

OPEN BORDERS FOR WILDLIFE IN THE CARPATHIANS (OBWIC) PROJECT

CONNECTIVITY REPORT – Draft 1

February, 2020



Map of OBWIC project transboundary area

CONTEXT

Our region is home to over a third of the approximately 12,000 wolves, 17,000 bears and 9,500 lynx living in Europe, excluding Russia. An estimated 8000 brown bears live in Central and South-eastern Europe. These ecologically critical, strictly protected and culturally significant mammals are threatened not only by poaching, but also by increasing fragmentation and shrinkage of their habitats brought about by the construction of roads and other infrastructure. Despite challenges, in recent years large carnivore populations, particularly wolves, have expanded both within our region and to other parts of Europe - often putting them into closer proximity with humans and leading to new challenges.

[Open Borders for Wildlife in the Carpathians¹](#) (OBWIC) project (1.10.2019 – 31.03.2022) will address some of these issues by creating stronger regional cross- border cooperation on sustainable development, biodiversity and landscape conservation in the ENI Carpathians (border area of Hungary-Slovakia-Romania-Ukraine). The project partners will work to maintain and improve ecological connectivity between habitats, as well as to maintain ecosystem services for the benefit of local communities, regions and society in general. The project targets preservation of common natural values on a landscape level, demolishing the negative effects of political borders on habitats.

INTRODUCTION

Based on desktop research and analysis of existing initiatives related to development of methodologies for identification and designation of ecological corridors at regional Carpathian level, the team are compiling the present draft report of the most appropriate methodology for the identification of ecological corridors of transboundary interest in the ENI Carpathians by using large carnivores (bear, wolf, lynx) as umbrella species. The structure of the present report has two sections:

- i) the first one enumerates some of the relevant connectivity initiatives from the Carpathian Mountains, with a special focus on the ConnectGREEN project (<http://www.interreg-danube.eu/approved-projects/connectgreen>) as we assumed that the outcome of the project (Methodology for Identification of Migration Corridors for Large Carnivores in the Carpathian Countries) will ensure synergies with OBWIC project.
- ii) the second section comprises the draft of the proposed methodology for identification and designation of ecological corridors that will be further on developed by the OBWIC transboundary expert group and put under a consultative forum input.

¹ The project is funded under the Hungary-Slovakia-Romania-Ukraine, [ENI Cross-border Cooperation Programme](#) 2014-2020. Project partners include [WWF-Romania](#) – Maramureş Branch as lead beneficiary, the [Slovak Ornithological Society/BirdLife](#), NGO RachivEcoTur (Ukraine) and [Aggtelek National Park](#) (Hungary).

I. RELEVANT INITIATIVES - PROJECTS RELATED TO CONNECTIVITY IN THE CARPATHIANS, PAST AND NEAR FUTURE

1. Project: Creation of Ecological Corridors in the Ukrainian Carpathians, Poland, Ukraine and Romania, 2010, In order to develop a methodology for the creation of functional and consolidated ecological corridors for the Carpathians, a pilot study has been conducted in two locations in Ukraine, thus creating corridors connecting Ukrainian protected areas with protected areas in Romania and Poland. The methodology was based on landscape ecological modelling, using the habitat requirements of brown bear, European bison, lynx and wildcat to locate the most suitable corridor areas. Manageable corridors were created by identifying interconnected land management units with a minimum of obstacles for wildlife and conflicts with land use, and forming the shortest possible connection. The location of the corridors and their management plans were developed in consultation with the users and owners of the land. Approval and inclusion of the corridors in the spatial planning system was achieved following a model elaborated after analysis of the Ukrainian institutional and regulatory framework related to ecological network development.

The pilot study has been carried out in two locations in the North-Western and the South-Eastern parts of the Ukrainian Carpathians, establishing local level ecological corridors between selected protected areas in Ukraine, Poland and Romania. The location in the North-West relates to the area between Skolivski Beskydy National Nature Park in Ukraine and Bieszczadzki National Park in Poland, while in the South-East it relates to the area between Vyzhnytskyi National Nature Park and the border with Romania towards Vânători-Neamț Nature Park.

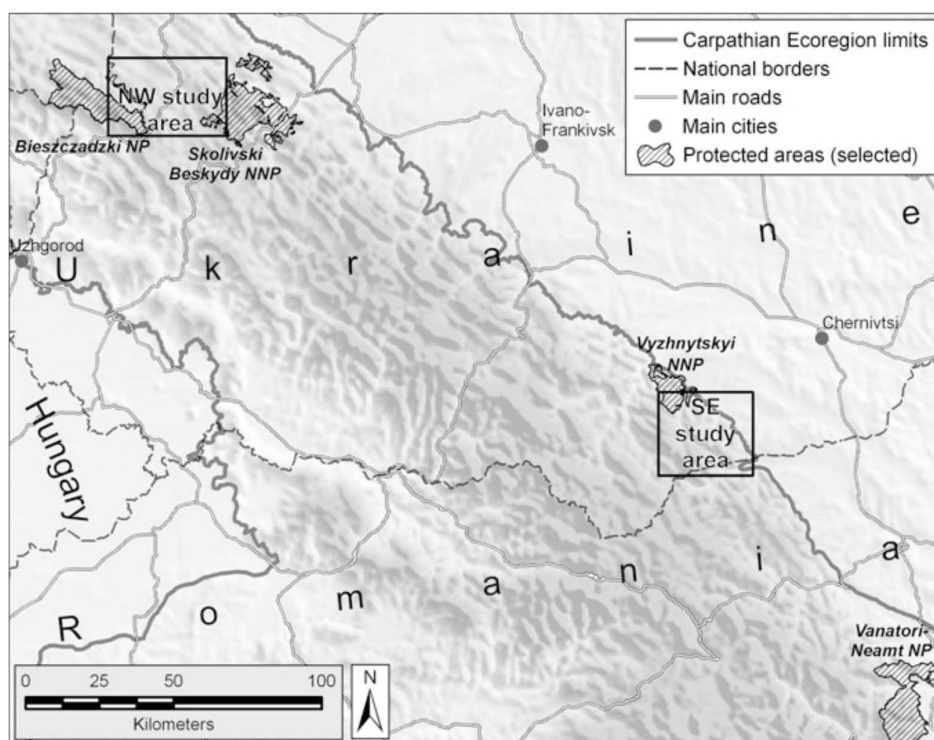


Fig. 1. Pilot areas for project Creation of Ecological Corridors in the Ukrainian Carpathians, Poland, Ukraine and Romania, 2010

More information on

https://www.researchgate.net/publication/290367845_Creation_of_Ecological_Corridors_in_the_Ukrainian_Carpathians

2. Project: Open borders for bears between Romanian and Ukrainian Carpathians, Romania and Ukraine, 2012-2014, donor ENI HUSKROUA Cross border Cooperation Programme 2007-2014

Maramures is one of the first regions in Romania where corridors securing bear movements between core bear habitats were identified. Properly managed, the corridors are vital elements securing free movement and healthy population of bears. The main objective of the above mentioned project was to preserve biodiversity in Maramures (historical Romanian - Ukrainian region of the Carpathians) as a critical stepping stone for the connectivity of the Carpathian Mountains by reducing the risks of habitat fragmentation, restoring ecological corridors for bears as an umbrella species and by securing responsible use of natural resources. It covered Maramures County, Romania and Ivano-Frankivsk and Zakarpatska regions of Ukraine. Critical habitats for brown bear have been identified firstly through questionnaires, field visits and various informal meetings with members of the local communities, hunters, foresters, etc. Maps with critical habitats and corridors have been generated based on the information collected. The digital model of the field for the project implementation area was completed with the critical corridors and other relevant information from the GAP analysis. It has identified the main gaps and weaknesses in the field of management and conservation of brown bears and their habitats, which serve the basis to define the right decisions for improving the effectiveness of managing and conserving the natural resources in Maramures. The project also led to the development in a participatory framework of the management measures for the network of corridors in Maramures area (Romania and Ukraine), which are the frame for cooperation among stakeholders involved in decision making and land use planning in the region.

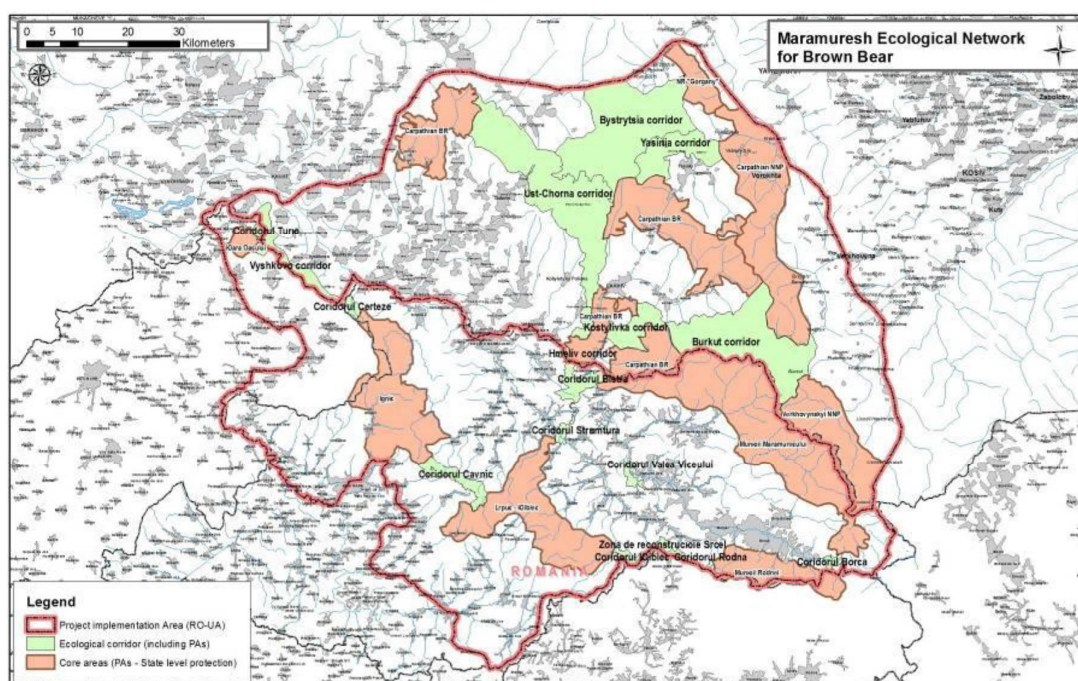


Fig 2. Maramures Ecological Network for Brown Bear

More information on http://assets.panda.org/downloads/wwf_factsheet_bear_project2014.pdf

3. MEMO on the negative impact of the planned Lugoj–Deva motorway and presentation of possible mitigation solutions, Romania, 2010

The document presents the results of a field assessment developed by a group of specialists to the designated route of the Lugoj–Deva motorway (Europe Aid 122273/D/SER/RO ISPA 2004/RO/16/P/PA/002/01; part of TEN-T Corridor IV) and specifically the sector that will intersect an extremely important ecological corridor between two mountain ranges in Romania: the Southern and Western Carpathians. Although, Romania has one of the lowest paved road densities in Europe (0.06 km/sqkm, compared to 3.5 km/sqkm in The Netherlands, for example), the volume of traffic on national roads is increasing. Some sections of road are now acting as barriers for wildlife. Sectors where major dispersal routes of large carnivores will be intersected by the motorway were identified and the impact of the construction for each of these sectors was consequently assessed. The study results clearly indicate that the mitigation measures proposed by the motorway's Final Feasibility Study and EIA are not appropriate for large carnivores and fail their securement.

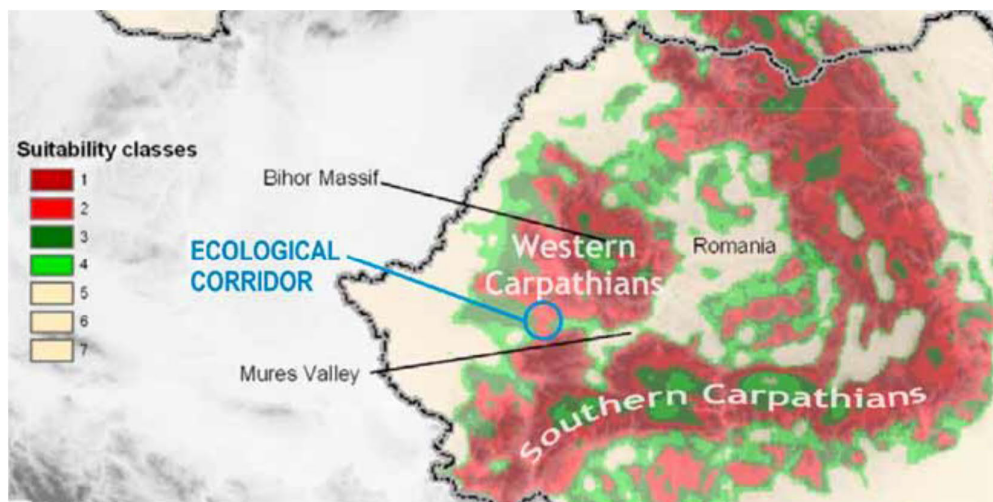


Fig 3. Location of the project area.

More information on http://assets.panda.org/downloads/memo_lugoj_deva.pdf

4. Project: Southwestern Carpathian Wilderness and Sustainable Development Initiatives, Romania, 2013-2017, Donor SWISS Cohesions Fund

The project aim was to contribute significantly to the preservation of the Southwestern Carpathians as Europe's premier wilderness area, demonstrating opportunities for conservation and management of wilderness areas including the implementation of EU legislation and support of local and regional development. The project set up the conditions for a functional network of wilderness areas in a core area of 5 protected areas (Semenic - Cheile Carasului NP, Cheile Nerei – Beusnita NP, Portile de Fier NP, Domogled – Valea Cernei NP, Retezat NP) in the Southwestern Carpathians, including improved policy and management, increased capacity of protected area managers and greater awareness and acceptance of key stakeholders. The objective is to create an ecological network at the SW Carpathian level where wildlife areas, protected natural areas and ecological corridors exist to protect and improve the health of natural ecosystems in the long term and the resilience of local communities to socio-economic challenges. Such an approach with regard to nature conservation at a large scale, as wilderness areas and landscape conservation, including the strengthening of the ecological network of protected areas from the area, should also consider climate change as well as the provision of benefits to surrounding communities that are socio-economically vulnerable at the moment.

Sustainable local and regional development related to the promotion of the Southwestern Carpathians as Europe's premiere wilderness area was supported, including the development of the area as part of the national Ecotourism Destinations programme. Relevant stakeholders such as local authorities and entrepreneurs were trained to develop, fundraise for and implement local development initiatives. Together with key stakeholders we developed The Action Plan for Wilderness in Southwestern Carpathians (https://d2ouvy59p0dg6k.cloudfront.net/downloads/plan_de_actiune_pentru_zonele_de_salbaticie_draft.pdf). Finally, project results and lessons learnt were used to inform national policymakers regarding the management of wilderness areas as well as related opportunities for sustainable local and regional development through the organization of a national roundtable and other lobbying activities.

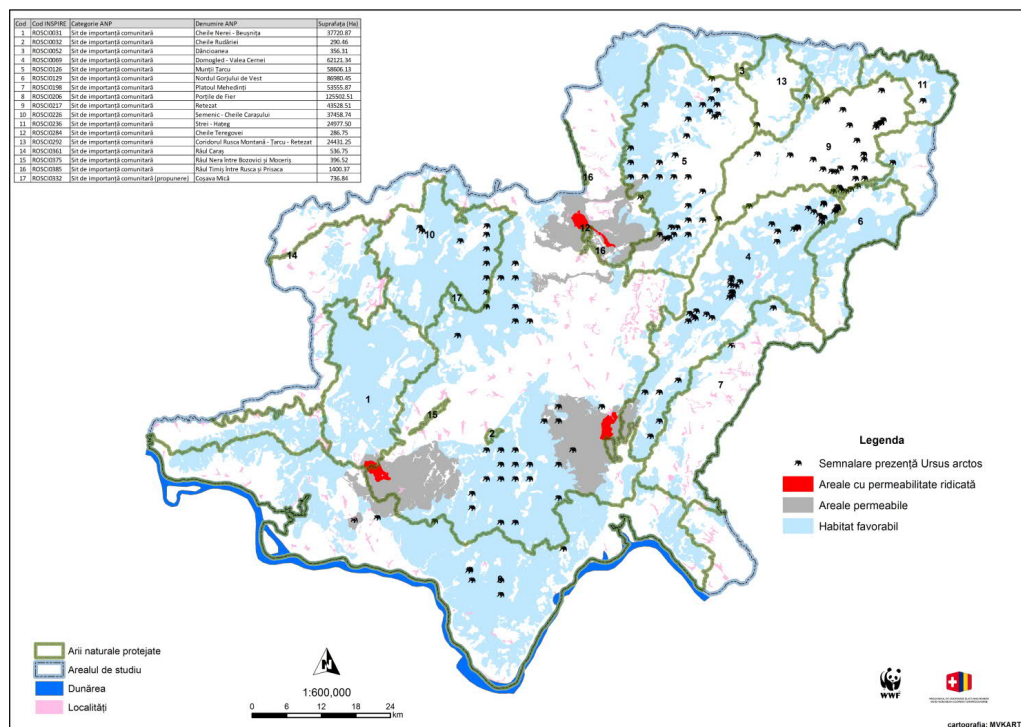


Fig. 4. Ursus arctos corridors in the wilderness area

More information on https://www.wwf.ro/ce_facem/arii_protejate/salbaticia_din_carpati/

- Project: TRANSGREEN Integrated Transport and Green Infrastructure Planning in the Danube-Carpathian Region for the Benefit of People and Nature, Czech Republic, Slovakia, Hungary, Romania, Ukraine, 2017-2019, Donor Danube Transnational Programme (DTP)

TRANSGREEN aims to contribute to safer and environmentally-friendly road and railway networks in mountainous regions of the Danube Basin with a special focus on the Carpathian Mountains. It did so by improving planning frameworks and developing concrete environmentally-friendly and safe road and rail transport solutions taking into account elements of green Infrastructure, in particular ecological corridors. Innovative pilot actions were focused on ecological corridors crossed by EU TEN-T road and railway projects in the Carpathians. Sharing experience and knowledge has been of great importance. An interdisciplinary partnership including planners, economists, engineers, and ecologists has been integrated by applying their specific knowledge across the region and cooperate on developing

“Wildlife and Traffic in the Carpathians. Guidelines how to minimize the impact of transport infrastructure development on nature in the Carpathian countries” taking into account aspects of road safety and biodiversity conservation. Partners collaborated on the production of ready-to-use methodologies for stakeholder participation processes, training modules on environmental impact assessment with a focus on ecological corridors, and catalogues of measures for each of the four pilot sites located in Beskydy (CZ-SK), Miskolc-Košice-Uzhgorod (HU-SK-UA), Tîrgu Mureş-Iasi and Arad (Radna-Deva) (RO). An inter-sectorial dialogue has been fostered at the policy level that seeks for mutual understanding and implementation of recommendations towards integrated transport infrastructure planning from the local to the transnational level including EU level.



Fig 5. Pilot sites for TRANSGREEN project

More information on <http://www.interreg-danube.eu/approved-projects/transgreen/outputs?page=1>

6. Project: MARAMURES The Green Heart of the Carpathian Mountains, with virgin forests and bears roaming across EU frontiers, Romania, 2013-2016, Donor WWF Belgium

Via the project, critical ecological corridors for bear migration in Maramures area (Romania and Ukraine) were secured through adequate protection and management measures of key ecosystems. Protection of virgin forest and sustainable forest management was obtained through: identifying and mapping virgin forest and high conservation value forest (HCVF), defining adequate management measures and ensure their enforcement in protected areas management plans, FSC certification or in connection to the ecological corridors designation. Analysis of the ownership of the identified corridors in Maramures region for ensuring their long-term security and functionality has been performed. The Project also included monitoring programme of bear population in ecological corridors, as well as assessment of existing threats.

7. Pilot project: Land development instrument testing in pilot site of Maramures, Romania for connectivity, Romania, 2017-2019, donor WWF Belgium

Project aim is to secure and manage ecological corridors for large carnivores in the Maramures area of Romania by testing land purchase / land swap as innovative instrument for nature conservation and analysing results for further replication to ensure long-term landscape and biodiversity preservation.

The pilot project tested 1 nature conservation instrument (land purchase/land swap) to ensure protection of ecological corridors in Maramures County, Romania.

Project activities include discussions and meetings with relevant stakeholders, assessment of legal cadastral documents, and development of action plan for selected pilot corridor, legal advice. The project aimed to implement an action plan for sustainable management of pilot critical ecological corridor.

8. Project: Development of the methodology for establishing ecological corridors and training the administrators of the protected areas for their better management, Romania, 2015-2017, Donor EES Grants

The project was implemented by the National Environment Guard from Romania, at the level of the General Commissariat. Taking into account the applicant's responsibilities regarding the control actions taken for the protected areas throughout the entire country, all the project's activities actually target Romania's territory. From the project's results benefited all of the 41 County Commissariats and the Bucharest Commissariat that are subordinated to the National Environmental Guard. Specific objectives of the project were: development of the methodologies establishing the ecological corridors for large mammals, migratory birds and migratory fishes; improvement of the capacity to manage and monitor the ecological corridors by training and equipping the administrators of the protected areas. Through project were elaborated a set of methodologies as: Methodology establishing ecological corridors for large mammals; Methodology establishing ecological corridors for migratory birds; Methodology establishing ecological corridors for migratory fishes. Another result of the project consists in an IT application (interactive) that helps employees of the protected areas' for efficient monitoring of ecological corridors, delimitate ecological corridors and report environmental incidents.

More information on <https://www.gnm.ro/ro02/?lang=en>

9. Project: Ecological corridors for habitats and species in Romania (COREHABS), Romania, 2015-2019, Donor EEA Grants

The project was financed by the European Economic Space (SEE) 2009 – 2014. The project implemented by the Transilvania University from Brasov as promoter focused on developing a package of methodologies for identification of ecological corridors.

The COREHABS project provided effective mechanisms for identifying, evaluating, monitoring and management of the connecting elements (corridors, areas of passage etc.) enabling the development of a coherent network of the protected areas. The project proposed the development of a typology of the ecological corridors, as well as their ranking. The COREHABS project provided a methodology to identify any type of corridors based on their typology and level. The project was based on a transdisciplinary methodology, using the same theoretical and practical knowledge from different disciplines such as biology, ecology, hydrology, geo-morphology, forestry, Sociology and Economics in the identification, mapping, assessment, development management activities and monitoring cues.

The overall objective of the project was to develop a system of methodologies necessary to establish ecological corridors at a national, regional and local level by identifying critical areas in Romania in order to create the scientific, technical and administrative conditions for the accurate definition of an effective ecological corridor system and monitoring it on a long term.

More information on <http://corehabs.ro/en/>

10. Project: Alps-Carpathians Corridor, Austria, Slovakia, 2007-2013, Donor European Commission through European Regional Development Fund

The mountain ranges of the Alps and the Carpathians, which straddle the border of Austria and Slovakia, are the largest sources of biodiversity in Central Europe. The Alps-Carpathians Corridor between these mountains has historically been a major migration route for wildlife crossing the Danube and has been disrupted by economic development. Pressure on land use in the region located between Vienna and Bratislava is considerable and a solution has been needed to combine ecological requirements with economic activity. As a part of the EU Strategy for the Danube Region (EUSDR) the Corridor is being restored to re-connect the eastern reaches of the Alps to the Western Carpathians and to support ecological connectivity and the sustainable development of the whole region. The project has brought together various institutions, NGOs, universities, as well as highway companies and regional and federal authorities from Austria and Slovakia to create a common cross-border platform facilitating the migration and genetic exchange of wild animal populations.

The project has increased the recreational attractiveness of the region and improved the environmental awareness of the population.

A joint Austrian-Slovakian Action Plan for the Corridor covering land use, communication, scientific fundamentals, protection and spatial planning has been developed. An implementation handbook is included as reference material for similar future projects. A comprehensive handbook on spatial planning has also been drawn up, which translates the spatial planning objectives into planning tools for all regional administrations.

A system of 'Green Bridges' was built to allow easy passage for wildlife and the first was constructed in Austria across the A4 Vienna-Budapest motorway. A similar wildlife overpass is being introduced in Slovakia to improve ecological connectivity across the highway from Bratislava to Brno. The Corridor's structure has created a forum for the managers of these regions to share ideas and develop solutions that can be applied within the entire region, instead of only per protected area.

To ensure long-term continuity, key stakeholders are party to a Memorandum of Understanding that contributes to sustainability in their area of responsibility. In addition, the relevant spatial development plans at regional and federal level include the results and recommendations from this project.

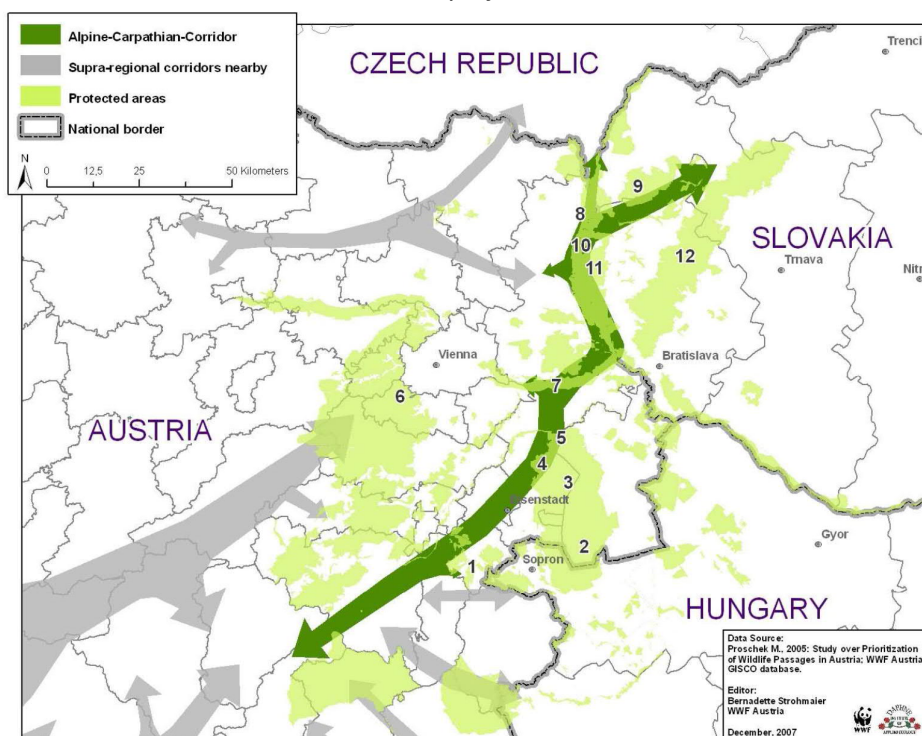


Fig. 6. Map of the Alpine-Carpathian Corridor region, major corridors and protected areas

More information on https://ec.europa.eu/regional_policy/en/projects/austria/innovative-alps-carpathians-corridor-re-establishes-a-major-migration-route-for-wild-animals

11. Project: ConnectGREEN, Restoring and managing ecological corridors in mountains as the green infrastructures in the Danube basin, Romania, Czech Republic, Slovakia, Serbia, and Hungary, 2018-2021, Donor Danube Transnational Programme (DTP)

In order to cope with the fast and increasing habitat fragmentation in the Danube region, ConnectGREEN aims at improving the ecological connectivity between natural habitats, especially between Natura 2000 sites and other protected area categories of transnational relevance in the Carpathian ecoregion. As a first step, using large carnivores as umbrella species, the project aims to develop a Carpathian-wide methodology and based on this it will identify core areas and ecological corridors used by the large carnivores.

At the level of 4 transnational pilot sites, the ecological corridors will be identified in more detail by using the above mentioned methodology. The four project pilot sites have been selected considering an equitable spatial distribution across the Carpathian ecoregion and representatives in terms of their potential contribution to safeguarding critical movement corridors for LCs and other large mammal species: (1) Piatra Craiului National Park (RO); (2) Apuseni-SW Carpathians (RO) - National Park Djerdap (SB); (3) Western Carpathians (CZ-SK) and (4) Bükk National Park (HU) – Cerová vrchovina Protected Landscape Area (SK). Three of them are transboundary sites and all of them are or at least overlap substantially with Natura 2000 sites or other PA categories.

Physical barriers and other threats will be identified and mapped in the field 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 will be 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.

Based on project results there will be a Strategy for identification and conservation of ecological corridors focusing on large carnivores' movement needs in the region. It will be enforced by the parties to the Carpathian Convention with the support of relevant Associated Strategic Partners.



Fig. 7. Map of project pilot sites prepared within the project ConnectGreen (ConnectGreen, 2019)

Methodology for identification of migration corridors for large carnivores in the Carpathian countries developed in ConnectGreen project has been divided in two sections. First section comprises practical steps and procedures towards identification of migration corridors of large carnivores. Section 2 provides reference material and additional information on topics like connectivity, target species, the Carpathians, main types of barriers, pro-connectivity measures, monitoring of pro-connectivity measures.

An approach of connected spatial structures of biotopes has become justified for the group of large carnivores (grey wolf, Eurasian lynx and brown bear) and adopted for the methodology. Once the habitat of large carnivores according to the methodology is identified, the measures to maintain and/or improve the connectivity can be developed and adopted.

Within Connect GREEN project there were two different scale approach: the level of the Carpathians and the level of Pilot areas.

At the large scale, based on a set of input data (occurrence of umbrella species and environmental variables), was developed habitat suitability model by running the MAXENT (Maximum Entropy Modelling) tool, leading to the identification of the core areas. Subsequently, resistance surface and anthropogenic barriers identification by using Opens Streets Maps Dataset provides the network of corridors. For the definition of the corridors in terms of lowest resistance to movement of species, Cicuitscape tool was used. ConnectGreen project established standards of minimum size for a core area, which is at least 300 square km, and also for minimum width of the corridors than cannot be less than 500 m. Along wildlife corridors, critical zones were identified at the intersection of proposed corridor with impermeable landscape structures (barriers). Accumulating all these data (core areas, corridors and critical zones) results the Carpathians level final map of habitats. During this process, expert verification was set-up at every step for fine tuning of the intermediate results.

At the Pilot areas level, the final map of the large carnivores was defined at this smaller scale trough verification of corridors and critical zones. The verification implies desktop verification phase and field verification also. For pilot areas, the final result is the layer of ecological network within these areas which are integrating valuable field data.

More information <http://www.interreg-danube.eu/approved-projects/connectgreen>

II. METHODOLOGY ON IDENTIFICATION AND DESIGNATION OF ECOLOGICAL CORRIDORS OF TRANSBOUNDARY INTEREST FOR "OPEN BORDERS FOR WILDLIFE IN THE CARPATHIANS" PROJECT (OBWIC)

Based on previous initiatives on connectivity for wildlife in the Carpathians, but mainly on ConnectGREEN outputs, OBWIC project will develop a methodology for IDENTIFICATION and DESIGNATION of ecological corridors of trans frontier interest in the ENI Carpathians (Hungary, Slovakia, Romania, Ukraine), in a project area which covers approximately 4 million ha. Umbrella species used for connectivity model are brown bear, Eurasian lynx and grey wolf. The methodology is split in two main phases: identification of ecological corridors and designation of ecological corridors. For identification and designation of wildlife corridor (i.e. large carnivores) some tools and standardisations used in ConnectGreen project will be adapted also for OBWIC in order to create a synergy of these projects.

The terminology used in the present methodology for key terms is:

- Core area of distribution: large areas of natural or semi-natural habitat that fulfil requirements for permanent residence of umbrella species. For large carnivores it consists mainly of forests that provide environmental conditions for development of the populations. Due to the fragmentation of the habitats mainly caused by human development, core areas can be divided into areas with permanent occurrence of target species (functional habitat) and areas with potential to host permanently target species (potential habitat). This is important in the process of identification of corridors that will allow dispersal of the large carnivore species. The size of a core area should not be less than 300 square km considering the target species large home-range needs.
- Stepping stone: an array of small patches of favourable habitat that individuals use during movement for shelter, feeding and resting.
- Wildlife corridor: landscape structures of various size, shape and vegetation cover that mutually interconnect core areas and allow movement and migration of species between them. They are defined to maintain, establish or enhance ecological connectivity in human-influenced landscapes. The width of the corridor should not be less than 500 m.
- Critical zones (bottle-necks): fragments of corridors with significant limitations of the land permeability for the target species due to the concentration of different types of barriers (e.g. fences, arable land, motor way etc.)

Some useful tools that ConnectGreen project proposed will be used by OBWIC Methodology such as:

- MAXENT – Maximum Entropy Modelling software was developed for species distribution modelling and predicts species occurrences by finding the distribution that is most spread out, or closest to uniform, while taking into account the limits of the environmental variables of known locations. Maxent only uses presence data and the algorithm compares the locations of where a species has been found to all the environments that are available in the study region.
- Circuitscape – is a connectivity analysis software package which borrows algorithms from electronic circuit theory to predict patterns of movement, gene flow, and genetic differentiation among plant and animal populations in heterogeneous landscapes. In terms of landscape ecology, it concerns interlinkage of core areas which behave like current sources. The pathways that connect them will have different resistance generating so called voltage maps.

- Survey123 for ArcGis - is a complete, form-centric solution for creating, sharing and analysing surveys. It is useful tool to collect field data of landscape features with barrier effect within wildlife corridors.
- Agisoft is a software product that performs photogrammetric processing of digital images and generates 3D spatial data to be used in GIS applications as well as for indirect measurements of objects of various scales.

1. Identification of Ecological Corridors of trans boundary interest

This stage is large scale design and involves desktop research and field survey. The connectivity model will cover all project area. The identification of wildlife corridors implies desktop phases of designing core areas and wildlife corridor based on available input data and soft modelling. Some general structural criteria will be proposed both for core areas and wildlife corridors. These criteria should be considered as well in second phase of identification when field survey and expert verification will add information in order to complete the physical connectivity model at the ENI Carpathians level.

1.1. Methods of identification and input data selection

In initial phase it is important to define the tools that will be used for analysis, and subsequently the datasets that should be collected.

For desktop research phase, a range of data as GIS layers will be provided:

- Natura 2000 sites
- National and international natural protected areas
- 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 units borders and hunting free areas, if available (GIS layer)

Nevertheless, if more precise data are available, these should be used for enhancing previous datasets. Specific data of small anthropogenic structures (e.g. fences) can be obtained at request from local environmental authorities, if is the case.

For identification of core areas and stepping stone habitat from connectivity network, the Habitat Suitability Model will be used. The specific tool for that task is Maxent software.

For modelling of potential ecological corridors (knowing the resistance of habitats) CircuitScape tool will be used.

1.2. Identification (modelling) of core areas

a) Criteria

Core areas of distribution for large carnivores are represented mainly of large areas of forest habitat. Some of these are superimposed with natural protected areas of national/international interest or Natura 2000 sites. Natural protected areas and Natura 2000 sites limits will not set-up the boundary of core areas by default. The existence of some degree of protection for large carnivore just enhances the abundance of species and is a reasonable prospect that these areas will remain suitable habitat. Also, some Natura 2000 sites may include settlements meaning that areas will not be part of core areas. A distance for build-up area of at least 500 m should be considered when designing the core areas boundaries.

Forest edge do not exhibit a continuous line meaning that the core areas limits should not follow exclusively the forest edge limits but also include stepping stone areas.

Large carnivore species are demanding large areas in order to ensure the long term viability of populations. Thus, even in the highly fragmented habitat features of Europe, the core areas for these species cannot be less than 300 km².

b) Methods

In order to run Maxent software for core areas distribution modelling, some technical specifications should set-up. Maxent only uses presence data and the algorithm compares the locations of where a species has been found to all the environments that are available in the study region. It defines these available environments by sampling a large number of points throughout the study area, which are referred to as background points. The presence data are correlated with a series of constraints based on the environmental variables of the locations where the species has been observed. Therefore, the inputs data will be:

Occurrence data – all relevant and verified observations (collected within project area of the Carpathians since the year 2000 up to now). Occurrence data may include observations of a living individuals or dead animal, occurrence signs that were collected in different ways (by-chance observations, observations on permanent monitoring spots according to the Methodology, telemetry data etc.). Possible types of data include point, linear or polygon layers of the occurrence records and should be represented as ESRI shapefiles or vector layers of open software (QGIS, PostGIS, GRASS, SAGA etc.).

Environmental variables – all relevant data on both natural and human conditions of the landscape will be collected for the whole region of project area. These include following datasets:

Abiotic factors – source data on topography (digital elevation model) will be collected and other datasets will be derived for it (vertical heterogeneity, solar radiation index) using specific tools of spatial analysis (focal statistics, moving window technique, etc.).

Habitat factors – combination of Global Land Cover data (pixel size 300m) and Corine Land Cover data (pixel size 100m) will be used. Generalized land cover layer as well as derived data on landscape structure (e.g. density of forest edges) will be involved as inputs into the model.

Anthropogenic factors – the last groups of environmental variables cover the human influence and the level of anthropogenic transformation of the landscape. Open Street Map (OSM) will be used as a data source to derive data on distance to settlements, road density etc.

The presented data sets characterize the essential environmental conditions, i.e. factors enhancing occurrence and variables causing a reduced population density or non-occurrence of the target species.

All data will be transformed into a single format on an ESRI grid (e.g. of 500 x 500 m) and subsequently into the ASCII T format, needed for further steps.

Output 1.2: Draft layer of core areas of distribution for large carnivores at project area level (ENI Carpathians area)

1.3. Identification (modelling) of wildlife corridors that ensure the connectivity between core areas.

a) Criteria

As a result of fragmentation of large carnivores' habitat mainly by anthropic infrastructure, linkage landscape structures should be identified between previously drafted core area of distribution. These linkage areas contain usually less favourable habitat for large carnivores but structurally allows the movement/migration of umbrella species between core areas. On the other hand, it is possible that between some core area the permeability of species to be cut-off (by motorways for example). For each case, different management measures (action) should be addressed (see Designation section).

Linkage landscape structures will define the paths for movement/migration of large carnivores, respectively the wildlife corridors. Some minimal structural parameters for wildlife corridors are compulsory in order to create a homogenous ecological network in the ENI Carpathians. The width of the wildlife corridor should be at least 500 m since all the umbrella species are human sensitive. Even so, this extent is an exception rather than a rule, meaning that the width of corridor should be 500 m wide only when landscape constraints induce that. Generally, the rule is that the wildlife corridor should be as wide as possible correlated with landscape features. Anyway, a 2 km width should not be exceeded mainly for management reasons. Width-length ratio is another determinant factor. For large carnivore the length of the corridor should ensure the passage of the individuals in discrete events of brief duration (days) since these species have great ecological demands. Basically, the wildlife corridor should be as short as possible. That will decrease the edge-effect also, effect caused by disturbances that can intrude into a corridor from adjacent human-dominated land. The corridors will not exhibit any appendix since it may induce the trap effect during the corridor movement.

b) Methods

Connectivity model interconnects particular core areas and stepping stones through the corridors generating a coherent network. Modelling software for potential corridor network is Circuitscape (available also Circuitscape for ArcGis). Running this tool implies the existence of resistance data as raster map input for Circuitscape software. Core areas, previously drafted as the result of desktop research from 1.2, will represent the current sources, since the rest of the landscape appears as conductors with different values of resistance for movement between core areas. Therefore, resistance surface should be developed by inverting the habitat suitability model and adding a layer containing linear barriers and settlements infrastructure. This data will be derived by using Open Street Map dataset (OSM). Exporting/re-importing existing GIS datasets to ASCII format may be necessary for running Circuitscape.

Output 1.3: Draft of corridor network in ENI Carpathians

1.4. Mapping of ecological network – model fine tuning

Ecological connectivity network identified by using desktop research (sections 1.2 and 1.3) will be the subject of expert verification and field survey for establishing clear landscape boundaries and barriers, with special focus on trans-boundary ecological corridors.

a) Criteria

The borders of core areas will be adjusted by adding the adjacent forest units not separated by physical barriers. The borders of corridors should be led with regard to the fixed boundaries of the landscape like small green landscape structures, water courses, paths etc. Hunting free zones should be included if possible in wildlife corridors.

After analysing the connectivity network design, experts will establish the locations where adjustments of the model are needed to clear delineate the boundary of wildlife corridors (or even core areas) based on existing draft map of core areas and wildlife corridors. Some of changes should be performed based on local knowledge of the experts since other should have field data support.

The field mapping will produce information about landscape structures and features which have influence on the permeability of the corridors and which are not possible to be identified from satellite imagery neither existent GIS data, such as: fenced roads, regulated sections of rivers, vineyards, intensive orchards, quarries or pits, game enclosures, forest nurseries and any other fenced site or structure that could influence the corridor design or permeability.

All these field data will be incorporated in GIS database and on that basis the final design of large-scale ecological corridors is made at the ENI Carpathians level, with special focus on trans-boundary wildlife corridors.

Bottle-necks sites will be identified according to the field data and after expert verification. These sites are the places where the corridor has the narrowest wide and/or concentrate much barrier that can generate by cumulative effect less permeable or impermeable zones.

b) Methods

For field survey, the mappers can use the Survey123 online application (available with ArcGis) to facilitate the field work and to enable a standardized data collecting for further processing. Standardised pictures of the location shall be performed also.

Aerial drone survey and 3D model image reconstruction (Agisoft) can produce data of positive landscape small structure not visible by usual satellite imagery which act as barriers for movement.

Output 1.4: Final map of connectivity network including clear definition (mapping) of core areas, wildlife corridors and bottle-neck identification.

2. Designation of Ecological Corridors

This stage is small scale design focused mainly on critical connectivity zones (bottle-necks). If the first phase of Methodology was focused on structural features that are enabling physical movement of wildlife through landscape structures, designation phase is focused on functional aspects of the connectivity network. It will consist in detailed critical zone mapping, field survey, elaborating management measures for maintaining, improving or restoring connectivity, validation of functionality of ecological corridors, legal procedure to safeguard the ecological corridors and post monitoring.

2.1. Methods and input data selection

As the bottle-neck are the most critical zone for the functionality of the wildlife corridors, detailed data should be processed:

- Forest management plans (GIS layer) at smallest unit of management
- Spatial development plans (GIS layer)
- Land use categories (Corine Land Cover)
- Land tenure
- Physical barriers (GIS layer)
- Umbrella species occurrence GIS data sets and roe deer, red deer also (point, line)

For other physical barriers that were missed on identification phase and are discovered during bottle-neck field verification Survey123 tool will be used. For wildlife occurrence (large carnivores and Cervidae family) transect method and trap camera (TC) will be used. Transect method will collect data as footprints, tracks, scat, hair. Trap camera method will be used only for presence/absence data for wildlife. Data about anthropic disturbances are collected also with TC such as tourism, logging, mushroom and fruits pickers etc. Genetic analysis should be performed for gene flow assessment between different core areas of distribution and inbreeding degree within a population from a certain

core area. Overall, the method provides strong information concerning the connectivity of populations of large carnivores.

2.2. Detailed mapping of bottle-necks

Delineating precisely of bottle-neck areas is meaningful for further management measures and action plan. The bottleneck map will include all layers that can impede the permeability of the wildlife corridor, existent or proposed by spatial developments plans.

The forest management plan dataset will be used to lead the border of the bottle-neck along the managements units according to the proposed logging plans and functional categories of the forest since the management measures for securing the ecological corridor could imply certain changes in forest management plan.

Spatial development plans can contain provisions of proposed build-up areas which are not yet in place. Even if at the moment of the identification of wildlife corridor no anthropic infrastructure or building is present on field, analysing the spatial development plan will underline the future threat concerning the permeability of the bottle-neck. In that case management measure should be prepared accordingly.

Land use categories from Corine Land Cover dataset should be compared with spatial development plan in order to correct some false data such forested pastures or abandoned arable land for example. Other more precise data can be used as well for this circumstance.

Land tenure dataset comprise data regarding the ownership of the lands: private or state owned land. This information will produce the database of right holders and/or stakeholders which shall be involved in agreeing management measures and to assume de action plan for connectivity.

Output 2.2: Maps for the bottle-necks comprising all functional data layers of the wildlife corridor

2.3. Collecting umbrella species occurrence data by field survey

It is essential for establishing the functionality of the wildlife corridor to collect data about occurrence of umbrella species as well Cervidae family in bottle-neck areas.

By following predetermined transects (based on expert opinion and bottle-neck topology) presence data will be collected as: footprints, tracks, scat, hair. GIS data as point and line will be associated with presence signs. This type of data will be filled in a database that will be maintained also for validation and post monitoring data collection.

Since the transect method is limited by weather conditions (snow, mud), information will be added by trap camera method. Only presence/absence data will be collected since other data are not relevant for bottle-neck areas (like relative abundance) as the large carnivores are not corridor dwelling species. The specific TC set-up is expert opinion and corridor topology dependent. The method will be implemented with usage of IUCN grids for better processing of data.

Genetic analysis of DNA collected in the field will indicate the degree of connectivity between different core areas. Isolated populations will exhibit a high degree of inbreeding with low genetic diversity. The method is species dependent (genetic markers) and is tailored according to species and population characteristics (size).

During filed survey, new identified small physical barriers will be added if identified (Survey123).

Output 2.3: Presence signs of umbrella species in corridors and bottle-necks zones added to corridor maps

2.4. Management measures

Management measures should be debated with right-holders and/or stakeholders and further more and action plan shall be developed. The outputs of modelling wildlife corridors (including GIS layers) are made available to all relevant right-holders and/or stakeholders before developing management measures.

Assessment of permeability by animal presence or displacement through corridors (also bottle-neck areas) will support the development of management measures meant to ensure the connectivity. The management measures could have a general applicability over ecological corridors, but for a specific critical connectivity zones specific management measures and actions should be applied. Here we have at least 2 goals: 1st one: maintaining connectivity and 2nd one would be restoring connectivity (e.g. green infrastructure).

For maintaining the connectivity in wildlife corridor building of anthropic barriers will be excluded and the disturbance of human activities will be minimized.

General management measures for maintaining the connectivity in wildlife corridors:

- a) Spatial planning measures
 - No housing area should be planned in corridors
 - No change in land use should be performed
 - No fences should be constructed in corridor
- b) Forest management measures
 - No clear cuts shall be allowed in corridors
 - Forested pastures will be preserved by legally binding measures or state acquisition
- c) Touristic management measures
 - No tourist route should intersect wildlife corridor
 - No litter container should be placed in corridor
- d) Transport infrastructure management measures (not for motorway or other fenced roads)
 - Wildlife passage warning signs for drivers
 - Guardrails should allow easy and fast exist of the animals from the roads
- e) Hunting management measures
 - Within corridor hunting-free zone should be designated
 - No wildlife observatory is placed in corridor
 - No wildlife feeding spot should be placed within corridor
 - Feral dogs should be removed
- f) Natural resources harvesting measures (e.g. mushrooms, berries)
 - Corridor will be exempted from harvesting activities

Management measures for restoring the connectivity between core areas of distribution of large carnivores when connectivity is disrupted by large anthropic infrastructure (e.g. motorway) imply green infrastructure construction as wildlife passages or ecoducts.

Output 2.4: General management measures for wildlife corridors

2.5. Validation of wildlife corridors functionality

Validation of wildlife corridor entail, from functional perspective, the extent to which the umbrella species can move through landscape elements. This activity should be performed at least 12 months to cover all ethological range of the target species (mating, breeding, foraging, dispersing etc.). Validation starts after the connectivity model is finished, however some findings during this process can induce changes in management measures or action plan but also in the design of wildlife corridor.

Validation process include field monitoring of large carnivore species mainly at the bottle-neck scale - these zones are less permeable in comparison with other parts of ecological corridors.

Trap camera method is useful since can continuously collect presence signs during weeks. Transect method is additional to TP having the advantage of active searching of signs and tracks of wildlife. Combining these two methods a continuous monitoring can be performed over a certain bottle-neck area. The most important data to collect during validation is the wildlife passage through corridor quantified in species and number of passages.

Equally important during the validation is to collect data about human presence and type of disturbances it generate. Even the corridor has all structural conditions for wildlife movement, human activities can induce disruption of connectivity. In these situation management measures will be modulated accordingly.

Output 2.5: Validation of functionality of wildlife corridors

2.6. Legal designation of wildlife corridors

This stage may have different solution for each country in respect of national legislation that is applied and enforced. Basically, it is important that every previously mentioned steps are to be performed before issuing official designation of an ecological corridor. Designation proposals shall comprise also the management measures without whom the connectivity network is ineffective.

Output 2.6: Official designated wildlife corridor and legal management instruments imposed at national level

2.7. Post monitoring

Whether the official designation of ecological corridors is made or not, post monitoring of identified wildlife corridors should be performed to ensure the functionality of connectivity network and financial resources for implementing management measures shall be ensured as well in the future.

An extensive monitoring set-up should be designed meaning at least twice a year field monitoring for every wildlife corridor of transboundary interest. Transect method and trap camera method can be used along with aerial monitoring by drones (to cover extended terrain surface at one time).