

GUIDELINES FOR THE IDENTIFICATION, CONSERVATION, RESTORATION, AND MANAGEMENT OF ECOLOGICAL CORRIDORS IN THE CARPATHIAN ECOREGION



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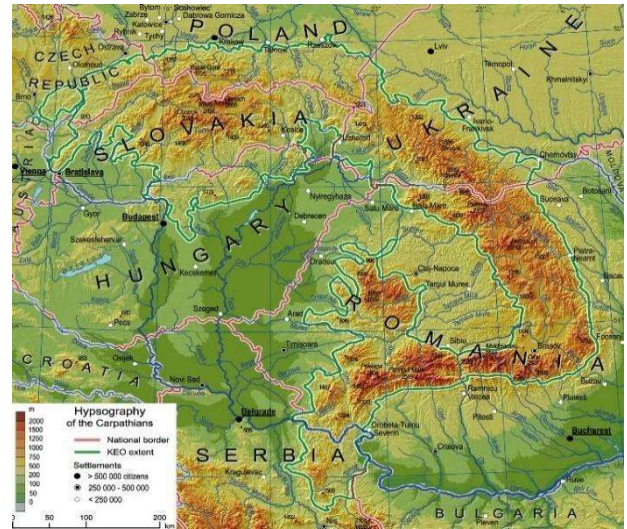
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Introduction

Forming an arch that stretches across seven Central and Eastern European countries (from the Czech Republic to Serbia, through the Slovak Republic, Hungary, Poland, Ukraine, and Romania), the Carpathian Range is the longest and most rugged mountain range in Europe. The Carpathian ecoregion is a relatively well-preserved region from an environmental point of view, with rich and unique natural and cultural diversity and connectivity of ecosystems, representing one of Europe's last largest wilderness areas. Carpathian large tracts of natural and semi-natural habitats harbor rich ecosystems, including extensive old-growth forests and large megafauna populations (including the largest numbers of big carnivores in Europe). This ecoregion is hence an invaluable asset which currently faces unprecedented changes, thus requiring urgent attention and protection measures (Okaniková et al., 2019; [17]; [21]; [22]).



Negative environmental changes within the observed landscape have three notable causes related with corresponsive three key challenges:

- First, uncontrolled **infrastructure development** (brought about by the economic growth in the last decades) has cut across previously undisturbed habitats in the region and led to significant landscape and ecosystem fragmentation, thus limiting dispersal and the genetic exchange of wildlife (Köck et al. 2014), being one of the major threats to the preservation of the unique biodiversity and landscape diversity of the Carpathians (Kadlečík ed. 2016).
- Second, **climate change** is drastically re-shaping the boundaries of natural habitats, which results in disturbed habitat availability and distribution and, as a consequence, fragmenting species movement and migration across the region (luell et al., 2003; Hlaváč et al., 2019; Georgiadis et al. (2018); [9]; [12]; [15]; [16]; [19]; [24]; [25]).
- The third key challenge is the countries' different national **governance frameworks**, specifically regarding nature conservation and spatial planning policies. Each Carpathian country has a diverse set of priorities, approaches, and solutions when it comes to the matters of landscape fragmentation, which undermines effort to address habitat connectivity challenges (luell et al. 2003; Hlaváč et al., 2019; [2]).

Having stated the above challenges, this document offers the Carpathian countries a blueprint to help them strengthen cooperation to adequately manage and protect such natural heritage. Priority action should target **restoring** already-existing habitat **connectivity gaps** (especially in fragmented core habitat areas) and preventing further habitat loss and degradation (Chapron et al., 2014; Favilli et al., 2013; Hilty et al., 2020, Hlaváč et al., 2019; Okaniková et al., 2019; Vasilijević et al., 2015; [6]; [10]; [17]; [21]; [22]; [23]; [24]).

To better deal with the identified challenges, it is essential to develop an integrated transboundary management approach focused on the development of a detailed **natural capital inventory** in the region (Hilty et al. 2020, Vasilijević et al. 2015). This long-overdue inventory should include databases in which datasets are embedded with integrated map databases, making all information available across sectors and borders (Anderson et al., 2006; Appleton-Meyer, 2014; Jongman et al., 2011; [21]; [22]; [23]; [24]). More than that, further **awareness-raising** on the importance of natural capital should be ensured at the social level. This should produce valuable knowledge not only amongst the general public, but also amongst stakeholders (both public and private) operating in sectors that are directly affecting the preservation of natural habitats (urban and infrastructure planning, spatial planning, and environmental protection).

The success of the aforementioned tasks will greatly depend on economic factors. This is due to the fact that the effective restoration and preservation of such natural capital requires harmonized and coordinated financial,

managerial, and cooperative action from the countries, regions, and communities of the Carpathians. It will also need the involvement of all sectors related to the development of the region, specifically those targeting integrated planning, management, and maintenance of natural and human infrastructure and assets (Hlaváč et al., 2019; Okaniková et al., 2019; Valachovič 2018).

Briefly, this document offers concrete guidelines for a common strategic framework for the identification, conservation, restoration, and management of ecological corridors in the Carpathian Ecoregion (hereinafter referred to simply as the 'guidelines') for the 2021-2026 period. Its target audience includes the Carpathian Convention Secretariat and the member state representatives of the Carpathian Convention, policy-makers in the Carpathian countries, and civil society. By creating a common strategic framework for concerted action and effort coordination across boundaries, this document represents a step forward towards the preservation and improvement of ecological connectivity in the Carpathian ecoregion. It aims to:

- a) cope with the increasing ecosystem and habitat fragmentation in the Danube region and
- b) improve ecological connectivity between natural habitats, especially between Natura 2000 sites, the Emerald Network, and other protected area categories of transnational importance in the Carpathian ecoregion.

ConnectGREEN: Restoring and managing ecological corridors in mountains as the green infrastructure in the Danube basin

Over a 3-year period (2018-2021), the ConnectGREEN project (funded by the Interreg Danube Transnational Programme) has addressed one main objective: to maintain and improve the ecological connectivity between natural habitats, especially between Natura 2000 sites and other protected areas of transnational relevance in the Carpathian ecoregion, namely in Czech Republic, Hungary, Romania, Slovakia, Serbia, and Ukraine. Specifically, the project aims at:

- Developing innovative solutions and guidance to identify ecological corridors and connectivity gaps in a harmonized way across the Carpathian ecoregion to maintain long-term, cross-border wildlife movement, associated ecosystem services, and a high level of biodiversity in the region.
- Engaging protected area and Natura 2000 site managers, conservationists, spatial planners, and other key stakeholders in an integrated approach for strengthening the capacity for identifying and managing ecological corridors.
- Reconciling nature conservation and spatial planning and development in ecological corridors and Natura 2000 sites by identifying and implementing strategies, instruments, and best practices.
- Increasing the knowledge and experience of relevant authorities and stakeholders via capacity building programmes and the dissemination of the key results coming from the Danube Transnational Programme (DTP) projects TRANSGREEN, ConnectGREEN, and HARMON, as well as from SaveGREEN itself, on how to maintain and improve the functionality and financing of GI.
- Cross-sectoral joint planning of robust mitigation measures for securing connectivity. This will be based on careful planning and design, secured funding, cross-sectoral dialogues, and sound scientific knowledge embedded in proper site-management.
- Establishing international and national governance frameworks which are more supportive of maintaining ecological corridors for the preservation of Danube's and Carpathian's biodiversity values.

Through ConnectGREEN, partners from different countries and various fields of activity (spatial planning, research, government, biodiversity conservation) joined forces to increase the capacity to identify and manage ecological corridors and to overcome the conflict between infrastructure development and biodiversity conservation. Valuable knowledge and experience have been made available to spatial planners in order to find the best ways to develop

infrastructure and other plans to secure ecological connectivity in the Carpathians. This knowledge has been capitalized in the following ConnectGREEN outputs:

- **Output 2.1.2.** Maps with the distribution of target species, core areas, ecological corridors and critical barrier sites in each pilot area.
- **Output 3.1.** Methodology for identification of ecological corridors in the Carpathian countries by using large carnivores as umbrella species¹.
- **Output 3.2.** Guidelines on reducing conflicts in corridor areas.
- **Output 3.3.1.** State of the Art Report on the existing planning systems and their application for ecological corridor identification and management in the Carpathians.
- **Output 3.3.2.** GAP analysis report on the identification of the needs for improving the planning processes and tools related to ecological corridors' identification and preservation.
- **Output 3.3.4.** A set of recommendations developed together with spatial planners to avoid/minimize fragmentation of ecological corridors and Natura 2000 sites.
- **Output 3.3.** Ecological connectivity related database under [CCIBIS](#)².
- **Output 4.1.** Database with all relevant spatial information in each pilot site.
- **Output 5.1. Guidelines for the identification, conservation, restoration, and management of ecological corridors in the Carpathians**³ as a supporting background document of the International Action Plan on Conservation of Large Carnivores and ensuring ecological Connectivity in the Carpathians⁴

Hence, these Guidelines build upon the knowledge generated by ConnectGREEN, articulating the lessons learned and the priorities identified in a set of actionable objectives and targets for harmonized, coordinated action amongst countries and stakeholders in the Carpathian ecoregion.

Achieving each of the strategic objectives is a step-by-step process which requires the implementation of a series of targets. Based on the current policy contexts, some of the proposed targets will be achievable in the short-term, meaning that their implementation will require a relatively short time after the adoption of this guideline. Other targets, on the other hand, have so far only been formulated as benchmarks within the process, and will require a longer process of implementation given their complexity.

In the transnational and regional policy context of the *Carpathian Convention*, the Guidelines for the Identification, Conservation, Restoration, and Management of Ecological Corridors provide recommendations to bridge two key documents relevant for ecological connectivity in the Carpathian Ecoregion, namely the *Joint Strategic Action Plan 2021 – 2026 for the implementation of the Protocol on Sustainable Transport* and the *International Action Plan on the conservation of large carnivores and ensuring ecological connectivity in the Carpathians*. All three documents shall guide and support the Parties of the Carpathian Convention and all relevant stakeholders in implementation of the Convention that is focused on environmental protection and sustainable development of the Carpathian region.

¹ Annexed to this document as Annex IV.

² <http://ccibis.org/about-ccibis>

³ Initial name: "Guidelines for a common strategic framework for the identification, conservation, restoration, and management of ecological corridors".

⁴ Adopted by the Carpathian Convention Implementation Committee at the Sixth Meeting of the Conference of the Parties to the Framework Convention on the Protection and Sustainable Development of the Carpathians (COP6) in November 2020.

I. Chapter: Problem analysis

1. Ecological networks and connectivity

One of the main drivers for the development of ecological networks across Europe is that biodiversity continues to decline due to a decrease of habitat quality, habitat extent, and increase in fragmentation related to anthropogenic activities (IPBES, 2019). These processes are consequently leading to the destabilization of ecosystem balance at the landscape level, while diminishing ecosystem functions, declining populations of natural species, and threatening their collective sustainability (Hilty et al., 2020, Vasiljević et al., 2015). Furthermore, a recent concern has been voiced about the small size and high fragmentation of existing protected areas, and their adequacy for the effective conservation of biodiversity (and, particularly, megafauna). This is particularly true in the case of large carnivores. The adequate protection of ecological networks can help protect these umbrella species and, with them, the integrity of their ecosystems (Hilty et al., 2020, Hlaváč, et al., 2019, Vasiljević et al., 2015; [2]; [5]; [16]).

The **ecological network** aims to conserve the **full range of ecosystems, habitats, species, and important landscapes** in the Carpathian bio-region to counteract the main causes of biodiversity and habitat loss by creating the right spatial and environmental conditions for their survival and functionality (Papp et al., 2019; [5]; [6]; [8]; [9]; [10]; [11]; [12]; [15]; [16]; [23]). By definition, an ecological network is *“a coherent system of natural and/or semi-natural landscape elements that is configured and managed with the objective of maintaining or restoring ecological functions as a means to conserve biodiversity while also providing appropriate opportunities for the sustainable use of natural resources”* (Hlaváč et al., 2019). An ecological network has three main pillars: core areas, linkage areas, and corridors (Okániková et al., 2019).

- **Core areas** are represented by large areas that fulfil requirements for the permanent occurrence of the selected species. It concerns mainly **forest with natural/semi-natural conditions** and an environment that enables the natural development of populations. Core areas can be divided into areas with already existing permanent occurrence of target species (so-called functional habitat) and areas with the potential to permanently host the target species (potential habitat) (Hlaváč et al., 2019).
- **Corridors** are strips of habitat serving as linear linkages between larger habitat patches, that maintain and increase the **ecological connectivity** across the landscape. Connectivity is an essential feature to ensure ecosystems' and communities' resilience, as corridors facilitate the flow of organisms and nutrients across the landscape, provide routes for the movement or gene flow between separated populations, and enable biological communities to migrate in response to habitat and climate change. Connectivity is therefore the solution to fragmentation (Hlaváč et al., 2019).
- **Linkage areas** are landscape features allowing the short-term survival of organisms and their movement towards other patches of suitable habitat. They are usually fundamental parts of wildlife corridors in a wider scale of the linkage areas than the linear corridors. Linkage areas and 'wildlife corridors' can help connect core areas, allowing species to move between them (Hlaváč et al., 2019).
- When discussing the protection and management of natural areas, it is also highly recommended to take into consideration a fourth element: **buffer zones**. These are transitional areas that ensure that key environmental systems are not directly influenced and tainted by threats and disturbance (Okániková et al., 2019).

The first steps towards a solid database of the ecological network will be the mapping and characterization of the different habitats and network categories, as well as the occurrence of target species using the latest available data (Anderson et al. (2006); Choi-Lee (2019); Okániková et al., 2019). Later, for the definition of the ecological network, the habitat suitability models of different target species, and the connectivity model will be crucial. A habitat suitability model defines areas that are suitable for the permanent occurrence of the species (HSP: “habitat suitability patches”) and the connectivity model links particular HSPs. This mapping and characterization process has been described in detail and tailored to the context of the Carpathian ecoregion under ConnectGREEN Output 3.1 “Methodology for the identification of migration corridors for large carnivores in the Carpathian Countries” (Okániková et al., 2019), as shown in Table 1.

Table 1. *ConnecGREEN classification of ecological corridors and their relation with the IUCN categories harmonized within the Methodology for the identification of migration corridors for large carnivores in the Carpathian Countries (Okániková et al. 2019).*

ConnectGREEN classification including IUCN categories			
IUCN	ConnectGREEN		
CATEGORIES	MAIN CATEGORY	SUBCATEGORIES	SPATIAL LIMITS
Protected areas A clearly defined geographical space, recognised, dedicated, and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values. Conservation is the primary objective.	Patches of suitable habitat Optimal habitat for long-term or temporal occurrence of large carnivores	Core area - meets both qualitative and spatial requirements of particular species - it is primarily a natural continuous habitat (usually forest)	area $\geq 300 \text{ km}^2$ width $\geq 1 \text{ km}$
		Stepping stones (Linkage area) - smaller patch of suitable habitat - used by individuals as transitional site during migration or dispersal	width $\geq 1 \text{ km}$
Conserved Areas (OECMs) A geographically defined area other than a Protected area, which is governed and managed in ways that achieve positive and sustained long-term outcomes for the in situ conservation of biodiversity with associated ecosystem functions and services and where applicable, cultural, spiritual, socio-economic, and other locally relevant values. Delivers the effective in-situ conservation of biodiversity, regardless of its objectives.	Migration zones Relatively suitable habitat, which must be preserved in order to maintain the landscape connectivity between patches of suitable habitat	Stepping stones (Linkage area) - area of relatively suitable heterogenous habitat, but in which the corridor cannot be clearly defined - connects two or more patches of suitable habitat	width $\geq 0.5 \text{ km}$
		Corridor - a "classic" corridor that connects patches of suitable habitat through a relatively permeable landscape	width $\geq 0.5 \text{ km}$
		Critical connectivity sector - narrow and/or single permeable linear infrastructure sector.	---
		Critical connectivity area - special type of "wide & short corridors" - an area that connects suitable habitats divided by a barrier (e.g., a narrow lane of road and surroundings that cuts through a continuous forest) - it may also be narrower throughout sectors on individual or parallel barriers	---
Ecological Corridors A clearly defined geographical space, not recognised as a 'protected area' or an 'other effective area-based conservation measure (OECM or conserved area)', that is governed and managed over the long-term to conserve or restore effective ecological connectivity, with associated ecosystem services and cultural and spiritual values.	Critical zones Zones critical in terms of barrier permeability, ie. places where migration is directly threatened mainly by line barriers (highways, settlements etc.) and/or by cumulative effect of barriers.		

2. Identified challenge areas

2.1. Protecting and enhancing existing natural capital

With its 1,500-kilometre-long arc across Central and Eastern Europe, the rich structural diversity of the Carpathian mountain landscape hosts many types of habitats and is thus considered to be one of the last strongholds of biodiversity in Europe. Landscape variation includes 9 main different forest types, 6 main ecological groups of grasslands (encompassing 38 vegetation types), and 7 simplified ecological groups of wetland habitats (Appleton et al., 2014). Within this scope, large extents of rare and unique primeval and old-growth forests are found there (covering approximately 300,000 ha), whereas the semi-natural dry grasslands host a rich diversity of endemic plants. Thus, the Carpathian ecoregion thus contains a unique diversity of landscapes with rare species, some of which are still poorly known (Hlaváč et al., 2019; [18]; [22]).

The Carpathians are also home to a great variety of wildlife. The ecoregion is inhabited by the largest and most viable population of big carnivores in Europe, with an estimated 7,200 brown bears (*Ursus arctos*), 3,000 grey wolves (*Canis lupus*), and 2,300-2,400 Eurasian lynxes (*Lynx lynx*) estimated in 2014 (Chapron et al., 2014). Herbivore megafauna is also rich and abundant; roe deer (*Capreolus capreolus*), red deer (*Cervus elaphus*), chamois (*Rupicapra rupicapra*), moose (*Alces alces*), and even the reintroduced European bison (*Bison bonasus*) play a key role in the ecology of the Carpathian ecoregion (Linnel-Zachos, 2011; [18]). The high diversity of other animal groups (the rare wildcat, golden eagle, raptors, reptiles, amphibians, and invertebrates) further enriches the existing natural heritage of the Carpathians.

Table 2. Main challenges related to infrastructure development and their ecological effects. Adapted from Hlavac et al. (2019).

Loss of wildlife habitat	Habitat fragmentation (barrier effect)	Fauna traffic mortality	Disturbance and pollution	New habitats on transport verges
Physical replacement of natural habitats with transport infrastructure or significant alteration related to it	Loss of landscape permeability due to roads, railways or urban settlements, limiting the possibility for wildlife to move in search of food, shelter, reproduction etc.	Mortality caused by collision on roads and railways	The construction and operation of transport infrastructure generate changes and impacts on the surrounding environment	Generation of a new type of habitats which play the double role of ecological corridors and traps for wildlife including invasive alien species and they are highly disturbed and polluted

Despite the fact that 18% of the Carpathian Mountains (approximately 36,000 km²) are under some form of legal protection, these natural habitats and wildlife species are increasingly threatened by habitat fragmentation from infrastructure development and urban sprawl (Hlaváč, 2019). Since 1989, in the Carpathian Countries the national and regional developing economies has started to demand a denser and safer transport infrastructure, causing the progressive fragmentation of core areas and the loss of **fundamental** linkages across landscapes. Such infrastructure has negatively impacted the ecological networks as it has resulted in the barriers that are hardly permeable for wildlife. Simply put, although the development of the infrastructure in the last few decades has undoubtedly benefited human societies, it has also significantly impacted both the wildlife (e.g. significant increase in road mortality and mortality due to the conflict with local communities) and the overall ecosystems of the Carpathian region (Kadlečík, 2016). It can be thus argued that both anthropogenic activities and the infrastructural development within this region have caused serious issues for its natural ecosystems and wildlife. This situation should be taken into an urgent account and dealt with efficiently, with the participation of all the relevant actors.

“We can see different geographical distribution of nature protected areas of both types – national sites and NATURA 2000 sites. In case of national protected areas, Slovakia, Poland, and Ukraine (out of project area) show large coverage of the Carpathians, however we can find many of them in Romania, too. The spatial pattern of NATURA 2000 network is even more irregular – we can see a dense network of large-scale Sites of Community Importance (SCIs)/Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) [LG1] in Romania and Slovakia, but the network doesn’t exist in Serbia and Ukraine as non-EU countries. Majority of Carpathian Mountain ranges is protected by NATURA

2000 SITES in Hungary, Slovakia and Czechia, in all these countries we can see extensive overlap with national protected areas (national parks, protected landscape areas, nature parks etc.).” Vlková K. et al. (2019)

Table 3. National protection (National Parks) in the Carpathian countries.

Country	Area of protection km ²	Urban area* km ²	Percentage of urban area* %	Roads length* km	Road density* km/10 km ²	Railway length* km	Railway density* km/10 km ²
Austria	92,590	0,240	0,260	2,311	0,250	1,975	0,213
Hungary	1256,830	29,087	2,314	82,406	0,656	176,914	1,408
Poland	821,600	0,181	0,022	0,002	0,000	0,000	0,000
Romania	3076,600	1,104	0,036	227,736	0,740	40,998	0,133
Serbia	778,740	1,095	0,141	62,457	0,802	0,000	0,000
Slovakia	3243,930	1,977	0,061	72,620	0,224	87,942	0,271
Ukraine	2243,400	33,205	1,480	145,970	0,651	149,742	0,667
Carpathians	11513,690	66,890	0,581	593,503	0,515	457,571	0,397

Table 4. National protection (other protected areas) in the Carpathian countries.

Country	Area of protection km ²	Urban area* km ²	Percentage of urban area* %	Roads length* km	Road density* km/10 km ²	Railway length* km	Railway density* km/10 km ²
Austria	294,680	6,700	2,274	40,667	1,380	29,308	0,995
Czech rep.	2119,140	36,389	1,717	158,329	0,747	204,605	0,966
Hungary	1011,600	1,744	0,172	26,240	0,259	8,082	0,080
Poland	13229,160	92,653	0,700	574,616	0,434	605,821	0,458
Romania	8330,360	1,738	0,021	208,820	0,251	5,921	0,007
Serbia	137,900	0,000	0,000	0,000	0,000	0,000	0,000
Slovakia	5687,990	22,748	0,400	136,727	0,240	97,614	0,172
Ukraine	1733,350	1,808	0,104	21,620	0,125	42,255	0,244
Carpathians	32544,180	163,780	0,503	1167,019	0,359	993,608	0,305

Table 5. Natura2000 Network (Special Protection Areas) in the Carpathian countries.

Country	Area of protection km ²	Urban area* km ²	Percentage of urban area* %	Roads length* km	Road density* km/10 km ²	Railway length* km	Railway density* km/10 km ²
Austria	183,089	0,904	0,494	10,664	0,582	14,717	0,804
Czech rep.	1792,108	10,945	0,611	100,084	0,558	54,234	0,303
Hungary	2144,211	5,702	0,266	17,714	0,083	65,764	0,307
Poland	4606,004	6,252	0,136	87,772	0,191	118,032	0,256
Romania	27895,144	67,203	0,241	1333,598	0,478	640,486	0,230
Slovakia	5145,285	0,948	0,018	39,962	0,078	38,343	0,075
Carpathians	41765,841	91,954	0,220	1589,794	0,381	931,575	0,223

Table 6. Natura2000 Network (Sites of Community Importance) in the Carpathian countries.

Country	Area of protection km ²	Urban area* km ²	Percentage of urban area* %	Roads length* km	Road density* km/10 km ²	Railway length* km	Railway density* km/10 km ²
Austria	238,906	2,399	1,004	23,200	0,971	34,314	1,436
Czech rep.	1035,867	12,035	1,162	30,978	0,299	180,548	1,743
Hungary	3897,263	8,216	0,211	78,736	0,202	156,455	0,401

Poland	4989,244	12,397	0,248	120,631	0,242	292,456	0,586
Romania	21766,574	67,116	0,308	870,616	0,400	441,880	0,203
Slovakia	12406,093	25,031	0,202	252,383	0,203	408,118	0,329
Carpathians	44333,947	127,194	0,287	1376,544	0,310	1513,770	0,341

Having mentioned the issues above, there is thus an urgent need to address the existing process of habitat fragmentation occurring across the Carpathian ecoregion and generating barriers and connectivity gaps between core habitats and protected areas. So far, all Carpathian countries have expressed the importance of ecological networks in their policy framework. However, **the implementation** of this idea remains weak [22] mainly in two basic aspects:

- A. First, there is a challenge related to **the identification process** and the **lack of a common and consolidated methodology**. Although all the analyzed countries are using indicator systems for the identification of ecological networks, usually based on the Natura 2000 and the Pan-European Ecological Network methodologies, the selected indicators and their importance vary greatly from one country to another. The main reason for this methodological incongruence stems from the availability of different **ecological databases** as well as issues related with the legislative background. As a result, such differences across the participating countries hinder the elaboration of a **common network and related communication** (Okániková et al., 2019).

An inventory of the ecological network in the region is long overdue, and it is an essential requirement for the establishment of management plans and frameworks that can ensure the effective protection of these natural capital. The creation of such inventory will involve the set-up of a sound ecological database and the integration of natural resources into this system. This systemic database will be available to all the participating parties across all sectors (Okániková et al., 2019).

- B. Second, on the social dimension, the awareness of the value of the natural heritage of the Carpathian is largely absent in all the Carpathian countries. When interviewed (EuroLargeCarnivores Project⁵), most of the local communities and stakeholders were not aware of the importance of the ecological networks. Rather, they have confirmed that the awareness raising is a major shortcoming and the lack of any communication and sensibilization campaign is a major problem.

Table 7. SWOT analysis of “Protecting and enhancing existing natural capital”.

Strengths	Weaknesses
Existing natural capital Good ecosystem conservation status Current good habitat connectivity and integrity (overall though with exceptions) Exceptional biodiversity Presence of key species in high abundances (specially megafauna) Existence of Carpathian Convention as a forum for regional cooperation and policy coordination Network of NGOs and civil society organizations across the region	Lack of a climate-resilience approach in protected area management plans and beyond (i.e. plague and invasive species management) Gaps in ecological connectivity between habitats, fragmenting core areas Lack of ecological network database Lack of mapping/attributes/free tools for sectors Lack of knowledge on existing assets Lack of social awareness of the assets Lack of science-policy communication Lack of political will Lack of meaningful requirements for construction and development supported by subsidy policies
Opportunities	Threats
General public acceptance and ownership of biodiversity and nature conservation values, as well expectation of protection of natural values by the authorities Existence of a Carpathian Convention to channel and coordinate efforts The new EU policy for Green Deal and nature restoration goals	Loss of habitat integrity, connectivity, and function Climate change Loss of biodiversity Poaching Fast development of hard barriers Loss of ecosystem resilience Limited financial resources available for environmental protection Human-wildlife conflict

⁵ <https://www.eurolargecarnivores.eu/en/>

2.2. On-going and forecasted land-use changes

One of the greatest and long-term challenges of the region is growing/increasing infrastructure development, which leads to increased landscape and habitat fragmentation. Fragmentation is a dynamic process (generally human-induced, which is the case of concern for this **roadmap**), that divides a natural environment into disconnected fragments, thus reducing its original extension. It also affects the physiology, behavior, and movement patterns of many plant and animal species. Being unable to move between habitat increases species vulnerability potentially culminating in local and regional extinction (Okániková, et al., 2019).

Wildlife depends on connected landscape structures to maintain a continuous exchange of genetic resources, food sources, and especially to adapt to climate change. Despite thousands of years of human-wildlife cohabitations, humans have often recently shaped and profoundly altered landscapes over the span of a few decades with little thought given to the cumulative impacts and at an unprecedented pace ([17]; [18]; [19]).

In a landscape intensively used by humans, the most efficient method to avoid population and habitat fragmentation is to define a sufficiently dense network of migration corridors that interconnect otherwise isolated sites of species occurrence. These ecological corridors need then to be incorporated into national and local land-use, development, and conservation plans in order to ensure their long-term functionality. Adequate spatial planning processes need to harmonize development needs with conservation requirements, preventing further fragmentation while maximizing economic development opportunities ([16]; [17]).

1.2.2. Urbanization

Big towns and interconnected villages surrounding mountain ranges can generate significant barriers of impermeable human landscape features, especially as their growth and development leads to territorial expansion and linear development. In dispersed settlements, agriculture can pose a threat to connectivity when it leads to a proliferation of fences or a higher density of agro-chemical application. Moreover, increased urbanization and agricultural activities increase the likelihood of human-wildlife conflict.

In many regions of Slovakia, the Czech Republic, and Romania, this effect is already visible at species with large spatial and/or high migration requirements (such as large mammals) which are particularly threatened by the development of linear infrastructure such as motorways, roads, and railways (Okániková et al., 2019).

1.2.3. Linear infrastructure

In the Carpathian region, fast infrastructure development (with a predominant role of roads and railways) has had a profound impact on the surrounding ecosystems (Iuell et al., 2019; Georgiadis et al., 2016). This rapid development within the last few decades has significantly contributed to the increase in landscape fragmentation, which in turn limits the dispersal and genetic exchange of wildlife across habitats and regions. Landscape and habitat fragmentation (including aquatic habitats) driven by infrastructure development has been identified as one of the major threats to the preservation of the unique biological and landscape diversity of the Carpathians (Kadlečík, 2016; Morris, 2014).

Large megafauna is often the most affected by these infrastructure developments, due to their extensive territories and wide regular movements across them. In the Carpathians, three species with extensive ranges and high mobility are especially threatened: the grey wolf (*Canis lupus*), the Eurasian lynx (*Lynx lynx*), and the brown bear (*Ursus arctos*) (Okániková et al., 2019). In lands experiencing intensive human use, the most efficient method of avoiding fragmentation of populations of the above-mentioned species is to define a sufficiently dense network of migration corridors that interconnects individual sites of species occurrence.

1.2.4. Blue spaces and blue infrastructure

Proximity and access to water have been central to both human settlements and wildlife wellbeing throughout history. For humans, besides providing sources of drinking water and food, water and the 'blue space' around it facilitate

transport, commerce and power generation, and allow for recreation and tourism. For the wildlife, on the other hand, blue spaces are the most required key resource, as daily life of every living organism is determined by spatial and temporal surface water distribution (Epaphras,2007). Given this importance, the efficient regulation of blue spaces in the Carpathian region is thus the key for both human and wildlife wellbeing in that area.

In today's world, however, blue spaces are considerably affected by climate change-related impacts. Changes in climate are stressing both urban and rural areas with an increased number of heat waves, droughts, and inland flooding. River regions are exposed to great hazards, as they are more affected by the frequent storm surge and river level rise (Rosenzweig et al., 2011). There is thus an urgent need to make sure that blue spaces are managed in a more efficient manner. To solve this concern, various states are investing more into the planning and building of blue infrastructure (e.g., canals, harbor walls) into both urban and rural planning. Some action has been taken in the region addressing this challenge, such as the Ramsar Convention's Carpathian Wetland Initiative⁶, but their further integration with other landscape-level initiatives and an ecological corridor approach is missing.

In this context, managing surface water in the rural areas of the Carpathian region requires new approaches that integrate the knowledge about territorial patterns and processes into the development of management practices and control structures designed for hydraulic and ecological performance. As integrated systems, blue infrastructure can reduce runoff, increase biodiversity, and offer cultural/health benefits through public access to valued natural resources.

Additionally, blue networks as rivers in Carpathians play a natural fragmentation role especially when they are used as waterways, and as their valleys are the main zones for road and railway development a parallel and multiple linear system of barriers increase the level of the fragmentation. Addressing the securing of the ecological connectivity in such cases an overall cumulative impact assessment has to be carried out (Hlavac et al, 2019).

1.2.5. Agriculture

The other main driver of habitat fragmentation is agricultural expansion and intensification. Agriculture (including farming and animal husbandry, among other agricultural activities) is essential to sustain human life but, if not managed appropriately, it can lead to habitat fragmentation, human-wildlife conflict, and biodiversity loss. Especially monocultures and the intensive use of agrochemicals can have negative effects. However, agriculture can create positive effects as well, depending on the planted species and agricultural practices, such as through the creation of additional ecotones and habitat niches that prompt higher levels of biodiversity ([26]).

Forestry needs special consideration, due to its implications on connectivity. Forestry involves the development of forest roads and selective logging of timber species, which can have important negative impacts for ecosystem structure and function where not managed adequately. Moreover, often forestry activities often involve the clearing of natural forests and their replacement with monoculture forests, with harmful effects on biodiversity and an increased vulnerability to stresses such as plagues (e.g., bark beetle) and climate change.

The EU CAP included amongst its objectives the role of farmers as stewards of the land and its biological diversity, as well of the wider agricultural landscapes, hence introducing clear environmental provisions into its framework ([27]). This can support the adoption of best environmental practices in the region, and acts as a foundation for the introduction of ecological practices into planning in the region.

1.2.6. Deforestation and overlogging of critical forest habitat

Over the last decade, there has been a sharp increase in the legal and illegal logging of forest across the Carpathians to cater the international demand (including within the EU) for precious timber. Reports of legal illegal logging in Romania (Shickhofer & Schwarz, 2019) and Ukraine (Earthsight 2020) warn of "catastrophic" reductions in forest

⁶ www.cwi.sk

covers and illegal activities within protected areas harboring high-biodiversity value ecosystems and primary and old-growth forests, being a significant driver of biodiversity loss and ecosystem fragmentation.

1.2.7. Energy infrastructure development in natural grasslands

Except of forests, large natural areas especially in mountain areas are threaten by the installation of windfarms and solar panels under the demand of development of renewable energy (Georgiadis et al, 2020). This demand leads to the loss of important grassland habitats but the same time decreases the isolation of critical areas for large carnivores and birds of prey [41]. Increasing the ability to approach natural refuges for wildlife, poaching and illegal logging on critical forest habitats and especially on old forests is leading to decreasing of their conservation. An adoption of the Roadless areas approach has to be established in Carpathian Ecoregion towards support the wilderness and the cohesion of mountain areas (IENE, 2014).

Table 8. SWOT analysis of “on-going and forecasted land-use changes”.

Strengths	Weaknesses
<ul style="list-style-type: none"> Considerably large protected areas Existence of Carpathian Convention as a forum for regional cooperation and policy coordination Network of NGOs and civil society organizations across the region 	<ul style="list-style-type: none"> Fast infrastructural development associated with lack of planning and inclusion of landscape connectivity considerations Increasing built environment Land-use change – traditional land-use loss Monoculture agriculture Habitat loss, degradation, and fragmentation Road mortality of wildlife Cumulative effect of barriers Low connectivity between existing protected areas (leading to poor ecosystem network function)
Opportunities	Threats
<ul style="list-style-type: none"> Land-use change into smaller intensive/precision agricultural solutions; changing livelihood expectations Change of transport technology (reduced CO2 emissions, renewable fuel types, shared mobility) Rehabilitation of missing eco-corridor elements and connections Mitigation measures Subsidies from CAP Relatively low density of infrastructure (currently) Leveraging on tourism to build sustainable, resilient local livelihoods The EU Green Deal and the restoration targets 	<ul style="list-style-type: none"> Lack of impact of nature protection on spatial planning process New technology doesn't decrease transport load – same territory need for capacity requirement Silent electric vehicle technology increases road-kill Lack of acceptance of Nature protection principles in EIA Lack of sectoral knowledge for high quality mitigation measure implementation Lack of well targeted funds Deforestation and overlogging of primeval forests (and high international demand for timber) Human-wildlife conflict Lack of cumulative impact assessment on infrastructure development

2.3. Legislation

Ecological networks can positively influence the functioning of habitats and survival of species in fragmented natural areas and human-dominated landscapes. They provide a model for conserving biodiversity, based on ecological principles while allowing a sustainable degree of human exploitation of the landscape. Wildlife depends on habitats of good quality and adequate size in order to survive and prosper. The protection of endangered natural habitats is therefore essential to the conservation of biodiversity in the Carpathians, Europe, and worldwide. Integrated legislative frameworks taking into consideration biodiversity and ecological values from an ecosystem and landscape approach are a key building block for the sustainable natural resource management (Hlaváč et al, 2019).

3. From Global thinking to Local Acting

3.1. International context

National biodiversity legislation often follows the lead of international policy developments undertaken on the aegis of major international conventions for the protection of the environment. In this regard, it is worth mentioning the CBD (the objectives of which are protecting biodiversity at all levels, sustainable use of its components, access to genetic resources and fair and equitable sharing of benefits from their use, mainstreaming biodiversity in development sectors) ([2]; [3]; [4], [37]), the **CITES** (regulating wildlife trade) ([28]), the **CMS** (concerning migratory species) ([6]), the Ramsar Convention (concerning the protection of wetlands) ([39]), and the **UNFCCC** (addressing climate change) ([29]). 2020 will be a key year for international biodiversity, since the current CBD Strategic Plan 2011-2020 (the “Aichi Targets”, [2]) is coming to an end. A new framework with more ambitious goals is currently in the making, and will be agreed upon at CBD COP15⁷.

The UNFCCC Paris Agreement (2015) sets specific goals to reduce emissions from deforestation and forest degradation, and to strengthen the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks. It also proposes alternative policy approaches, such as joint mitigation and adaptation approaches for the integral and sustainable management of forests, while reaffirming the importance of incentivizing, as appropriate, non-carbon benefits associated with such approaches ([29]). The Espoo Convention on Environmental Impact Assessment on a Transboundary Context ([30]) also deserves a special mention in the context of accelerating regional development and shared regional spatial planning and conservation objectives.

3.2 European and cross-continental regional level

At the internationally regional level between continents, relevant frameworks include **AEWA** ([31]), a flyway-level convention for the protection of migratory birds across Europe, Africa and Eurasia, though Serbia and Poland are not parties to this agreement. Another relevant framework is the **Bern Convention** ([13]) (covering 39 European and non-European States, including all Carpathian States) and its **Emerald Network** ([32]), an ecological network built of “areas of special conservation interest”, set up by the Council of Europe in 1989 and launched in 1996. The Bern Convention (1979) aims to conserve wild flora and fauna and their natural habitats, especially those species and habitats whose conservation requires the co-operation of several states. Furthermore, it seeks to promote such co-operation and to give special attention to the protection of areas that are of importance for the migratory species in its Appendices I and II. The Council of Europe also advanced the **European Landscape Convention** ([19]), which promotes the protection, management, and planning of landscapes and organizes international cooperation on landscape issues.

The **European Union** has been a pioneer in terms of policies for the protection of environment and biodiversity. The **EU Birds (2009) and Habitats (1992) Directives** ([11]; [12]; [15]) set the building blocks for the protection of European biodiversity and the establishment of the **Natura 2000 Network** of natural sites, extending along 27 EU Member

⁷ Due to the current COVID-19 emergency, the event has been postponed. It was originally scheduled on 15-18 October 2020 in Kunming, Yunnan (China). It is now expected to take place in 2021.

States. The Natura 2000 network is currently being created in Serbia under the “EU for Nature 2000 in Serbia”, as part of the preparatory work for a possible future accession to the European Union.

Other EU policies relevant to biodiversity and habitat protection as well as to infrastructure development include the EU 2020 Biodiversity Strategy ([8]), the EU Environmental Impact Assessment ([33]), the Freshwater Framework Directive ([34]), the European Green Infrastructure Strategy ([9]) and The European Green Deal ([35]) amongst many others. However, EU policies only apply in 5 out of the 7 Carpathian States, leaving out Serbia and Ukraine.

Together, the Emerald and Natura 2000 networks have protected vital habitats and contributed to improving the conservation status of rare species. Both have focused on wide-ranging species, like large carnivores, the conservation of which requires cooperation between neighboring states. But, until now they have depended on the individual nations for implementation.

In the case of the Carpathian range, the single most relevant piece of policy is the Framework Convention on the Protection and Sustainable Development of the Carpathians, or **Carpathian Convention** ([21]). This is the only multi-level governance mechanism covering the entire Carpathian area, and the main instrument for transboundary cooperation in environmental issues in the Carpathians. In the framework of the Memorandum of Cooperation between the Secretariat of the Carpathian Convention and the International Council for Game and Wildlife Conservation signed in Rožnov pod Radhoštěm, a workshop laid the basis for achieving the harmonization of monitoring of large carnivores in the Carpathians. It was organized in Eger (Hungary) in October 2018 as a part of the 5th Forum Carpathicum. The workshop initiated the preparation of the report on the population status of large carnivores and monitoring methods in every Carpathian country as one of the most important strategic actions under the umbrella of the Large Carnivore Action Plan (“International Action Plan on the Conservation and Sustainable Management of the Carpathian Large Carnivores Populations”, currently under development by the Secretariat of the Carpathian Convention).

Another initiative worth noting for the Carpathian ecoregion is the **Carpathian Wetland Initiative**⁸. The CWI is a Ramsar regional initiative, whose mission is to ensure and support the effective conservation and wise use of wetlands in the Carpathian region and beyond, through local, national, regional, and international activities. The mission of the CWI is to facilitate collaboration between the Ramsar and Carpathian Conventions.

3.3. National level

However, it is at the national level that we find the main challenges regarding legislation ConnectGREEN has undertaken an assessment of national legislations related to spatial planning and ecological corridors, which is reflected in two outputs:

- **Output 3.3.1.** State of the Art Report on the existing planning systems and their application for ecological corridor identification and management in the Carpathians.
- **Output 3.3.2.** Gap analysis on the identification of the needs for improving the planning processes and tools related to ecological corridors identification and preservation.

In general, all of the Carpathian countries express the importance of ecological networks in their policy framework (including their 2020 action plans/strategies). In many cases, the implementation of this concept has not been effectively completed.

The most important gap is about the **types of regulations and consistency**, with many regulatory frameworks being either weak (such as non-binding agreements, or limited to background documents), inconsistent, insufficient, or lacking means and/or provisions for enforcement. Generally speaking, gaps in the protected areas-related policy framework consist of irregularities and insufficient regulations and sanctions in the field of spatial planning for the

⁸ www.cwi.sk

protection of natural heritage, conflicts of competences between authorities in these fields, and poor implementation of legal provisions.

ConnectGREEN has also identified gaps related to the **social agreement and conflicting interests** and **Institutional framework** in more than one country, with different interest groups with conflicting interests causing serious problems during the implementation of the regulations and programs. Also, ineffective SEA and EIA implementation has been identified as a key challenge in some cases. Furthermore, it was also found that the **methodology** applied to the identification, definition, and protection of the corridors is often outdated. Last, the lack of sufficient **financial resources** was identified as a key challenge for the implementation of regulatory frameworks.

There is currently no established methodology for planning an ecological corridor, several projects (national and European) making steps ahead and proposing different approaches. ConnectGREEN has also taken the lead on this regard. **Output 3.1** created a **Methodology for the identification of migration corridors for large carnivores in the Carpathian Countries** (Okániková et al., 2019), which set the foundation for this document.

Table 9. SWOT analysis of “Legislation”.

Strengths	Weaknesses
Comprehensive body of international and regional policy for the protection of biodiversity Strong and standardized legislation at EU level Existence of Carpathian Convention as a forum for regional cooperation and policy coordination Network of NGOs and civil society organizations across the region	Weak execution of international and EU legislation commitment Back steps in embedding nature protection horizontal principles in sectoral policies Lack of cooperation in sectoral policy making Uncertified authority responsibilities and tasks on illegal killing treat as criminal acts Weak cross-border cooperation
Opportunities	Threats
Strengthen laws according to international/regional/EU level policy commitments Strengthen implementation of regional/EU requirements Renew sectoral cooperation affected by climate change resilience solutions Strengthen regional cooperation for environmental protection and infrastructure development	Different sectoral approaches Historical disagreements within sectors and actors Lack of funds – no execution of policy Conflicting policies and priorities within and between countries Human-wildlife conflict

4. Awareness of natural capital

On the social dimension, the **awareness** of the value of the natural capital of the Carpathian ecoregion is largely absent in all the Carpathian countries. ConnectGREEN project identified that, when interviewed for the preparation of the guidelines on transport impact mitigation (Hlaváč, et al., 2019; [22]), most of the locals and the stakeholders were not aware of the importance of the ecological network, and they confirmed the need for information campaigns and awareness raising activities. However, in the wider society, this trend is changing [18].

Community involvement and understanding of the wildlife corridor concept is essential and will assist in the future formation of partnerships between local communities and governmental authorities to establish and manage corridors. Though there is a growing awareness across society about the threats to biodiversity and ecosystems, and even about the global scope of these problems, there is a weak knowledge about the ways to enhance nature management and protection, improve spatial planning approaches, and mitigate biodiversity and habitat loss and degradation. This is true both for both the wider public and those in the sector of the grey infrastructure (Hlaváč et al., 2019; Okániková et al., 2019; [18]; [36]).

In all the Carpathian States, legal frameworks define the stakeholders, public bodies (e.g., ministries, public enterprises, and public institutions), and their respective roles and responsibilities. In EU countries, the SEA Directive ([38]) favored the engagement of stakeholders in spatial planning processes. In the Carpathian region, it is the right of citizens to be consulted in (and request information of) the decision-making process regarding the development of environmental policy and legislation, issuance of regulatory acts in this field, and the elaboration of related plans and programs. However, in practice, public participation is limited due to a lack of human and financial capacity as well as lack of interest, reducing public participation to a mere giving of information, rather than a real process of discussion and cooperation (Hlaváč et al., 2019; Okániková et al., 2019; [1]; [3]; [9]; [11]; [12]; [16]; [18]; [22]; [33]).

It is important to make sure that resource managers, planners, and decision-makers have access to the most up to date research and monitoring results on ecological connectivity, corridors, as well as the management plans of the protected areas. To achieve this, a solution might be to invest resources or supporting ongoing practices in workshops or capacity-building and training, or supporting already existing cooperation initiatives with relevant institutions, key research institutes, and universities in order to make the conversation on the topic more effective. Public institutions may also invest in facilitating the sharing of knowledge for landscape connectivity and corridor conservation gained during applied practice (Appleton-Meyer, 2014; Chapron et al., 2014; Choi-Lee, 2019; Hlaváč et al., 2019; Luell et al., 2003; Okániková et al., 2019; [1]; [2]; [3]; [4]; [5]; [9]; [16]; [17]; [32]; [36]).

Efforts should be made to build up a culture of mutual learning, as well as to support continuous evaluation and exchange of knowledge and experience among the interested, relevant, and authorized organizations and state services. Environmental Officers of diverse organizations and institutions are involved in community presentations and workshops on a range of topics and the ecological corridor strategies can be promoted as part of these activities given its integrated nature and linkages with many other environmental projects (Appleton-Meyer, 2014; Chapron et al., 2014; Choi-Lee, 2019; Hlaváč et al., 2019; Luell et al., 2003; Okániková et al., 2019; [1]; [2]; [3]; [4]; [5]; [9]; [16]; [17]; [32]; [36]).

Funding is an important factor for the implementation of such a comprehensive and long-term environmental project such as this ecological corridor strategy, and has strong implications regarding its success over time. Proper funding through active contribution from all states in the region is required to ensure successful implementation of this strategy. Project activities could even be aligned with EU processes and be supported by EU projects (Hlaváč et al., 2019; Okániková et al., 2019).

Table 10. SWOT analysis of “Awareness of natural capital”.

Strengths	Weaknesses
General requirement of protection from the society (with expectancies) Existence of Carpathian Convention as a forum for regional cooperation and policy coordination Network of NGOs and civil society organizations across the region	Not in my back-yard effect Potential human-wildlife conflict, fear of wild large-sized carnivores Lack of information and knowledge and/or access thereto

	<p>Lack of sufficient levels of awareness amongst the general public and stakeholders Weak „Green” authority in some countries</p>
Opportunities	Threats
<p>Proper information through projects to different target groups Multilevel/multi-sectoral communication Involvement – understanding – awareness flow Growing awareness amongst the general public Awareness raising through tourism, environmental education, and environmental interpretation</p>	<p>Poaching Provision of incomplete and/or inaccurate information can lead to even more misunderstanding Conflicting priorities and policies within and between countries</p>

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Glossary

Barrier effect – Combination of different factors (technical structures and their parameters, disturbances, fauna mortality) that together decrease the probability and success rate of crossing linear infrastructure by wildlife.

Biodiversity/Biological diversity – The richness among living organisms including terrestrial, marine, and freshwater ecosystems and the ecological complexes of which they are a part. It includes diversity within and between species and within and between ecosystems as well the processes linking ecosystems and species.

Biotope – The area inhabited by a distinct community of plants and animals. Biotope is commonly used among central European ecologists to describe distinct land units and vegetation patches identified from an anthropocentric perspective. Biotope is often confused with and exchanged by the term habitat.

Blue infrastructure – The network of natural, semi-natural, and man-made freshwater elements and systems, including rivers, canals, ponds, wetlands, floodplains, water treatment facilities, reservoirs, and others.

Buffer zone – Peripheral areas intended to enhance protection of sensitive habitats, e.g. protected sites, from negative impacts of infrastructure such as pollution or disturbance.

Connectivity – The state of structural landscape features being connected, enabling access between places via a continuous route of passage. The physical connections between landscape elements.

Connectivity Conservation Area – A recognized large and/or significant spatially defined geographical space of one or more tenures that is actively and equitably governed and managed to ensure that viable populations of species are able to survive, evolve, move, and interconnect within and between systems of protected areas and OECMs.

Conserved Areas/OECMs (Other Effective area-based Conservation Measures) – A geographically defined area other than a protected area, which is governed and managed in ways that achieve positive and sustained long-term outcomes for the in-situ conservation of biodiversity with associated ecosystem functions and services and where applicable, cultural, spiritual, socio-economic, and other locally relevant values. The main aim of these areas is to act as effective in-situ conservation sites for biodiversity, and often also have secondary accompanied by other secondary objectives (such as sustainable resource use).

Core areas – Areas meeting the habitat and size requirements of target species for their sustainable permanent occurrence and providing them with sufficient food supply, shelters, breeding, and dispersal conditions.

Critical zones – Localities with significant limitations of the land permeability owing to the difficult passable migration barriers. Barriers are often concentrated in one point because of topographic conditions and create a cumulative barrier effect. Sometimes there are cases where separate barriers (e.g. road of lower category, rail, and arable land) would not represent a connectivity challenge in the landscape, but where the accumulation of such barriers creates a critical zone.

Ecological connectivity – The binding or interconnection of eco-landscape elements (semi-natural habitats, natural habitats, or buffer zones) and biological corridors between them from the point of view 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.

Ecological corridor – A clearly defined geographical space, not recognized as a 'protected area' or an 'OECM', that is governed and managed over the long-term to conserve or restore effective ecological connectivity, with associated ecosystem services and non-material benefits (such as recreation and cultural and spiritual values, among others). The TransGREEN and ConnecGREEN projects adopted definitions of different types of corridors:

- **Ecological corridor** – Landscape structures of various size, shape, and vegetation cover that mutually interconnect core areas and allow migration of species between them. They are defined to maintain, establish, and/or enhance ecological connectivity in human-influenced landscapes.
- **Wildlife corridors** – Corridors that allow the movement of a wide range of organisms between high natural value areas.

- **Critical zones** – Zones critical in terms of barrier permeability, e.g., places where migration is directly threatened mainly by line barriers (highways, settlements etc.) and/or by cumulative effect of barriers.
- **Critical connectivity sector** – Narrow and/or single permeable linear infrastructure sector.
- **Critical connectivity area** – A special type of "wide & short corridors", an area that connects suitable habitats divided by a barrier (e.g., a narrow lane of road and surroundings that cuts through a continuous forest).
- **Migration corridors** – Corridors that allow animal movement (both regular and irregular) between areas of their permanent distribution (core areas).
- **Migration zones** – Relatively suitable habitat, which must be preserved in order to maintain the landscape connectivity between patches of suitable habitat.
- **Movement corridors** – Corridors that allow animal movement within core areas (including daily movements in search of food, etc).
- **Linkage area** – An area of relatively suitable heterogeneous habitat, but in which the corridor cannot be clearly defined, and connects two or more patches of suitable habitat.

Ecological network – Coherent system of natural and/or semi-natural landscape elements configured and managed with the objective of maintaining or restoring ecological functions as a means to conserve biodiversity while also providing appropriate opportunities for the sustainable use of natural resources (Bennett 2006). Ecological network consists of core areas, corridors and buffer zones.

Emerald Network – The network of Areas of Special Conservation Interest to conserve wild flora and fauna and their natural habitats of Europe, which was launched in 1989 by the Council of Europe as part of its work under the Convention on the Conservation of European Wildlife and Natural Habitats or Bern Convention (which came into force on 1 June 1982).

Fragmentation (of landscape, habitats, and/or populations) – Process, in which a formerly continuous landscape is divided into increasingly smaller units that are mutually isolated, or reduced in area. Such units then gradually lose their potential for fulfilling their original functions. Transformation of large habitat patches into smaller, more isolated fragments of habitat⁹.

Grey infrastructure – The network of man-made structures and engineering works, including buildings, roads, railways, power lines, and other urban constructions.

Green Infrastructure – A strategically planned network of high quality natural and semi-natural areas with other environmental features, which is designed and managed to deliver a wide range of ecosystem services and to protect biodiversity in both rural and urban settings.

Habitat – The type of site (vegetation, soils, etc.) consisting of biotopes, where an organism or population naturally occurs - including a mosaic of components required for the survival of a species. Assemblage of all biotic and abiotic factors that create the environment of a specific species, population, and/or community.

Habitat of large carnivores – Habitat of the core areas, corridors (including linkage areas) and critical zones for large carnivores.

Habitat suitability patches – Optimal habitat for long term or temporal occurrence of certain species.

Home range – Area regularly used by an individual, where it satisfies its basic needs.

Land use/spatial planning – Activity aimed at predetermining the future spatial usage of land and water by society. Process of spatial planning with aim of using the landscape resources in a sustainable way, balancing socio-economic and environmental needs and conditions.

⁹ <https://www.eea.europa.eu/publications/landscape-fragmentation-in-europe>

Linkage areas – Broader areas of connectivity important to facilitate the movement of multiple species and to maintain ecological processes within two or more neighboring core areas, where delineating clear migration corridors for species is difficult due to relatively high degree of permeability.

Migration – Regular (and often periodical and predictable) movement of animals outside of their usual territories and/or ranges. For the purpose of TRANSGREEN¹⁰ and ConnectGREEN¹¹ projects, the term migration is applied also to other types of animal movement (within home ranges, food searching, dispersal of young, etc.).

Migration barrier – Natural and anthropogenic structures in the landscape which restrain the free movement of the animals.

Natura 2000 – Network of protected natural sites identified as Sites of Community Importance / Special Areas of Conservation (SACs) under the Habitats Directive 92/43/EEC, or classified as Special Protection Areas (SPAs) under the Birds Directive 79/409/EEC (amended as 2009/147/EC). Together, the SPAs and SACs designated by the Member States make up the European network of protected sites, Natura 2000.

Natural capital – The World's stock of natural assets which include geology, soil, air, water, and all living things. All the land, minerals, and fossil fuels, solar energy, water, living organisms, and the services provided by the interactions of all these elements in ecological systems.

Permeability (of linear transport infrastructure or landscape) – The ability to let animals safely pass through.

Protected areas – A clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values. In this areas, biodiversity conservation is the primary objective.

Linkage areas – Smaller patch of suitable habitat used by individuals as transitional site during migration or dispersal.

Target species – A species that is the subject of a conservation action or the focus of a study.

Wildlife – Wild animals collectively; the native fauna (and sometimes flora) of a region; animals and plants that grow independently of people, usually in natural conditions.

¹⁰ TRANSGREEN aims to contribute to safer and environmentally friendly road and rail networks in mountainous regions of the Danube Basin with a special focus on the Carpathian Mountains (<http://www.interreg-danube.eu/approved-projects/transgreen>).

¹¹ ConnectGREEN aims to cope with the increasing ecosystem fragmentation in the Danube region in order to improve ecological connectivity between natural habitats, especially between Natura 2000 sites and other categories of protected areas in the Carpathian ecoregion. Specifically, it focuses on improving the restoration and further maintenance of ecological corridors to secure a viable population of large carnivores and preserve one of the largest biodiversity hotspots on the continent. (<http://www.interreg-danube.eu/approved-projects/connectgreen>).

Abbreviations

AEWA	African-Eurasian Waterbird Agreement
CAP	Common Agricultural Policy of the European Union
CBD	Convention on Biological Diversity
CITES	Convention on the International Trade of Endangered Species
CMS	Convention on Migratory Species
EIA	Environmental Impact Assessment
EU	European Union
IENE	Infra Eco Network Europe
OECMs	Other Effective area-based Conservation Measures
SAC	Special Areas of Conservation
SCI	Sites of Community Importance
SEA	Strategic Environmental Assessment
SPA	Special Protection Areas
UNFCCC	United Nations Framework Convention on Climate Change

I. Chapter: Methodology for identification of ecological corridors in the Carpathian countries by using large carnivores as umbrella species

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II. Chapter: Summary on best practices addressing ecological connectivity and spatial development project activity

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