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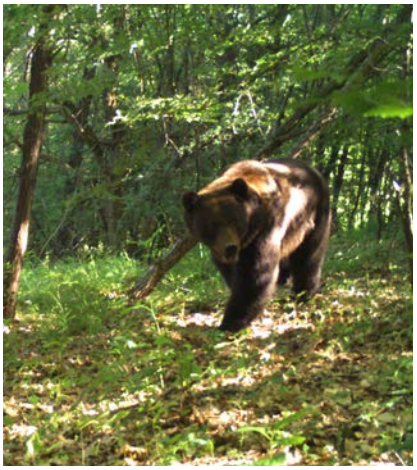

Catalogue of Measures

Tîrgu Mureș – Iași Pilot Area

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Catalogue of Measures

Tîrgu Mureș – Iași Pilot Area (Romania)

Part of Output 4.1

TRANSGREEN Project "Integrated Transport and Green Infrastructure Planning in the Danube-Carpathian Region for the Benefit of People and Nature"

Danube Transnational Programme, DTP1-187-3.1

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Motion-sensor camera data was gathered and analyzed within the frame of the TRANSGREEN project. Fieldwork was carried out by the following people: István Komáromi, Szilárd Sugár, Tibor Sos, Tamás Miholcsa, Iulia Vizi, Szilárd Ölvedi, Zsolt Hegyeli and Réka Komáromi. Data sorting and analysis was carried out by: István Komáromi, Szilárd Sugár, Tibor Sos, Zsolt Hegyeli, Réka Komáromi and Réka Beáta Kiss. GIS work (final data analysis) was carried out by Gábor Bóné.

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About TRANSGREEN

TRANSGREEN means a better connected Carpathian region with transport infrastructure that takes nature into account. The project aims to contribute to safer and environmentally-friendly road and rail networks that are being developed in the Czech Republic, Hungary, Romania, Slovakia, and Ukraine.
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Output 4.1 Catalogues of measures available for:

Kysuce-Beskydy cross-border pilot area (the Czech Republic, Slovakia)

Miskolc-Košice-Uzhgorod trilateral pilot area (Hungary, Slovakia, Ukraine)

Arad-Deva pilot area (Romania)

Tîrgu Mureș-Iași pilot area (Romania)

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1. Pilot area description

Pilot area 4 is located in Eastern Transylvania, Romania, along the planned Tîrgu Mureș-Iași-Ungheni (A8) highway. This highway is supposed to link the historic Romanian regions of Transylvania and Moldova. Of the total planned length of 311 km, our work within the TRANSGREEN project mainly focused on the Westernmost of the three sections of the actual highway route, located between Tîrgu Mureș (Ilieni) and Ditrău (section length: 92.1 km) - Fig. 1. This section is situated in the Mureș and Harghita counties. Still, some of our activities have also 'scraped' the mid-section of the planned highway, between the localities of Ditrău and Târgu Neamț (Harghita and Neamt counties). The planned highway is part of the TEN-T Core network. Milvus Group is based in the general area (Western end of the planned highway) and has a long history of working on biodiversity and with local communities in the area. Some of Milvus Group's prior activities in the area focused specifically on the possible negative effects of the planned highway, yielding some relevant preliminary data.

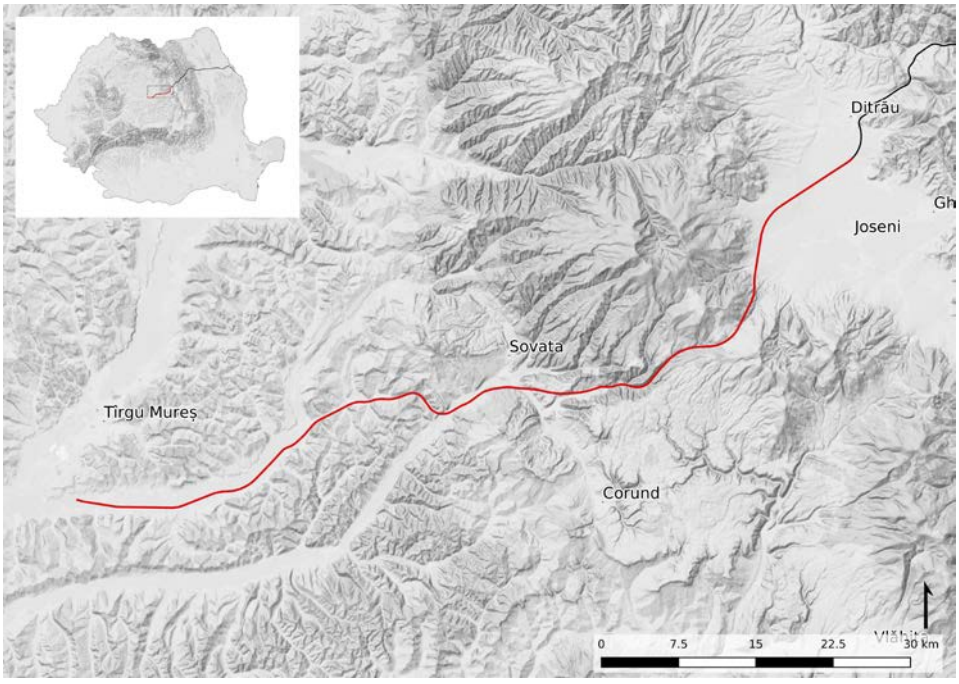


Fig. 1. - The location of Pilot Area 4 within Romania (upper left corner) and detailed map of the Tîrgu Mureș-Ditrău section of the planned Tîrgu Mureș-Iași-Ungheni (A8) highway (red line), with major nearby settlements.

The Westernmost section of the planned highway will cut through the western foothills of Romania's Eastern Carpathians, or possibly through the western part of the Eastern Carpathians themselves (the Gurghiu Mountains). The area has a general topographic gradient with lower elevations in the West, respectively higher elevations in the East (except for the last few kilometres of this section in the East, inside the Giurgeu basin).

The Western part of our section of interest (e.g. the section in the foothills) cuts through an area with numerous settlements, ranging from small villages to cities. Geographically, this includes parts of the lower and mid-river basins of the Niraj river, the Nirajul Mic river basin, or potentially part of the upper river basin of the Târnava Mică river. Here, the highway will intersect the administrative territories of a total of 11 localities / parishes: Gheorghe Doja,

Crăciunești, Acățari, Păsăreni, Gălești, Miercurea Nirajului, Măgherani, Ghindari, Sărățeni, Sovata and Praid. The main land use in the area is for agriculture purposes. Arable fields occur mainly at lower elevations and close to human settlements, while semi-natural pastures, hayfields and orchards are usually located at higher elevations. Forest succession occurs within abandoned fields, forming almost impenetrable thickets. As most private lands are of small size, the foothills form a mosaic of human land use with forests at higher elevations and in more inaccessible valleys. Treed areas include deciduous (the European hornbeam [*Carpinus betulus*], the oak [*Quercus sp.*], the European beech, the black locust [*Robinia pseudoacacia*]), the planted conifer (Scots pine [*Pinus sylvestris*]) and mixed forests.

The Eastern part of our section of interest intersects an area that is mostly mountainous and includes part of Romania's Eastern Carpathians (the volcanic Gurghiu Mountains in the vicinity of the Bucin pass), or alternately part of the Giurgeu basin. This section includes human settlements only in the Giurgeu basin. In this mountainous section, the highway will intersect the administrative territories of a total of 3 localities / parishes: Praid, Joseni and Lăzarea (all situated in Harghita county). The predominant land cover is forest, including deciduous (mainly the European beech [*Fagus sylvatica*]), the conifer (Norway spruce [*Picea abies*], the silver fir [*Abies alba*] and the European larch [*Larix decidua*]) and mixed forests. Agriculture also occurs here, most notably in the form of mountain pastures used from late spring to early autumn (May-September), or arable fields located in the Giurgeu basin.

2 On-the-field monitoring

2.1. Radio telemetry study of brown bears in and adjacent to Pilot Area 4 and results relevant in relation to the planned Tîrgu Mureș-Iași-Ungheni (A8) highway (Tîrgu Mureș-Ditrău section)

Data collection

Starting with 2011, brown bears are continuously captured, fitted with GPS-GSM collars and monitored in the frame of the long-term initiative the "Brown bear conservation and research program in a model area in Romania", carried out by the Milvus Group. Bears are captured in cage traps (Fig. 2) and immobilized with a combination of medetomidine and tiletamine-zolazepam at a dosage of 35 µg Medetomidine and 2-5 mg Zoletil / kg visually estimated body weight, administered with dart syringes fired from a Dan-Inject® CO2 Injection Rifle Model J.M.SP™. We fit captured bears with Vectronic Aerospace® (Berlin, Germany) GPS Pro Light-4™, or Vertex Lite-4D GPS-GSM collars (Fig. 3). Collars are set to acquire a GPS fix every 1h, including the denning period. All collars are equipped with an automatic drop-off system, pre-programmed to fire the collar off the animal's neck 110 weeks after the start of the monitoring period (some of the first monitored animals' collars were pre-set for longer monitoring periods).

Fig. 2 - Capture of adult male brown bear M4 for collar deployment in the frame of Milvus Group's radio telemetry study. Source: Milvus Group

Fig. 3 - Adult female brown bear F6, still under anaesthesia, fitted with a GPS-GSM collar in the frame of Milvus Group's radio telemetry study. Source: Milvus Group

The monitoring of bears in the general area of Pilot Area 4 is ongoing, within the frame of the "Brown bear conservation and research program in a model area in Romania". For the purpose of this study, we have selected data originating from a total of 10 individuals (7 males and 3 females; from both finalized and ongoing monitoring [for the latter cases, data available in early February 2019], summarized in Table 1). The criterion for the selection of these specific data sets was for the collared bear to cross the planned route of the A8 highway at least on 1 occasion (data sets not corresponding to this criterion were not considered). In the case of each individual bear, available GPS data sets were filtered for a minimum quality of GPS-2D fixes (fixes below this quality were excluded from the analysis).

Table 1 - Summary of the brown bear radio telemetry data selected for analysis in relation to the planned Tîrgu Mureș-Iași-Ungheni (A8) highway (Tîrgu Mureș-Ditrău section).

Bear ID	Sex and estimated age*	Monitoring period (in days)	No. of GPS-2D and above quality fixes
M2	♂ sub-adult	756	17,880
M3	♂ sub-adult	502	9,875
M6	♂ sub-adult	178	3,795
M9	♂ adult	84	1,585
M10	♂ sub-adult	672	12,239
M11	♂ sub-adult	165	3,902
M12	♂ sub-adult	616	14,138
F3	♀ adult	91	1,862
F6	♀ adult	771	12,608
F8	♀ adult	529	11,372

* age estimation method: degree of teeth wear (based on experience); in the case of females we also examined the tits (if the female bear has already lactated young, it was considered an adult). Some of our collared sub-adult bears have matured during the period they were monitored, becoming adults.

Data analysis

For the purpose of this study, for each data set originating from an individual collared bear, we have used the total of the shortest distances connecting 2 consecutive GPS fixes registered by the respective collar (Fig. 4). Thus, the data set originating from a collared bear was converted from the sum of GPS locations (collar fixes) to a continuous linear data set (sum of the shortest distances connecting actual collar fixes; Fig. 5).

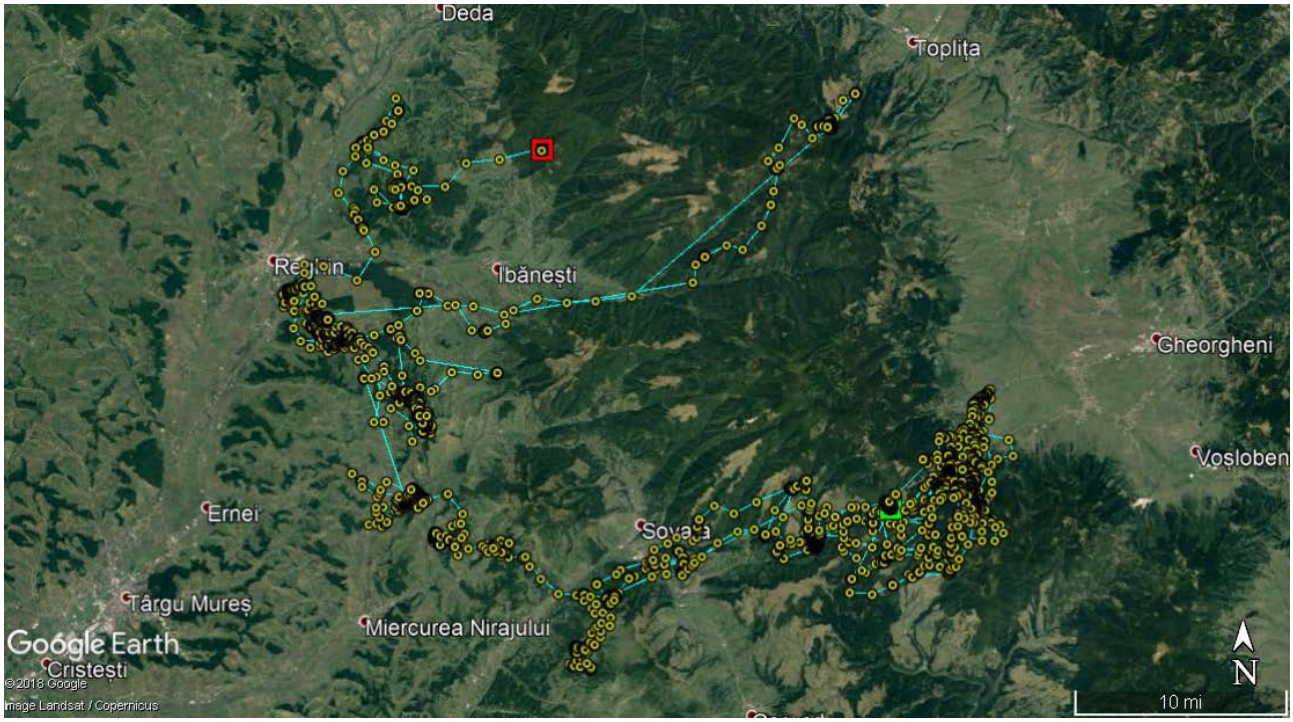


Fig. 4 - Telemetry data set originating from collared sub-adult male bear M6. Yellow dots represent actual GPS fixes registered by the collar, while the blue lines connecting 2 consecutive GPS fixes represent the shortest straight distances between the 2 consecutive GPS fixes. Source: Milvus Group

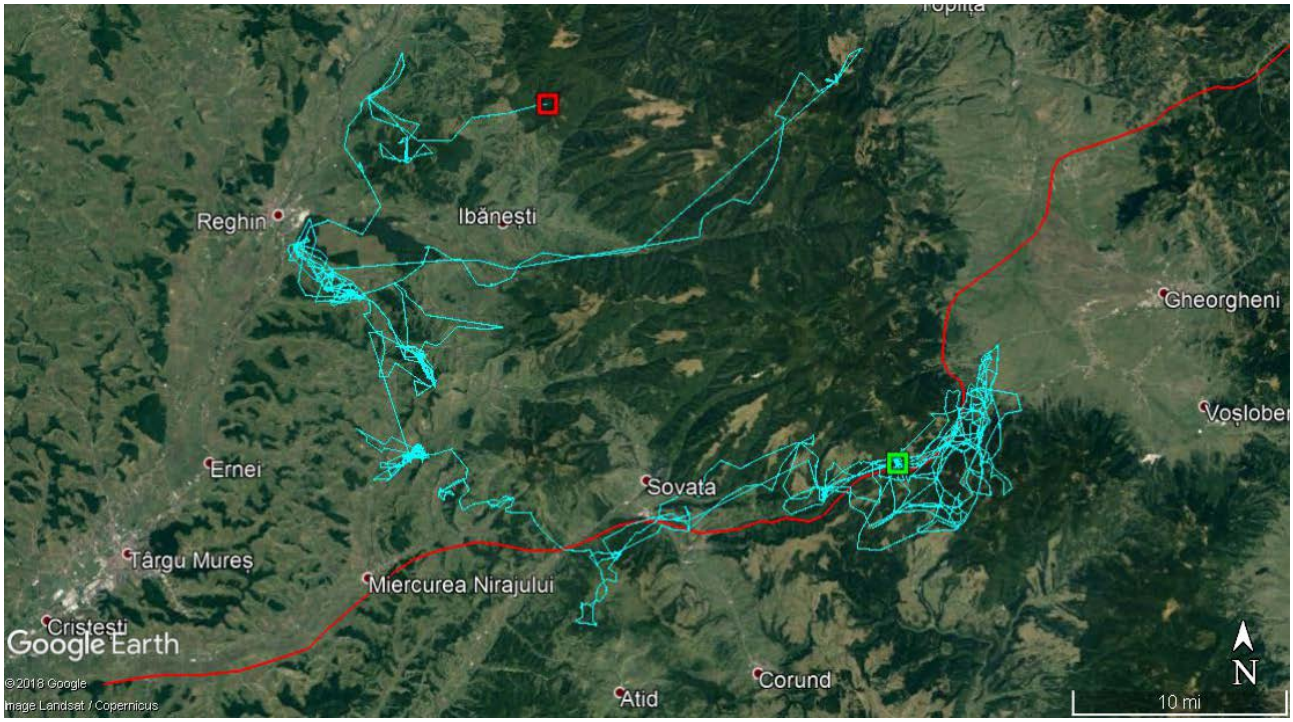


Fig. 5 - Telemetry data set originating from collared sub-adult male bear M6, already converted into a linear data set (in blue), overlaid with the actual route of the planned A8 highway (in red). Source: Milvus Group

With the resulting linear data sets we have performed 2 analyses, after dividing the planned highway route into 1 km long and 100 m wide segments (while keeping the original highway segment coding):

1. the linear data sets from the 10 individual collared bears were intersected with the actual route of the planned A8 highway. For each highway segment intersected by at least 1 collared bear, we have counted the actual number of collared bears that have intersected that specific segment.
2. the linear data sets from the 10 individual collared bears were pooled and the resulting data set was intersected with the actual route of the planned A8 highway and the total number of intersections was counted within each highway segment (Fig. 6).

Results

According to radio telemetry monitoring data available in early February 2019, the 10 collared bears have intersected segments of the route of the planned A8 highway (Tîrgu Mureș-Ditrău section) on a total of 457 occasions. Intersections by collared bears were detected in 60 different 1 km long and 100 m wide segments (65.1% of the Tîrgu Mureș-Ditrău section). The number of collared bears intersecting any given segment varied between 1 (minimum) and 4 (maximum) individuals / 1 km long and 100 m wide planned highway segment (Fig. 7). The frequency of intersections varied between 1 (minimum) and 44 intersections (maximum) / 1 km long and 100 m wide planned highway segment (Fig. 8).

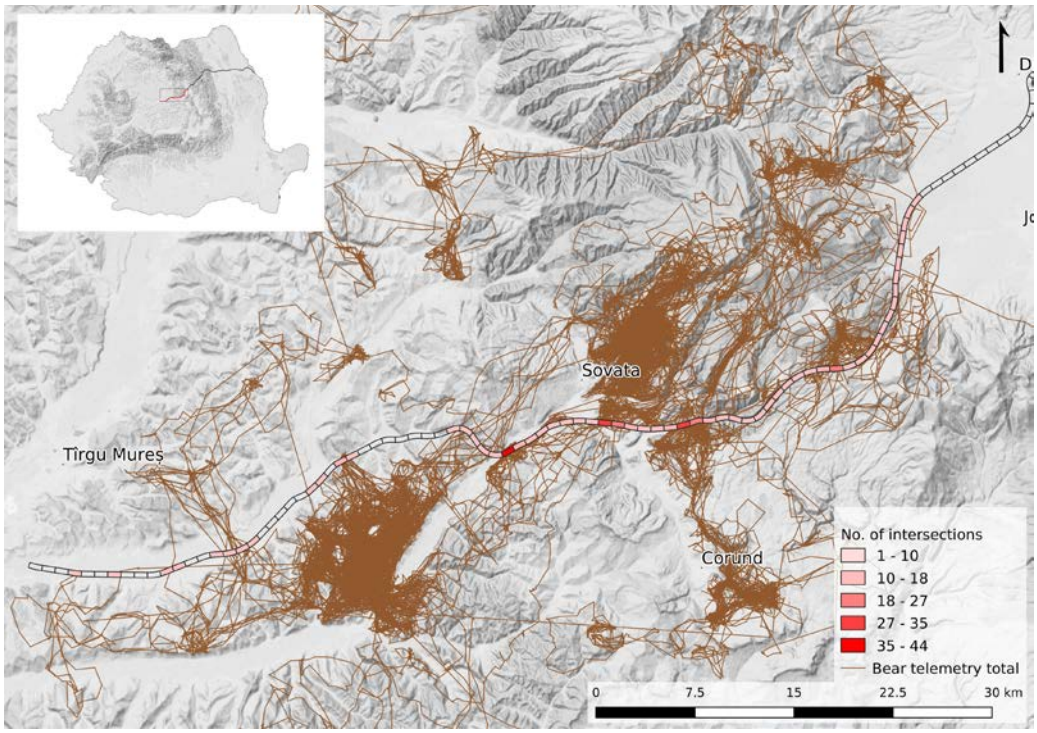


Fig. 6 - Pooled linear data sets originating from the 10 collared bears (in brown), intersected with the planned route of the A8 highway, and divided into 1 km long, 100 m wide segments. Source: Milvus Group

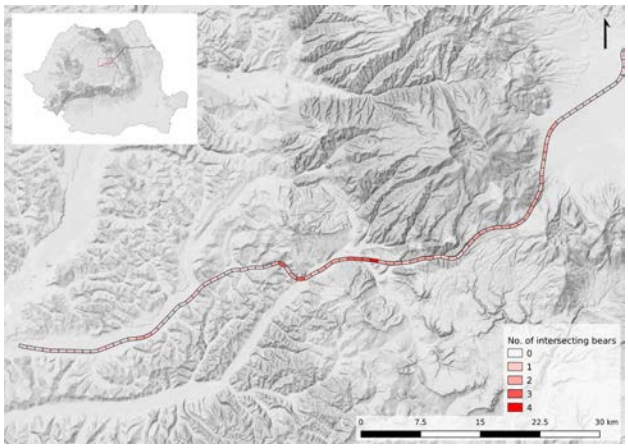


Fig. 7 - No. of collared bears intersecting the planned route of the A8 highway, divided into 1 km long, 100 m wide segments. Source: Milvus Group

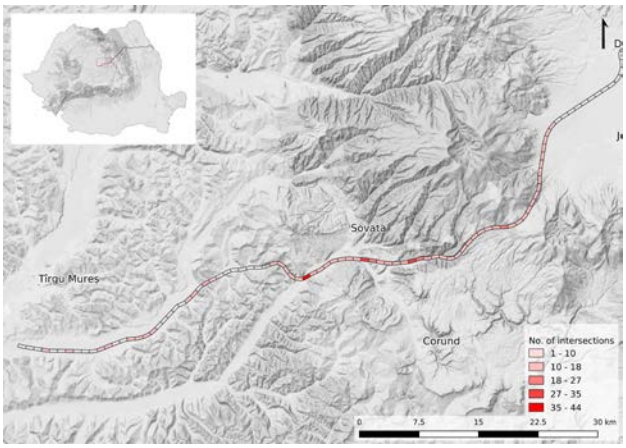


Fig. 8 - The frequencies by which the planned A8 highway route's 1 km long and 100 m wide segments were intersected by at least 1 collared bear. Source: Milvus Group

In the following we present detailed information on the 1 km long segments that were intersected by at least 1 collared bear (Table 2).

Highway segment identification	Total no. of intersections by at least 1 collared bear	No. of collared bears that have intersected the highway segment at least 1 time
3+000 ››› 4+000	1	1
6+000 ››› 7+000	1	1
10+000 ››› 11+000	2	1
11+000 ››› 12+000	1	1
14+000 ››› 15+000	1	1
15+000 ››› 16+000	7	2
16+000 ››› 17+000	7	2
17+000 ››› 18+000	1	1
23+000 ››› 24+000	1	1
24+000 ››› 25+000	1	1
26+000 ››› 27+000	17	1
27+000 ››› 28+000	2	1
35+000 ››› 36+000	2	2
36+000 ››› 37+000	8	3
37+000 ››› 38+000	2	1
38+000 ››› 39+000	6	2
39+000 ››› 40+000	6	3
40+000 ››› 41+000	44	2
41+000 ››› 42+000	18	1
42+000 ››› 43+000	8	2
43+000 ››› 44+000	8	2
44+000 ››› 45+000	5	2
45+000 ››› 46+000	6	2
46+000 ››› 47+000	5	3
47+000 ››› 48+000	6	3
48+000 ››› 49+000	29	3
49+000 ››› 50+000	21	4
50+000 ››› 51+000	10	2
51+000 ››› 52+000	3	2
52+000 ››› 53+000	7	2

Highway segment identification	Total no. of intersections by at least 1 collared bear	No. of collared bears that have intersected the highway segment at least 1 time
53+000 ››› 54+000	10	1
54+000 ››› 55+000	34	2
55+000 ››› 56+000	26	2
56+000 ››› 57+000	13	2
57+000 ››› 58+000	2	1
58+000 ››› 59+000	2	1
59+000 ››› 60+000	2	1
60+000 ››› 61+000	4	1
61+000 ››› 62+000	8	1
62+000 ››› 63+000	8	2
63+000 ››› 64+000	6	2
64+000 ››› 65+000	6	2
65+000 ››› 66+000	9	2
66+000 ››› 67+000	16	2
67+000 ››› 68+000	19	2
68+000 ››› 69+000	5	2
69+000 ››› 70+000	7	2
70+000 ››› 71+000	6	2
71+000 ››› 72+000	9	2
72+000 ››› 73+000	2	2
73+000 ››› 74+000	3	2
74+000 ››› 75+000	2	1
75+000 ››› 76+000	8	2
76+000 ››› 77+000	2	1
77+000 ››› 78+000	1	1
78+000 ››› 79+000	2	2
79+000 ››› 80+000	3	2
80+000 ››› 81+000	2	1
81+000 ››› 82+000	2	2
82+000 ››› 83+000	2	2

2.2. Brown bear den mapping and denning habitat modelling in and adjacent to Pilot Area 4 and results relevant in relation to the planned Tîrgu Mureș-Iași-Ungheni (A8) highway (Tîrgu Mureș-Ditrău section)[1]

Fig. 9 - Excavated bear den in Pilot Area 4, under the roots of a conifer. Source: Milvus Group

Fig. 10 - Natural rock cavity used by a hibernating bear in Pilot Area 4. Source: Milvus Group

Data collection

» In the general area of Pilot Area 4, bear dens were located in 2008-2013 and 2015-2017, in the frame of the long-term initiative "Brown bear conservation and research program in a model area in Romania", carried out by the Milvus Group. In the process, we relied heavily on local knowledge: in the mountains the locations were found with the help from foresters and game managers; in the foothills the dens were located with the assistance of game managers, pastoralists, forest owners and mushroom or berry pickers. In 2015-2017 some dens were identified based on telemetry data from bears fitted with GPS-GSM collars (for collaring protocols, please consult the previous sub-chapter).

A total of 115 bear dens and 8 open nests were identified (Fig. 9, 10 and 11).

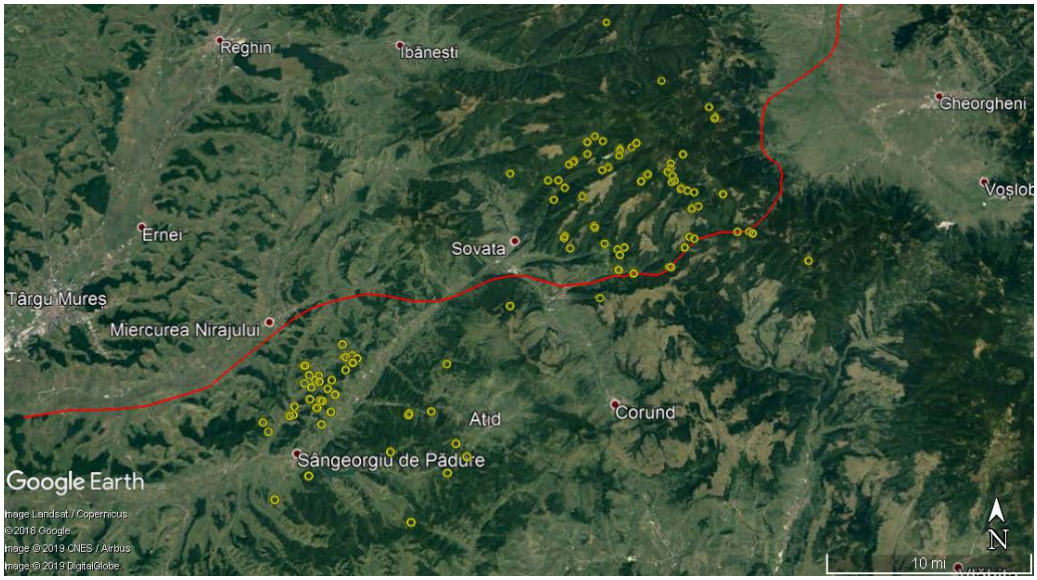


Fig. 11 - The locations of a total of 115 bear dens and 8 open nests (yellow circles) identified in Pilot Area 4, overlaid with the actual route of the planned A8 highway (in red). Source: Milvus Group

1 based on: Faure U., C. Domokos, A. Leriche, and B. Cristescu. Submitted for peer-review. Human risk and/or thermal insulation? Brown bear denning habitat selection in Eastern Transylvania, Romania.

Data analysis

We used maximum entropy modelling (MaxEnt) to identify potentially suitable areas for brown bear denning in a study area partially overlapping with the Pilot Area 4 (Fig. 12). Of the 123 total denning locations, 119 were used for modelling. The other 4 locations were omitted by MaxEnt because they were spatially close to each other being contained in grid cells that already had a known denning location.

The detailed technical description of the modelling procedure will be available once the manuscript presenting the results (Faure U., C. Domokos, A. Leriche, and B. Cristescu. *Submitted for peer-review.* Human risk and/or thermal insulation? The Brown bear denning habitat selection in Eastern Transylvania, Romania.) will be published in a peer-reviewed journal.

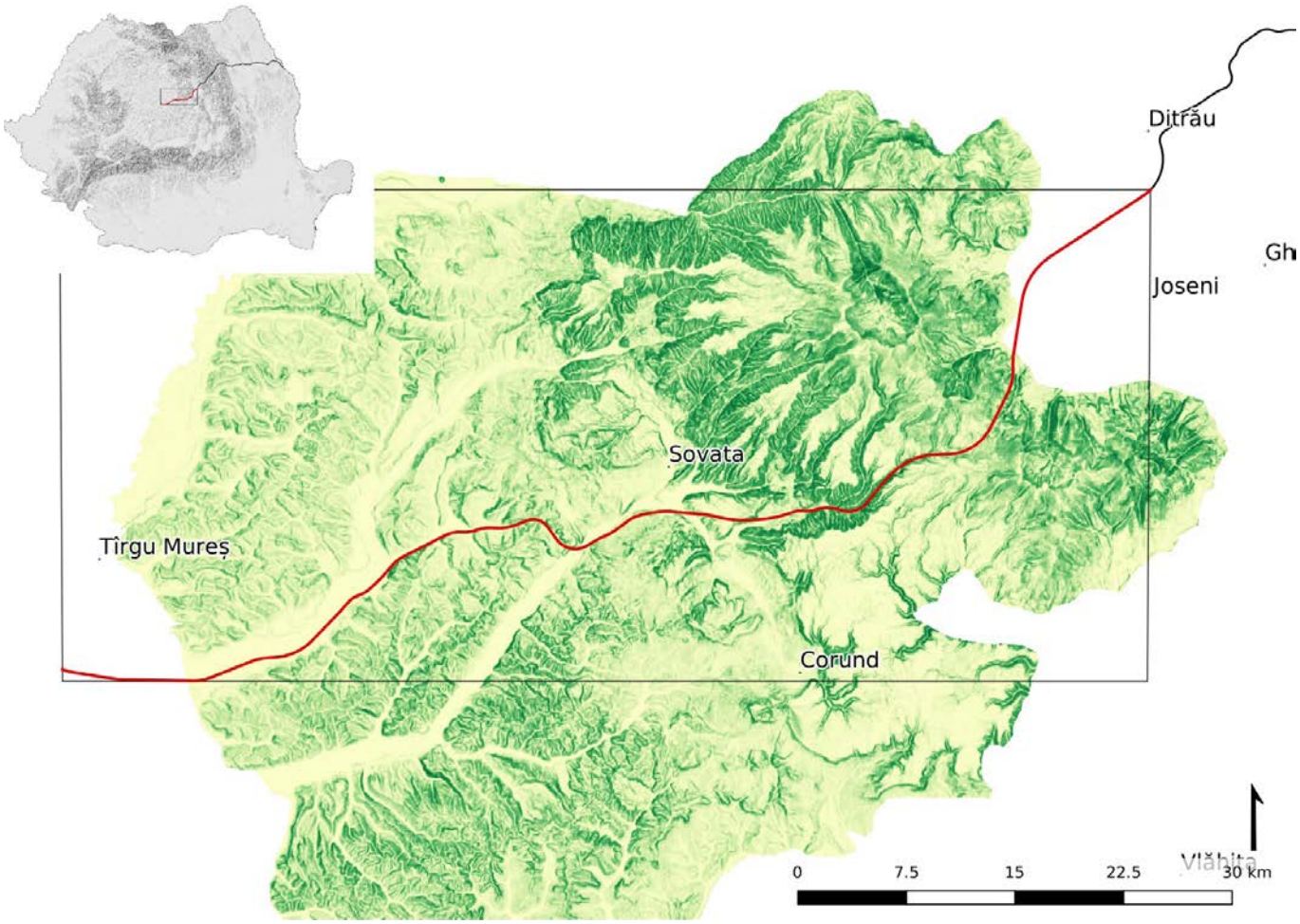


Fig. 12 - Modelled potentially suitable areas for brown bear denning in Pilot Area 4, based on MaxEnt algorithm fitted using 119 occurrences of wintering structures with linear and quadratic features (in green; the darker green the cells are, the more suitable the habitat is), overlaid with the actual route of the planned A8 highway (in red). Source: Milvus Group.

The map of denning habitat suitability was intersected with the planned highway route, which was again divided into 1 km long and 100 m wide segments (while keeping the original highway segment coding). This way, we have calculated effective denning habitat suitability of the planned highway route segments, based on the suitability indexes provided by the original denning habitat suitability map (by calculating the mean value from the suitability indexes of each 30*30 m cell from the denning habitat suitability map intersected by the planned highway's 1 km long and 100 m wide segments).

Value range	Simplified category
0.0172 - 0.1485	0 (unsuitable as denning habitat)
0.1485 - 0.2799	1 (poor quality denning habitat)
0.2799 - 0.4112	2 (mediocre quality denning habitat)
0.4112 - 0.5425	3 (good quality denning habitat)
0.5425 - 0.6738	4 (very good quality denning habitat)

Results

For an easier visualisation and interpretation, we have classified the 1 km long and 100 m wide segments into 5 distinct categories, based on their mean value resulting from their intersection with the denning habitat suitability map:

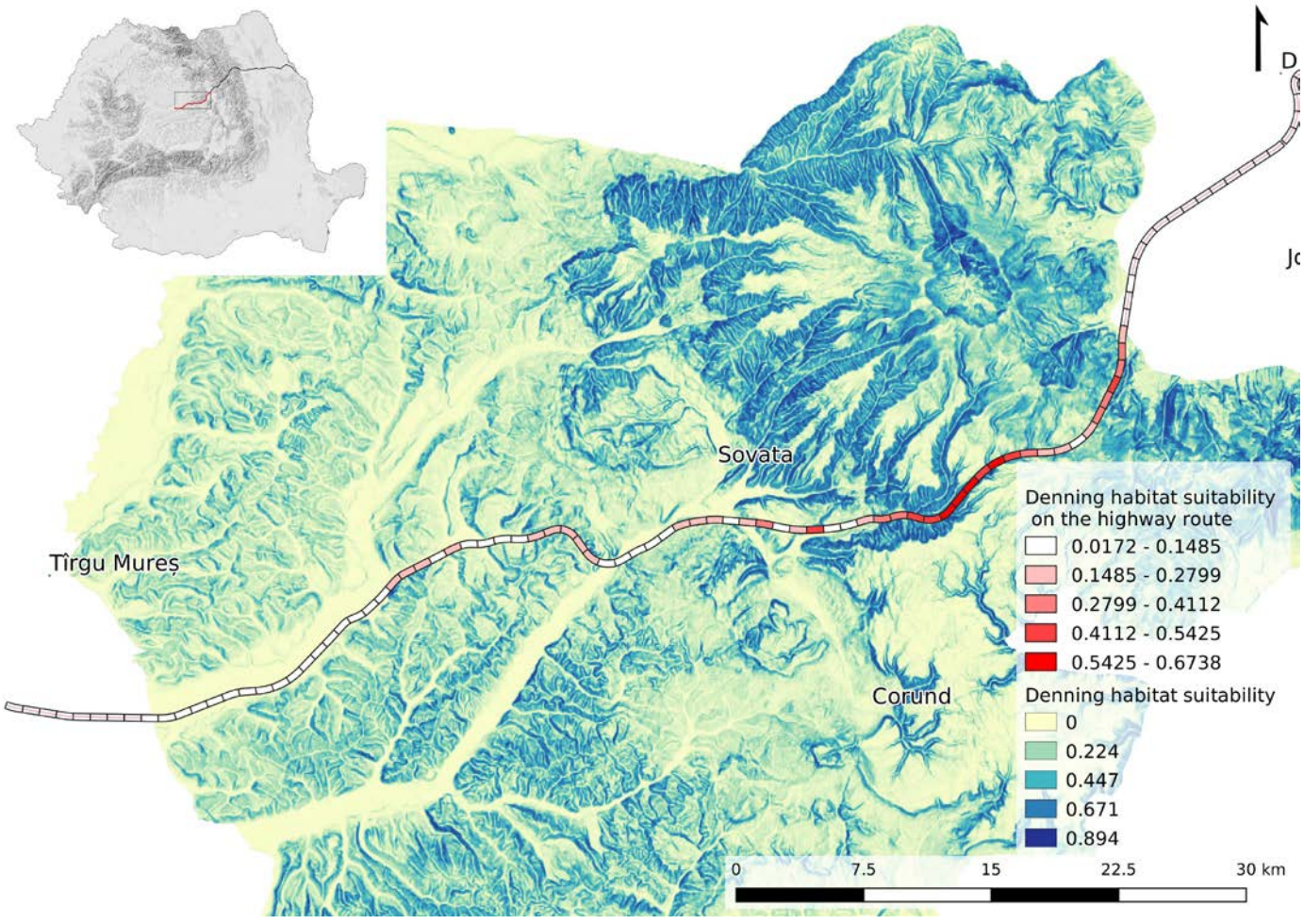


Fig. 13 - Bear denning habitat suitability of the planned A8 highway route's 1 km long and 100 m wide segments. Source: Milvus Group

Highway segment identification	Value attributed after intersection with the denning habitat suitability model	Simplified category
8+000 ››› 9+000	0.017339	0
9+000 ››› 10+000	0.020403	0
10+000 ››› 11+000	0.018243	0
11+000 ››› 12+000	0.019444	0
12+000 ››› 13+000	0.019115	0
13+000 ››› 14+000	0.018984	0
14+000 ››› 15+000	0.019238	0
15+000 ››› 16+000	0.020075	0
16+000 ››› 17+000	0.02326	0
17+000 ››› 18+000	0.018182	0
18+000 ››› 19+000	0.017201	0
19+000 ››› 20+000	0.021642	0
20+000 ››› 21+000	0.019569	0
21+000 ››› 22+000	0.047557	0
22+000 ››› 23+000	0.050661	0
23+000 ››› 24+000	0.021041	0
24+000 ››› 25+000	0.034169	0
25+000 ››› 26+000	0.224052	1
26+000 ››› 27+000	0.241829	1
27+000 ››› 28+000	0.176962	1
28+000 ››› 29+000	0.144584	0
29+000 ››› 30+000	0.196695	1
30+000 ››› 31+000	0.077126	0
31+000 ››› 32+000	0.107161	0
32+000 ››› 33+000	0.084309	0
33+000 ››› 34+000	0.060233	0
34+000 ››› 35+000	0.161473	1
35+000 ››› 36+000	0.277446	1
36+000 ››› 37+000	0.256137	1
37+000 ››› 38+000	0.157057	1
38+000 ››› 39+000	0.162386	1
39+000 ››› 40+000	0.133373	0
40+000 ››› 41+000	0.10031	0
41+000 ››› 42+000	0.133168	0
42+000 ››› 43+000	0.108756	0

Highway segment identification	Value attributed after intersection with the denning habitat suitability model	Simplified category
43+000 ››› 44+000	0.122686	0
44+000 ››› 45+000	0.158803	1
45+000 ››› 46+000	0.259153	1
46+000 ››› 47+000	0.235785	1
47+000 ››› 48+000	0.137702	0
48+000 ››› 49+000	0.246179	1
49+000 ››› 50+000	0.304276	2
50+000 ››› 51+000	0.100094	0
51+000 ››› 52+000	0.239924	1
52+000 ››› 53+000	0.496044	3
53+000 ››› 54+000	0.089393	0
54+000 ››› 55+000	0.126413	0
55+000 ››› 56+000	0.1541	1
56+000 ››› 57+000	0.323072	2
57+000 ››› 58+000	0.348361	2
58+000 ››› 59+000	0.523027	3
59+000 ››› 60+000	0.524259	3
60+000 ››› 61+000	0.642384	4
61+000 ››› 62+000	0.616254	4
62+000 ››› 63+000	0.673833	4
63+000 ››› 64+000	0.508925	3
64+000 ››› 65+000	0.580612	4
65+000 ››› 66+000	0.450577	3
66+000 ››› 67+000	0.371953	2
67+000 ››› 68+000	0.269575	1
68+000 ››› 69+000	0.241239	1
69+000 ››› 70+000	0.088858	0
70+000 ››› 71+000	0.2773	1
71+000 ››› 72+000	0.330271	2
72+000 ››› 73+000	0.310724	2
73+000 ››› 74+000	0.425401	3
74+000 ››› 75+000	0.410392	2
75+000 ››› 76+000	0.284261	2
76+000 ››› 77+000	0.204881	1
79+000 ››› 80+000	0.039417	0

2.3. Camera trapping in Pilot Area 4 along the planned route of the Târgu Mureș-Iași-Unghe-ni (A8) highway (Târgu Mureș-Ditrău section)

Data collection

For the survey, the planned highway route has been divided into 1 km-long segments. Motion-triggered cameras were mounted in each segment (1 camera / 1 segment), in between kilometres 31+000 ››› 70+000 of the planned highway route, at a distance of <100 m from the actual route. Cameras were placed in locations conducive for large mammal movements (e.g. forestry roads, trails, ridges), or in locations already indicated as suitable by the presence of tracks and other signs of the animals' presence. The cameras were placed at a height of about 50-70 cm, in a secured metal casing. Camera locations were recorded with a handheld GPS unit. If a camera did not record any of the targeted species for an extended period of time (e.g. one month), it was removed and placed in a different location within the same 1 km-long segment. Each segment was surveyed for an extended period of time (at least 12 months, with the exception of segments where the cameras were stolen during the monitoring period). During this period, the camera was checked several times, on average every 2 weeks (photos were downloaded, and batteries were exchanged, if needed). Data was stored systematically: for each photo, provenance location (camera station location), date, and other accompanying information were recorded.

Data analysis

Data sets recorded by various camera stations were not compared amongst each other. Data for each camera station was sorted and analysed according to two counting methods: a) number of events / detected species, respectively b) minimum number of individuals / event / detected species.

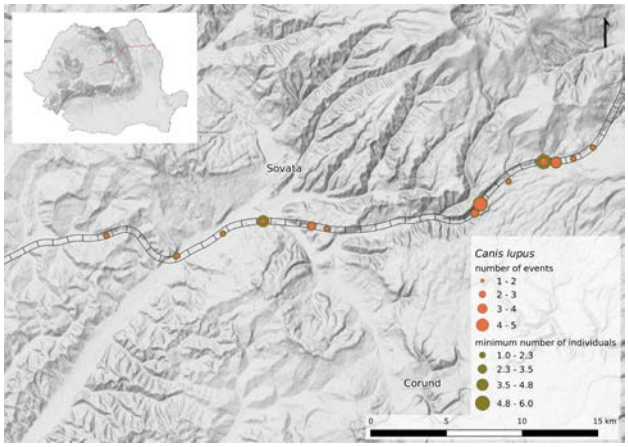
Events were defined as a 30-minute period following the first detection of any given species. For example, when a wild boar was recorded by a camera, even if the same camera recorded any numbers of wild boars within the next 30 min, these were still considered as the same event.

Minimum numbers of individuals were counted according to two separate scenarios, for each event:

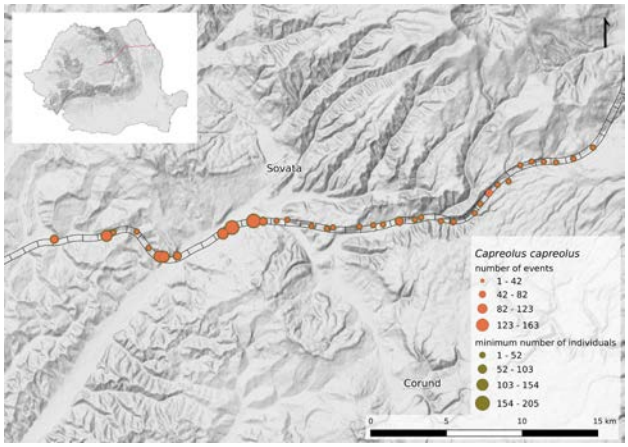
i) if several individuals from any given species were captured on the same photo (during the same event), we considered the total number of individuals as the minimum number of individuals. This principle was also applied in the case of consecutive photos of individuals from the same species during the same event (for example, if a series of consecutive photos within the same event were recorded showing 3, 5, 2, 1 individuals of the wild boar, the recorded minimum number of individuals for that specific event was 5).

ii) if individuals from the same species were distinguishable for any reason (e.g. age, sex, distinct injuries, fur patterns and more), these were counted accordingly, within the same event. For example, if a series of consecutive photos recorded within the same event were showing two females, or 1 male individual of the red deer, the recorded minimum number of individuals for that specific event was 3.

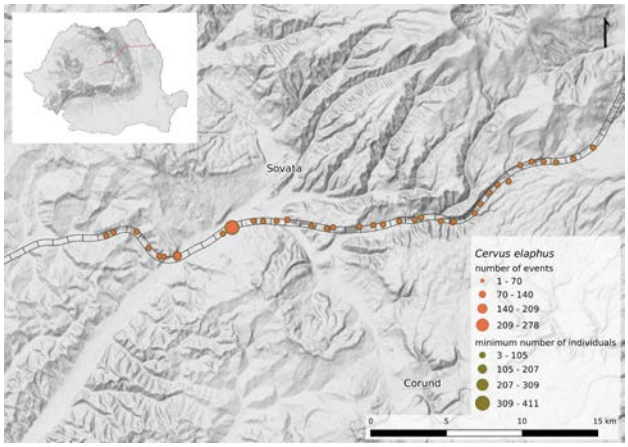
Results (species are listed in alphabetical order of their scientific names)



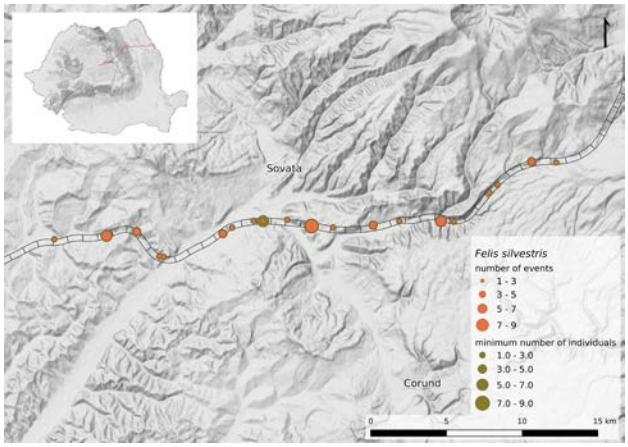
Grey wolf (*Canis lupus*) occurrence, number of detections and minimum number of individuals detected through camera trapping on the planned A8 highway route's 1 km long and 100 m wide segments. Below: an actual photograph from the monitoring. Source: Milvus Group



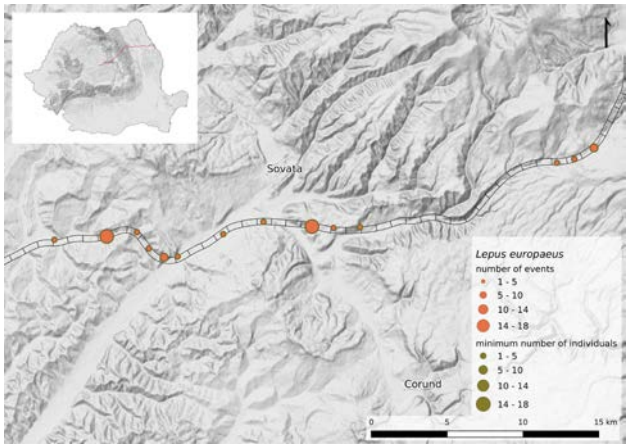
The Roe deer (*Capreolus capreolus*) occurrence, number of detections and minimum number of individuals detected through camera trapping on the planned A8 highway route's 1 km long and 100 m wide segments. Below: an actual photograph from the monitoring. Source: Milvus Group



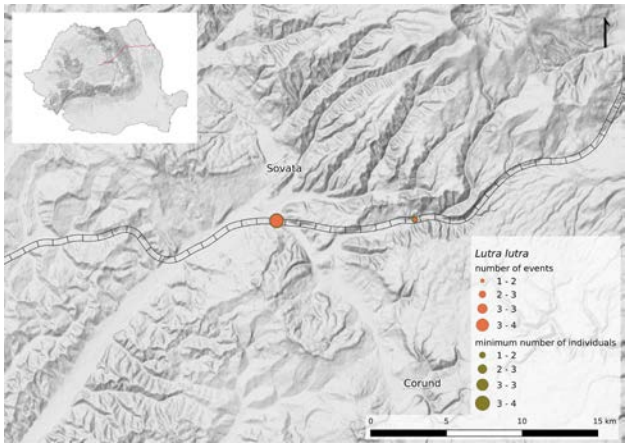
The Red deer (*Cervus elaphus*) occurrence, number of detections and minimum number of individuals detected through camera trapping on the planned A8 highway route's 1 km long and 100 m wide segments. Below: an actual photograph from the monitoring. Source: Milvus Group



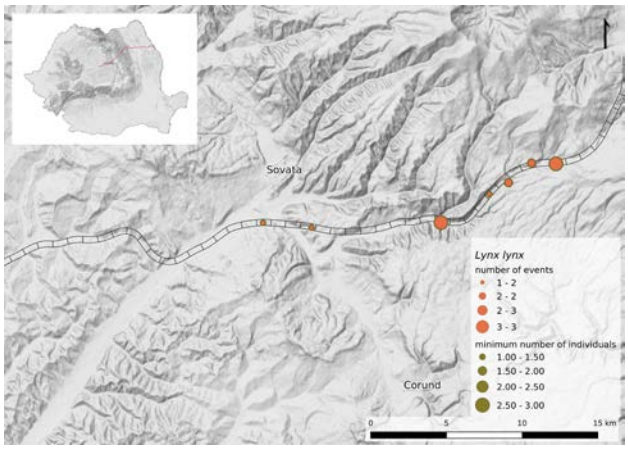
The European wildcat (*Felis silvestris*) occurrence, number of detections and minimum number of individuals detected through camera trapping on the planned A8 highway route's 1 km long and 100 m wide segments. Below: an actual photograph from the monitoring. Source: Milvus Group



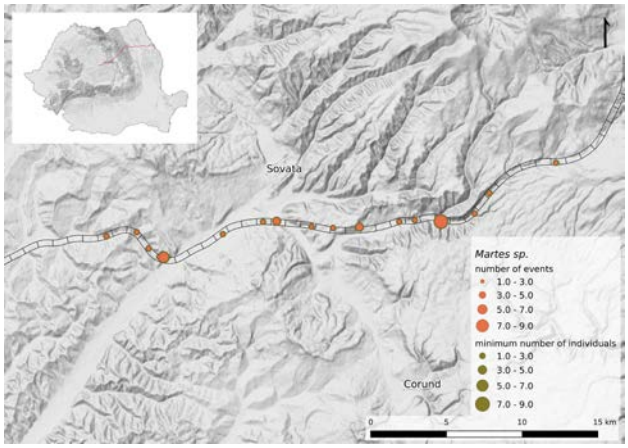
The European hare (*Lepus europaeus*) occurrence, number of detections and minimum number of individuals detected through camera trapping on the planned A8 highway route's 1 km long and 100 m wide segments. Below: an actual photograph from the monitoring. Source: Milvus Group



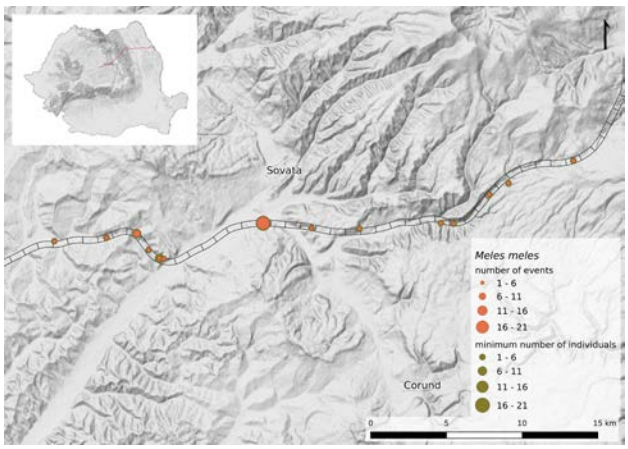
The Eurasian otter (*Lutra lutra*) occurrence, number of detections and minimum number of individuals detected through camera trapping on the planned A8 highway route's 1 km long and 100 m wide segments. Below: an actual photograph from the monitoring. Source: Milvus Group



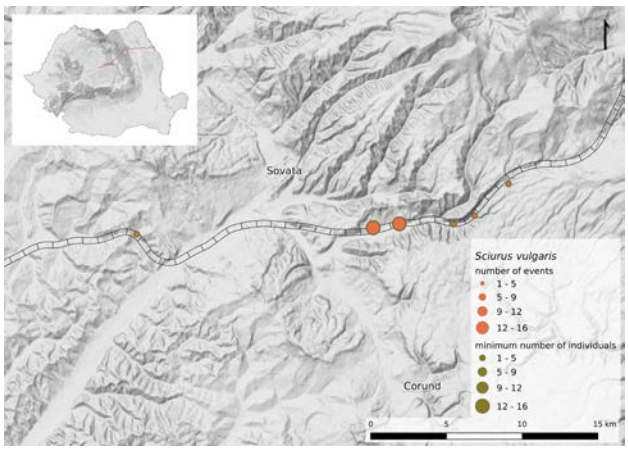
The Eurasian lynx (*Lynx lynx*) occurrence, number of detections and minimum number of individuals detected through camera trapping on the planned A8 highway route's 1 km long and 100 m wide segments. Below: an actual photograph from the monitoring. Source: Milvus Group



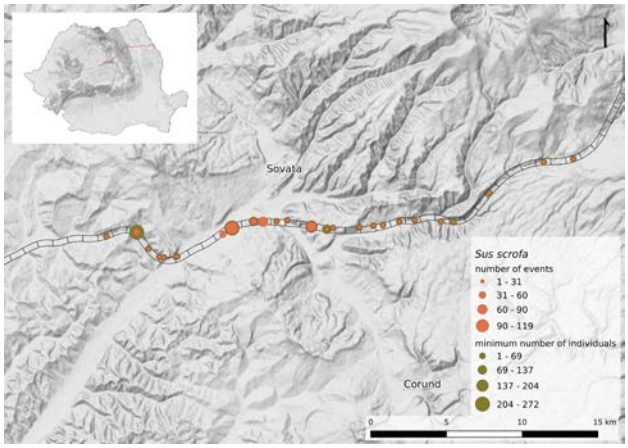
The Stone marten (*Martes foina*) and the European pine marten (*Martes martes*) occurrence, number of detections and minimum number of individuals detected through camera trapping on the planned A8 highway route's 1 km long and 100 m wide segments. Most of the time, these two species are difficult to differentiate on camera trap photos, hence they were considered as martens (*Martes sp.*). Below: an actual photograph of a stone marten from the monitoring. Source: Milvus Group



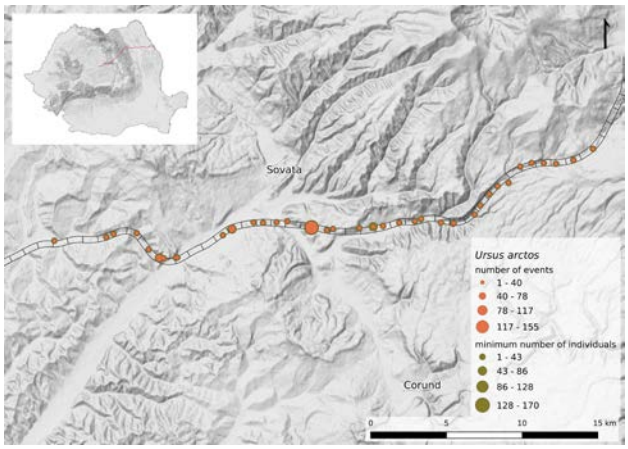
The European badger (*Meles meles*) occurrence, number of detections and minimum number of individuals detected through camera trapping on the planned A8 highway route's 1 km long and 100 m wide segments. Below: an actual photograph from the monitoring. Source: Milvus Group



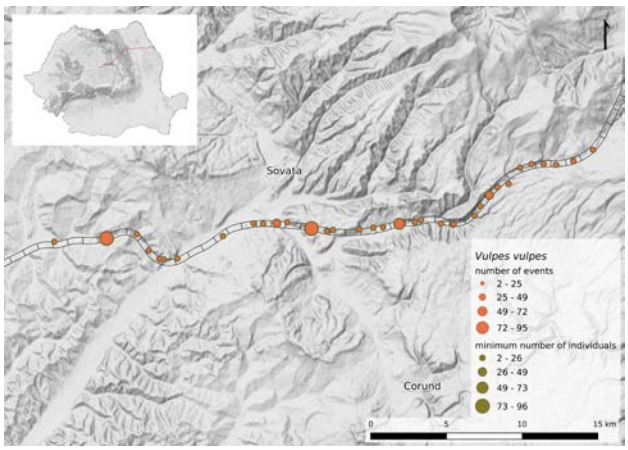
The Red squirrel (*Sciurus vulgaris*) occurrence, number of detections and minimum number of individuals detected through camera trapping on the planned A8 highway route's 1 km long and 100 m wide segments. Below: an actual photograph from the monitoring. Source: Milvus Group

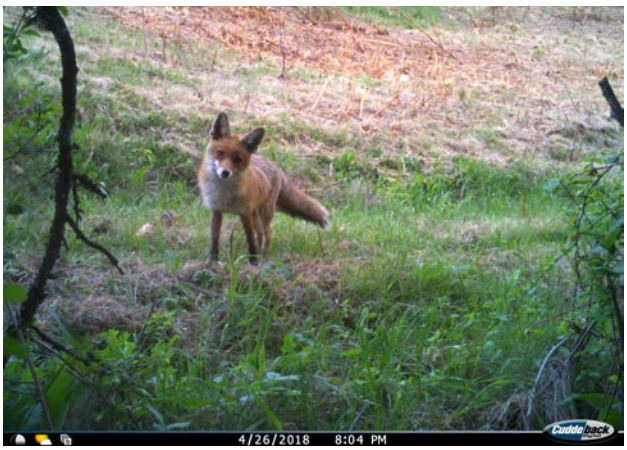


The Wild boar (*Sus scrofa*) occurrence, number of detections and minimum number of individuals detected through camera trapping on the planned A8 highway route's 1 km long and 100 m wide segments. Below: an actual photograph from the monitoring. Source: Milvus Group



The Brown bear (*Ursus arctos*) occurrence, number of detections and minimum number of individuals detected through camera trapping on the planned A8 highway route's 1 km long and 100 m wide segments. Below: an actual photograph from the monitoring. Source: Milvus Group





The Red fox (*Vulpes vulpes*) occurrence, number of detections and minimum number of individuals detected through camera trapping on the planned A8 highway route's 1 km long and 100 m wide segments. Below: an actual photograph from the monitoring. Source: Milvus Group

3

The permeability for wildlife of the planned Târgu Mureș-Iași-Ungheni (A8) highway (Târgu Mureș-Ditrău section)

Permeability as a landscape feature indicates the degree to which the wild fauna can move within a territory. It is known that urban development and both infrastructure and mainly transport infrastructure development can reduce landscape permeability.

The analysis of permeability is needed to develop a permeable infrastructure by choosing the best options to the selected alternative, thus avoiding a high degree of fragmentation, by proposing passages, or perhaps adapting the technical solutions and the management of traffic etc.

When an infrastructure plan is proposed, besides the spatial analysis, it is recommended that matrixes and diagrams of permeability be used to identify the supplementary passages needed to assure an optimal level of connectivity for all the important fauna species. These must include a details analysis (kilometre by kilometre), identifying the background conditions (the importance of the areas crossed by the project) and the permeability of the structures to be put in place by the project.

We conducted a similar analysis on the Ilieni (Mureș) – Joseni (Harghita) section of Tîrgu Mureș – Iași – Ungheni planned highway, based on technical maps provided by the most recent feasibility study.

The permeability of the highway section was assessed using two indexes, one referring to the functionality of the structures, i.e. if a structure is large enough to be used by certain groups of species, while the second index refers to the structure frequency.

We calculated these indexes in three categories of mammals like Large mammals with specific target species defined as the Brown bear (*Ursus arctos*) and/or the Red deer (*Cervus elaphus*), Medium mammals represented by the Roe deer (*Capreolus capreolus*) and the Small mammals group represented by the Red fox (*Vulpes vulpes*) and all other smaller species.

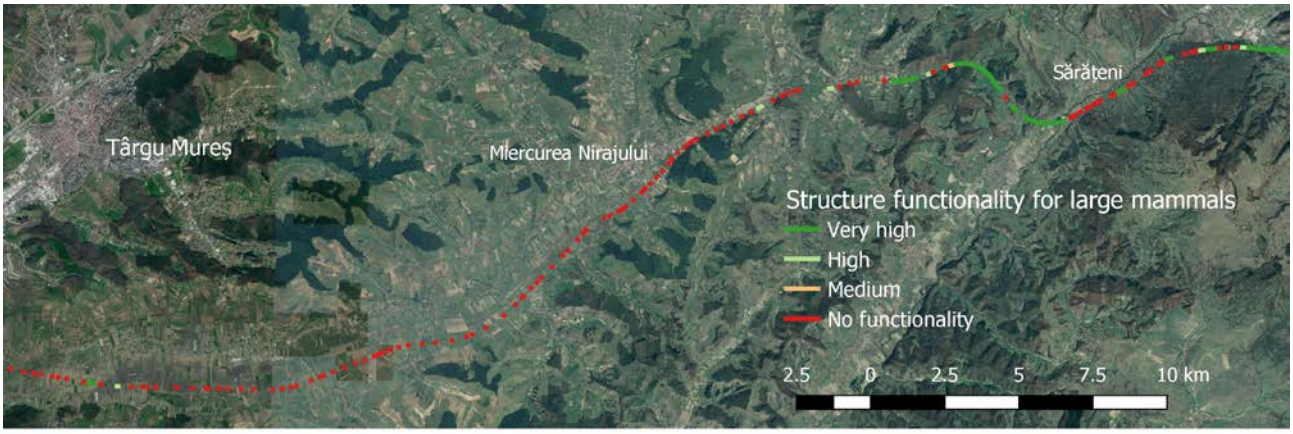
The functionality of structures was assessed based on the openness index (length * height/width of the structure). According to our classification, a minimum functionality structure for the Large mammal group starts from IO = 4 (for example 20 m length * 6 m height/28 m width structure), a good functionality from IO = 8, and a very good one from IO = 40 to higher.

According to our classification, a minimum functionality of a structure for the Medium mammal group starts from IO = 1.5 (for example 10 m length * 4 m height/28 m width structure), a good functionality from IO = 7, and a very good one from IO = 30 to higher.

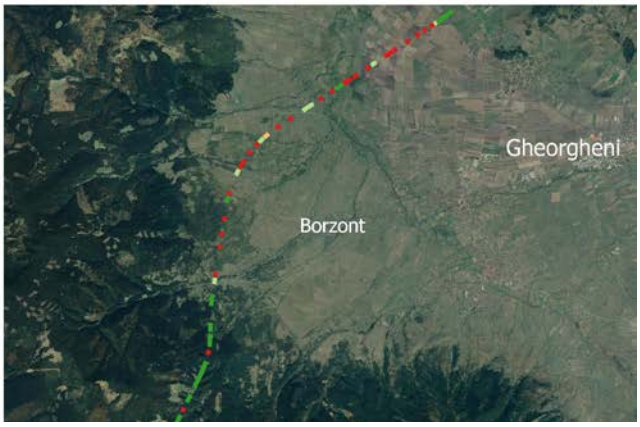
In case of Small mammals, a minimum functionality of a structure starts from IO = 0.21 (for example 5 m length * 3.5 m height/28 m width structure), a good functionality from IO = 0.97, and a very good one from IO = 4.15 to higher.

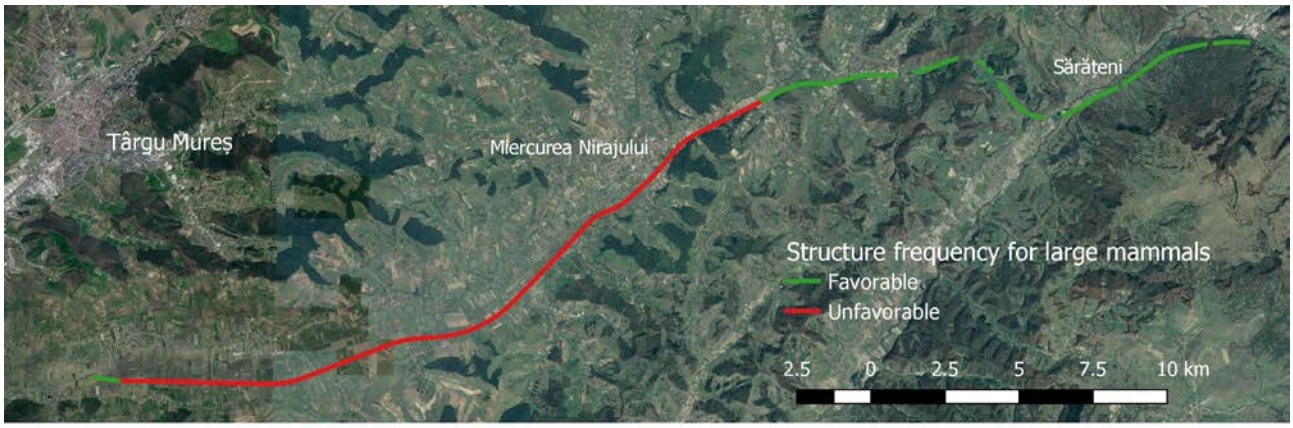
The second index, the frequencies of favourable structures were set as follows: at least one functional structure is needed in each 3 km section for Large mammals, 1.5 km for Medium mammals and 1 km for Small mammals.

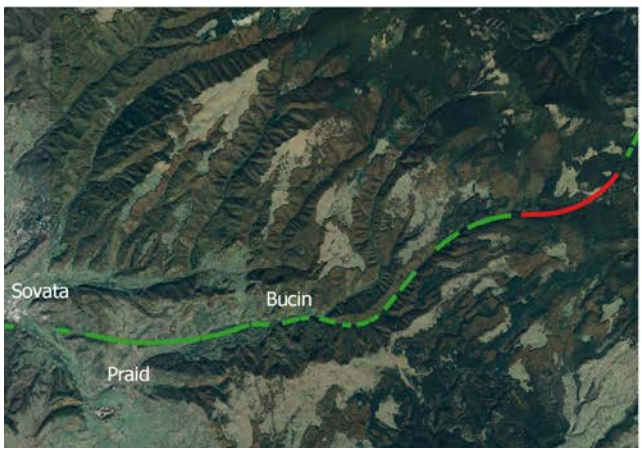
Results


Târgu Mureș
Mlercurea Nirajului
Sărățeni
Structure functionality for large mammals
Very high
High
Medium
No functionality
2.5 0 2.5 5 7.5 10 km

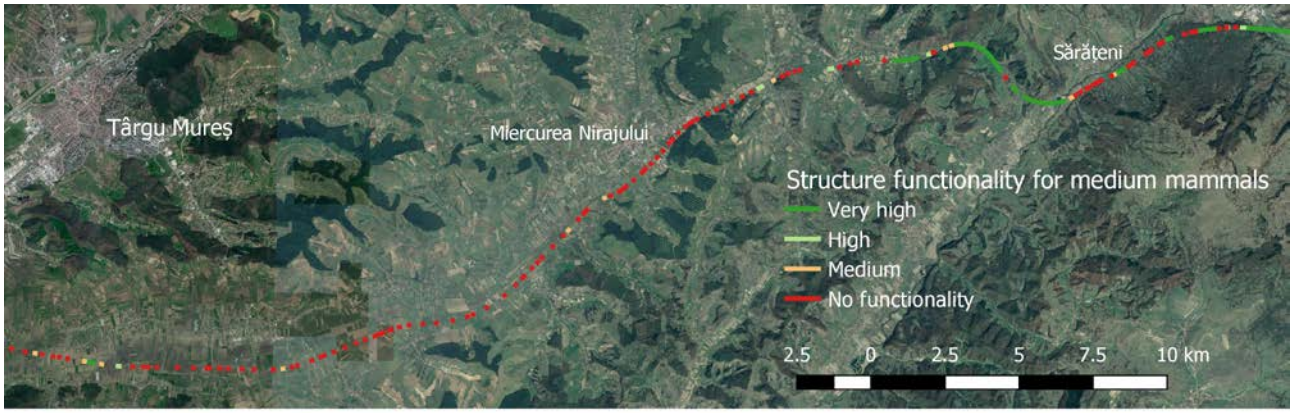

Sovata
Bucin
Praid

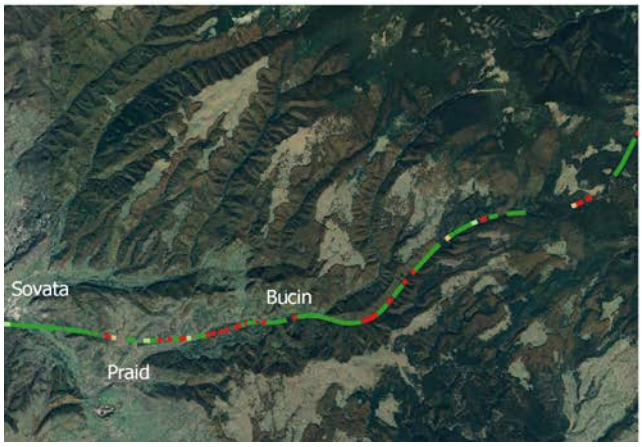

Gheorgheni
Borzont

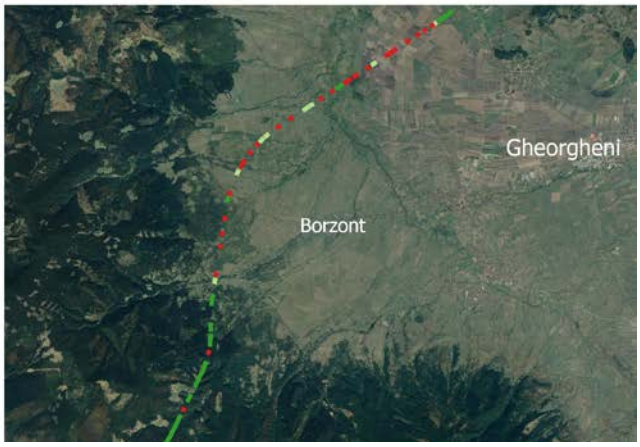

Târgu Mureș
Mlercurea Nirajului
Sărățeni
Structure frequency for large mammals
Favorable
Unfavorable
2.5 0 2.5 5 7.5 10 km

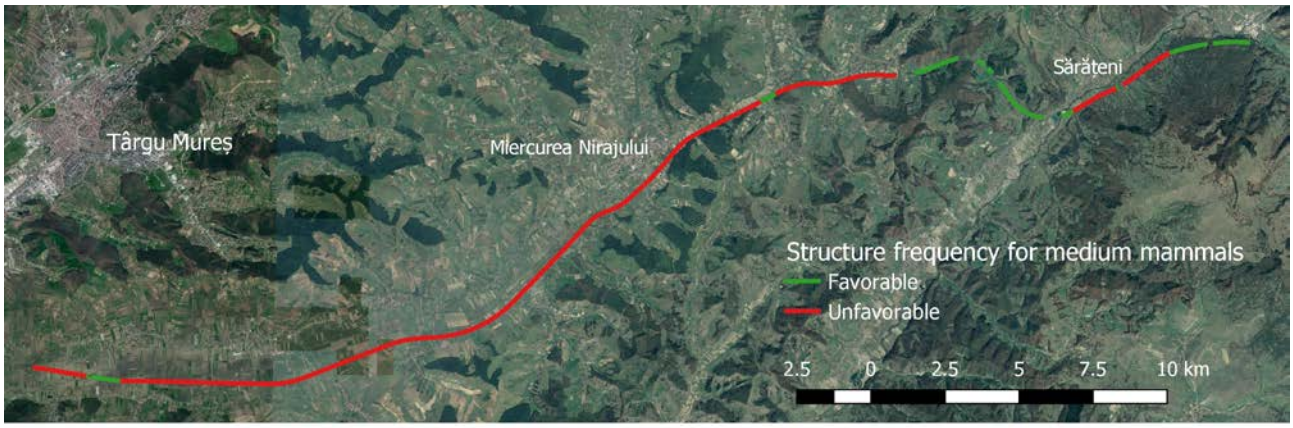

Sovata
Bucin
Praid

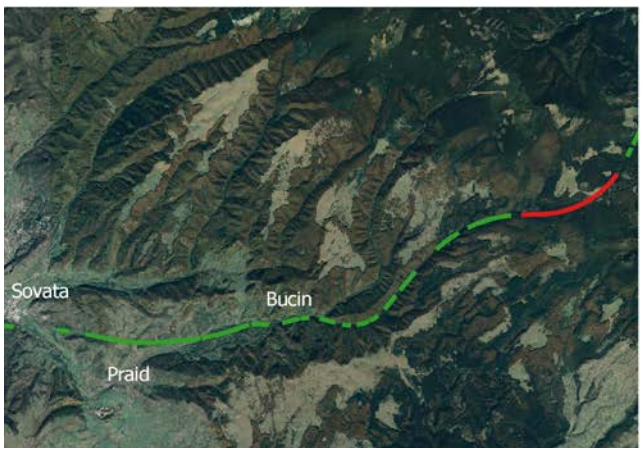

Gheorgheni
Borzont

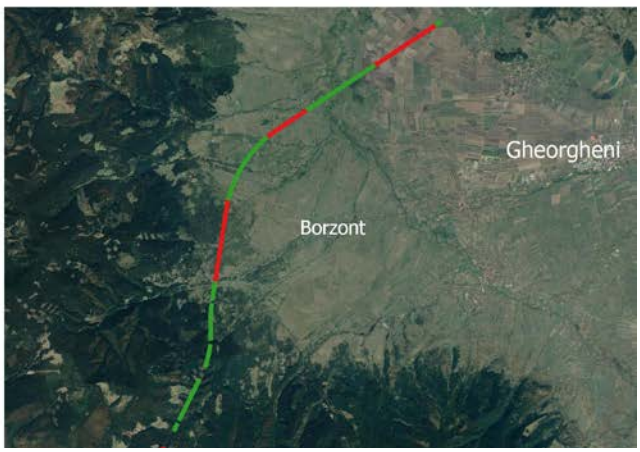

Târgu Mureș
Miercurea Nirajului
Sărățeni
Structure functionality for medium mammals
Very high
High
Medium
No functionality
2.5 0 2.5 5 7.5 10 km

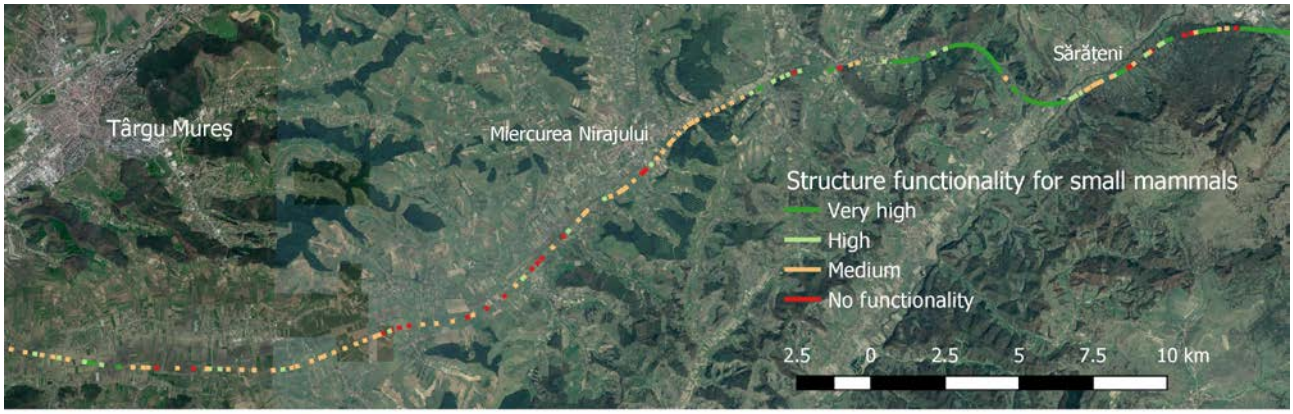

Sovata
Bucin
Praid

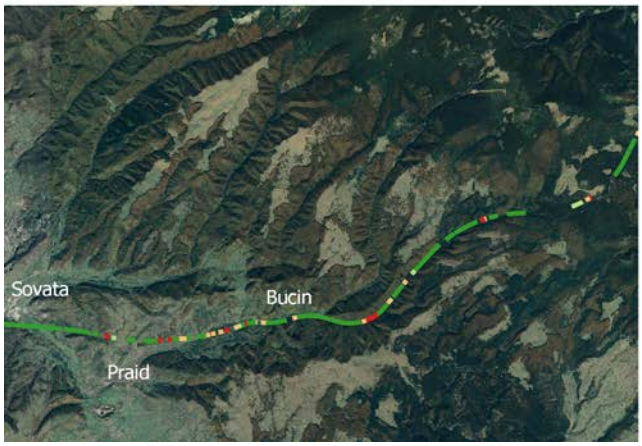

Gheorgheni
Borzont

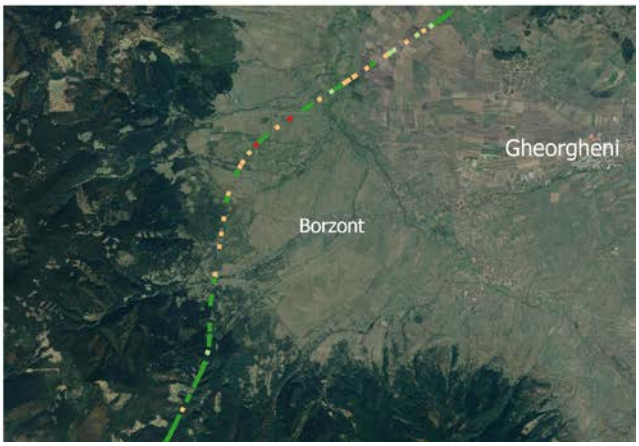

Târgu Mureș
Miercurea Nirajului
Sărățeni
Structure frequency for medium mammals
Favorable
Unfavorable
2.5 0 2.5 5 7.5 10 km

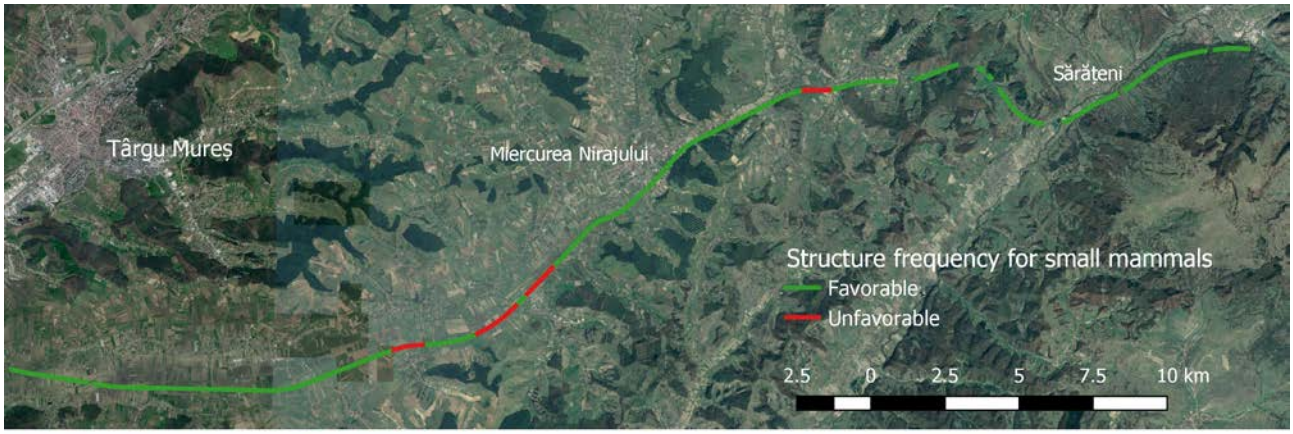

Sovata
Bucin
Praid

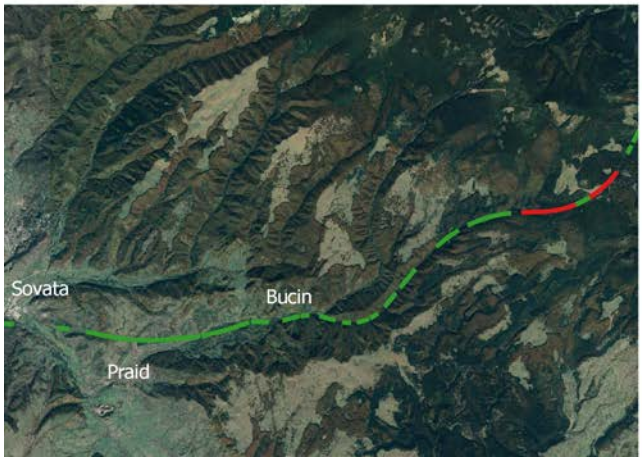

Gheorgheni
Borzont


Târgu Mureș
Mlercurea Nirajului
Sărățeni
Structure functionality for small mammals
Very high
High
Medium
No functionality
2.5 0 2.5 5 7.5 10 km

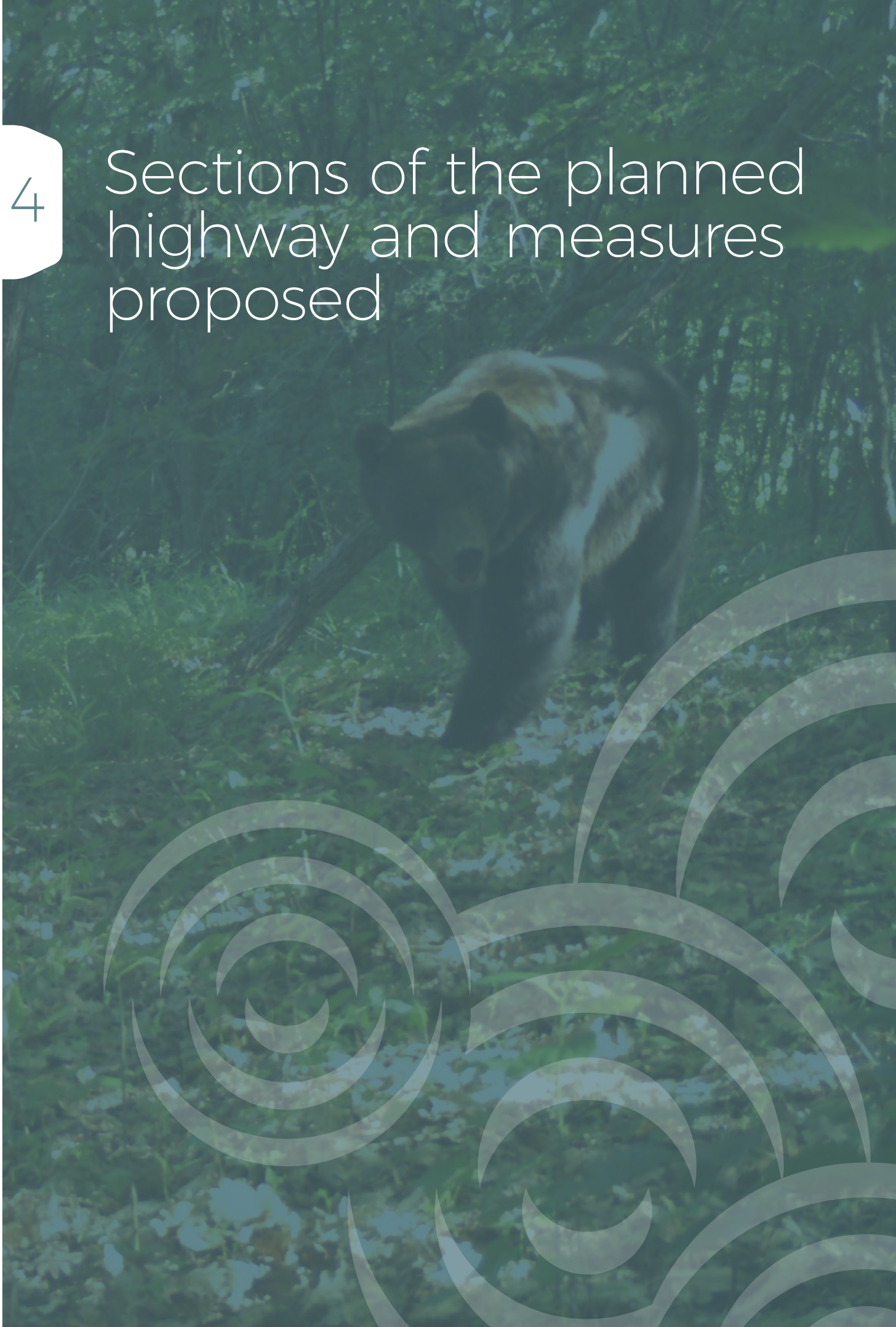

Sovata
Bucin
Praid


Gheorgheni
Borzont


Târgu Mureș
Mlercurea Nirajului
Sărățeni
Structure frequency for small mammals
Favorable
Unfavorable
2.5 0 2.5 5 7.5 10 km


Sovata
Bucin
Praid


Gheorgheni
Borzont



4 Sections of the planned highway and measures proposed

For our analysis, the planned route of the A8 highway (Tîrgu Mureș-Ditrău section) was divided into 14 sections, following distinguishable geographical units:

Section ID	Official highway segment identification	Total length (in km)
Section 1	0+000 ››› 23+000	23 km
Section 2	23+000 ››› 30+000	7 km
Section 3	30+000 ››› 34+000	4 km
Section 4	34+000 ››› 39+000	5 km
Section 5	39+000 ››› 41+000	2 km
Section 6	41+000 ››› 47+000	6 km
Section 7	47+000 ››› 49+000	2 km
Section 8	49+000 ››› 53+000	4 km
Section 9	53+000 ››› 58+000	5 km
Section 10	58+000 ››› 68+000	10 km
Section 11	68+000 ››› 70+000	2 km
Section 12	70+000 ››› 77+000	7 km
Section 13	77+000 ››› 84+000	7 km
Section 14	84+000 ››› 92+000	8 km

4.1. Section 1

Location: planned **highway segment 0+000 ››› 23+000** (23 km long)

Data availability:

Brown bear telemetry data	Brown bear denning habitat data	Motion sensor camera data	General permeability data
☑	☑	☒	☑

Description:

Section 1 follows the bottom of the Niraj river valley (between the localities of Ilieni in the west and Miercurea Nirajului in the east), running roughly in parallel with the river, with the Vețca man-made channel and with the DJ151D county-level road. This section also intersects the E60, one of Romania's busiest roads. On this section, the highway will intersect almost exclusively agricultural fields and will be passing close to a number of human settlements (villages).

Section 1 does not intersect important bear denning habitat (category 0). Telemetry data is available for this section, as follows:

Highway segment identification	Total no. of intersections by at least 1 collared bear	No. of collared bears that have intersected the highway segment at least 1 time
3+000 ››› 4+000	1	1
6+000 ››› 7+000	1	1
10+000 ››› 11+000	2	1
11+000 ››› 12+000	1	1
14+000 ››› 15+000	1	1
15+000 ››› 16+000	7	2
16+000 ››› 17+000	7	2
17+000 ››› 18+000	1	1

Permeability of the current technical plans (for more details, see Chapter 3):

Species group / functionality and frequency	Structure functionality	Structure frequency
Large mammals	almost exclusively no functionality	almost exclusively unfavourable
Medium-sized mammals	almost exclusively no functionality	almost exclusively unfavourable
Small mammals	mostly medium functionality	mostly favourable

Measures proposed:

- **The permeability of this highway section for large mammals should be improved**, as the only structures suitable for large mammal crossing (see map in Chapter 3) do not overlap with and are not even relatively close to the critical segments identified through brown bear telemetry data (see above). In this sense, **one green bridge** should be built in the most critical segment of Section 1, namely in Segment 15+000 ››› 17+000. More precisely, we recommend that the green bridge **should be built in the segment 16+000 ››› 17+000**, as this is located furthest from the nearby 4 villages. In order for the green bridge to be functional for brown bears (and implicitly for smaller species as well), it should have a minimum width of 100 m.[2]
- **The permeability of this highway section for medium-sized mammals should be extensively improved**. However, this does not require the building of new structures. Instead, it can be done through the physical enlargement of already planned bridges and culverts, so that these become suitable for crossing by medium-sized mammals. An important aspect in improving the permeability of this section for medium-sized mammals is also the improvement of the frequency of structures suitable for crossing by this species group. Thus, a structure with an Openness Index of at least 1.5 (e.g. minimum length of 10 m and height of 4 m) should be located on at least every 1.5 km of Section 1 of the planned highway (except for the segment 15+000 ››› 18+000, where this problem would be solved by the construction of the green bridge suggested above).
- Section 1 should be **fenced in with wildlife-proof fence (bear and red deer proof fencing along the whole length**, except for the potential crossing structures). The purpose of the wildlife-proof fence would be two-fold: to prevent wildlife accessing the highway (thus limiting wildlife-vehicle collisions), and also to funnel movements of wildlife through the purpose-built crossing structures and other structures suitable for wildlife crossing, thereby ensuring safe highway passage.
- Possible attractants for wildlife in the immediate vicinity or on the highway should be avoided. For Section 1, we propose a **50 m wide corn cultivation-free stripe on both sides of the future highway (e.g., the exclusive cultivation of crop types which don't provide effective cover for wildlife**), starting right from the highway fence. This measure would prevent the aggregation of wildlife species in the immediate vicinity of the highway, and simultaneously it would also increase visibility for the passengers using the highway. Also, **human-related waste in highway parking lots should be stored in wildlife-proof containers.**

4.2. Section 2

Location: planned **highway segment 23+000 ››› 30+000** (7 km long)

Data availability:

Brown bear telemetry data	Brown bear denning habitat data	Motion sensor camera data	General permeability data
☑	☑	☒	☑

Description:

Section 2 starts close to the village of Dumitrești in the west, passes next to the small town of Miercurea Nirajului and ends close to the village of Bereni in the east. It runs roughly in parallel with county-level road DJ135 and with the Nirajul Mic stream, a tributary of the Niraj River. On this section, the highway will intersect a wide variety of habitats: agricultural fields, forested areas, pastures and hay making fields. Also, Section 2 will pass close to a number of human settlements (villages and a small town).

Section 2 does not intersect important bear denning habitat (categories 0 and 1). Telemetry data is available for this section, as follows:

Highway segment identification	Total no. of intersections by at least 1 collared bear	No. of collared bears that have intersected the highway segment at least 1 time
23+000 ››› 24+000	1	1
24+000 ››› 25+000	1	1
26+000 ››› 27+000	17	1
27+000 ››› 28+000	2	1

2 Kusak J., D. Huber, T. Gomerčić, G. Schwaderer, and G. Gužvica. 2009. The permeability of highway in Gorski kotar (Croatia) for large mammals. European Journal of Wildlife Research 55(1): 7-21.

Permeability of the current technical plans
(for more details, see Chapter 3):

Species group / functionality and frequency	Structure functionality	Structure frequency
Large mammals	almost exclusively no functionality	mostly unfavourable
Medium-sized mammals	almost exclusively no functionality	mostly unfavourable
Small mammals	mostly medium functionality	mostly favourable

Measures proposed:

- **The permeability of this highway section for large mammals should be improved.** From our brown bear telemetry data, the most critical sector in Section 2 is 26+000 ››› 27+000. However, this is situated close to the small town of Miercurea Nirajului. Therefore, in order to ensure the permeability of Section 2 for large mammals (e.g. brown bears, and implicitly for smaller species as well), we recommend mitigation measures more to the east and thus somewhat further from the town. In this sense, **one green bridge should be built** in Section 2, namely **in segment 27+000 ››› 28+000**. In order for the green bridge to be functional for brown bears (and implicitly for smaller species as well), it should have a minimum width of 100 m.
- Considering that the recommended green bridge would be located relatively close to the town of Miercurea Nirajului, steps need to be taken in order to ensure that there will be no buildings, fences, or anything else that would reduce the functionality of the structure (e.g. harmonization of landscape planning).
- **The permeability of this highway section for medium-sized mammals should be extensively improved.** However, this does not require the building of new structures. Instead, it can be done **through the physical enlargement of already planned bridges and culverts**, so that these become suitable for crossing by medium-sized mammals. An important aspect in improving the permeability of this section for medium-sized mammals is also the improvement of the frequency of structures suitable for crossing by this species group. Thus, **a structure with an Openness Index of at least 1.5 (e.g. minimum length of 10 m and height of 4 m) should be located on at least every 1.5 km of Section 2 of the planned highway** (except for the segment 26+000 ››› 29+000, where this problem would be solved by the construction of the green bridge suggested above).
- Section 2 should be **fenced in with wildlife-proof fence (bear and red deer proof fencing along the whole length**, except for the potential crossing structures). The purpose of the wildlife-proof fence would be two-fold: to prevent wildlife accessing the highway (thus limiting wildlife-vehicle collisions), and also to funnel movements of wildlife through the purpose-built crossing structures and other structures suitable for wildlife crossing, thereby ensuring safe highway passage.
- Possible attractants for wildlife in the immediate vicinity or on the highway should be avoided. For Section 2 (in crop production areas), we propose a **50 m wide corn cultivation-free stripe on both sides of the future highway (e.g., the exclusive cultivation of crop types which don't provide effective cover for wildlife)** starting right from the highway fence. This measure would prevent the aggregation of wildlife species in the immediate vicinity of the highway, and simultaneously it would also increase visibility for the passengers using the highway. Also, **human-related waste in highway parking lots should be stored in wildlife-proof containers.**

4.3. Section 3

Location: planned **highway segment 30+000 ››› 34+000** (4 km long)

Data availability:

Brown bear telemetry data	Brown bear denning habitat data	Motion sensor camera data	General permeability data
☒	☑	☑	☑

Description:

Section 3 starts next to the village of Bereni in the west and ends next to the village of Măgherani in the east, running roughly in parallel with the county-level road DJ135. In this section, the highway will intersect a wide variety of habitats: agricultural fields, forested areas, pastures and hay making fields.

Section 3 does not intersect important bear denning habitat (category 0).

Species detected by monitoring through camera trapping along Section 3:

Capreolus capreolus, Felis silvestris, Lepus europaeus, Meles meles, Ursus arctos, Vulpes vulpes.

No. of events when species were detected in Section 3 through photo trapping (period: November 2017 – December 2018; species are represented by the initials of their scientific names; for more details, please see maps in Subchapter 2.3.):

Permeability of the current technical plans (for more details, see Chapter 3):

Species group / functionality and frequency	Structure functionality	Structure frequency
Large mammals	medium functionality	favourable
Medium-sized mammals	medium functionality	unfavourable
Small mammals	medium functionality	mostly favourable *(except for the western part)*

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
C.c.	-	-	7	7	9	-	-	25	5	-	-	-	8	1
F.s.	-	-	-	-	3	-	-	-	-	-	-	-	-	-
L.e.	-	-	-	1	2	-	-	-	-	-	-	-	-	-
M.m	-	-	-	-	1	-	1	-	-	-	-	-	-	-
U.a.	-	-	-	-	-	-	-	-	-	-	1	2	-	-
V.v.	-	3	-	-	5	-	3	1	-	1	2	4	1	2

Measures proposed:

» The **permeability of this highway section for large, medium-sized, and small mammals in the western part of Section 3 (31+000 »» 32+000) should be improved by increasing the length of the planned bridge over the Fagului lung stream. Also, for small mammals, structure frequency should be increased in the western sectors 30+000 »» 32+000.**

» Section 3 should be **fenced in with wildlife-proof fence (bear and red deer proof fencing along the whole length**, except for the potential crossing structures). The purpose of the wildlife-proof fence would be two-fold: to prevent wildlife accessing the highway (thus limiting wildlife-vehicle collisions), and also to funnel movements of wildlife through the purpose-built crossing structures and other structures suitable for wildlife crossing, thereby ensuring safe highway passage.

» Possible attractants for wildlife in the immediate vicinity or on the highway should be avoided. For Section 3 (in crop production areas), we propose a **50 m wide corn cultivation-free stripe on both sides of the future highway (e.g., the exclusive cultivation of crop types which don't provide effective cover for wildlife)**, starting right from the highway fence. This measure would prevent the aggregation of wildlife species in the immediate vicinity of the highway, and simultaneously it would also increase visibility for the passengers using the highway. Also, **human-related waste in highway parking lots should be stored in wildlife-proof containers.**

4.4. Section 4

Location: planned **highway segment 34+000 ››› 39+000** (5 km long)

Data availability:

Brown bear telemetry data	Brown bear denning habitat data	Motion sensor camera data	General permeability data
☑	☑	☑	☑

Description:

Section 4 starts next to the village of Măgherani in the west, and, after crossing the watershed limit between the Nirajul Mic and the Târnava Mică rivers, ends close to the Târnava Mică river valley bottom, in the proximity of the DN13A national road. In this section, the highway will intersect almost exclusively natural and semi-natural habitats consisting of forests, pastures and hay making fields.

Section 4 does not intersect important bear denning habitat (category 1). Telemetry data is available for this section, as follows:

Highway segment identification	Total no. of intersections by at least 1 collared bear	No. of collared bears that have intersected the highway segment at least 1 time
35+000 ››› 36+000	2	2
36+000 ››› 37+000	8	3
37+000 ››› 38+000	2	1
38+000 ››› 39+000	6	2

Species detected by monitoring through camera trapping along Section 4:

Canis lupus, Capreolus capreolus, Cervus elaphus, Felis silvestris, Lepus europaeus, Martes sp., Meles meles, Sciurus vulgaris, Sus scrofa, Ursus arctos, Vulpes vulpes.

No. of events when species were detected in Section 4 through photo trapping (period: November 2017 – December 2018; species are represented by the initials of their scientific names; for more details, please see maps in Subchapter 2.3.):

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
C.l.	-	-	-	1	-	-	-	-	-	-	-	-	-	-
C.c.	-	28	36	21	12	17	34	15	24	36	24	12	12	10
C.e.	-	2	3	9	10	8	5	5	7	35	5	3	-	4
F.s.	-	-	-	1	1	3	5	-	-	-	-	-	2	-
L.e.	-	-	2	4	3	-	-	4	-	-	-	-	1	5
M.sp	-	1	-	2	1	-	1	-	-	-	2	1	1	-
M.m	-	1	-	3	3	3	2	1	-	-	2	2	-	3
S.v.	-	-	-	-	1	-	-	-	-	-	-	-	-	-
S.s.	-	8	5	3	1	10	3	5	5	9	9	6	13	3
U.a.	-	-	-	-	1	2	11	6	4	14	30	7	-	2
V.v.	-	7	15	16	19	9	3	3	3	3	12	12	10	7

Permeability of the current technical plans (for more details, see Chapter 3):

Species group / functionality and frequency	Structure functionality	Structure frequency
Large mammals	mostly very high	favourable
Medium-sized mammals	mostly very high	favourable
Small mammals	almost exclusively very high	favourable

Measures proposed:

- The **permeability of this highway section for large mammals, medium-sized mammals and small mammals alike is adequate**, no additional measures need to be implemented to increase permeability (if the planned structures - e.g. viaducts and tunnels – will be executed according to the technical parameters provided in the existing plans).
- Section 4 should be **fenced in with wildlife-proof fence (bear and red deer proof fencing along the whole length**, except for the potential crossing structures). The purpose of the wildlife-proof fence would be two-fold: to prevent wildlife accessing the highway (thus limiting wildlife-vehicle collisions), and also to funnel movements of wildlife through the structures suitable for wildlife crossing, thereby ensuring safe highway passage.
- Possible attractants for wildlife in the immediate vicinity or on the highway should be avoided. **Fruit trees** in Section 4 **should be cleared in a 50 m wide stripe on both sides of the future highway**, starting right from the highway fence. This measure would prevent the aggregation of wildlife species in the immediate vicinity of the highway. **Human-related waste in highway parking lots should be stored in wildlife-proof containers.**

4.5. Section 5

Location: planned **highway segment 39+000 ››› 41+000** (2 km long)

Data availability:

Brown bear telemetry data	Brown bear denning habitat data	Motion sensor camera data	General permeability data
☑	☑	☑	☑

Description:

Section 5 crosses the bottom of the Târnava Mică river valley, between the villages of Chibed in the west and Sărățeni in the east. The section also intersects the busy DN13A national road, as well as the Târnava Mică river.

Section 5 does not intersect important bear denning habitat (category 1). Telemetry data is available for this section, as follows:

Highway segment identification	Total no. of intersections by at least 1 collared bear	No. of collared bears that have intersected the highway segment at least 1 time
39+000 ››› 40+000	6	3
40+000 ››› 41+000	44	2

Species detected by monitoring through camera trapping along Section 5:

Canis lupus, Capreolus capreolus, Cervus elaphus, Felis silvestris, Lepus europaeus, Martes sp., Meles meles, Sus scrofa, Ursus arctos, Vulpes vulpes.

No. of events when species were detected in Section 5 through photo trapping (period: November 2017 – December 2018; species are represented by the initials of their scientific names; for more details, please see maps in Subchapter 2.3.):

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
C.l.	-	-	1	-	1	-	-	-	-	-	-	-	-	-
C.c.	-	4	9	8	7	8	28	18	29	12	14	24	6	14
C.e.	-	5	3	11	12	5	21	10	13	13	18	22	30	1
F.s.	-	-	-	-	-	-	-	-	-	-	-	1	-	-
L.e.	-	-	-	-	1	-	-	-	-	-	-	-	1	6
M.sp	-	-	-	-	-	-	-	-	-	-	-	6	-	-
M.m	-	-	-	-	-	-	-	-	-	-	-	4	1	-
S.s.	-	1	1	-	2	4	13	7	8	3	5	8	-	2
U.a.	-	-	-	-	-	1	3	1	2	2	10	8	6	-
V.v.	-	2	3	8	-	-	-	-	1	1	1	4	-	2

Permeability of the current technical plans

(for more details, see Chapter 3):

Species group / functionality and frequency	Structure functionality	Structure frequency
Large mammals	very high	favourable
Medium-sized mammals	very high	favourable
Small mammals	very high	favourable

Measures proposed:

- The **permeability of this highway section for large mammals, medium-sized mammals and small mammals alike is adequate**, no additional measures need to be implemented to increase permeability (if the planned structures – e.g. viaducts and tunnels – will be executed according to the technical parameters provided in the existing plans).
- We have documented intensive wildlife presence and activity (based on both brown bear telemetry and camera trapping data, see above) in this area. It is possible that with the building of the highway (even if the highway's permeability for wildlife in this section will be adequate), cumulative negative effects of the A8 highway, the busy DN13A national road and the railway will have a significant negative influence on wildlife activity and movement in the area. Therefore, **we propose that a green bridge should be built over both the DN13A national road and the railway**. The green bridge should be built in **between the coordinates 46˚32'57.79"N, 24˚59'24.05"E and 46˚33'4.91"N, 24˚59'34.27"E, perpendicularly to the national road and to the railway**. In order for the green bridge to be functional for brown bears (and implicitly for smaller species as well), it should have a minimum width of 100 m.[4]
- Section 5 should be **fenced in with wildlife-proof fence (bear and red deer proof fencing along the whole length**, except for the potential crossing structures). The purpose of the wildlife-proof fence would be two-fold: to prevent wildlife access onto the highway (thus limiting wildlife-vehicle collisions), and also to funnel movements of wildlife through the structures suitable for wildlife crossing, thereby ensuring safe highway passage.
- Possible attractants for wildlife in the immediate vicinity or on the highway should be avoided. For Section 5 (in crop production areas), we propose a **50 m wide corn cultivation-free stripe on both sides of the future highway (e.g., the exclusive cultivation of crop types which don't provide effective cover for wildlife)**, starting right from the highway fence. Fruit trees in Section 5 **should also be cleared in a 50 m wide stripe on both sides of the future highway**, starting right from the highway fence. This measure would prevent the aggregation of wildlife species in the immediate vicinity of the highway, and simultaneously it would also increase the visibility for the passengers using **the highway. Also, human-related waste in highway parking lots should be stored in wildlife-proof containers.**

4 Kusak J., D. Huber, T. Gomerčić, G. Schwaderer, and G. Gužvica. 2009. The permeability of highway in Gorski kotar (Croatia) for large mammals. European Journal of Wildlife Research 55(1): 7-21.

4.6. Section 6

Location: planned **highway segment 41+000 ››› 47+000** (6 km long)

Data availability:

Brown bear telemetry data	Brown bear denning habitat data	Motion sensor camera data	General permeability data
☑	☑	☑	☑

Description:

Section 6 starts close to the village of Sărățeni in the west and, after following the course of the Târnava Mică river, ends close to the town of Sovata (exit towards Praid), running roughly in parallel with the busy national road DN13A, and with the Târnava Mică river. This section intersects wood pastures in the western part and forested habitats in the eastern part.

Section 6 does not intersect important bear denning habitat (categories 0 and 1). Telemetry data is available for this section, as follows:

Highway segment identification	Total no. of intersections by at least 1 collared bear	No. of collared bears that have intersected the highway segment at least 1 time
41+000 ››› 42+000	18	1
42+000 ››› 43+000	8	2
43+000 ››› 44+000	8	2
44+000 ››› 45+000	5	2
45+000 ››› 46+000	6	2
46+000 ››› 47+000	5	3

Species detected by monitoring through camera trapping along Section 6:

Canis lupus, Capreolus capreolus, Cervus elaphus, Felis silvestris, Lepus europaeus, Lynx lynx, Martes sp., Meles meles, Sus scrofa, Ursus arctos, Vulpes vulpes.

No. of events when species were detected in Section 6 through photo trapping (period: November 2017 - December 2018; species are represented by the initials of their scientific names; for more details, please see maps in Subchapter 2.3.):

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
C.l.	-	-	-	-	-	-	-	-	-	-	-	-	-	4
C.c.	-	12	26	29	18	16	34	13	10	46	31	87	81	52
C.e.	-	3	3	5	8	17	66	29	26	44	56	81	64	46
F.s.	-	2	1	1	1	1	-	1	-	1	1	1	1	-
L.e.	-	-	-	2	-	1	-	-	-	-	-	-	-	-
L.ly.	-	-	-	-	1	-	-	-	-	-	-	-	-	-
M.sp	-	-	-	2	-	-	-	-	-	-	-	-	1	-
M.m	-	-	-	1	7	11	1	1	-	-	-	-	-	-
S.s.	-	3	2	14	9	19	23	56	6	45	29	38	17	6
U.a.	-	3	-	1	1	3	6	11	1	7	19	34	6	2
V.v.	-	-	10	20	8	1	1	2	1	-	1	1	1	2

Permeability of the current technical plans (for more details, see Chapter 3):

Species group / functionality and frequency	Structure functionality	Structure frequency
Large mammals	High	favourable
Medium-sized mammals	medium to low	favourable in the 3 eastern sectors, unfavourable in the western 3 sectors
Small mammals	high	favourable

Measures proposed:

The **permeability of the western 3 sectors of this highway section (41+000 ››› 44+000) for medium-sized mammals should be improved by increasing the frequency (or the size, e.g. the length) of structures suitable for crossing by this species group.**

We considered the planned viaduct (42+000 ››› 43+000, 320 m long) in the western sector of Section 6 as suitable for crossing by large mammal species (and implicitly by smaller species as well). However, this is planned very close to the outskirts of the village of Sărățeni. **No further infrastructure development (e.g. extension of the village towards the highway, or on the other side of it) should be allowed in the vicinity of this viaduct, in order for it to maintain its functionality.**

Section 6 should be **fenced in with wildlife-proof fence (bear and red deer proof fencing along the whole length**, except for the potential crossing structures). The purpose of the wildlife-proof fence would be two-fold: to prevent wildlife access onto the highway (thus limiting wildlife-vehicle collisions), and also to funnel movements of wildlife through the structures suitable for wildlife crossing, thereby ensuring safe highway passage.

Possible attractants for wildlife in the immediate vicinity or on the highway should be avoided. **Fruit trees** in Section 6's western part **(close to the village of Sărățeni) should be cleared in a 50 m wide stripe on both sides of the future highway**, starting right from the highway fence. This measure would prevent the aggregation of wildlife species in the immediate vicinity of the highway. **Human-related waste in highway parking lots should be stored in wildlife-proof containers.**

4.7. Section 7

Location: planned **highway segment 47+000 ››› 49+000** (6 km long)

Data availability:

Brown bear telemetry data	Brown bear denning habitat data	Motion sensor camera data	General permeability data
☑	☑	☑	☑

Description:

Section 7 crosses the Târnava Mică river and the busy national road DN13A. It is located close to the industrial area of the town of Sovata. It intersects semi-natural forested habitats, and mostly extensively used hay making fields.

Section 7 does not intersect important bear denning habitat (categories 0 and 1). Telemetry data is available for this section, as follows:

Highway segment identification	Total no. of intersections by at least 1 collared bear	No. of collared bears that have intersected the highway segment at least 1 time
47+000 ››› 48+000	6	3
48+000 ››› 49+000	29	3

Species detected by monitoring through camera trapping along Section 7:

Capreolus capreolus, Cervus elaphus, Felis silvestris, Lutra lutra, Martes sp., Sus scrofa, Ursus arctos, Vulpes vulpes.

No. of events when species were detected in Section 7 through photo trapping (period: November 2017 – December 2018; species are represented by the initials of their scientific names; for more details, please see maps in Subchapter 2.3.):

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
C.c.	-	7	2	2	4	3	5	8	13	10	11	1	1	1
C.e.	-	2	1	2	1	-	16	-	-	6	4	5	-	-
F.s.	-	-	-	-	-	-	1	-	-	-	-	-	-	-
L.lu.	-	-	-	-	-	-	-	-	1	-	-	2	-	1
M.sp	-	-	1	-	1	-	-	-	-	-	-	-	2	-
S.s.	-	2	-	1	-	-	3	3	-	2	8	4	1	-
U.a.	-	-	-	-	-	1	6	1	2	3	6	6	4	-
V.v.	-	2	5	3	8	-	4	-	2	1	1	4	2	5

Permeability of the current technical plans

(for more details, see Chapter 3):

Species group / functionality and frequency	Structure functionality	Structure frequency
Large mammals	very high (see below)	favourable (see below)
Medium-sized mammals	very high (see below)	favourable (see below)
Small mammals	very high	favourable

Measures proposed:

» **the permeability of this highway section for large mammals, medium-sized mammals and small mammals alike is adequate, according to the calculations done focusing only on the highway itself, or potentially considering the 1,720 m long viaduct planned here. However, the highway access routes are also planned here, and these will make most of the 1,720 m long viaduct actually impermeable for wildlife. The fact that Praid's development area (e.g. the area where building is allowed) stretches approximately until the planned highway access routes only further aggravates the situation, as it is foreseeable that in the future, Praid will effectively extend all the way until the highway access routes. Thus, at least the partial permeability of the 1,720 m long viaduct should be maintained at all costs. With this being one of the most critical sectors of the A8's Ilieni-Ditrău section, we recommend that the highway access routes should be planned and built in a way that keeps the planned viaduct permeable for wildlife in the sector 47+500 »» 48+500.**

» Section 7 should be **fenced in with wildlife-proof fence (bear and red deer proof fencing on the whole length**, except for the potential crossing structures). The purpose of the wildlife-proof fence would be two-fold: to prevent wildlife access onto the highway (thus limiting wildlife-vehicle collisions), and also to funnel movements of wildlife through the structures suitable for wildlife crossing, thereby ensuring safe highway passage.

» Possible attractants for wildlife in the immediate vicinity or on the highway should be avoided. For Section 7 (in crop production areas), we propose a **50 m wide corn cultivation-free stripe on both sides of the future highway (e.g., the exclusive cultivation of crop types which don't provide effective cover for wildlife)**, starting right from the highway fence. This measure would prevent the aggregation of wildlife species in the immediate vicinity of the highway, and simultaneously it would also increase visibility for the passengers using the highway. Also, **human-related waste in highway parking lots should be stored in wildlife-proof containers.**

4.8. Section 8

Location: planned **highway segment 49+000 ››› 53+000** (4 km long)

Data availability:

Brown bear telemetry data	Brown bear denning habitat data	Motion sensor camera data	General permeability data
☑	☑	☑	☑

Description:

Section 8 starts close to the busy national road DN13A, and following a forested valley, basically goes around the village of Praid, ending in the proximity of the national road DN13B. This section crosses forested habitats, as well as semi-natural hay making fields located close to Praid.

Section 8 does intersect important bear denning habitat, as follows:

Highway segment identification	Value attributed after intersection with the denning habitat suitability model	No. of collared bears that have intersected the highway segment at least 1 time
49+000 ››› 50+000	0.304276	2
50+000 ››› 51+000	0.100094	0
51+000 ››› 52+000	0.239924	1
52+000 ››› 53+000	0.496044	3

Telemetry data is available for this section, as follows:

Highway segment identification	Total no. of intersections by at least 1 collared bear	No. of collared bears that have intersected the highway segment at least 1 time
49+000 ››› 50+000	21	4
50+000 ››› 51+000	10	2
51+000 ››› 52+000	3	2
52+000››› 53+000	7	2

Species detected by monitoring through camera trapping along Section 8:

Canis lupus, Capreolus capreolus, Cervus elaphus, Felis silvestris, Lepus europaeus, Lynx lynx, Martes sp., Meles meles, Sus scrofa, Ursus arctos, Vulpes vulpes.

No. of events when species were detected in Section 8 through photo trapping (period: November 2017 - December 2018; species are represented by the initials of their scientific names; for more details, please see maps in Subchapter 2.3.):

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
C.l.	-	-	-	1	1	1	-	-	-	-	-	-	-	1
C.c.	-	8	8	7	5	14	8	8	10	8	4	1	1	-
C.e.	-	1	2	6	2	1	8	13	8	3	8	7	4	-
F.s.	-	-	-	-	1	2	-	-	-	-	2	3	2	-
L.e.	-	4	4	3	1	5	-	1	2	-	-	-	2	1
L.ly.	-	-	-	-	-	-	-	-	-	-	1	-	-	-
M.sp	-	1	3	-	1	-	-	-	-	-	-	4	-	-
M.m	-	-	-	-	1	-	2	-	1	-	-	-	-	-
S.s.	-	3	6	9	7	15	12	7	11	7	6	12	10	3
U.a.	-	7	1	2	1	17	16	18	16	22	43	24	17	6
V.v.	-	38	16	32	5	18	9	5	2	2	11	10	2	3

Permeability of the current technical plans

(for more details, see Chapter 3):

Species group / functionality and frequency	Structure functionality	Structure frequency
Large mammals	high	favourable
Medium-sized mammals	high	favourable
Small mammals	high	favourable

Measures proposed:

The **permeability of this highway section for large mammals, medium-sized mammals and small mammals alike is adequate** (if the planned structures - e.g. viaducts - will be executed according to the technical parameters of the existing plans). **Still, this permeability is useful only if Praid's effectively built-in area towards Sovata is limited to its current (e.g. early 2019) extent. This means that Praid's development area towards Sovata (e.g. the area where effective building is allowed) should be restricted to the current junction of the railway with the DN13A national road.** Otherwise, wildlife that manages to cross Section 8 to the south will end up in an area bordered on all sides by a continuous locality (Praid).

Section 8 should be **fenced in with wildlife-proof fence (bear and red deer proof fencing on the whole length**, except for the potential crossing structures). The purpose of the wildlife-proof fence would be two-fold: to prevent wildlife access onto the highway (thus limiting wildlife-vehicle collisions), and also to funnel movements of wildlife through the structures suitable for wildlife crossing, thereby ensuring safe highway passage.

Possible attractants for wildlife in the immediate vicinity or on the highway should be avoided. **Human-related waste in highway parking lots should be stored in wildlife-proof containers.**

4.9. Section 9

Location: planned **highway segment 53+000 ››› 58+000** (5 km long)

Data availability:

Brown bear telemetry data	Brown bear denning habitat data	Motion sensor camera data	General permeability data
☑	☑	☑	☑

Description:

Section 9 starts in the proximity of the national road DN13B, crosses the road and ends at the entrance into the valley of the Creanga Mică stream. On its way, it crosses semi-forested areas with scattered weekend homes.

Section 9 does not intersect important bear denning habitat (categories 0, 1 and 2). Telemetry data is available for this section, as follows:

Highway segment identification	Total no. of intersections by at least 1 collared bear	No. of collared bears that have intersected the highway segment at least 1 time
53+000 ››› 54+000	10	1
54+000 ››› 55+000	34	2
55+000 ››› 56+000	26	2
56+000 ››› 57+000	13	2
57+000 ››› 58+000	2	1

Species detected by monitoring through camera trapping along Section 9:

Capreolus capreolus, Cervus elaphus, Felis silvestris, Lutra lutra, Martes sp., Sciurus vulgaris, Sus scrofa, Ursus arctos, Vulpes vulpes.

No. of events when species were detected in Section 9 through photo trapping (period: November 2017 – December 2018; species are represented by the initials of their scientific names; for more details, please see maps in Subchapter 2.3.):

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
C.c.	3	10	12	17	24	9	5	8	15	5	8	10	3	1
C.e.	1	6	3	2	2	2	11	7	6	10	5	16	1	-
F.s.	-	2	-	4	-	-	-	-	-	-	-	1	-	-
L.lu.	-	1	-	-	-	-	-	-	-	-	-	-	-	-
M.sp	-	1	1	1	2	1	-	-	-	-	-	-	-	-
S.v.	-	-	-	-	1	1	1	-	1	6	7	11	1	1
S.s.	-	-	-	-	-	-	4	-	3	1	7	3	-	-
U.a.	-	-	-	-	-	1	-	1	3	11	20	4	-	-
V.v.	-	5	7	8	9	3	8	4	12	8	8	4	9	1

Permeability of the current technical plans (for more details, see Chapter 3):

Species group / functionality and frequency	Structure functionality	Structure frequency
Large mammals	high	favourable
Medium-sized mammals	high	favourable
Small mammals	high	favourable

Measures proposed:

- The **permeability of this highway section for large mammals, medium-sized mammals and small mammals alike is adequate**, no additional measures need to be implemented to increase permeability (if the planned structures – e.g. viaducts and tunnels – will be executed according to the technical parameters of the existing plans). However, in order to effectively maintain the functionality of the planned structures, no additional weekend homes should be authorized and built in the area.
- Section 9 should be **fenced in with wildlife-proof fence (bear and red deer proof fencing along the whole length**, except for the potential crossing structures). The purpose of the wildlife-proof fence would be two-fold: to prevent wildlife access onto the highway (thus limiting wildlife-vehicle collisions), and also to funnel movements of wildlife through the structures suitable for wildlife crossing, thereby ensuring safe highway passage.
- Possible attractants for wildlife in the immediate vicinity or on the highway should be avoided. **Human-related waste in highway parking lots should be stored in wildlife-proof containers.**

4.10 Section 10

Location: planned **highway segment 58+000 ››› 68+000** (10 km long)

Data availability:

Brown bear telemetry data	Brown bear denning habitat data	Motion sensor camera data	General permeability data
☑	☑	☑	☑

Description:

Section 10 follows the forested valley of the Creanga Mică stream, starting from the valley entrance and ending close to the watershed. On its way, it crosses exclusively natural, forested areas and approaches natural, extensively used pastures.

Section 10 does intersect important bear denning habitat, as follows:

Highway segment identification	Value attributed after intersection with the denning habitat suitability model	No. of collared bears that have intersected the highway segment at least 1 time
58+000 ››› 59+000	0.523027	3
59+000 ››› 60+000	0.524259	3
60+000 ››› 61+000	0.642384	4
61+000 ››› 62+000	0.616254	4
62+000 ››› 63+000	0.673833	4
63+000 ››› 64+000	0.508925	3
64+000 ››› 65+000	0.580612	4
65+000 ››› 66+000	0.450577	3
66+000 ››› 67+000	0.371953	2
67+000 ››› 68+000	0.269575	1

Telemetry data is available for this section, as follows:

Highway segment identification	Total no. of intersections by at least 1 collared bear	No. of collared bears that have intersected the highway segment at least 1 time
58+000 ››› 59+000	2	1
59+000 ››› 60+000	2	1
60+000 ››› 61+000	4	1
61+000 ››› 62+000	8	1
62+000 ››› 63+000	8	2
63+000 ››› 64+000	6	2
64+000 ››› 65+000	6	2
65+000 ››› 66+000	9	2
66+000 ››› 67+000	16	2
67+000 ››› 68+000	19	2

Species detected by monitoring through camera trapping along Section 10:

Canis lupus, Capreolus capreolus, Cervus elaphus, Felis silvestris, Lepus europaeus, Lynx lynx, Martes sp., Meles meles, Sciurus vulgaris, Sus scrofa, Ursus arctos, Vulpes vulpes.

No. of events when species were detected in Section 10 through photo trapping (period: November 2017 - Decembe 2018; species are represented by the initials of their scientific names; for more details, please see maps in Subchapter 2.3.):

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
C.l.	2	-	-	-	-	3	-	3	1	1	3	2	1	-
C.c.	4	25	4	6	7	20	27	26	25	19	10	20	16	18
C.e.	6	11	4	1	3	23	54	41	19	21	8	9	28	14
F.s.	-	-	-	1	-	1	2	4	4	1	1	1	2	-
L.e.	-	-	-	-	-	-	-	-	-	-	-	-	-	1
L.ly.	-	1	2	2	-	1	-	1	-	-	-	1	1	2
M.sp	-	1	1	1	-	1	3	1	3	1	-	-	-	-
M.m	-	-	-	1	-	2	2	1	1	1	1	-	-	-
S.v.	-	-	-	-	-	1	1	-	-	-	-	-	1	-
S.s.	-	-	-	-	-	-	1	1	2	2	-	-	-	1
U.a.	6	4	1	-	5	12	13	25	9	16	8	6	10	6
V.v.	3	13	11	13	6	9	15	23	19	7	7	8	4	2

Permeability of the current technical plans (for more details, see Chapter 3):

Species group / functionality and frequency	Structure functionality	Structure frequency
Large mammals	high (see below)	favourable (see below)
Medium-sized mammals	high	favourable
Small mammals	high	favourable

Measures proposed:

- The **permeability of this highway section for large mammals, medium-sized mammals and small mammals alike is adequate** (if the planned structures – e.g. viaducts – will be executed according to the technical parameters of the existing plans). **However, the problem on Section 10 is not only the permeability for wildlife species, but also effective habitat loss – e.g. in this case, the loss and degradation of highly valuable brown bear denning habitat (see above). Thus, for minimizing the loss and degradation of the most valuable denning habitat and for minimizing disturbance through the operation of the highway, we recommend that the most crucial segment of Section 10, (58+000 ››› 66+000) should be included in one, or, if it's the case, in several, almost continuous tunnels. Preferably, the tunnel(s) shouldn't be of the cut & cover type, as this approach implies effective habitat destruction and degradation in the construction phase.**
- Section 10 should be **fenced in with wildlife-proof fence (bear and red deer proof fencing along the whole length**, except for the potential crossing structures). The purpose of the wildlife-proof fence would be two-fold: to prevent wildlife access onto the highway (thus limiting wildlife-vehicle collisions), and also to funnel movements of wildlife through the structures suitable for wildlife crossing, thereby ensuring safe highway passage.
- Possible attractants for wildlife in the immediate vicinity or on the highway should be avoided. **Human-related waste in highway parking lots should be stored in wildlife-proof containers.**

4.11. Section 11

Location: planned **highway segment 68+000 ››› 70+000** (2 km long)

Data availability:

Brown bear telemetry data	Brown bear denning habitat data	Motion sensor camera data	General permeability data
☑	☑	☑	☑

Description:

Section 11 crosses the upper part of the Creanga Mică stream's watershed, or potentially the peak of the mountain. It crosses exclusively natural, forested areas and approaches natural, extensively used pastures.

Section 11 does not intersect important bear denning habitat (categories 0 and 1). Telemetry data is available for this section, as follows:

Highway segment identification	Total no. of intersections by at least 1 collared bear	No. of collared bears that have intersected the highway segment at least 1 time
68+000 ››› 69+000	5	2
69+000 ››› 70+000	7	2

Species detected by monitoring through camera trapping along Section 11:

Canis lupus, Capreolus capreolus, Cervus elaphus, Lepus europaeus, Meles meles, Sus scrofa, Ursus arctos, Vulpes vulpes.

No. of events when species were detected in Section 11 through photo trapping (period: November 2017 – December 2018; species are represented by the initials of their scientific names; for more details, please see maps in Subchapter 2.3.):

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
C.l.	-	-	-	-	-	-	-	2	-	-	-	-	-	-
C.c.	-	-	-	-	-	1	2	4	7	11	3	-	-	-
C.e.	-	-	-	-	-	8	15	5	6	4	3	-	2	-
L.e.	-	-	-	-	-	3	5	-	-	-	-	-	-	-
M.m	-	-	-	-	-	-	-	-	-	-	1	-	-	-
S.s.	-	-	-	-	-	-	-	-	2	-	-	1	1	-
U.a.	1	2	-	-	-	-	7	3	3	1	1	-	1	-
V.v.	-	1	-	-	-	-	3	1	4	-	1	-	-	-

Permeability of the current technical plans

(for more details, see Chapter 3):

Species group / functionality and frequency	Structure functionality	Structure frequency
Large mammals	no functionality	unfavourable
Medium-sized mammals	no functionality	unfavourable
Small mammals	medium functionality	mostly unfavourable

Measures proposed:

» **The permeability of this highway section for large and medium-sized mammals should be extensively improved.** For a total length of approximately 3.5 km of the planned highway (the last km of Section 10 and the whole length of Section 11), there are no planned structures that are suitable for crossing by large and medium-sized mammals. To address this problem, **we recommend the building of a structure with an Openness Index of at least 4 (e.g. minimum length of 20 m and height of 6 m) in the middle of Section 11. Alternatively, we recommend the extension of structures already planned in Section 11 in a way that would make these suitable for crossing also by large mammals (e.g. with an Openness Index of at least 4).**

» Section 11 should be **fenced in with wildlife-proof fence (bear and red deer proof fencing along the whole length,** except for the potential crossing structures). The purpose of the wildlife-proof fence would be two-fold: to prevent wildlife access onto the highway (thus limiting wildlife-vehicle collisions), and also to funnel movements of wildlife through the structures suitable for wildlife crossing, thereby ensuring safe highway passage.

» Possible attractants for wildlife in the immediate vicinity or on the highway should be avoided. **Human-related waste in highway parking lots should be stored in wildlife-proof containers.**

4.12 Section 12

Location: planned **highway segment 70+000 ››› 77+000** (7 km long)

Data availability:

Brown bear telemetry data	Brown bear denning habitat data	Motion sensor camera data	General permeability data
☑	☑	☒	☑

Description:

Section 12 roughly follows the course of the Putna stream and crosses exclusively natural, forested areas and approaches the natural, extensively used pastures and hay making fields. In the west, it starts near the mountain peak, whereas in the east it ends near the DN13B national road and the limit of Borzont village, in an area with numerous weekend homes and fenced in hay making fields.

Section 12 does intersect important bear denning habitat, as follows:

Highway segment identification	Value attributed after intersection with the denning habitat suitability model	No. of collared bears that have intersected the highway segment at least 1 time
70+000 ››› 71+000	0.2773	1
71+000 ››› 72+000	0.330271	2
72+000 ››› 73+000	0.310724	2
73+000 ››› 74+000	0.425401	3
74+000 ››› 75+000	0.410392	2
75+000 ››› 76+000	0.284261	2
76+000 ››› 77+000	0.204881	1

Telemetry data is available for this section, as follows:

Highway segment identification	Total no. of intersections by at least 1 collared bear	No. of collared bears that have intersected the highway segment at least 1 time
70+000 ››› 71+000	6	2
71+000 ››› 72+000	9	2
72+000 ››› 73+000	2	2
73+000 ››› 74+000	3	2
74+000 ››› 75+000	2	1
75+000 ››› 76+000	8	2
76+000 ››› 77+000	2	1

Permeability of the current technical plans

(for more details, see Chapter 3):

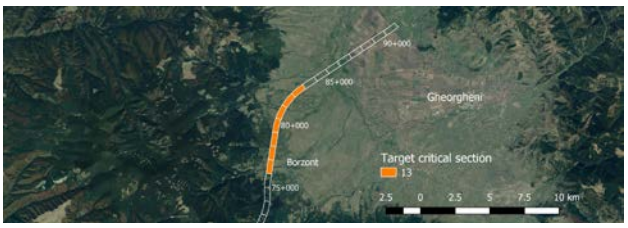
Species group / functionality and frequency	Structure functionality	Structure frequency
Large mammals	high	favourable
Medium-sized mammals	high	favourable
Small mammals	high	favourable

Measures proposed:

- The **permeability of this highway section for large mammals, medium-sized mammals and small mammals alike is adequate**, no additional measures need to be implemented to increase permeability (if the planned structures – e.g. viaducts – will be executed according to the technical parameters provided in the existing plans).
- Section 12 should be **fenced in with wildlife-proof fence (bear and red deer proof fencing along the whole length**, except for the potential crossing structures). The purpose of the wildlife-proof fence would be two-fold: to prevent wildlife access onto the highway (thus limiting wildlife-vehicle collisions), and also to funnel movements of wildlife through the structures suitable for wildlife crossing, thereby ensuring safe highway passage.
- Possible attractants for wildlife in the immediate vicinity or on the highway should be avoided. **Human-related waste in highway parking lots should be stored in wildlife-proof containers.**

4.13 Section 13

Location: planned **highway segment 77+000 ››› 84+000** (7 km long)



Data availability:

Brown bear telemetry data	Brown bear denning habitat data	Motion sensor camera data	General permeability data
☑	☑	☒	☑

Description:

Section 13 starts in the forested areas at the bottom of the Bucin pass in the west, in the vicinity of the DN13B national road and the limit of Borzont village, in an area with numerous weekend homes and fenced in hay making fields. In the east, it ends in the flat terrain in the Giurgeu basin, after crossing natural pastures, hay making fields, and shrub areas.

Section 13 does not intersect important bear denning habitat (category 0). Telemetry data is available for this section, as follows:

Highway segment identification	Total no. of intersections by at least 1 collared bear	No. of collared bears that have intersected the highway segment at least 1 time
77+000 ››› 78+000	1	1
78+000 ››› 79+000	2	2
79+000 ››› 80+000	3	2
80+000 ››› 81+000	2	1
81+000 ››› 82+000	2	2
82+000 ››› 83+000	2	2

Permeability of the current technical plans (for more details, see Chapter 3):

Species group / functionality and frequency	Structure functionality	Structure frequency
Large mammals	dysfunctional in the southern part, medium functionality in the northern part	unfavourable in the southern part, favourable in the northern part
Medium-sized mammals	dysfunctional in the southern part, medium functionality in the northern part	unfavourable in the southern part, favourable in the northern part
Small mammals	medium	favourable

Measures proposed:

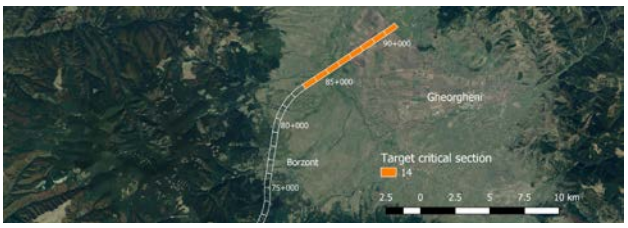
» The **permeability of this highway section for medium-sized mammals should be extensively improved. This can be done through the physical enlargement of the already planned small bridges and culverts. Thus, a structure with an Openness Index of at least 1.5 (e.g. minimum length of 10 m and height of 4 m) should be located on at least every 1.5 km of Section 13 of the planned highway** (section 77+000 ››› 80+000).

» Section 13 should be **fenced in with wildlife-proof fence (bear and red deer proof fencing along the whole length**, except for the potential crossing structures). The purpose of the wildlife-proof fence would be two-fold: to prevent wildlife accessing the highway (thus limiting wildlife-vehicle collisions), and also to funnel movements of wildlife through the purpose-built crossing structures and other structures suitable for wildlife crossing, thereby ensuring safe highway passage.

» Possible attractants for wildlife in the immediate vicinity or on the highway should be avoided. For Section 13 (in crop production areas), we propose a **50 m wide corn cultivation-free stripe on both sides of the future highway (e.g., the exclusive cultivation of crop types which don't provide effective cover for wildlife)**, starting right from the highway fence. This measure would prevent the aggregation of wildlife species in the immediate vicinity of the highway, and simultaneously it would also increase the visibility for the passengers using the highway. Also, **human-related waste in highway parking lots should be stored in wildlife-proof containers.**

4.14 Section 14

Location: planned **highway segment 84+000 ››› 92+000** (8 km long)



Data availability:

Brown bear telemetry data	Brown bear denning habitat data	Motion sensor camera data	General permeability data
☒	☒	☒	☑

Description:

Section 14 is the easternmost section of the Tîrgu Mureș-Ditrău section of the future A8 highway. It crosses flat terrain in the Giurgeu basin, intersects the Mureș River and in the east ends in the proximity of the DN12 national road, in between the localities of Lăzarea and Ditrău. Its western part (west from the Mureș River) mostly crosses through natural grasslands and transitional woodland, while its eastern part (east of the Mureș River) cuts through agricultural fields.

Permeability of the current technical plans

(for more details, see Chapter 3):

Species group / functionality and frequency	Structure functionality	Structure frequency
Large mammals	medium	favourable
Medium-sized mammals	medium	unfavourable in the eastern part
Small mammals	high	favourable

Measures proposed:

» Section 14 should be **fenced in with wildlife-proof fence (bear and red deer proof fencing along the whole length**, except for the potential crossing structures). The purpose of the wildlife-proof fence would be two-fold: to prevent wildlife accessing the highway (thus limiting wildlife-vehicle collisions), and also to funnel movements of wildlife through the purpose-built crossing structures and other structures suitable for wildlife crossing, thereby ensuring safe highway passage.

» Possible attractants for wildlife in the immediate vicinity or on the highway should be avoided. For Section 14 (in crop production areas), we propose a **50 m wide corn cultivation-free stripe on both sides of the future highway (e.g., the exclusive cultivation of crop types which don't provide effective cover for wildlife)**, starting right from the highway fence. This measure would prevent the aggregation of wildlife species in the immediate vicinity of the highway, and simultaneously it would also increase visibility for the passengers using the highway. Also, **human-related waste in highway parking lots should be stored in wildlife-proof containers.**

5. Conclusions

At the moment, the Tîrgu Mureș-Iași-Ungheni (A8) highway only exists on paper and construction work has not begun yet. Moreover, the Feasibility Study of the planned highway needs to be revised and updated. This gives us a unique opportunity to intervene in a timely manner and to attempt to positively influence the planning process, minimizing the future highway's potential negative effects on local communities and on both wildlife species and natural habitats of national and EU importance. Ideally, effective mitigation measures should be incorporated in the highway's technical plans before the actual construction of the highway begins – ensuring that these costs are considered, and measures are implemented from the very beginning.

We strongly believe that effective mitigation measures need to be based on sound scientific data. Moreover, this section of the planned A8 highway is unique from this perspective: even before environmental impact assessments have been carried out in the area, a wealth of data is already available, at least concerning mammalian species. Moreover, the data that is already available is of a type that environmental impact assessments rarely manage to produce: it originates from long-term, labour-intensive and costly monitoring processes.

Our approach in creating a list of specific recommendations for improving the future A8 highway's permeability for mammal species has been conservative and minimalistic. However, we would like to highlight one crucial aspect: **for most of its length, the westernmost section of the planned A8 highway will not intersect well-definable ecological corridors connecting crucial habitats. Instead, the A8 highway will intersect the crucial, functional habitats themselves, inhabited and actively used by wildlife species of national and EU importance.** This is evident from the variety of species, or potentially the sheer number of individuals from these species recorded through the monitoring with motion sensor cameras (Subchapter 2.3.), but also from the brown bear telemetry data we possess from the area around the route of the planned A8 highway (e.g., Fig. 6, page 7). Accordingly, the negative effects of the planned A8 highway will not be caused by a number of short segments, but rather by significant lengths of the future highway. Considering this, the list of recommendations presented in this document represents a minimum set of requirements in order to mitigate to some degree the damage caused to the natural and semi-natural habitats the planned A8 highway will intersect. Undoubtedly, even with these technical solutions implemented, the highway will still have a significant negative effect, leading to the effective loss, fragmentation and deterioration of natural habitats, especially in areas where currently human presence and activities are negligible.

6

Annex:
In-depth Analysis
TÎRGU MUREȘ-IAȘI-UNGHENI (A8) PLANNED HIGHWAY PILOT AREA, ROMANIA

Table of contents

1. Introduction

The loss, degradation and fragmentation of natural habitats represent major threats to terrestrial mammal diversity (Baillie *et al.* 2004). In recent decades an increasing number of studies have analyzed the impact of roads on ecosystems (Coffin 2007) and found that roads are one of the main driving forces behind the global alteration of natural habitats (Forman & Alexander 1998; Spellerberg 1998; Trombulak & Frissell 2000). Roads affect the abiotic and biotic components of ecosystems, and their associated edge effects can manifest at local and landscape levels (Coffin 2007). Animal species with wide ranging movements, large home ranges and long dispersal distances are especially vulnerable to roads.

The TRANSGREEN project (January 2017-June 2019) aims to contribute to safer and environmentally-friendly road and rail networks in the mountainous regions of the Danube Basin, with a special focus on four pilot sites within the Carpathian Mountains: Beskydy-Kysuce (CZ-SK), Miskolc-Kosice-Uzhgorod (HU-SK-UA), Tîrgu Mureș-Iași and Arad(Radna)-Deva (RO). The initiative strives towards this target 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.

This In-depth Analysis focuses on one of the Romanian pilot sites, namely on the Tîrgu Mureș-Iași-Ungheni planned highway (Pilot Area 4). It provides an overview of the policies influencing the planning and construction of transport infrastructure in the area, along with an overview of the specific stakeholders involved in this process. Furthermore, it provides a description of the current status of ecological corridors in the area. The aim of the document is to present the issue of landscape connectivity in Pilot Area 4 and to create a basis for discussion, cooperation and informed decision-making. The document should assist relevant authorities, officers, planners of construction projects and other stakeholders to take / contribute to decisions which will benefit both people and nature.

The Tîrgu Mureș-Iași-Ungheni Pilot Area in Romania (Pilot Area 4, part of the TEN-T Core network) is somewhat unique among the target locations of the TRANSGREEN project. At the moment the planned Tîrgu Mureș-Iași-Ungheni (A8) highway only exists on paper and construction work has not begun yet. Moreover, the Feasibility Study of the planned highway needs to be revised and updated. This represents a unique opportunity for a timely intervention to positively influence the planning process, minimizing the future highway's potential negative effects on local communities and on both wildlife species and natural habitats of national and EU importance. Ideally, effective mitigation measures should be incorporated in the highway's technical plans before the actual construction of the highway begins - ensuring that these costs are considered and measures are implemented from the very beginning.

2 Geographical identification of the pilot area

Pilot area 4 is located in Eastern Transylvania, Romania, along the planned Tîrgu Mureș-Iași-Ungheni highway. This highway is supposed to link the historic Romanian regions of Transylvania and Moldova. Of the total planned length of 311 km, our work within the TRANSGREEN project focused mainly on the Westernmost of the three sections of the actual highway route, located between Tîrgu Mureș (Ilieni) and Ditrău (section length: 92.1 km) - Fig. 1. This section is situated in Mureș and Harghita counties. Still, some of our activities have also 'scraped' the mid-section of the planned highway, between the localities of Ditrău and Târgu Neamț (Harghita and Neamt counties). The planned highway is part of the TEN-T Core network. Milvus Group is based in the general area (Western end of the planned highway) and has a long history of working on biodiversity and with local communities in the area. Some of Milvus Group's prior activities in the area focused specifically on the possible negative effects of the planned highway, yielding some relevant preliminary data.

The Westernmost section of the planned highway will cut through the western foothills of Romania's Eastern Carpathians, respectively through the western part of the Eastern Carpathians themselves (the Gurghiu Mountains). The area has a general topographic gradient with lower elevations in the West, respectively higher elevations in the East (except for the last few kilometers of this section in the East, inside the Gheorgheni basin).

The Western part of our section of interest (e.g. the section in the foothills) cuts through an area with numerous settlements, ranging from small villages to cities. Geographically, this includes parts of the lower and mid river basins of the Niraj river, the Nirajul Mic river basin, respectively part of the upper river basin of the Târnava Mică river. Here, the highway will intersect the administrative territories of a total of 11 localities / parishes: Gheorghe Doja, Crăciunești, Acățari, Păsăreni, Gălești, Miercurea Nirajului, Măgherani, Ghindari, Sărățeni, Sovata and Praid. The main land use in the area is agriculture. Arable fields occur mainly at lower elevations and close to human settlements, while semi-natural pastures, hayfields and orchards are usually located at higher elevations. Forest succession occurs within abandoned fields, forming almost impenetrable thickets. As most private lands are of small size, the foothills form a mosaic of human land use with forests at higher elevations and in more inaccessible valleys. Treed areas include deciduous (European hornbeam [*Carpinus betulus*], oak [*Quercus sp.*], European beech, black locust [*Robinia pseudoacacia*]), planted conifer (Scots pine [*Pinus sylvestris*]) and mixed forests.

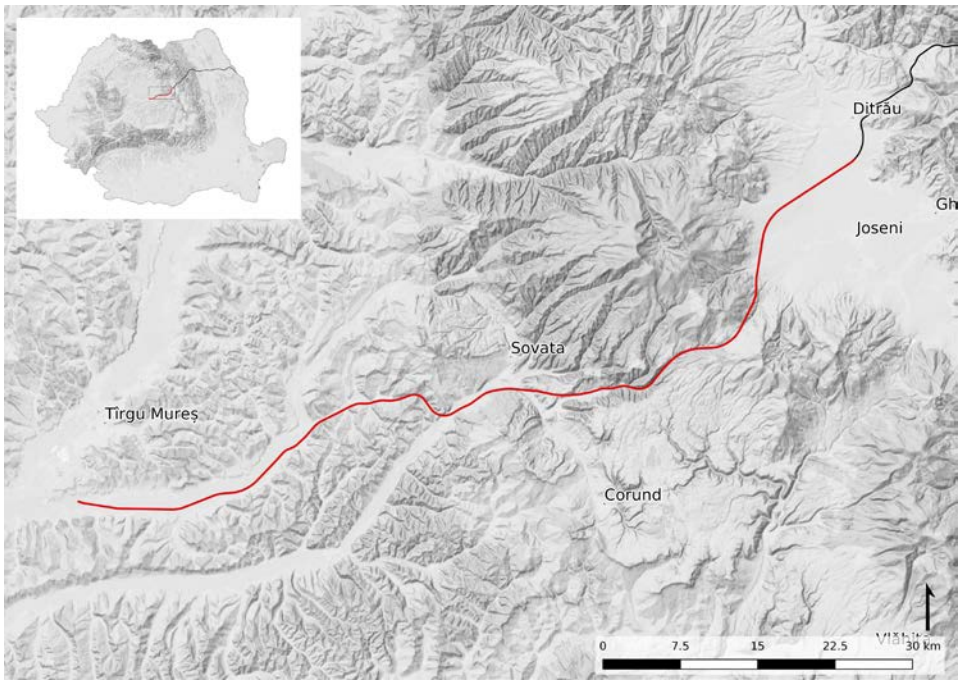
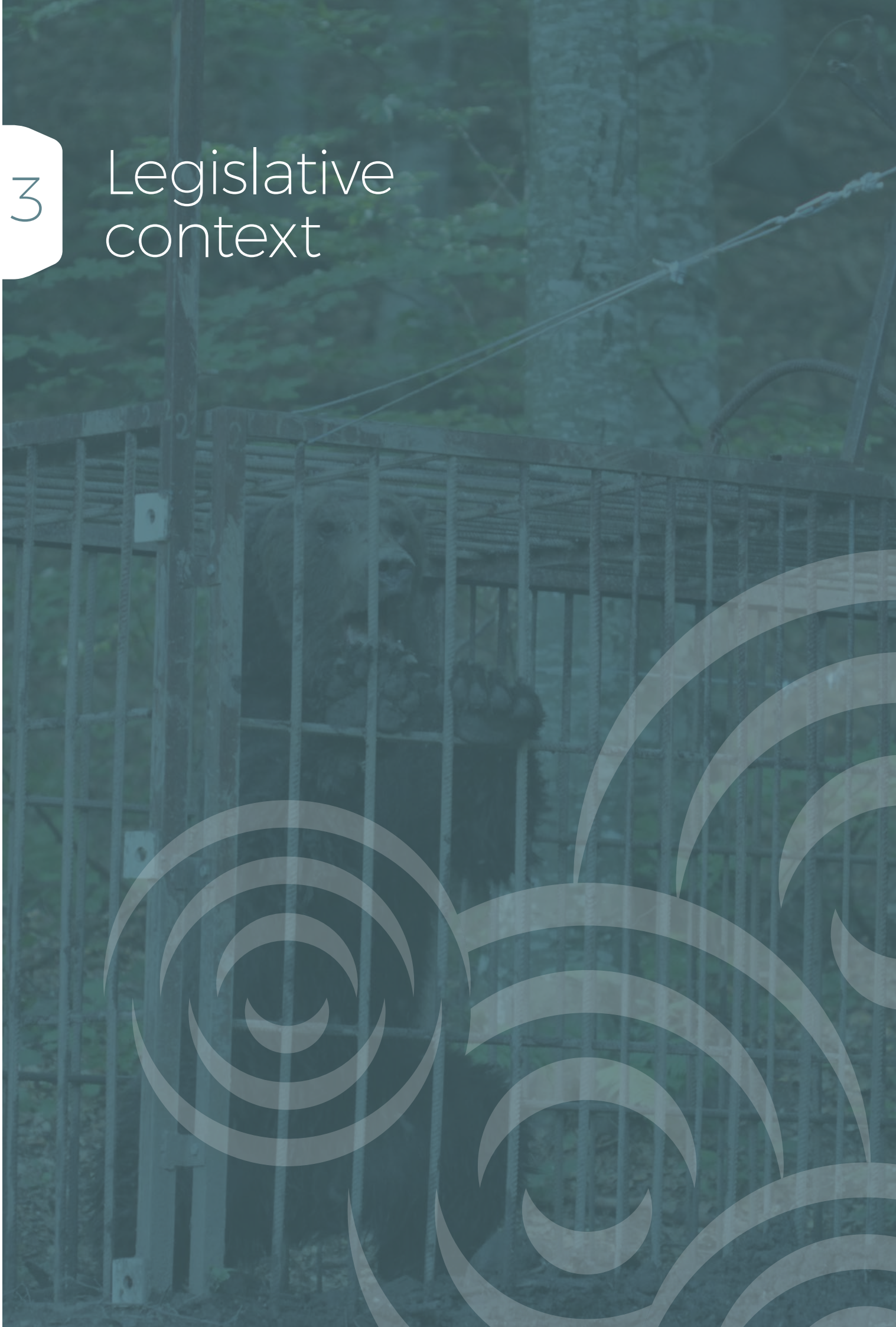


Fig. 1. - The location of Pilot Area 4 within Romania (upper left corner) and detailed map of the Tîrgu Mureș-Ditrău section of the planned Tîrgu Mureș-Iași-Ungheni (A8) planned highway (red line), with major nearby settlements.

The Eastern part of our section of interest intersects an area that is mostly mountainous and includes part of Romania's Eastern Carpathians (the volcanic Gurghiu Mountains in the vicinity of the Bucin pass), respectively part of the Giurgeu basin. This section includes human settlements only in the Giurgeu basin. In this mountainous section, the highway will intersect the administrative territories of a total of 3 localities / parishes: Praid, Joseni and Lăzarea (all situated in Harghita county). The predominant land cover is forest, including deciduous (mainly European beech [*Fagus sylvatica*]), conifer (Norway spruce [*Picea abies*], silver fir [*Abies alba*] and European larch [*Larix decidua*]) and mixed forests. Agriculture also occurs here, most notably in the form of mountain pastures used from late spring to early autumn (May-September), respectively arable fields located in the Giurgeu basin.



3 Legislative context

Romania has significantly improved its environmental performance since its accession in 2007. While Romanian legislation accurately reflects the environmental requirements agreed at EU level, their implementation on the ground is in general a challenge, prompted inter alia by a lack of planning, coordination and appropriate funding[1].

Relevant legislation in terms of nature protection[2]:

- Law no. 5/2000 regarding the planning of the national territorial (section III is dealing with protected areas).
- Emergency Government Ordinance no. 195/2005 for environmental protection, approved weith changes through Law no 245/2006.
- Ministerial Order no. 1338/2008 regarding the procedure for issuing the Natura 2000 permit.
- Emergency Government Ordinance no. 57/2007 regarding the regime of protected areas, conservation of natural habitats and of wild flora and fauna.
- Ministerial Order no. 19/2010 for approving the methodological guidelines on the appropriate assessment of the potential effects of plans and projects on protected areas of community interest.
- Ministerial Order no. 135/2010 for approving the methodology for environmental impact assessments for public and private projects.
- Law no. 137/2010 for ratifying the Protocol on the conservation and sustainable use of biological and landscape diversity, adopted and signed in Bucharest on June 19, 2008, at the Framework Convention on the protection and sustainable development of the Carpathians, adopted in Kiev on May 22, 2003.

Laws for ratifying relevant Conventions and Protocols:

- Law no. 187/1990 for ratifying the Convention on the Protection of World Cultural and Natural Heritage (Paris);
- Law no. 5/1991 for ratifying the Convention on Wetlands of International Importance (RAMSAR).
- Law no. 13/1993 for ratifying the Convention on the Conservation of European Wildlife and Natural Habitats (Bern).
- Law no. 58/1994 for ratifying the Biodiversity Convention (Rio de Janeiro).
- Law no. 69/1994 for ratifying the Convention on the International Trade with Endangered Species (Washington).
- Law no. 13/1998 for ratifying the Convention on the Conservation of Wild Migratory Species (Bonn).
- Law no. 389/2006 for ratifying the Framework Convention on the protection and sustainable development of the Carpathians, adopted in Kiev on May 22, 2003.
- Law no. 137/2010 for ratifying the Protocol on the conservation and sustainable use of biological and landscape diversity, adopted and signed in Bucharest on June 19, 2008, at the Framework Convention on the protection and sustainable development of the Carpathians, adopted in Kiev on May 22, 2003.

Regarding transportation, the Master Plan for Transport in Romania 2030 mentions the need to respect conservation measures in future projects including integrating non-structural and Green Infrastructure measures, and avoiding negative impacts on protected areas, forested areas and non-protected areas where species of community interest are identified, by reconsidering planning of routes. The Territorial Development Strategy of Romania 2035 clearly refers to Green Infrastructure as an efficient way to adapt to climate change and to diminish natural risks compared to physical or grey infrastructure. Specific measures include protecting natural habitats (by ensuring diversity of and interconnectivity between natural areas, particularly in the context of Natural 2000 management) and developing green spaces in urban areas and green belts around major cities[3].

The Transport White Paper 'Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system' (2011) represents the vision of the EU's transport policy for the 2050 time horizon, focusing on the sustainable development of this sector, thereby understanding the need to reduce the environmental impact, the drastic reduction of greenhouse gas emissions with a view to limiting climate change, increasing investment in road infrastructure to support economic growth, fostering geographic accessibility and mobility, increasing social welfare, increasing traffic safety, reducing accidents, increasing the quality of road infrastructure systems (implementing Intelligent Transport Systems – ITS), improving traffic management systems. The White Paper is the basic document on the development of the national policies and strategies of the member states, Romania correlating and integrating the European objectives with the national policies in the strategic document finalized in 2015 - the General Transport Master Plan.

1 http://ec.europa.eu/environment/eir/pdf/factsheet_ro_en.pdf
2 http://www.mmediu.ro/articol/legislatie/433
3 https://biodiversity.europa.eu/countries/gi/romania

4 Stakeholder analysis

4.1. Organizations, institutions and state administration bodies involved in nature conservation and their competencies in the pilot site

MINISTRY OF ENVIRONMENT

Description and competencies: the Ministry of Environment (http://www.mmediu.ro/) establishes the national policy in the fields of environment, fulfilling the role of state authority through synthesis, coordination and control in the environmental fields, directly or through specialized technical bodies, authorities or public institutions under the subordination, coordination or under the authority of the ministry.

MINISTRY OF WATERS AND FORESTS

Description and competencies: the Ministry of Waters and Forests (http://apepaduri.gov.ro/) is active in the following areas: strategic planning, forestry and hunting / wildlife management, water management, hydrology, hydrogeology, protection, conservation and restoration of the natural capital. The Ministry of Waters and Forests coordinates the activity of integrating the requirements of strategic planning, forestry and hunting management, water management, hydrology, hydrogeology into other sectoral policies, in line with European and international requirements and standards.

NATIONAL ENVIRONMENTAL PROTECTION AGENCY

Description and competencies: the National Environmental Protection Agency (http://www-old.anpm.ro/) is the central public administration's specialized institution, with competences in the implementation of policies and legislation in the field of environmental protection. It is subordinated to the Ministry of Environment. Its competences include: strategic environmental planning; monitoring of environmental factors; authorization of activities with an impact on the environment; implementation of environmental legislation and policies at national and regional levels; reporting to the European Environmental Agency on the following: air quality, climate change, protected areas, soil contamination, water.

COUNTY-LEVEL ENVIRONMENTAL PROTECTION AGENCIES

Description and competencies: territorial (county-level) representatives of the Ministry of Environment and of the National Environmental Protection Agency. Their competences include: issuing environmental authorizations and permits; monitoring protected area management; monitoring environmental factors; monitoring of waste and hazardous materials' management; monitoring the implementation of environmental legislation, and more. Our section of interest from the planned Tîrgu Mureș-Iași-Ungheni highway falls under the jurisdiction of the Mureș County-level Environmental Protection Agency, respectively that of the Harghita County-level Environmental Protection Agency.

PROTECTED AREA MANAGERS

Description and competencies: according to the national legislation there were two ways to manage protected areas. The smaller areas could be managed by custodians (on voluntary basis, without obligatory dedicated staff), while the larger areas needed an independent (legally established) administration. Their responsibilities were similar, being obliged by the management contract signed with the Ministry of Environment to safeguard the enforcement of the legislation regarding protected areas. Responsibilities included the formulation of an opinion regarding every development plan or project which may affect the conservation status of the protected areas. This opinion is one of the documents on the basis of which the environmental permit is issued for every project, before its implementation. Our section of interest from the planned highway is intersecting several protected areas, with different management structures. In the recent months the legal framework regarding protected area management has changed. The foreseen changes are significant: as planned by the new framework, the management of every protected area will be overtaken by the National Agency for Protected Natural Areas. The changes foreseen have not been enforced yet.

WILDLIFE MANAGERS (hunting associations and forestry services that also possess hunting rights)

Description and competencies: responsible for one or several wildlife management units (WMUs), for which they have management contracts signed for a pre-established period of the time. Within the WMUs, they are responsible for the monitoring, management and on-the-field, effective protection of wildlife populations, both for game and protected species. In the case of wildlife-vehicle collisions, they are automatically notified (although in reality this doesn't always happen). The employed personnel of local wildlife managers usually possesses in-depth, practical knowledge about animal movements within their WMU(s). Our section of interest from the planned Tg. Mureș-Iași-Ungheni highway will intersect a total of 11 WMUs.

FORESTRY SERVICES (with no hunting rights)

Description and competencies: responsible for the management and on-the-field, effective protection of forest parcels, according to pre-established, long-term forest management plans. On the route of the planned Tîrgu Mureș-Iași-Ungheni highway (and in its vicinity) there are both forest parcels which are not managed by a forestry service (usually small parcels of forest owned by a number of locals, but covering a significant percentage of the future highway, especially on the westernmost section of the highway, between Tîrgu Mureș and Praid) and forest bodies managed by a number of private forestry services, or by the National Forest Administration (ROMSILVA). Besides privately owned forest parcels, a significant percentage of the forests in our area of interest represent the properties of Common Ownership Structures (especially in Harghita County) or are state-owned. The employed personnel of forestry services active in the area sometimes possesses in-depth, practical knowledge about animal movements in their working area.

ENVIRONMENTAL CONSULTANCY COMPANIES

Description and competencies: Environmental Consultancy Companies are important players in the development of each project with a potentially negative impact on the environment. Those possessing a special attestation from the Ministry of Environment, are entitled to develop the Environmental Impact Assessment, or, if necessary, the Strategic Environmental Impact Assessments for projects or plans, under the environmental authorisation procedure. As a result, these companies may have a significant impact on the mitigation of the potential environmental damages a project may cause. Unfortunately, in line with the legislation, these companies are contracted by the direct beneficiaries of the projects, and as a result in many cases no mitigation measures are proposed, which would require significant financial effort from the developers.

NGOs (ENVIRONMENT)

Description and competencies: there is a number of strong environmental NGOs in the country, and despite the fact that they don't have any legal competencies in the environmental sector, these are still important actors, thanks to their opinion-leader and watchdog roles. The most important NGOs involved in nature conservation are working together under the umbrella of the Natura 2000 Coalition, a structure which proved to be quite successful in opposing certain major projects with considerable negative effects for nature. Another important aspect is that nature conservation NGOs are regularly involved in the management of protected areas, including some areas to be intersected by the section of interest of the planned highway. However, this latter role is compromised according to the new, still unenforced legal framework.

4.2. Organizations, institutions and state administration bodies involved in transport infrastructure development, management and their competencies in the pilot site

MINISTRY OF TRANSPORTS

Description and competencies: the Ministry of Transports (http://mt.gov.ro/web14/) is the specialized institution of the central public administration that establishes the transport policy at the national level, elaborates the specific strategies and regulations for the development and harmonization of the transport activities within the general policy of the Government and fulfills the role of state authority in the transportation sector. It does so directly or through specialized technical bodies, subordinated public institutions, units operating under its authority or coordination or through authorized companies.

NATIONAL COMPANY FOR ROAD INFRASTRUCTURE ADMINISTRATION (CNAIR)

Description and competencies: company of strategic national importance (http://www.cnadnr.ro/), functioning under the authority of the Ministry of Transports. Its main responsibilities are the administration, operation, maintenance, modernization and development of the Romanian national road and highway networks (lower category roads, such as county and communal roads, or sections of national roads within localities do not fall under CNAIR's jurisdiction). CNAIR is the main beneficiary of the future Tîrgu Mureș-Iași-Ungheni highway, in all of its phases: planning, building and operation.

INFRASTRUCTURE ENGINEERING COMPANIES

Description and competencies: a limited number of Romanian private companies that are usually contracted to carry out the technical planning of highway segments. These companies provide services of planning, design, consulting and management of transport infrastructure. SEARCH CORPORATION (http://www.searchltd.ro/) was responsible for the technical design of our section of interest from the planned Tîrgu Mureș-Iași-Ungheni highway, respectively for preparing and later, as part of a consortium, updating the Feasibility Study for this section. The technical design was finalized, the Feasibility Study was prepared, but the consortium' s contract was cancelled in early 2018, during the process of updating the Feasibility Study.

NGOs (INFRASTRUCTURE)

Description and competencies: represent civil society and act for improving the transparency and promptness of the development of transport infrastructure in Romania. Probably the most significant infrastructure NGO in Romania is Asociatia Pro Infrastructura (http://www.proinfrastructura.ro/), which operates on the national level. The NGO permanently monitors the major transport infrastructure projects, takes positions and carries out lobby work. Asociatia Pro Infrastructura is also very interested in the planned Tîrgu Mureș-Iași-Ungheni highway.

4.3. Organizations, institutions and state administration bodies involved in spatial planning and their competencies in the pilot size

COUNTY-LEVEL AUTHORITIES (County Councils)

Description and competencies: the authority of the local public administration in Romania, established at the county level, for the coordination of the activity of municipal and town councils, in order to provide public services of county interest. Among the attributions of the county council are the establishment of county taxes and fees, the elaboration of economic and social development programs, respectively spatial planning programs. These latter fall under the jurisdiction of a specialized department under each County Council. The Tîrgu Mureș-Ditrău section of the planned Tîrgu Mureș-Iași-Ungheni highway will intersect the administrative territories of 2 counties: Mureș and Harghita.

LOCAL PUBLIC AUTHORITIES (Mayor's Offices, Local Councils)

Description and competencies: representatives of the local communities living on and in the vicinity of the Westernmost section of the route of the planned Tîrgu Mureș-Iași-Ungheni highway. Lowest tier of administration within Romania, acting within powers delegated by legislation or directives of the higher level of government. Decisions taken and implemented by local public authorities are restricted to the administrative level of a parish (small number of villages), town, city or municipality. Representatives of the local public authorities generally show little or no interest to the threats posed by the planned highway to natural habitats or wildlife - e.g. alteration and fragmentation (possible exceptions include local officials who are also hunters, for example). However, they are highly susceptible to environmental hazards represented by the future infrastructure (for example, pollution of the drinking water source for a community by the usage of salt on the highway during the winter; emissions associated to vehicular traffic; noise pollution close to or within localities), possible changes in land use practices on the local level (for example, small parcels of agricultural land abandoned because the owner has to take a long detour due to the highway), or possible negative economic impacts on the local level (for example, bankruptcy of small local shops, because the highway detours traffic). The Tîrgu Mureș-Ditrău section of the planned Tîrgu Mureș-Iași-Ungheni highway will intersect the administrative territories of a total of 13 localities / parishes, each represented by independent local public authorities.

4.4. Other stakeholders

MICRO REGIONAL ASSOCIATIONS (NGOs)

Description and competencies: Micro-regional Associations are NGOs created by local public authorities of a certain region. In the project area these were established by authorities clustered in different river catchment basins. The associations from the project area in particular have been created as Local Action Groups under the LEADER program, which is implemented under the national Rural Development Program (RDPs) and is co-financed from the European Agricultural Fund for Rural Development (EAFRD). Nevertheless, at the moment the micro-regional associations can be considered a working, informal network of the local authorities, and decisions taken on this level may reflect in the following, legally binding decisions on the local administrative level. As a result, the micro-regional associations are an ideal fora to raise and discuss, for example environmental issues related to infrastructure development, simultaneously with relevant decision makers from several parishes.

COMMON OWNERSHIP STRUCTURES

Description and competencies: historical form of social venture, characteristic for regions with a Hungarian ethnic majority. On the Westernmost section of the route of the planned Tîrgu Mureș-Iași-Ungheni highway, especially in Harghita County, Common Ownership Structures own extended amounts of land (mainly forests, haymaking fields and pastures). In the case of Common Ownership Structures (although possessing more significant amounts of land and being more organized than individual land owners), the process will likely be similar, with these institutions also simply settling for a high as possible compensation following the expropriation process. In consequence, these structures will most likely have little competencies in the planning, building and operating of the future highway.

LOCAL COMMUNITIES

Description and competencies: locals living on and in the vicinity of the route of the planned Tîrgu Mureș-Iași-Ungheni highway, Westernmost section. They are represented by the Local public authorities (Mayor's Offices, Local Councils). Local communities generally show little or no interest to the threats posed by the planned highway to natural habitats or wildlife - e.g. alteration and fragmentation. However, they are highly susceptible to environmental hazards represented by the future infrastructure (for example, pollution of the drinking water source for a community by the usage of salt on the highway during the winter; emissions associated to vehicular traffic; noise pollution close to or within localities), possible changes in land use practices on the local level (for example, small parcels of agricultural land abandoned because the owner has to take a long detour due to the highway), or possible negative economic impacts on the local level (for example, bankruptcy of small local shops, because the highway detours traffic). Still, considering that in Romania active participation of local communities in the decision making process does not have a long history, local communities will be somewhat reluctant to be actively involved, in an organized way. Thus, most likely, they will have little to say in the process.

INDIVIDUAL LAND OWNERS

Description and competencies: owners of parcels of forests, haymaking fields, pastures or crop fields on the route of the planned Tîrgu Mureș-Iași-Ungheni highway, Westernmost section. Individual land owners will probably have little competencies in the planning, building and operating of the future highway. These parcels will be expropriated with a pre-established compensation paid to the owners and the numerous, but unorganized small owners will likely have nothing or very little to say in the process. As the expropriation process is ultimately inevitable, their main concern will be to receive the highest possible compensations for their properties.

GENERAL PUBLIC

Description and competencies: in Romania, mostly due to the constant attention the mass-media is paying to the subject, the general public is quite aware and well informed on the status of the various highway projects. Especially in the historical region of Moldavia, the general feeling (fueled by the negative tone of mass-media coverages) is that investments in big transport infrastructure projects are missing and that there is no political will to improve the area's connection to the other regions of Romania (especially towards the West - e.g. the planned Tîrgu Mureș-Iași-Ungheni highway).

MASS-MEDIA

Description and competencies: in recent years, the issue of transport infrastructure development has received permanent and extensive coverage in the Romanian mass-media. The stages of the various highway (building) projects were constantly monitored by journalists, who than drew attention to failed political promises, inefficient processes and deadlines that were not kept. With the negative stories by far outweighing positive ones, the mass-media has managed to sensitize the general public to the issue.

5 Status of the road and railway network development in the pilot area

5.1. Existing transport infrastructure

The Tîrgu Mureș-Ditrău section of the planned Tîrgu Mureș-Iași-Ungheni (A8) highway will intersect an area with no other highways or express roads. The existing road infrastructure in the vicinity of the planned segment (Fig. 2., vicinity means the inside of the rectangle drawn around the section of interest) consists of:

- national roads (class I, managed by the National Company for Road Infrastructure administration [CNAIR]), with a density of 0.056 km / km^2
- county-level roads (class II, managed by the County Councils - e.g. Mureș and Harghita County Councils), with a density of 0.39 km / km^2
- communal roads, including forestry roads (class III, managed by the local authorities, forestry services, etc.), with a density of 0.11 km / km^2. However, in reality, the density of communal roads should be somewhat higher, as at least some forestry roads in the area are not included in existing GIS datasets.

The current capacity of the existing road infrastructure in Pilot Area 4 (or, more broadly, on the Tîrgu Mureș-Iași-Ungheni axis) is judged to be insufficient by Romanian transportation planners. According to the General Transport Master Plan, the main justification for the planned investment (e.g. the planned Tîrgu Mureș-Iași-Ungheni highway, on its entire length) is represented by poor average travel times, as typical average speeds for this route are around 61 km/h. Also, the bulk of the infrastructure provision in the corridor is poor – 100% of the route is only single carriageway standard.

5.2. Planned transport infrastructure

In general, there is little or no information available on planned roads (I-III. class) in Pilot Area 4. It is unlikely that in the nearby future any new national roads (class I) will be created in the area. A number of county-level roads (class II) that are currently

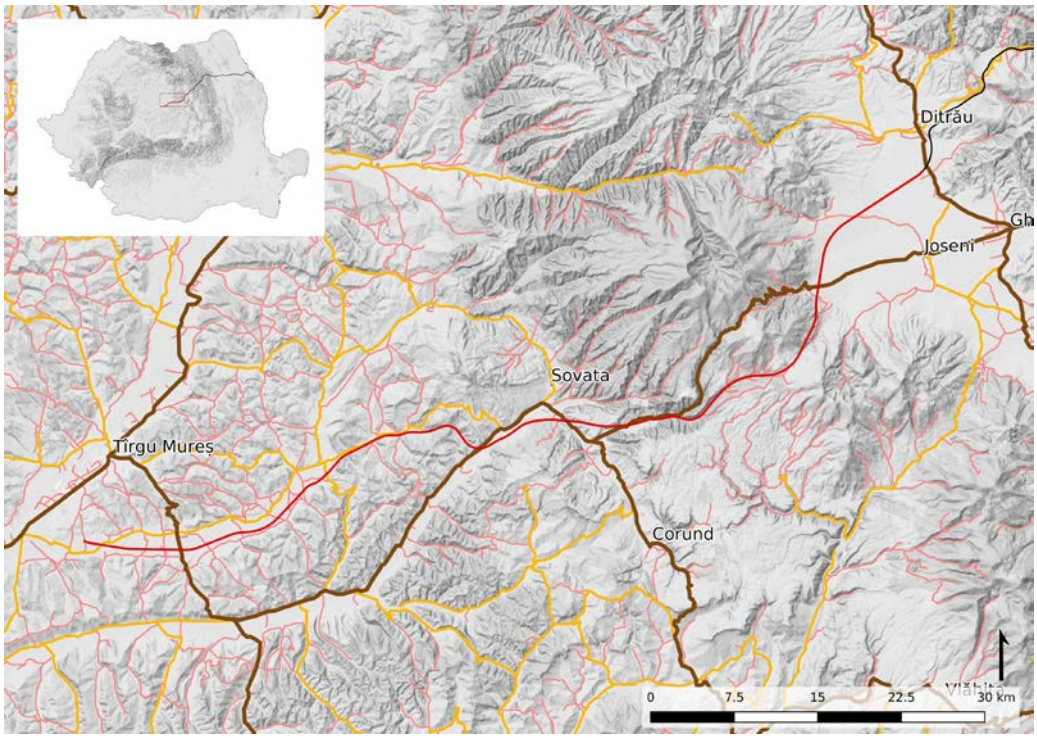


Fig.2. - The Tîrgu Mureș-Ditrău section of the planned highway (red line) and existing adjacent road infrastructure: national roads (brown), county-level roads (orange), respectively communal roads (pink).

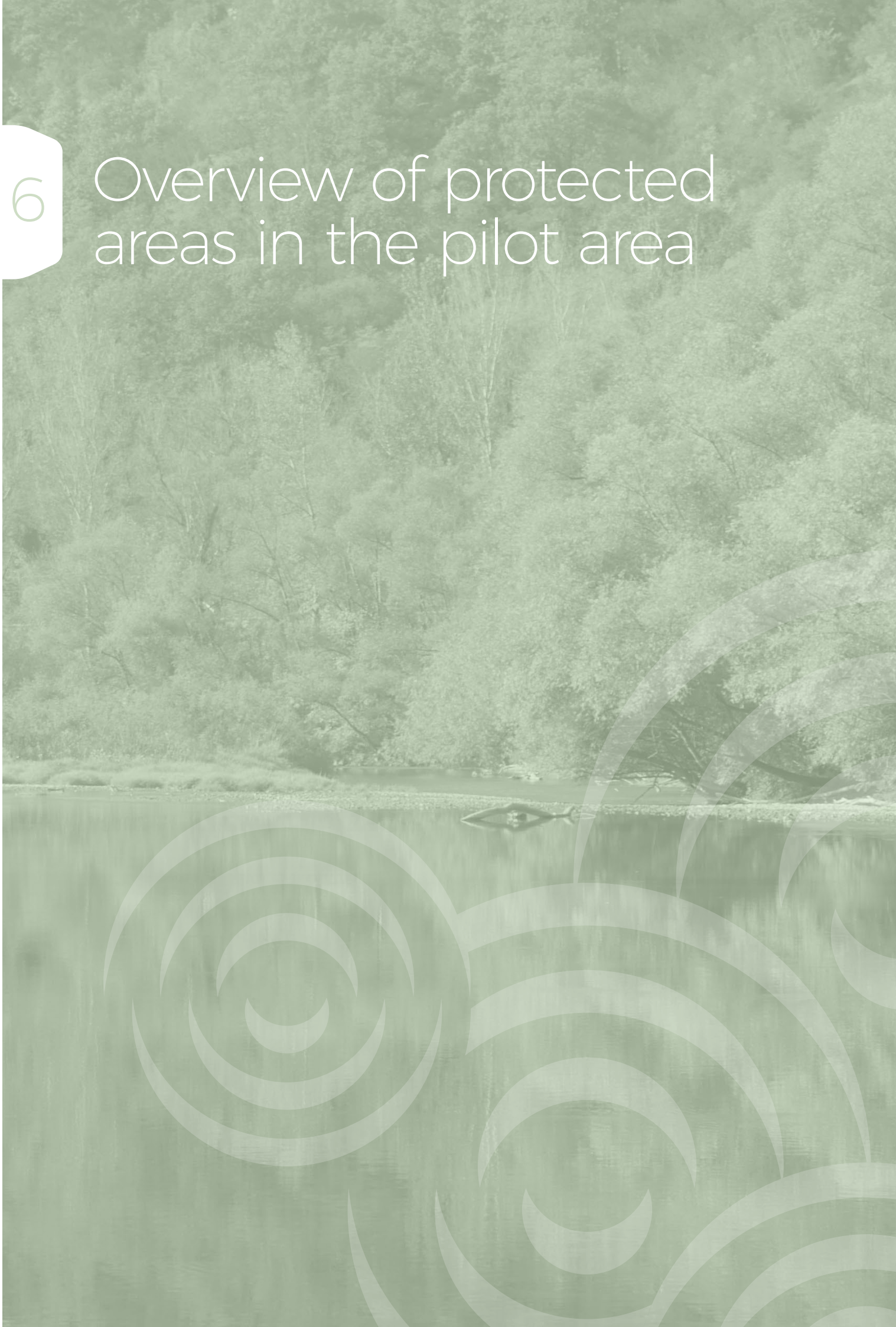
unpaved and thus inaccessible for significant periods of the year - except for 4WD vehicles - will be modernized (paved) in the nearby future. Both the Mureș County Council and the Harghita County Council have such renovations planned, mostly through EU funding.

By far the most significant planned transport infrastructure in Pilot Area 4 is the planned Tîrgu Mureș-Iași-Ungheni (A8) highway, more precisely, the Tîrgu Mureș-Ditrău section of the planned highway. In March 2012, the European Commission has accepted to include the proposed route into the TEN-T Core network. According to the Annex of Romania's General Transport Master Plan (August 2016), this investment is predicted to have a total cost of 1,215.95 million Euros. According to the interactive map on the website of the Ministry of Transports (http://mtransporturi.maps.arcgis.com/apps/webappviewer/index.html?id=4e84b8ff37de48c6a001c0bae9974693), this highway is to be finalized in the period 2021-2026. According to the Revised Final Report on the Master Plan Short, Medium and Long Term from September 2014 (https://www.izvoznookno.si/Dokumenti/14_10_08_Master_Plan_Report_EN.pdf unavailable on the Ministry of Transport's own website), the investment is planned to be finalized in the period 2021-2030.

According to modeling predictions, the planned highway would have an annual average daily traffic (AADT) of 31,000 vehicles. Also according to the General Transport Master Plan, the new infrastructure would draw in over half of the existing traffic in the immediate corridor (6,000 AADT; Fig. 3). Average speeds are predicted to increase to 100 km/h, and peak time journey times are predicted to be reduced by 42%. The planned A8 highway should link the Romanian A3 highway (near Tîrgu Mureș) to the Pan-European Transport Corridor IX (Helsinki - Vyborg - St. Petersburg - Pskov - Gomel - Kiev - Liubashivka - Chisinau - Bucharest - Dimitrovgrad - Alexandroupolis). On the mid- and long term, the A8 highway is envisioned to attract a significant part of the transit traffic between the Pan-European Transport Corridors IX and IV (Dresden/Nuremberg - Prague - Vienna - Bratislava - Gyor - Budapest - Arad - Bucharest - Constanța / Craiova - Sofia - Thessaloniki / Plovdiv - Istanbul).

Pre-feasibility studies performed in 2007 were followed by feasibility studies in 2010. As the documentation has not been utilized in the meanwhile, on May 20, 2015 the National Company for Road Infrastructure Administration (CNAIR) has contracted private contractors (AECOM INGENIERIA SRL – CONSITRANS SRL – SEARCH CORPORATION SRL) for the revision and update of the Feasibility Study for the Tîrgu Mureș-Ditrău section of the planned highway. According to CNAIR (http://www.cnadnr.ro/ro/proiecte/autostrazi-pregatire), following a report by the Court of Auditors and a subsequent start of investigation by the National Anticorruption Directorate (DNA), on December 20, 2016 the contract was suspended and on January 19, 2018 the contract was terminated. CNAIR has promised that a bid for the completion of the technical documentation for this section will be launched in July 2018.

Fig. 3. - Predicted traffic flow changes after the finalization of the planned Tg. Mureș-Iași-Ungheni (A8) highway. Source: General Transport Master Plan of Romania.



6 Overview of protected areas in the pilot area

6.1. Overview of areas protected on the national level

The Tîrgu Mureș-Ditrău section of the planned Tîrgu Mureș-Iași-Ungheni highway will pass in the vicinity of a number of nationally protected areas, but will not intersect any of these (Fig. 4.). Nationally protected areas in the relative vicinity of our section of interest include: RONPA0645 Padurea Mociar, RONPA0890 Seaca, RONPA0654 Poiana cu narcise Gurghiu, RONPA0478 Dealul Melcului, RONPA0653 Lacul Ursul si arboretele de pe saraturi, RONPA0657 Stejarii seculari de la Sangeorgiu de Mureș, RONPA0488 Mlastina cea Mare, RONPA0486 Piemontul Nyires, RONPA0475 Muntele de sare Praid and RONPA0648 Lacul Faragau.

There are no national parks, nature parks or protected landscape areas (IUCN categories II and V) on the route, or in the immediate vicinity of this section of the planned highway.

6.2. Overview of areas protected on the international level

The Tîrgu Mureș-Ditrău section of the planned Tîrgu Mureș-Iași-Ungheni highway will intersect, respectively pass in the vicinity of a number of internationally protected areas, namely Natura 2000 sites (Fig. 5. and 6.). There are no other categories of international protected areas (e.g. Biosphere reserves or Ramsar sites) on the route or in the immediate vicinity of this section of the planned highway.

Our section of interest will intersect a total of 4 Natura sites: 2 Special Protection Areas (SPAs), designated on the basis of Council Directive 2009/147/EC on the conservation of wild birds (Birds Directive), respectively 2 Sites of Community Interest (SCIs), designated on the basis of Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora (Habitats Directive). A total of 53.49 km (58.08 %) of this section of the planned highway will pass through at least one or sometimes several overlapping Natura 2000 sites, as follows (from West to East):

- ROSPA0028 Dealurile Tarnavelor-Valea Nirajului (on a length of 33.7 km)
- ROSCI0297 Dealurile Tarnavei Mici–Biches (on a length of 22.8 km)
- ROSPA0033 Depresiunea si Muntii Giurgeului (on a length of 12.36 km)
- ROSCI 0279 Borzont (on a length of 0.84 km)

Of the Natura 2000 sites to be intersected by our section of interest of the planned highway, the Standard Data Form (SDF) of ROSCI0297 Dealurile Tarnavei Mici–Biches explicitly mentions the planned A8 highway as a threat.

Another SPA in the relative vicinity of the section of interest of the planned highway (Fig. 5.) is ROSPA0034 Depresiunea si Muntii Ciucului. Other SCIs in the relative vicinity of the section of interest of the planned highway (Fig. 6.) include: ROSCI0154 Padurea Glodeni, ROSCI0244 Tinovul de la Fantana BrazilorROSCI0243 Tinovul de la Dealul Albinelor, ROSCI0019 Calimani-Gurghiu, ROSCI0090 Harghita Madaras, ROSCI0342 Padurea Tîrgu Mureș, ROSCI0369 Raul Mureș intre Iernuteni si Peris, ROSCI0320 Mociar and ROSCI0100 Lacurile Faragau-Glodeni,

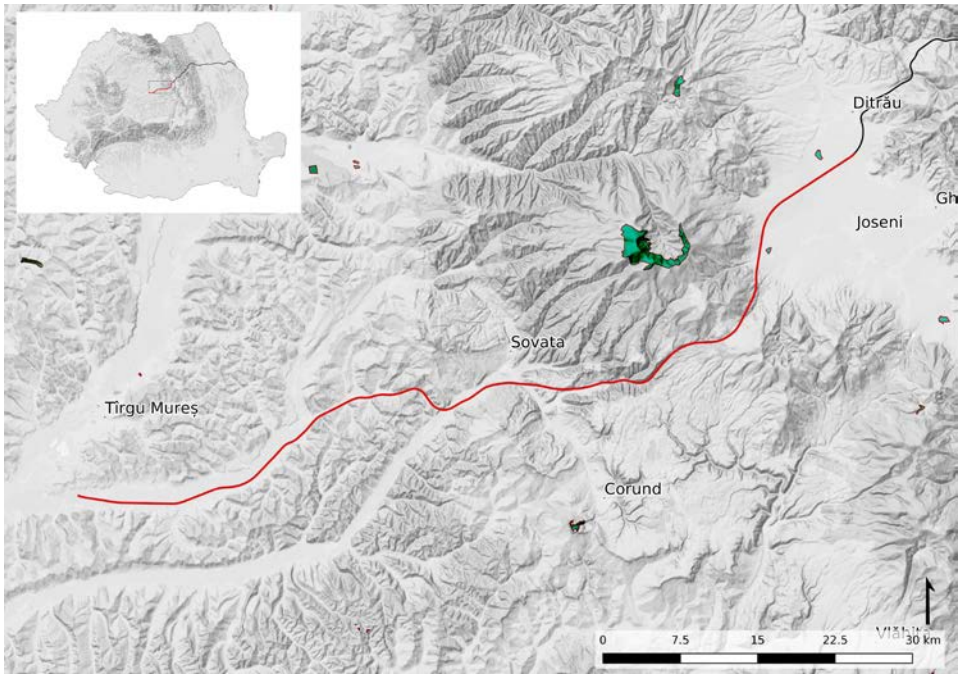


Fig.4. - The Tîrgu Mureș-Ditrău section of the planned highway (red line) and local protected areas (bluish areas). Some of these are very small and thus invisible at this scale.

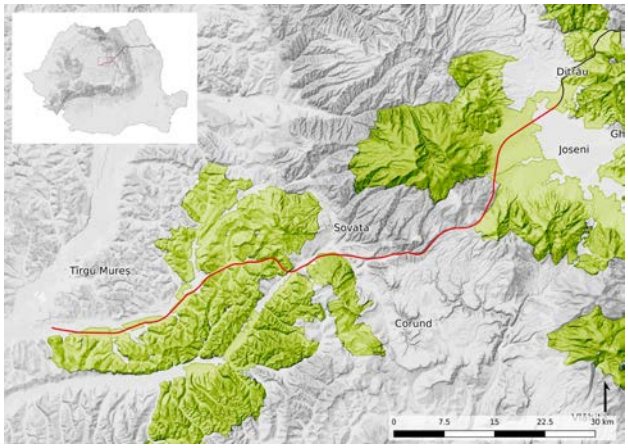


Fig. 5. - The Tîrgu Mureș-Ditrău section of the planned highway (red line), intersecting a total of 2 SPAs (green areas)

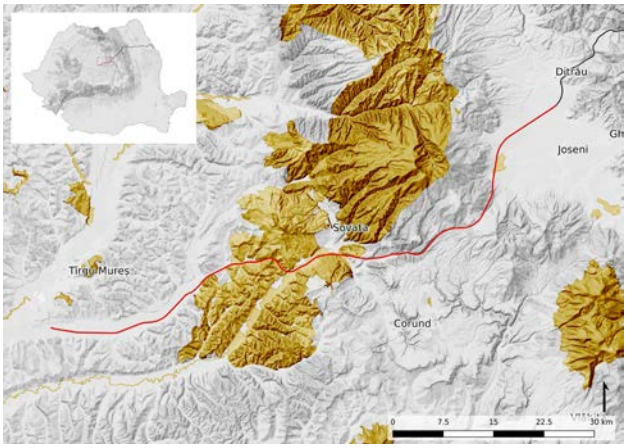


Fig. 6. - The Tîrgu Mureș-Ditrău section of the planned highway (red line), intersecting a total of 2 SCIs (brown areas)

6.3. Biodiversity of the pilot area

Species present in the Natura 2000 sites that will be intersected by the Tîrgu Mureș-Ditrău section of the planned Tîrgu Mureș-Iași-Ungheni highway (and elsewhere along the planned route) and likely to be negatively affected by the future infrastructure are, as follows:

MAMMALS listed in Annex II of Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora (Habitats Directive)	
Large carnivores	brown bear (*Ursus arctos*), grey wolf (*Canis lupus*), Eurasian lynx (*Lynx lynx*)
Bats	greater mouse-eared bat (*Myotis myotis*), lesser mouse-eared bat (*Myotis blythii*), lesser horseshoe bat (*Rhinolophus hipposideros*), barbastelle (*Barbastella barbastellus*)
Other	Eurasian otter (*Lutra lutra*)
OTHER MAMMALS (not listed in Annex II of the Habitats Directive)	
Ungulates	red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*), wild boar (*Sus scrofa*)
Mesocarnivores	European wildcat (*Felis silvestris*), European badger (*Meles meles*), red fox (*Vulpes vulpes*), beech marten (*Martes foina*), European pine marten (*Martes martes*)
AMPHIBIANS and REPTILES listed in Annex II of Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora (Habitats Directive)	
Amphibians and reptiles	great crested newt (*Triturus cristatus*), smooth newt (*Lissotriton vulgaris ampelensis*), yellow-bellied toad (*Bombina variegata*), red-bellied toad (*Bombina bombina*), European pond turtle (*Emys orbicularis*)
OTHER AMPHIBIANS AND REPTILES (not listed in Annex II of the Habitats Directive)	
Amphibians and reptiles	fire salamander (*Salamandra salamandra*), common toad (*Bufo bufo*), green toad (*Bufotes viridis*), common spadefoot (*Pelobates fuscus*), European tree frog (*Hyla arborea*), common frog (*Rana temporaria*), agile frog (*Rana dalmatina*), marsh frog (*Pelophylax ridibundus*), green lizard (*Lacerta viridis*), sand lizard (*Lacerta agilis*), common lizard (*Zootoca vivipara*), slow-worm (*Anguis colchica*), Aesculapian snake (*Zamenis longissimus*), grass snake (*Natrix natrix*), smooth snake (*Coronella austriaca*), adder (*Vipera berus*).

FISH listed in Annex II of Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora (Habitats Directive)	
Fish	southern barbel (*Barbus meridionalis*), Amur bitterling (*Rhodeus sericeus amarus*), golden spined loach (*Sabanejewia aurata*)
BIRDS referred to in Article 4 of Council Directive 2009/147/EC on the conservation of wild birds (Birds Directive)	
Birds	northern goshawk (*Accipiter gentilis*), Eurasian sparrowhawk (*Accipiter nisus*), boreal owl (*Aegolius funereus*), common kingfisher (*Alcedo atthis*), mallard (*Anas platyrhynchos*), tawny pipit (*Anthus campestris*), meadow pipit (*Anthus pratensis*), golden eagle (*Aquila chrysaetos*), lesser spotted eagle (*Aquila pomarina*), short-eared owl (*Asio flammeus*), long-eared owl (*Asio otus*), Bohemian waxwing (*Bombycilla garrulus*), hazel grouse (*Tetrastes bonasia*), Eurasian eagle-owl (*Bubo bubo*), common buzzard (*Buteo buteo*), rough-legged buzzard (*Buteo lagopus*), long-legged buzzard (*Buteo rufinus*), European nightjar (*Caprimulgus europaeus*), whiskered tern (*Chlidonias hybrida*), white stork (*Ciconia ciconia*), black stork (*Ciconia nigra*), short-toed snake eagle (*Circaetus gallicus*), western marsh harrier (*Circus aeruginosus*), hen harrier (*Circus cyaneus*), Montagu's harrier (*Circus pygargus*), stock dove (*Columba oenas*), corncrake (*Crex crex*), white-backed woodpecker (*Dendrocopos leucotos*), middle spotted woodpecker (*Dendrocopos medius*), Syrian woodpecker (*Dendrocopos syriacus*), black woodpecker (*Dryocopus martius*), great egret (*Ardea alba*), ortolan (*Emberiza hortulana*), Merlin (*Falco columbarius*), peregrine falcon (*Falco peregrinus*), Eurasian hobby (Falco subbuteo), common kestrel (Falco tinnunculus), collared flycatcher (*Ficedula albicollis*), red-breasted flycatcher (*Ficedula parva*), Eurasian pygmy owl (*Glaucidium passerinum*), booted eagle (*Hieraaetus pennatus*), common little bittern (*Ixobrychus minutus*), Eurasian wryneck (*Jynx torquilla*), red-backed shrike (*Lanius collurio*), northern shrike (*Lanius excubitor*), lesser grey shrike (*Lanius minor*), wood lark (*Lullula arborea*), European bee-eater (*Merops apiaster*), black-crowned night heron (*Nycticorax nycticorax*), grey partridge (*Perdix perdix*), European honey buzzard (*Pernis apivorus*), ruff (*Calidris pugnax*), three-toed woodpecker (*Picoides tridactylus*), grey-headed woodpecker (*Picus canus*), Ural owl (*Strix uralensis*), barred warbler (*Sylvia nisoria*), western capercaillie (*Tetrao urogallus*), wood sandpiper (*Tringa glareola*), Eurasian hoopoe (*Upupa epops*)

6.4. Typical species which could be affected by transport infrastructure[4]

Arthropods

Arthropods of different life cycles are susceptible to the influence of traffic to various extents. Traffic can cause considerable damage to insect populations that fly in a short period of time in great numbers over roads. Such are, primarily during swarm, some bees, or some beetles. Several nocturnal and diurnal butterflies are also threatened. Diurnal species are much more endangered by traffic than nocturnal ones. As opposed to swarming behaviour (limited only to a short period of the year), arthropods whose feeding and dwelling habitats are divided by roads, are restricted or ravaged by traffic during nearly the whole vegetation period. Similarly, aquatic beetles are also in danger, owing to nocturnal dispersion swarm characteristics. As they cannot differentiate between water surface and the similarly glittering wet road surface, they might land on the roads and fly away with difficulty. This way enormous numbers can be killed by traffic.

Carnivorous or necrophagous protected carabids may also fall victim to road traffic, as they feed on the carcass of previously run-over animals lying on roads. Distinction must be made between good flyers (hymenopterans, dragonflies) and poor, slow, straight flyers (beetles, butterflies), the latter group being much more vulnerable. Beside the direct impacts, bare road surfaces stretching long distances can cause the fragmentation of populations too. Studies have shown that road-like objects deter some insect species from trying to fly over. This phenomenon is caused by the ecophysiological properties of roads, completely different from the habit and microclimate of the surrounding environment. As a result, gene-flow among the subpopulations becomes highly restricted or even ceased, which may cause their genetic impoverishment and finally extinction. The majority of wild bee species use various habitat fragments (hive habitat, feeding habitat, nesting material collecting habitat), which, if separated by roads can cause the decline of the given Hymenoptera population.

Amphibians

Several works prove that road traffic drastically decreases the abundance of amphibian populations. The reason is that most amphibians

4 from Pallag (2000). For more information, including detailed references, please consult the original document. This subchapter is not exhaustive, as it doesn't deal with large carnivores, plant species, or the issue of the potential spread of invasive species.

have different habitats for mating, overwintering and feeding. Fire salamanders, newts and frogs, waking up from hibernation in spring start migrating to small or large ponds to mate and lay their eggs. Should this migration route be crossed by a road, as much as 70–90% of the population may be destroyed under car wheels. The influence of roads on amphibians is species specific. The number of perishing individuals basically depends on the daily activity and migration speed of the given species compared to the density of vehicles and the width of road surface. The daily distribution of traffic is equally important. At roads where traffic is evenly distributed in time, the daily activity pattern is less important. The migration speed of species has a more prominent role in the survival of a given individual in these cases, than does the intensity of traffic. Another complicating factor is that the majority of frog species (e.g. toads) were found to behave in a different way on road surfaces, than on natural ground in the herb layer. Roads, having a higher temperature than the surroundings, coupled with better sight conditions, make frogs pause and linger on the roads for long. Being cold-blooded animals, frogs are very keen on staying on the warm surface of roads and furthermore males are more likely to catch sight of females approaching ponds. At a certain level of traffic intensity the number of adult amphibians drops so drastically, that the number of eggs laid will be lower than if eaten by predators. Consequently – although some specimens manage to survive the slaughter of traffic and even reproduce – the survival of the population becomes uncertain. Vulnerability depends on the migration features, avoiding strategy, and population size of the species. Slow-moving animals that migrate in concentrated, large masses are most prone to danger. Such species are the common and green toad, the spadefoot toad, to a lesser extent the fire salamander, the crested newt, the European treefrog, the agile frog and the common frog. Amphibian larvae become small frogs in July and August and leave the water to migrate to their feeding and overwintering habitats. Although this migration is less intense than in spring, the number of animals can be many times more than that of adults migrating in the mating season.

Reptiles

Traffic has been found to be less dangerous for reptiles than for amphibians. One reason is that reptiles do not migrate in masses and besides, their populations are usually smaller. Another reason is that most reptiles – principally lizards – have a more effective avoiding strategy. Still, a lot of tortoises (European pond turtle) and lizards fall victim to traffic. The explanation lies in the fact that native reptiles are all diurnal, so high intensity daily traffic can cause considerable damage to their populations. The European pond turtle is outstandingly endangered, as it lives in freshwater but lays its eggs far from the water in sand or loess. The distance covered can be the order of a kilometre. Beside being slow moving, the European pond turtle is vulnerable also because of its poor defensive strategy (the animals retreat into their shell in case of danger). The young hatching from the eggs at the end of summer start migrating to the water nearly at the same time in great numbers. Traffic can cause considerable damages to a population in this case. Altogether there are two highly dangerous periods in the vegetative season of turtles. For similar reasons, but to a lesser extent, some snake species are also threatened: the Aesculapian snake, the smooth snake, and the grass snake. Reptiles – primarily lizards and snakes – often creep to road verges or even onto the asphalt in order to warm themselves on the road surface which is hotter than the surrounding areas. These shrubby roadsides are often the most popular territories for some lizards. Large amount of lizards fall victim to the drifting force of fast vehicles. The greatest threat for reptiles, just like for other animal taxa, is the habitat segregation effect of roads especially for endangered species with small population sizes. As a result of road construction the water supply of the nearby fens is also at risk.

Birds

The endangering effects of traffic on birds are principally direct, caused mainly by running over. Certain bird species are attracted by roads and get more often knocked down by cars. Seed-eating or granivorous birds may feed on grains fallen from cereal transporting lorries. Insectivorous shrikes and small predators that chase small birds alerted by traffic often choose fences and other erect objects along roads as their watching places. Red-footed falcons are often seen sitting on posts along roads as they look for orthopterans over the roads. Buzzards are also frequently found in winter sitting on the tip of lamp posts, watching small mammals. Although the above species are very good flyers, they frequently get run over by the modern fast and silent vehicles. However, more birds die by electric shocking during landing, sitting or flying through electric infrastructures (poles and wires). After road constructions borrow pits filled with water are often left behind, which usually increase biodiversity. However, water birds (ducks, grebes, waders) are at risk due to the proximity of roads. Heavy traffic roads might cross the flight route of bird species that nest in the wayside shrubby vegetation. In such cases even flocks of birds may be knocked down. Species that nest on the ground and fly low and slowly (partridges, pheasants) are also endangered by traffic. The probability of road kills greatly depends on the speed of vehicles. Birds

have generally been observed to be incapable of avoiding cars travelling faster than 70–80 km/h. Thus, each type or section of road that carries cars running at a speed higher than this means a potential threat to birds.

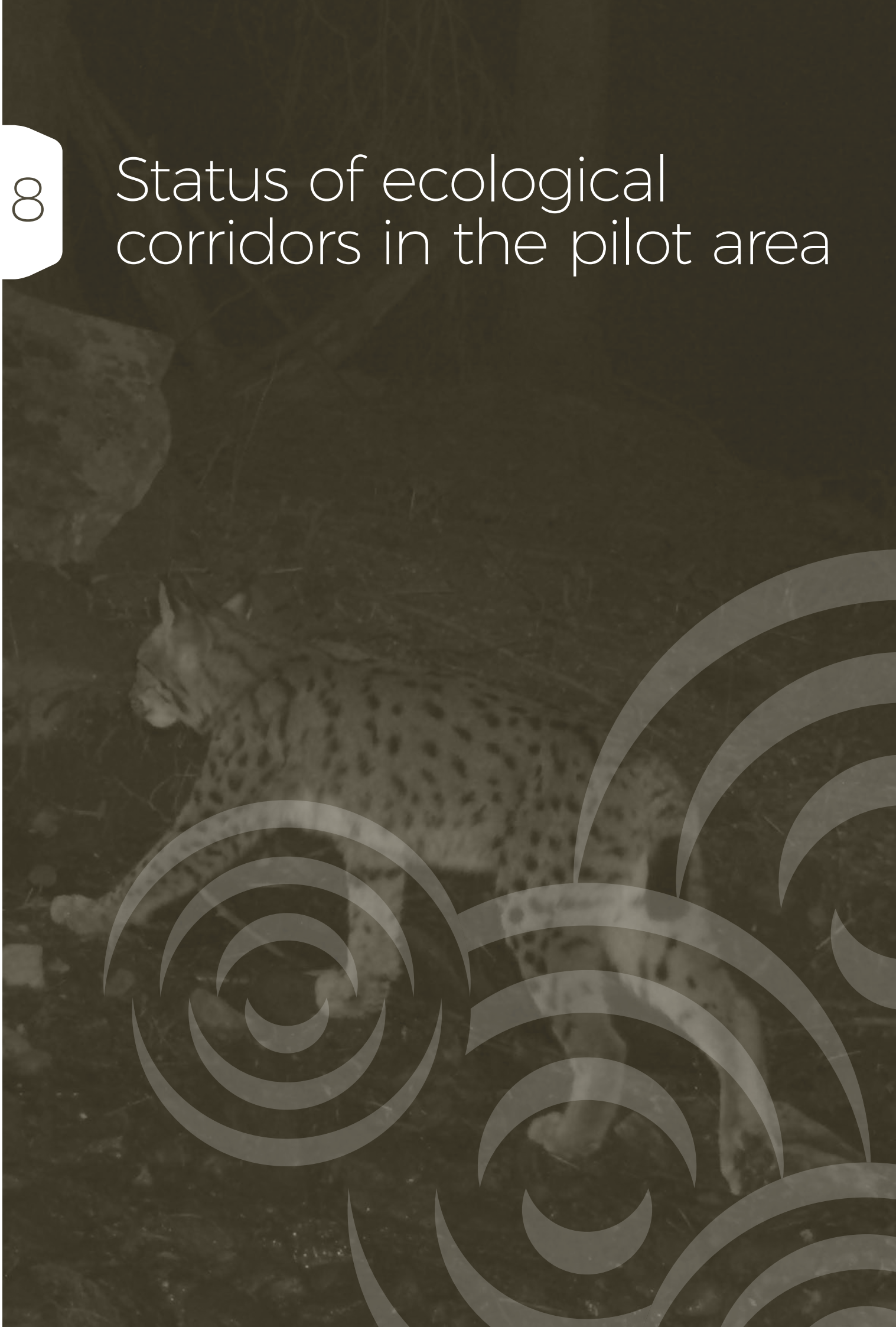
Mammals

When discussing the effects of roads on mammals, distinction should be made between small mammals and larger game. The first group is less visible and has a poor avoiding strategy, while the latter has a more complex avoiding strategy and may even be potentially dangerous for passengers. Among small mammals, principally those feeding on animals or plants near roads are endangered by the direct effects of roads. The nocturnal Eastern hedgehog, some shrew species or the common hamster, may all feed on the carcass of run-over animals. Hamsters, however, mainly collect grains fallen on the road surfaces, as do voles and mice. The habitat fragmentation effect of roads primarily affects animals that avoid bare surfaces. Such mammals are the dormouse species and the water shrews. Bats can also frequently get run over at dusk by vehicles of high speed. Wire-fences generally used in along highways are not suitable for the protection of small mammals either, as the animals easily climb through or over them. Frog-tunnels, however, are frequently used by mice and voles. Driving fences, on the other hand, are too low and do not hinder these mammals from climbing or jumping over onto the road surface. Considering game run-over, roads leading through habitats permanently or temporarily used by large populations are especially crucial. Such permanent habitats are extensive, contiguous woodlands and natural grasslands. Agricultural fields (maize, rape, cereals, etc.) may serve as temporary habitats for great numbers of game.

7. Existing planning and strategic documents

Land use plans are generally unavailable for Pilot Area 4. However, the most relevant document from the point of view of potential landscape fragmentation is the Romanian Transport Master Plan. For more details, please consult Subchapter 5.2 Planned transport infrastructure.

8 Status of ecological corridors in the pilot area



8.1. Role and importance of ecological corridors[5]

Habitat loss and fragmentation are among the most pervasive threats to the conservation of biological diversity. Habitat fragmentation often leads to the isolation of small populations, which have higher extinction rates. Ultimately, the processes of isolation and population extinction lead to a reduction in biological diversity. Concern for this loss has motivated conservation biologists to discuss the actions that are needed to increase the effective size of local populations. Predominant among these possible strategies has been the recommendation that corridors be included in conservation plans to increase the connectivity of otherwise isolated patches. This strategy was motivated by theoretical and empirical observations demonstrating that increased interchange of individuals among populations may increase local and regional population persistence, particularly for small, isolated populations. The importance of such interchange in both reducing extinction rates and increasing colonization rates has become a paradigm in conservation biology. This understanding, together with the public interest in "greenways" has led conservation biologists and land planners to advocate corridors as essential components of reserve design. Although connectivity can be achieved in many ways, including movement through low-quality habitats surrounding reserves, corridors have been advocated as the primary means to connect isolated populations. Protecting naturally existing corridors likely promotes ecological processes and may benefit regional and local biological diversity. It is important to evaluate critically both the effectiveness of biological corridors and the trade-off with diminished habitat area that often accompanies habitat conservation plans.

The planned Tîrgu Mureș-Iași-Ungheni (A8) highway currently only exists on paper. Pilot area 4 is still relatively unfragmented (however, please see also subchapter 8.2 Main threats to ecological connectivity). In consequence, more often than not, on and along the planned highway route there are actually large areas of relatively undisturbed, unfragmented and functional habitats, instead of well defined, localized ecological corridors. For example, in the frame of the long term initiative Brown bear conservation and research program in a model area in Romania (Milvus Group), during 2008-2013 and 2015-2017 we have mapped and measured bear dens. The study area for this specific activity has more or less incorporated (and stretched beyond) the boundaries of Pilot Area 4 within the TRANSGREEN project. During the study, we have located a total of 115 bear dens and 8 open nests used by wintering bears. Based on the actual den locations and using a total of seven abiotic and biotic habitat characteristics and human-related covariates, we have performed maximum entropy modelling (with the software MaxEnt) to identify brown bear denning habitat within the study area. If we overlay the brown bear denning habitat map generated in this study (Fig. 7; Faure et al. *in preparation*) with the planned highway route, it becomes obvious that in Pilot Area 4 the planned highway will intersect and potentially fragment large, contiguous areas of good quality bear denning habitat, critical for the species (please note the presence of prime bear denning habitat along the planned highway route in the Eastern [mountainous] section, which doesn't even have a protected status).

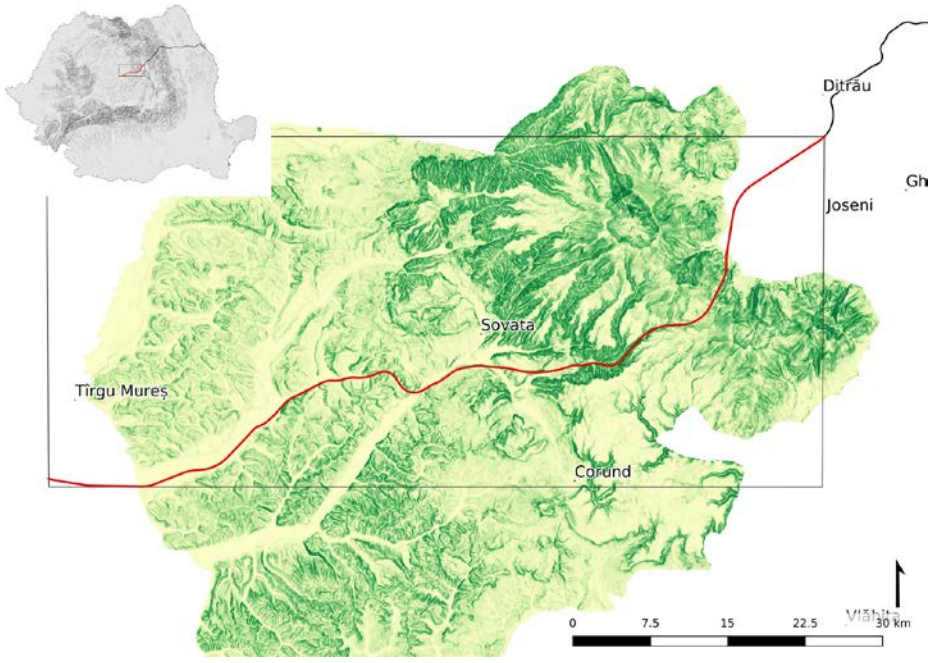


Fig. 7. - Distribution of brown bear denning habitat (in green; darker green locations represent more suitable habitats), overlaid with the route of the planned A8 highway (in red). Source of the denning habitat map: Faure et al. (in preparation)

5 partially from Rosenberg *et al.* (1997). For more information, including detailed references, please consult the original document.

8.2. Main threats to ecological connectivity

In the Westernmost (foothills) area along the route of the planned Tîrgu Mureș-Ditrău section of the future Tîrgu Mureș-Iași-Ungheni (A8) highway, the main threat to ecological connectivity is currently represented by the gradual extension of localities. Whereas most localities have an aging population and the migration of younger residents towards nearby urban centers or abroad represents a major problem, the revisions of local urban plans generally result in the gradual extension of built-up areas. Considering that there are nearby localities all along the two main river courses in the area (the Niraj and Târnava Mică rivers), the currently functional ecological corridors located in between these localities are gradually shrinking, as the localities are extending towards each other (Fig. 8. and 9.). Moreover, considering high rates of unemployment in the area, local authorities are keen to attract any investments which would create jobs for the local residents and generate revenue for the limited local budgets. Often, they encourage the investments to be located in between the localities, close to the main roads (Fig. 10). This phenomenon fragments even further currently functional ecological corridors in the area.

In the mountainous area along the route of the planned Tîrgu Mureș-Ditrău section of the future Tîrgu Mureș-Iași-Ungheni (A8) highway, the main

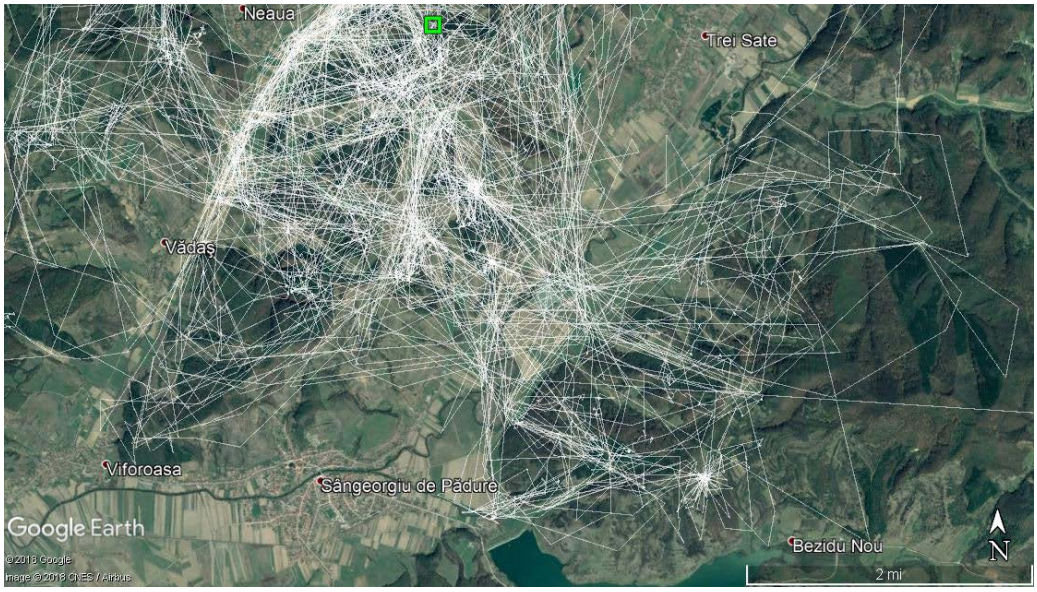


Fig. 8. - Movements of adult female bear F8, fitted with a GPS-GSM collar (in white), across a functional ecological corridor located between the town of Sangeorgiu de Padure and the village of Trei Sate.

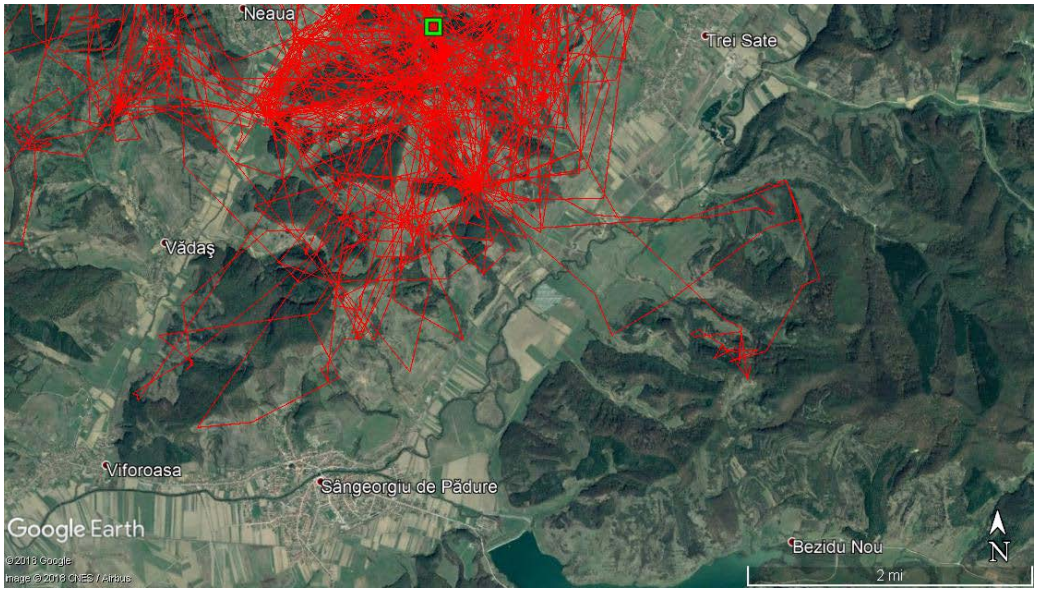


Fig. 9. - Movements of adult male bear M12, fitted with a GPS-GSM collar (in red), across the same functional ecological corridor.

Fig. 10 - The same, currently still functional ecological corridor in detail. The maximum effective width is of approx. 3100 m. However, in recent years, 2 distinct investments have been approved and realized here: a solar panel park, and a blueberry plantation (red areas). Both resulted in effective habitat loss and in the fragmentation of the corridor. Besides avoiding these obstacles, bears and other wildlife species have to cross a busy national road (several bears and large herbivores are killed here each year) and a railway. Furthermore, there are a number of crop fields and permanent shepherd camps located within the corridor.

threat to ecological connectivity is represented by the fact that in later years a number of forestry roads (class III) have been modernized by various local authorities (for example, forestry roads in the Gurghiu Mountains, above the settlements of Sovata and Praid). Considering that the mentioned localities represent important tourist destinations (especially during summers) and that forestry roads modernized with EU funding cannot be closed down for the general public for some years (e.g. local forestry services are unable to mount gates on these roads), motorized public access has increased considerably in these areas, at least during the peak tourist season. This has resulted in the increase of the number and frequency of (so far relatively peaceful) human-wildlife encounters and interactions. In the future, several permanent quarries are planned in the mountainous area (at least 1 close to the route of the planned highway). There are also discussions about new ski slopes in the area.

Still, the currently existing threats to connectivity in Pilot Area 4 will probably be dwarfed by the planned A8 highway.

8.3. Corridor identification

For the identification of potential future fragmentation hotspots along the planned highway in Pilot Area 4, Milvus Group has used / is using several complementary methods.

» **Improving scientific knowledge about brown bear home ranges, movement, activity patterns and habitat use, (also) in relation to the planned A8 highway route**: done through the capture of bears for deployment of radio collars which provide temporally-referenced spatial data on bear movements (Fig. 11). Bears were / are being captured in cage traps set in 3 different locations (2 in the mountains and 1 in the foothills). All our study animals receive GPS-GSM collars manufactured by Vectronic Aerospace (Berlin, Germany). Each collar is set to register a location every 60 minutes (also during the denning period), for a total monitoring duration of 110 weeks (collars are fitted with both automatic and remote drop-off systems). This study, started back in 2011, is ongoing in the frame of a separate project (Brown bear conservation and research in a model area in Romania) implemented by Milvus Group. Consequently, only partial and preliminary (raw) results are available at the moment (Fig. 12).

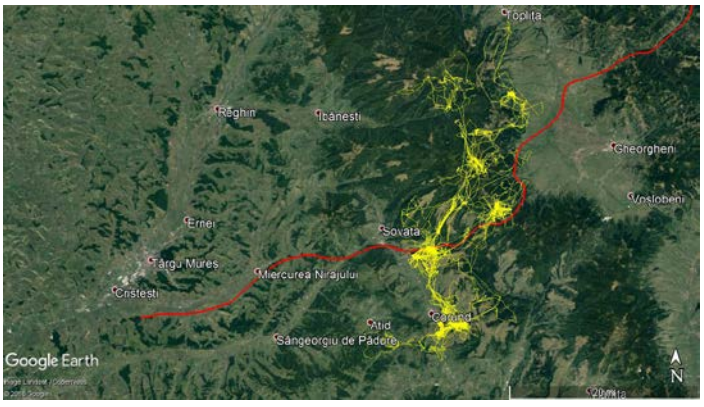


Fig. 11. - Example of the route of the planned Târgu Mureș-Iași-Ungheni highway (A8; in red), overlaid with the movements of adult male bear M2, fitted with a GPS-GSM collar (in yellow).

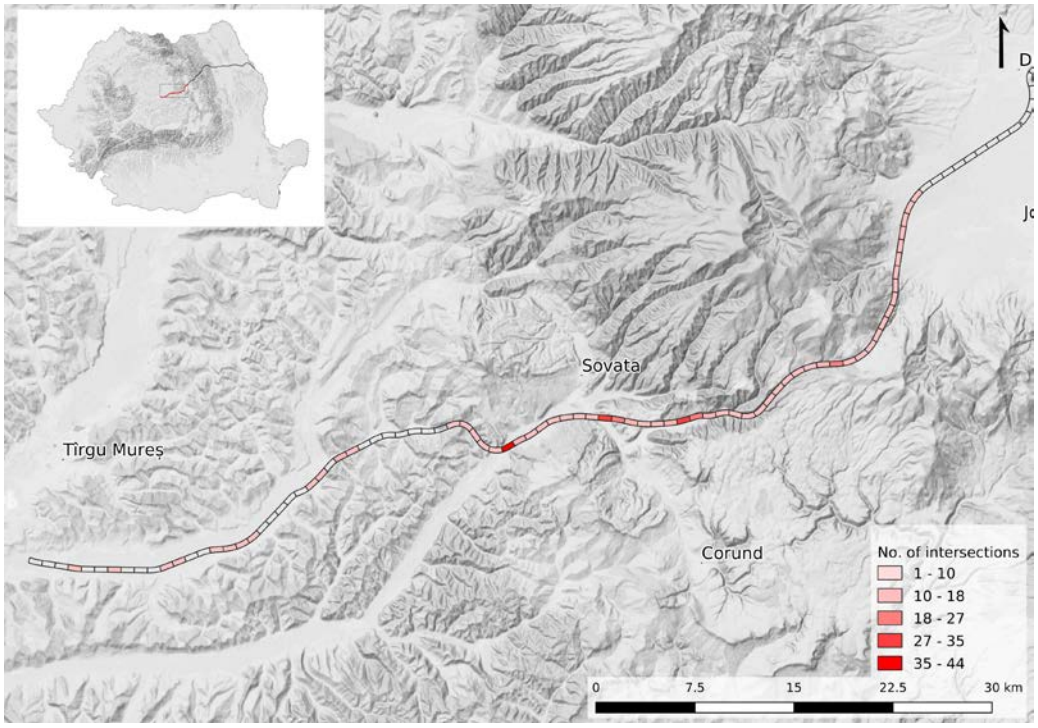


Fig. 12. - A preliminary data set resulted from the intersection of spatial data on bear movements (from a total of 20 bears fitted with GPS-GSM collars) with the planned route of the A8 highway. The planned highway section has been divided into 1 km long segments (much finer resolution is also possible). The colour-coding represents the number of crossings on each segment by at least 1 collared bear.

» **Highway route monitoring within the frame of the TRANSGREEN project**: the methodology consisted of a long-term monitoring of the planned highway route through the use of motion-triggered cameras (Fig. 13, 14, and 15). This methodology has the advantage of being non-invasive and useful in mapping large mammal species in extended areas, with relatively little investment of physical effort and time. The disadvantage of the applied methodology is that the differentiation of individuals within a species is in most cases impossible, so, in most cases, we were unable to tell exactly how many individuals of a certain species have crossed the planned highway route during our survey.

For the survey, the planned highway route has been divided into 1 km-long segments. Motion-triggered cameras were mounted in each segment (1 camera / 1 segment), at a distance of <100 m from the planned route (Fig. 16). Cameras were placed in locations conducive for large mammal movements, or in locations already indicated as suitable by the presence of tracks and other signs of the animals' presence. The cameras were placed at a height of about 50-70 cm. Each camera was placed in a secured metal casing. Camera locations were recorded with a handheld GPS unit. If a camera did not record any of the targeted species for an extended period of time, it was removed and placed in a different location within the same 1 km-long segment. Each segment was surveyed for at least 1 month. During this period, the camera was checked several times (photos were downloaded and batteries were exchanged, if needed). Data was stored systematically: for each photo, provenance location (camera station location), date, and other accompanying information was recorded.

Fig. 13. - Brown bear along the planned A8 highway route, captured on a motion sensor camera during fieldwork in the TRANSGREEN project.

Fig. 14. - Grey wolf along the planned A8 highway route, captured on a motion sensor camera during fieldwork in the TRANSGREEN project.

Fig. 15. - Eurasian lynx along the planned A8 highway route, captured on a motion sensor camera during fieldwork in the TRANSGREEN project.

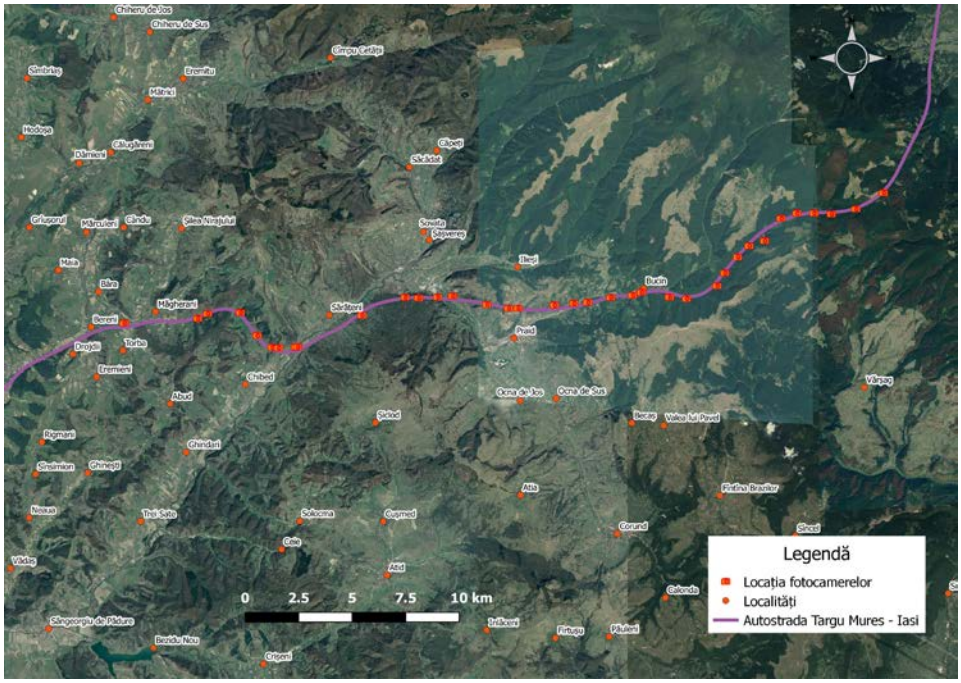


Fig. 16. - Locations of motion-triggered cameras (red dots) during the TRANSGREEN project fieldwork in Pilot Area 4, along the planned Tîrgu Mureș-Iași-Ungheni (A8) highway, Tîrgu Mureș-Ditrău section.

Fieldwork was carried out in the period November 14, 2017 - June 30, 2018. The results of the survey, in numbers:

- a total of 5,698 camera-trapping days
- 273 photos of brown bears; 26 photos of grey wolves; 11 photos of Eurasian lynx; 3703 photos of wild ungulates (roe deer, red deer, wild boar); 675 photos of mid-sized and small carnivores (European wildcats, European badgers, red foxes, otters, beech marten, pine marten). Additionally, livestock (domestic animals) on 2,099 photos and people present on 739 photos.

The processing of data resulted from this field survey is ongoing.

8.4. Potential for conflict management

Despite the fact that the identification of future habitat fragmentation hotspots along the planned Tîrgu Mureș-Iași-Ungheni (A8) highway is still ongoing, a number of generally valid recommendations can already be formulated for the Tîrgu Mureș-Ditrău section of the planned infrastructure:

- Targeted wildlife crossing structures should be planned, built and monitored (on the long term) for wildlife use on highway segments on or adjacent to intensively used wildlife corridors or habitat. This is critical on sections where non-targeted technical measures, also suitable for wildlife crossings, will not be implemented. To maximize effectiveness, crossing structures should respect technical parameters described in a number of dedicated scientific publications (for example, Clevenger and Waltho 2005, Kusak *et al.* 2009). Technical solutions implemented because of other considerations (e.g. bridges, viaducts, culverts, tunnels built because of the local topography) should also respect the above mentioned technical parameters, in order to be considered suitable for crossing by various wildlife species. Similarly to targeted wildlife crossing structures, these should also be monitored on the long term for effective wildlife use.
- The planned highway should be fenced in with wildlife-proof fence (for example, bear-proof fencing all along the Tîrgu Mureș-Ditrău section) in or adjacent to areas with high wildlife use and in proximity to potential crossing structures. The purpose of the wildlife-proof fence would be twofold: to prevent wildlife access onto the highway (thus limiting wildlife-vehicle collisions), and also to funnel movements of wildlife through the crossing structures, thereby ensuring safe highway passage.
- Possible attractants for wildlife in the immediate vicinity or on the highway should be avoided. These include for example fruit trees in the foothills section of Pilot Area 4 which could be cleared or fenced-in, and human-related waste in highway parking lots which should be stored in wildlife-proof containers.

9 Best and bad practices

In September 2018, Romania had a total of approx. 777 km of operational highways or highway sections. In our opinion, Romania currently doesn't really have any best and / or bad practices in the planning, building and operation of environmentally-friendly major transport infrastructure projects. The primary reason for this is that the Romanian major transport infrastructure network is underdeveloped, when compared to other EU Member States (Fig. 17.). The currently operational highways or highway sections in Romania have not yet intersected areas of outstanding natural values (at least not to our best knowledge).

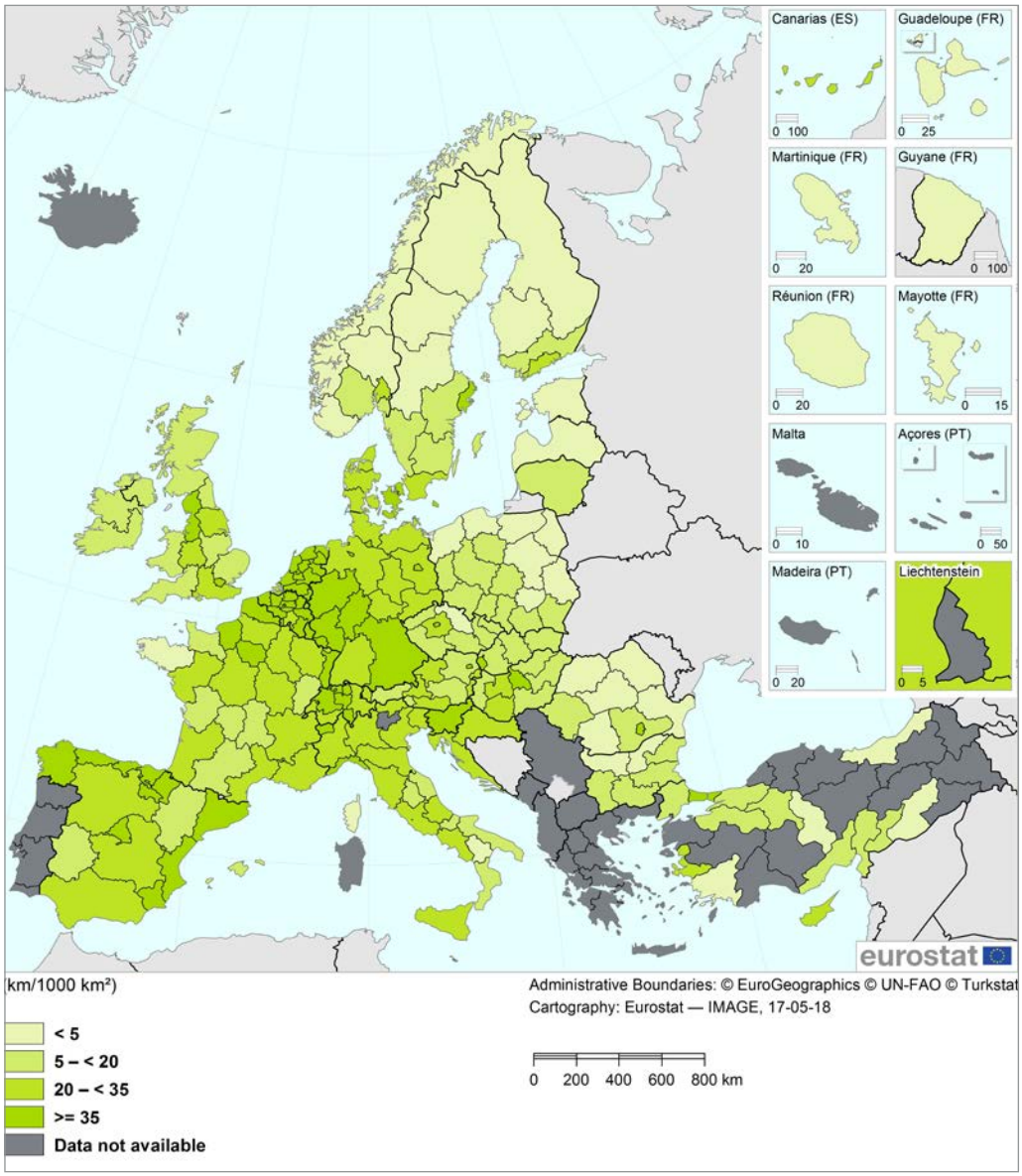


Fig. 17. - Highway density (km/1,000 km2) in Europe by NUTS 2 regions in 2016. Source: Eurostat

10. Gaps of available knowledge, accessibility and availability of biodiversity and transport data

In general, biodiversity data is deficient in Romania (e.g. lack of scientific, peer-reviewed publications, accessible online databases, technical reports). Even basic data, such as the distribution and density of various species or the distribution of various habitat types is mostly unavailable (e.g. national distribution and density maps). This is true even for most of the species or habitats of national or EU importance. The data collection on species and habitats of EU importance - with the goal of elaborating the management plans of various Natura 2000 sites - didn't do much to solve this issue. In most cases, even if some data is available, this is basically unaccessible. Moreover, the reliability of the existing data sets is questionable, or the various data sets can not be compared, more often than not. Data collection is often chaotic and does not occur according to clearly established, replicable methodologies (data collection methodologies for the various data sets are anyway not accessible, in most cases). Data processing is also deficient. As most often there is a lack of experienced personnel (e.g. field experts for various taxa, statisticians, GIS experts, computer modelers) and resources (e.g. field and office equipment), biodiversity data is usually only available in raw format - in the best case. Even long term national data sets, such as the distribution and density of game species or those of the protected large carnivores (on which management and conservation actions should be based) are questionable, to say the least (Popescu *et al.* 2016). Even if appropriate scientific data exists, the scientific community (which is often different from the conservation community) is reluctant to share it with conservation practitioners and relevant stakeholders, decision makers.

Transportation data is also deficient in Romania, and it's most of the times not publicly available / accessible, at least not in real time. Information on infrastructure planning (exact planned routes for roads of various categories, technical details), construction, operation (e.g. traffic values, environmental indicators), maintenance (e.g. temporarily closed roads or road sections) or upgrade is often not readily available for the general public, or even to relevant stakeholders and other decision makers. A good illustration for this shortcoming is the fact that on the planned route of the Tîrgu Mureș-Iași-Ungheni (A8) highway several investments (which require the physical building of various types of infrastructure, even from EU funding) have been approved, also by County-level Environmental Protection Agencies (e.g. the territorial, county-level representatives of the Ministry of Environment). The transportation planners and the relevant Romanian authorities usually view environmental regulations and nature conservation in general as costly complications, which delay, slow down, or even block planned investments. As such, "bats", "bat caves with or without bats" and "bears" have been publicly blamed on several occasions for delays in various construction projects, or for added construction costs - even by prominent Romanian authorities. This general attitude of the Romanian transportation decision makers towards environmental regulations and nature conservation is often reflected in the quality of relevant environmental documentations, which often state that the planned investment has no negative effects on wildlife species or on local natural habitats.

11. Recommendations to fill in the gaps

- High-quality, systematic scientific research and data sharing should be encouraged and supported, with a special focus on underrepresented species and habitats. Awareness about conservation issues (including on the negative effects of transport infrastructure on ecological connectivity) should be raised within the environmental scientific community. Active cooperation of the scientific community with conservation practitioners, stakeholders and decision makers should be encouraged and supported.
- General awareness should be raised in the transportation sector (on all levels) concerning the issue of ecological connectivity. High quality, systematic scientific research and data sharing should also be encouraged and supported within the transport sector, with a special focus on the possible negative effects of transport infrastructure on wildlife species and natural habitats (for example, animal mortality on roads). The quality of relevant environmental impact assessments and monitoring procedures should be improved, mainly through an increased allocation of time and resources.
- Active cooperation (e.g. regular, constructive consultations and data sharing, based on mutual trust) between the environmental and transport sectors should be established and supported, on every level.

12. Conclusions

We strongly believe that effective mitigation measures need to be based on sound scientific data. Technical solutions (e.g. viaducts, bridges) implemented only because of topographic (or other, not wildlife-related) considerations will not automatically benefit wildlife, unless these are built in the right locations (on or close to functional ecological corridors that will be intersected by the future highway) and concomitantly fulfil a set of minimum requirements, making them adequate for wildlife crossings. Most likely additional, on-purpose wildlife crossing structures (for example, green bridges) will need to be built as well in key locations, to ensure a high permeability of the future Tîrgu Mureș-Iași-Ungheni (A8) highway. Moreover, in key locations (again, on or close to functional ecological corridors or suitable habitats) standard technical parameters will need to be adapted to local conditions. For example, the standard highway fencing is easily climbed by brown bears or jumped over by red deer - putting at risk both human passengers and wildlife; human waste or roadside vegetation can attract a number of wildlife species close to or onto the highway - again, endangering both people and animals.

Consequently, in Pilot Area 4, a considerable part of our efforts within the TRANSGREEN project was so far directed towards identifying functional ecological corridors and suitable habitats that are intersected by the planned highway route, for a number of species (large carnivores, large herbivores, mesocarnivores and more). The goal was (and still is) to identify key future fragmentation hotspots, where adequate mitigation measures will need to be implemented.

More often than not, transport infrastructure development has neglected ecological considerations, causing basically irreversible damage to natural ecosystems. Occasionally, local communities also have to endure the negative effects of poorly planned or executed developments. **In the case of the planned Tîrgu Mureș-Iași-Ungheni (A8) highway in Romania, we have a unique opportunity to intervene in a timely manner, minimizing the future highway's potential negative effects on local communities and on both wildlife species and natural habitats of national and EU importance.**

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