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Landscape Connectivity bottlenecks in the Moravian-Slovak Borderlands - Transport Infrastructure and Other Anthropogenic Threats

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1. Abstract

Based on the findings of the TRANSGREEN and SaveGREEN projects, changes in land use in selected critical locations were analysed for the period after 1990, when new socio-economic conditions emerged. Aerial images and 1:10,000 topographic maps were used for the detailed analysis. Also changes in traffic intensities according to the National Traffic Census were explored. The next step was field visits to evaluate the permeability of existing transport infrastructure and other barriers in the landscape based on the principles and recommendations from the Wildlife and Traffic in the Carpathians handbook and new national Methodology of environmental audit. Estimation of future development was investigated by evaluating existing spatial-planning documentation. A selection of examples of good and bad practice affecting the connectivity for wildlife will accompany the paper.

2. Introduction

The area between Czech Republic and Slovakia is a mountainous cross-border region at the edge of the Western Carpathians' arch. It consists of several ranges including Moravskoslezské Beskydy, Javorníky and Bílé Karpaty mountains. The region is home to many rare species and includes protected sites within the Natura 2000 network. Most notably, it features the western-most permanent occurrence of Carpathian carnivore populations – i.e., brown bear (*Ursus arctos L.*), the wolf (*Canis lupus L.*) and European lynx (*Lynx lynx L.*) (Chapron et al. 2014; Hulva et al. 2018).

However, the long period of human development concentrated in deep river valleys is demanding its price, and the individual mountain ranges remain separated into independent units without maintaining landscape connectivity. High levels of anthropogenic fragmentation have meant that the permeability of the landscape has only been partially maintained in a few places, threatening local vulnerable populations, particularly of species particularly dependent on long-distance migratory movements (Anděl 2010). The general drivers that significantly affect habitat's connectivity and integrity are the development of transport and other types of infrastructures (Papp et al. 2022), land-use change including anthropogenic land-cover change and conversion (Súľovský et al. 2017), intensive agriculture (Žarnovičan et al. 2021), urbanisation and climate change. Recreational activities may be also considered among the significant anthropogenic negative impacts (Havlíček and Dostál 2019).

This paper seeks to answer the question, "Has the structural connectivity of landscape been significantly affected by the development of anthropogenic structures over the time period under study?" and a side research question can be formulated as: "Do existing (or newly created) roads form an impassable barrier to wildlife?"

3. Method and Data

3.1 Study area

Total of six model sites (figure 1) within Beskydy mountains were chosen among critical sections identified within Habitat of selected specially protected species of large mammals, the proposed ecological network to ensure the landscape connectivity for wildlife in the Czech Republic (Romportl et al. 2017). A common feature of these sites is the presence of multiple types of barriers that threaten connectivity, including railways, non-forest areas, arable land, and development in addition to roads.

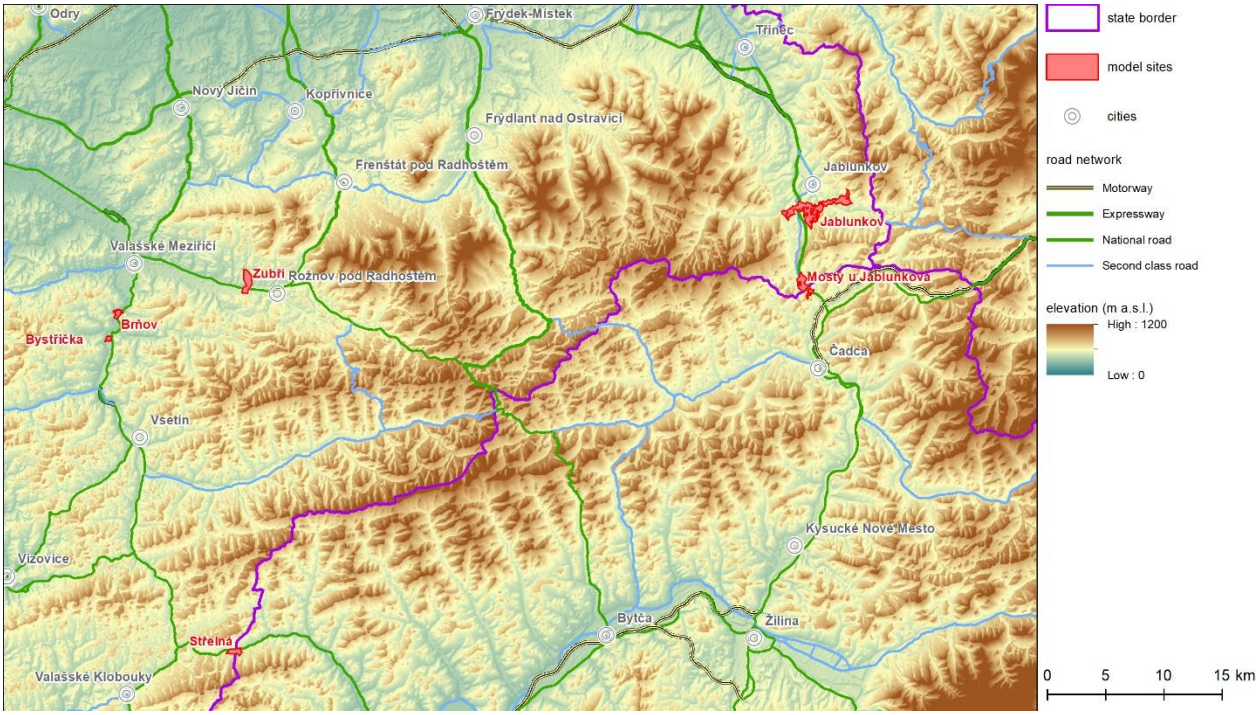

Figure 1. Study area and six model sites

3.2 Map resources and GIS processing

In monitoring detailed changes in land use (LU), the Base Maps of the Czech Republic were used at a scale of 1:10,000 and aerial photographs from three time horizons (1990, 2006, 2020). The aim was to describe the changes in the landscape structure in the period after the change of the political system and the transition to the market economy. The smallest mapping unit was an area of 0.1 ha. It was monitored in following LU categories: 1 - arable land, 2 - permanent grassland, 3 - garden and orchard, 4 - vineyards and hop fields, 5 - forest, 6 - water area, 7 - built-up area, 8 - recreational area, 9 - roads and railways and 0 - other area. Contrary to previous research, the category of transport infrastructure has been introduced. Comparison of the different periods in the GIS environment will result in comparative map layers that show the processes and trends of LU change using single-digit codes mentioned above (Havlíček, Chrudina 2013).

Roads and railways passing through individual critical points were evaluated in terms of meeting basic standards for wildlife permeability according to the relevant part of the new Czech methodology for Environmental Audit of Roads (Jedlička et al. 2022). Special attention was paid

to the development of traffic intensity based on the results of the National Transport Census in 1990, 2005 and 2020. For roads of European importance (according to the AGR agreement) and railways included in the TEN-T, which are typically characterised by higher traffic intensity, the presence of migration objects suitable for large and medium-sized mammals was also monitored with an assessment of the fulfilment of the standards (dimensions, nature of sub-bridges, additional mitigation measures, integration into the surrounding landscape etc.) required in the Carpathian Guidelines (Hlaváč et al. 2019).

The spatial master plans available on the websites of the municipalities in the model sites were surveyed to identify those developments that could significantly affect the future permeability of these sites. Potentially threatening anthropogenic structures included new roads, railways, housing developments, fenced areas and artificial water bodies.

4. Results and discussion

The proportions of land use categories in all six sites were evaluated as a basic characteristic of land use change in order to identify LU changes that have positive (e.g. afforestation) or negative (e.g. housing growth, agricultural intensification) effects on landscape connectivity for wildlife. Stable LU areas and LU change processes were used for assessing the dynamics of landscape.

Table 1. Percentage of stable land use areas between 1990 and 2006 (%)

LU category	Brňov	Bystřička	Jablunkov	Mosty u J.	Střelná	Zubří
arable land	5.53	31.09	14.01	9.03	20.04	47.55
permanent grassland	12.84	11.77	12.12	8.84	9.27	3.52
orchard	0.00	0.22	0.00	0.00	0.11	2.02
forest	53.67	30.82	27.72	33.4	38.17	22.09
water area	2.24	2.18	0.00	0.00	0.00	0.64
built-up area	5.56	6.19	9.66	5.49	2.36	7.82
recreational area	0.29	0.75	0.00	0.00	0.00	0.00
roads and railways	1.31	1.59	0.67	0.81	2.93	0.85
Total	**81.44**	**84.61**	**64.18**	**57.57**	**72.88**	**84.49**

Between 1990 and 2006, all six sites were characterised by a high proportion of stable forest areas (Table 1). In the case of Zubří and Bystřička, however, the highest proportion of stable land use was in arable land. During this period, some arable land areas were still preserved in the upland landscape (Súľovský et al. 2017, Havlíček and Chrudina 2013). The proportion of stably used areas of permanent grassland in this period ranged from approx. 4% to 13%. Overall, the Brňov, Bystřička and Zubří sites can be considered as stably used areas, with more than 80% of the area being stably used. Most LU changes took place in the Mosty u Jablunkova locality. Also in second comparison period, the highest proportions of stably used areas were predominantly in the forest category (Table 2). Stable areas of permanent grassland occured especially at the sites of Jablunkov and Mosty u Jablunkova. An exception is the high proportion of stable areas in the Zubří locality, which is an agricultural area in a part of the territory with a slightly undulating or flat relief. The proportions of stable land use are higher in this intermediate period than in the previous period, with the most dynamic change in the landscape around Bystřička.

Table 2. Proportion of stable land use areas between 2006 and 2020 (%)

LU category	Brňov	Bystřička	Jablunkov	Mosty u J.	Střelná	Zubří
arable land	2.38	13.82	2.01	1.11	16.41	43.62
permanent grassland	10.70	12.26	35.50	29.52	12.79	14.19
orchard	0.00	0.40	0.00	0.00	0.11	2.12
forest	60.32	31.17	32.08	44.42	52.09	24.78
water area	1.88	1.87	0.00	0.00	0.04	0.64
built-up area	7.55	7.51	11.22	9.26	3.06	8.30
recreational area	0.30	0.17	0.00	0.00	0.00	0.00
roads and railways	1.31	1.59	1.03	1.21	3.33	0.85
Total	**84.44**	**68.79**	**81.84**	**85.52**	**87.83**	**94.50**

Table 3. Land use change processes between 1990 and 2006 (%)

Process	Brňov	Bystřička	Jablunkov	Mosty u J.	Střelná	Zubří
1>2	3.25	7.97	26.65	23.44	5.38	12.13
1>5	0.45	0.41	0.87	6.91	2.02	0.56
1>6	0.00	0.47	0.00	0.00	0.00	0.00
1>7	0.20	1.06	1.03	2.02	0.00	0.48
2>1	1.02	0.90	0.29	0.78	0.51	0.00
2>5	4.57	1.27	3.16	4.90	11.78	2.14
2>7	0.96	0.63	0.49	2.48	0.62	0.00
3>7	0.91	0.04	0.15	0.05	0.00	0.00
5>2	0.75	0.32	0.58	0.53	4.69	0.07
7>2	0.94	0.39	1.34	0.70	0.22	0.00
8>7	0.85	0.00	0.04	0.00	0.00	0.00

Explanation of LU codes: see chapter 3.2

The processes of LU change show the dynamics of development in the areas (Table 3). Among the selected localities, the most intensive process of grassing on arable land (code 1>2) was between 1990 and 2006, with the highest representation in the localities of Jablunkov and Mosty u Jablunkova. The creation of forest from permanent grassland (code 2>5) is also a very important process in these sites. From the point of view of the impact of landscape development on wildlife migration, it is also important to monitor the dynamics of the growth of built-up areas (i.e. in the category with code 7). The most dynamic growth of built-up areas occurred in the Mosty u Jablunkova locality. Even between 2006 and 2020, there were high proportions of areas in processes from arable land to permanent grassland, which is in line with the trend of targeted grassing of less fertile agricultural land in litter (Súľovský et al. 2017, Havlíček, Chrudina 2013). Among the more intensive processes was also the emergence of forest from permanent grassland. In this period, more intensive growth of built-up areas was recorded only in the Bystřička and Jablunkov sites (Table 4).

Table 4. Land use change processes between 2006 and 2020 (%)

Process	Brňov	Bystřička	Jablunkov	Mosty u J.	Střelná	Zubří
1>2	3.76	17.31	12.80	8.18	4.16	3.93
1>5	0.54	0.30	0.06	0.72	0.41	0.00
1>6	0.00	0.02	0.00	0.00	0.00	0.00
1>7	0.38	1.61	0.27	0.04	0.10	0.00
2>1	0.37	0.62	0.34	0.02	2.33	0.26
2>5	6.47	5.24	2.68	3.61	4.91	0.44
2>7	0.95	1.65	1.32	0.28	0.02	0.87
3>7	0.86	0.03	0.00	0.35	0.00	0.00
5>2	0.26	0.25	0.06	0.35	0.24	0.00
7>2	0.44	0.44	0.13	0.53	0.00	0.00
8>7	0.00	0.56	0.00	0.00	0.00	0.00

Explanation of LU codes: see chapter 3.2

The five sites were characterised by a high proportion of arable land in the early period, which is in line with findings from other sites in the area (Súľovský et al. 2017, Havlíček and Dostál 2019). In the case of the Jablunkov, Mosty u Jablunkova sites, there was a very significant reduction in the proportion of arable land areas (from over 40% to 2%), and in the Bystřička site, the proportion was reduced from 40% to 15%. A high proportion of arable land remains only in Zubří (decrease from 60% to 44%), and arable land is partially preserved in Střelná (decrease from 28% to 19%). The significantly wooded landscape has always been around the Brňov site (the share of forest increased from 55% to 67%). Permanent grassland was a very dynamic land use category in all sites, with an increase from 16% to 49% and 39% in the Jablunkov and Mosty u Jablunkov sites, respectively. This finding is consistent with data on development in less favourable agricultural areas of Central Europe (Súľovský et al. 2017). There was a gradual increase in the proportion of built-up areas in all six sites increasing by up to 4% in some sites.

In addition to land-use, another major aspect affecting the connectivity of the landscape is the linear transport infrastructure. Due to the lack of highway-type roads in the study area, the barrier effect of traffic is composed mainly of a dynamic component in the form of traffic volumes. It is evident from figure 2 that national roads I/35 (site Zubří) and I/57 (sites Brňov and Bystřička) show very similar trends in traffic volumes. Between 1990 and 2005 intensity doubled, while in the next period the growth was significantly mild. The sites close to the border with Slovakia (Střelná, Jablunkov and Mosty u Jablunkova) are characterised by a decrease in intensity during the 2020 census compared to 2005 while the growth in the first period was significant. This can be explained by the reduction of cross-border traffic due to covid restrictions. The section of the I/11 road through the Jablunkov site was opened in 2001, diverting traffic from the original road, now known as II/474. No traffic counts were carried out on county road III/01149 in 1990, so results are presented only for the subsequent period. According to the Iuell et al. (2003) only roads with traffic intensity up to 2,500 vehicles/day should be considered a limited problem. That's the case of Střelná site and side roads in Jablunkov site. Intensity between 2,500 and 10,000 vehicles/day (sites Jablunkov and Mosty u Jablunkova) is considered a "deadly trap" with

high risk of animal-vehicle collision. Sites Zubří, Brňov and Bystřička should be considered as almost impermeable due to high intensity of traffic causing severe barrier effect.

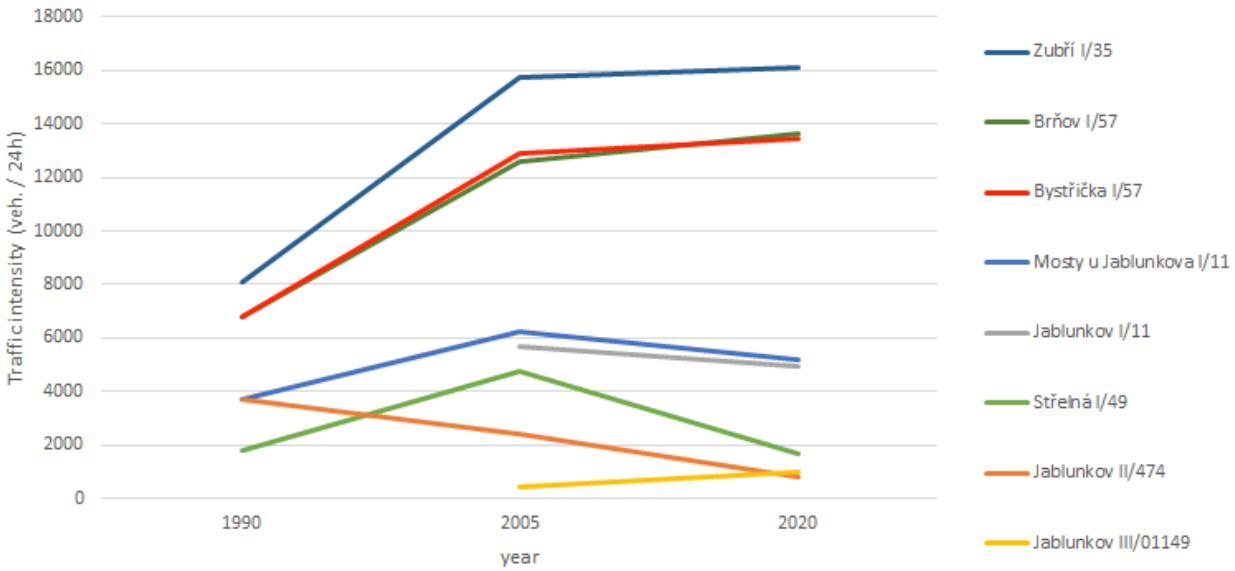

Figure 2. Traffic intensity on the roads in model sites (vehicles/day)

Table 5. Description of future threats in each model site from spatial plans

site	description
Brňov	the relocation of the I/57 road is being considered for the future, the main barriers in the area. one of the variants assumes the construction of a tunnel, which is the best solution in terms of connectivity
Bystřička	a new relocation of the I/57 road in the form of an expressway is in the planning process, an intersection is planned at the current corridor location, migration object is planned using underpass (crossing with river) south of the current corridor
Jablunkov	the spatial master plan accepts the function of the area as a biocorridor, the addition of green belts is proposed to strengthen this function
Mosty u Jablunkova	no major structures are planned, the status quo is preserved, green bridge over the road and railway is discussed to improve situation
Střelná	a new motorway D49 included in the TEN-T network is planned in the future, it is assumed that the corridor's permeability will be preserved with green bridge
Zubří	strengthening the functions of the biocorridor, but the permeability of the main barrier in the form of traffic density on the I/35 road is not addressed

Analysis of the spatial plans yielded different findings for each model site (Table 5). In four of the six sites, a new, higher capacity, road is planned to be built in place of the existing national road. In one case (Střelná) a new green bridge is planned, for two sites the impact of this construction will depend on the final option chosen, while at the Zubří site, the throughput has not been considered in the designs. The improvement of the function of the existing corridors by planning new green belts in the landscape and the defragmentation measures considered in the form of a new green bridge at the Mosty u Jablunkova site are beneficial.

The evaluation of objects usable as potential passages for large and medium-sized animals resulted in the discovery that suitable structures are located only on the relatively newly built I/11 road near Jablunkov and the railway line there (Figure 3,4,6). The other older roads, despite high traffic intensity, do not have suitable structures, on the contrary, the permeability is degraded by the structural-technical layout of the road, e.g. in the form of a retaining wall (Figure 5).

Figure 3. Site Jablunkov, bridge nr. 11-193. The crossing of the migration corridor at Jablunkov through the I/11 road is secured by a 440 m long flyover bridge.

Figure 4. Railway bridge near Mosty u Jablunkova. Originally a small culvert enlarged into a passage suitable for all animal species during the modernisation

Figure 5. I/57 road in the model site Brňov. The retaining wall in combination with the railway line forms an absolutely impassable barrier.

Figure 6. Railway bridge in Jablunkov. Another example of a structure adapted to wildlife migration during railway reconstruction

5. Conclusion

During the 30 years of landscape use development in the six monitored sites, both trends with negative and positive impacts on wildlife migration were recorded. The negative impacts are mainly the growth of built-up areas and the interconnection of settlement structures. Especially the areas with higher dynamics of these processes (Jablunkov, Mosty u Jablunkova, Bystřička) seem to be problematic. The growth of forest areas, which is typical for most of the monitored localities, can be considered as positive trend. The growth of permanent grassland at the expense of arable land is also a positive trend, but a detailed field survey revealed that some of these areas are fenced, and the free movement of wildlife is restricted. Overall, for these critical sites, it is necessary to restrict further construction of housing, industrial and logistics sites along the axis of the migration corridors and to promote measures to improve wildlife permeability such as green

belts. The implementation of such measures will also help positively in addressing big stakes such as improving ecological stability, mitigating the impacts of climate change, promoting biodiversity and avoiding soil erosion. The transportation tends to further create barriers in the area, with existing national roads being replaced by higher type roads such as expressways. However, this does not necessarily mean a deterioration in the permeability of the area, but rather the opposite, as the design of modern roads tends to be better adapted to the needs of wildlife.

6. Acknowledgement

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7. References

Chapron G., Kaczensky P., Linnell J. D. C. et al. 2014. Recovery of large carnivores in Europe's modern human-dominated landscapes. *Science* 346:1517–1519.

Havlíček, M., Chrudina, Z., 2013. Long-term land use changes in relation to selected relief characteristics in Western Carpathians and Western Pannonian basin – case study from Hodonín District (Czech Republic). *Carpathian J. Earth Environ. Sci.* 8 (3): 231-244

Havlíček, M., Dostál, I. 2019 Spatial conflicts of winter ski resorts with wildlife habitats – case study Beskydy Mts. and Moravian Wallachia. In: Fialová J. (ed) *Public Recreation and Landscape Protection - with Sense Hand in Hand...* Conference proceeding. Mendel University in Brno, Křtiny, 365–370.

Hlaváč, V., Anděl, P., Matoušová, J. et al. 2019. *Wildlife and Traffic in the Carpathians. Guidelines how to minimize the impact of transport infrastructure development on nature in the Carpathian countries*. Danube Transnational Programme TRANSGREEN project, Part of Output 3.2. Banská Bystrica: Štátna ochrana prírody SR, 225 pp. ISBN 978-80-8184-068-5.

Hulva P., Černá Bolfíková B., Woznicová V. et al. 2018. Wolves at the crossroad: Fission-fusion range biogeography in the Western Carpathians and Central Europe. *Divers. Distrib.* 24:179–192.

Iuell, B., Bekker, G. J., Cuperus, R. et al. 2003. Wildlife and Traffic: A European Handbook for Identifying Conflicts and Designing Solutions. Utrecht: EC, COST 341, KNNV, 172 pp.

Jedlička, J., Anděl, P., Dostál, I., Havlíček, M., Gorčicová, I. 2022. Metodika Environmentálního auditu dopravní infrastruktury. *Silniční obzor*, 83(2):24-28.

Papp, C.R., Dostál, I., Hlaváč, V., Berchi, G.M., Romportl, D. 2022. Rapid linear transport infrastructure development in the Carpathians: a major threat to the integrity of ecological connectivity for large carnivores. *Nat. Conserv.*, 47:35-63.

Romportl, D. (ed.), Zýka, V., Skokanová, H. et al. 2017. *Atlas fragmentace a konektivity terestrických ekosystémů v České republice*. Praha: AOPK ČR, 34 p. ISBN 978-80-88076-50-6.

Súľovský M., Falťan V. et al. 2017. Spatial analysis of long-term land-use de-velopment in regard to physiotopes: case studies from the Carpathians. *Phys. Geogr* 38(5): 470–488.

Žarnovičan H., Kollár J., Falťan V., Petrovič F. 2021. Management and land cover changes in the western Carpathian traditional orchard landscape in the period after 1948. *Agronomy* 11(2):366.