Nature Conservation 11: 95–111 (2015)
doi: 10.3897/natureconservation.11.4424
http://natureconservation.pensoft.net

RESEARCH ARTICLE

A peer-reviewed open-access journal
Nature Conservation
Launched to accelerate biodiversity conservation

The BioREGIO Carpathians project: aims, methodology and results from the "Continuity and Connectivity" analysis

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Academic editor: *A. Seiler* | Received 30 December 2014 | Accepted 18 May 2015 | Published 28 July 2015

http://zoobank.org/2D1F21C9-1114-4193-A963-5BCD14D13C34

Citation: Favilli F, Hoffmann C, Elmi M, Ravazzoli E, Streifeneder T (2015) The BioREGIO Carpathians project: aims, methodology and results from the "Continuity and Connectivity" analysis. In: Seiler A, Helldin J-O (Eds) Proceedings of IENE 2014 International Conference on Ecology and Transportation, Malmö, Sweden. Nature Conservation 11: 95–111. doi: 10.3897/natureconservation.11.4424

Abstract

BioREGIO Carpathians is a transnational cooperation project, co-financed under the second call of the EU South East Europe Transnational Cooperation Programme, priority area "Protection and Improvement of the Environment". BioREGIO Carpathians run for three years (2011–2013) and is a flagship project for the Carpathian Convention (article four dealing with landscape and biological diversity), its Biodiversity Protocol and the Biodiversity Working Group. The project is built on the conservation, restoration and valorisation of the Carpathians ecological continuum to enable large herbivores and carnivores to live in coexistence with modern society. The Carpathian countries are expecting a massive pressure to modernize and extend their road infrastructures. If not considering the requirements of ecological network, this run-to-development will enhance landscape fragmentation, limit dispersal and genetic exchange of wildlife species. BioREGIO applied a multi-disciplinary approach (physical, legal and socio-economic) in order to identify the most influencing barriers regarding connectivity throughout the Carpathians. Using two ArcGIS 10.0 tools in a three-step approach and a series of site visits, the continuity and connectivity analysis identified not only physical barriers but also legal aspects and socio-economic behaviour that are influencing ecological connectivity and playing a major role to conserve wildlife population. The investigation on the ground together with local experts and stakeholders enabled the adaptation of the GIS results and the development of feasible solutions to overcome the detected barriers with recommended priorities for implementing appropriate measurements to maintain connectivity and to sustain large carnivores, herbivores and biodiversity in the Carpathians.

Keywords
Ecological connectivity, physical, socio-economic and legal barriers, umbrella species, GIS

Introduction

Continuity and Connectivity in the BioREGIO Carpathians project

Ecological corridors are "linear elements which connect the core areas and serve as migrating and dispersal routes" (Tillmann 2005). A regional ecological network can provide connectivity between spatially separated populations, countering biological processes that lead to species extinction (Beier 1995, Bennett 1998, Taylor et al. 2006). Road infrastructures are fragmenting landscape structures and are thus endangering wildlife populations by reducing the options to disperse among habitat patches (Forman et al. 2003). Fragmentation increases the risk of collisions with vehicles and limits the access to resources (Jaeger and Madriñán 2011). The above quotations, among the others, illustrate the bases on which the BioREGIO Carpathians project was built. BioREGIO was the first attempt in the Carpathian mountain range highlighting in an integrated approach the necessity for the protection of biodiversity and natural heritage beyond protected areas. The BioREGIO's charge was to cope with the new challenges of modernization: deforestation, fragmentation and habitat conversion as well as with pollution and overexploitation of resources (Kock et al. 2014). One major part in the BioREGIO Carpathians project dealt particularly with *Continuity and Connectivity*. Therein the focus was put on detecting physical, legal and socioeconomic barriers. Each of these types of barriers has an impact on hindering ecological connectivity in the Carpathians. BioREGIO Carpathians aimed to point out, where the least-cost paths for the seven selected umbrella species are located for dispersing among their most probable core areas. Least-cost modelling is one of the methods used in landscape ecology to measure ecological connectivity – by representing the landscape as an energy-cost surface, least-cost paths can be calculated that represent the route of maximum efficiency between two locations as a function of the distance travelled and the costs traversed (Douglas 1994, Adriansen et al. 2003, Etherington and Holland 2013). The selection of the species of interest was done according to literature and together with the project partners, in order to identify those:

– Being representative of the different habitats of the Carpathians environment
– Being more prone to human/wildlife conflicts
– Having a different attitude towards human society
– Being ecological indicators

After several internal discussions, the species selected were: Eurasian Lynx (*Lynx lynx* L.), Brown Bear (*Ursus arctos* L.), Grey Wolf (*Canis lupus* L.), Eurasian Otter (*Lutra lutra* L.), Western Capercaillie (*Tetrao Urogallus* L.), Chamois (*Rupicapra rupicapra* L.), European Hare (*Lepus europaeus* P.).

The target of that *working approach* was to focus on the following research questions: How are the most suitable landscape patches for the umbrella species spatially distributed across the Carpathians? Are there chances for the most mobile species to reach other suitable patches? In addition, if yes, which paths are most likely appropriate to them? Are there social, legal or physical barriers in the identified routes? Are they surmountable? To reply efficiently to these questions it was fundamental to:

1. Select a Habitat Suitability Model and to define the parameters for detecting the general ecological connectivity in the Carpathians,
2. Assess the connectivity via the visualization of core areas, least-cost paths and potential barriers,
3. Perform site visits in specific locations to check the supposed barriers,
4. Perform interviews to partners and local experts,
5. Develop a web-GIS application for the visualization of the Carpathians' ecological network
6. Elaborate specific recommendations to overcome the identified barriers

Due to the necessity of a bilateral nature management in several locations in the Carpathians, common management measures and harmonized strategies were developed in transboundary ecosystems, where adjacent habitat types and nature values have to be preserved under different legal, social and economic circumstances. The following national and nature parks, located at national boarders and facing transboundary challenges were selected as pilot regions in BioREGIO Carpathians (Fig. 1):

Duna-Ipoly National Park: Ipoly-valley (HU) / Poiplie Ramsar site (SK)
Iron Gates Nature Park (RO) / Djerdap National Park (RS)
Maramures Mountains Nature Park (RO) / Carpathian Biosphere Reserve (UA).

Methods and Data

Habitat suitability and linkage model

After a comprehensive literature review (i.e, Adriansen et al. 2003, Ardeleanu and Mirea 2009, Beier 1995, Breitenmoser and Haller 1993, Forman et al. 2003, Majka et al. 2007, Salvatori 2004) on GIS wildlife habitat modelling, we identified the appropriate GIS tools for our purposes. Among the available GIS habitat suitability models, we developed a combined GIS approach using the ArcGIS 10.0 tools CorridorDesign (Majka et al. 2007) and Linkage Mapper (http://code.google.com/p/linkage-mapper/). These tools are free of charge, relatively easy to apply, adaptable to specific situations and do not require the collection of empirical data on wildlife presence. CorridorDesign is applied to create a general suitability map for the ecological requirements of certain species in particular areas. Those maps indicate for each umbrella species at pixel-level the percentage of their affinity towards a set of habitat factors (e.g. land

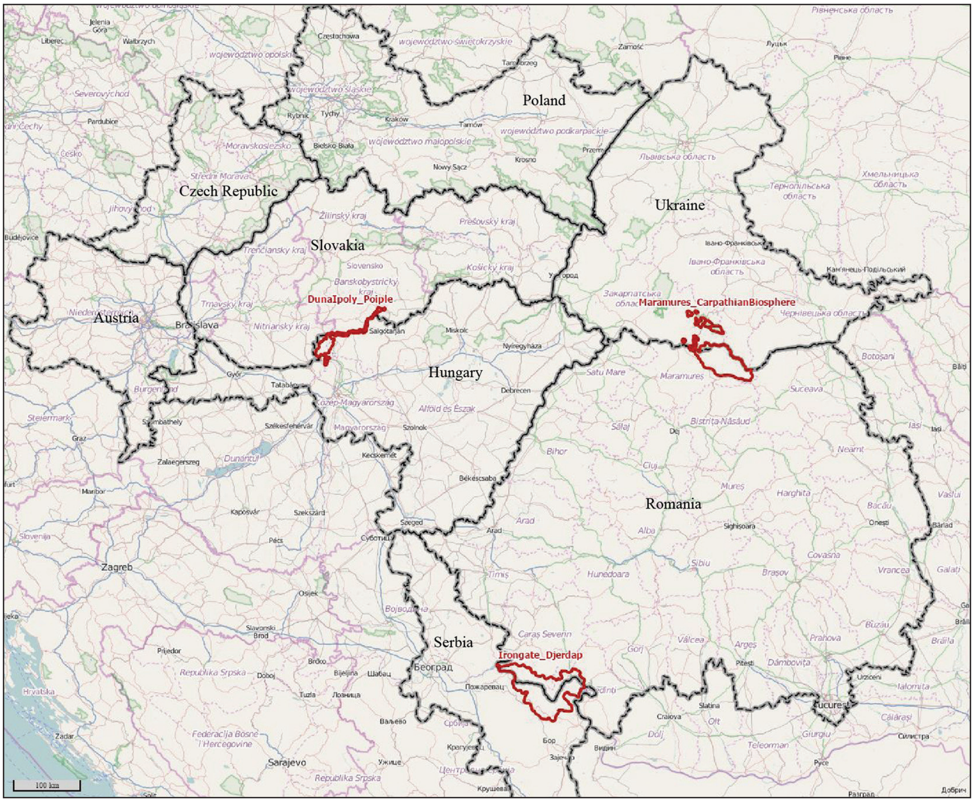

Figure 1. Web-GIS screenshot showing the BioREGIO Study site and Pilot Areas. The red polygons represent the selected national/nature parks (from http://webgis.eurac.edu/bioregio/).

cover, elevation, topography) describing the ecological framework conditions. The percentage suitability values for each species-specific factor and classes, considered as homogeneous for the whole BioREGIO study site, were taken from the literature and decided with partners and local experts. Within each habitat factor, several classes are differentiated. Every class is valuated according to its suitability towards the dispersal habit of the umbrella species For example the factor "land cover" considers classes like grassland, forest and urban areas, or the factor "topographic position" consist of classes like ridge top, canyon bottom, & steep slope.

Factors' classes and weights were combined through a geometric mean. With this approach, a pixel remains 0 if only one of the category is 0. Each pixel can then be assigned to a certain suitability class:

Suitability: 50–100% = Optimal habitat
Suitability: 25–50% = Sub-optimal habitat
Suitability: 0–25% = Occasional habitat
Suitability: 0 = Avoided, barrier

Table 1. Shows the selected factors and weights for each considered species used in our study. The weight of each factor reflects the relative importance it has for a certain species regarding its distribution and potential barrier.

Species	Land Cover	Elevation	Topographic position	Distance to Roads	Distance to urban
Lynx	40	10	20	15	15
Brown Bear	30	10	30	20	20
Grey Wolf	30	20	10	20	20
Chamois	50	15	20	5	10
Otter	40	15	20	20	5
European Hare	40	15	20	20	5
Capercaillie	40	15	20	20	5

The integration of an additional species-specific factor that concretely limits the species' dispersal (i.e., prey availability, distance from a food source, size of core area, distance of stepping stones etc.), allows the identification of the most probable core areas through the reduced extension of the general habitat suitability. For each species, the second-step factors were taken from the literature and then selected with local partners and experts (i.e., for the Lynx: Breitenmoser and Haller 1993, Kramer-Schadt et al. 2005). The pixels having a suitability values above 50% (sub-optimal and optimal habitat) were selected. In the second step, to identify the main core areas for some species, we used values taken from the literature and adapted to the Carpathians through a discussion with project partners (Table 2).

Table 2. Pixels' suitability and core areas size.

Species	Suitability	Size
Lynx	> 50%	> 10.000 ha
Brown Bear	> 75%	> 5000 ha
Grey Wolf	> 50%	> 100 ha
Chamois	> 50%	> 1000 ha

The identified supposed core areas were then used in *Linkage Mapper* to detect dispersal and connection paths requiring a minor expense of energy (*Least Cost Paths*). For a complete explanation of the model used, refer to the BioREGIO publication "Advanced tools and methodologies adopted – GIS Model Design for deriving ecological corridors" (Favilli et al. 2013, 2014).

The Least-Cost paths analysis, done through Linkage Mapper, allowed the identification of the energy spent by each species in moving from one core area to another (Cost-Weighted Distance, CWD) and of the Euclidean Distance between two core areas. The ratio CWD/Euclidean distance, calculated by Linkage Mapper, can be a clue to identify the more probable least-cost paths (LCPs) (McRae and Kavanagh 2012).

Identification of main social and economic barriers and challenges related to ecological connectivity

Three main methods were applied to collect and elaborate data for analysing the interaction between ecological connectivity and social as well as economic influences: a series of semi-structured interviews, an online questionnaire for partners and site visits at those bottleneck areas (hot-spots), the applied GIS model has identified. For obtaining relevant background information, the aspects of socio-economic impacts on ecological connectivity were enlightened in the interviews from the research view and the experiences from current practices. Hence the semi-structured interviews focused on these two main groups:

- Researchers and NGOs from the Carpathians and the Alps working on the topic of ecological connectivity: the interviews (30–40 min each) were carried out during the Forum Carpaticum in Slovakia 2012. Mainly researchers from agriculture and land use planning were interviewed.
- Stakeholders at Carpathian level – mainly from park administration and local administrations: the interviews (30– 40 min each) were carried out during the CNPA (Carpathian Network of Protected Areas event) and the Mid Term Conference of BioREGIO in Slovakia 2013.

The interviews were structured differently according to the interviewee's background and were composed as follows:

- Researchers/NGOs: in the Carpathians on the topic they research/work on and ecological connectivity, regarding critical aspects about the interaction of human activities and wildlife and possible solutions.
- Stakeholder experiences of concrete conflicts: between human activities and wildlife; concerning initiatives undertaken at local protected area/administrative level; due to the level of awareness towards the topic of ecological connectivity; regarding critical issues in the interactions among stakeholders from different sectors.

In parallel with the semi-structured interviews, an online questionnaire for the BioREGIO consortium partner has been developed. In this questionnaire, partners were first provided with a list of sectors (such as agriculture, forestry, protected area management, water management, administration); they were requested to list, for each of this macro-sectors, the stakeholder they deemed more relevant for the issue of ecological connectivity (for example, for the sector protected area managers, park directors and rangers). In a following step, the partners had to evaluate on a scale from 1 (min) to 5 (max), for each identified stakeholder category, the level of three main dimensions regarding stakeholders connected to ecological connectivity: (1) awareness, (2) influence and (3) activity. "*Awareness*" highlights the degree on how well stakeholders from different sectors are informed and know about the topic of ecological connectivity. "*Influence*" refers to the extent to which these stakeholder categories have the power to foster initiatives for promoting ecological connectivity. Finally, "*Activity*" is focusing on the degree in which these stakeholder categories actively contribute to the promotion and fostering of ecological connectivity.

Site visits and stakeholder meeting

The visual interpretation of the GIS results have shown several locations as potential "hot-spots" for connectivity. Mainly roads could be detected as barriers for connectivity, but the absence of a deep knowledge on the local (national/regional) socio-economic situation and human-wildlife conflicts, did not allow us to get a clear picture of each country. Missing data, unavailability or other issues related to data property were hindering data sharing. This forced us to organize site/field visits in specific locations of the Carpathians countries. These visits were performed in five of the seven Carpathians countries (Serbia, Hungary, Slovakia, Romania and Ukraine) at specific sites. Local partners chose the exact locations of the field investigations from several possible "hot-spots" (potential barriers for ecological connectivity) the GIS analysis has detected in a visual analysis of the Carpathians, according to the local relevancy and the socio-economic influence (Fig. 2). These explorative analyses intended to check potential physical barriers for connectivity and to discuss with local partner and stakeholders additional barriers coming from hunting, tourism, socio-economic development or legal limitations concerning transboundary cooperation.

Results

Habitat Suitability Map and Least Cost Paths for umbrella species from the corridor model

The application of the GIS *Habitat Suitability Model* to all the Umbrella Species allowed us to produce seven suitability maps for the whole Carpathians range (see Figure 3 for the Lynx).

This kind of maps are based on suitability values given to ecological factors in order to obtain a probabilistic map that needs to be verified with real empirical and field data. According to these first results and as reliable empirical data at local scale are usually not available to verify the actual presence of certain species at a specific location, the organization of site visits turned out to become a practical solution. According to their ecological preferences (extension or other ecological features), the suitability map process identified the supposed core area, where the presence of a specific species is expectable with a high probability.

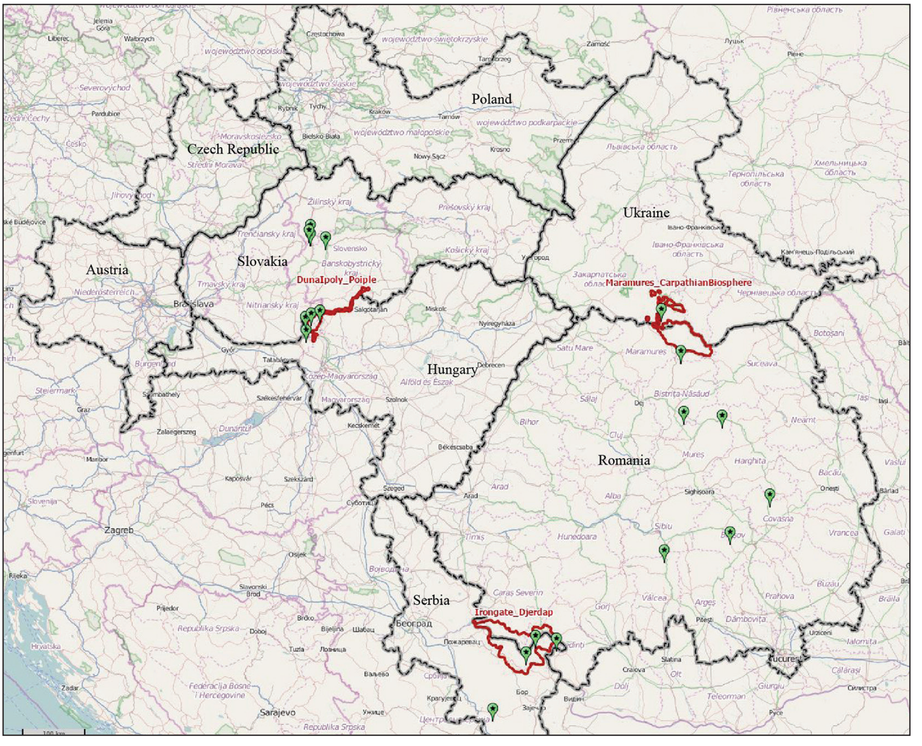

Figure 2. Web-GIS screenshot showing the selected locations (green dots) for the site visit analysis. The red polygons show the Pilot Areas (from http://webgis.eurac.edu/bioregio/).

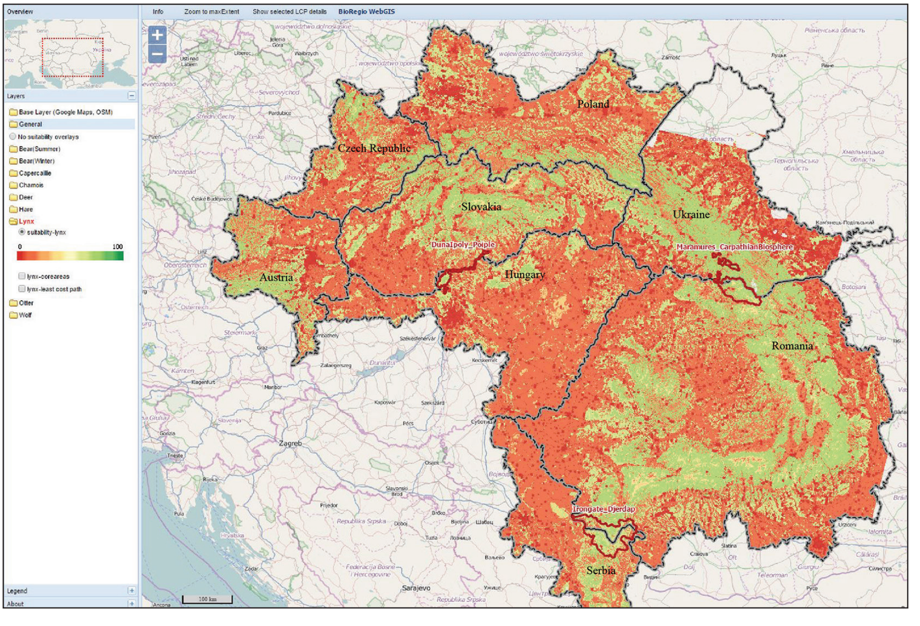

Figure 3. Web-GIS screenshot showing the Carpathians Habitat Suitability Map for the Lynx (from http://webgis.eurac.edu/bioregio/).

A case study: The Lynx in the Pilot Area Djerdap National Park (Serbia) / Iron Gate Nature Park (Romania)

Considering the overlap of the suitability maps from prey and predator species (e.g. wolf/deer; lynx/chamois etc.), it was possible to specify the potential suitability area for a certain species closer-to-reality. The subsequent application of *Linkage Mapper* to the results of *CorridorDesign* enabled the identification of the most probable paths connecting the different core areas based on the resistance of the matrix (the energy cost needed to cross a less suitable environment – see Figure 4 for the Lynx in Djerdap/Iron Gate).

The visual overlapping of the *Least Cost Paths* for each species with human infrastructures (mainly roads) enabled us, to identify the most probable physical barriers (hot spots) hindering dispersal across certain territories (Fig. 5).

Linkage Mapper therein detects all the possible *Least-Cost Paths* between all the core areas. These detected paths have to be categorized according to the CWD (cost-weighted distance): the length, the presence of barriers that increase the species' mortality risk (LCP risk), and the presence of protected areas, increasing the species' safety (LCP safe). According to the priority of these paths only those were chosen, which are more likely to be used by the selected species. In the Pilot Region Djerdap/Iron Gate, only 16 LCPs were designated to highlight the general ecological network for

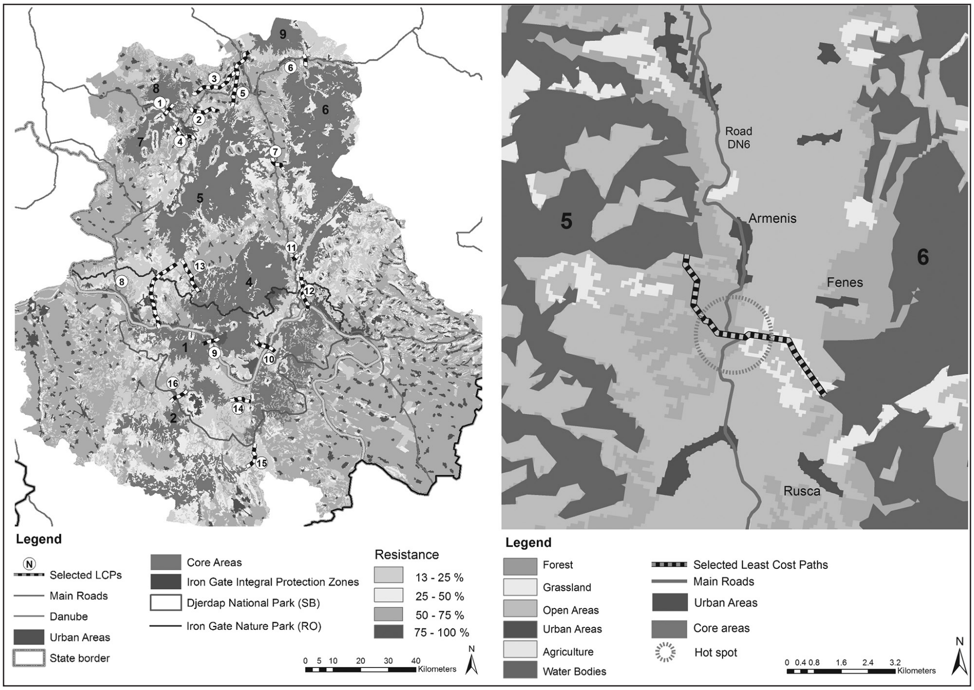

Figure 4–5. 4 Least Cost Paths for Lynx in the PA Djerdap/Iron Gate **5** Closer view of the LCP 7 and the supposed barrier.

the Lynx. Since the ratio CWD/LCP is not sufficient to identify the sites where the lynx may disperse most likely, for each species the evaluation considered the biological requirements, the impact from the different land cover types along the LCPs and the conformity to the presence of human society, to which the dispersal of these umbrella species is dependent of. The appropriateness of the LCPS for dispersal was then divided in 5 cut off categories (1 – Best; 2 – Probable usage; 3 – Possible usage; 4 – Difficult; 5 – Worst) (Table 3).

From the 16 selected LCPs, only 2 can be assigned to Category 1 because they are inside a forest in a protected area and do not meet any barrier. All the LCPs crossing the Danube have been marked with a (?) because of the uncertainties if the lynx has ever crossed it by swimming. It is more likely to assume the presence of the Danube as an insurmountable barrier, although sporadic lynx observations in this region were made and Serbian lynx populations have acquired some of the characteristics of the Balkan ones (Atanasov 1968, Paunovic et al. 2001). Nevertheless, the Danube has a seasonal changeability and for the lynx it could be passable during some winter months (Simeonovski and Zlatanova 2001, Spassov 2001). The LCPs belonging to Categories 1 to 3 seem to be usable by the lynx. The 4 and 5 ones are unlikely to be used due to the less suitable landcover classes the lynx would have to pass through and on the kind of barriers encountered.

The hereby-reported LCPs belong only to the Lynx, but the same analysis has been done for all the selected species. The selection of most likely LCPs could bring to the

Table 3. LCPs classification for the Lynx in the Pilot Area Djerdap/Iron Gate.

LCP ID	CWD (Meters)	LCP (Meters)	LCP risk	LCP safe	Land Cover*	Barrier	Ratio CWD/LCP	Usage	Category
16	34.082	1838	0	1	1	None	**18,52**	Best	**1**
14	167.728	7887	0	1	1	Agriculture	**21,26**	Best	**1**
10	87.806	3455	1	1	1-6	DN57/ Danube	**25,41**	(?)	**2**
12	83.860	3289	1	1	1-6	DN6/ DN57/ Danube	**25,49**	(?)	**2**
15	147.597	10.166	0	0	1-3	Agriculture	**14,51**	Probable	**2**
9	41.314	865	1	1	1-6	DN57/ Danube	**47,76**	(?)	**3**
13	225.601	13.340	0	0	1	Urban zone	**16,91**	Possible	**3**
1	28.443	624	1	0	1	DN58b	**45,58**	Possible	**3**
2	247.331	11.142	1	0	1-4-5	DN58	**22,19**	Possible	**3**
6	154.113	4462	1	0	1-3-4	DN68	**34,53**	Possible	**3**
8	482.063	28.736	0	2	1-6	DN57/ Danube	**16,77**	(?)	**3**
11	77.503	2997	1	0	1-5	DN6	**25,86**	Possible	**3**
7	172.290	5797	1	0	1-3-5	DN6/ Agriculture	**29,72**	Possible	**3**
4	240.811	10.315	2	0	1	DN58/ Urban zone/ Mine	**23,34**	Difficult	**4**
3	771.166	29.277	1	0	1-4-5-6	DN6/ Agriculture	**26,34**	Worst	**5**
5	679.716	23.185	2	0	1-4-5-6	DN6/ DN58b/ Agriculture	**29,31**	Worst	**5**

*Land Cover classes crossed: 1 = Forest; 2 = Grassland; 3 = Open Areas; 4 = Urban Areas; 5 = Agriculture; 6 = Water Bodies optimization of LCPs in one or more single paths for all the species. This procedure could help identifying the most important corridors for both wildlife movements and human/wildlife coexistence.

Site visits

The site visits gave the opportunity to discuss directly with local people and stakeholder the issues related to the relationship human/wildlife and the concept of ecological connectivity.

Because each country has its own history, landscape structure, laws, socio-economic environment and relationship with the local wildlife species, it was taken into consideration not only the perspective of science but also of residents, farmers and industry in order to find solutions that are practical and that may provide mutual benefits for humans and wildlife. The identified issues were then different for each country and ranged from animal – vehicle collision, building of new road infrastructures, hunting procedures and laws, forest management, intensive agriculture, trans-boundary laws, urban sprawl, and compensation of damages.

Socioeconomic barriers

The analysis on socio-economic barriers was mainly based on the preliminary semi-structured interviews and questionnaire for partners and on the site visits. Main aim was to identify the most crucial issues regarding the analyzed sectors and to propose a series of recommendations. First, this analysis provided a clear identification of the most relevant sectors connected to ecological connectivity in the Carpathians: the most relevant are protected areas, infrastructure planning, forestry, agriculture, energy, industry and the public administration at state level (ministries). Other relevant, to a lesser extent, sectors are local administrations, tourism and water management. A particularly relevant role is played, although in different measure according to the Carpathian country considered, by hunting. All these sectors have different levels of awareness and influence towards ecological connectivity. The main relevant gaps are shown in Figure 6, which represents the results of a questionnaire administered to the BioREGIO consortium. The evaluation scale for awareness and influence goes from 1 (lowest level) to 5 (highest level). It can be observed that the stakeholder group classified as the most aware (scientific community) is also the one that is considered as having the less influence. The respondents came largely from the scientific community and therefore they would possibly tend to overemphasize the perceived lack of influence. A part from that, the results nevertheless show how, often, a high influence is not associated to a high awareness.

Socio-economic barriers and possibilities take in consideration the expansion and the limitation of ecological connectivity coming not only from physical barriers. Besides, economic and social aspects have a significant impact too. This is particularly true for the Carpathian countries, which are currently experiencing quick social and economic trans-

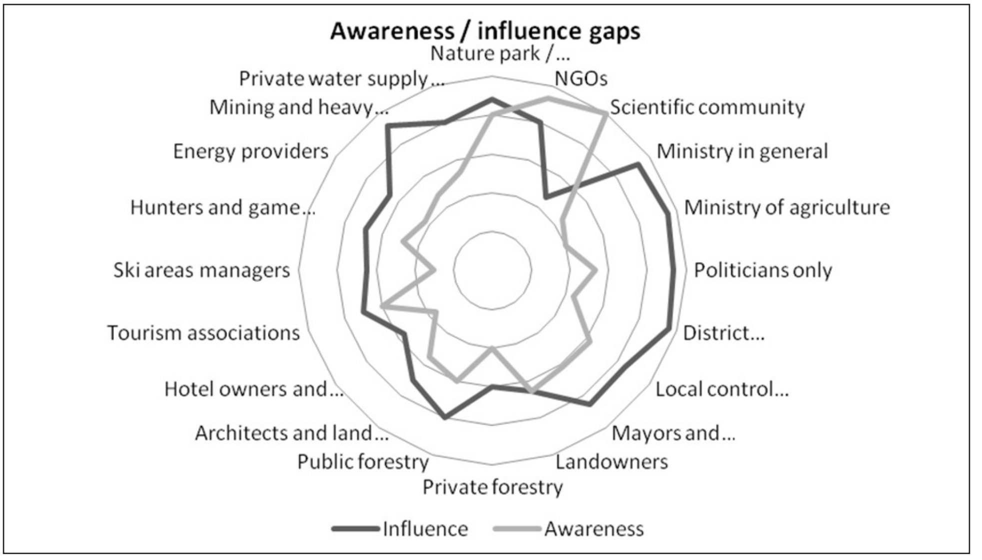

Figure 6. Awareness-influence gaps.

formation processes. Additionally, the attitude and awareness of local population towards protected areas and wildlife presence enhances significantly the effective implementation of connectivity measures. The socio-economic analysis tried to consider the impact of the different stakeholder in the different countries on the ecological connectivity

Web-GIS application

Within the framework of the BioREGIO project, a WebGIS application was designed with the attempt to spread the results of the ecological connectivity analysis and of the site visits, allowing people to know more of the structure of the Carpathians ecological network, its barriers and functionality (http://webgis.eurac.edu/bioregio/). Web-GIS applications can manage a large extent of geographical information, enabling their distribution among a large audience. The WebGIS contains both raster and vector data and it is structured into three main components: an information window; a real time maps browser with different layers containing general information concerning both the landscape and the connectivity specifically and a search engine (Fig. 7).

Discussion

Lesson learned

This suitability model developed in the framework of the BioREGIO project wanted to be a first attempt to identify the most probable areas of occurrence and dispersal

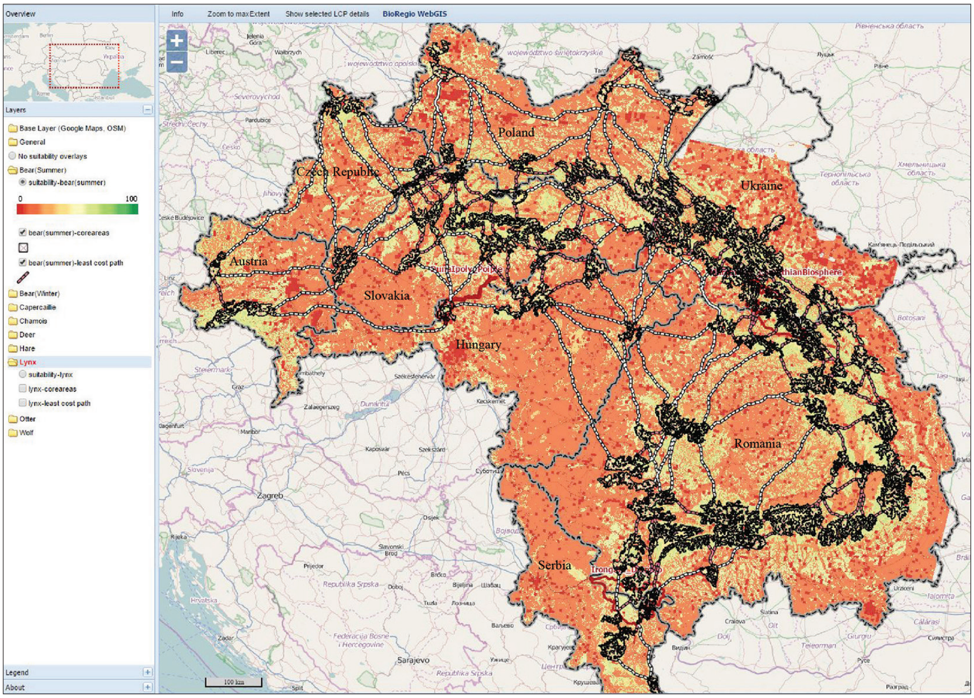

Figure 7. Web-GIS screenshot of the potential suitability map, core areas (black polygons) and least cost paths (dotted lines) for the Bear (Summer Model) in the Carpathians.

of seven Carpathians' flag species. The BioREGIO analysis started from the results obtained in previous investigations in the Carpathians such as Ardeleanu et al. 2009, Maanen et al. 2006, Salvatori 2004.

The analysis took in consideration biological, environmental and human feature in order to identify the main barriers blocking or hindering the dispersal and the socio economic situations of each Carpathians country. The obtained results do not want to be very comprehensive; the large extension of the Carpathians' arc, the different habitats and ecosystems, the socio economic and legislative aspects of the different countries require a follow-up of the investigations and actions at local scale to improve the connectivity and the human/wildlife relationship.

The GIS model tested in the BioREGIO project was a powerful tool that needed few available data to create a probabilistic map of the regional ecological connectivity. To perform a valuable analysis, it needed to receive inputs from local experts regarding the values to give to each factor's class and each factor's weight for each species. If the input data, factors, values and weights used are consistent with the actual situation, the model is able to visualize the general connectivity of the studied areas, detecting the paths that may provide safe and alternative routes. Local data on the presence and the extension of human-related infrastructures are needed to detect potential barriers to wildlife dispersal. In many cases, depending on the investigated region, this data could be obsolete and incomplete. Due to the use of the CORINE LAND COVER 2006 as a base Landcover map, some landscape features, or legal/illegal urban sprawl could not be projected in the actual way and some results could be badly interpreted or overestimated. Therefore, it was essential to perform the site visits in specific areas with the help of local stakeholder and experts to evaluate and validate the physical barriers detected through the GIS analysis and to know the local socioeconomic and legal environment. The GIS model does not want to be predictive; but the results derived from the least cost paths, the socioeconomic and legal analysis can be useful to prevent future threats to the ecological network due to the development of human infrastructures and to identify the most important corridors and the actions needed for their preservation.

Conclusions

Elaboration of recommendations

The final aim of the "Continuity and Connectivity" analysis was to produce a series of ten recommendations to overcome the barriers detected during the project lifetime. During the project lifetime, these 10 recommendations were indicated as the most relevant ones. They all refer to the initial concept to separate the barriers/possibilities influencing ecological continuum and connectivity into a physical, legal and socio-economic part. Due to the large extension of the Carpathians mountain range and to the national differences, it was intended to elaborate recommendations being applicable in all the Carpathian countries. From the practical point of view, it is almost impossible to give the derived recommendations the same priorities in each Carpathian country. It is in the nature of things that the same topic/problem is faced in different ways in different locations. That is evident due to historical reasons, the socio-economic environment, the national/local laws, the conformity of landscape, the species present causing conflicts with the human society and the personal relation of the people with local wildlife.

The ten recommendations do not want to be comprehensive. They are providing a general introduction and overview of the main barriers highlighted during the lifetime of the BioREGIO Carpathians project. The main aim of these recommendations was to look beyond the natural aspects of ecological networks and suitable areas for wildlife dispersal. Considering landscape maps is an almost straightforward strategy to define the most probable passage sites and core areas for each of the selected umbrella species. What the continuity and connectivity analysis aimed at was to define the most impacting forces influencing ecological networks, in order to prevent future fragmentation or other conflicts related to ecological connectivity.

The first five recommendations refer to physical barriers/possibilities and they concentrate on:

– New infrastructures, roads and motorways (with special focus on Deva-Lugoj Motorway, the planned D1 motorway in Slovakia and the planned M2 motorway in Hungary)

– Animal-Vehicle Collisions (highlighting the absence of mitigation structures and the driving behaviour – special focus on the road 25-1 in Djerdap National Park, Serbia)
– Hunting Procedures (the business of hunting, poaching and the impact on connectivity – special focus on feeding points in Romania)
– Forest Management (adaptation of forest management measures to promote connectivity – how to cope with economic interests and nature conservation?)
– Agriculture (Impact of intensively used agricultural fields on wildlife species – i.e., the hare)

Two recommendations refer to the legal field:
– Trans-boundary issues (cross-border natural areas, management plans, cooperation between EU and non-EU protected areas)
– Hunting laws (selective hunting, national infringements to EU legislation)

The last three recommendations refer to socio-economic topics:
– Urban sprawl and settlement expansion (the impact of (unauthorized) settlement expansion and of touristic infrastructures on the behaviour of species)
– Ecological connectivity beyond protected areas (stakeholder perception and combination of legislation and practices of sustainable integrated management)

The recommendations are providing a final assumption of topics touched during BioREGIO concerning ecological connectivity. This brief overview should enable a compact knowledge transfer, in which problems, opportunities, threats and strengths dealing with dispersal of wildlife are focused at, and in which the Carpathian particularities as well as natural assets playing herein a major role are underlined.

Recommendations are free for downloading from the project's website (http://www.bioregio-carpathians.eu/tl_files/bioregio/donwnloads_resources/Key%20Outputs%20and%20Publication/Recommendations_Connectivity_EURAC.pdf). The strategy followed took in consideration the ecological preferences of those species, their ranges of distribution and their sensitivity to human-related infrastructures. The collected information was used to develop GIS maps of habitat suitability in order to predict potentially the species' current distribution and daily/seasonal movements. Data on human activities (current/foreseen roads, settlements, hunting, forestry, agriculture and social attitude) were collected and integrated to detect the locations of possible human-wildlife conflicts and derive subsequently specific recommendations for their positive solutions. The ten recommendations are providing a general introduction and overview of the main barriers highlighted during the lifetime of the BioREGIO Carpathians project. The main aim of these recommendations was to look beyond the natural aspects of ecological networks and suitable areas for wildlife dispersal. Considering landscape maps is an almost straightforward strategy to define the most probable passage sites and core areas for each of the selected umbrella species. What the continuity and connectivity analysis aimed at was to define the most impacting forces influencing ecological networks, especially outside protected areas, in order to prevent future fragmentation or other conflicts related to ecological connectivity. Humans and wildlife share the same environment, therefore only when the factors causing conflicts are understood and solved, biodiversity together with human life could gain a higher value. Hence, it is fundamental to adapt the recommendations to the needs of the seven Carpathian countries. Based on the results of the site visits, each partner was requested to define in a questionnaire priorities concerning the importance and impact of each single recommendation in their countries and to underline their choice with a short explanation. With these essential contributions, the partners were able to derive specific approaches and recommendations that could be integrated in any legal act/guideline of a Carpathian country to sustain its ecological network and the human/wildlife coexistence.

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