OPEN BORDERS FOR WILDLIFE IN THE CARPATHIANS, OBWIC

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

March 2020

Map of OBWIC project transboundary area

CONTEXT

Europe (excluding Russia) is home to approximately 12,000 wolves, 17,000 bears and 9,500 lynx and over a third are living in this region. Only in the Central and South-eastern Europe an estimated 8000 brown bears are living in that territories. These ecologically critical, 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 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 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 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.

Legal framework concerning ecological connectivity in the partners' country are divers. In Romania actions for wildlife connectivity are not put in place. Applicable legislation at this date specify just the need for a methodology for identification of ecological corridors that should be prepared and adopted. Ukrainian legislation concerning connectivity is developed, but a clear methodology for identification of ecological corridors is lacking. Ecological network in Ukraine is developed at the country level. Ukrainian econetwork comprise key territories (e.g. nature reserves, wetlands of international importance) and links between these key territories. In Hungary, both legislation and connectivity elements are developed. The same situation is available for Slovakia. Nevertheless, improvements and harmonisation of the connectivity network among countries are necessary.

[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).

METHODOLOGY ON IDENTIFICATION AND DESIGNATION OF ECOLOGICAL CORRIDORS 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.
- 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.
- 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 connectivity tools that ConnectGreen project previously proposed may be used also 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. General structural criteria will be proposed both for core areas and wildlife corridors. Structural criteria mean the criteria which define the morphology of the corridors or core areas in terms of measurable parameters as: length, width, surface, shape etc. 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 (where available)
- Emerald ecological network (where available)
- National and international natural protected areas
- Official designated pristine forest or other protection form of the forests outside of natural protected areas (where available).
- State borders fences (if the case)
- Forest habitats (Corine Land Cover dataset)
- Settlement and built-up areas (Open Street Map dataset)
- Roads (Open Street Map dataset)
- Elevation map
- Spatial development plans (datasets)
- Aerial and satellite imagery of the project area
- Hunting unit's borders

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 competent authorities, if is the case.
Based on input data sets, identification of core areas and stepping stone habitat from connectivity network may be performed by Maxent software. For modelling of potential ecological corridors CircuitScape tool may be useful. In the following sections both software will be detailed as examples of functional tools for connectivity modelling.

1.2 Identification (modelling) of core areas

Core areas of distribution for large carnivores are represented mainly of large areas of forest habitat. As Open borders for bears between Romanian and Ukrainian Carpathians project reveals, 90% of collared bears location were in forested areas.
Some forests 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 in future. 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. That distance is documented by Open borders for bears between Romanian and Ukrainian Carpathians project since less than 0.5% of the location of bears were recorded closer to 500 m from the residential areas.
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 km^2.

Various tools were developed for drawing core areas in connectivity models. A strong option is to run Maxent software for core areas distribution modelling. 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) can 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.

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.

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 o homogenous ecological network in the ENI Carpathians. The width of the wildlife corridor is recommended to be at least 500 m since all the umbrella species are human sensitive. The edge effect appears to be manifest at a distance of 300 m inside of forest from the edge. The minimum 500 m width of the wildlife corridor was also used as reference when designing National Ecological Network EECONET – Poland (1995) or Ukraine (2011). In any cases where the width of corridor cannot reach 500 m wide because of landscape constrains (including anthropogenic ones) lesser width can be accepted if the functionality of the corridor can be ensured. 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 has 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.

Connectivity model interconnects particular core areas and stepping stones through the corridors generating a coherent network. Modelling potential corridor network around different established core areas can be done using one of the several software available. An open source tool is Circuitscape software (available also Circutscape for ArcGis). Running this tool imply 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).

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.

The borders of core areas will be adjusted by adding the adjacent forest clusters 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 developed according to Sections 1.2 and 1.3, experts will establish the locations where adjustments of the model are needed to clear delineate de 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.

On field, the mappers can use Survey123 online application (available with ArcGis) to facilitate the field work and to enable a standardized data collecting for further processing. Other standardised tools can be used including standardized paper forms developed for this process. Standardised pictures of the location shall be performed also, as the field mapping collected data will be used as input in a database. Standardized picture includes using the same formatting (.jpg for example), geotagging each picture, includes ruler marks to integrate the size of the object.

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. Ensuring the Functionality 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 trough landscape structures, designation phase is focused on functional aspects of the connectivity network. It will consist in detailed identified 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 additional species: red deer and golden jackal (point, line)

For other physical barriers that were missed on identification phase and are discovered during bottle-neck field verification data form (Survey123 tool or similar) 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 (10x10km) for better processing of data.

Genetic analysis of DNA collected from the field samples 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. 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 (matting, breeding, foraging, dispersing etc.). Validation starts after de 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 period does not confine the existence of the ecological corridor but it is a condition consisting of monitoring and data collection from the field within corridor bottle-neck zone in order to substantiate the functionality of the corridor.

Validation process include field monitoring of large carnivore species and additional 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. Data concerning human presence and activities will be monitored as: number of individuals per unit of time, by foot or by car or other vehicles, type of activity (pickers, logging, touristic, shepherds etc.), humans with dogs or feral dogs etc.

Output 2.4: Validation of functionality off wildlife corridors

2.5. Management measures

Management measures should be debated with right-holders and/or stakeholders and furthermore an 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, mainly in bottle-neck zones building of anthropic barriers will be excluded and the disturbance of human activities will be minimized.

General management measures are proposed for maintaining the connectivity through bottle-neck zone:

a) Spatial planning measures
   - No housing area should be planned in bottle-necks

- No change in land use should be performed for forests.
- No fences should be constructed in bottle-necks

b) Forest management measures
- Forested pastures will be preserved by legally binding measures or state acquisition

c) Touristic management measures
- No litter container should be placed in bottle-neck zones

d) Transport infrastructure management measures (not for motorway or other fenced roads)
- Wildlife passage warning signs for drivers along corridor or bottle-neck zones

e) Hunting management measures
- No wildlife observatory is placed in bottle-neck zone
- Feral dogs should be removed

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 construction of migration objects. This is a secondary measure to ensure connectivity and the more expensive one.

Output 2.5: General management measures for 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

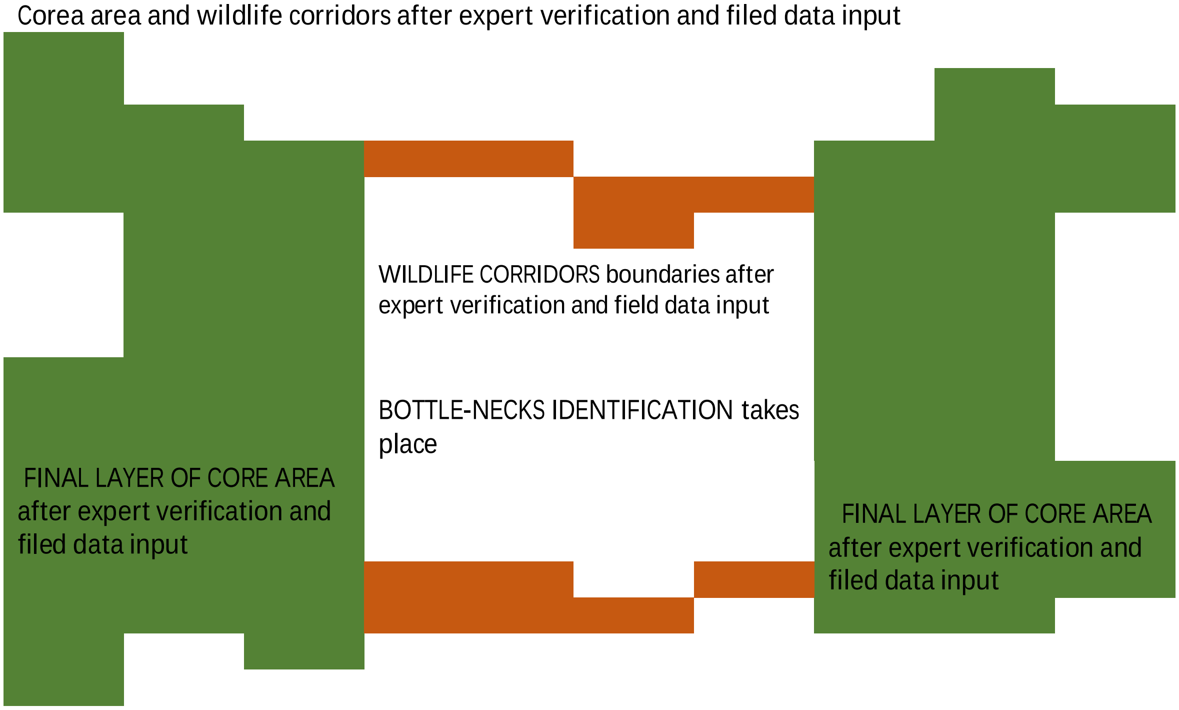
Whether the official designation of ecological corridors is made or not, post monitoring of identified wildlife corridors should be performed to ensure the functionality of connectivity network and financial resources for implementing management measures shall be ensured as well in the future.

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).

Methodology process diagrams

Desktop core area design and wildlife corridors modeling

Corea area and wildlife corridors after expert verification and filed data input



Bibliography:

Creation of Ecological Corridors in the Ukrainian Carpathians (p. 701-7014), The Carpathians: Integrating Nature and Society towards Sustainability, 2013

MEMO On the negative impact of the planned Lugoj–Deva motorway and presentation of possible mitigation solutions, 2011

Final Report on Five Bears Individuals Monitoring, 2014, Open Borders for Bears in the Carpathians Project

http://assets.panda.org/downloads/memo_lugoj_deva.pdf

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

http://corehabs.ro/en/

http://elvetiaromania.ro/en/proiecte/south-western-carpathian-wilderness-and-sustainable-development-initiatives/

https://www.gnm.ro/ro02/

http://www.interreg-danube.eu/approved-projects/transgreen/outputs

http://www.interreg-danube.eu/approved-projects/connectgreen

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