Open Borders for Wildlife in the Carpathians (OBWIC)

Activity 1.1 (GA 1)

CONNECTIVITY REPORT

December 2019

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 illegal hunting, 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 Carpathians[1] (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 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 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, (https://www.researchgate.net/publication/290367845_Creation_of_Ecological_Corridors_in_the_Ukrainian_Carpathians)

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-Neamţ Nature Park.

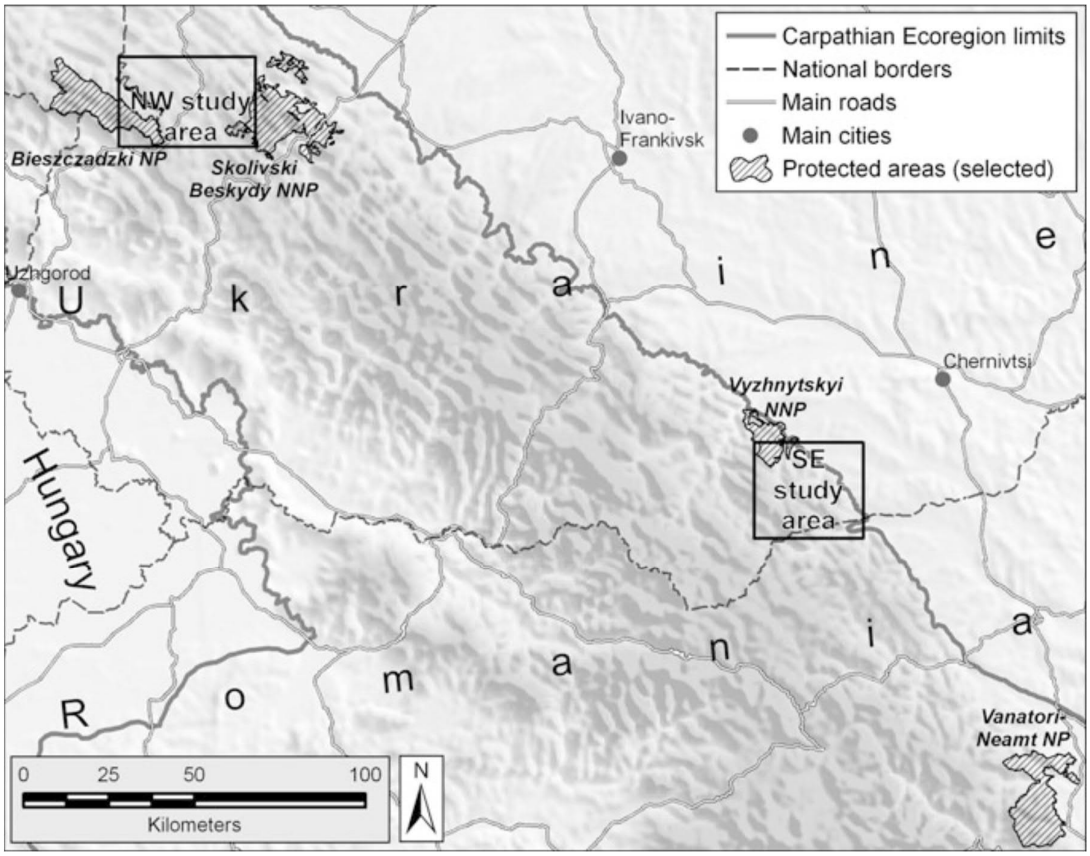

Figure 1. Pilot areas for project Creation of Ecological Corridors in the Ukrainian Carpathians, Poland, Ukraine and Romania, 2010

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 (http://assets.panda.org/downloads/wwf_factsheet_bear_project2014.pdf) 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.

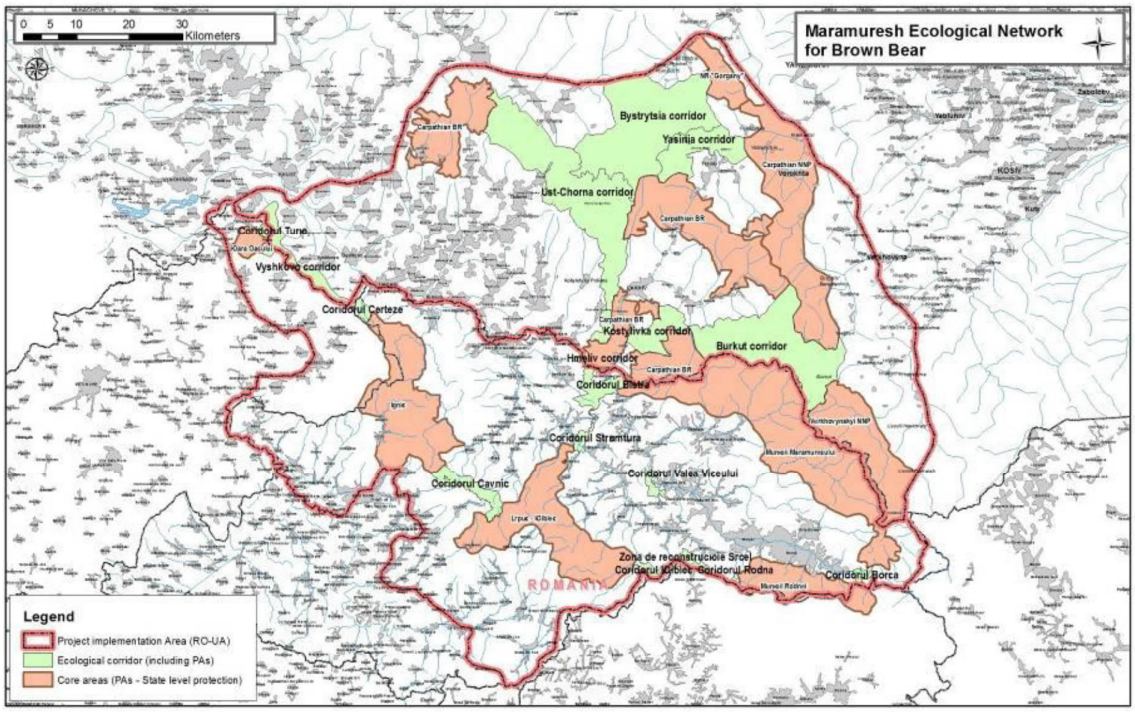

Figure 2. Maramures Ecological Network for Brown Bear.

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

The document (http://assets.panda.org/downloads/memo_lugoj_deva.pdf) 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.

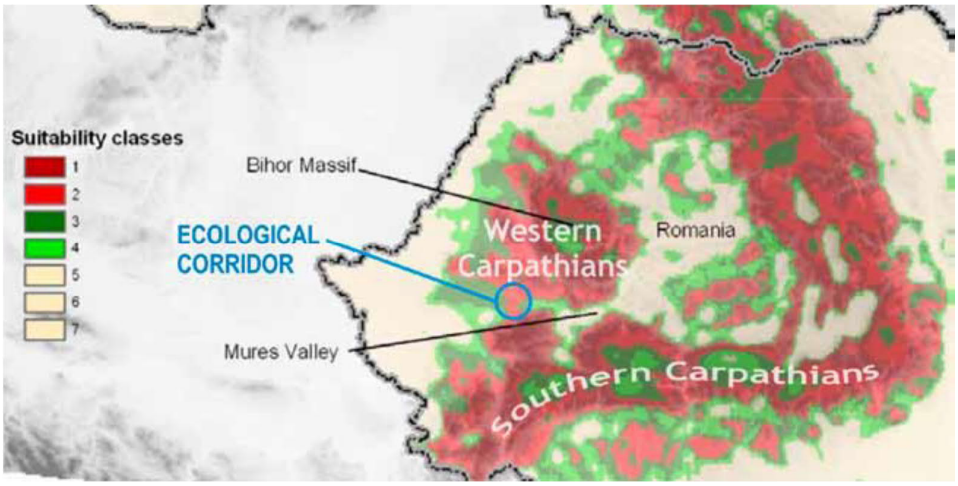

Figure 3. Location of the project area.

4. Project: Southwestern Carpathian Wilderness and Sustainable Development Initiatives, Romania, 2013-2016, Donor SWISS Cohesions Fund

The project (http://elvetiaromania.ro/en/proiecte/south-western-carpathian-wilderness-and-sustainable-development-initiatives/) 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 in the Southwestern Carpathians, including improved policy and management, increased capacity of protected area managers and greater awareness and acceptance of key stakeholders. Sustainable local and regional development related to the promotion of the Southwestern Carpathians as Europe's premiere wilderness area will be 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. Key stakeholders were assisted to develop a Wilderness Strategy for the Southwestern Carpathians. Finally, project results and lessons learnt will be used to inform national policymaking 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.

5. 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 (http://www.interreg-danube.eu/approved-projects/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. It will do 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 will focus on ecological corridors crossed by EU TEN-T road and rail projects in the Carpathians. Sharing experience and knowledge

will be of great importance. An interdisciplinary partnership including planners, economists, engineers, and ecologists will integrate and apply their specific knowledge across the region and cooperate on developing Guidelines on integrated transport infrastructure planning, construction, management and monitoring, taking into account aspects of road safety and biodiversity conservation. Partners will also collaborate 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-Kosice-Uzhgorod (HU-SK-UA), Tirgu Mures-Iasi and Arad (Radna)-Deva (RO). An inter-sectorial dialogue will be 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.

Figure 4. Pilot sites for TRANSGREEN project.

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 attained trough: 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. 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.

By 2021 the pilot project will test 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 aim 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, 2015, Donor EEA Grants

   The project (https://www.gnm.ro/ro02/) was implemented by the National Environment Guard, 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. This project's results will benefit 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. Trough 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. Other result of the project consists in an IT application (interactive) that helps delimitate ecological corridors and report environmental incidents.

9. Proiect: Ecological corridors for habitats and species in Romania (COREHABS), 2015, 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 (http://corehabs.ro/ro/) 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.

10. 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 (http://www.interreg-danube.eu/approved-projects/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, the project aims to develop a Carpathian-wide methodology and based on this it will identify core areas and ecological corridors used by large carnivores as umbrella species.

At the level of 4 transnational relevant pilot sites, the ecological corridors will be identified in more detail by using the above mentioned methodology. Physical barriers and other threats will be identified in these areas and integrated together with other spatial data categories into the Carpathian Countries Integrated Biodiversity Information System (CCIBIS). Specific management and restoration measures 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 analyzing a broad range of spatial data and various individual scenarios.

A Strategy is developed based on the methodology and the project's findings on identifying, preserving, and managing 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 ASPs.

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.

Methodology for identification of migration corridors for large carnivores in the Carpathian countries has been developed in two sections.

Section 1 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.

The following pages will focus on Section 1 mentioned above, as it represents the methodology for identification of ecological corridors that will consist the backbone of the methodology that will be used in OBWIC project.

The ecological network has three main pillars – core areas, stepping stones and corridors. An approach of connected spatial structures of biotopes has become justified for the group of large carnivores and adopted for the methodology. The most affected groups of species influenced by fragmentation of the landscape are those bound to the well-preserved natural environment, those which have high demands on the size of the home range or their biology includes regular or occasional migration, especially the three species of large carnivores: grey wolf, Eurasian lynx and brown bear. Once the habitat of large carnivores according to this methodology is identified, the measures to maintain and/or improve the connectivity can be developed and adopted.

Within TRANSGREEN and ConnectGREEN projects definitions of different types of corridors were adopted:

- Ecological corridors as landscape structures of various size, shape and vegetation cover that mutually interconnect core areas and allow migration of species between them.
- Wildlife corridors – which allow the movement of a wide range of organisms between high natural value areas.
- Migration corridors – which allow animal movement (both regular and irregular) between areas of their permanent distribution (core areas).
- Movement corridors – that allow animal movement within core areas (including daily movements in search of food, etc). Habitat of the target species is to be identified based on the habitat preferences using the latest occurrence data for the Carpathians.

Within ConnectGREEN project there were two different scale approach:

A. The level of the Carpathians
B. Pilot areas

A. CARPATHIAN LEVEL

In order to design ecological corridors, HABITAT SUITABILITY MODELING theory was used. First, a collection and preparation of input data necessary to fulfil further steps were needed: OCCURRENCE DATA – all relevant and verified observations (include observations of a living individuals or dead animal) and ENVIRONMENTAL VARIABLES (abiotic factors, habitat factors, anthropogenic factors). All data were 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.

Further development of the habitat suitability model on input data conduct to identification of the core areas and subsequently ecological networks for the protection of biodiversity by running the MAXENT (Maximum Entropy Modelling) tool. The most important outputs of the model include raster of habitat suitability and several graphs showing importance of input variables and their influence on species occurrence.

Output of the habitat suitability model are represented by CORE AREAS and STEPPING STONES which provides the basis for the final connectivity model – patches of suitable habitat will be interconnected by migration corridors. Minimum size of the core area should be 300 km². Expert discussion/verification of the layer of core areas and stepping stones by national and local experts for finalization of the layer is needed.

For CONNECTIVITY MODELING, preparation of the resistance surface including barriers has been made. These data are derived by using Open Street Maps datasets (OSM). The output of the connectivity model provides the coherent network of corridors. These are not of regular shape and the character of corridors reflects the

quality of the land cover. The method applied for interconnecting core areas is Circuitscape built on the principle of electricity conductance. The minimum width of the corridors to be considered is 500 m.

This connectivity model should pass the expert verification based on local expert knowledge and the result will be the FINAL LAYER OF CORRIDORS. Concerning the CRITICAL ZONES, identification and classification of basic migration barriers and potential critical zones based on GIS modelling is made. The potential critical zone is identified if there is an intersection of proposed corridors with impermeable or disturbing landscape structures/barriers. Under this stage, expert input is needed and based on their local expert knowledge, the national/local experts will complete the layer of critical zones.

Based on the verified data - core areas, stepping stones, corridors, critical zones will form the first draft of the MAP OF HABITAT OF LARGE CARNIVORES on the level of the Carpathians will be created and furthermore verified by using independent occurrence data sets acquired by telemetry and/or by chance observations. Finalization of the map of habitat of large carnivores for the Carpathians should be prepared based on local experts' input (raster of 500x500m and GIS inserts of local experts)

B. PILOT AREAS

Based on the final map of habitat of large carnivores developed for the Carpathians (see above), the habitat of large carnivores for the pilot areas will be defined. The process will include the VERIFICATION OF CORRIDORS in respect to real permeability and the VERIFICATION OF CRITICAL ZONES. The results of the verification will be transposed to the final map of habitat of large carnivores for the pilot area.

DESKTOP VERIFICATION of corridors should be made by experts with support of existing knowledge and reference material (base map, aerial maps, knowledge of mapper, etc.). The borders (borderlines) of the whole habitat of large carnivores will be specified based on few rules such as:

- Presence of designated protected areas
- Presence of military areas
- Respect of landscape elements which support the migration of large carnivores
- Borders of core areas are lead outside the settlements
- Borders of core areas are lead outside the arable land
- Adjust forest units will be added to the core zone (not separated by an evident migration barrier)
- Borders are delineated in regional context of the landscape

Desktop verification of critical zones include areas of corridors crossing with barriers – highways, railways, cumulative effect of barriers etc.

FIELD VERIFICATION OF CORRIDORS zones should be performed also to gain solid detailed data of high quality for a qualified evaluation of the corridors.

For the verification of corridors, the real detailed field mapping of the pilot areas will be conducted with focus on the corridor permeability (barriers, stepping stones) supported by collecting complementary data e.g. on the occurrence of target species or small green landscape structures. The field mapping will include landscape structures and features which have influence on the permeability of the corridors such as:

- Motorways, roads and railways – may include technical structures which may prevent or on the other hand facilitate connectivity
- Vineyards (may be fenced, plus the direction in which the vineyard rows are established may hamper movement of wildlife)
- Orchards, especially intensive (may be fenced)
- Pastures (may be fenced)
- Quarries and pits, both active and old
- Regulated sections of rivers, streams and ditches and other technical features for water management – sections with concrete or rocky embankment may act as migration barrier to wildlife
- Game enclosures
- Commercial or recreational fishponds (may be fenced)
- Forest nurseries (usually fenced)
- Gardens and garden clusters
- Other fenced sites (both permanent or temporary) not described above

Most of the landscape features with barrier effect will include linear transport infrastructure and fencing. An ArcGIS online application Survey123 was developed for easy recording of such data. The focus should be on structures, which could not be detected from the land cover data, satellite nor aerial imagery or those which may possess specific features resulting into their barrier effect, but as such are equally not detectable from the datasets used for Carpathian-level modelling. The pilot area scale may benefit from more precise delineation of small green landscape structures, such as hedgerows, bankside vegetation, riparian galleries, linear and dispersed woods and shrubs, small grassland patches, set-asides, etc.

Targeted field mapping of the presence of large carnivores and possibly other mammals in addition (red deer, otter, etc.) will be organized to detail the delineation of the core areas and stepping stone habitats for the target species as well as to determine the more accurate corridors used by the target species for their translocation or dispersal. The field mapping may be carried out through different monitoring methods including photo traps, tracking on snow, tracking and mapping of signs of presence during spring and autumn period, etc.

FIELD VERIFICATION OF CRITICAL ZONES. Based on the final map of habitat of large carnivores developed for the Carpathians (see above), the potential/proposed critical zones were identified as places of intersection between the corridor and the barrier. The potential critical zones defined on the Carpathian level are further discussed and verified at the desktop verification by expert discussion. These potential critical zones need to be verified in field. A descriptive form of a critical zone was developed to unify the assessment of individual critical zones. In this form a mapper will provide detailed description of the area, the list of significant barriers as well as suggestion of measures to ensure the permeability for target species, all complemented by photographs and standardized maps.

Based on the field verification of corridors and critical zones as described in previous steps, the collected data will be transferred into the final layer of the ecological network in the pilot area.

II. OBWIC METHODOLOGY ON IDENTIFICATION AND DESIGNATION OF ECOLOGICAL CORRIDORS

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 cover 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.

1. Identification of Ecological Corridors of trans frontier interest

This stage is large scale design and imply desktop research and field survey.

Methods of identification: input data selection

In the first place, it is important to define the tools that will be used for analysis, and subsequently the data that should be collected.

For identification of core areas, stepping stone habitat and connectivity network, the Habitat Suitability Model will be used. The specific tools for that task are Corridor Design software and Maxent software.

For identification of permeability (resistance) of habitats Open Street Map tool can be used in order to collect GIS data about barriers that are intersecting the connectivity network.

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

For clear boundaries of corridors, field survey of the potential corridors will be performed. Data collection sheet will be developed for standardisation of data set collection.

Identification of core areas (central areas)

Habitat suitability data should be collected: areal/distribution/population size/abundance in core area for large carnivores; habitat structure (mainly forest habitat shall be considered); natural protected areas; anthropic infrastructure. These data will be analysed using Corridor Design an Maxent tools. Running Corridor Design tool could imply more information input than Maxent tool. A layer of core areas, stepping stones and connectivity network between those will be generated.

Design of core areas and stepping-stones should reflect the ConnectGREEN standard where minimum size of a core area is 300 sqkm.

Identification of critical zones of connectivity.

Permeability (resistance) assessment along connectivity network should be performed. That will include identification of anthropic barriers as roads, settlements etc. A layer with this information would be generated. Open Street Map tool will be used to provide these types of data. Certain areas from connectivity modelling will intersect less permeable or impermeable zones which are the rough critical zone of connectivity.

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

By using Circuitscape tool based on previous data and outputs, a coherent network of corridors between core areas and stepping stones is designed. Critical connectivity zone will be more accurate in this design but still remains only red spots of connectivity taking into account the large-scale approach (the ENI Carpathians area).

Mapping of ecological network

Ecological corridors identified by using desktop data will be the subject of field survey for establishing clear boundaries and barriers, with special focus on trans-boundary ecological corridors.

The field mapping will include also landscape structures and features which have influence on the permeability of the corridors and which are not possible to be identified from satellite imagery or existent GIS data, such as: fenced roads, regulated sections of rivers and any other large structure that could influence the corridor design or permeability.

All these 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. We take into account that the minimum width of the corridors to be considered is 500 m. This phase will comprise the classification of ecological corridors identified.

2. Designation of Ecological Corridors

This stage is small scale design focused in critical connectivity zones. It will consist in 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.

Bottle-neck identification and analysis (critical connectivity zones fine tuning)

In the critical connectivity areas will be identified antrophic features that could affect negatively the passage of large carnivore trough ecological corridors. That will be done by field survey and will be a detailed inventory of:

- Motorways, roads and railways – may include technical structures which may prevent or on the other hand facilitate connectivity;
- Vineyards (may be fenced, plus the direction in which the vineyard rows are established may hamper movement of wildlife);
- Orchards, especially intensive (may be fenced);
- Pastures (may be fenced);
- Quarries and pits, both active and old;
- Regulated sections of rivers, streams and ditches and other technical features for water management – sections with concrete or rocky embankment may act as migration barrier to wildlife;
- Game enclosures;
- Commercial or recreational fishponds (may be fenced);
- Forest nurseries (usually fenced);

- Gardens and garden clusters;
- Other fenced sites (both permanent and temporary) not described above.

Permeability assessment against the data collected in the field will be performed. An ArcGIS online application Survey123 was developed for easy recording of such data, and could be used.

In the same time, occurrence data of the umbrella species will be collected from critical connectivity zones.

Using above data, the GIS design of bottle-neck will be performed, i.e. final critical connectivity zone structure and boundaries.

Validation of functionality of corridors

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 monitoring, presence signs, aerial drone survey will be performed in order to collect data; genetic DNA tests for LC species could also be used (eg Hungary).

Management measures

Assessment of permeability and animal presence or displacement through bottle-neck areas will support the development of management measures meant to ensure the connectivity. Here we have at least 2 goals: 1st one: maintaining connectivity and 2nd one would be restoring connectivity (e.g. green infrastructure). Besides resistance of habitat due to various existing infrastructure, the management measures have to consider the land use situation and the land ownership structure. 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.

For example, in case of linear transport infrastructure, ConnectGreen project proposes a series of general measures to facilitate safe passage of infrastructure and to prevent traffic kills and human casualties.

Official designation at national level of ecological 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.

Post monitoring

Whether the official designation of ecological corridors is made or not, post monitoring of identified ecological 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.

Annex 1 Technical summary of the projects related to connectivity in Carpathians

	Project	Project area	Methods used	Umbrella species
1.	Open borders for bears between Romanian and Ukrainian Carpathians, Romania and Ukraine, 2012-2014, donor HUSKROUA ENI 2007-2014	Maramures County, Romania and Ivano-Frankivsk and Zakarpatska regions of Ukraine	Input data: collared bears GSM data, questionnaires, field visits, meetings with local communities, hunters, foresters. Data analyse: Maxent software, Corridor design software.	brown bear
2.	Creation of Ecological Corridors in the Ukrainian Carpathians, Poland, Ukraine and Romania, 2010	2 pilot areas. One in Skolivski Beskydy National Nature Park in Ukraine and Bieszczadzki National Park in Poland. Second area between Vyzhnytskyi National Nature Park and the border with Romania towards Vanatori-Neamt Nature Park.	Landscape ecological modelling, using habitat suitability, criteria determined for selected model species, habitat requirements based on expert knowledge as well as publications on habitat utilization, possible corridors were manually drafted based on habitat suitability maps for each species, and these ‘‘species corridors’’ were merged into a single ‘‘robust’’ corridor. The final corridor boundaries are achieved through direct consultations with land owners and land users with the aim to agree on a final course of the corridor using boundaries of municipalities and forest management units, taken from administrative and forestry maps.	brown bear, European bison, lynx and wildcat

3.	MEMO on the negative impact of the planned Lugoj–Deva motorway and presentation of possible mitigation solutions, Romania, 2010	Podisul Lipovei – Poiana Rusca proposed Natura 2000 site (RO)	Permeability assessment of the habitat along 2 sectors of the motorway. Ecoducts construction was proposed.	large carnivores
4.	Southwestern Carpathian Wilderness and Sustainable Development Initiatives, Romania, 2013-2016	Southwestern Carpathians, Romania	Analysis of environmental legislation, policy. A draft of designation methodology for ecological corridors has been submitted to Environmental Ministry in 2017.	not defined
5.	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,	Pilot sites are segments of rail and roads as follows: Beskydy (CZ-SK), Miskolc-Kosice-Uzhgorod (HU-SK-UA), Tirgu Mures-Iasi and Arad (Radna)-Deva (RO)	On-field monitoring trough radio telemetry data from collared bears, trap camera, permeability analysis, denning habitat monitoring, road mortality assessment. For GIS data analyse and modelling was used MaxEnt software. The project brought into discussion restoration of connectivity affected by linear infrastructure (ecoducts).	Brown bear, large mammals (CT and permeability)
6.	MARAMURES The Green Heart of the Carpathian Mountains, with virgin forests and bears roaming across EU frontiers, Romania, 2013-2016	Maramures County, Romania	Trap camera monitoring, habitat mapping and further protection instruments for protection implemented.	brown bear
7.	Land development instrument testing in pilot site of Maramures, Romania for connectivity, Romania, 2017-2019	Maramures County, Romania	Implement instrument for securing ecological corridors trough land purchase / land swap.	no umbrella species
8.	Development of the methodology for establishing ecological corridors and training the administrators of the	Country level, Romania	Desktop research	Large mammals, birds, fish

	protected areas for their better management, 2015			
9.	Ecological corridors for habitats and species in Romania (COREHABS), 2015	Country level, Romania	The project will be based on a transdisciplinary methodology. Firstly, establish a set of criteria for identify ecological corridors and to perform a selection of umbrella species for every group of habitats and ecoregion. The approach of connectivity has three levels: local, regional and national. Permeability assessment has been taken into account for mapping activity of the corridors. Furthermore, the project proposed a set of guides for ecological corridors management and monitoring.	For any type of habitat and ecoregion, a selection of umbrella species shall be performed.

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