
- Implementation of measures (including fences, deterrents for wildlife and warning signs for drivers) for reducing mortality due to collisions;
- Prevention to implement poor practices in relation to connectivity (changes in land use which affect connectivity, installation of fences, spread of invasive species, poaching, poor farming practices, etc.);
- Improvement of stakeholder understanding and perception in relation to ecological connectivity, including support for research and dissemination of information, awareness and education.

7.5. Solutions for multiple functions & specific solutions

The solutions for ensuring connectivity at landscape level are varied and specific to each domain. Some examples of solutions and best practices are presented in detail in the case studies of this Handbook.

In the case of infrastructure, some of the most important solutions are:

- The construction of fauna passages (overpasses or underpasses) bypassing the infrastructure;
- The adaptation of the existing structures (e.g. bridges or viaducts) to be used by fauna for crossing underneath the infrastructure;
- The construction of fences and guidance structures for fauna;
- Planting of tree corridors for fauna guidance;
- Other site-specific measures that can maintain ecological connectivity.

All of the measures proposed, however, should be analysed at landscape level and should be integrated with the specific conditions to the area in which they are implemented, in order to ensure that ecological connectivity is fulfilled in the whole area.

To ensure the implementation and maintenance of connectivity measures, it is necessary to involve local stakeholders in the planning, design and maintenance of measures necessary for connectivity. All of the relevant sectors should be included in the discussions and an agreement should be reached in regards to connectivity.

7.6. Monitoring and adaptation

Monitoring of landscape level connectivity needs to consider all of the relevant components, not only transport infrastructure.

The two main components underlying the monitoring of landscape (ecoscape) connectivity are: structural connectivity and functional connectivity.

Structural connectivity is considered to be “anything that links separate populations” (Doerr et al., 2014). Examples include ecological corridors, vegetated verges, tree alignments, etc. Functional connectivity is considered to be the desired outcome of these features, namely the degree to which wildlife movement and dispersal actually occur (Doerr et al., 2014).

For **structural connectivity assessments**, protected area sizes and spatial arrangement, including nearest neighbour measures and Euclidean distances between protected areas, can be measured using globally available map layers. By incorporating dispersal distances of groups of terrestrial vertebrates (e.g. short-distance, medium-distance, and long-distance dispersers), connectivity of the ecoscape can be considered for different life histories (e.g. Saura et al., 2017). Disadvantages of these structural indices are the lack of an explicit relation to ecological processes and the failure to consider differences in the scale at which species respond to ecoscape structure. Simple measures such as nearest neighbour measures can ignore important areas that fall within movement distance (Gurrutxaga et al., 2011) or barriers to movement such as highways that are located between neighbouring patches. In landscapes dominated by cities or intense agriculture, a binary view of the landscape consisting of habitat patches, stepping stones, and continuous corridors embedded in a hostile matrix may be useful. However, in shared landscapes considering the resistance of the matrix to movement makes a connectivity index more meaningful for species that may be able to move through the matrix and would benefit from such movement (Watling et al., 2011). This can be achieved in a structural sense by specifically considering the existing ecological corridors and linear barriers (e.g. roads, railways, or canals) (e.g.

Marulli and Mallarach, 2005; Hou et al., 2017), and by relating the resistance to the degree of human impact or the naturalness of the matrix (e.g. Krosby et al., 2015; Dickson et al., 2016). The naturalness approach assumes that many species will move through natural areas more easily than through areas heavily modified by human activities. GIS layers that reflect the importance of landscape elements to connectivity are becoming more accurate and widely available.

Functional connectivity assessments are species-specific and, therefore, are mostly applied at local or regional scales. Functional connectivity measures can incorporate varying levels of biological information that may reflect a species' movement ability, an individual's internal motivation to move, and the level of risk encountered when travelling in relation to the ecoscape features (B´elisle, 2005; Elliot et al., 2014). They can (1) include the information on dispersal ability (e.g. Moilanen and Nieminen, 2002), (2) be based on simulations that are parameterized related to the knowledge of the species' natural history (e.g. Tischendorf and Fahrig, 2000), (3) reflect how much land cover types and landscape features impede or facilitate organism movement (Storfer et al., 2007; McRae et al., 2008), or (4) be informed by empirical data (e.g. movement paths, patch occupancy, patch colonisation, dispersal rates, abundances, capture-recapture data) (e.g. Zeller et al., 2012). Data driven estimates of species- or taxon-specific resistance values for different land cover types in the matrix can yield well-performing matrix composition metrics (e.g. Greenwald et al., 2009; Watling et al., 2011).

Biological data, coupled with information on small landscape structures that serve as corridors and stepping stones increase the realism and ecological relevance of connectivity metrics (Morin et al., 2017; Hou et al., 2017). Functional connectivity is species-specific, which means that selecting focal species is a crucial consideration because it will never be possible to estimate functional connectivity for all species. It is strongly recommended to assess connectivity for a suite of focal species (rather than a single species). To serve as good umbrellas for the movement needs of most species, Beier et al. (2008) recommended that the focal species should include area-sensitive species, species sensitive to barriers, habitat specialists, keystone species, species with differing dispersal capabilities, species requiring dispersal for metapopulation persistence, and species important for ecological processes such as predation or pollination. While mobile mammals are frequently used as focal species for functional connectivity assessments because they are sensitive to the barrier effects of roads and other human land uses (Gurrutxaga et al., 2011), studies that tested whether corridors designed for these species will also provide connectivity for other species have yielded mixed results (Hilty et al., 2019b, pp. 118–120)[9].

To measure the extent to which a corridor is functional, biological data collection is required. In the pilot areas studied, data collection methods were proposed for species categories (large and medium sized mammals, including large carnivores, small mammals, amphibians and reptiles, birds, bats, fishes, aquatic macroinvertebrates, pollinators, ground beetles, terrestrial spiders, and terrestrial molluscs).

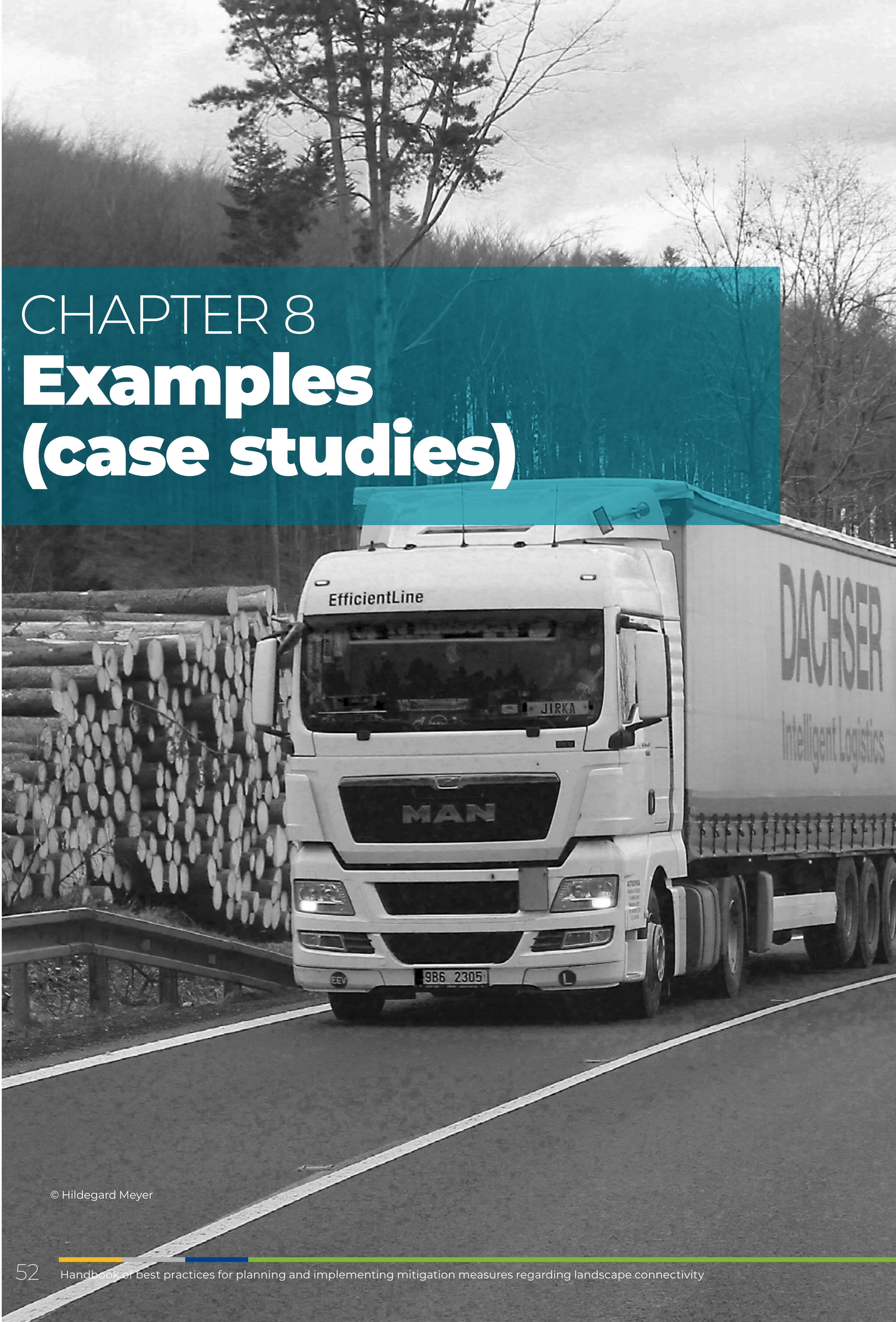
Details on the appropriate methodologies for monitoring structural and functional ecological connectivity are presented in the *Methodology for Standardised Monitoring of Ecological Connectivity* deliverable, elaborated within SaveGREEN[10].

9 Keeley, Annika & Beier, Paul & Jenness, Jeff. (2021). Connectivity metrics for conservation planning and monitoring. Biological Conservation. 255. 109008. 10.1016/j.biocon.2021.109008.

10 Deliverable available here https://www.interreg-danube.eu/uploads/media/approved_project_output/0001/55/c77d06b226f6713e45a22497856ac10c45610e78.pdf

CHAPTER 8

Examples (case studies)



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This section presents examples of good and bad practices in the form of case studies, collected from various Project Partners and stakeholders from different countries, working in different domains.

The case studies were collected through a specific template, which ensured that all input had an identical structure. The targeted stakeholders were people involved in various domains relevant to ecological connectivity, previously working on the implementation of projects or doing research on relevant topics. The case studies were collected between 2021 and 2022.

The examples provided by the stakeholders from different countries are presented here in relation to their relevant topic in different subsections of the chapter.

8.1 Transport infrastructure

This section presents case studies related to transport infrastructure, motorways and railways in particular. They detail the best practices implemented in different countries for ensuring the maintenance and restoration of ecological connectivity.

Case study on transport no. 1

Name of case study	**Optimization of the railway between the CZ-SK national border – Mosty u Jablunkova and Bystřice n. Olší**
Country & Region	Czech Republic, Slovakia
Brief description of the case	The area was identified as important for large carnivores' movements from Slovakia and Poland (also facilitated by the SCI CZ0724089 Beskydy). Two movement corridors were identified, allowing free animal movement in an eastern – western direction. Beskydy Protected Landscape Area Administration proposed the construction of two underpasses located in the corridors during the preparatory phase of the railway reconstruction. These two mitigation structures were constructed. Both meet the requirements to allow large mammals' movement.  Newly constructed underpass for large mammals on railway line, national border section – Mosty u Jablunkova and Bystřice n. Olší © Ivo Dostál
To what sector is the case study applicable?	Transport infrastructure
What were the main methods for assessing connectivity (including software)?	Corridors were identified as part of a nation-wide ecological network using a comprehensive methodology based on the analysis of large mammal finding data, categorization and description of migration barriers, mathematical models of landscape potential and habitat preferences, and primarily on extensive field research (Anděl et al., 2010).
What were the target species analysed?	Large carnivores

What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	As part of the modernisation process of the railway line, the original small culverts and bridges were replaced with adequately dimensioned objects that allow large mammals to cross the barrier.
What were the main proposals for maintaining/ restoring connectivity (if it was necessary)?	Underpasses were proposed for use by large mammals.
How do you plan to monitor the proposed measures? What are the main indicators you will use?	Animal tracking (sand and snow tracking)
What did the monitoring show? Were the proposed measures effective and to what extent?	The underpasses were used by large mammals for underpassing the railway
Further information available at	Správa železnic (Railway administration)

Case study on transport no. 2

Name of case study	**National Defragmentation Programme**
Country & Region	Austria
Brief description of the case	The Ministry Directive "Habitat connectivity for wild living animals" requires the retrofitting of 20 green bridges along the existing motorway network in Austria. Dienstanweisung "Lebensraumvernetzung Wildtiere" (bmk.gv.at)
To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	The directive is dedicated to motorways, but could be modified and applied to all other linear infrastructures that pose a barrier to wildlife.
What were the main methods for assessing connectivity (including software)?	Various studies are the baseline for that directive, modelling of the main corridors, permeability of the existing motorway network, etc.
What were the target species analysed?	Wild living mammals
Regarding the input data, what types of land use did you consider as being important for connectivity?	Mainly forest areas
Did you consider certain landscape features more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	Mainly forest areas

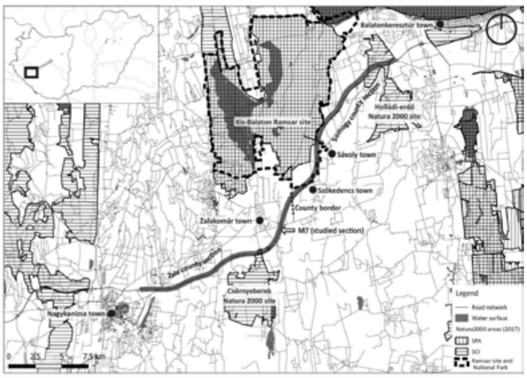
What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	All motorways in Austria are fenced and thereby pose a barrier for wildlife; the directive aims to reconnect the most important, supra regional corridors. Main problems are the cooperation of different stakeholders, especially missing protection by spatial planning and other linear infrastructures.
What were the main proposals for maintaining/restoring connectivity (if it were necessary)?	The main goal is to implement new green bridges over motorways. Where this is not possible, other solutions are explored (for example improving the existing bridges or underpasses).
How do you plan to monitor the proposed measures? What are the main indicators you will use?	Asfinag, the motorway company, did the monitoring on some of the newly-built green bridges.
Further information available at	Dienstanweisung "Lebensraumvernetzung Wildtiere" (bmk.gv.at) Schlagwort | ASFINAG Blog Nachhaltigkeit | ASFINAG
Contact details for more information	Elke Hahn, elke.hahn@bmk.gv.at

Case study on transport no. 3

Name of case study	**Technical guidelines for wildlife protection**
Country & Region	Austria
Brief description of the case	The guidelines describe all types of wildlife protection measures (signs, deterring systems, fences) but mainly determine the need for crossing structures in case of barrier situations. The necessary amount and width according to the importance of the corridor are defined. The guidelines are relevant for new projects, but not for the already existing infrastructure.
To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	The guidelines are obligatory for motorway projects in Austria, but they are recommended for other roads and railways and seen as state-of–the-art.
What were the main methods for assessing connectivity (including software)?	This is not part of the guideline; it only deals with measures and relies on the existing or new modelled/defined corridors. All the existing data in Austria are available at: www.lebensraumvernetzung.at
What were the target species analysed?	Furred wildlife
Regarding the input data, what types of land use did you consider important for connectivity?	This is not part of the guideline; it only deals with species-oriented measures.

Did you consider certain landscape features more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	This is not part of the guideline; it only deals with species-oriented measures.
What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	In case infrastructure is a full barrier all corridors, supra-regional, regional and local, need crossing structures for animals to cross the infrastructure safely. On average every 3 km of motorway needs a crossing structure.
What were the main proposals for maintaining/restoring connectivity (if it were necessary)?	See above
How do you plan to monitor the proposed measures? What are the main indicators you will use?	The planned crossing structures are part of the EIA permission process.
Further information available at	www.fsv.at
Contact details for more information	Elke Hahn, elke.hahn@bmk.gv.at

Case study on transport no. 4

Name of case study	**Motorway M7 section Balatonkeresztúr-Nagykanizsa**
Country & Region	Hungary
Brief description of the case	Motorway M7 section Balatonkeresztúr-Nagykanizsa, 35.5 km, 2x2 lanes, crown width: 26.6 m. Mostly serves transit and touristic traffic. It is part of TEN-T network (originally V. Pan-European corridor), E71. The motorway passes by the Kis-Balaton nature protection area, it crosses several ecological corridors, and even core areas of Kis-Balaton and forest-Hollád.  The planning process of the motorway section started in 1992 and lasted until 2007. The first step in motorway planning was a Study Plan, which was mainly a technical plan that assessed the alternative motorway corridors. The major environmental impacts of at least two corridor alternatives were assessed in the preliminary EIA. The problem was that the Natura 2000 areas were designated later on, and up to 2007, 'nothing was in force according to legislation, which made it difficult to implement environmental mitigation and avoidance solutions. (Mészáros & Antonsonc, 2020)

To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	Motorways
What were the main methods for assessing connectivity (including software)?	Mostly based on ecosystems
What target species were analysed?	Wildlife generally
Regarding the input data, what types of land use did you consider important for connectivity?	All kinds of natural semi-natural land use forms, from forests to grassland
Did you consider certain landscape features more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	Wetlands, forest patches, other landscape elements in the cultural landscape
What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	By altering the course of the motorway, it was possible to minimise the impact of valuable areas.
What were the main proposals for maintaining/restoring connectivity (if it were necessary)?	But it was impossible to completely avoid nature conservation areas as it crosses two Natura2000 areas (forest-Holládi, Csörnyeberek). Plantation of a forest belt, 300 m long viaduct, 6 animal crossings, 7 complex crossings along watercourses were established. One good example for animal crossings: at Szőkedencs: https://www.youtube.com/watch?v=ZomzNIxE5Ao
How do you plan to monitor the proposed measures? What are the main indicators you will use?	High grade avoidance of valuable habitats. Landscape was deprioritized in the planning process, but the protection of Kis-Balaton was a priority (because it is part of a national park, not due to international protection).
Further information available at	Source of information: Szilvia Mészáros, Hans Antonsonc (2020): Struggling, settling, solutions: A qualitative study of landscape protection in motorway planning https://www.sciencedirect.com/science/article/pii/S1361920919315986
Contact details for more information	Source of information: Szilvia Mészáros, Hans Antonsonc (2020): Struggling, settling, solutions: A qualitative study of landscape protection in motorway planning https://www.sciencedirect.com/science/article/pii/S1361920919315986

Case study on transport no. 5

Name of case study	**M30 - No. 26 (Main road no. 306) Miskolc northern bypass road (phase II) and the related flood drainage channel**
Country & Region	Hungary, Northern-Hungarian Region
Brief description of the case	Construction of a two-lane road section, partly on a new route. The nearly six-kilometre-long road, which is a first-degree flood protection dam, includes a Sajó bridge with two x fifty-two metres wide, four reinforced concrete bridges, a circular dam around Arnó, a 4.5-kilometer north-south drainage channel, and a dam for protecting the M30 roundabout and four dirt road connections. To drain the floods, a 4.5-kilometer-deep, 120-160-metre-wide deep ditch will be created from the northern corner of Lake Csorba to the Sajó River, which will channel the water into the Sajó. Embankment will also be built around the M30 roundabout, which is the deepest area, so the area surrounded by Highway 26 will be completely flood-free.
To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	Roads, agriculture, water management, spatial planning
What were the main methods for assessing connectivity (including software)?	Mostly based on ecosystems
What were the target species analysed?	Wildlife generally
Regarding the input data, what types of land use did you consider important for connectivity?	All kinds of natural, semi-natural land use forms, from forests to grassland
Did you consider certain landscape features more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	All kinds of natural, semi-natural land use forms, from forests to grassland
What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	The measures proposed contributed to the reduction of fragmentation caused by the construction of the bypass between the Kis-Sajó and the gravel mining lakes (Lake Csorba, Lake Berki)

What were the main proposals for maintaining/restoring connectivity (if it were necessary)?	Construction of ecological passages (amphibian passage)   https://www.eco-tec.hu/reference-project/m30-26-sz-fout-miskolc-eszaki-elkerulo-ut/
How do you plan to monitor the proposed measures? What are the main indicators you will use?	Biological monitoring is in progress (there are no available results yet)
Further information available at	https://www.eco-tec.hu/reference-project/m30-26-sz-fout-miskolc-eszaki-elkerulo-ut/
Contact details for more information	https://www.eco-tec.hu/reference-project/m30-26-sz-fout-miskolc-eszaki-elkerulo-ut/ https://nif.hu/projektek/2015/11/m30-26-sz-fout-miskolc-eszaki-elkerulo-ii-utem-2/

Case study on transport no. 6

Name of case study	**Barrier Free Sky Agreement**
Country & Region	Hungary
Brief description of the case	The three Hungarian electricity supply companies (E.On, ELMŰ-ÉMÁSZ, DÉMÁSZ), the Ministry of the Environment and Water Management (KvVM) and the Hungarian Ornithological and Nature Conservation Association (MME) signed on 26 February 2008 the Barrier-Free Sky Agreement. In the Voluntary Agreement, the Parties collaborated in minimising the damage to wildlife caused by electric shocks and cable collisions.
To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	Medium-voltage power lines
What were the main methods for assessing connectivity (including software)?	Under the agreement, by 31 March 2008, nature conservation organisations were required to prepare a bird protection classification for medium-voltage power line sections. According to preliminary plans, Priority I. contained particularly dangerous sections, the deadline for the conversion to become bird-friendly by 31 May 2008. Priority II. includes the other hazardous sections, the first 50% of which are scheduled for 31 March 2009 and the second 50% for 31 March 2011. I.-II. and sets a deadline of 31 January 2020 for the conversion of priority sections.
What were the target species analysed?	Birds

Regarding the input data, what types of land use did you consider important for connectivity?	It was mostly about barriers of birds, especially in areas of migration routes
Did you consider certain landscape features more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	It was mostly about barriers of birds, especially in areas of migration routes
What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	The cooperation of main stakeholders is crucial
What were the main proposals for maintaining/restoring connectivity (if it were necessary)?	A total of 3,446 km of power line sections were insulated (protection against electric shock), 120 km of overhead cables were replaced with earth cables and 2,724 visibility-enhancing devices were installed to reduce collisions. The problem was practically eliminated in the inner core areas of the Hortobágy National Park (HNPI projects), in the Borsod Mezőség Landscape Protection Area and in the Heves Grassland Landscape Protection Area (BNPI).
How do you plan to monitor the proposed measures? What are the main indicators you will use?	The agreement and mitigation measures are based on decade-long examination and experiences and agreed among several parties. Sources:
Further information available at	https://www.mme.hu/madarak_es_vezetekek https://www.mme.hu/binary_uploads/6_termeszetvedelem/elektromos_halozat_es_madarvedelem/madarak_es_legvezetekek_vegleges.pdf https://www.villanylap.hu/lapszamok/2017/majus/4523-kozepfeszultsegu-szabadvezetek-halozatok-madarbarat-meretezese
Contact details for more information	Magyar Madártani Egyesület/Hungarian Ornithological and Nature Conservation Association info@mme.hu

Case study on transport no. 7

Name of case study	**Scheduled construction of the section of the M4 expressway between Püspökladány and Berettyóújfalu (sections 183 + 065 - 213 + 000 km)**
Country & Region	Hungary, Észak-Alföld (HU32, Region No. 6.)
Brief description of the case	The planning of the M4 motorway section between Püspökladány and Berettyóújfalu has been in progress for more than ten years under the management of the National Infrastructure Development Ltd. The original plans failed to get environmental permit because in the south of road 42, there were contiguous Natura 2000 target species rich nature conservation areas, the crossing of which would have had a significant habitat destruction or segregation effect. In the summer of 2015, an environmental permit was finally granted for the nearly 30-kilometre-long motorway section, which runs north of the main road 42, bypassing the town of Kaba from the south and the municipalities of Tetétlen and Földes from the north. The environmental permit has been approved by the municipalities, and the population have had the opportunity to express their views on the route at a public forum. The planned route version I/1 of the M4 motorway runs in the administrative areas of Püspökladány, Kaba, Tetétlen, Földes and Derecske. The starting section of the route variant 1/1 is marked by the end of the acceleration-deceleration lane of road junction 42 of the Fegyvernek - Püspökladány section and the complex resting area formed together with the junction. End section is the intersection of the axes of section between M35 expressway and road No. 4. further, the section between M4 motorway - Berettyóújfalu and the national border. Length of authorised route: 29,935 km M4 motorway design class and design speed: Design department: K.I. Environmental condition: A Speed: 110 km/h Main geometrical data: a, Traffic lane width: 3.5 m b. Number of lanes: 2x2 c. Width of the middle dividing strip: 3.0 m d. Stop lane width: 3.0 m e. Bench width: 1.5 m f. Crown width: 20.0 m The section of the planned M4 expressway between Püspökladány and Berettyóújfalu runs on flat terrain, on an embankment of of almost 2.0 m in height. Area requirement: 189.36 ha

To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	Motorways
What were the main methods for assessing connectivity (including software)?	Mostly based on ecosystems
What were the target species analysed?	Wildlife
Regarding the input data, what types of land use did you consider important for connectivity?	All kinds of natural semi-natural land use forms, from forests to grassland
Did you consider certain landscape features more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	All kinds of natural semi-natural land use forms, from forests to grassland
What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	With careful planning and consultation process it become possible to avoid nature protection areas
What were the main proposals for maintaining/restoring connectivity (if it were necessary)?	1. Bridges and culverts that also function as ecological connections 2. Construction of bird protection walls to prevent collisions; at least 2.5 m high, wood braided, or lattice along either both sides of the road or just one side of the road 3. Safe installation of electrical overhead lines from a bird protection viewpoint 4. Installation of forest belts to protect grasslands 5. Protection of birds of prey by the installation of a shrub strip on the embankment slopes
How do you plan to monitor the proposed measures? What are the main indicators you will use?	The investment has received an environmental permit, construction is in progress; monitoring is planned.
Further information available at	https://www.innoteka.hu/cikk/az_m4_es_autopalya_puspok_ladanyberettyoujfalu_kozotti_szakaszanak_tanulmanyterve_es_kornyezeti_hatasvizsgalata.1261.html
Contact details for more information	National Infrastructure Development Ltd., info@nif.hu

Case study on transport no. 8

Name of case study	**Power lines and their impact on the regional Green Infrastructure in the Western Weinviertel**
Country & Region	Western Weinviertel, Lower Austria
Brief description of the case	To stop the progressive loss of plant and animal species and their habitats, it is necessary to examine all areas of the rural landscape and assess their suitability for nature conservation purposes. With the help of a conservation-oriented management plan, a power line could act as part of the ecological network. The purpose of this study was to identify at a landscape structural level the suitability of power lines as part of GI and recommend any sustainable management measures.
To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	Conservation planning
What were the main methods for assessing connectivity (including software)?	Based on landscape-mapping and selective biotope-mapping, the relevant landscape parameters were collected and processed by means of a geographic information system. The "GI-connectivity-value" created specifically for this project is a multifactorial approach that combines important ecological parameters (SHDI, edge density, ecosystem services) to reflect connectivity and naturalness.
What were the target species analysed?	The project worked at the landscape structure level. For example, endangered species were considered, but were not the focus of the project.
Regarding the input data, what types of land use did you consider important for connectivity?	Study area was the open agricultural landscape. Structural elements, such as hedges and natural field margins, are the most important biotope types in intensive agricultural landscapes and must be preserved.
Did you consider certain landscape features more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	Different cultural landscapes and land uses must be evaluated individually for conservation. In the intensive agricultural landscape, hedges are more important for connectivity than their surroundings.
What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	In summary, the studied areas of the 380 kV high-voltage line Dürnrohr (AT) – Slavětice (CZ) contribute to a higher functionality of the regional GI and improve the connectivity of the landscape. Scrub and fallow areas under power poles proved to be important stepping stones for flora and fauna in the intensive agricultural landscape.
What were the main proposals for maintaining/restoring connectivity (if it were necessary)?	An ongoing nature conservation dialogue between energy companies and landowners is the most effective way for restoring connectivity. The creation of structure elements in the cleared agricultural landscape is particularly important, i.e. the creation of hedges, shrubs, fallows, field margins and flower strips along the power line.
How do you plan to monitor the proposed measures? What are the main indicators you will use?	A field study will document the maintenance of power pole footprints and evaluate the naturalness and ecosystem service.

Further information available at	Seilern, J. (2020): Leitungstrassen und deren Bedeutung als Teil der Green Infrastructure, am Beispiel von Abschnitten der 380-kV Hochspannungsleitung Dürnrohr (AT)- Slavětice (CZ). Universität Wien, Wien Online: https://utheses.univie.ac.at/detail/56650 Danzinger, F., Drius, M., Fuchs, S., Wrbka, T., Marrs, C. (2020). Handbuch zur Bewertung der Funktionalität Grüner Infrastruktur – Instrument zur Entscheidungsfindung. Interreg Central Europe Projekt MaGICLandscapes. Output O.T2.1, Wien Online https://www.interreg-central.eu/Content.Node/MaGICLandscapes-Handbuch-zur-Bewertung-der-Funktionalitaet-G.pdf
Contact details for more information	Jacob Seilern jacobseilern@vum.co.at

Case study on transport no. 9

Name of case study	**Suspension of the construction work on a motorway during the nesting time of the eastern imperial eagle (Aquila heliaca)**
Country & Region	Slovakia, Košice region
Brief description of the case	The eastern imperial eagle is a threatened species in Europe, very sensitive to disturbance during the incubation period. Thanks to the cooperation between conservationists and the National Motorway Company of Slovakia, the construction in a selected section of the newly built D1 motorway (between Budimír and Bidovce) was repeatedly suspended in years 2017 - 2018 for the time of nesting of this bird of prey (1st February till 31st July). During the process of building, a temporary wall minimising the disturbances was built between the construction site and the nest, at 150 m distance to each side of the nest. This wall was replaced by a permanent barrier after the nesting period was over, which should make low flights of the eagles above the motorway impossible, and therefore prevent direct collisions.
To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	Motorway
What were the main methods for assessing connectivity (including software)?	Field monitoring
What were the target species analysed?	Eastern imperial eagle monitoring.
Regarding the input data, what types of land use did you consider important for connectivity?	Forest, agriculture land and roads (mainly D1)
Did you consider certain landscape features more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	No

What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	Nesting eagles were undisturbed; the noise of the reconstruction was very limited and the eagles could safely end their nesting period.
What were the main proposals for maintaining/restoring connectivity (if it were necessary)?	Construction of the wall minimises the disturbances present during motorway construction in this section between the construction site and the nest, at 150 m distance from each side of the nest. Permanent barriers should make low flights of the eagles above the motorway impossible, and so prevent direct collisions.
How do you plan to monitor the proposed measures? What are the main indicators you will use?	The main indicator will be the preservation of nesting on the given site even after the construction of the road has finished. It will be monitored by field monitoring in following years.
Further information available at	Not published
Contact details for more information	Roman Trojčák, State Nature Conservancy of the Slovak Republic

Case study on transport no. 10

Name of case study	**Mitigation measures for the Eurasian otter (Lutra lutra) in the Liptov region, Slovakia**
Country & Region	Slovakia, Žilina region
Brief description of the case	High mortality rates of the Eurasian Otter on the D1 motorway section between Ivachnová - Važec during the years 2016-2017 led to the cooperation between the National Motorway Company and the State Nature Conservancy of the Slovak Republic. First, a special traffic sign 'Attention otter!' was proposed and eight of these signs were installed along the road. The sign has already been approved by the police, although it is not a standardised sign according to the Slovak Technical Norms. Subsequently, new fences were installed near several bridges over the following years. Fences have also been installed in complicated terrain near the water reservoir of Liptovská Mara.
To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	Motorway
What were the main methods for assessing connectivity (including software)?	Field monitoring and processing of the data by statistical methods
What were the target species analysed?	Eurasian Otter
Regarding the input data, what types of land use did you consider important for connectivity?	There were no types of land use identified. This case study was based on the mortality data from the road.

Did you consider certain landscape features more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	No
What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	Reduction of Eurasian Otter mortality in critical sections. The success of the implemented measures is not yet clear.
What were the main proposals for maintaining/restoring connectivity (if it were necessary)?	Eight special traffic signs "Attention otter!". New fences were installed along the road.
How do you plan to monitor the proposed measures? What are the main indicators you will use?	The main indicator is the reduction of Eurasian Otter mortality in critical sections. It will be monitored by the Eurasian Otter road-kill data in critical sections.
Further information available at	Not available
Contact details for more information	State Nature Conservancy of the Slovak Republic

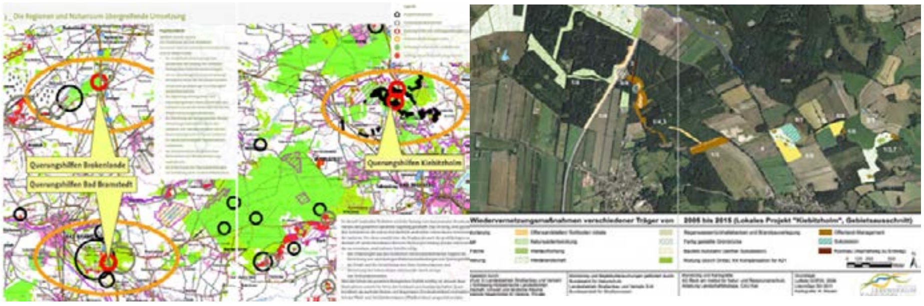
Case study on transport no. 11

Name of case study	**Action plan for the protection of the Alpine-Carpathian corridor. Mitigation measures on the section of the D2 motorway near Moravský Svätý Ján.**
Country & Region	Slovakia, Trnava region
Brief description of the case	In order to restore the Alpine-Carpathian corridor, an ecoduct on the D2 motorway south of Moravský Svätý Ján has been constructed. It is the section with the highest concentration of migration barriers - D2 motorway, 110 railway, state road I/2 - section Malacky - Moravský Ján. A plant for the production of asphalt is located near the motorway. The whole area is poorly supplied by water sources/channels and thus animal migration is even more restricted.
To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	Motorway
What were the main methods for assessing connectivity (including software)?	Phototraps and field mapping of occurrence signs
What were the target species analysed?	Large Herbivores and Large Carnivores

Regarding the input data, what types of land use did you consider important for connectivity?	Mainly forest area
Did you consider certain landscape features more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	Mainly forest area
What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	To build a new ecoduct for the improvement and preservation of migration in this section of the Alpine-Carpathian Corridor.
What were the main proposals for maintaining/restoring connectivity (if it were necessary)?	New ecoduct was built.
How do you plan to monitor the proposed measures? What are the main indicators you will use?	Phototrap monitoring has confirmed the occurrence of several species. Ecoduct as a mitigation measure had an impact on the recovery of the Alpine-Carpathian corridor.
Further information available at	Alpine-Carpathian Corridor project (AKK)
Contact details for more information	National Motorway Company, State Nature Conservancy of the Slovak Republic, WWF Slovakia,

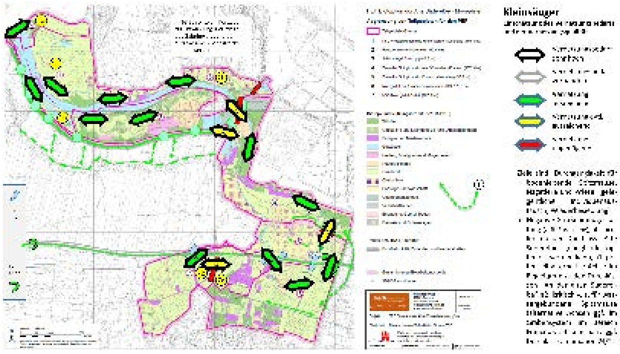
Case study on transport no. 12

Name of case study	**D1/2 "Holsatian Habitat Corridors" and "Supra regional defragmentation in Central Schleswig Holstein"**
Country & Region	Germany, Schleswig-Holstein, Natural Regions D22, D23
Brief description of the case	The first project took place within the framework of mitigation and compensation measures as an answer to impacts due to the upgrading of a federal highway to a motorway. By integrating further compensation measures and using compensation money (e.g. compensation for mining) and contributions of nature and water authorities, forestry, municipalities, foundations and even private people and the use of energy lines, a coherent ecological corridor was created with fauna passages as the focal points. The same principle was applied at regional level in the second project

	
To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	Motorway
What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	Migration of animals and dispersal of animals and plants was re-established, population growth of threatened species was enabled Monitoring of movements and/or activities and/or occurrence/distribution of larger mammals, mice, bats, reptiles, amphibians, ground beetles, grasshoppers and crickets, butterflies and vascular plants
What were the main proposals for maintaining/restoring connectivity (if it were necessary)?	Combining and supplementing different avoidance measures and different compensation measures of different projects to form a functioning ecological network. Construction of green bridges (three so far, one is ahead in conjunction with a new motorway) and some fauna underpasses in conjunction with directing stepping stone habitats or broad ecological corridors as well as the use of verges for the small fauna.
Further information available at	https://www.stiftungsland.de/fileadmin/pdf/Downloads_Wiedervernetzung/12Field_Guide_Holstein_Habitat_Corridors_2011.pdf

Case study on transport no. 13

Name of case study	**D3 Hamburg Habitat Corridor "Floodplain-Moorland" (D4) "Interlinking Habitats in Hamburg Billwerder"**
Country & Region	Germany, Hamburg, Natural Region D24
Brief description of the case	D3: As a result of interventions of NGO's the immediate mitigation and compensation measures for a new motorway had to be combined with the development of a 12-km habitat corridor between nature reserves across and along the motorway. Both the motorway and the measures have been approved and are under construction. (D4: A similar approach - but for a smaller area - was used for mitigation and compensation of the impacts of a new housing area and its new traffic infrastructure).
To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	Motorways

What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	The combination of measures shall safeguard and even improve migration of animals and dispersal of animals and plants as well as population growth of threatened species
What were the main proposals for maintaining/restoring connectivity (if it were necessary)?	D3: Coherent integration of mitigation and compensation measures into a functioning habitat network; construction of a green bridge and several fauna under- and overpasses. (D4: instead of overpasses the development of a surmountable “landscape road” was advised) D3: Overview on the project area (containing several hundred measures) highlighting the predicted corridor function for small mammals 
How do you plan to monitor the proposed measures? What are the main indicators you will use?	D3: Based on inventories, a “prognostic control of success” (ex ante assessment) was carried out for larger mammals, for small mammals, reptiles and amphibians, invertebrates of woodland, invertebrates of dry and mesophilic habitats, invertebrates of wetlands, invertebrates of water sides and an ex post monitoring based on mapping of habitats, representative ecological guilds/taxa and target species is advised (D4: the plan is not yet approved)
Further information available at	https://www.stiftungsland.de/fileadmin/pdf/Downloads_Wiedervernetzung/12Field_Guide_Holstein_Habitat_Corridors_2011.pdf

Case study on transport no. 14

Name of case study	**Collective compensation for impacts due to highway development**
Country & Region	Germany, Schleswig-Holstein , Natural Region D23
Brief description of the case	The combination and concentration of single compensation needs into an integrative concept and a coherent area leads to practicable goal-oriented maintenance (e.g. by grazing), sustainable functioning and added value. Improvement of grassland (larger low intensity grazing areas) and forests (creating near natural woodland) was combined with single local measures as drainage destruction (rewetting) or creation of ponds

To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	Motorways
What were the target species analysed?	Mammals, birds
What were the main proposals for maintaining/restoring connectivity (if it was necessary)?	Grazing with low and varying intensity, rewetting and (expected in the next decade) forest conversion   Habitats after implementing 2014 and after some succession 2016 (next inventory 2021 or 2022)
How do you plan to monitor the proposed measures? What are the main indicators you will use?	Monitoring of the habitat development, of plant communities and of the occurrence and distribution of plant target species as well as of ground beetle and grasshopper communities and of breeding birds
Further information available at	https://www.stiftungsland.de/fileadmin/pdf/Downloads_Wiedervernetzung/12Field_Guide_Holstein_Habitat_Corridors_2011.pdf

Case study on transport no. 15

Name of case study	**Monitoring the use and effectiveness of wildlife passages for small and medium-sized mammals along the Highway 175, Quebec (Canada)**
Country & Region	Canada, Quebec, region between Quebec City and Saguenay
Brief description of the case	During the widening of the Highway 175 between Québec City and Saguenay from two to four lanes (in 2006 - 2011), 33 wildlife underpasses for medium-sized and small mammals were constructed along the highway between km 60 and km 144. They are among the first designated wildlife passages for medium-sized and small mammals in the province of Québec. About two thirds (133 km) of the total length of HWY 175 between Quebec and Saguenay (210 km) traverse the Réserve Faunique des Laurentides. Large parts of the road are directly adjacent to the Parc National de la Jacques-Cartier. Exclusion fences for medium-sized mammals were placed on both sides of each passage entrance. They are about 100 m long on either side, 90 cm high with a 6 x 6 cm mesh size.
To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	Motorways
What were the target species analysed?	Mammals
What were the main proposals for maintaining/restoring connectivity (if it were necessary)?	Wildlife passages and fences. The fences may have helped guide animals to the wildlife underpasses, but they were too short (only 100 m on either side of the wildlife passages) to significantly reduce road mortality of animals on the road (Plante et al., 2019). We observed a strong fence-end effect.
How do you plan to monitor the proposed measures? What are the main indicators you will use?	Complete crossings were documented for all of the 18 wildlife passages that were monitored by at least one medium-sized and one small mammal species. The new wildlife passages are being used by small and medium-sized mammals, only four to six years after their construction (depending on their time of construction). However, during the time of the study, some species were never documented of performing a full crossing in any type of wildlife passage, including American marten, fisher, Canada lynx, and northern flying squirrel, and only one full crossing was documented for river otter, only six for red fox, and only 10 for North American porcupine and raccoon. In contrast, the fences were too short to significantly reduce road mortality (Plante et al., 2019).

Further information available at	More detailed information is available here: Spanowicz, A.G., Teixeira, F.Z., Jaeger, J.A.G. (2020): An adaptive plan for prioritising road sections for fencing to reduce animal mortality. Conservation Biology 34(5): 1210-1220. doi.org/10.1111/cobi.13502 – Summarised for the general public at https://wildlife.org/new-fencing-framework-can-help-managers-reduce-roadkill/ Plante, J., Jaeger, J.A.G., Desrochers, A. (2019): How do landscape context and fences influence roadkill locations of small and medium-sized mammals? Journal of Environmental Management 235: 511-520. Plante, J., Bélanger-Smith, K., Spanowicz, A.G., Clevenger, A.P., Jaeger, J.A.G. (2018): Road mortality locations of small and medium-sized mammals along a partly-fenced highway in Quebec, Canada, 2012-2015. Data in Brief 21: 1209-1215, doi: 10.1016/j.dib.2018.10.048 Jaeger, J.A.G., Spanowicz, A.G., Bowman, J., Clevenger, A.P. (2019): Clôtures et passages fauniques pour les petits et moyens mammifères le long de la route 175 au Québec : quelle est leur efficacité ? Le naturaliste canadien 143(1): 69-80 (in the special issue on « Écologie routière et changements climatiques »). Jaeger, J., Spanowicz, A., Bowman, J., Clevenger, A. (2017): Monitoring the use and effectiveness of wildlife passages for small and medium-sized mammals along Highway 175: Main results and recommendations. News Bulletin No. 8 – December 2017. Concordia University, Montréal. 12 pp. Online: https://spectrum.library.concordia.ca/983448/ Jaeger, J.A.G., Bélanger-Smith, K., Gaitan J., Plante, J., Bowman, J., Clevenger, A.P. (2017): Suivi de l'utilisation et de l'efficacité des passages à faune le long de la route 175 pour les petits et moyens mammifères. Projet R709.1. Rapport final pour le ministère des Transports, de la Mobilité durable et de l'Électrification des transports du Québec. 494 pp. Online: http://www.bv.transports.gouv.qc.ca/mono/1202547.pdf

Case study on transport no. 16

Name of case study	**Design and Construction of new section of Egnatia Motorway "Panagia - Grevena" - by EGNATIA ODOS S.A.**
Country & Region	Greece, Region of Western Macedonia
Brief description of the case	The new 35 km-long section is crossing an area characterised as "Bear Habitat". After several design solutions and conflicts with NGOs, the approved design incorporated a high percentage of tunnels, bridges, big underpasses and a green bridge.
To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	Motorway
What were the main methods for assessing connectivity (including software)?	Bear distribution and monitoring of bio-evidences (such as tracks, signs, scats, food remains, damage to crops, livestock and beehives), and bear telemetry data (GPS collars)

What were the target species analysed?	Bear
Regarding the input data, what types of land use did you consider important for connectivity?	Habitats' suitability for bears.
Did you consider certain landscape features more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	Habitats' suitability for bears in combination with the collected monitoring data.
What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	The big density of structures serving as animal crossings, in combination with fencing, was proved efficient for bear-vehicle collisions avoidance.
What were the main proposals for maintaining/restoring connectivity (if it were necessary)?	Very dense structures (tunnels, bridges, underpasses). For the length of 35 km, a 2-km distance was the only one not covered with other structures, and that is where a green bridge was designed and constructed.
How do you plan to monitor the proposed measures? What are the main indicators you will use?	Since the beginning of operation of the motorway section in 2008, 3 accidents with bears occurred (in 2008 and 2009), 2 of them close to Interchanges. After those accidents, no other incidents ve been recorded
Further information available at	http://www.lifestrade.it/files/abstract/Abstract_Psaroudas.pdf
Contact details for more information	Niki Voumvoulaki, NVOUM@egnatia.gr

Case study on transport no. 17

Name of case study	**Mitigation of animal-vehicle collisions during the operation of the section "Siatista - Koromilia" of the Vertical Axis A29 of Egnatia Motorway - by EGNATIA ODOS S.A.**
Country & Region	Greece, Region of Western Macedonia
Brief description of the case	Since the beginning of operation of the motorway section in 2009, many bear-vehicle collisions took place (up to 5 incidents per year), as well as many indications for bear crossing over the motorway (over the 1.6m-high fence. It was then decided to take immediate measures, as long as short-term and long-term measures were in place.

To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	Immediate measures: (1) special signs for speed reduction, (2) warning signs for bear crossings, (3) information and warning leaflets spread in close toll stations. Short-term measure: Design and construction of reinforced fencing along the 50-km long motorway section. The reinforced fence was specially designed for "bear-proofing". Long-term measures: Improvements of the existing underpasses with specific interventions (planting to attract animals, pruning, structure cleaning, ramps and dry corridors to facilitate crossing, fence improvement details to work also as escape points, light screens.
What were the main methods for assessing connectivity (including software)?	Monitoring of the local bear population and the use of the surrounding area by the species in combination with the monitoring of road-kill data especially before installing the reinforced fence.
What were the target species analysed?	Mammals, with a focus on large carnivores.
Regarding the input data, what types of land use did you consider important for connectivity?	Land use of bears based on telemetry data.
Did you consider certain landscape features more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	Creeks and streams with vegetation seem to be more important for wildlife to be followed as corridors connected with the Egnatia Motorway's culverts and bridges.
What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	With all the set of measures, especially after the implementation of reinforced fences, bear-vehicle collisions were diminished (very few cases since then, close to Interchanges).
What were the main proposals for maintaining/restoring connectivity (if it were necessary)?	The reinforced fence was the reason that accidents stopped occurring. The improvement of structures implemented during 2021 and 2022 in the frame of LIFE SAFE CROSSING and its effectiveness for habitat de-fragmentation will be evaluated in time (end of project in 2023).
How do you plan to monitor the proposed measures? What are the main indicators you will use?	Monitoring of the use of the re-adapted underpasses through camera-trapping
Further information available at	https://life.safe-crossing.eu/
Contact details for more information	Niki Voumvoulaki, NVOUM@egnatia.gr

Case study on transport no. 18

Name of case study	**Promoting Green and Blue Municipal Infrastructure[i]**
Country & Region	Hungary (national level)
Brief description of the case	The project led by the Hungarian Ministry of Innovation and Technology (until 2022; in 2022 followed by the Ministry of Technology and Industry) initiates a broader use of Nature-based Solutions (NbS) throughout Hungary. The project is being carried out under the auspices of the OECD, involving national experts. The project aims to strengthen spatial planning and development framework at the national and municipality levels to have an integrated land, soil and water management strategy on the municipality level as well as to develop regulatory instruments that incentives investments in NbS. The project provides a set of recommendations to mainstream NbS, as well as Blue-Green Infrastructure development into the government apparatus thematizing: » Management and coordination frameworks » Strategic background » Regulatory frameworks » Capacity building » Financing opportunities » European Union grants addressing areas of expertise as well as its government responsible delegates, identifying also yet non-existent, 'ideal' responsible delegate for the area. Nature-based Solutions, Green- and Blue Infrastructure and Ecosystem Service Assessments are interconnected concepts. The European Commission defines Nature-based Solutions as solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diversity, natural features and processes into cities, landscapes and seascapes, through locally adapted, and resource-efficient and systemic interventions. Nature-based solutions must, therefore, benefit biodiversity and support the delivery of a range of ecosystem services.[ii] Moreover, the project emphasises the need for the harmonisation of Green- and Blue Infrastructure.
To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	The project identifies a set of recommendations mainly addressing the governmental-structural level to support municipalities in the use of Nature-Based Solutions.

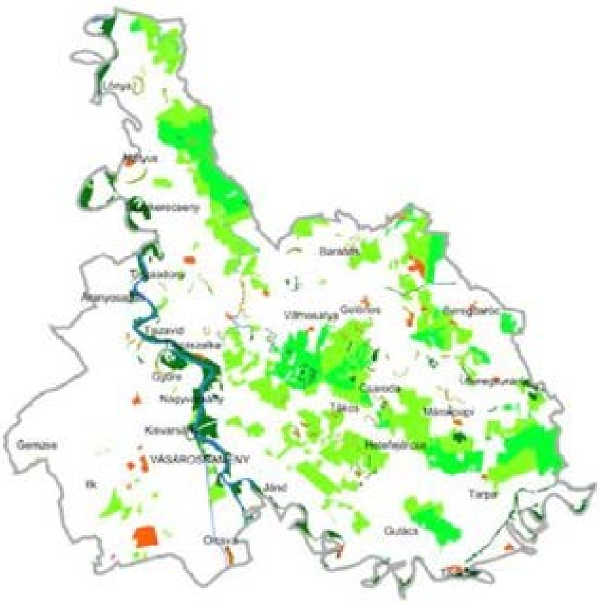
<table>
<tr><td>What were the main methods for assessing connectivity (including software)?</td><td>The main objectives:
» Explore the problems of national construction regulations concerning Green Infrastructure and the possibilities of amending the regulations, to ensure that the construction regulations support the development of Green-Blue Infrastructure
» Map the possibilities for amending policy regulations closely related to Green Infrastructure (e.g. transport, water utilities, etc.) to ensure that the sector-specific regulation helps the development of Green-Blue Infrastructure
» Determine how local governments and local bodies involved in construction, settlement, regional and territorial development can enforce the aspects of Green- and Blue Infrastructure in their regulations
» Assess the available data and data gaps for the implementation of future specific investments</td></tr>
<tr><td>What were the target species analysed?</td><td>The analysis is based on evaluating Nature-based Solutions, but the modelling was not species-specific.</td></tr>
<tr><td>Regarding the input data, what types of land use did you consider important for connectivity?</td><td>Important NbSs in Hungarian municipalities:
Land-use types:
» Alleys
» Urban forests
» Orchards
» Public parks
» Churchyards
» Cemeteries
» Institution gardens, private gardens
» Community gardens
» Greenways
» Rain gardens
» Drainage beds
» Ditches
» Water reservoir (lake)
» Artificial bogs
» Extensive, semi-intensive and intensive green roofs
» Green walls, green facades
Process-based solutions:
» Bioengineering
» Restoration of natural riverbeds
» Restoration of flood zones
Biodiversity-related solutions:
» Habitat restorations
» Use of native species</td></tr>
<tr><td>Did you consider certain landscape features more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?</td><td>All possible Nature-based Solutions should be considered when it comes to municipal developments, which requires a holistic and integrative approach.</td></tr>
</table>

What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	Although the project is not closed yet, some important observations have already been made: » Gap analysis regarding NbS database and know-how is needed » Monitoring of NbS data is needed » Systemic consultation between different policy fields is needed to solve complex problems » NbS implementation is not dependent on the building industry. If there was a high demand for NbS in the market, the construction companies would adapt to the needs. The project is not species-specific, although its approach does serve the protection of animals in a holistic manner.
What were the main proposals for maintaining/restoring connectivity (if it were necessary)?	The project provides a set of systematic recommendations addressing areas of expertise (here only a few selected recommendations are listed. Recommendations related to management and coordination frameworks: » The ministry responsible for (1) coordination of the development of Green Infrastructure (green surface system), (2) general soil protection, and (3) rainwater management must be designated at the government decree level. The necessary human and technical conditions and the legal regulation of the areas must also be ensured. Recommendations related to regulatory frameworks: » Supplement urban planning requirements with the conditions and tools for Green Infrastructure development and the application of NbS (preservation, development, sustainable use of ecosystem services, water retention) » Integrating the protection of ecosystem services into the environmental impact assessment system Recommendations related to financing opportunities: » Exclusion of investments without Green Infrastructure from subsidies for Green Infrastructure development » **Development of NbS criteria for transport development:** NbS rainwater treatment and green space development as a condition for traffic developments
How do you plan to monitor the proposed measures? What are the main indicators you will use?	The project is closely linked to the Natural Water Retention Measures (NWRM) http://nwrm.eu/ initiative. Requiring the implementation of the actual measures with 5 pilot areas, and replicable detailed strategic plans, several dissemination events and stakeholder involvement actions took place. The project itself hasn't identified a follow-up monitoring system, the main point is to engage and empower local municipalities to become independent actors in NbS implementation.
Further information available at	https://vizmegtartomegoldasok.bm.hu/hu
Contact details for more information	zoldkek@tfm.gov.hu ohegyi@ceeweb.org

Case study on transport no. 19

Name of case study	**Summary Study of the TRANSGREEN project pilot area's research on ecosystem services[i]**
Country & Region	Hungary, East-Hungary, Northern Alföld region, Vásárosnamény subregion (Nyírség, Bereg) (subregional level)
Brief description of the case	Green Infrastructure and Mapping of Ecosystems and their Services are interconnected concepts. The Ecosystem Service Approach is getting increasingly popular to assess an area's natural and cultural values – whether it be local, subregional, regional, or even national level. **Ecosystem services are all the goods that humans obtain from ecosystems and that directly or indirectly contribute to social well-being**. The study providing the basis of the current case study was conducted in eastern Hungary, Vásárosnamény subregion as part of the TRANSGREEN project.  Vásárosnamény subregion's location in Hungary is marked with red. Three versions of the M3 motorway tracks in the planning phase. Source: Study of the TRANSGREEN project pilot area's research on ecosystem services, 2018. Subregion Information Module; 2018., VIKÖTI Ltd., 2018b) The study showcases the potential impacts of a planned motorway (M3) — part of the TEN-T network to be built — on ecosystem services. Thus, to understand the motorway's implications on ecosystem services, it was first required to establish what ecosystem services were found in the region and how local stakeholders depended on and valued them. The research identified twenty ecosystem services in the pilot area, from which six, considered as the most important by the focus group, were further discussed and analysed: » Tisza as a place for recreation and has a unique landscape » Local identity and spirit of nature » Tourism » Water (well water for households, water of rivers for agriculture and industry, hot springs) » Game » Mosaic landscape The research analysis has provided thematic recommendations to policymakers related to the preservation of the 6 most important ecosystem services in the subregion alongside the suggestions related to the motorway construction.

To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	The case study identifies ecosystem services on a subregional scale in the pilot area, which, ideally, should be identified prior to every investment along with Environmental Impact Assessments. Sectors concerned: agriculture, forestry, wetlands, (one of the characteristics of the landscape is the river Tisza), grasslands (only cover a limited area), spatial planning (the ecological network is included in spatial plans in Hungary), road and rail network development. Key stakeholders: the national motorway development company, relevant ministries responsible for nature conservation (numerous Natura 2000 sites and a Landscape Protection Area "Szatmár-Bereg" are adjacent to the planned motorway) and for investments, environmental NGOs, spatial planners.
What were the main methods for assessing connectivity (including software)?	**Participatory approach was the cornerstone of the investigation.** After identifying key stakeholders, 106 surveys with mostly local participants, interviews, including 6 deep interviews were conducted, as well as the focus group was established. Furthermore, the research built on the Cascade system model[v] as well and was relying on the European Commission's CICES (Common International Classification of Ecosystem Services) classification system. For assessing the value of key ecosystem services, quantitative and qualitative methods have been used.  Modelling the participatory approach, the cornerstone of the research. Source: Study of the TRANSGREEN project pilot area's research on ecosystem services, 2018.
What were the target species analysed?	The analysis was based on evaluating ecosystem services, but the modelling was not species-specific. Ecosystem service assessment can be performed by using different assessment methods – biophysical, social, or economic. These methods are complementary to each other, but each one can provide a different set of answers, essential for decision-makers.

Regarding input data, what types of land use did you consider as being important for connectivity?	In Hungary, the National Ecological Network – which is also included in the National Spatial Plan – has three zones: core zone, ecological corridor zone, and buffer zone. In general, this network provides the backbone of ecological connectivity assessments. According to the pilot area's geographical and hydro-geographical description, the Bereg part is especially rich in ecological networks. In addition to the landscape protection area, there are several Natura 2000 sites within the border of the subregion.  Land use related to natural systems in the region (dark green: natural forests in wet areas; light green: natural forests not in wet areas and natural grasslands; blue: natural water surfaces; brown: marshlands; red: settlements) Source: Study of the TRANSGREEN project pilot area's research on ecosystem services, 2018., (VATI, 2005).  Existing wildlife overpass on M3 motorway in Hungary (Source: https://magyarepitok.hu/vasarosnamenyig-er-az-m3)

Did you consider certain landscape features as being more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	Survey participants considered and valued natural areas more than not natural areas. As one of the most important ecosystem services, the **mosaic landscape**, the **River Tisza as a place for recreation and as a unique landscape**, as well as **local identity and spirit of nature** were identified.
What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	The survey proved that implementing a common public planning process is achievable and that meaningful sources might be reached within the local stakeholders and local community. Proper involvement of locals from the beginning of the process can bring a better understanding of the potential added values and threats of the planned infrastructure, and can even cause an active scheduling period before the construction takes place. Ecosystem service assessment is a comprehensive approach that targets socio-demographic aspects rather than specific animal groups in the investigated area. Certainly, based on the result of the assessment, the key ecosystem services may be connected to animal species (e.g. pollinators). Thematic suggestions related to the identified ecosystem services in terms of the motorway construction (showcasing here only a few selected from the study): Water: » To ensure that all wetland habitats are entirely preserved, and the sensitive water system is not being further damaged before and during the construction of the motorway Hunting and game: » The highway track should avoid places where game occurs frequently, thus the motorway should cross through arable lands and pastures instead of forested areas. » Forest-covered broad wildlife overpasses (200 m at the entrances with gradually narrowing to 60 m) [EÓ1] should be constructed frequently, especially adjacent to protected areas in order not to fatally impact the game populations. Land use and agriculture: Elevated compensation of mosaic landscape in case the motorway impacts such landscape element or providing similar compensation areas in exchange for the construction affected areas.
What were the main proposals for maintaining/restoring connectivity (if it were necessary)?	The research is replicable and should not take longer than 6 months, depending on the capacities of the researcher(s).
Further information available at	https://www.interreg-danube.eu/approved-projects/transgreen/outputs
Contact details for more information	office@ceeweb.org CEEweb for Biodiversity

Case study on transport no. 20

Name of case study	**Choosing alternative for Struma Motorway project – to avoid fragmentation of bio corridors in Kresna Gorge**
Country & Region	Bulgaria, South-Western Region, near borders of Greece and North Macedonia
Brief description of the case	The Kresna gorge is a deep valley located between high mountains and having a north-south direction. It is a NATURA 2000 site, which has two most essential functions: » The bottom of the gorge forms a linear habitat between the slopes and the valley for a number of species, incl. 4 types of protected reptiles in NATURA 2000 (2 species of tortoises, 2 species of snakes). This linear habitat has a bio-corridor role for populations north and south of the gorge for both the tortoise species. And for the 2 species of snakes (leopard snake, four-lined snake), the gorge is a northern distribution border and a bio-corridor for future range expansion (especially in light of climate change). » At the same time, the gorge is a connecting natural habitat of prime importance for the bear and wolf that inhabit the mountains to the west and east of the gorge. The gorge is occupied by natural habitats and the entire habitat is suitable for migration. The width of this biocorridor in a straight line is 12-13 km. A road and a railway pass through Kresna Gorge, which are part of the trans-European transport corridor Vienna-Athens. For 25 years, the construction of a motorway has been planned there, which is the subject of a dispute and a campaign to save the Kresnen Gorge. The government wants the motorway to use the existing road through the gorge to reduce construction costs, and environmental NGOs are advocating that construction be alternatively done entirely outside the gorge, and that the road through it be downgraded to a local road. The arguments of NGOs for choosing such an alternative are: » High level traffic on the existing road leads to significant mortality of small animal species – invertebrates, reptiles, and small mammals. The road crosses and divides the linear habitat in the gorge – the slopes from one side and riparian habitat from the other, and makes it unviable for those species - most of them form their individual territories, which are not large, on the dry slopes with scrub and rocks and simultaneously on the moist and cool riverside habitats. The road interrupts the daily and seasonal migrations of these species and deteriorates the habitats and makes them not functional and unviable. Taking effective defragmentation measures to address precisely this specific adverse impact is impossible - on the one hand, to avoid the impact for daily and seasonal migrations, at all stages, incl. of juvenile individuals, a high frequency of such facilities will be needed along the entire length of the damaged linear habitat. And secondly, the steep slopes do not allow 80% of the length of the gorge to build effective small underpasses for animals. The end effect is fragmentation - significant damage to all linear habitats along the main valley in the gorge and the preservation of isolated undamaged island habitats only in the side river valleys and some extensions of the gorge. The only remaining effective mitigation is – to take heavy transit traffic out of the gorge. » The now existing road through the gorge, despite the high level of traffic, especially in summer, is not yet a complete barrier to bear and wolf movements. On the one hand, at night and in autumn, winter and spring, the traffic is not so high. On the other hand, there are no barriers anywhere on the road. When categorising this road as a trans-European motorway, fencing facilities will be built and it will become an effective barrier to wolf and bear movements, without providing defragmentation facilities.

To what sector is the case study applicable?	Planning new motorway construction
What were the main methods for assessing connectivity (including software)?	Monitoring of road death occurrences was carried out along the length of the now existing road in the Kresna gorge. The monitoring was carried out in the period 2003-2004 and again after 10 years in the period 2013-2014. Monitoring of radio-collared wolves was carried out and a regular crossing of the road in Kresna Gorge was established.
What were the target species analysed?	Reptiles: *Elaphe situla, Elaphe quatuorlineata, Testudo graeca, Eurotestudo hermanni* Large carnivores: Ursus arctos, Canis lupus
Regarding input data, what types of land use did you consider as being important for connectivity?	The whole length of the Gorge is created by primary natural and semi-natural habitats – a suitable bio-corridor for large carnivores.
Did you consider certain landscape features more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	For small species of invertebrates, reptiles and mammals, a key landscape is the boundary between wet and cooler riparian habitats and hot and dry slopes. For many slope-dwelling species, riparian habitat remains key to their life cycle, providing specific year-round functions within it – for example, feeding habitat and/or access to water during dry and hot summers or a wintering site. For example, for many species of reptiles living on dry and hot slopes - the valley is the place where they lay their eggs, due to the suitable moderate temperatures and the presence of moisture in the soil. This landscape feature has a linear structure and is highly vulnerable to the built-up linear road and rail infrastructure that disconnects the two habitat types.
What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	The comparison of the data from the monitoring of road mortality in the two periods - 2003-2004 and 2013-2014 showed a drastic decrease in the abundance of the populations of small animals (reptiles and mammals), with a significant decrease affecting not only rare species, but also mass species of animals
What were the main proposals for maintaining/restoring connectivity (if it was necessary)?	The new motorway should be built by alternative outside the Kresna Gorge, with the existing road in the Gorge being downgraded to a local one. This will allow: » Avoiding the habitats of reptiles in the gorge, moving the intensive transit traffic out of the gorge and, additionally, in 20% of the length of the gorge, additional defragmentation measures can be taken with frequently located (within daily migrations, including juvenile phases) underpasses for small animal species (umbrella species are the 2 species of tortoises and the 2 species of snakes). » Construction of a sufficient number of tunnels, viaducts and bridges and places for additional animal underpasses, combined with effective fencing facilities incl. for a bear (following the experience gathered in the Via Egnatia in Greece) – enabling effective defragmentation of the biocorridor of the bear and the wolf

How do you plan to monitor the proposed measures? What are the main indicators you will use?	Necessary monitoring measures after construction of the motorway » Periodic survey of the road mortality of all species (protected and mass) along the existing road in the gorge » Monitoring the state of the populations of some key species in the habitats up to the existing road » Monitoring the effectiveness of defragmentation facilities – both the existing road in the Gorge and newly constructed motorway lanes outside the Gorge » Radio tracking of bears and wolves
What did the monitoring show? Were the measures proposed effective and to what extent?	
Further information available at	Petko Tzvetkov, Bulgarian Biodiversity Foundation Andrey Kovatchev, BALKANI Wildlife Society
Contact details for more information	petko.tzvetkov@biodiversity.bg, +359 887 522 206 kovatchev6@gmail.com, + 359 887 788 218

Negative case study on transport no. 1

Name of case study	**Genetic exchange between Hungarian subpopulations and Poľana Mountains is blocked alongside the expressway R2, section Zvolen - Kriváň**
Country & Region	Slovakia, Banská Bystrica region
Brief description of the case	Expressway R2, section Zvolen - Kriváň has dramatic negative impacts on the movement of wildlife because of its construction and absence of useful wildlife crossing structures. Nearly the entire section is located on an embankment, which creates a complete barrier for the movement of any wildlife species. Not a single mitigation measure has been implemented. The road section cuts off the valuable Poľana Mountain range from the south of the country and further away from Hungary. Poľana is home to many wildlife species, including the three large carnivores: the brown bear, the grey wolf and the Eurasian lynx in very healthy population numbers. Large predators originating from the Poľana Mts. had a potential to disperse further south of Slovakia and even up to Hungary, but this is impossible nowadays. Vice versa, genetic exchange between Hungarian subpopulations and Poľana is now blocked alongside this section. Sadly enough, even if attempts to reconnect the area again are emerging, the embankment makes the construction of a green bridge nearly impossible.
To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	Roads
What were the main methods for assessing connectivity (including software)?	Phototraps and field mapping of occurrence signs

What were the target species analysed?	Large herbivores and large carnivores
Regarding the input data, what types of land use did you consider important for connectivity?	On one side of the road it is forest area and on the other side it is mainly agriculture land
Did you consider certain landscape features more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	The forest area is good for connectivity. The problem is on the other side of the road, where there are missing green landscape features in the intensive agricultural landscape, and also in some parts of the section is a problem of ever increasing spatial planning tendencies.
What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	It is a negative case study showing how important it is to think about preventive measures during the process of planning the construction and to know the main ecological corridors across the country.
What were the main proposals for maintaining/restoring connectivity (if it was necessary)?	None have been proposed. There is a plan to build a green bridge on another section of the road, leading from Kriváň to Lovinobaňa. There are nooptions for the construction of other preventive measures. We need to focus on protecting those migration corridors which are still in function, but are endangered by spatial planning.
How do you plan to monitor the proposed measures? What are the main indicators you will use?	It is necessary to introduce systematic monitoring of critical sections and threatened corridors, as well as the functionality of the proposed measures. At present, it is not clear who will be responsible for this monitoring. Determining responsibility and introducing systematic monitoring is also part of the CSOP.
Further information available at	Not available
Contact details for more information	State Nature Conservancy of the Slovak Republic

Negative case study on transport no. 2

Name of case study	**Reconstruction of the lower 1st class road I/72 between Pohronská Polhora and Tisovec, NP Muránska planina**
Country & Region	Slovakia, Banská Bystrica region
Brief description of the case	The reconstruction of the road I/72 generally improves traffic safety and enables an increase in traffic speed. On the other hand, it also increases the barrier effect of the road for fauna. In cooperation with the Administration of the National Park Muránska planina, mitigation measures to improve the permeability of the road for animals were suggested for four corridors. For two of them, the measures have been implemented.

To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	Transport infrastructure
What were the main methods for assessing connectivity (including software)?	Near the locality of Zbojská, a part of the old road has been removed, a curve has been softened and a bridge on pillars has been built in order to secure the permeability for animals. It is still necessary to plant guiding vegetation under the bridge and within its surroundings. Several underpasses for various animal species, amphibians including, have been built.
What were the target species analysed?	Large Herbivores and Large Carnivores
Regarding the input data, what types of land use did you consider important for connectivity?	Forest area
Did you consider certain landscape features more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	Forest area
What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	In this case, mitigation measures weren't sufficient. Requirements for animal migration were considered during their planning. For example, in relation to underpasses for amphibians, the slope is too steep, causing the water to run down it. Further, unsuitable materials were used in the body of the underpass itself, which caused the death of juvenile amphibians due to lack of moisture. In relation to underpasses and culverts for larger species built as part of the reconstruction, unsuitable material (metal) was used, causing it to be very noisy. From the monitoring realised up to 2016, the use of the underpass was only confirmed in case of the fox. Other animals choose not to use the underpass and prefer to cross the road. There have been no new data since. Moreover, additional road safety structures built now act as further migration barriers.
What were the main proposals for maintaining/restoring connectivity (if it were necessary)?	None have been proposed
How do you plan to monitor the proposed measures? What are the main indicators you will use?	Employees from the National park Muránska planina do the monitoring of this area during the field monitoring.
Further information available at	Not available
Contact details for more information	Tomáš Iľko, State Nature Conservancy of the Slovak Republic

8.2 Agriculture

The case studies presented here associate with agriculture and agriculture-related practices, which can contribute to the maintenance of ecological connectivity.

Case study on agriculture no. 1

Name of case study	**Windbreaks as part of the green infrastructure in the western Weinviertel - an example of plantations of different ages in Platt and Guntersdorf**
Country & Region	Austria, western Weinviertel, Platt and Guntersdorf
Brief description of the case	Due to the increasing mechanisation of agriculture in the middle of the 20th century, small strips of agricultural fields were combined into large agricultural areas and many landscape elements such as hedges and their biotopes disappeared. The result was large cleared open landscapes, which caused wind erosion; to prevent this, windbreaks were built to ensure the harvest. Windbreaks belong to green infrastructure in the field of agriculture. With their multifunction nature, the systems not only protect erosion; they can also provide added value for biodiversity and support habitat connectivity. In the western Weinviertel you can see some windbreaks, which show clear differences to each other. This implies occurring changes over the years. In the course of this work it was analysed to what extent the new windbreaks in Guntersdorf make a better contribution to multifunctionality than the old wind breaks systems in Platt.
To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	Agriculture
What were the main methods for assessing connectivity (including software)?	The results were determined and analysed based on vegetation studies in July 2019. For this purpose, the woody species of 20 new wind protection systems and 20 old wind breaks were observed each on a length of 100 metres and their coverage determined. By entering the data in ArcGIS, the results can be visualised and evaluated in an MSPA (Morphological Spatial Pattern Analysis) on the connectivity of the network.
What were the target species analysed?	The woody species, the construction and type of care are only some characteristics that were observed and then compared between old and new wind breaks.
Regarding the input data, what types of land use did you consider important for connectivity?	Connectivity was analysed based on windbreaks, although windbreaks represent only one type of green infrastructure in the agricultural landscape.

Did you consider certain landscape features more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	The study only compared windbreaks of different ages; But not only the hedges of this system, also the border vegetation, as a part of the wind protection system, which is important for connectivity in the agricultural lands.
What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	The windbreaks were divided into six vegetation types, which also showed the geographical accumulation. Based on vegetation surveys, it could be determined that the systems in Platt are strongly dominated by neophytes, whereas the wind breaks in Guntersdorf are built up by native woody species. In addition to the meaningful results of the vegetation study, the documented structural, significant and endangered characteristics of the plants were also dealt with. There are only minor structural differences between the two recognizable areas. However, the result of the marginal vegetation shows a significantly better nature conservation quality in Guntersdorf, while Platt hardly shows any border structure.
What were the main proposals for maintaining/restoring connectivity (if it were necessary)?	Both areas are exposed to dangers. In discussions with the agricultural district authority (ABB Hollabrunn) and the Mayor of Guntersdorf, residues of care and their reasons could be processed and commented on. The lack of understanding on the side of agriculture plays a major role in care and preservation of green infrastructure.
How do you plan to monitor the proposed measures? What are the main indicators you will use?	This work can be used as an incentive to work on improvements in care and preservation of windbreak systems and promote the awareness of nature conservation of society.
Further information available at	University of Vienna, u:theses: https://utheses.univie.ac.at/detail/53902#
Contact details for more information	Patricia Schmid patricia.schmid@gmx.at

Case study on agriculture no. 2

Name of case study	**Understanding the habitat and functional connectivity of calcareous grassland**
Country & Region	Pewsey Vale, southern England
Brief description of the case	In response to the decline and isolation of semi-natural grasslands, considerable effort has now shifted towards the restoration and re-creation of semi-natural grassland. Pewsey Down National Nature Reserve and Salisbury Plain are important calcareous grassland sites in south England. With Euclidean distance of less than 10 km, this study explored the potential for restoring connectivity between the sites. Habitat and functional connectivity were calculated using a simple metric, which worked on the principle that connectivity increased with increasing proximity to the target habitat, and when the target habitat patches were larger. To calculate functional connectivity, the threatened Marsh fritillary butterfly was used as a case study.

To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	Conservation planning
What were the main methods for assessing connectivity (including software)?	The connectivity metric was generated in R v4.0.3 and calculates the inverse of the mean Euclidean distance to the nearest X number of cells of target habitat within a given radius. It calculates this for cells which are potential targets for restoration.
What were the target species analysed?	The Marsh fritillary butterfly (*Euphydryas aurinia*) was used as a case study to calculate functional connectivity. The number of target habitat cells and search radius required for the connectivity metric were instead based on specific values which relate to the Marsh fritillary using evidence from the literature.
Regarding the input data, what types of land use did you consider important for connectivity?	Calcareous grassland was the target habitat for this study, but data were also required for the locations of arable land and improved grassland, both of which were targets for restoration. This data were extracted from the UKCEH Land Cover Map 2020. Natural England's Priority Habitat Inventory was also used to support the location of calcareous grassland in the study region.
Did you consider certain landscape features more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	Calcareous grassland was the target habitat in this study. Using the Priority Habitat Inventory in combination with the UKCEH Land Cover Map ensured that smaller, thin grassland areas were also captured that are important for connectivity.
What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	The Pewsey Vale landscape revealed high connectivity towards the north and south of the region, close to where Pewsey Down and Salisbury Plain were located; however, the central areas demonstrated low connectivity. Habitat patches would need to be generated in these central areas to act as stepping stones or corridors to bridge the gap between the north and the south.
What were the main proposals for maintaining/restoring connectivity (if it were necessary)?	The connectivity of existing habitats is essential to consider when exploring where to restore and create new habitats. If populations of associated species are to colonise these new habitats, they need to be connected to the existing patches, in order to enable organisms to disperse across.
How do you plan to monitor the proposed measures? What are the main indicators you will use?	A field survey will be required to explore potential sites for restoration on the ground. Occurrence data for species such as the Marsh fritillary will help to understand the locations of the existing populations.
Further information available at	Ridding, L., Redhead, J., Boyd, R., Pescott, O., Roy, D., Pywell, R., 2021. Pewsey Vale Habitat Potential Mapping. UKCEH report to Natural England. 45pp
Contact details for more information	Richard Pywell rfp@ceh.ac.uk

8.3 Forestry

The following case studies relate to forestry practices or forestry related interventions. As forested areas represent some of the most important components for ecological connectivity, it is important for forestry practices not to ignore ecological connectivity.

Case study on forestry no. 1

Name of case study	**Ecological connectivity for large carnivores in the transboundary area of HUSKROUA Carpathians (project Open Borders for Wildlife in the Carpathians,** www.openbordersforbears.com)
Country & Region	Hungary (Borsod-Abaúj-Zemplén County), Slovakia (Košice Region, Prešov Region), Romania (Maramures County), Ukraine (Zakarpattia, Ivano-Frankivsk)
Brief description of the case	Partners in four countries (WWF-Romania, RakhivEcoTour Ukraine, Aggtelek National Park Administration Hungary and SOS BirdLife Slovakia) and multi-level stakeholders embarked in a dynamic journey called "Open borders for wildlife in the Carpathians" to design and secure transboundary ecological connectivity between habitats. They started this journey to prevent and/or reverse the trends of diminishing wildlife populations. This will furthermore support the maintenance of ecosystem functions and services, for the benefit of local communities and society in general. Solutions to biodiversity loss in the Carpathian Region must include cross-border cooperation. The area faces chaotic development, with many species and habitats threatened by habitat fragmentation caused by unsustainable infrastructure planning. Since large carnivores (LC) frequently move across national borders in search of food and mates, the negative effects of fragmentation and creation of barriers to wildlife corridors requires a coherent cross-border solution. Transboundary cooperation is an essential precondition for preservation of the large and complex ecosystems in the region. Harmonised data collection in Romania, Ukraine, Slovakia and Hungary have been combined with joint lobbying and policy actions for biodiversity conservation. The project has improved the connectivity across 4 countries and supported integrated habitat management for brown bears (*Ursus arctos*) wolves (*Canis lupus*) and Eurasian lynx (*Lynx lynx*), specifically by: » developing a harmonised methodology for identification and designation of ecological corridors in the ENI Carpathians, developed in a participatory manner; » designing a network of key ecological corridors of transboundary interest in the ENI Carpathians, (approx. 73,000 ha of key corridors identified by using the developed harmonised methodology); » co-developing harmonised, participatory conservation measures for LCs and sustainable development of communities; » improving corridor functionality, ensuring connectivity for more than 300,000 ha of habitats by implementing at least 5 management (conservation) measures in the RO-UA transboundary area (e.g. forest edge restoration, natural pasture restoration, prevention of human-wildlife conflicts); » building a stakeholder conservation capacity for ecological corridors through advocacy; » increasing the level of information, education and awareness on the importance of safeguarding the ecological corridors for large carnivores in the Carpathian Mountains.

To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	Forestry, spatial planning
What were the main methods for assessing connectivity (including software)?	Identification of Ecological Corridors of trans boundary interest used a data driven approach and included two phases: *Phase 1 - large scale design of core areas and wildlife corridors* including desktop research and field survey; available input data and soft modelling were used. For desktop research phase, a range of data as GIS layers were provided by each country/partner: » Natura 2000 sites (where available) » Emerald ecological network (where available) » National and international natural protected areas » Official designated pristine forest or other protection form of the forests outside of natural protected areas (where available). » State borders fences (if the case) » Forest habitats (Corine Land Cover dataset) » Settlement and built-up areas (Open Street Map dataset) » Roads (Open Street Map dataset) » Elevation map » Spatial development plans (datasets) » Aerial and satellite imagery of the project area » Hunting unit's borders Based on the input data sets, identification of core areas and stepping stone habitats from connectivity networks were performed by using MAXENT & GDAL tools (Maximum Entropy Modelling software and Species distribution modelling tool). Observation data related to target species were provided by project experts from the four countries - QGIS tool was used; approximately 5,000 data points were included in the model. For core areas – the tool used was QGIS (Minimum size required 300 km^2) For the identification of spots with critical permeability (barriers), the QGIS & GDAL tools were used. The input data used for this step relate to infrastructure data (OSM) as well as barrier data from project partners. For ecological corridors Circuitscape tool was used. *Phase 2 - Critical sites (bottlenecks) analysis* - field survey and expert verification of EC for completing the physical connectivity model at the ENI Carpathians level. For the identification of bottlenecks, the following were performed: » Manual inspection » Visual interpretation » Field work

What were the target species analysed?	4 umbrella species: brown bear, Eurasian lynx, grey wolf and golden jackal
Regarding the input data, what types of land use did you consider important for connectivity?	As the input data, we considered the following types of land use: forest habitat area and stepping-stone (favourable habitat), residential areas, transport infrastructure (barriers) and species occurrence data.
Did you consider certain landscape features more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	When designing ecological corridors for large carnivores, the most important features relate to the most favourable habitat, which is the forest. However, in many cases, ecological corridors comprise other types of habitats as well - a mosaic landscape which is important to be present in ecological corridors (this includes forests, hedges or forested patches, and small pastures as well).
What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	The main conclusions of the project regarding the landscape level connectivity, the studied infrastructure and the target species are briefly stated below: » Designing ecological corridors between natural protected areas is not a feasible approach since the distribution area of large carnivores exceeds the protected areas in all cases. Ecological connectivity should be ensured between the core areas of distribution of these species. Otherwise, the risk to generate a separation model is increased, or to induce the perception that large carnivores should/can live only in protected areas (keeping people and predators apart); » Systematic data collection and scientific analysis on large carnivores' data should be produced at population level to sustain adaptive management (e.g. census, distribution range, population structure etc.); » There is a need to translate and embed ecological terminology in other sectoral plans (spatial planning, transportation infrastructure etc.) for effective implementation of measures to maintain/improve connectivity » Hunters as wildlife managers at national scale can improve large carnivores' management as they have the motivation and necessary resources to accomplish these tasks. Nevertheless, sound ecologic goals should be set for hunting/wildlife management. Some general recommendations are considered for follow up activities: » advocate for improvement of legislation on protection of EC; » advocate for inclusion of EC within spatial planning; » secure financing for ecological connectivity in HUSKROUA transboundary area (transboundary component, CBC Programmes); » scale up measures to improve the mosaic habitats for benefit of wildlife and communities (natural pasture and forest edge restoration, electric fences, barriers); » build up the capacity for management of ecological corridors.

What were the main proposals for maintaining/ restoring connectivity (if it were necessary)?	The measures for maintaining connectivity implemented/tested in Romania and Ukraine (in ecological corridor areas) relate to: » Natural pasture restoration (10 ha in RO) » Forest edge restoration (7 ha in UA, 2,000 metres in RO) » Placement of barriers in forestry fund for prevention of illegal logging, motorised access and forest fires (10 items in RO) » Installation of electric fences (1 for apiary and 1 for cattle/sheep farm) to prevent human-wildlife conflicts, in isolated mountainous areas of Ukraine. These conservation measures improve favourability for critical ecological corridors in pilot areas and are aiming to (i) improve the mosaic of habitats serving as shelter habitats and food during the vegetative season for the bear as an umbrella species; (ii) increase the natural food diversification and iii) reduce human-wildlife conflicts.
How do you plan to monitor the proposed measures? What are the main indicators you will use?	As far as the set of conservation measures for improving the functionality of EC (implemented in RO and UA), there are Memorandums of Understanding (MoUs) agreed and signed with the relevant forest administrators/owners/farmers in order to ensure the conservation measures' implementation as well as sustainability of results (4 MoUs in RO, 3 MoUs in UA). Beyond the OBWIC project boundaries, WWF RO will continue to advocate for protection of EC, aiming as one of its strategic priorities to ensure the integration of requirements for ecological coherence of key Large Carnivore habitats into plans/ policies through spatial planning mechanisms and enforcement of legislation. Indicators used: » Surface of renatured feeding grounds » Natural food availability » Frequency of illegal forest passing/entrance and negative impact events in the forest (illegal logging, forest fires, off-road)
Further information available at	www.openbordersforbears.com
Contact details for more information	Alexandra Puscas, senior project manager, apuscas@wwf.ro, +40735552931 Calin Ardelean, senior wildlife expert, cardelean@wwf.ro, +40735317548

Case study on forestry no. 2

Name of case study	**Holstein Corridors (Holsteiner Lebensraumkorridore)**
Country & Region	Germany, Schleswig-Holstein
Brief description of the case	The goal of the project was to implement the defragmentation and compensation measures in order to reconnect both legally defined and non-protected high-value habitats and isolated populations of local species. Alongside other measures, the "Naturwaldband" was developed and tested as a new type of reconnection measure, which consisted of transforming an intensive, spruce-dominated forest into a near natural woodland corridor.

Definition	Natural forest bands are strips of forest that are exempt from forestry use. On the one hand, such natural forest bands should ensure that more old-growth and zero-use areas are created in the forest through a complete absence of timber harvesting. On the other hand, they should be aligned in a way that the existing old-growth forest islands (or old-growth forest strips, e.g. the former hedgerows still present in the areas in Schleswig Holstein that were afforested a few decades ago) are connected with one another.
To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	The measure is applicable as an avoidance, mitigation or compensation measure in response to impacts by railways or motorways, which dissect the landscape. It can also be used as a restoration measure to reconnect high quality habitats embedded in intensively used landscapes.
What were the main methods for assessing connectivity (including software)?	The main indicators were/are the distribution of habitats or biotopes, habitat features, and indicator species of woodland herbs, woodland bird species and reptiles, ground beetles, butterflies, dormice and larger mammals. www.lebensraumkorridore.de
What were the target species analysed?	All characteristic, and especially the endangered woodland and woodland edge species of the impacted region, but also larger herbivores as bio engineers.
Regarding input data, what types of land use did you consider as being important for connectivity?	In this area, valuable habitats important for connectivity were e.g. old forest groves, old trees, species rich areas, dry and/or wet habitats, extensively grazed habitats, etc. Land use practices must be adapted to demands of the characteristic species of the impacted landscape. This differs between regions.
Did you consider certain landscape features as being more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	This depends on the quality of the landscape; e.g. roadside verges in intensively managed agricultural landscapes act as habitats and migration corridors for native butterflies.
What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	It is necessary to tailor the green bridges, their surrounding areas and the land beyond to the needs of all the species which are typical for the affected ecosystems.
What were the main proposals for maintaining / restoring connectivity (if it was necessary)?	See above!
How do you plan to monitor the proposed measures? What are the main indicators you will use?	The monitoring of the implemented measure was a part of the project. The main indicators were characteristic plant and animal species (see the species groups listed above).
Further information available at	www.holsteiner lebensraumkorridore.de Research gate link Bundesamt für Naturschutz (BFN) publication link BFN publication link
Contact details for more information	Marita Böttcher, Marita.Boettcher@bfn.de

Case study on forestry no. 3

Name of case study	**Visualisation of Austrian ecological corridors in the Forest Development Plan (WEP).**
Country & Region	Austria, nationwide on the basis of forest districts
Brief description of the case	The Forest Development Plan (WEP) is the planning instrument that covers the entire federal territory and is composed of sub-plans. The WEP, as a nationwide uniform, comprehensive expert assessment, thus forms a well-founded orientation on the subject of forests at the district, state and federal level, and has been an important and justified basis for forestry, forest policy and planning-relevant decisions going beyond this for decades. Therefore, the WEP offers the great possibility of an Austria-wide visualisation of ecological corridors in an official planning document. This way, the forest development plan and the ecological corridors integrated therein will also be used for non-forest planning activities in the areas of transport, landscape development and general spatial planning. The planning results and data are, thus, used in a wide variety of ways, both in specific authority procedures and in complex planning processes.
To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	Forestry, railways, roads, motorways, agriculture, spatial planning
What were the main methods for assessing connectivity (including software)?	To implement a system of automated generation of the specific maps for the WEP, all the existing designations of ecological corridors in Austria had to be merged into a so-called "integral dataset for ecological corridors". This dataset contains all official designations of ecological corridors in Austria that have been created within the framework of different public and scientific projects. For quality assurance, the selection of data sources was evaluated by experts. The data sources were then digitised on an expert basis and merged into an integral dataset regarding the habitat connectivity in Austria.
What were the target species analysed?	The designation was conducted independent of specific target species and is intended to ensure permeability for a variety of species.
Regarding input data, what types of land use did you consider as being important for connectivity?	Connectivity was analysed based on the permeability of different land use and land cover. The land cover types of forest and semi-natural areas and their subtypes were considered as the most permeable habitat types.
Did you consider certain landscape features more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	Hedges, woodlots, isolated trees, trees in lines, trees in groups, ditches and field margins were specifically considered as stepping-stones and guiding elements in agricultural land and other man-made landscapes.

What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	The integral dataset on ecological corridors in Austria contains all the existing designations of ecological corridors within Austria. The dataset is subject to continuous updating. Thus, on the one hand, the dataset represents the reference dataset for ecological corridors in Austria; on the other hand a dynamic overall planning basis, which has been available nationwide since 1991 and has been updated at 10-year intervals ever since. Due to the dynamics of land-use change in Austria, this is a particularly important feature. The designated corridors in the WFP are not legally binding and are primarily a basis for planning and voluntary actions.
What were the main proposals for maintaining/restoring connectivity (if it were necessary)?	The present project serves merely to visualise the Austrian ecological corridors in the forest development plan as a basis for planning and does not show a valuation of connectivity.
How do you plan to monitor the proposed measures? What are the main indicators you will use?	The integral dataset for ecological corridors of Austria is continuously updated to capture the dynamics of land use changes and to regularly review the status of ecological corridors based on permeability.
Further information available at	Project webpage https://www.waldentwicklungsplan.at/
Contact details for more information	Environment Agency Austria Gebhard Banko gebhard.banko@umweltbundesamt.at

8.4 Water management

As regulation of rivers and other hydrotechnical works can contribute to ecological fragmentation, the water management component is one of the most important when it comes to maintenance or restoration of connectivity. The following case studies relate to water management.

Case study on water management no. 1

Name of case study	**Sasfészek-tó (Lake Sasfészek) revitalization in Páty**
Country & Region	Hungary, Central-Region, Páty

Brief description of the case	The degradation of the lake and wetland area started decades ago, but for now it is surrounded completely by different infrastructure lines (railway Győr- Budapest, M1 motorway and road No. 1), and even an industrial park was built next to it. The industrial park developed 33,000 m2. In the neighbourhood of the industrial park, 4 ha lake and wetland area was restored and a study trail was elaborated. https://logisztika.com/okologiai-tanosveny-nyilt-patyon/ http://tortenetekkepekkel.blogspot.com/2020/06/sasfeszek-to-egy-megmentett-elohely.html http://www.oplab.sztaki.hu/p_sasf3_hu.htm
To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	Roads, water management, habitat restoration
What were the main methods for assessing connectivity (including software)?	Mostly based on the ecosystems, distribution of habitats or biotopes,
What were the target species analysed?	Wildlife related to water and wetland
Regarding the input data, what types of land use did you consider important for connectivity?	Wetland, water, riparian forest  http://tortenetekkepekkel.blogspot.com/2020/06/sasfeszek-to-egy-megmentett-elohely.html
Did you consider certain landscape features more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	Wetland, other water-related ecosystems
What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	Cooperation among stakeholders of different sectors are crucial for success of habitat rehabilitation

What were the main proposals for maintaining/restoring connectivity (if it was necessary)?	Restoration of the water supply of the wetland and lake.
How do you plan to monitor the proposed measures? What are the main indicators you will use?	Civil organisations and the industrial park take responsibility and make an agreement. The industrial park has seen good PR opportunities in revitalising the lake and wetland, and maintaining a study trail.
Further information available at	https://logisztika.com/okologiai-tanosveny-nyilt-patyon/ http://tortenetekkepekkel.blogspot.com/2020/06/sasfeszek-to-egy-megmentett-elohely.html http://www.oplab.sztaki.hu/p_sasf3_hu.htm
Contact details for more information	To be identified

Case study on water management no. 2

Name of case study	**Revitalisation of the Muránka River in the framework of the projects "For the Nature of the Muránska Planina" and "The River without Barriers".**
Country & Region	Slovakia, Mokrá Lúka
Brief description of the case	The projects were aimed at removing the two biggest migration barriers for fish on the Muránka River. Subsequently, monitoring of the effect of barrier removal and mapping of selected species (thick shelled river mussel) was carried out. Removal of water barriers helped to restore the migration routes of aquatic animals as well as ecological value of the river ecosystem above the barrier by repopulation of native fish. It has also contributed to good cooperation and relations between the conservation and fishing communities.
To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	Water management and spatial planning
What were the main methods for assessing connectivity (including software)?	Field survey of watercourse migration barriers' permeability.
What were the target species analysed?	Fish species, thick shelled river mussel (*Unio crassus*) and European crayfish (*Astacus astacus*)
Regarding the input data, what types of land use did you consider important for connectivity?	Muránka river
Did you consider certain landscape features more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	Height of the barrier, length of the permeable section, importance of the site from the ecological viewpoint and Natura 2000 protected area

What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	The removed water barrier has been replaced by a roughened slipway, allowing six native fish species to repopulate their original range. However, the restoration of the river longitudinal continuity in that stretch and its function as a bio-corridor has also helped other species, such as the Carpathian brook lamprey (Eudontomyzon danfordi) and the European crayfish (Astacus astacus).
What were the main proposals for maintaining/restoring connectivity (if it were necessary)?	Removal of the water barrier and its replacement by a roughened slipway.
How do you plan to monitor the proposed measures? What are the main indicators you will use?	By realising the ichthyological survey and mapping of the occurrence of protected aquatic species.
Further information available at	https://mynovohrad.sme.sk/c/5629612/rybam-v-rieke-muran-uz-nebrania-v-pohybe-bariery.html https://www.facebook.com/CSRzK/posts/1243505585681926 https://www.enviromagazin.sk/enviro2010/enviromc2/20_obnova_riecnych.pdf
Contact details for more information	NP Muránska planina Administration: https://www.npmuranskaplanina.sk/kontakt/ Ervín Hapl: ervin.hapl@gmail.com

8.5 Urban development / Spatial planning

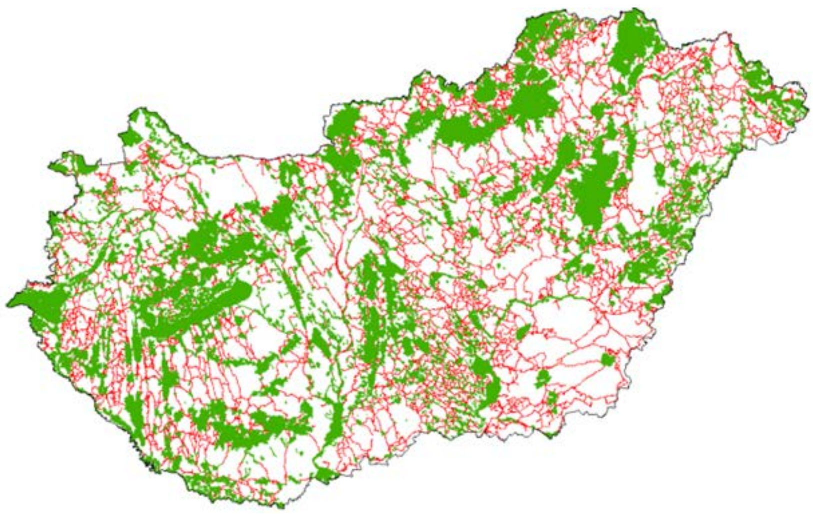
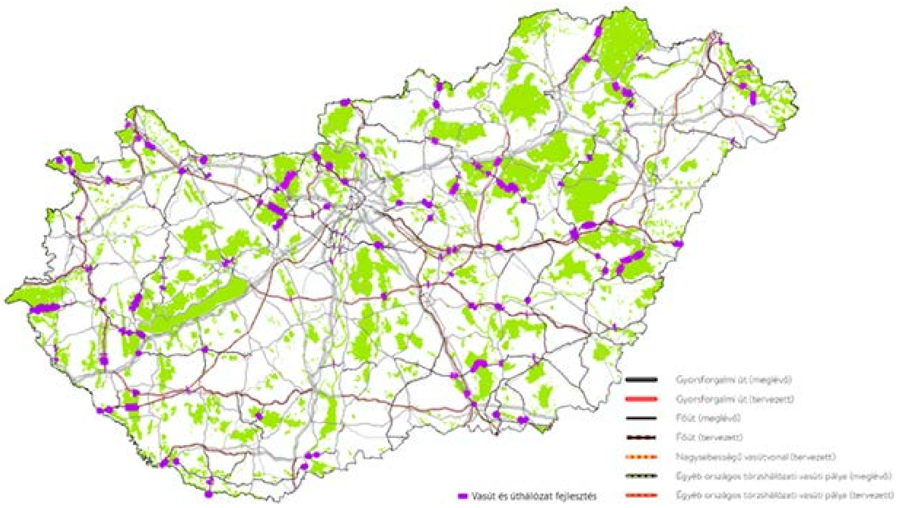
The following case studies relate to spatial planning, Spatial planning offers a unique opportunity to integrate connectivity and ecological corridors in urban development and to ensure the best possible development, which takes into account the necessity for connectivity.

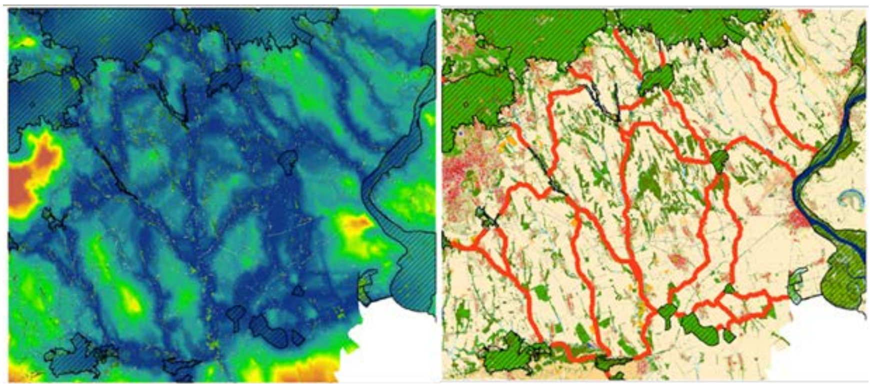
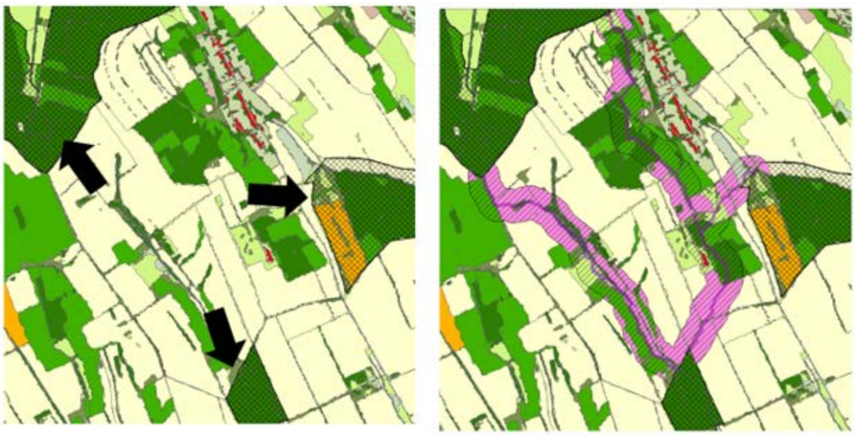
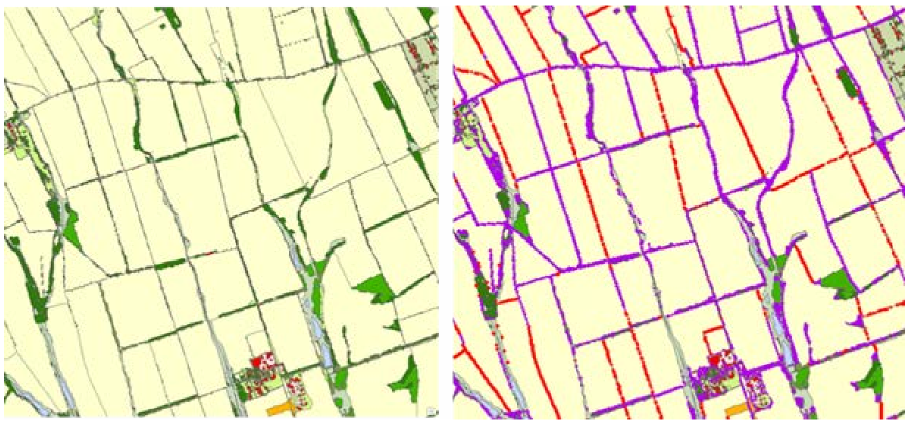
Case study on spatial planning no. 1

Name of case study	**Guiding vegetation near Jablunkov**
Country & Region	Czech Republic
Brief description of the case	The municipality of Jablunkov is located in a bottleneck area between the Moravskoslezské Beskydy Mountains and the cCentral Carpathians. The connectivity in the valley is crucial to preserving large carnivore populations in Moravskoslezské Beskydy because their viability is dependent on migrations of new individuals from the core populations. The municipality has planned a new industrial zone in one of the last migration corridors which would significantly decrease its width (the location was later identified as one of the two official remaining corridors in the area). Surrounding areas are built up by settlements or used as large fields and meadows without natural vegetation. After the intervention of NGO, the zone area was decreased and Jablunkov together with Friends of the Earth and local hunter association planted several patches of guiding vegetation in the migration corridor on the land owned by the municipality. Thus, the meadows were enriched by bushes and trees leading from the wood complex next to the valley to a safe underpass under a main road (E75) in the middle. Jablunkov became the first municipality in the Czech Republic to protect a migration corridor in their spatial plan and the project served as good PR for the town. Among other tree species, apple trees were included because of the name of the town (jablko = apple in Czech) and to serve the local citizens.  Newly grown guiding vegetation patch in the Jablunkov area © Ivo Dostál

To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	Spatial planning, agriculture
What were the main methods for assessing connectivity (including software)?	The area is part of the official migration corridor for large mammals according to the Biotope of selected specially protected species of large mammals in the Czech Republic (see case study on spatial planning no. 4).
What were the target species analysed?	Large mammals
Regarding the input data, what types of land use did you consider important for connectivity?	—
Did you consider certain landscape features more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	—
What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	The measure has improved structural connectivity, but on-site monitoring still needs to be performed.
What were the main proposals for maintaining/restoring connectivity (if it were necessary)?	The planting project was somewhat unofficial mitigation for the municipality development and was elaborated to ease the movement of animal species through agricultural land with lack of tree cover.
How do you plan to monitor the proposed measures? What are the main indicators you will use?	Direct sight observation (insects, birds, medium mammals). The use of the patches by large carnivores was not directly observed and systematic on-site monitoring was not performed. However, the movement of a lynx individual across the valley was mapped using camera traps in the core areas on both sites. The probability that the specific corridor was used is high. After removing protection fences in 2022, further monitoring is recommended to map the full potential of the measure.
Further information available at	https://www.selmy.cz/
Contact details for more information	miroslav.kutal@hnutiduha.cz, radek.kricek@hnutiduha.cz, michal.feller@hnutiduha.cz

Case study on spatial planning no. 2

Name of case study	**Ecological corridor modelling in National Green Infrastructure Plan**
Country & Region	Hungary (national level)
Brief description of the case	The National Ecological Network is part of the National Spatial Plan. The network was previously designated on an empirical basis, based on the opinions of national park experts. The network consists of three elements: core areas, ecological corridors and buffer areas. The interconnectivity, connectivity, (gaps) and potential development of the ecological network have been assessed in the framework of the National Green Infrastructure Development Plan. The connectivity of the core areas was modelled using the Least Cost Path analysis, which is also used widely in the international literature. As a result of the modelling, more than 21,000 ecological corridors were identified, some of which are the already existing ecological corridors and others are potential new corridors or missing links. The network analysis has identified the conflict areas, points among the national transport network and the potential ecological network. 
To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	The ecological network modelling case study identifies the conflict areas of road and rail network development concepts and the ecological network on a national scale, and assists in the review of the National Spatial Plan and sectoral plans. 

What were the main methods for assessing connectivity (including software)?	The Least Cost Path modelling was used in the analysis. Circuitscape Linkage Mapper and ArcGIS software were used for the modelling. 
What were the target species analysed?	The analysis was primarily based on the distribution of terrestrial species, but the modelling was not species-specific. The modelling was essentially based on structural ecological relationship modelling.
Regarding the input data, what types of land use did you consider important for connectivity?	For the network modelling, the land use map based on the Sentinel2 space image was used. The core areas were the core areas of the ecological network of the National Spatial Plan. 
Did you consider certain landscape features more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	The modelling of ecological network is based on a resistance map compiled from land uses. Resistivity is the permeability of each land use. In the resistance, or impedance map, the buffer areas of watercourses, the existing field margins and field edges are highlighted. 

What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	The analysis has clearly demonstrated that spatial network surveys at landscape, regional and national scales model ecological corridors well. At the country level, the analysis of structural relationships rather than species-level analysis yields satisfactory results.
What were the main proposals for maintaining/ restoring connectivity (if it were necessary)?	The ecological network modelling was one of the three pillars of the national green infrastructure plan (ecological baseline, ecosystem service, ecological connectivity). The connectivity was, thus, a key aspect in the foundation of the national green infrastructure network development. The national network analysis will also be used in the development of various transport development concepts and sectoral development strategies.
How do you plan to monitor the proposed measures? What are the main indicators you will use?	The ecological network is reviewed every six years in Hungary. The development achievements and shortcomings of the past period are analysed by the experts of the national parks. The new ecological network developments will reduce the fragmentation of natural areas and increase the connectivity of areas. Fragmentation is well measured at national and regional level by the Effective Mesh Size indicator, which is a landscape metric indicator. Successful network development is also well measured by the reduction in animal collisions. https://r-spatialecology.github.io/landscapemetrics/reference/lsm_c_mesh.html
Further information available at	https://termeszetem.hu/hu/zoldinfrastruktura/feladatok-3 https://web.okir.hu/map/?config=TIR&lang=hu
Contact details for more information	Laszlo Kollanyi kollanyi.laszlo@uni-mate.hu Hungarian University of Agriculture and Life Sciences

Case study on spatial planning no. 3

Name of case study	**Visualization of Austrian ecological corridors in the Forest Development Plan (WEP).**
Country & Region	Austria, nationwide on the basis of forest districts
Brief description of the case	The Forest Development Plan (WEP) is the planning instrument that covers the entire federal territory and is composed of sub-plans. Therefore, the WEP as a nationwide, uniform, and comprehensive expert assessment forms a well-founded orientation on the subject of forests at the district, state and federal level and has been an important and justified basis for forestry, forest policy and planning-relevant decisions going beyond this for decades. Thus, the WEP offers the great possibility of an Austria-wide visualization of ecological corridors in an official planning document. This way, the forest development plan and the ecological corridors integrated therein will also be used for non-forest planning activities in the areas of transport, landscape development and general spatial planning. The planning results and data are, thus, used in a wide variety of ways, both in specific authority procedures and in complex planning processes.
To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	Forestry, railways, roads, motorways, agriculture, spatial planning

What were the main methods for assessing connectivity (including software)?	To implement an automated generation of the specific maps for the WEP, all the existing designations of ecological corridors in Austria had to be merged into a so-called “integral dataset for ecological corridors”. This dataset contains all official designations of ecological corridors in Austria that have been created within the framework of different public and scientific projects. For quality assurance, the selection of data sources was evaluated by experts. The data sources were then digitized on an expert basis and merged into an integral dataset regarding the habitat connectivity in Austria.
What were the target species analysed?	The designation was conducted independent of specific target species and is intended to ensure permeability for a variety of species.
Regarding the input data, what types of land use did you consider important for connectivity?	Connectivity was analysed based on the permeability of different land use and land cover. The land cover types of forest and semi-natural areas and their subtypes were considered as the most permeable habitat types.
Did you consider certain landscape features as being more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	Hedges, woodlots, isolated trees, trees in lines, trees in groups, ditches and field margins were specifically considered as stepping-stones and guiding elements in agricultural land and other man-made landscapes.
What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	The integral dataset on ecological corridors in Austria contains all the existing designations of ecological corridors within Austria. The dataset is subject to continuous updating. Thus, on the one hand, the dataset represents the reference dataset for ecological corridors in Austria, and on the other hand a dynamic overall planning basis, which has been available nationwide since 1991 and has been updated at 10-year intervals ever since. Due to the dynamics of land-use change in Austria, this is a particularly important feature. The designated corridors in the WFP are not legally binding and are primarily a basis for planning and voluntary actions.
What were the main proposals for maintaining/restoring connectivity (if it were necessary)?	The present project serves merely to visualise the Austrian ecological corridors in the forest development plan as a basis for planning and does not show a valuation of connectivity.
How do you plan to monitor the proposed measures? What are the main indicators you will use?	The integral dataset for ecological corridors of Austria is continuously updated to capture the dynamics of land use changes and to regularly review the status of ecological corridors based on permeability.
Further information available at	Project webpage https://www.waldentwicklungsplan.at/
Contact details for more information	Environment Agency Austria Gebhard Banko gebhard.banko@umweltbundesamt.at

Case study on spatial planning no. 4

Name of case study	**Biotope of selected specially protected species of large mammals in the Czech Republic**
Country & Region	Czech Republic
Brief description of the case	Landscape fragmentation in the Czech Republic is treated by GIS layer of biotope of specially protected large mammals, which was elaborated during the project: Complex Approach to the Protection of Fauna of Terrestrial Ecosystems from Landscape Fragmentation in the Czech Republic and was realised between 2015-2017. We used the results from the previous project and updated the approach for core area, especially the migration corridor´s delineation. The resulting output consists of the synthesis of inputs such as data on the occurrence of focal species (lynx, bear, and wolf moose), habitat suitability models, barrier permeability assessment and landscape connectivity analyses. The most apparent difference is that the migration corridors were designated not only as an axis (with 250 m buffer), but as a surface of suitable biotopes interlinking the core areas. The migration corridors were checked in the field. The problematic sites with identified barriers for migration (highway, high speed railway, first class roads, settlement, fences, water bodies, build up area, forest free area) were visited and possible solutions to allow the migration permeability were described. The core areas were designated as a compact territory, which hosts or has a high probability to allow long-term occurrence of large mammal populations (large carnivores – lynx, wolf, bear, as well as moose) in the future. The area must provide enough food, shelter and undisturbed space for reproduction. Those areas are covered in vast forests and other suitable biotopes such as meadows, shrubs or extensively used fields.

Results of the corridor delineation project in the Czech Republic

	This new concept is legislatively treated as a biotope of the selected specially protected species of large mammals of national importance. This tool is obliged to use in territorial planning procedures according to the Building Act (No. 183/2006 Coll.) and related Decree No. 500/2006 Coll. The Nature Conservation Agency of the CZ has the responsibility and competence to provide biotopes, or localities of the occurrence of the nationally important species for spatial planning purposes. This procedure in particular is based on Section 26 of Act No. 183/2006 Coll., on Spatial Planning and Building Regulations and Decree No. 500/2006 Coll. on Territorial Analytical Documents, Territorial Planning Documents and on the Means of Registration of Territorial Planning Activities (phenomenon number 36 in Annex 1 to this Decree). Because the phenomenon 36 (species of national importance) is in Decree No. 500/2006 Coll. defined only vaguely (by reference to Act No. 114/1992 Coll. on Nature and Landscape Protection), the NCA prepared the criteria and rules for the species selection into a category of national importance. Until now, the NCA has only put a few species into this species of national importance phenomenon (species for which there is Action plan, those species are mostly forest species or with limited occurrence in small scale protected areas). On the contrary, the species directly influenced by human activity are often not listed. Moreover, under the above mentioned category 36, a sub-category 36b biotope of selected specially protected species of large mammals (GIS layer is provided separately together with regulations to core areas, migration corridors and barrier sites) has been defined, which is also already defined in Decree No. 500/2006 Coll. The protection of biotope and necessary connectivity in the landscape is addressed through a map source (a composite GIS layer corresponding to the biotopes of these species: lynx, bear, wolf and moose), which will be in accordance with the Building Act (No. 183/2006 Coll.) and related Decree No. 500/2006 Coll. This source is provided on a regular basis as a binding material for spatial planning purposes. Together with the delimitation of this map, the limits/regulations of the use of its different parts were formulated, considering the needs of the given species and the type of environment. These regulations and conditions should then be automatically taken into account when designing territorial and regulatory plans. The principles and recommendations to the biotope are described in methodology (in Czech only): Ochrana biotopu vybraných zvláště chráněných druhů v územním plánování.
To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	Spatial planning
What were the main methods for assessing connectivity (including software)?	GIS analysis
What were the target species analysed?	Large mammals, moose
Regarding the input data, what types of land use did you consider important for connectivity?	Natural areas (particularly forested areas, meadows, shrubs)
Did you consider certain landscape features more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	Hedges, forests, meadows, shrubs.

What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	The project resulted in a connectivity map, which should be used for all spatial planning, under law, to take ecological corridors into consideration.
What were the main proposals for maintaining/restoring connectivity (if it was necessary)?	-
How do you plan to monitor the proposed measures? What are the main indicators you will use?	-
Further information available at	Project results available at https://data.nature.cz/ds/53_
Contact details for more information	Martin Strnad martin.strnad@nature.cz

8.6 Cross sectoral examples

The following case studies refer to cross sectoral approaches in ensuring the restoration or maintenance of ecological connectivity.

Case study on cross sectoral approach no. 1

Name of case study	**Wildlife protection crossing the road infrastructure**
Country & Region	Ukraine, Zakarpattya (Beregove district)
Brief description of the case	Wildlife study in the pilot area. Ascertaining of critical points for the connectivity along the existing and planned roads. The EIA training with a practical focus and an interactive approach, targeting the social actors who can have a real impact on the planning and development of an integrated and green infrastructure in the region. Stimulation of active involvement of local stakeholders in activities related to environmental impact assessment, including an assessment of the existing situation in the Zakarpattya region, design of road infrastructure, and a professional assessment of the decisions taken. Considering the measures to be taken to mitigate fragmentation and connection of ecosystems by transport infrastructure.
To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	Roads, forestry, agriculture, spatial planning
What were the main methods for assessing connectivity (including software)?	Field investigations GIS spatial modelling approaches - QGIS tools

What were the target species analysed?	Carnivore and herbivore mammals
Regarding the input data, what types of land use did you consider important for connectivity?	Forestry, transport, agricultural as well as recreational and commercial land use function may have an important influence on the connectivity.
Did you consider certain landscape features more important for connectivity than their surroundings (e.g., hedges in agricultural lands)?	Forest patches, linear structure (like bushes), afforested channels, hedges in agricultural lands
What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	Ascertaining of critical areas, preparation of possible appropriate protection measures. Maintaining the natural linear structures as the features important for connectivity. EIA training for local stakeholders and authorities for considering the measures to take in order to mitigate fragmentation and connection of ecosystems by transport infrastructure.
What were the main proposals for maintaining/restoring connectivity (if it were necessary)?	Practical solutions aimed to improve the road permeability (wildlife crossings, culverts suitable for migration of amphibians, reptiles and small and medium mammals). Investigation of species to pass the road and elaboration of corresponding management plan. To lower the maximum speed of the traffic on important sections of the roads (to 70 km/hour maximum) To put road sign 1.36 “Wild animals” in the critical area of connectivity.
How do you plan to monitor the proposed measures? What are the main indicators you will use?	Field investigations: » Field research to identify and specify migratory routes, species, time etc. » Ascertaining the road crossing points in the area and recording the animal road-kill level as the indicator of saving the possibility of migration corridors.
Further information available at	Link
Contact details for more information	Andriy-Taras Bashta, atbashta@gmail.com Taras Yamelynets, yamelynets@wwf.ua

Case study on cross sectoral approach no. 2

Name of case study	**Restoring and managing ecological corridors in mountains as the green infrastructure in the Danube basin (ConnectGREEN)** https://www.interreg-danube.eu/approved-projects/connectgreen
Country & Region	1. Piatra Craiului National Park (Romania) ; 2. Apuseni-SW Carpathians (Romania/National Park Djerdap (Serbia); 3. Western Carpathians (Czech Republic – Slovakia); 4. Bükk National Park (Hungary)/Cerová vrchovina Protected Landscape Area (Slovakia).
Brief description of the case	In order to cope with the fast and increasing habitat fragmentation in the Danube region, the ConnectGREEN project aimed to improve the ecological connectivity between natural habitats, especially between the Natura 2000 sites and other protected area categories in the Carpathian ecoregion of transnational relevance. As the first step, the project has develop a Carpathian-wide methodology and based on this, it has identified core areas and ecological corridors used by large carnivores as umbrella species. The existing tools, instruments and frameworks were explored and assessed to find ways together with spatial planners to legally and/or effectively foster the connectivity approach in practice. At the level of 4 transnationally relevant pilot sites, the ecological corridors were identified in more detail by using the above mentioned methodology. Physical barriers and other threats were identified in these areas and integrated together with other spatial data categories into the Carpathian Countries Integrated Biodiversity Information System (CCIBIS). Specific management and restoration measures were developed in a participative way with key stakeholders (conservationists, spatial planners, authorities, hunters, foresters, etc.) for safeguarding the ecological connectivity in each pilot site. The Decision Support Tool (DST), created by the spatial planners (and included in CCIBIS) will support this process by overlapping and analysing a broad range of spatial data and various individual scenarios. A Strategy has been developed based on the methodology and the project's findings as for identifying, preserving, and managing ecological corridors, while focusing on large carnivores' movement needs in the region. It will be enforced by the parties to the Carpathian Convention with the support of the relevant ASPs.
To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	Through the ConnectGREEN project, partners from different countries and various fields of activity (spatial planning, research, government, biodiversity conservation) joined forces to increase the capacity of ecological corridors identification and management and to overcome the conflict between infrastructure development and wildlife conservation. Valuable knowledge and experience was made available to spatial planners and vice versa for finding the best ways to develop infrastructure and other plans in order to secure ecological connectivity in the Carpathians. The case study is applicable for railways, roads, motorways, forestry and spatial planning sectors.

What were the main methods for assessing connectivity (including software)?	Identification of Ecological Corridors used a data driven approach and included several phases: 1 Reviewing all the existing identification methodologies In this respect the project reviewed and assessed the existing methodologies and best practices for identifying corridors and defined one harmonised methodology to be used across the region. Based on this and on the research, experience and findings of the pilot areas core areas for ecological connectivity as well as corridors have been identified in the Carpathian ecoregion through GIS modelling (large carnivores have been used as target species and their movement needs across the landscape) and integrated into the Carpathian Countries Integrated Biodiversity Information System (CCIBIS). 2. GIS database related to the identified ecological corridors at pilot sites as well as at national and Carpathian levels has been incorporated into the existing CCIBIS database. This database together with the spatial planning toolkit also developed in the project is accessible to all stakeholders dealing with ecological corridors management or spatial planning. 3. On-sites analysis – a field survey and expert verification of ecological corridors by comparing the results of the GIS modelling with the actual situation identified in the field, it helped to correct/improve/adjust the parameters of the GIS modelled maps and to better match with the reality in the field. For the field testing/verification of the ecological corridors the following methods were applied: » Visual inspection (snow tracking, mud tracking) » Visual interpretation » Field work » Aerial footage (by drone) » Camera trapping
What were the target species analysed?	Umbrella species – large carnivores. Brown bear (Ursus arctos) Wolf (Canis lupus), Lynx (Lynx lynx)
Regarding the input data, what types of land use did you consider important for connectivity?	As the input data, we considered the following types of land use: forest habitat area and stepping-stone (favourable habitat), residential areas, transport infrastructure (barriers) and species occurrence data.
Did you consider certain landscape features more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	When designing the ecological corridors for large carnivores, the most important features relate to the most favourable habitat, which is the forest. However, in many cases, ecological corridors comprise other types of habitats as well – a mosaic landscape which is important to be present in ecological corridors, (this includes forests, hedges or forested patches, and small pastures as well).

What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	Almost all the area is featured by the appearance of signs referring to the presence of large carnivores. All three large carnivore species that are present in the Carpathians, namely brown bear, grey wolf and Eurasian lynx, can be found in the pilot area in different numbers. The national and nature parks or the larger Natura 2000 sites represent the areas with the highest numbers of these species. However, the presence of the large carnivore species is more frequent in areas where traditionally they never used to be present, including near large cities like Cluj-Napoca. Human activities are widely present in the area, affecting the presence and movement of large carnivores and their prey species, ranging from cultivation of land and logging to hunting or use of 4x4 vehicles. The main anthropogenic barriers are represented by linear transport infrastructure (highways, European and national roads, and railways) and related structures (battlements), fences around properties (including electric fences). Fragmentation is growing in the area due to the rapid development of infrastructures. There are only 3 ecoducts in the pilot area (no other such ecoducts have yet been constructed in other parts of the country) dedicated to large carnivores. We detected the use of these GI structures by the target species.
What were the main proposals for maintaining/ restoring connectivity (if it were necessary)?	We provided 3 main types of recommendations » Habitat preservation/development; » Infrastructure development/modification; » Capitalization/awareness rising. The measures developed refer to three separate categories: critical connectivity sectors, critical connectivity areas and ecological corridors, as they are the most threatened in terms of landscape connectivity. The other two areas, namely, stepping stones and core areas are generally not highly threatened, and no urgent measures have been developed for them, other than the ones that are generally applicable for the corridors (this is the reason why no measures have been included for them). However, depending on future developments, targeted measures can also be assigned for these elements of the ecological network for large carnivores. There were other areas important for connectivity identified and assessed in the field during the project, which fell outside the 2nd GIS modelling (in the original modelling they were identified as relevant through the least-cost path method). They remain important from the connectivity viewpoint and the measures developed for corridors apply to these areas as well. **Infrastructure development/modification** **Critical connectivity sector** Monitor green infrastructure elements (green bridges, viaducts, tunnels, etc.) along the existing highways and major roads. Develop and implement the mitigation measures for future highways and other major infrastructure projects. Place animal crossing traffic signs on both sides along the road, ensure maintenance and install further devices to attract drivers' and animals' attention. Guarantee defragmentation (wildlife crossings) in the case of the existing major transport infrastructure intersecting key/critical ecological corridors.

	Monitor the functionality of the existing infrastructure objects/crossings (culverts, boxes, etc.). Ensure the funding to build the GI elements for maintaining/improving ecological connectivity. Implement the IENE recommendations on sustainable transport infrastructure development (minimum requirements for mitigation measures). Limit the construction of new buildings in corridor areas. **Critical connectivity area** Monitor the green infrastructure elements (green bridges, viaducts, tunnels, etc.) along the existing highways and major roads. Develop and implement mitigation measures for future highways and other major infrastructure projects. Place animal crossing traffic signs on both sides along the road, ensure maintenance and install further devices to attract drivers' and animals' attention. Guarantee defragmentation (wildlife crossings) in the case of the existing major transport infrastructure intersecting key/critical ecological corridors. Monitor the functionality of the existing infrastructure objects/crossings (culverts, boxes, etc.). Ensure funding to build the GI elements for maintaining/improving ecological connectivity. Implement the IENE recommendations on sustainable transport infrastructure development (minimum requirements for mitigation measures). Limit the construction of new buildings in corridor areas. **Migration corridor** Monitor the green infrastructure elements (green bridges, viaducts, tunnels, etc.) along the existing highways and major roads. Develop and implement mitigation measures for future highways and other major infrastructure projects. Place animal crossing traffic signs on both sides along the road, ensure maintenance and install further devices to attract drivers' and animals' attention. Guarantee defragmentation (wildlife crossings) in the case of the existing major transport infrastructure intersecting key/critical ecological corridors. Monitor the functionality of the existing infrastructure objects/crossings (culverts, boxes, etc.). Ensure funding to build the GI elements for maintaining/improving ecological connectivity. Implement the IENE recommendations on sustainable transport infrastructure development (minimum requirements for mitigation measures). Limit the construction of new buildings in corridor areas.

	Habitat preservation/development **Critical connectivity sector** Official adoption of the methodology for identifying and designation of ecological corridor/network by the MoE. Official designation of the corridors and their inclusion into spatial planning documents/plans. Developing specific management measures for every key ecological corridor during or after the official designation. National legislation should be improved and harmonised to preserve ecological connectivity. Inclusion of the ecological corridor into the management plans of PA as well of the hunting and forestry management plans. Improving the cooperation between protected areas for maintaining/improving connectivity between them (Harmonise actions between their management plans). Periodical (at least every other year) monitoring of the functionality of ecological corridors. The location of the particular ecological corridor might change due to biotic and abiotic factors (e.g. climate change, human activities, land use). Development and update of an on-line database regarding connectivity (occurrence of target species and their prey species) Creation of hedgerows in open landscapes close to favourable habitats for large carnivores. Maintenance of landscape matrix to allow the dispersal/movement of large mammals (maintain a diverse/mosaic land use). Inclusion of the presence of ecological corridors/network into EIA/SEA, pastoral studies etc. Promoting a transdisciplinary approach to connectivity conservation. Land swapping/land acquisition in corridor areas. Controlling of invasive and alien species in corridor areas, which might affect the presence and dynamics of large carnivores

	Critical connectivity area Official adoption of the methodology for identifying and designation of ecological corridor/network by the MoE. Official designation of the corridors and their inclusion into spatial planning documents/plans. Developing specific management measures for every key ecological corridor during or after the official designation. National legislation should be improved and harmonised to preserve ecological connectivity. Inclusion of ecological corridors into the management plans of PA as well as the hunting and forestry management plans. Improving the cooperation between protected areas for maintaining/improving connectivity between them (Harmonise actions between their management plans). Periodical (at least every other year) monitoring of the functionality of ecological corridors. The location of the particular ecological corridor might change due to biotic and abiotic factors (e.g. climate change, human activities, land use) Development and update of an on-line database regarding connectivity (occurrence of target species and their prey species) Creation of hedgerows in open landscapes close to favourable habitats for large carnivores. Maintenance of landscape matrix to allow the dispersal/movement of large mammals (maintain a diverse/mosaic land use) Inclusion of the presence of ecological corridors/network into EIA/SEA, pastoral studies etc. Promoting a transdisciplinary approach to connectivity conservation. Land swapping/land acquisition in corridor areas. Controlling of invasive and alien species in corridor areas, which might affect the presence and dynamics of large carnivores.

	Migration corridor Official adoption of the methodology for identifying and designation of ecological corridor/network by the MoE. Official designation of the corridors and their inclusion into spatial planning documents/plans. Developing specific management measures for every key ecological corridor during or after the official designation. National legislation should be improved and harmonised to preserve ecological connectivity. Inclusion of ecological corridors into the management plans of PA as well as the hunting and forestry management plans. Improving the cooperation between protected areas for maintaining/improving connectivity between them (Harmonise actions between their management plans). Periodical (at least every other year) monitoring of the functionality of ecological corridors. The location of the particular ecological corridor might change due to biotic and abiotic factors (e.g. climate change, human activities, land use). Development and update of an on-line database regarding connectivity (occurrence of target species and their prey species). Creation of hedgerows in open landscapes close to favourable habitats for large carnivores. Maintenance of landscape matrix to allow the dispersal/movement of large mammals (maintain a diverse/mosaic land use). Inclusion of the presence of ecological corridors/network into EIA/SEA, pastoral studies etc. Promoting a transdisciplinary approach to connectivity conservation. Land swapping/land acquisition in corridor areas. Controlling of invasive and alien species in corridor areas, which might affect the presence and dynamics of large carnivores.

	Capitalization/awareness rising **Critical connectivity sector** Boost the information exchange within the Apuseni Coexistence Platform and communication materials to be made for the general public and tourists on possible occurrence of large carnivores on the territory of protected areas (core areas), as well as outside these areas. Improve the dialogue and constant communication with stakeholders. Promote coexistence measures with large carnivores (electric fences, specialised guarding dogs etc.) Permanent communication with local communities and authorities to raise awareness on the presence of large carnivores, especially on proper behaviour in the presence of these species and continuous collection of valid information and data Information materials with “ethical codex” to be made for locals and tourists (how to behave in areas where large carnivores occur). Promote and develop the GREENweb professional platform. Engage universities, develop curricula for connectivity conservation and adjust university plans to accommodate the needs of the labour market. Improve the image of large carnivores through public campaigns (including myth busters). **Critical connectivity area** Information within the Apuseni Coexistence Platform and communication materials to be made for the general public, tourists on possible occurrence of large carnivores on the territory of protected areas (core areas) as well as outside these areas. Improve dialogue and constant communication with stakeholders Promote coexistence measures with large carnivores (electric fences, specialised guarding dogs etc.) Permanent communication with local communities and authorities to raise awareness on the presence of large carnivores, especially on proper behaviour in the presence of these species and continuous collection of valid information and data Information materials with “ethical codex” to be made for locals and tourists (how to behave in areas where large carnivores occur). Promote and develop the GREENweb professional platform. Engage universities, develop curricula for connectivity conservation and adjust university plans to accommodate the needs of the labour market. Improve the image of large carnivores through public campaigns (including myth busters).

	Migration corridor Information within the Apuseni Coexistence Platform and communication materials to be made for the general public, tourists on possible occurrence of large carnivores on the territory of protected areas (core areas) as well as outside these areas. Improve dialogue and constant communication with stakeholders. Promote coexistence measures with large carnivores (electric fences, specialised guarding dogs etc.). Encourage permanent communication with the local communities and authorities to raise awareness on the presence of large carnivores, especially on proper desired behaviour in the presence of these species and continuous collection of valid information and data. Information materials with "ethical codex" to be made for locals and tourists (how to behave in areas where large carnivores occur). Promote and develop the GREENweb professional platform. Engage universities, develop curricula for connectivity conservation and adjust university plans to accommodate the needs of the labour market. Improve the image of large carnivores through public campaigns (including myth busters).
How do you plan to monitor the proposed measures? What are the main indicators you will use?	Beyond the ConnectGreen project boundaries, WWF Romania will continue to advocate for protection of ecological corridors, listing as one of its strategic priorities ensuring the integration of requirements for ecological coherence of key large carnivore habitats into plans/policies through spatial planning mechanisms and enforcement of legislation.
Further information available at	https://www.interreg-danube.eu/approved-projects/connectgreen https://wwf.ro/ce-facem/specii/coridoare-ecologice/connectgreen/
Contact details for more information	Adrian Grancea, senior project officer, agrancea@wwf.ro, +40743775130 Ioana Ismail, project manager, iismail@wwf.ro, +40723332543

Case study on cross sectoral approach no. 3

Name of case study	**Târgu Mureş - Târgu Neamţ Ecoduct on E60 road (10 km from motorway)**
Country & Region	Romania, south of Târgu Mureş
Brief description of the case	The case relates to the EIA process for the Târgu Mureş - Târgu Neamţ motorway and the analysis of indirect impacts of a motorway. During the EIA, an analysis was done on the expected traffic level on the roads adjacent to the new motorway. It was observed that a particular European road (E60), which crosses a critical area for connectivity (as defined during the ConnectGREEN project) will remain impermeable for fauna with high levels of traffic. Therefore, the need to propose some defragmentation measures was evident in this case.

To what sector is the case study applicable (railways, roads, motorways, etc.)?	Motorways
What were the main methods for assessing connectivity (including software)?	The existing data were used, mainly the results of the ConnectGREEN project. The results regarding connectivity were confirmed by the data with long-term collar monitoring of bears in the area, which showed that the identified area is indeed used by animals for movement.
What were the target species analysed?	Brown bears
Regarding the input data, what types of land use did you consider important for connectivity?	It mainly is a forested area, but the connectivity area is dominated by pastures.
Did you consider certain landscape features more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	No
What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	The movement of the species was confirmed in the area defined as critical for connectivity. This area was at risk because of the maintenance of the high level of traffic on E60, even after the construction of the motorway. Because of this, the road represented a barrier for free movement of fauna, as well as a risk factor for animal mortality.
What were the main proposals for maintaining/restoring connectivity (if it were necessary)?	An ecoduct was proposed near a forested area, with the intention of linking two patches of forest. The ecoduct needs additional reforestation to ensure connection with natural areas (see the figure below - pink areas are proposed for reforestation).  The area for afforestation was discussed with the local authorities and a compromise was reached, which allowed for implementing the afforestation needed for connectivity, as well as maintenance of the local agricultural lands which are important for the community.

How do you plan to monitor the proposed measures? What are the main indicators you will use?	The proposed measures will be monitored during construction and operation. During operation, it is proposed to install video cameras on ecoducts in order to analyse their use. Animal tracking can also be used to monitor their usage. Local NGOs can also contribute with additional information from collared bears.
Further information available at	-
Contact details for more information	Silvia Borlea, EPC Consulting silvia.borlea@epcmediu.ro

Case study on cross sectoral approach no. 4

Name of case study	**Piatra Craiului National Park – Bucegi Natural Park Pilot Area**
Country & Region	Romania – Southern Carpathians; counties: Arges, Brasov, Dambovita, Prahova
Brief description of the case	The overarching purpose of the work undertaken in this region is to maintain and enhance ecological connectivity between natural habitats found in these two protected areas of national and community importance. Furthermore, specific objectives included: developing innovative solutions and recommendations to guide the identification of ecological corridors and permeability areas that facilitate the movement of large carnivore and their prey species within the landscape, and ultimately, to enhance ecosystem services and biodiversity; involving protected area managers, conservationists, spatial planners and other key stakeholders in an integrated approach to strengthen their capacity to identify and manage ecological corridors; and reconciling nature conservation, spatial planning and development by contributing to strategic documents and tools for practical implementation. Building on previous projects and extant data, a complex programme of fieldwork and desk-based activities was carried out in order to identify and map suitable habitats for the target species (large carnivores – brown bear, wolf and Eurasian lynx), including core areas, buffer zones, ecological corridors and critical areas for connectivity, and to develop management measures for conflict mitigation and the maintenance of landscape permeability. The results were finalised following a series of consultations with the representatives of local communities and authorities, scientists and other key stakeholders, recognising the fact that collectively defined measures based on a common recognition of the value of ecological connectivity carry the potential for sustainable and long-term solutions.
To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	Spatial planning, transport infrastructure (roads), agriculture, forestry

What were the main methods for assessing connectivity (including software)?	Structural and functional connectivity for large carnivores was assessed by means of fieldwork and spatial analyses conducted in the ArcGIS software. Two main data collection methods were employed in order to identify core areas and ecological corridors and the target species presence, distribution and abundance: 1. capture-mark-resight with the help of motion sensor cameras; and 2. track and sign surveys (including snow-tracking). Combined data for all species allowed the identification of core and corridor areas and demonstrated their use by the target species. The results indicated the presence of seven core areas that are linked by means of three corridors. Furthermore, spatial analyses were conducted to assess potential risks to permeability in the area and identify critical areas within the corridors. All barriers that could pose a risk to wildlife movement along the corridors were considered. Data from Corine Land Cover CLC 2018 were used to evaluate areas that could contribute to or hinder wildlife movement. In potentially critical spots, the data were supplemented with photos taken with the help of drones equipped with cameras. In addition, the presence of barriers alongside public roads was analysed with the help of Street View on Google Maps, followed by ground validation. Together, these combined methods led to the identification of several barriers: residential fences, electric fences used for livestock protection and safety railings found alongside roads. A barrier risk scale was developed (based on the information collected through the fence inventory form method) ranging from low to high. The spatial analyses resulted in the identification of four critical areas. One of these areas was further used to test the decision-support tool that was developed. The results were combined with the information included in the General Urban Development Plan (PUG) in order to identify the areas of overlap. The results showed that potentially permeable areas are shrinking. They have been included in the PUG and could be developed unless the plans are changed to include the ecological corridors as areas excluded from development.
What were the target species analysed?	*Ursus arctos, Canis lupus, Lynx lynx*
Regarding the input data, what types of land use did you consider important for connectivity?	Land use categories that facilitate connectivity include low intensity forestry, agriculture (pastureland) and water courses. Connectivity is hampered by urban or built-up land, transport networks, intensive forestry and agriculture, including the fencing of properties that act as barriers to dispersal.
Did you consider certain landscape features more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	Natural forests and forest buffers along water courses, shrubs and natural areas without settlements and with no permanent anthropic pressures.
What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	The complex, combined analysis of field and desktop - based data resulted in the identification of three corridors that facilitate the movement of target species between the two protected areas included in this case study. Along these corridors, four critical areas for landscape permeability were also identified. The study revealed that the rapid development of human settlements in the area poses a real risk and has the potential to become a barrier to connectivity in the region. Therefore, a practical implementation of the results (decision – support tool and management measures) is both important and urgent.

What were the main proposals for maintaining/restoring connectivity (if it were necessary)?	» Legal designation of the identified ecological corridors to ensure viable populations of large carnivores in the Carpathian Mountains and the survival of one of the largest functional ecosystems on the continent. » Infrastructure development/improvement by means of: » Maintenance of small, narrow corridors alongside roads » Setting speed limits in the corridor area and installing traffic signs (animal crossing) to warn drivers of the presence of wildlife and the potential risk of collision. » Habitat conservation: » Exclusion of ecological corridors from development (urban/industrial/ infrastructure) » Protection of green corridors along water courses. » Capitalization/awareness raising: » Implementation of measures to mitigate conflicts between humans and large carnivores (improved garbage management, installing bear-proof containers, using electrical fences, solving the problem of habituated bears, awareness raising activities in local communities on the importance of ecological connectivity.
How do you plan to monitor the proposed measures? What are the main indicators you will use?	The following activities will be undertaken: » Monitoring of core and corridor area use by the target species through motion sensor camera trapping and snow tracking surveys – indicator: species presence and abundance. » Monitoring of human-large carnivore conflicts (including traffic collisions) – indicator: number of conflicts. In addition, all efforts will be undertaken to contribute to changing legislation, to enable the legal designation of the identified ecological corridors and safeguard the connectivity in the region and country-wide.
Further information available at	https://www.pcrai.ro/proiect-connectgreen
Contact details for more information	office@pcrai.ro

Case study on cross sectoral approach no. 5

Name of case study	**Interreg SaveGREEN pilot area Pöttsching located along the Alpine-Carpathian corridor**
Country & Region	Austria, border region Lower Austria-Burgenland, open landscape between Pöttsching and Müllendorf
Brief description of the case	The pilot area Pöttsching represents a bottleneck in the true sense of the word, constituting a larger openland area between the woodland dominated Leitha Mountains in the north and the Rosalia Mountains in the south. These ranges are offshoots of the Alps and form the most important connection to the Carpathians. The studied bottleneck is, therefore, of particular importance for wildlife migration and is highly sensitive due to intensive agricultural use, the proximity to the growing metropolitan areas of Wiener Neustadt, Eisenstadt as well as Mattersburg, and in addition to the presence of highway A3 and the expressways S4 as well as S31. Based on the relevant geodata sets, the structural connectivity for corridor bridging the present bottleneck was assessed by using GIS techniques. The identified crucial areas were subsequently monitored by collecting field survey data to evaluating the functional connectivity. Thereby, SaveGREEN aimed to contribute to improvements in both of these aspects of ecological connectivity in bottleneck areas by adapting land use and management in the surroundings, involving stakeholders from different fields of experience.
To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	Roads, motorways, forestry, agriculture, spatial planning
What were the main methods for assessing connectivity (including software)?	The underlying method for the evaluation of structural connectivity was based on the designation of ecological corridors and classification of the permeability of segments within the ecological corridors. By using the geographic information system software QGIS, suitable input data were processed. A customised model framework and the add-ons Linkage Mapper as well as Pinchpoint Mapper provided the technical implementation. The validation of these modelling results was ensured in the field by various monitoring methods, e.g. camera traps, direct species observation or the mapping of animal tracks.
What were the target species analysed?	For the pilot area of Pöttsching, the two large herbivores red deer and wild boar served as target species, due to their regional importance and migration behaviour.
Regarding the input data, what types of land use did you consider important for connectivity?	Connectivity was analysed based on the EUNIS habitat types. The groups of Woodland, forest and other wooded land (G), Grassland and lands dominated by forbs, mosses or lichens (E), Mires, bogs and fens (D) and their subtypes were considered as the most permeable habitat types.

Did you consider certain landscape features more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	Hedges, isolated trees, trees in lines, trees in groups, ditches and field margins were specifically considered as stepping-stones and guiding elements.
What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	Even the best data-based modelling results require validation using real-world data obtained in the field. The green bridges studied are located at suitable sites in the bottleneck area and they clearly have structural and functional connectivity to support animal migration. However, the surrounding landscape, which integrates the bridges into a larger biotope network or corridor in the first place, does not support the structural and functional connectivity or even has a barrier effect, especially for the two forest-bound target species wild boar and red deer. In addition, the most advanced green bridges in the ideal locations need a well-structured environment with landscape elements as guiding features and stepping stones to support animal migration. However, to be successful, local stakeholders need to be informed and involved, and organised during the project implementation, for their buy-in and support-realising ecological connectivity. Much more time would be needed to get a broader consensus of the importance of ecological connectivity and its conservation.
What were the main proposals for maintaining/restoring connectivity (if it were necessary)?	To integrate the green bridges into the ecological network, targeted restoration of degraded landscapes over the entire bottleneck situation and especially in the feeder areas of green bridges is urgently needed.
How do you plan to monitor the proposed measures? What are the main indicators you will use?	This work can be used as a reference and suggestion for similar situations and problem dealing with bottleneck areas for the management and planning of wildlife corridors.
Further information available at	Project webpage https://www.interreg-danube.eu/SaveGREEN
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Case study on cross sectoral approach no. 6

Name of case study	**Interreg SaveGREEN pilot area Kobernausser forest at the foot of the Alps**
Country & Region	Austria, Upper Austrian Hausruck Quarter, a low mountain range of hills
Brief description of the case	The pilot area of Kobernausser forest and the specifically considered municipality of Aistersheim lies in the middle of a wildlife migration corridor of international importance, connecting theKobernausser forest with Bavaria and Czechia. The A8 highway runs along the outskirts of the village and represents a major barrier for wildlife, which is why authorities have decided to build agreen bridge in the greater area of the municipality. Thus, the project should also help validate ideal locations for such a newly constructed green bridge, taking into account the surrounding landscape and its features. The studied bottleneck is, therefore, of particular importance for wildlife migration and is highly sensitive due to intensive agricultural use, the proximity to the growing metropolitan areas of Wels and Ried im Innkreis and in addition to the presence of the highway A8 as well as the federal roads B135 and B141, representing important and heavily frequented feeder roads. Based on the relevant geodata sets, the structural connectivity for corridors bridging the present bottleneck was assessed by using the GIS techniques. The identified crucial areas were subsequently monitored by collecting field survey data to evaluate the functional connectivity. Thereby, SaveGREEN aimed to contribute to improvements in both of these aspects of ecological connectivity in bottleneck areas by adapting land use and management in the surroundings, involving stakeholders from different fields of experience.
To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	roads, motorways, forestry, agriculture, spatial planning
What were the main methods for assessing connectivity (including software)?	The underlying method for the evaluation of structural connectivity was based on the designation of ecological corridors and classification of the permeability of segments within the ecological corridors. By using the geographic information system software QGIS, suitable input data were processed. A customised model framework and the add-ons Linkage Mapper as well as Pinchpoint Mapper provided the technical implementation. The validation of these modelling results was ensured in the field by various monitoring methods, e.g. camera traps, direct species observation or the mapping of animal tracks.
What were the target species analysed?	For the pilot area of Kobernausser forest, the two large herbivores red deer and wild boar served as target species, due to their regional importance and migration behaviour.
Regarding the input data, what types of land use did you consider important for connectivity?	Connectivity was analysed based on the EUNIS habitat types. The groups of Woodland, forest and other wooded land (G), Grassland and lands dominated by forbes, mosses or lichens (E), Mires, bogs and fens (D) and their subtypes were considered as the most permeable habitat types.

Did you consider certain landscape features more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	Hedges, isolated trees, trees in lines, trees in groups, ditches and field margins were specifically considered as stepping-stones and guiding elements.
What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	In the pilot region, the A8 autobahn can currently only be crossed via several, rather narrow underpasses; individual smaller bridges for road traffic are of little significance. The underpasses studied are located at suitable sites in the bottleneck area and they clearly have structural and functional connectivity to support animal migration. However, with not a single recorded crossing, the existing underpasses do not support the migration of the target species red deer and wild boar. The implementation of an appropriately designed green bridge in the immediate vicinity can therefore be clearly underlined, in accordance with the results of the previous studies. Another finding was that even the best data-based modelling results require validation using real-world data obtained in the field. However, to be successful, local stakeholders need to be informed and involved, and organised during the project implementation, for their buy-in and support realising ecological connectivity. Much more time would be needed to get a broader consensus of the importance of ecological connectivity and its conservation.
What were the main proposals for maintaining/restoring connectivity (if it were necessary)?	To allow migration of target species, the existing very narrow underpasses, which were designed for human use and are frequented accordingly, are not sufficient. The construction of a green bridge integrated into the landscape is, therefore, urgently required. Their embedding in the existing and ideally enhanced landscape structures must go hand in hand with the erection in order to make the structure also accessible and usable for wildlife.
How do you plan to monitor the proposed measures? What are the main indicators you will use?	This work can be used as a reference and suggestion for similar situations and problems dealing with bottleneck areas for the management and planning of wildlife corridors and green bridges.
Further information available at	Project webpage https://www.interreg-danube.eu/SaveGREEN
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Case study on cross sectoral approach no. 7

Name of case study	**Cross-sectoral operational program in the region of the planned M2 motorway**
Country & Region	Hungary, Northern-Hungarian Region
Brief description of the case	We carried out a complex, landscape level analysis of the study area. We elaborated a general cross-sectoral analysis and exploration of land-use conflicts.
To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	Infrastructure planning, roads, agriculture, water management, and spatial planning in particular
What were the main methods for assessing connectivity (including software)?	We identified the "target" animal groups and species occurring in the area, which is a total of 13 animal species. Then we defined their needs according to the six given criteria, such as their demand for vegetation or how well they tolerate disturbance. Following that, we examined the properties of ecological corridors. The following 6 aspects were identified: corridor length, width, vegetation, water presence, continuity, and surrounding land use or confusion. We compared these values with the needs of animals and examined how suitable a particular property of a corridor is for different animal species.
What were the target species analysed?	Wildlife, from fish, amphibian species to large mammals
Regarding the input data, what types of land use did you consider important for connectivity?	All kinds of natural and semi natural land use forms, from forests to grassland. The complex system of green infrastructure including core habitats and ecological corridors which is cut through by the planned motorway (red line, blue are the bridges)
Did you consider certain landscape features more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	We carried out a focused assessment regarding watercourses, which serve as ecological corridors and the planned motorway is going across them. In the following we highlighted the critical sections. The most important critical sections of the planned M2 are the crossing zones of the above mentioned watercourses. Later, we gave recommendations to mitigate the barrier effect of the planned motorway, and on a higher scale we formed proposals to improve the landscape connectivity and general ecological conditions.
What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	The main outcome was a complex, cross-sectoral analysis and collection of proposals. The most important critical sections of the planned M2 are the crossing zones of the watercourses which are the backbone of the ecological network of the region and provide a corridor between the core habitats of the Ipoly valley and vast forests of Börzsöny. The most sensitive section is where the planned motorway crosses the natural habitats of the Ipoly valley, which belong to the Natura 2000 areas as well, where a landscape bridge would be necessary. The most critical section is the crossing of the Natura 2000 areas of the Ipoly valley.

What were the main proposals for maintaining/restoring connectivity (if it were necessary)?	The Logframe gives an overview of the major conflicts and objectives related to the barrier effect of the new and existing infrastructure lines, including the changes in land management. The Logframe provides the country specific suggestions for the mitigation of negative effects.
How do you plan to monitor the proposed measures? What are the main indicators you will use?	Monitoring of fish and amphibian species and mammals is planned. Focused attention is necessary on the amphibian species.
Further information available at	https://www.interreg-danube.eu/approved-projects/savegreen
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Case study on cross sectoral approach no. 8

Name of case study	**Pilot area work during SaveGREEN**
Country & Region	CZ-SK PA: Beskydy-Kysuce
Brief description of the case	Local activities consisted of a robust monitoring of connectivity (mainly with respect to large mammals), mapping the situation in bottlenecks in Bílé & Biele Karpaty, monitoring and intervening in SEA & EIA procedures and of the activities of the local working group including developing the local CSOP.
To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	Transport infrastructure (existing and new), spatial planning, agriculture, hunting.
What were the main methods for assessing connectivity (including software)?	Field work, camera traps, telemetry, mapping of bottleneck areas.
What were the target species analysed?	Large carnivores; other species were also monitored using camera traps & reflected in proposed measures in CSOP.
Regarding the input data, what types of land use did you consider important for connectivity?	Dispersal of target species occurs mainly via forested areas and through vegetated patches within the cultural landscape.
Did you consider certain landscape features more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	---
What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	Only the last remaining migration corridors are still functional. To preserve the ability of large carnivores to migrate within and between individual core areas, specific measures were proposed in the CSOP. It is crucial to implement the solutions and enhance legal protection of the existing migration corridors.

What were the main proposals for maintaining/restoring connectivity (if it were necessary)?	To ensure that investors respect the existing corridors for large mammals. In the case of linear infrastructure, the existing methodology for measures developed by NCA must be followed. The authorities must request the evaluation of permeability of all planned projects according to binding guidelines (often not the case nowadays) and request the implementation of measures recommended by migration studies.
How do you plan to monitor the proposed measures? What are the main indicators you will use?	FoE CZ will keep the results of the project including the CSOP, together with other members of the local working group, as was agreed during the latter meeting of the group. FoE CZ will also continue monitoring the linear infrastructure and other projects. However, a systematic way of ensuring and monitoring landscape connectivity independent of the NGO sector also needs to be set up.
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Case study on cross sectoral approach no. 9

Name of case study	**Protecting wildlife that cross road infrastructure (Latorytsia river valley)**
Country & Region	Ukraine, Zakarpattia region
Brief description of the case	A wildlife study was conducted in the Zarkapattia pilot area of the EU Interreg project SaveGREEN, looking specifically at the road along the Latorytsia river. It included a survey and evaluation of the bridges and underpasses used by wildlife regarding the degree to which they offer safe passage in the critical connectivity points along the existing E50 motorway. Furthermore, an EIA training was conducted with a practical focus and an interactive approach, targeting those stakeholders who can have a direct impact on the planning and development of integrated green infrastructure in the region. Alongside this training, the local stakeholders were encouraged to become involved in environmental impact assessments, particularly the assessment of the existing situation in the Zakarpattia region, the design of road infrastructure, and professional assessments of the decisions taken. The training promoted measures to mitigate fragmentation and improve connectivity between ecosystems when constructing new transport infrastructure.
To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	Roads, motorways, forestry, spatial planning

What were the main methods for assessing connectivity (including software)?	Monitoring of key sections in-situ (by SaveGREEN expert): visual observation, searching for signs of wildlife (tracks etc.), use of camera-traps Software: QField
What were the target species analysed?	All occurring mammal species with special attention accorded to the following carnivores (brown bear, lynx, wolf, red fox, wildcat, otter, mustelids) and the following herbivores (red deer, roe deer, wild boar).
Regarding the input data, what types of land use did you consider important for connectivity?	Forestry, transport as well as recreational and commercial land use may have an important influence on the ecological connectivity in this area.
Did you consider certain landscape features more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	Forest patches, trees, and bushes in the area and in the vicinity of monitoring points, as well as the presence of a bank under the extreme sections of the bridges, which offer animals an opportunity to pass.
What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	» Identifying the most important underpasses for crossing the critical areas of road, and elaborating appropriate protection and mitigation measures. Maintaining and preserving the inviolability (prohibition of use and transformation, including for recreational purposes) of areas in the vicinity of bridges. » EIA training for local stakeholders and authorities on measures to mitigate fragmentation and improve connectivity between ecosystems when constructing new transport infrastructure.
What were the main proposals for maintaining/restoring connectivity (if it were necessary)?	Identification of bridges that serve as important underpasses for animals, analysis of their functionality, assessment of threats and opportunities to optimize and elaborate a corresponding management plan. One suggested measure was the erection of the road sign 1.36 “Wild animals” in the critical areas of connectivity.
How do you plan to monitor the proposed measures? What are the main indicators you will use?	Field investigations: » Field research to identify occurring wildlife species, crossing periods and intensity of crossing-activity, etc. » Monitoring of underpasses to prevent any possible negative alteration to their current state (habitat transformation, creation of any infrastructure objects, etc.).
Further information available at	www.interreg-danube.eu/savegreen
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Case study on cross sectoral approach no. 10

Name of case study	**Reducing the risk of wildlife collisions on roads**
Country & Region	Slovakia/Novohrad pilot area

Brief description of the case

One of the important biocorridors identified in the pilot Novograt region is located near the Ľuboreč municipality. It is a stretch of forested land crossected by a relatively frequented first-class road. The wolf (Canis lupus) is one of the species registered by phototrap monitoring in this biocorridor.

At a stakeholder meeting with the Slovak Road Administration (Slovenská správa ciest, SSC), WWF Slovakia learned that the SSC is, in cases when the roads are reconstructed, installing new roadside reflector posts equipped also with the warning reflectors for wildlife. The SSC is responsible for maintenance of the first-class roads in Slovakia, i.e. also for the road crossecting the biocorridor. This was important information as the old first-class roadside post are only equipped with reflectors for drivers.

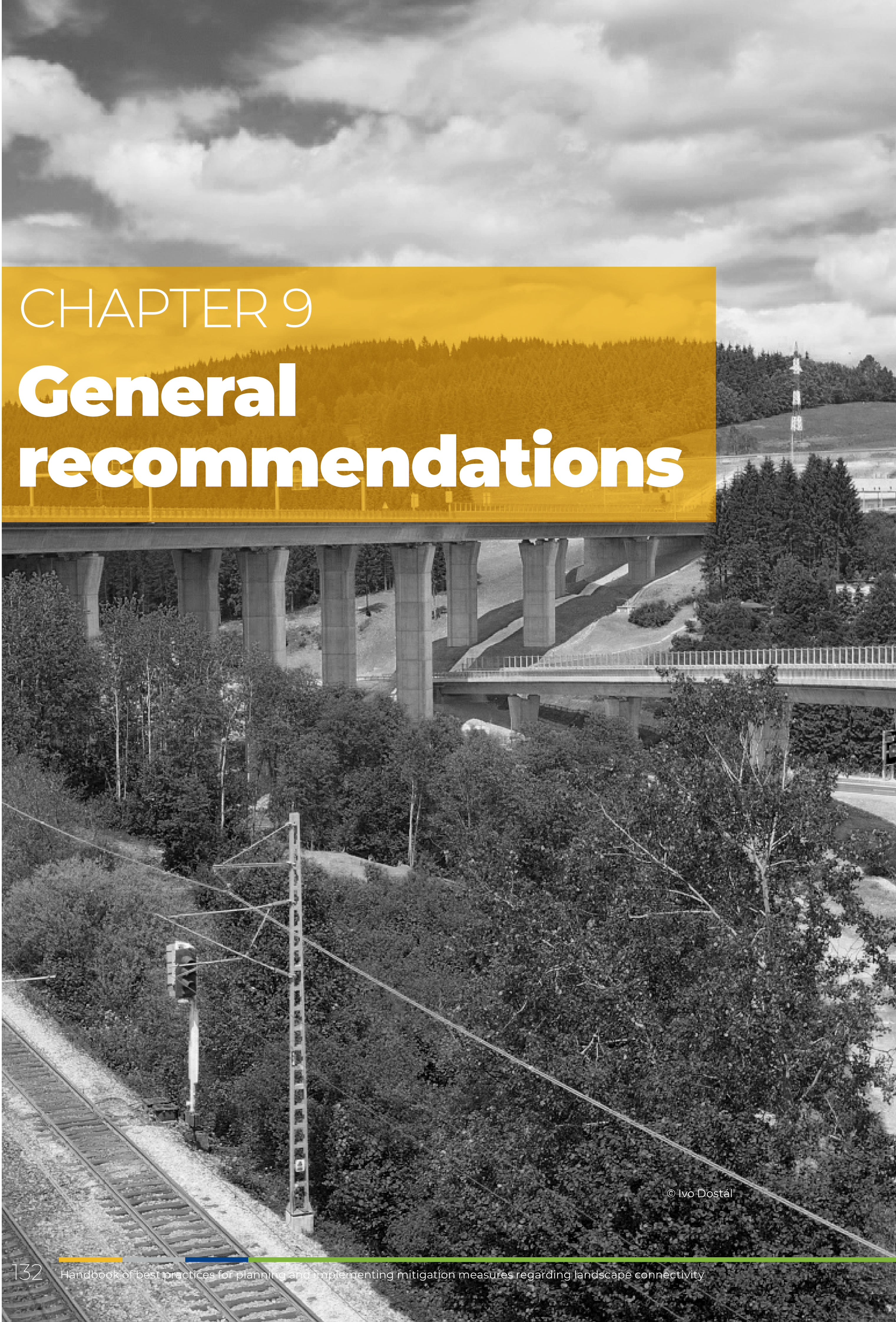
As a result of the discussion, the WWF SK and the SSC agreed that if the WWF SK will deliver the SSC a supply of warning reflectors for wildlife, they will install them on roadside posts in a territory in question. The WWF SK afterwards selected a critical approximately 2 km-long road section transecting the biocorridor near Ľuboreč and delivered the map data to the SSC.

Another important element of this case is a cooperation of the WWF SK with a private company. In a project the company supported, the WWF SK also planned to safeguard connectivity by suitable technical measures. As a result, 600 reflectors warning of wildlife presence (a product tested for this purpose) could be purchased. About 200 of them will be used in the biocorridor near the Ľuboreč municipality.

Reflectors warning of wildlife presence divert the beam of the headlights specifically into the terrain.

To what sector is the case study applicable (railways, roads, motorways, forestry, agriculture, spatial planning etc.)?	Roads
What were the main methods for assessing connectivity (including software)?	Monitoring of biocorridors using phototraps
What were the target species analysed?	Large mammals generally
Regarding the input data, what types of land use did you consider important for connectivity?	Forested land and roads
Did you consider certain landscape features more important for connectivity than their surroundings (e.g. hedges in agricultural lands)?	No
What were the main conclusions of the project in regards to landscape level connectivity, the studied infrastructure and the target species?	Reflectors warning of wildlife presence, if proved effective, can also be used in other critical road sections.
What were the main proposals for maintaining/restoring connectivity (if it was necessary)?	Reflectors warning of wildlife presence will be installed on the roadside posts on the road crossing the selected biocorridor.
How do you plan to monitor the proposed measures? What are the main indicators you will use?	Phototrap monitoring, evaluation of the data on wildlife collisions in the biocorridor.
Further information available at	NA
Contact details for more information	ruhrinova@wwfsk.org

CHAPTER 9
General recommendations



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9.1 Transport sector

Planning related recommendations

The main initial phases of transport infrastructure planning and processes as part of the overall life cycle of a linear transport project and in order to ensure the protection of fauna and ecological connectivity are the scoping, the planning and the designing (Hlavac et al., 2019) in which:

1. In the scoping phase in transport policies, an analysis of the regional conflicts with the protected areas and the main migration corridors are the key topics in every SEA process.

2. In the phase between scoping and planning in the SEA process, key topics are the delimitation and survey of a wider transport corridor, the selection of the basic conflicts with protected areas, and the main migration corridors and starting of a biological survey.

3. In the planning phase, the EIA process starts with a route selection, and the key topics are the assessment of proposed variants, the basic proposal for placement and type of the fauna passages, with a detailed biological survey and a start of the monitoring programme.

4. In the phase of designing and in the EIA process, the key topics are solving the details in placement of fauna passages, the technical parameters, the surfaces of bridges and areas under them and the connection to the surroundings in the means of spatial protection of migration corridors and the documentation for building permit.

These main steps can be visualised in the following figure, which shows an overview of the basic phases, corresponding processes and recommended tools for transport infrastructure projects.

	Phase	Key topics	Processes	Tools
SCOPING	Transport policies	Transport concepts, analysis of the above-regional conflicts with protected areas and main migration corridors	SEA	Strategic migration study, map of protected areas, Natura 2000 (Special Protection Areas, Sites of Community Importance, Natura 2000 habitats), core areas and main migration corridors for target species, important and protected Species Action Plans and their distribution, etc. (T1)
SCOPING / PLANNING	Delimiting a transport corridor	Delimiting and survey of a wider transport corridor, selecting basic conflicts with protected areas and main migration corridors, starting a biological survey	SEA	
PLANNING	Route selection	Assessment of proposed variants, basic proposal for placement and type of fauna passages, detailed biological survey, monitoring program	EIA	Biological survey (T2) Framework migration study (T3)
DESIGNING	Detailed project	Solving details in placement of fauna passages, technical parameters, surfaces of bridges and areas under them, connection to the surroundings, means of spatial protection of migration corridors	EIA Planning proceedings Building permit	Monitoring program (T4) Detailed migration study (T5) Incorporation of migration corridor(s) near fauna passage(s) into spatial plan (T6) Monitoring before construction (T4) Plan to protect biota during construction (T7)
CONSTRUCTION	Construction	Minimizing impacts on natural habitats, prevention of animals entering the construction site, building time schedule, protecting surrounding habitats of fauna from contamination and disturbance	Ecological construction supervision Final inspection	Ecological supervision (T8) Monitoring during construction (T4)
OPERATION	Operation and maintenance	Assessing the effects of infrastructure operation and maintenance on fauna, functionality of mitigation measures (underpasses, overpasses), contamination and disturbance on habitats of fauna, animal mortality		Monitoring after construction, monitoring the impacts of operation (including maintenance) on fauna (T4) Post-project analysis (T9)

Figure 2 The main stages in transport infrastructure development, from an environmental protection standpoint (© Hlavac et al., 2019).

The basic premise of sustainable strategic planning of major linear infrastructure projects is to follow the Mitigation Hierarchy of priorities **Avoiding - Mitigation – Compensation** to resolve conflicts between green and transport infrastructure (Georgiadis, 2020). Following this hierarchy when planning new infrastructure is also a prerequisite for adhering to the DNSH (do not significantly harm) principles in line with EU requirements (EU, 2021), in the field of protection and restoration of biodiversity and ecosystems not to be significantly detrimental to the good condition and resilience of ecosystems, or detrimental to the conservation status of habitats and species, including those of the EU interest.

The EIA process is the utmost tool for this phase. It is desirable to start this process as early as possible in the planning phase, ideally at the stage of evaluating possible route options, which has the advantage of allowing the most environmentally friendly option to choose and requests for fundamental modifications to the technical design of the project to make. This can often help to avoid the necessity to implement costly mitigation measures.

The mutual **cooperation between transport and other sectors** across the planning process is essential to harmonise green and linear infrastructure, especially from a landscape perspective. Weak planning can hamper efforts to ensure the permeability of a linear construction. It is not useful to build an ecoduct as a mitigation measure for a motorway, for instance, if agriculture field owners/waterbody management/ municipalities/forestry management will not contribute to the improvement of habitats on either side of the ecoduct (see example below).

The construction of new infrastructure in order to replace or complement an old one (such as the development of a motorway in an area where only national roads exist), can even have a positive impact on connectivity if it is consciously designed to meet the needs of wildlife permeability and contributes to reducing the barrier effect of the original road (e.g. redirecting traffic) which was projected without any consideration of landscape or habitats. Necessary complementary components of the roads/railway may be also important for preserving the biodiversity, when verges often act as the last remnants of green infrastructure in intensively used agricultural landscapes providing a habitat for invertebrates (Knapp et al., 2013; Hula, 2020), or road water treatment and drainage facilities can be used as refugia for various amphibian species (Jumeau et al., 2020).

For **upgrading the projects** where environmental connectivity was not considered in the preparation of the original road/rail project, current standards and recommendations must be taken into account in an overall defragmentation approach. Modernisation is then an excellent opportunity to improve the wildlife permeability of the infrastructure according to current requirements.

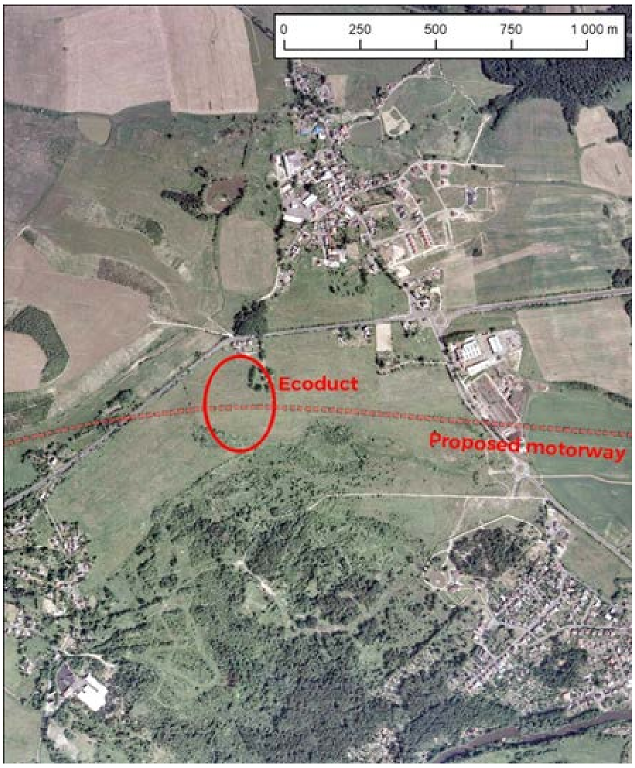
The complicated orography of the Carpathian region predetermined the routes for transport networks. Their directions follow the deep narrow valleys of main rivers embedded in mountain ranges. This often leads to a situation where there is a doubling of linear infrastructure, with a **new road or railway being built in parallel with the existing linear infrastructure.** The cumulative impact of this parallel system of infrastructure upon ecological connectivity then needs to be examined while estimating the overall complex needs for connectivity and comprehensive measures need to be put in place to mitigate or offset these impacts. As parallel routing of transport infrastructure does always significantly degrade the permeability of an area for fauna, the construction of new infrastructure may require measures to be implemented on the original road/ railway as well. In particular, migration profiles through river valleys in which anthropogenic barriers accumulate often demand a comprehensive barrier assessment with the inclusion of barriers in the form of engineered watercourses or expanding human settlements (Hlavac et al., 2019).

Ecoduct in Jenišov

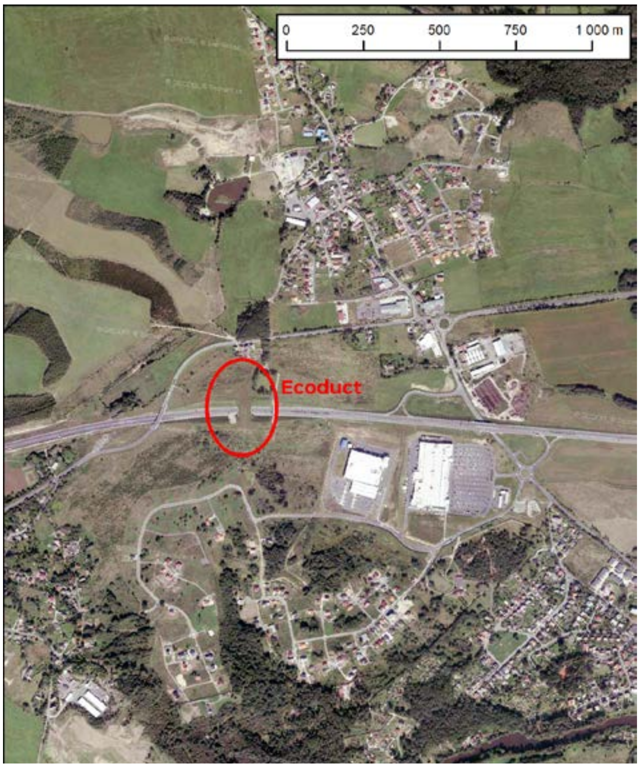
The next example illustrates the importance of spatial planning in protecting the functionality of the mitigation facility - the constructed ecoduct on the D6 motorway in the westernmost part of the Czech Republic. Within the EIA process, an important migration corridor was identified there, and thus, a green bridge was proposed on the planned motorway (see the left picture with the situation in 2003). However, between the approval of the construction and the start of the implementation, the municipality changed its spatial plan and the area south of the planned green bridge was designated for a hypermarket and residential housing development. In the right picture from year 2012, we can already see the completed motorway with the finished green bridge, but also the built-up area south of the highway, which completely closes off the access to the green bridge. The funds spent on the construction of this green bridge were completely wasted in this case, and even the migration corridor was irreversibly interrupted at the site.

Management related recommendations (during operation)

Although a good linear infrastructure planning process can avoid many of the negative impacts on connectivity that are caused by the function of the road/rail as a physical barrier, it is equally important to focus on connectivity issues in the management of the road during its **period of operation**. This is of even greater importance since such an operational phase of roads' life cycle can even take decades. During this period, the road/railway not only becomes a physical barrier, but also **a dynamic one**. Vehicle traffic that generates noise, light interference or chemical pollution acts as a psychological barrier for animals. Last but not least, it creates a high risk of vehicle-wildlife collision and mortality. In addition to the above impacts, **secondary effects** may also occur during the operation of the road, especially long-term land-use changes in the surrounding area due to improved accessibility. Keeping these pressures in rein is a challenge for spatial planning.



a) situation in 2003



b) situation in 2012

Within the system of management and maintenance of the road/railway, it is necessary to consider the following actions:

- continuously maintain all mitigation measures (underpasses, overpasses, fencing) and immediately eliminate discovered problems;
- Prohibit hunting close to mitigation measures;
- set up regular management of vegetation in the right-of-way;
- detect and actively remove invasive species;
- monitor animal mortality along all linear infrastructures (including overground power lines) and take appropriate measures to reduce it;
- develop an integrated monitoring programme – procedures, database, indicators, assessment – for the assessment of the impact of operation and maintenance on flora and fauna;
- monitor the chemical contamination of environment;
- conduct a post-project analysis approximately 3-5 years after the infrastructure is put into operation (see recommendations for monitoring for more info).

Monitoring related recommendations

Monitoring is one of the most important activities during the **whole life cycle of a road/railway**; therefore, some recommendations are already mentioned in the previous chapters. Its main objective is **to obtain unbiased information** about the different species along the infrastructure and the impacts of the infrastructure upon them. It can provide us with the information on the reality of animal mortality along the infrastructure, the impacts of the barrier effect on populations and the effects of disturbances on target species (Hlavac et al., 2019).

Measurements and monitoring procedures **should be standardised** so that comparisons can be made across periods and projects. Monitoring of the biota in the area of interest should be carried out in the periods **before** (min. two years) and **during construction** and, last but not least, during the **operational period** (for at least two years in detail, and in general periodically all the time).

An important tool that will contribute to evaluating the impact of the road/railway is the **Post Project Analysis**. The document should be prepared at least 3 to 5 years after the construction has been commissioned. Its aim is to summarise in one comprehensive document **the basic experience with the construction and operation** of a given section of infrastructure in relation to protecting of the fauna, flora and landscape connectivity. This document should reveal shortcomings in the implementation of the conditions set by the state authorities for the project implementation as well as evaluate the real functionality of the measures that have been implemented, such as the replacement habitats for amphibians or the use of ecoducts for migration. If necessary, additional measures may be proposed to improve the existing situation. It is also a valuable feedback for the development of future measures. The analysis should address the following areas of concern:

- compliance with and fulfilment of the requirements set out in the decisions of the state authorities during the planning process
- impact on the general connectivity of the landscape - changes in migration corridors
- changes in the surrounding habitats - changes in land use; ensuring the permeability of the wildlife crossings and landscape connectivity along the migration profiles
- long-term impact on populations of the selected species

- contamination and disturbance of the surrounding environment - changes in concentrations of indicator substances in soils, biota and water; impact of noise and light pollution; regulation of hunting within the proximity of the mitigation measures;

- lessons learned - results of monitoring of the functionality of individual measures, maintenance experience and feedback for future projects

- a monitoring plan for the next period

Policy related recommendations
The issue of permeability of the landscape and its fragmentation is often narrowed down to the construction of ecoducts or other technical solutions. Partial technical solutions are important on a local scale, but from a systemic viewpoint they are mostly insufficient. Therefore, it is necessary to include in strategic and policy documents a set of fundamental steps to reduce the primary sources of fragmentation, at the level of developing the residential and transport infrastructure, while considering the mutual relationship between the construction of new sections of transport infrastructure and the solution of the traffic situation of the surrounding area. A conceptual approach must cover not only all sources of fragmentation, but also all groups of animals negatively affected by fragmentation, including humans themselves. A structural solution requires the cooperation of other ministries, such as the Ministry for Regional Development, the Ministry of the Environment, the Ministry of Agriculture or the Ministry of Health.

However, from the viewpoint of practical application, the hierarchical levels of authority must be respected:

a) national – a basis for national concepts and policies and for international comparison, recognizing the process of strategic environmental impact assessment (SEA);

b) regional – a focus on the preparation and negotiation of land-use plans (territorial development) of large territorial units, including strategic environmental impact assessments (SEA);

c) local – the basic use is within the framework of local policies and land-use plans of individual municipalities.

9.2 Agriculture sector

Planning related recommendations
Conversion of natural ecosystems for human land uses leads to fragmentation, loss of habitats and restriction of species movement.

Regarding agriculture, the following general recommendations for planning have been identified as good practices for maintaining ecological connectivity at landscape level:

- Plan agricultural landscape management in context of ownership pressure, and prioritise multifunctionality in agricultural lands as an environmental issue;

- Identify the critical areas for landscape connectivity and promote the existing elements in agricultural lands, such as vegetation strips, riparian buffer zones, wetlands, etc.

- Landscape elements, such as integrated buffer zones (Zak et al., 2019), vegetative strips (Prosser et al., 2020), riparian buffer zones (Stutter et al., 2019, 2012), vegetated hedges (Lazzaro et al., 2008), or constructed wetlands (Haddis et al., 2020; Metcalfe et al., 2018; Tournebize et al., 2017), can buffer the degradation of water quality by intercepting the transfer of particles, nutrients and pesticides between crops and surface waters.

- In addition to regulating the pollution levels, buffer areas can improve biodiversity in agricultural landscapes. Vegetated strips and hedges have been shown to improve the abundance and richness of birds and invertebrates, providing habitats and refuges for some species, as well as nesting and foraging sites (see Haddaway et al., 2016). Artificial wetlands can provide habitat and breeding sites for amphibians (Rannap et al., 2020).

- Semi-natural elements can also enhance ecosystem services such as pollination, biological control and soil conservation

- Maintaining landscape structures such as constructed wetlands that both mitigate water pollution from agricultural inputs and promote biodiversity meets the objective of multifunctionality. Adding constructed wetlands enhances hydrological connectivity, even in case of geographically isolated wetlands (McLaughlin et al., 2014), and contributes to the green and blue infrastructure, while providing corridors or stepping-stone patches that enhance connectivity within the agricultural matrix (Donald and Evans, 2006; EC, 2013).

Management related recommendations
In relation to management of agricultural areas, the following general recommendations can be implemented:

<u>Maintenance of scattered trees on agricultural plot edges</u>

Mature trees scattered throughout agricultural landscapes are a critical habitat for some biota and provide a range of ecosystem services. Scattered trees are a prominent feature of agricultural landscapes globally (Gibbons & Boak 2002; Manning et al. 2006); however, where these landscapes are managed intensively, the occurrence of scattered trees is in decline. They have been identified as keystone structures because of their ecological importance relative to their low abundance (Munzbergova & Ward 2002; Plieninger et al. 2004; Manning et al. 2006). Scattered trees can form a critical habitat for biota (Dean et al., 1999; Western & Maitumo 2004; Manning et al., 2006) and contribute to the viability of wildlife populations in fragmented landscapes (Fischer & Lindenmayer, 2002). Scattered trees provide a range of ecosystem services—shade for stock (Harvey & Haber, 1999) or shade-tolerant crops (Bentley et al. 2004), a buffer against soil acidity (Wilson 2002), a control measure against erosion and desertification (Plieninger et al., 2004), and insect control (Lumsden & Bennett 2005), and are a cost effective source of seed for revegetation (Dorrough & Moxham, 2005).

The effects of an approaching bottleneck of mature trees in agricultural landscapes can be mitigated with a strategy that reduces mortality of the existing trees with a particular emphasis on reducing mortality in stands with a high mean diameter (or age)[11]. Another measure is to retain scattered trees in agricultural areas, periodical inventory and monitoring of the phytosanitary status.

<u>Maintenance of roadside corridors in areas of agricultural roads</u>

Linear landscape elements are supposed to be suitable as dispersal corridors, and, therefore, are considered as possible solutions to mitigate the negative effects of fragmentation of more natural areas in agricultural landscapes.

The structure and composition of roadside vegetation vary from frequently mown grass to shrubs and trees and from artificial landscaping to natural plant communities. Roadside vegetation (Figure 1) can perform many important functions, including the provision of habitat for rare plants and animals, a source of seeds for adjacent landscapes, a buffer to reduce the penetration of traffic noise and light, carbon sinks and enhanced aesthetics for road users[12].

11 P. GIBBONS, D. B. LINDENMAYER, J. FISCHER, A. D. MANNING, A. WEINBERG, J. SEDDON, P. RYAN,§ AND G. BARRET, The Future of Scattered Trees in Agricultural Landscapes, March 3, 2008.

12 The Function and Management of Roadside Vegetation, Suzanne J. Milton,W. Richard J. Dean,Leonard E. Sielecki,Rodney van der Ree, 01 April 2015.

In addition to the functions listed above, roadside corridors can be used to guide large and small mammal, amphibian and reptile species to specific habitats.

To maintain the functionality of roadside corridors, the following actions should be considered:

- avoid fencing in critical areas;
- establish guidelines and impose fencing-related conditions linked with subsidy programmes;
- facilitate/support changes of land-use to highly permeable categories;
- support and promote the development of good-practice examples of agricultural and forestry practices fostering ecological connectivity;
- incentivise landowners to maintain the existing strips of woody vegetation;
- identify the critical areas for connectivity and creation of vegetation strips through planting;
- implement measures for illegal cutting of vegetation strips.

<u>Maintenance of small habitat patches (e.g. small wooded areas, small grassland areas, etc.) for different fauna species</u>

These habitats are represented by areas removed from agricultural production and left in a natural state. Most commonly, they are represented by grassland strips located at the edges of agricultural fields. Research has shown that these areas can be a solution for maintaining or restoring connectivity, but only for high dispersal/high-density species, mostly invertebrates. Low dispersal species did not benefit much from this measure (Threadgill et al., 2020).

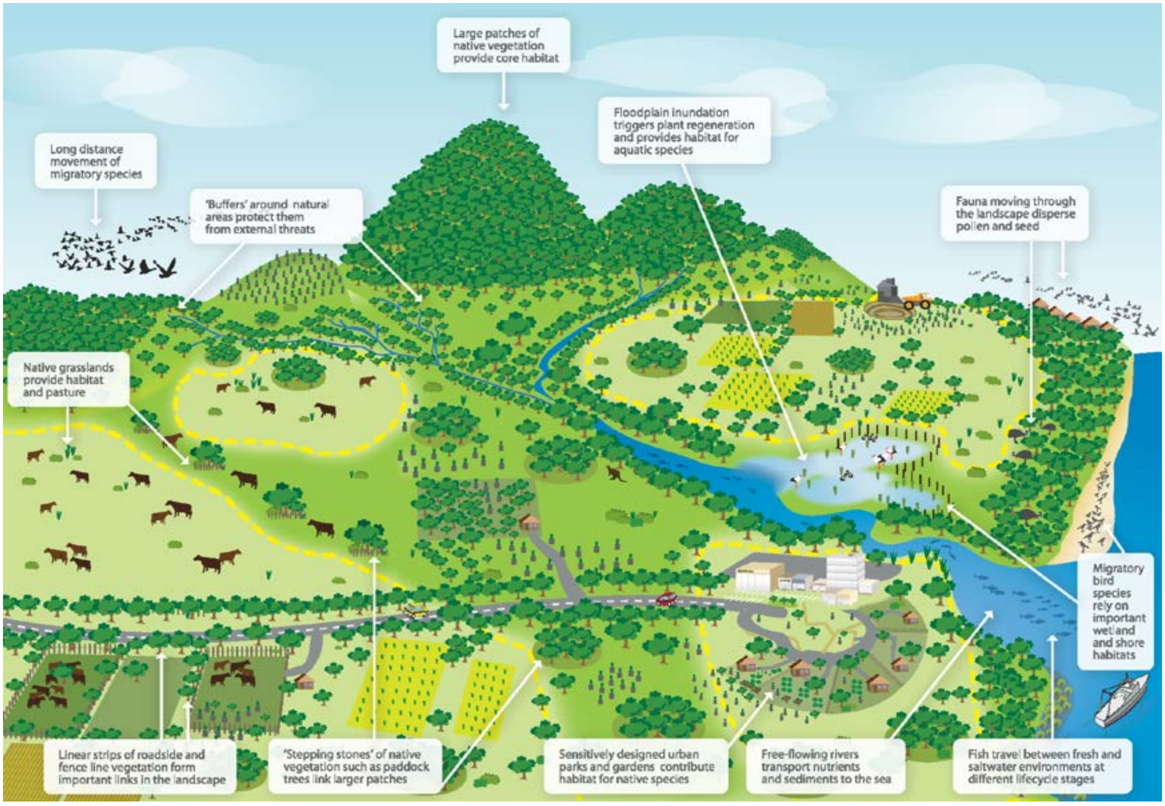


Figure 3 Examples of corridors include retained riparian woodland along streams and rivers, patches of bush or single trees in pastureland (source: www.environment.gov.au)

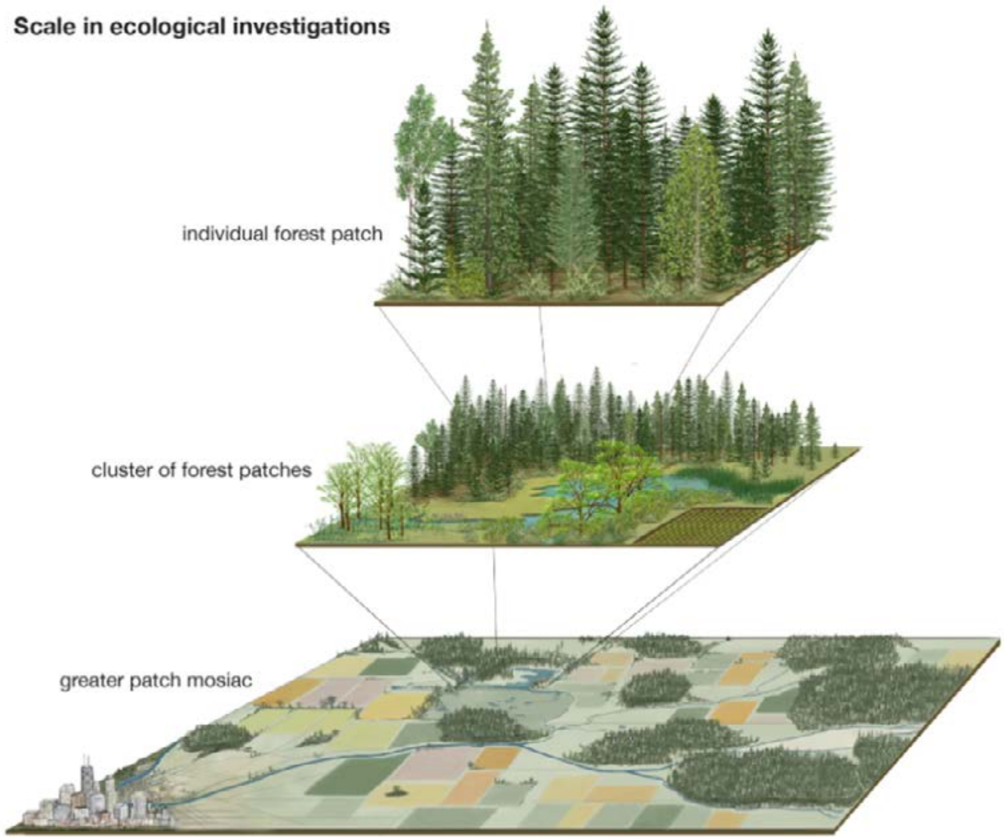


Figure 4 Examples of forest patches, maintained in a mainly agricultural landscape

Maintenance of hedgerow edges on agricultural plots

The use of edge habitats, such as hedgerows, on areas in agricultural fields has been proven to be an effective measure for ensuring ecological connectivity. An article based on field surveys and remotely sensed data in Quebec, Canada shows that medium- and large-sized mammals from seven species have used the hedgerows intensely. The results show that the length of the hedgerows as well as the tree cover (a better tree covering of the hedgerows increased the use of the hedgerows) is of particular importance. These results also showed that forest specialist species (members of the Martes sp. genus for instance) did not use the hedgerows (Pelletier – Guittier et al., 2020).

The measure is particularly effective for generalist medium and large mammal species (e.g., foxes, hedgehogs, badgers, etc.). It is ineffective in areas with a high concentration of human presence.

Monitoring related recommendations
In terms of monitoring, considering the relatively large scale of agricultural enterprises for purposes of observing ecological connectivity, it is necessary to analyse the distribution of features at a large scale. Thus, it is recommended to monitor ecological connectivity in agricultural areas through methods such as satellite imagery, drones, or other low flying devices, which can show the landscape features in their entirety.

Policy related recommendations
On the issue of policy, it is recommended for national and regional level policies to include connectivity as a requirement for practitioners. It is also recommended to ensure adequate payments for farmers, corresponding to the implementation of good practices related to connectivity in their agricultural activities. The

Figure 5 Examples of hedgerow connectivity in agricultural fields (© National Geographic Society)

specific legislation should clarify these issues, and should define the good practices to be implemented for maintenance of connectivity in the agriculture domain, in a specific manner for each country.

9.3 Forestry sector

Planning related recommendations
On the topic of forestry practices, the following general recommendations for planning have been identified as good practices for maintaining ecological connectivity at landscape level:

» Identify the critical woodland areas relevant to ecological connectivity, and facilitate inclusion of wooded areas in the forestry fund.

» Wet and dry grasslands and small patches of forest or other types of habitats can be included as strictly protected areas, and act as "stepping stones" to connect core areas.

» Create strong collaboration with stakeholders to intensify security and anti-poaching actions in the critical core forest areas.

Management related recommendations
For the management stage, the following general recommendations have been identified as good practices for maintaining ecological connectivity at landscape level.

Maintenance of old non-commercial (biodiversity) trees within forest bodies

The maintenance of biodiversity trees or tree retention is a conservation measure that has been implemented in certain Northern European countries. These trees represent either standing deadwood trees or trees which have the potential to become deadwood in the future, and which are not cut during tree harvesting. Their main purpose is to allow an area of habitat for beetles and other wood-related species in an otherwise altered habitat.

Research results show that in general, in areas where retention trees are maintained, there is a higher level of biodiversity as opposed to clear-cutting. However, the levels are not as high as in the undisturbed habitats. Nevertheless, these areas can represent important stepping stones for certain invertebrates and can contribute to the maintenance of structural connectivity (Gustafsson et al., 2020).

The applicability is mainly useful for areas where saproxylic beetles are present, areas of forest within the Natura 2000 sites or other protected areas, and areas subject to timber harvesting.

Figure 6 Examples of tree retention for a patch in Norway (© Anne Sverdrup-Thygeson)

Figure 7 Examples of stumps left for encouraging biodiversity in Sweden (© Lena Gustafsson)

Maintenance of special conservation regime areas of forests in which to prioritise non-intervention or very low levels of intervention

One example for such recommendations was detailed in the chapter on case studies, showing how such areas were implemented in order to “reconnect” fragmented landscapes.

They can be implemented both in natural areas, such as inside protected areas at national or international levels, or, in a landscape dominated by anthropic interventions. The following figure shows possible combinations for implementing special regime forested areas.

Monitoring related recommendations

Recommendations for this domain are similar to the ones for agriculture, indicating the need for a higher, landscape level approach to observing ecological connectivity. The monitoring should show any areas of interconnectedness between forested patches as well as bottlenecks where fauna associated with this type of ecosystem might be forced to aggregate.

In terms of the quality of habitats in forested areas, it is recommended to monitor exploitation activities, including their effects upon the surrounding areas (such as increase in noise levels, increase in light pollution, reduced air quality, etc.). The monitoring should also indicate the dynamics of the

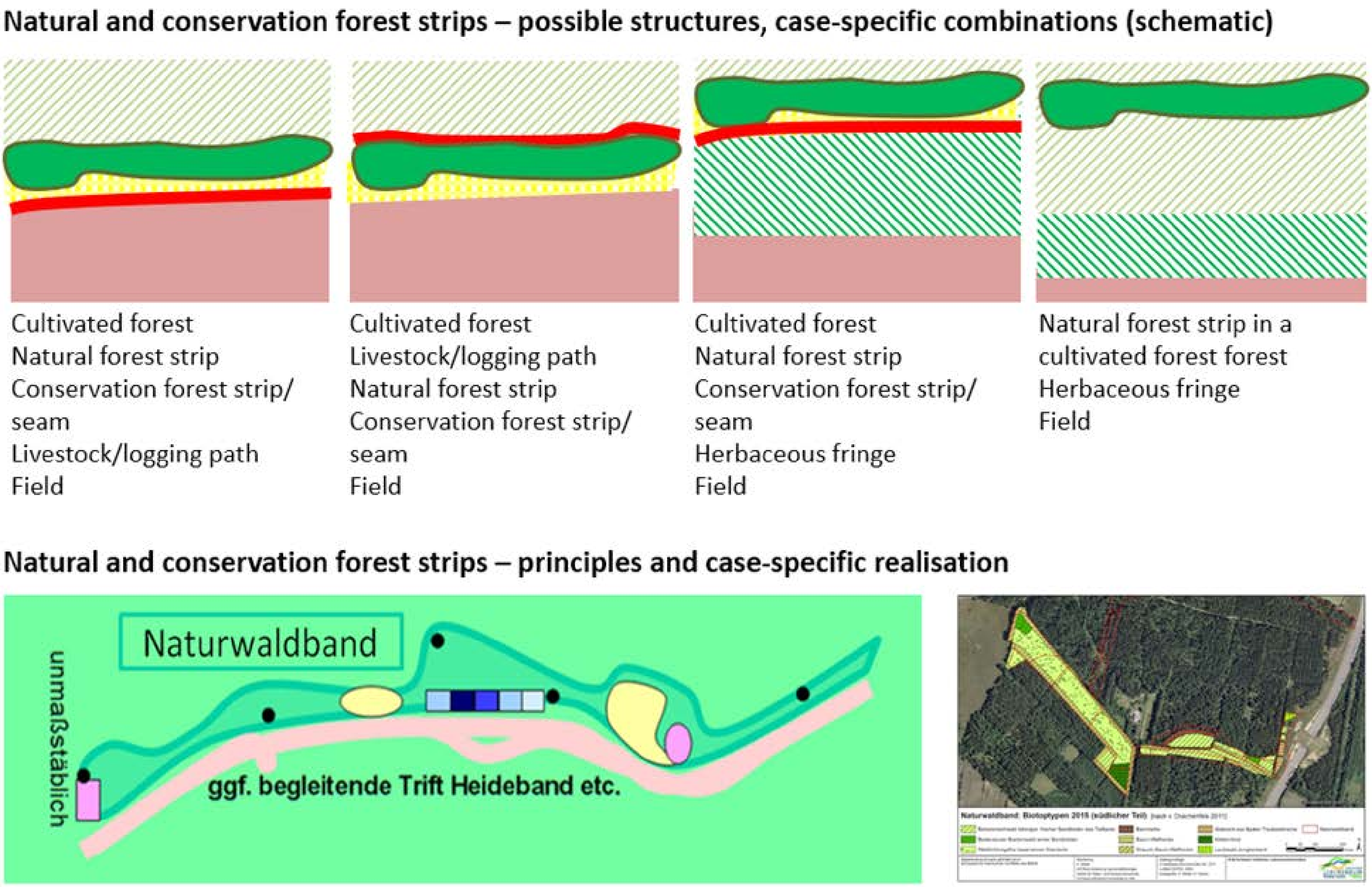


Figure 8 Natural and conservation forest strips – possible structures, case-specific combinations (© Reck et al., 2019)

logging activities, with their associated necessary infrastructure (increase in forest roads, clearings for timber storage, etc.).

Policy related recommendations
Strategies and plans in the forestry domain should include a specific preoccupation with ecological connectivity as this issue is very tightly related to forest habitats. At a high level, it is recommended for national level strategies and plans to include ecological connectivity in the analysis of areas planned for reforestation or afforestation, and propose these operations also in areas where ecological connectivity needs to be restored or improved.

The planning for timber production and the identification of areas meant for exploitation should also acknowledge ecological corridors, in order to avoid human activities in areas that are important for connectivity.

9.4 Water management sector

Planning related recommendations
Rivers are dramatically transformed to obtain energy and water supply for drinking and industrial uses (Malmqvist and Rundle, 2002). The construction of dams and reservoirs is necessary to exploit river resources. One of the main consequences of these types of infrastructure is that rivers' connectivity, an essential feature in streams and population ecology (Jansson et al., 2007), has been interrupted. Connectivity disruption not only affects physical-chemical components in rivers (e.g., Leibowitz et al., 2018), but also community composition and diversity patterns (Altermatt et al., 2013). One of the most documented effects of river barriers is the obstruction of upstream access for many valued migratory fish species.[13]

The impacts caused by the fragmentation of rivers underline the importance of restoring river and water body connectivity. To incorporate connectivity restoration in conservation programmes, it is crucial to improve the awareness within the society of the importance to maintain continuous river courses.

For proper management to maintain or restore connectivity, it is recommended: to restore habitats by removing fish barriers where connectivity has been disrupted, elaborate plans in hydro-engineering constructions recognizing the specific ecology of fish, amphibian and aquatic mammal species (such as otters and beavers) within a habitat, and undertake water quality monitoring, maintenance or reconstruction of riparian vegetation where appropriate.

Management related recommendations
Regarding the management of water resources, the main recommendations identified include the following:

Maintenance of riparian habitats, preferably with woodland riparian species. A width of more than 30 metres should be maintained to ensure ecological functionality.

Riparian vegetation has multiple roles in relation to the maintenance of wildlife. On the one hand, it can represent important corridors for the movement of species, especially of water-dependent species; additionally, it is an important buffer filter between agricultural areas (where there is usually a high level of nutrient transport towards waterways) and rivers.

13 Arboleya E, Fernández S, Clusa L, Dopico E and Garcia-Vazquez E (2021) River Connectivity is Crucial for Safeguarding Biodiversity but May be Socially Overlooked. Insights from Spanish University Students. Front. Environ. Sci. 9:643820. doi: 10.3389/fenvs.2021.643820

This is particularly important for maintaining adequate habitats for aquatic species such as fish and aquatic invertebrates, birds, and mammals, as well as functional connectivity (fish species for example).

Research has shown that for riparian vegetation to act as a buffer and facilitate the presence of bird species in these areas, it requires a width of at least 150 metres between the agricultural fields and the rivers that it surrounds (Lind et al., 2019).

Riparian vegetation can also act as an ecological corridor. Research from Portugal has shown that riparian areas are of particular importance for bird species (da Silva Mendes, 2016).

Riparian corridors are of considerable relevance for otters and other water-dependent mammals, amphibians, and fish species. These can contribute to a healthy aquatic ecosystem, which in turn will ensure the functional connectivity for aquatic species.

Re-establishment of aquatic connectivity in fragmented rivers

The re-establishment of aquatic connectivity (either through barrier removal or adaptation) is one of the main targets of the European Commission for 2030, as outlined in the Biodiversity Strategy for year 2030.

There are many examples of fish passes in Europe, but perhaps the most stunning examples come from Austria. One such example is a new fish pass constructed at the Annabrücke power plant. This fish pass overcomes a 26-metre height difference between the upstream area of the dam and the downstream area. The fishway is presented in the following figure.

Monitoring related recommendations
Monitoring of ecological connectivity in the case of water management should

Figure 9 Riparian corridor along a river in Romania (© EPC Consultanţă de mediu)

mainly focus on the analysis of longitudinal connectivity. Rivers should be free of any transversal structures that can impede the free movement of fish and other fauna species, and monitoring should aim at identifying those structures that can represent obstacles for fish movement.

Another issue that has to be included in the monitoring done for water management is the risk of fragmentation due to changes in the physical or chemical parameters of the water. This can occur particularly in areas with industrial activities or where the risk of pollution is high. Changes in these parameters in certain river sections can represent a barrier for the movement of fauna species, and thus should be monitored accordingly.

Policy related recommendations

Assessment of ecological status for water bodies already recognizes the interruption of longitudinal connectivity of rivers, as required by the Water Framework Directive. However, national methodologies (such as the Romanian methodology) relates the ecological status to the density of transversal barriers, not necessarily to their presence. Thus, a water body can be considered to have a good status, even if it is highly fragmented and its ecological connectivity has been interrupted. It is recommended that the methodology for assessment be adapted to acknowledge the ecological requirements of aquatic species and of the species dependent on it.

In the case of the existing barriers, including barriers which are very important from an economic viewpoint (such as large dams, the Iron Gates dam in Romania for instance), policies should be drafted aimed to identify the solutions for restoring the longitudinal connectivity of the rivers. While this point is also applicable to smaller level barriers, large barriers will require a much higher level of implication, their management often being a national issue.

Figure 10 Example of a fishway built in Austria, to overcome a barrier of 26 metres (© VERBUND AG)

9.5 Urban development sector

Planning related recommendations
Spatial plans define the frames of territorial sustainability that refers to an ordered, resource-efficient and environmentally-friendly spatial distribution of human activities. The complexity of the issue is reflected by the dimensions of territorial sustainability:

- "Territorial quality: the quality of the living and working environment; the relative homogeneity of living standards across territories;
- Territorial efficiency: resource-efficiency with respect to energy, land and natural resources; competitiveness and attractiveness;
- Territorial identity: enhancing "social capital"; developing a shared vision of the future; safeguarding specific cities, strengthening productive "vocations" and competitive advantage." (Camagni, 2017)

Spatial planning represents an appropriate institutional, technical and policy framework for managing the territorial dimension of sustainability. The key role of spatial planning is to promote a more rational arrangement of activities. Spatial planning differs from one country to another, but the majority of them share the most important characteristics:

- spatial planning is concerned with identifying long- or medium-term objectives and strategies for territories,
- dealing with land use and physical development,
- it is a distinct sector of government activity, and
- it has an important coordinating role between sectoral policies such as transport, agriculture and environment (Koresawa and Konvitz, 2001).

The most effective way to develop a green infrastructure network lies in spatial planning, which represents a larger scale and area-based approach, allowing for the identification of opportunities for a cooperation between different land-use forms. Planning takes place at different levels, across local, regional and national levels, and even across national borders; the key at all levels is the strategic long-term approach which integrates ecological processes and the preservation of nature into the planning stages. This method has the added benefit of drawing attention to the goods and services associated with these ecosystems, alongside their vulnerability and the potential consequences of losing access to these benefits, for example if their function becomes diminished or depleted.

Spatial development plans are responsible for identifying the opportunities and constraints for spatial development while ensuring the protection of the value of natural and built environments.

Some recommendations of best practices in spatial planning for ecological connectivity across different European countries are presented below. These examples were kindly provided by the SaveGREEN Project Partners and Strategic Partners and are based on their specific experience from their countries.

<u>Austria</u>

The Austrian Biodiversity Strategy 2020+ includes actions to strengthen habitat connectivity. Austria has specific targets for integrating biodiversity and ecosystem services in spatial planning. Some of the most important measures include:

- incorporating green infrastructure in spatial planning;
- consideration of functional connectivity and the habitat network when establishing compensating areas;

- increasing grassland space in urban areas;
- the provision of features that promote biodiversity in newly established green areas;
- the preservation of unfragmented areas and migration corridors.

In Austria, most activities are executed at the local or federal province level and are funded by a variety of sources, including the EU support.

The Czech Republic

The first delineation of migration corridors was published in 2010 as part of the research project "Evaluation of the migratory permeability of the landscape for large mammals and proposal of conservation and optimisation measures", using a comprehensive methodology that was based on the analysis of large mammal finding data, categorization and description of migration barriers, mathematical models of landscape potential and habitat preferences, and primarily on extensive field research (Anděl et al., 2010). The originally linearly defined corridors were further refined in the project called "The Complex Approach to the Protection of Fauna of Terrestrial Ecosystems from Landscape Fragmentation in the Czech Republic" (years 2015-2017) into polygonal definition based on real-world land-use and the existing barriers. Core areas, migration corridors, and critical barrier sites for large mammal migration were delineated in the whole country. The Outputs consist of the synthesis of partial inputs such as data regarding the occurrence of focal species, habitat suitability models, barrier permeability assessment, and landscape connectivity analyses. The migration corridors were checked in the field. The problematic sites with identified barriers for migration (such as highways, high-speed railways, 1. class roads, settlements, pasture fencing) were visited and possible solutions to allow the migration permeability were identified and described.

The core areas were designated as a compact territory that hosts or has a high potential to allow for the long-term occurrence of large mammal populations (large carnivores, Eurasian elk) in the future.

This new concept was prepared to be legislated as a biotope of the selected specially protected species of large mammals of national importance (according to the Law 114/1992 Coll.). Since 2020, it has been mandatory to use this tool in territorial planning procedures according to the Building Act (No. 183/2006 Coll.) and related Decree No. 500/2006 Coll. (biotope of the selected specially protected species of mammals is already mentioned there).

Also in the Czech Republic, a new methodology "Doprava a fauna v ČR" (Traffic and Wildlife in CZ) was published by the Nature Conservation Agency. This methodology is aimed to reduce the impact of traffic on fauna. The basic level of knowledge used in this publication has been acquired through more than 20 years of intensive collaboration of authors within the international network of experts, Infrastructure and Ecology Network Europe (IENE). The results of discussions on current topics of transport development in the Carpathian region within the TransGREEN project have also been used. The ambition of this methodology was to prepare an expert basis for the assessment of transport infrastructure in terms of fauna protection, which would also be acceptable for an investor. Therefore, the preparation of the publication was carried out in consultation with the representatives of the Road and Motorway Directorate of the Czech Republic, who continuously contributed with many suggestions to find mutually acceptable solutions.

Denmark

The 2016 Danish Nature Programme (Naturpakken) focuses on natural forests and allocates new areas to natural forests (up to 25,000 ha). It also establishes initiatives for local projects and new interconnected nature areas for the benefit of threatened species. The programme:

- encourages the development of nature areas close to cities and the promotion of opportunities for the population to enjoy nature through outdoor activities;

- attaches priority to stimulating farmers to manage and protect nature through subsidies for hedgerows and possibilities to redistribute land to protect vulnerable natural areas and use non-vulnerable areas in a better way;

- revises the regulatory framework for nature protection to create a more efficient and less bureaucratic administration.

- includes an additional 13,300 ha high-natural-value forest into the national forests (owned by the government) and at least 900 additional hectares in privately owned forests.

France

In France, the Green and Blue Trail (*Trame verte et bleue*) aims to create a network of biodiversity corridors and reservoirs. These go beyond the Natura 2000 requirements. Many actors are already implementing the trail at national, regional, departmental and local levels. The state sets the framework as well as develop the "regional ecological coherence schemes" together with the regions, which are further passed for public discussion. Local authorities take into account ecological continuity in spatial planning. Companies can act by managing their sites to preserve ecological continuity, as well as by reducing their environmental impact. Citizens can act individually in their gardens or as part of an association.

Germany

In Germany, the approach to green infrastructure is advanced, with a planned national green infrastructure concept and a Federal Blue Ecological Network Programme. All the relevant federal nature conservation strategies, objectives, and concepts will be brought together to improve the integration of nature conservation policy in all federal activities, e.g., flood protection, federal transport infrastructure, etc.

In 2012, the German government adopted the Federal Defragmentation Programme, aimed at maintaining and restoring green infrastructure across the national German road network. The programme aims to reconnect habitat corridors for flora and fauna focusing primarily on the existing road network, but also on new planned federal roads, nature conservation, and landscape management as well as integrated spatial planning to facilitate the reconnection of a national habitat network.

Hungary

The new National Biodiversity Strategy of Hungary 2015-2020 aims to halt biodiversity loss and further degradation of ecosystem services, and improve their status where possible. Furthermore, the strategy highlights the need for biodiversity conservation aspects to be integrated into cross-sectoral policies, strategies and programmes across sectors and their implementation.

The Government has adopted Decision 1128/2017 on the National Landscape Strategy for the period 2017-2026 (NTS), which focuses on three horizontal principles. It includes general protection of natural resources and cultural heritage which encompasses the wise and economical use of land and the use of sustainable management practices, tourism and use of natural resources.

Considering spatial plans, the ecological network zone or zones (core area, ecological corridor and buffer area) constitute the backbone of the green infrastructure of high ecological importance at national and county level. Several further elements of the zoning scheme support the potential elements of the green infrastructure network (arable land of excellent soil quality, good soil quality, and arable land with high productive potential, woodland with high productive potential, flood areas and the areas of emergency reservoirs for flood prevention).

The Strategic Environmental Assessment based on EC Directive 2001/42/EC serves the preservation and development of green infrastructure aspects of green and environmental protection, but its position and effects for the planning process need to be further developed.

The Hungarian state launched a national scale project co-financed by the European Union: Strategic Assessments supporting the long-term conservation of natural values of community interest as well as the national implementation of the EU Biodiversity Strategy by 2020. The actions of the GREEN INFRASTRUCTURE subproject were to define the elements and assess the status of green infrastructure; setting objectives and defining priorities for restoration of green infrastructure, defining conflict areas, and providing a delimitation of restoration zones.

Conscious spatial planning has the potential to support the creation of sustainable urban patterns, protecting ecosystems and maintaining ecosystem services. As part of sustainable development, ecological links such as ecological corridors should be preserved to sustain the balance and endurance of basic natural processes. Therefore, planning processes shall acknowledge the environmental aspects and barriers to ecological connectivity. Sustainable planning shall outline and preserve ecological corridors and embed them into spatial development plans. (Rozenau-Rybowicz et al, 2008). The optimisation of urban ecological infrastructure shall also be fostered by urban and spatial planning policies and practices to improve the urban environment by urban sprawl control, biodiversity conservation, climate adaptation, pollution control and flood risk management (Wang et al, 2021).

<u>Slovakia</u>

The Slovak EnviroStrategy includes actions to strengthen habitat connectivity. Spatial planning will ensure a balanced relationship between the needs of the human population, economic activity, and the environment. The measures proposed in nature and landscape protection documentation and the Territorial System of Ecological Connectivity will be an obligatory basis for landscape planning and land consolidation processes. The protection of elements of the Territorial System of Ecological Stability will be ensured.

Documentation containing proposals for landscape elements, including land consolidation projects and urban planning will be integrated and will include the concept of green infrastructure. The impact on the landscape will also be assessed under the Environmental Impact Assessment (EIA) procedures and, in the case of policies and strategic documents, under the Strategic Environmental Assessment. The fragmentation of animal populations will be prevented and appropriate prevention, mitigation, or reconstruction measures will be put in place to secure animal migration corridors and tackle their collisions with infrastructure. This will be done by building wildlife overpasses in places with the most frequent occurrence of wild animal road-kill.

<u>Ukraine</u>

M. P. Shulgin State Road Research Institute State Enterprise (DerzhdorNDI SE) is in the process of developing the standard “*Highways. Wildlife-crossings. Design requirements*”. Requirements for the building of wildlife crossings on public roads meet this standard, which will be applicable in the development of design documentation for new buildings, reconstruction, and overhaul of roads with the installation of wildlife crossings.

Management related recommendations
The originally continuous distribution of many animal species is being disintegrated by rapid

recent landscape fragmentation. In a human-dominated landscape, people continue to fragment natural environments via urbanisation and agricultural activities, but also through the expansion of transport infrastructure. Urbanisation is defined as habitat destruction, whereas transport infrastructure fragments and transects wildlife habitats. Through the identification of ecological corridors, the level of habitat fragmentation can be reduced by implementing suitable mitigation measures (Moț, R. et. al., 2019).

Regional-scale ecological networks maintain the stability of urban ecological networks by connecting high-quality habitats structurally and functionally (Li et al., 2013, Yu et al., 2018). A stable ecological network not only benefits the development of biodiversity, but also provides the land layout for the harmonious development of economy and ecology.

In relation to urban development and spatial planning, in order to maintain ecological connectivity it is recommended to impose the following management measures:

» address ecological connectivity issues in urban development by including them in Urban Spatial Planning (PUZ);

» include ecological connectivity issues into national legislation;

» identify problems related to large-scale habitat connectivity and create a set of measures to mitigate the impacts of urbanisation.

Maintenance of scattered trees within the urbanised landscape

The biodiversity value of scattered trees in modified landscapes is often overlooked in planning and conservation decisions.

Scattered trees support a diversity of wildlife. However, landscape context and tree size have affected wildlife in contrasting ways. Land management strategies are needed to collectively account for responses exhibited by multiple taxa at varying spatial scales. It is recommended that the retention and perpetuation of scattered trees in modified landscapes should be prioritised, thereby providing crucial habitat benefits to a multitude of taxa.

Scattered trees (isolated remnant and planted trees; Manning, Fischer, & Lindenmayer, 2006) are prominent features of human-modified landscapes worldwide and have been identified as "keystone ecological structures." Large and old scattered trees in particular, can provide disproportionate habitat benefits for the biota relative to their size and availability (Lindenmayer & Laurance, 2017; Lindenmayer et al., 2013). For example, trees in commercial production forests (Matveinen-Huju, Niemelä, Rita, & O'Hara, 2006; Mazurek & Zielinski, 2004), agricultural landscapes (DeMars, Rosenberg, & Fontaine, 2010; Dunn, 2000) and urban environments (Stagoll, Lindenmayer, Knight, Fischer, & Manning, 2012; Yasuda & Koike, 2009) significantly contribute to wildlife diversity. Locally, scattered trees provide distinct microclimates and unique structural elements like hollows and woody debris (Manning, Gibbons, Fischer, Oliver, & Lindenmayer, 2012; Tews et al., 2004). At a landscape scale, scattered trees increase spatial heterogeneity and connectivity that can add to species dispersal (Fischer & Lindenmayer, 2002b; Manning, Gibbons, & Lindenmayer, 2009). Despite the growing empirical evidence demonstrating the ecological importance of scattered trees, few studies have quantified response patterns for multiple taxa at individual trees and evaluated whether the use of trees differs between intact and modified landscapes. This knowledge is important as it could help to justify tree protection efforts, particularly in modified landscapes.

Retaining scattered trees in modified landscapes requires a concerted effort to resolve conflicts of interest and mitigate and avoid the loss of established trees wherever possible (Le Roux, Ikin, Lindenmayer, Manning et al., 2015; Lindenmayer et al., 2013).

For example, strategically planned urban developments could retain more of the existing trees in urban greenspace rather than remove trees at construction (Ikin et al., 2015; Le Roux, Ikin, Lindenmayer, Manning et al., 2014; Rayner et al., 2015). Retaining scattered trees can provide immediate habitat benefits to wildlife, while also being a more feasible conservation approach compared to ameliorating development impacts through costly biodiversity offset strategies like planting and maintaining large quantities of replacement seedlings (tubestock), purchasing "set-aside" reserve land or recreating mature tree structures such as artificial hollows (Gibbons & Lindenmayer, 2007; Le Roux et al., 2015; Lindenmayer et al., 2017; Maron et al., 2012; Vesk, Nolan, Thomson, Dorrough, & Mac Nally, 2008). Scattered trees can also serve as useful indicator structures of ecosystem function (Hunter et al., 2017; Lindenmayer, Margules, & Botkin, 2000; Tews et al., 2004). Conserving trees in disturbed landscapes can maintain high levels of biodiversity, which may also facilitate vital ecological services (e.g., pollination and seed dispersal; Herrera & García, 2009) that can ultimately provide numerous socio-economic benefits (e.g., arthropod pest control by birds and bats in agricultural land; Maas, Clough, & Tscharntke, 2013)[14].

Maintenance of empty lots (no-building areas) within urban landscapes. These areas should be covered in natural vegetation and free from any construction elements (including fences)

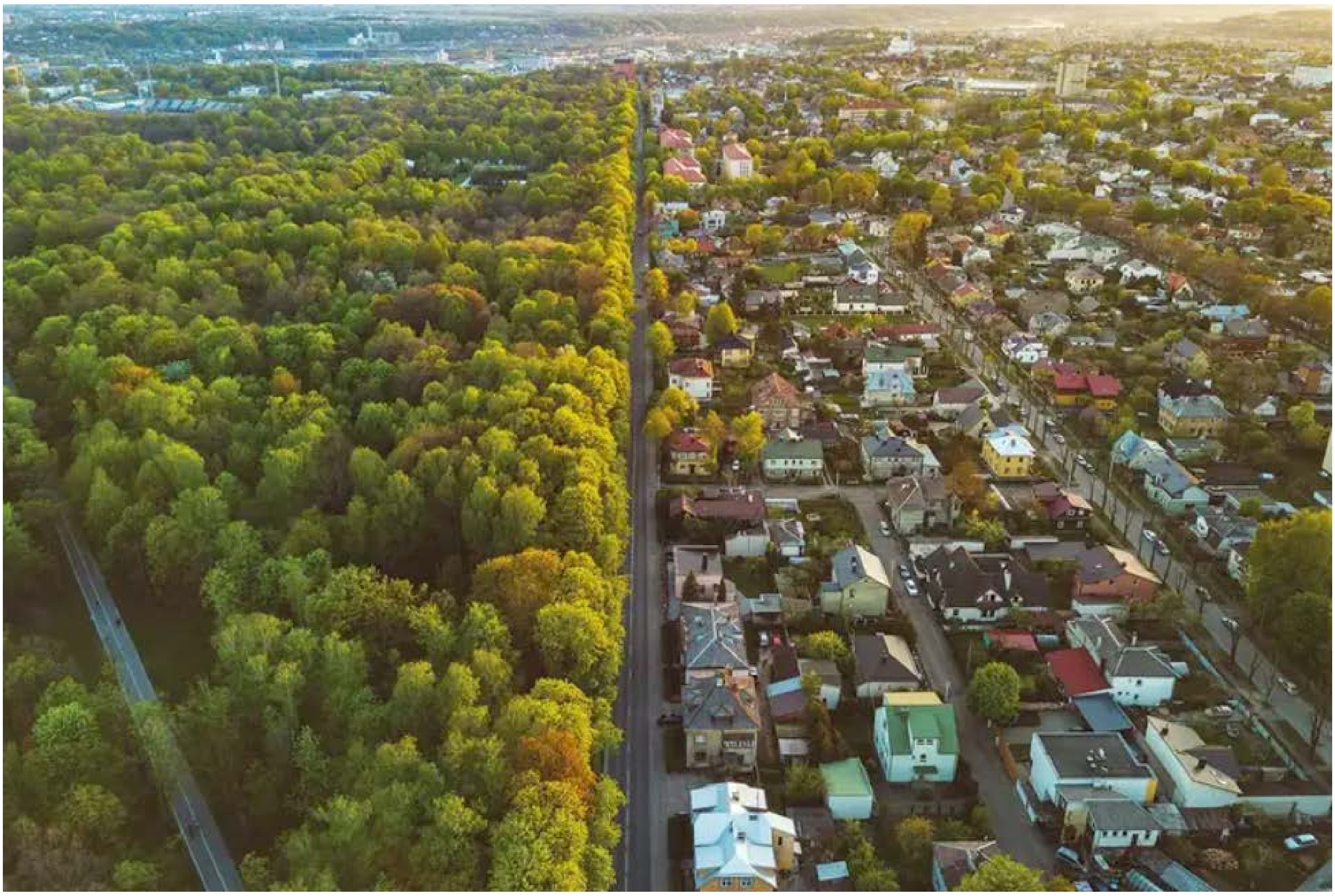


Figure 11 Urban woodland (left) and urban scattered trees (right) - www.newscientist.com

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Figure 12 Natural Park Văcăreşti - Bucharest, Romania (© parcnaturalvacaresti.ro)

Ecosystem services are the processes through which ecosystems and species support and enrich human life. Applied to urban planning, the ecosystem services concept reveals urban populations' dependence on the goods and services appropriated from ecosystems (Elmqvist, Fragkias, Goodness, Güneralp, Marcotullio, & McDonald, 2013; Gómez-Baggethun & Barton, 2013). This concept has now been further developed by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) as nature's contributions to people, encompassing all contributions, both positive and negative (Díaz, Pascual, Stenseke, Martín-López, Watson, & Molnár, 2018). The three categories of ecosystem services as defined by the Common International Classification of Ecosystem Services (CICES) are: provisioning services such as food, water, and timber; regulating and maintenance services which are those that moderate the phenomena such as climate, water quality, and viability of species; cultural ecosystem services which represent nonmaterial benefits that people obtain from ecosystems through spiritual enrichment, cognitive development, social infrastructure, and aesthetic experiences (Haines-Young & Potschin, 2012). Within an urban context, regulation and cultural services dominate, although the relative importance of different services varies in cities depending on the socioeconomic and geographical dynamics and contexts (Luederitz, Brink, Gralla, Hermelingmeier, Meyer, & Niven, 2015). A quantitative assessment of studies considering nature-based solutions can identify the current evidence-base for improving the provisioning of plant ecosystem services management and understanding barriers to adoption of nature-based solutions to mitigate the impact of urbanisation.

Monitoring related recommendations

As urban development represents another domain which has an extensive spatial reach, monitoring should be done in a similar manner to the agriculture and forestry sectors. Analysis of satellite images, aerial photographs, drone footage, etc. can be used to monitor the development of urban areas, on a regional scale.

Additionally, monitoring of urban development planning can include analyses of the development plans proposed for the area, including the plans detailing the areas advised to be built/urbanised. These can be evaluated through a GIS system, taking into account the designated important areas for ecological connectivity from each specific country.

Policy related recommendations

Policies for urban development should be aimed to maintain areas of connectivity in the case of sections which are not yet developed and are still somewhat kept natural. These areas should be maintained as much as possible. In the case of already built areas, including areas such as large cities, the development of urban plans should include issues related to connectivity, in addition to requirements for ensuring green mobility and a higher air quality. A higher preoccupation with connectivity can mean that a higher importance is attributed to ensuring green spaces inside cities, and that grey infrastructure is improved with "greener" measures.

Library of resources

IENE Wildlife & Traffic A European Handbook for Identifying Conflicts and Designing Solutions:
https://handbookwildlifetraffic.info/handbook-wildlife-traffic/

TRANSGREEN Wildlife and Traffic in the Carpathians
https://www.interreg-danube.eu/uploads/media/approved_project_output/0001/35/02caaafe3c1c1365f76574e754ddbdc4e1af4a7a.pdf

TRANSGREEN Keeping Nature Connected - Environmental Impact Assessment (EIA) for Integrated Green Infrastructure Planning
https://www.interreg-danube.eu/uploads/media/approved_project_output/0001/35/f5374e0aee3813cfd352c8005b5ceb0da52d52c5.pdf

Other TRANSGREEN project outputs
https://www.interreg-danube.eu/approved-projects/transgreen/outputs

ConnectGREEN project outputs
https://www.interreg-danube.eu/approved-projects/connectgreen/outputs

ConnectGREEN map of ecological corridors in the Carpathian region
https://experience.arcgis.com/experience/03da1f6f67404518b3efe0d11f444e5a?data_id=dataSource_2-1756f2f018f-layer-19:190

CCIBIS portal
https://ccibis.org/

The EU Common agricultural policy
https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cap-glance_en

EC Guideline "Farming for Natura 2000"
https://ec.europa.eu/environment/nature/natura2000/management/docs/FARMING%20FOR%20NATURA%202000-final%20guidance.pdf

Managing farmland in Natura 2000
https://ec.europa.eu/environment/nature/natura2000/management/docs/Farmland_Annex-E_WEB_en.pdf

New EU Forest strategy for 2030
https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=COM%3A2021%3A572%3AFIN

Natura 2000 and Forests
https://ec.europa.eu/environment/nature/natura2000/management/docs/Final%20Guide%20N2000%20%20Forests%20Part%20I-II-Annexes.pdf

Water Framework Directive
https://ec.europa.eu/environment/water/water-framework/index_en.html

Environmental Quality Standards Directive
https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02008L0105-20130913

Transport ecology.info

https://transportecology.info/

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PILOT AREAS:

Austria

1 Kobernausser forest

2 Pöttsching (Alpine-Carpathian Corridor)

Czech Republic/Slovakia

3 Beskydy-Kysuce CZ-SK cross-border area

Hungary/Slovakia

4 Novohrad-Nógrád SK-HU cross-border area

Ukraine

5 Zakarpattia region

Romania

6 Mureş valley (Arad-Deva)

7 Mureş Valley (Târgu Mureş – Târgu Neamţ)

Bulgaria

8 Rila-Verila-Kraishte corridor

Project partners:

Austria: WWF Central and Eastern Europe (Lead Partner), Environment Agency Austria

Bulgaria: Black Sea NGO Network, Bulgarian Biodiversity Foundation

Czech Republic: Friends of the Earth Czech Republic – Carnivore Conservation Programme, Transport Research Centre Czech Republic

Hungary: CEEweb for Biodiversity, Hungarian University for Agriculture and Life Sciencis

Romania: Zarand Association, EPC Environmental Consultancy Ltd., WWF Romania

Slovakia: Slovak University of Technology in Bratislava – SPECTRA Centre of Excellence of EU

Associated Strategic Partners:

Austria: Ministry for Climate Action, Environment, Energy, Mobility, Innovation, and Technology

Bulgaria: Ministry of Agriculture, Food and Forestry – Executive Forest Agency, Southwestern State Enterprise SE – Blagoevgrad

Czech Republic: Ministry of the Environment, Nature Conservation Agency

France: Infrastructure and Ecology Network Europe (IENE)

Germany: Bavarian State Ministry of the Environment and Consumer Protection

Greece: Egnatia ODOS S.A.

Hungary: Natinoal Infrastructure Developing Private Company Ltd. (NIF Ltd.), Ministry of Agriculture, Danube-Ipoly National Park Directorate

Romania: Ministry of Environment, Waters and Forests, Ministry of Public Works, Development and Administration, Ministry of Transport, Infrastructure and Communications

Slovakia: State Nature Conservancy, Ministry of Environment, Ministry of Transport and Construction, National Motorway Company

Ukraine: M.P. Shulgin State Road Research Institute State Enterprise – DerzhdorNDI SE, Department of Ecology and Nature Resources of Zakarpattia Oblast Administration

SaveGREEN "Safeguarding the functionality of transnationally important ecological corridors in the Danube basin"

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