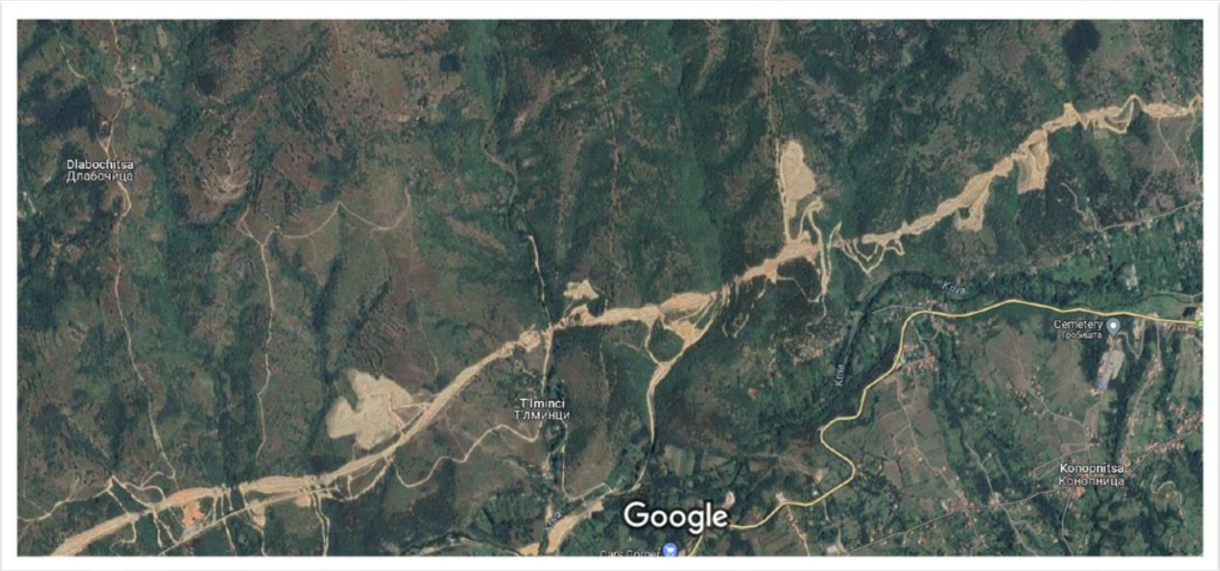

"Summary of the actual impacts on biodiversity in the area of the Osogovo-German biocorridor and effectiveness of mitigation measures during construction of Expressway A2, LOT 2: Sub-section Kriva Palanka – Dlabocica"

Final report

Zagreb, September 2024.

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CONTRACT No.	U-291/20
PROJECT	Survey of the large mammal fauna during construction of Expressway A2, LOT 2: Sub-section Kriva Palanka - Dlabocica
DOCUMENT	Summary of the actual impacts on biodiversity in the area of the Osogovo-German biocorridor and effectiveness of mitigation measures during construction of Expressway A2, LOT 2: Sub-section Kriva Palanka – Dlabocica. Final report.
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DATE	Zagreb, September 2024

Contents

1. Introduction

The National strategy for transport of Republic of North Macedonia (2018) foresees competition of the Pan-European Corridors which are passing through the territory of the Republic Macedonia, and the highest priority is given to improving the interconnection of roads.

The section Kriva Palanka – Rankovce is part of the Corridor VIII. This Corridor in the present time research covers the relation of the Southern Italian Ports – Albanian port Durres, Elbasan - Albanian - Macedonian border – Kjafasan – Struga – Ohrid – Skopje - Kumanovo – Kriva Palanka - Macedonian-Bulgarian border (Deve Bair), then through Bulgaria three transcontinental routes to the north through a community of independent states and the Baltic, to Azerbaijan and a third option to the Middle East via Turkey are possible. As stated above, the Corridor K-8 East - West covers parts of the western and northern territory of the Republic of Macedonia (Kafasan, Struga, Kicevo, Skopje, Kumanovo, Kriva Palanka, Deve Bair).

As part of the primary road network of the Republic of Macedonia, the East - West Corridor (VIII) along with the North - South Corridor (X) will constitute the main routes around which the most significant part of the transport activity in the Republic of North Macedonia will take place.

In order to build a new expressway, the Public Enterprise for State Roads has prepared project documentation for the design and construction of a new expressway from Kriva Palanka to Rankovce. This road is located in the north-eastern part of the territory of the Republic of Macedonia, near the border with the Republic of Bulgaria.

The total length of the section covered by the construction activities is 25 km and it is divided into two subsections: the first subsection from Kriva Palanka to Dlabocica and second subsection from Dlabocica to Stracin (Chatal) with the total length of 15 km.

For the realization of the envisaged construction works the Public Enterprise for State Roads has been financially supported by a loan from the World Bank.

According the national legislation of the Republic of North Macedonia for this type of projects, as well as the World Bank Operative Politics, during the preparation of the project documentation an environmental impact assessment process has been carried out during the preparation of the project documentation and an Environmental and Social Impact Assessment Study (ESIA) for construction of state road A2, section Kriva Palanka – Rankovce was prepared. The ESIA among other content, includes description of the baseline condition for biodiversity, habitats, protected areas and other identified significant areas at national or international level, assessed impacts from implementation of the project activities and proposed mitigation measures to reduce the estimated impacts.

Among other things, the ESIA has identified the presence of landscape bio corridor Osogovo - German, but does not show the exact locations on which the bio corridor intersects the State Route A2.

According to the identified mitigation measures and the Environmental Management Plan, it is necessary to determine in which part of the area the corridor intersects with the state road A2, and to monitor it during the construction phase.

The purpose of this document is to assess the overall impact on the landscape bio-corridor German-Osogovo, occurred as a result of the construction of the expressway A2, LOT 2: section Kriva Palanka - Dlabochica and to assess the effectivity of the implemented mitigation measures.

2. Baseline data on significant areas and identified habitats

2.1 Identified significant areas along the subsection Kriva Palanka – Dlabocica

Regarding the significant areas, the ESIA Study identifies, and additional field investigations confirmed that the alignment of the envisaged road is intersecting only with landscape bio-corridor German - Osogovo. This biocorridor is established according to the Macedonian National Ecological Network MAK-NEN.

The identified landscape bio-corridor links the Osogovo core area with the restoration area Kozjak/German/Bilina Mountain (Fig.1).

The Corridor extends south-north from the Osogovo Mountains. In the region of the villages Mozdivnjak and Konopnitsa to the German Mountains in the region of the village Petralica. The corridor is densely populated (major villages include Dlabocica, T'lminci, Konopnica, Mozdivnjak, etc.), although the processes of leaving the remote villages has been intensified.

Its function as a biocorridor results from the fact that it enables daily, periodic and seasonal migrations of different animals and spread of plants. It is important for the normal life cycle of many animal species:

- Amphibians: Migrations during the reproductive period to breeding areas (common green frog, green frog);
- Brown bear: Migration for foraging. The brown bear is extremely rare in the project area. The presence of this species is irregular and this corridor is very important for establishing independent populations of brown bears in the future;
- Wolf. Migration for food and breeding;
- Ungulates, especially roe deer: Seasonal food migration;
- Small mammals: Periodic and seasonal migrations.

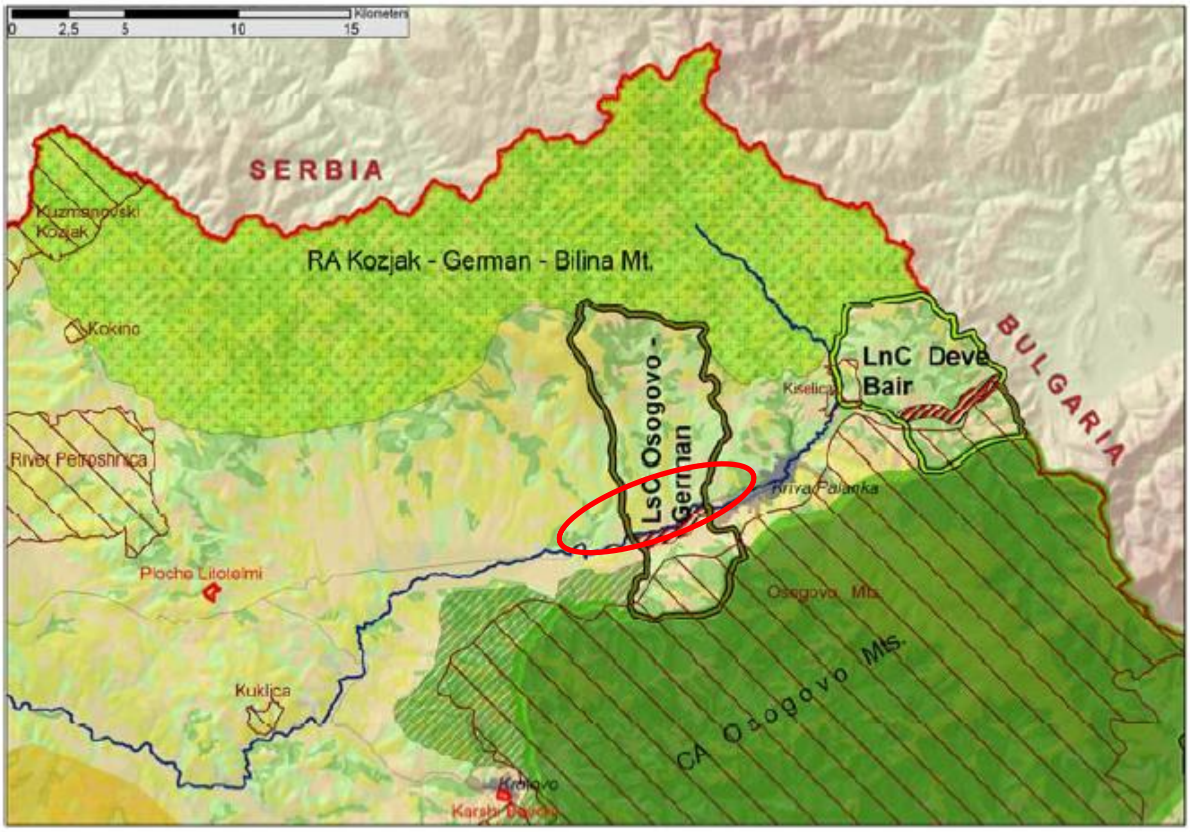

Figure 1. *Corridors in the north-east part of Macedonia according to MAK-NEN network*

Table 1. *Surface of the main habitat types in the biocorridor (ha) (according to Corine Land Cover, 2006)*

Habitat type	Area of habitat (ha)	Percent (%)
Forest habitats	1696	27.5
Shrubs habitats	1777	28.8
Open habitats	1161	18.8
Agricultural land	1546	25.0
Total surface of the bio-corridor	**6180**	**100**

2.2 Identified habitats

According the ESIA Study, along the subsection Kriva Palanka – Dlabocica several types of habitats, from natural and anthropogenic origin have been identified:

- Xerotermophilous Oak Forests – Pubescent oak and Oriental hornbeam forests
- Degraded Xerothermophillous Oak Forests - Pubescent Oak and Oriental hornbeam forests
- Thermophilous Oak Forests – Mixed Italian Oak and Turky Oak Forests

- Mesophilus Oak Forests – Flowering Ash and Sesile Oak Forests
- Hill Pastures with Sparse Shrubs
- Hiporhithral Steams – Rivers (Approximately narrower than 5 m)
- Conifer Tree Plantation (Black Pine)
- Small Broad leaf Tree Plantation
- Rural settlements – villages
- Urban settlements – Kriva Palanka

For all identified habitats in the ESIA Study (Fig.2) a description of their main characteristics is given, the most characteristic plant species, and the distribution along the route, characteristic fungal species, mammals, birds, reptiles and amphibians.

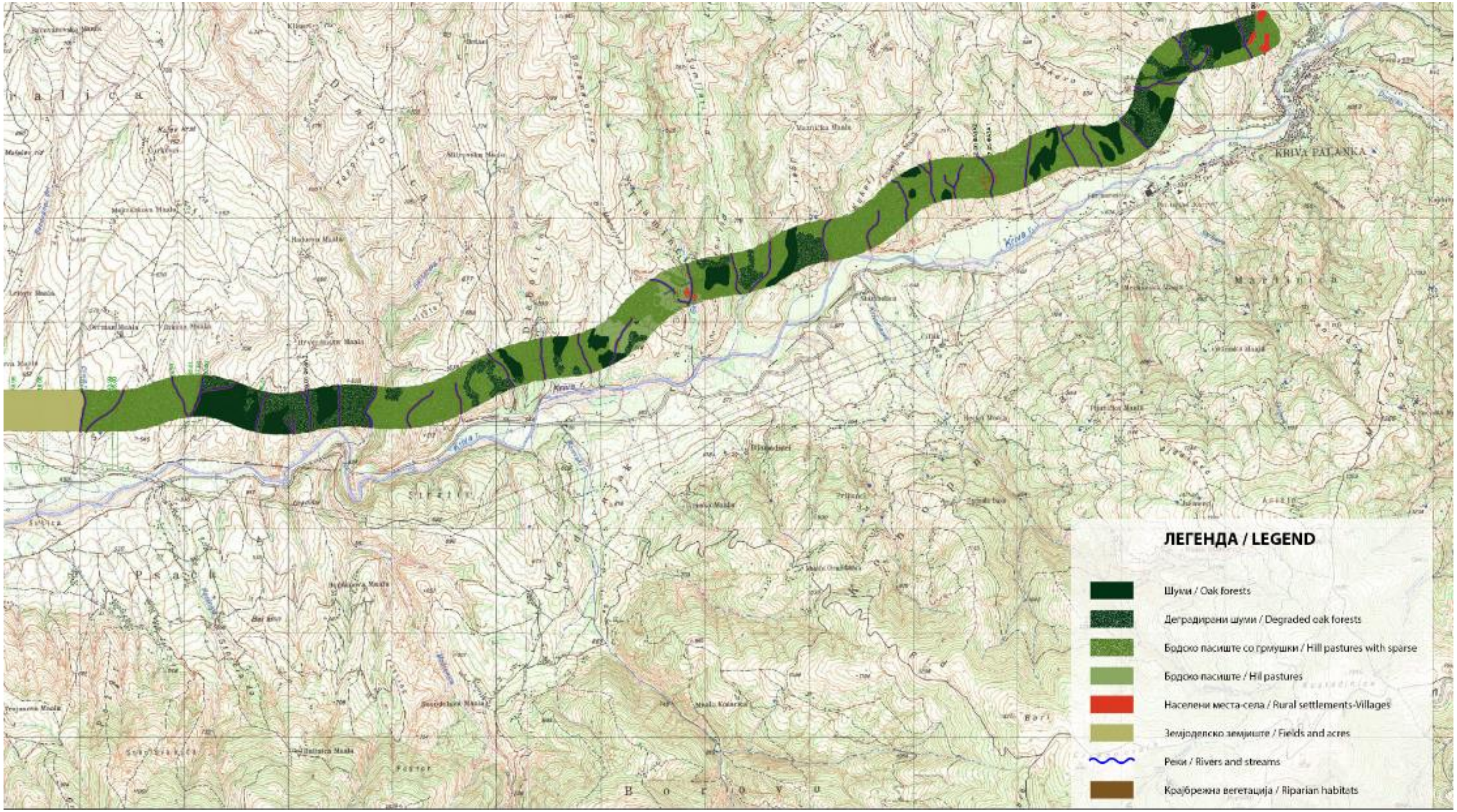

Figure 2**. **Habitat map – Habitats along the subsection Kriva Palanka – Dlabocica

3. Final impact assessment from road construction (large mammals)

3.1 Current state of the road construction activities

In the period from 2022 until end of September 2024, the following construction activities have been carried out:

• The upper structure of the viaducts are completely finished – only the fences, waterproofing of the pavement and the final layer of asphalt remains to be finished;

• Four retaining walls on Ramp 1 have been completed, two of which are reinforced concrete and two are gabion; one reinforced concrete retaining wall on Viaduct 10 next to end pillar C6 has been completed, work is underway on an additional reinforced concrete retaining wall on Ramp 1 on which the last fifth column remains;

• On the route, intensive work was done on digging for the rehabilitation of slopes and their protection with a net, until recent all the cuts from the Main Route have been completed, 50% of the last cut on Ramp 1 remains, and 75% of the work on protection with nets has been completed;

• Work was actively carried out on the construction of the drainage system, i.e. the construction of concrete channels on berms and embankments, rim channels, segmental channels and drainage on the Main Route and Ramp 1 - there are still 5% of the channels planned for construction and additional 10% of the total lengths of the drainage system remain to be constructed;

• Arrangement of the bed, installation of a buffer layer, installation of curbs, construction of banks was carried out, the first layer of asphalt - BNS was also installed and that on the following sections from km 7+250 to the beginning of Viaduct 13A, from the end of Viaduct 13A to the beginning of Viaduct 14 and from the end of Viaduct 14 to the beginning of Viaduct 15 – from the upper layer – the roadway remains to install a buffer on the remaining sections and subsequently a first layer of asphalt BNS and a final layer of asphalt AB;

• An elastic rebound fence along the entire route has been installed.

• The remaining works on the route include the installation of vertical and horizontal signalling, as well as the lighting of the Kriva Palanka road junction and the Kriva Palanka intersection.

• In the mentioned construction period there was no use of explosives along any segment of the route.

3.2 Remote sensing drone imagery

The results from the first two drone imagery have been presented in the past reports while this report includes the results from the third (and last) high resolution drone imagery performed in July 2023 and encompasses the changes in habitat loss between October 2020 and July 2023. For the creation of the orthophoto we used the same drone - DJI Phantom 4 pro+. To repeat the drone imagery systematically the same three take off points were selected in the same order (Fig.3) for best coverage of the area of interest. The drone flew at the height of 250m with the average speed of 40 km/h. To get the best possible quality from the optical instruments, the option with the highest resolution (4096×2160) was used. Given the fact that each picture needs to overlap with the neighbouring picture at least in 45% we were obligated to set the drone to take picture at every 5 seconds. The geo-referencing of the pictures was made using the Pix4D software (https://www.pix4d.com/).

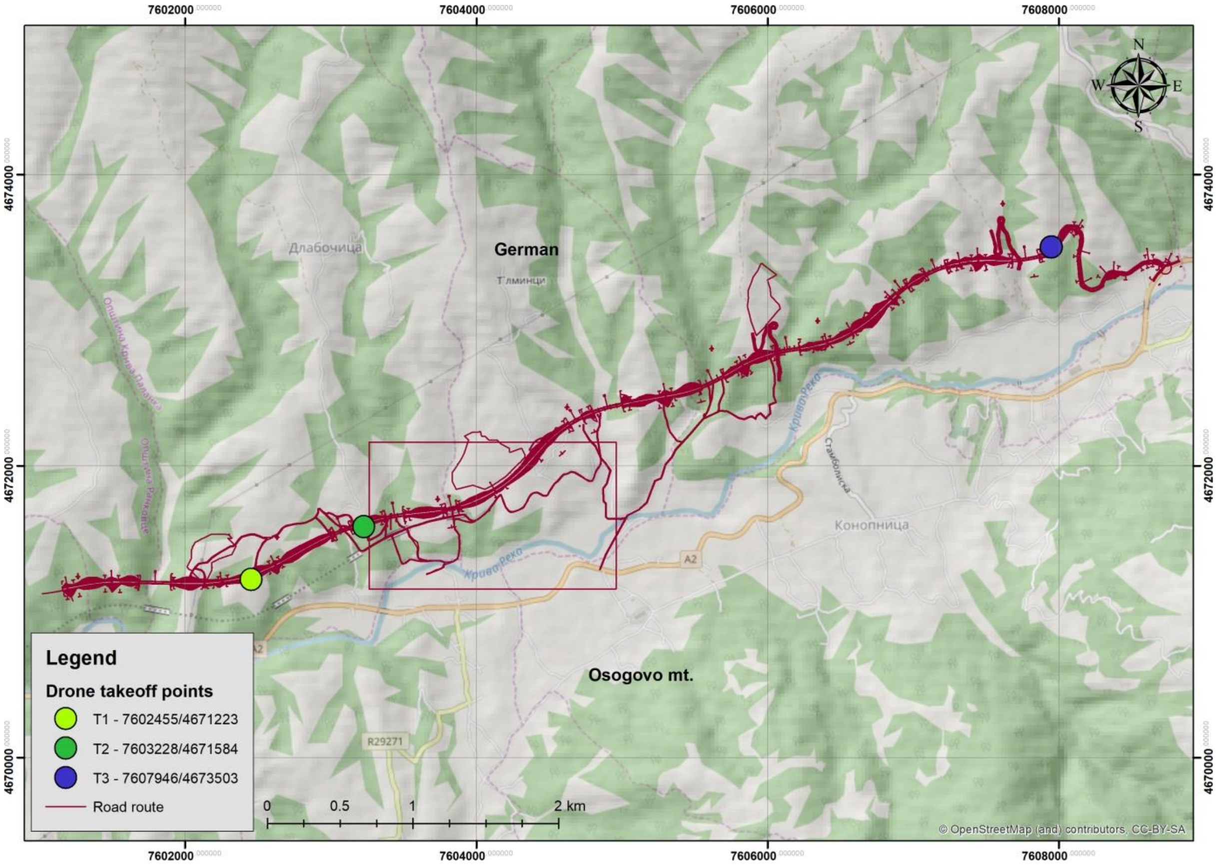

***Figure 3.** Locations of the drone take off for the third drone imagery.*

The GIS analysis was performed using the same data sets (except for the new drone images) to compare the situation regarding the habitat loss between the second recording in October 2020 and the last in July 2023. After the preparation of the orthophoto vector files (shape files), the procedure required to prepare the layers that helped us to calculate the habitat loss related to the road construction activities along the route. The data from these files was overlapped and intersected with the bio-corridor and the CORINE Land Cover 2018 data. The results from these analyses produced tables with areas and habitats under impact from the road construction. A 2 km buffer overlapping with the CORINE 2018 Land Cover habitat classes in the borders of the biocorridor was created to be able to track the habitat changes in the obtained orthophoto layer (Fig.4). All the analysis was conducted in two separate software (despite Pix4D) QGIS v3.4.10 and Excel 2017.

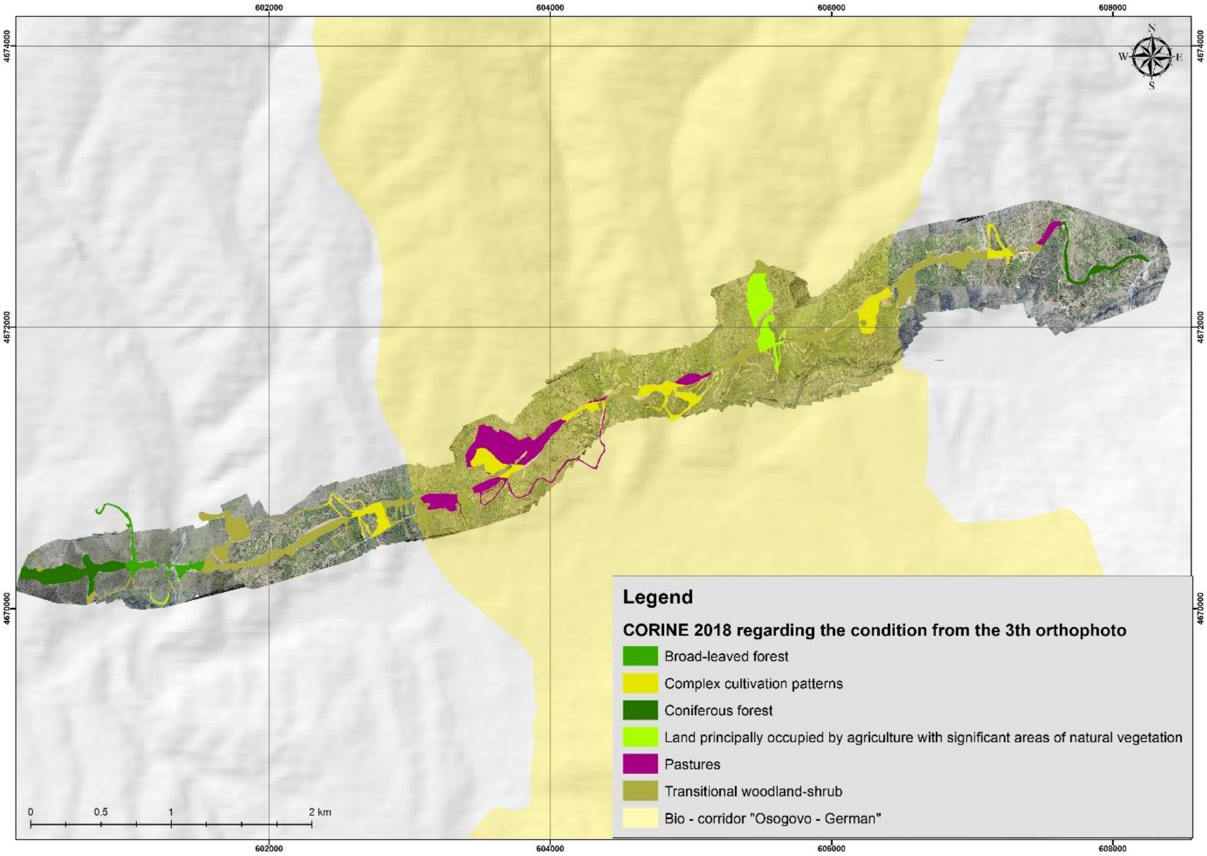

Figure 4. ***An overview map of the expressway route with the results from the third orthophoto imagery and the spatial distribution of the habitat loss by habitat classes (CLC)***

3.3 Habitat loss impact analysis

The results from the GIS analysis of the third remote sensing drone imagery and the intersection of the habitat loss layer with CORINE Land Cover 2018 dataset are presented in Table 2, Figure. 4. The results presented in the table show the last recorded habitat loss (as by July 2023) in the construction area by type of construction and by different habitat type according to CORINE classification. The total area by habitat type before construction of the expressway took place is given in Table 3 for comparison.

Table 2. Habitat loss along the expressway route by the type of construction and by different habitat type according to CORINE Land Cover classification (third drone imagery)

Habitat class (CLC)	Last recorded (Area, ha)	Percentage of habitat loss (%)
Depo Areas (Total)	**31,58**	**34,85%**

Broad-leaved forest	0,10	0,11%
Complex cultivation patterns	6,71	7,40%
Land principally occupied by agriculture with significant areas of natural vegetation	5,01	5,53%
Pastures	6,73	7,42%
Transitional woodland-shrub	13,03	14,38%
Access roads (Total)	**12,40**	**13,68%**
Broad-leaved forest	2,24	2,47%
Complex cultivation patterns	2,21	2,44%
Coniferous forest	0,65	0,72%
Land principally occupied by agriculture with significant areas of natural vegetation	1,29	1,42%
Pastures	1,43	1,57%
Transitional woodland-shrub	4,58	5,05%
Expressway route (Total)	**46,63**	**51,47%**
Broad-leaved forest	1,20	1,32%
Complex cultivation patterns	10,34	11,41%
Coniferous forest	8,19	9,04%
Land principally occupied by agriculture with significant areas of natural vegetation	2,41	2,66%
Pastures	5,17	5,71%
Transitional woodland-shrub	19,32	21,33%
Total loss of habitats (ha)	**90,61**	**100,00%**

Table 2 shows the total area of the last recorded habitat loss (July, 2023). The area of total habitat loss is **90,61** ha without a significant increase (6,71 ha) compared to the state of the second drone imagery (October 2020). According to the new analysis most of the habitat loss is again due to the opening of the expressway route (**46,63** ha or **51,47%**) following by the Depo Areas for the excavation material (**31,58** ha or **34,85%**) and the access roads (**12,40** ha or **13,68%**).

The following table (Table 3) shows the habitat losses from the third (and last) drone imagery by the CORINE Land Cover (CLC) habitats classes. Most of the area as a habitat loss is in the class of Transitional Woodland and shrubs (**36,94** ha or **40,77**%) followed by classes of complex cultivation patterns (**19,26** ha or **21,26**%) and pastures (**13,33** ha or **14,71**%). The loss in the other habitat classes: Land principally occupied by agriculture with significant areas of natural vegetation, Coniferous forest and Broad-leaved forest is altogether **22,37**%. Table 3 also gives an overview of the areas of each habitat class within the drone recorded area before construction took place, and the percentage of the last recorded habitat loss from the initial situation.

Table 3. ***Habitat loss along expressway route by habitat type according CORINE Land Cover classification (third drone imagery)***

Habitat class (CLC)	Land cover before start of project implementation (within the drone recorded area) (ha)	Last recorded habitat loss (Area, ha)	Percentage of last recorded habitat loss from the situation before expressway construction (%)
Broad-leaved forest	20,8	3,54	17,02
Complex cultivation patterns	139,5	19,26	13,81
Coniferous forest	42,5	8,84	20,80
Land principally occupied by agriculture with significant areas of natural vegetation	52,2	8,71	16,69
Pastures	99,1	13,33	13,45
Transitional woodland-shrub	256,3	36,94	14,41
Total (ha)	**614,6**	**90,61**	**/**

The separate analysis of habitat loss concerning the biocorridor German-Osogovo were made including a wider area involving the impact zone of 2km buffer. The analysis follows the same methodology calculating the habitat loss only in the impact area of 2km on both sides of the expressway route.

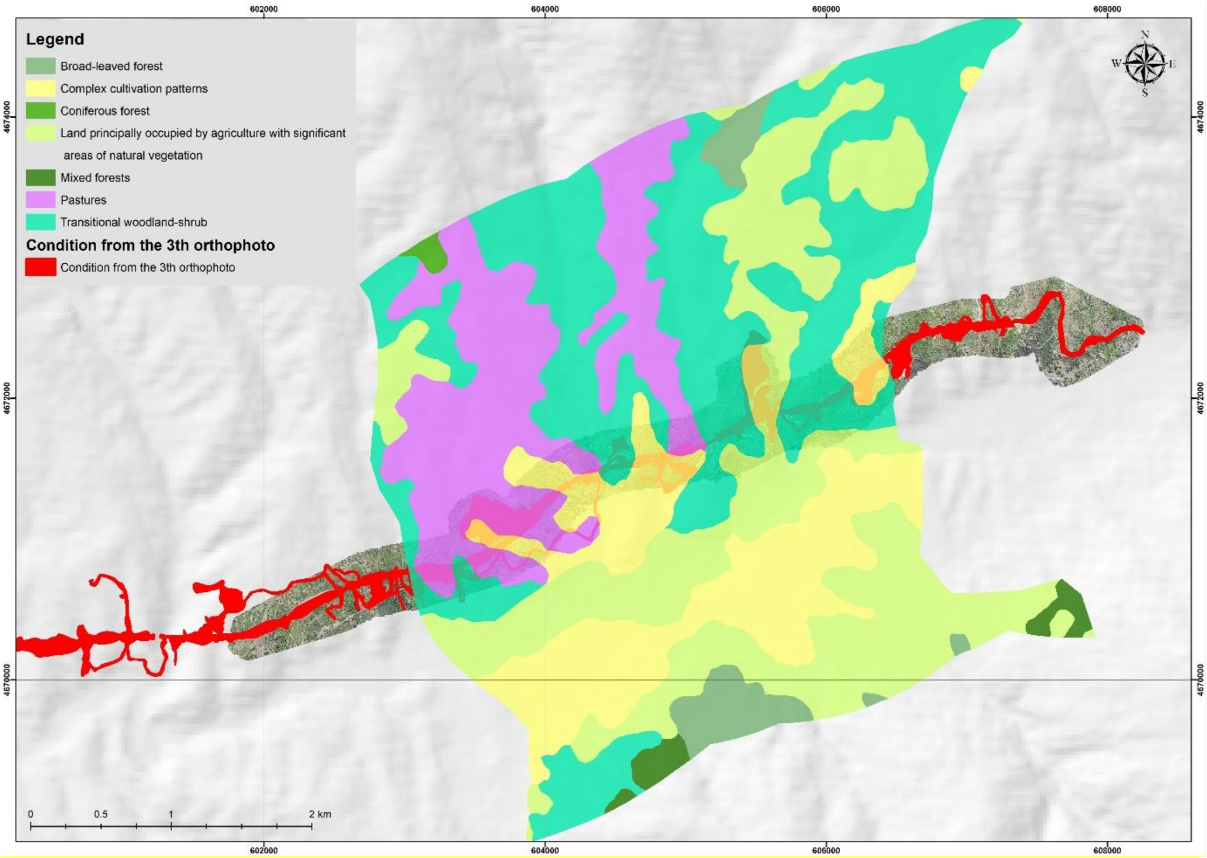

Figure 5. Overview map of the expressway route transecting the biocorridor German-Osogovo including information on the available habitats in the 2km impact zone.

The results from the habitat loss analysis within the 2 km impact zone along the biocorridor German-Osogovo are presented in Table 4, Figure 5. The total habitat loss (in the bio-corridor area) as a result of the construction activities and recorded with the third drone imagery is **46,60** ha. Most of the habitat loss are due to the creation of the Depo Areas for the excavation material (**21,62** ha or **46,41**%) followed by the opening of the expressway route with almost identical area (**21,29** ha or **45,68**%). The habitat loss due to construction of access roads covers smaller area of **3,69** ha or **7,91**%**.**

***Table 4**. Habitat loss within impact zone (2km) in the borders of biocorridor by the type of construction and by different habitat type according CORINE Land Cover classification (third drone imagery).*

Habitat class (CLC)	Last recorded (Area, ha)	Percentage of habitat loss (%)
Depo Areas (Total)	**21,62**	**46,41%**
Complex cultivation patterns	5,00	10,72%
Land principally occupied by agriculture with significant areas of natural vegetation	4,67	10,01%
Pastures	8,61	18,49%

Transitional woodland-shrub	3,35	7,18%
Access roads (Total)	**3,69**	**7,91%**
Complex cultivation patterns	0,73	1,56%
Land principally occupied by agriculture with significant areas of natural vegetation	0,22	0,47%
Pastures	1,68	3,61%
Transitional woodland-shrub	1,06	2,27%
Expressway route (Total)	**21,29**	**45,68%**
Complex cultivation patterns	5,55	11,92%
Land principally occupied by agriculture with significant areas of natural vegetation	2,62	5,61%
Pastures	6,77	14,54%
Transitional woodland-shrub	6,34	13,61%
Total loss of habitats (ha)	**46,60**	**100,00**

The following table (Tab. 5) reveals the total area of habitat loss in the impact area (2 km) within the borders of the biocorridor presented by the CORINE Land Cover habitats classes. The largest habitat loss is in the class of Pastures (**17,06** ha or **36,60**%), followed by the class Transitional woodland and shrubs (**10,75** ha or **23,07**%) and Complex cultivation patterns (**11,28** ha or **24,20**%). The loss in the habitat class Land principally occupied by agriculture with significant areas of natural vegetation is **7,51** ha or **16,11**%.

Table 5. ***Habitat loss within the impact zone in the biocorridor by habitat type according CORINE Land Cover classification (third drone imagery).***

Habitat class (CLC)	Last recorded (Area, ha)	Percentage of habitat loss (%)
Complex cultivation patterns	11,28	24,20
Land principally occupied by agriculture with significant areas of natural vegetation	7,51	16,11
Pastures	17,06	36,60
Transitional woodland-shrub	10,75	23,07
Total loss of habitats (ha)	**46,60**	**100**

Additional calculations of the total available CORINE habitat classes have been performed to see the proportion between habitat losses of the certain class versus the total available for the impact area 2 km of the biocorridor area (Table 6) as the most important landscape feature in the area of the expressway route. According literature, during the construction phase most of the impact on large carnivores as our target species is expected to be within the impact area of 2 km, so this area is considered as lost or degraded habitats for their ecological needs especially reproduction. However, since the area of interest is recognised as a landscape biocorridor for large carnivores (brown bear, Brajanoska et al. 2009) connecting two core areas it is crucial to secure the permeability of this area for large carnivores during construction and beyond. The impact of the future expressway on the large carnivores during operational phase have different nature and is not in the scope of this project.

Table 6. ***Updated habitat loss (third drone imagery) by construction compared with the total available habitats within impact area (2km) inside the biocorridor.***

Habitat loss by different habitat type according CORINE Land Cover classification	Area of habitat loss per habitat class (ha)	Total area available per habitat class within impact area of 2km (ha)	Percentage of habitat loss from the total available (%)
Broad-leaved forest	/	308,22	0
Complex cultivation patterns	11,28	820,17	1,37
Coniferous forest	/	230,91	0
Discontinuous urban fabric	/	204,37	0
Industrial or commercial units	/	29,99	0
Land principally occupied by agriculture with significant areas of natural vegetation	7,51	1003,08	0,75
Mixed forest	/	89,53	0
Natural grasslands	/	2,81	0
Pastures	17,06	724,85	2,35
Transitional woodland-shrub	10,75	1235,66	0,87
Total area (ha)	**46,60**	**4649,57**	**1**

The results from the table above reveal that the total habitat loss (all habitat classes) is exactly **1**% from the total available habitats found within the 2km impact zone of the biocorridor. Even with the small increase in habitat loss between second and third drone imagery (October 2020-July 2023), the calculated percentage of habitat loss of all habitat classes according CLC 2018 is not more than **1**%.

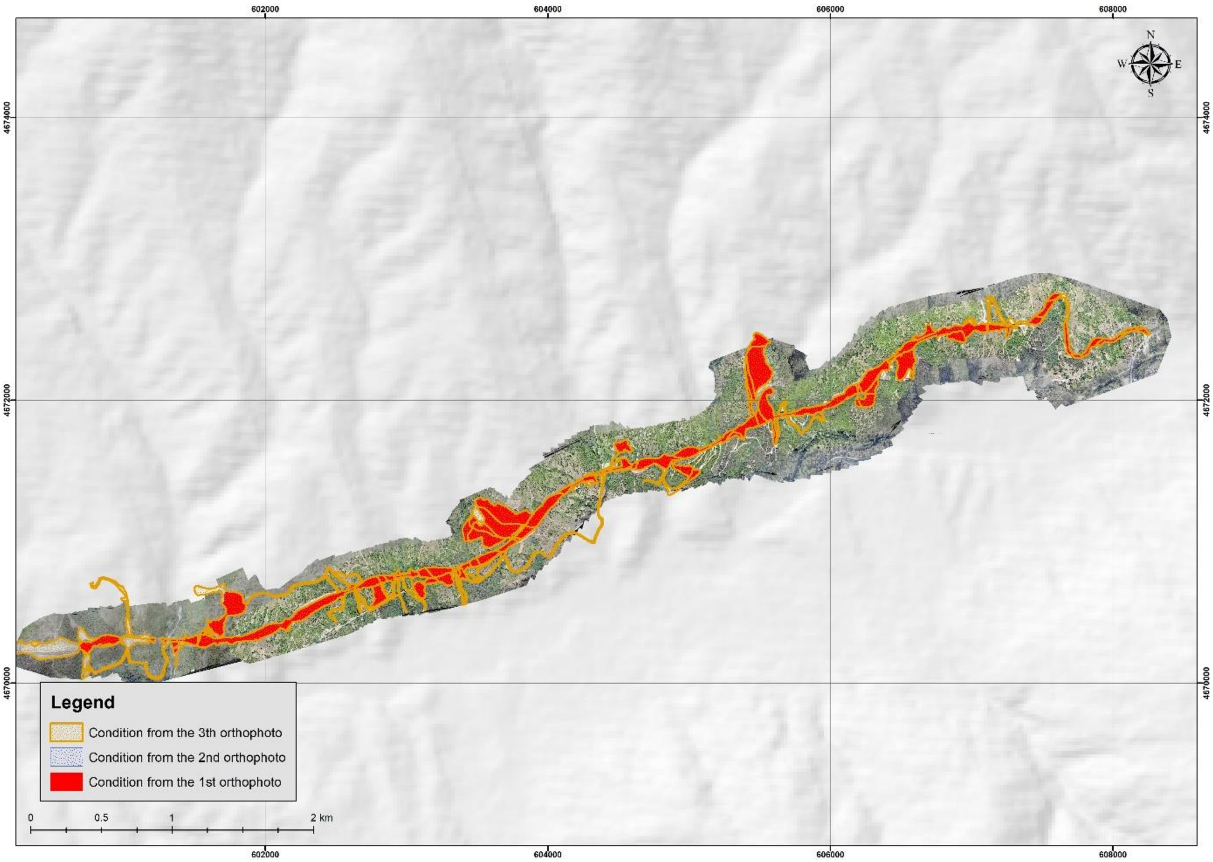

Figure 6. Orthophoto image showing the progress of the construction work and the habitat loss from all three drone imagery analysis.

3.4 Monitoring results and impact assessment on the large mammals

The monitoring of large mammals in the study area (mainly within the borders of the biocorridor German – Osogovo) has been designed and conducted to answer several questions like what the composition of mammal fauna is and how do they use the area of the biocorridor; and do large carnivores (wolf, bear and lynx) use the biocorridor and how during the monitoring period. The methodology used was described in the agreement documents and discussed in a joint meeting held on 22.11. 2019 at the Granit field stationary office with participation by Representative of employer, Supervising engineer and Contractor (Minutes of Meeting – Phase EHS). The field monitoring started in late November 2019 and was an ongoing activity till June 2022 aiming to cover most of the period of construction activities in the project area. Two monitoring techniques – camera trapping and transect tracking have been used and conducted in parallel in the mentioned period with frequent field trips. All the monitoring results are presented in detail in the submitted Field reports, and in this report a summary is presented for an overview of the field collected data. All the collected field data and results presented in this report and the conclusions are used for impact assessment and evaluation of the undertaken mitigation measures.

Transect tracking method (described in detail in Ivanov et al. 2020) focuses on discovering wildlife tracks that indicate the presence of species of interest. The main species of interest were large carnivores (wolf, brown bear and lynx) and their main prey species (roe deer, wild boar and brown hare). The transect tracking along the defined transects (I-IV) for the complete monitoring period resulted in discovering wolf tracks on five locations, roe deer on 30, wild boar on 47 and brown hare on 22 locations (Table 7, Fig. 7). Red fox and beech marten tracks were discovered on multiple locations in the field, however not always recorded and presented since their presence is quite abundant in the area which was also confirmed by the camera traps as well, so one can assume they are wide spread in all study area.

Table 7. Results from transect tracking and identified tracks along the transect.

Species name	Latin name	Tipe of track	X (Longitude)	Y (Latitude)
Wild boar	*Sus scrofa*	footprints	21.365422	42.075905
Brown hare	*Lepus europaeus*	scat	21.395333	42.077931
Marten	*Martes sp.*	scat	22.549147	42.096077
Marten	*Martes sp.*	scat	22.553293	42.099805
Brown hare	*Lepus europaeus*	scat	22.555698	42.103386
Marten	*Martes sp.*	scat	22.556198	42.104648
Brown hare	*Lepus europaeus*	scat	22.555140	42.105084
Roe deer	*Capreolus capreolus*	bed-site	22.555909	42.106908
Brown hare	*Lepus europaeus*	scat	22.553311	42.107444
Red fox	*Vulpes vulpes*	scat	22.552042	42.107678
Wild boar	*Sus scrofa*	footprints	22.553926	42.108140
Brown hare	*Lepus europaeus*	scat	22.548344	42.108235
Brown hare	*Lepus europaeus*	scat	22.545243	42.109508
Brown hare	*Lepus europaeus*	scat	22.544361	42.110832
Roe deer	*Capreolus capreolus*	scat	21.319344	42.111181
Marten	*Martes sp.*	scat	22.543103	42.111943
Brown hare	*Lepus europaeus*	scat	22.543381	42.113236
Red fox	*Vulpes vulpes*	fur hair	22.542218	42.114033
Red fox	*Vulpes vulpes*	scat	22.543653	42.117514
Roe deer	*Capreolus capreolus*	bed-site	22.541823	42.118837
Wild boar	*Sus scrofa*	footprints	22.543024	42.118928
Roe deer	*Capreolus capreolus*	footprints	22.542389	42.118967
Marten	*Martes sp.*	scat	22.542265	42.119580
Wild boar	*Sus scrofa*	footprints	22.542599	42.119842

Species name	Latin name	Tipe of track	X (Longitude)	Y (Latitude)
Red fox	*Vulpes vulpes*	scat	22.543489	42.120786
Brown hare	*Lepus europaeus*	scat	22.534897	42.121144
Wild boar	*Sus scrofa*	footprints	22.543734	42.122097
Wild boar	*Sus scrofa*	digging	22.535020	42.122170
Marten	*Martes sp.*	scat	22.535860	42.122266
Brown hare	*Lepus europaeus*	scat	22.541393	42.122493
Red fox	*Vulpes vulpes*	scat	22.535720	42.122638
Red fox	*Vulpes vulpes*	scat	22.514804	42.122715
Roe deer	*Capreolus capreolus*	bed-site	22.540047	42.123552
Wild boar	*Sus scrofa*	footprints	22.514845	42.123878
Roe deer	*Capreolus capreolus*	footprints	22.535542	42.123976
Wolf	*Canis lupus*	scat	22.539501	42.125557
Wild boar	*Sus scrofa*	digging	22.537548	42.125715
Wild boar	*Sus scrofa*	digging	22.501197	42.126167
Roe deer	*Capreolus capreolus*	bed-site	22.538875	42.126692
Wild boar	*Sus scrofa*	digging	22.539095	42.126799
Wild boar	*Sus scrofa*	scat	22.507801	42.127490
Roe deer	*Capreolus capreolus*	bed-site	22.504342	42.127828
Marten	*Martes sp.*	scat	22.500339	42.127840
Wild boar	*Sus scrofa*	digging	22.503683	42.127858
Red fox	*Vulpes vulpes*	scat	22.503905	42.128084
Wild boar	*Sus scrofa*	digging	22.500791	42.128395
Brown hare	*Lepus europaeus*	fur hair	22.506761	42.128414
Wolf	*Canis lupus*	footprints	22.501871	42.128446
Wild boar	*Sus scrofa*	digging	22.501630	42.128929
Brown hare	*Lepus europaeus*	scat	22.501630	42.128929
Wild boar	*Sus scrofa*	digging	22.509356	42.129231
Wild boar	*Sus scrofa*	scat	22.508897	42.130834
Wild boar	*Sus scrofa*	digging	22.509836	42.131879
Brown hare	*Lepus europaeus*	scat	22.505400	42.132854
Red fox	*Vulpes vulpes*	scat	22.505400	42.132854
Brown hare	*Lepus europaeus*	scat	22.509014	42.133125
Wild boar	*Sus scrofa*	digging	22.506232	42.134197

Species name	Latin name	Tipe of track	X (Longitude)	Y (Latitude)
Red fox	*Vulpes vulpes*	footprints	22.511290	42.135640
Marten	*Martes sp.*	scat	22.508644	42.138062
Red fox	*Vulpes vulpes*	footprints	22.508708	42.140004
Marten	*Martes sp.*	footprints	22.507983	42.140427
Wild boar	*Sus scrofa*	footprints	21.382560	42.143261
Roe deer	*Capreolus capreolus*	den	21.382560	42.143261
Marten	*Martes sp.*	scat	22.250438	42.190283
Roe deer	*Capreolus capreolus*	bed-site	22.250262	42.190555
Wild boar	*Sus scrofa*	digging	22.241501	42.191592
Wild boar	*Sus scrofa*	digging	22.263700	42.192140
Roe deer	*Capreolus capreolus*	footprints	22.281428	42.192260
Brown hare	*Lepus europaeus*	scat	22.281592	42.192481
Roe deer	*Capreolus capreolus*	bed-site	22.242193	42.192489
Wolf	*Canis lupus*	footprints	22.279831	42.192908
Roe deer	*Capreolus capreolus*	bed-site	22.261625	42.192921
Wild boar	*Sus scrofa*	scat	22.262791	42.193022
Wild boar	*Sus scrofa*	digging	22.282395	42.193698
Roe deer	*Capreolus capreolus*	bed-site	22.262096	42.193852
Roe deer	*Capreolus capreolus*	bed-site	22.281765	42.194045
Brown hare	*Lepus europaeus*	footprints	22.283195	42.194095
Wild boar	*Sus scrofa*	footprints	22.282474	42.194238
Wild boar	*Sus scrofa*	digging	22.282976	42.194257
Roe deer	*Capreolus capreolus*	bed-site	22.282801	42.194503
Wild boar	*Sus scrofa*	digging	22.261990	42.194525
Roe deer	*Capreolus capreolus*	observed individual	22.261715	42.195035
Roe deer	*Capreolus capreolus*	observed individual	22.261806	42.195040
Brown hare	*Lepus europaeus*	scat	22.261341	42.196241
Wild boar	*Sus scrofa*	digging	22.261564	42.197819
Wolf	*Canis lupus*	scat	22.261692	42.197949
Marten	*Martes sp.*	scat	22.262024	42.198621
Wild boar	*Sus scrofa*	digging	22.261271	42.198947

Species name	Latin name	Tipe of track	X (Longitude)	Y (Latitude)
Roe deer	*Capreolus capreolus*	fur hair	22.261662	42.199386
Wild boar	*Sus scrofa*	digging	22.261762	42.199786
Wild boar	*Sus scrofa*	scat	22.261459	42.201493
Wild boar	*Sus scrofa*	scat	22.260717	42.203909
Wild boar	*Sus scrofa*	digging	21.542178	42.209377
Wild boar	*Sus scrofa*	footprints	22.281382	42.192596
Roe deer	*Capreolus capreolus*	bed-site	22.281646	42.193146
Wild boar	*Sus scrofa*	digging	22.261233	42.201756
Wolf	*Canis lupus*	footprints	22.261564	42.197819
Roe deer	*Capreolus capreolus*	scat	22.261692	42.197949
Marten	*Martes sp.*	scat	22.262024	42.198621
Marten	*Martes sp.*	footprints	22.261271	42.198947
Wild boar	*Sus scrofa*	digging	22.261662	42.199386
Red fox	*Vulpes vulpes*	footprints	22.261762	42.199786
Wild boar	*Sus scrofa*	footprints	22.261459	42.201493
Wild boar	*Sus scrofa*	digging	22.260717	42.203909
Wild boar	*Sus scrofa*	digging	22.261625	42.192921
Wild boar	*Sus scrofa*	digging	22.250262	42.190555
Wild boar	*Sus scrofa*	footprints	22.282474	42.194238
Roe deer	*Capreolus capreolus*	bed-site	22.283195	42.194095
Roe deer	*Capreolus capreolus*	footprints	22.250438	42.190283
Brown hare	*Lepus europaeus*	scat	22.261762	42.199786
Brown hare	*Lepus europaeus*	fur hair	22.241501	42.191592
Wild boar	*Sus scrofa*	digging	22.263700	42.192140
Roe deer	*Capreolus capreolus*	bed-site	22.261990	42.194525
Wild boar	*Sus scrofa*	digging	22.282395	42.193698
Roe deer	*Capreolus capreolus*	footprints	22.282976	42.194257
Brown hare	*Lepus europaeus*	scat	22.261271	42.198947
Wild boar	*Sus scrofa*	footprints	22.262024	42.198621
Wild boar	*Sus scrofa*	digging	22.241978	42.191176
Brown hare	*Lepus europaeus*	scat	22.242369	42.191737
Roe deer	*Capreolus capreolus*	scat	22.250696	42.190164
Roe deer	*Capreolus capreolus*	bed-site	22.281959	42.194392

Species name	Latin name	Tipe of track	X (Longitude)	Y (Latitude)
Wild boar	*Sus scrofa*	digging	22.260699	42.196384
Wild boar	*Sus scrofa*	scat	22.261556	42.201983
Roe deer	*Capreolus capreolus*	scat	22.261566	42.200381
Brown hare	*Lepus europaeus*	footprints	22.249800	42.190063
Wild boar	*Sus scrofa*	digging	22.242369	42.180900
Roe deer	*Capreolus capreolus*	scat	22.282947	42.194073
Roe deer	*Capreolus capreolus*	footprints	22.275385	42.197177

The other monitoring technique for this survey was the method of camera trapping (Geonatura d.o.o. 2020). With its “remote sensing” capabilities and automated work it is a useful technique for non-invasive monitoring of elusive species like wild mammals which are mostly active during night. The camera trapping survey has resulted by recording a total of 16 different mammal species (not counting bats and rodents) in the survey area, including: cattle (*Bos taurus*), golden jackal (*Canis aureus*), dog (*Canis l, familiaris*), wolf (*Canis lupus*), roe deer (*Capreolus capreolus*), european hedgehog (*Erinaceus concolor*) domestic cat (*Felis s, catus*), wild cat (*Felis silvestris*), human (*Homo sapiens*), brown hare (*Lepus europaeus*), martens (*Martes sp*.), badger (*Meles meles*), sheep (*Ovis aries*), squirrel (*Sciurus vulgaris*), wild boar (*Sus scrofa*) and red fox (*Vulpes vulpes*) (Table 8). Wolf is the only representative species from large carnivores recorded by camera traps during the entire monitoring period, once on each of two different locations (M100 and M110) (Tab. 8, Fig. 7).

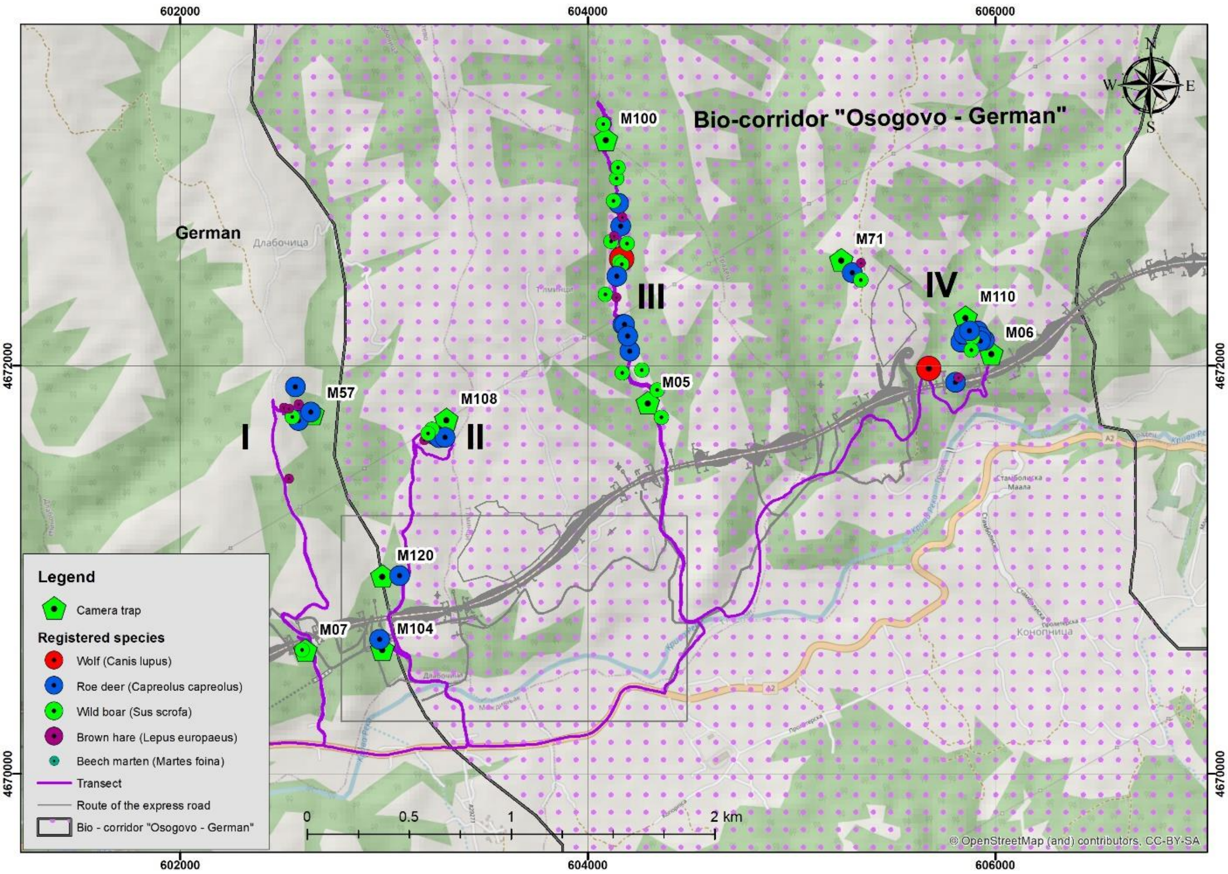

Figure 7. Results from transect tracking and locations of the camera traps.

***Table 8.** Results from camera traping survey. Number of events by species and by location where it was photographed.*

Species	Total number of events	Number of events per specific location (site) of installed camera trap							
		M5	M7	M9	M57	M100	M104	M108	M110
Bos taurus (cattle)	13		3				9	1	
Canis aureus (шакал)	2								2
Canis lupus familiaris (dog)	143	11	35	14	27	13		5	38
Canis lupus (wolf)	2					1			1
Capreolus capreolus (roe deer)	388	82	25	9	61	99		15	97

Erinaceus concolor (hedgehog)	1				1				
Felis s. catus (cat)	21			7					14
Felis silvestris (wild cat)	48				21	6			21
Homo sapiens (human)	92	6	1	18	8	12	14		33
Lepus europaeus (brown hare)	100		7	17	9			3	64
Martes sp. (martens)	236		10	2	36	60	1		127
Meles meles (badger)	130			2	36	21		2	69
Ovis aries (sheep)	2						2		
Sciurus vulgaris (squirrel)	191	11	138		7	18			17
Sus scrofa (wild boar)	114	17	15	1	12	46			23
Vulpes vulpes (red fox)	815	21	31	7	202	60	1	19	474

The combined results from the camera trapping collected in the mentioned period are revealing the presence, composition, and the frequency of occurrence of mammal fauna in the surveyed area. Some of the major conclusions from the overview of the filed collected data (Tab. 7, Tab. 8, Fig. 7) are as following:

1. The registered species with the use of both monitoring techniques in the survey area are part of the expected mammal fauna in the broader area, which corresponds to the habitat types found in the biocorridor German-Osogovo, specific in the 2km impact zone of the expressway route. The biocorridor was recognised as a landscape corridor to ensure the movement of brown bear as an umbrella species (Brajanoska et al. 2009, National biodiversity strategy with action plan, 2015). Even though brown bear has not yet been registered in the study area, one can notice that other large carnivores (like wolf) and their prey are using the biocorridor. The presence of main large carnivore prey species (roe deer, wild boar and brown hare) together

with preserved movement routes within the borders of the biocorridor will ensure the functionality of the biocorridor and connectivity between the two core areas Osogovo Mts. (already a protected area) on the south and German Mt. on the north for all three large carnivores (brown bear, wolf and lynx).

2. One camera location - M110, stands out with the most recorded species (13) and highest number of registered wildlife events (980). Next are camera locations M57 and M100 with 11 and 10 different species recorded and 420 and 336 wildlife events respectively. All three camera traps are set at different distance from the expressway route expecting different impact from the construction activities, meaning that the location of the camera trap M110 set closer to the route should have larger impact due to the disturbance from the construction. Yet, it has the most recorded mammal species with the highest frequency of occurrence for at least half of the registered species. The above mentioned can be confirmed with the frequency of the tracks found on transect III and IV (Fig. 7) in the vicinity of the mentioned camera locations.
3. The most abundant species is red fox with total of 815 events, followed by roe deer (388) and martens (236). Wild boar and brown hare are also relatively abundant with 114 and 100 events respectively. All three main prey species (wild boar, roe deer and hare) are least recorded at location of camera M104. This location is not favoured for brown hare due to the habitat composition on the site, and the lack of events of other species can be attributed to the proximity of the near village and relatively permanent anthropogenic disturbance around the site.
4. Wolf is the only large carnivore species recorded in this study. It is captured by camera traps on the mentioned camera locations (M100 and M110) and the discovered tracks are coming from those areas as well. Wolf was captured on a single events on both cameras in the early months of the monitoring (December 2019 and January 2020) and hasn’t reappeared on the cameras since then. Judging from both independent events only one adult wolf individual has been captured each time. We can’t confirm from photos if those are two separate individuals or one, or if it’s a part of a wolf pack or an independent individual. The same counts for its home range. It remains unknown if it’s a vagrant or resident individual(s).
5. The occurrence of domestic animals (dog, cat, pig, cattle) and people on almost every camera trap location confirms that the area is used by locals for various reasons but mostly for livestock breeding (grazing), hunting, picking mushrooms etc. These activities are not necessary pointing to intensive use or high anthropogenic pressure (at least not in the entire study area), however it represents an impact that needs to be considered since the impact assessment to large carnivores needs to be cumulatively assessed. On the other side the extensive land use (specific for the region) can be beneficial for large carnivores and their prey, e.g. brown bears can find more semi wild fruiting trees as a food source, natural mortality of livestock represents alternative food source for scavengers (including wolf and bear), pastures are maintained open for wild herbivores, etc.

Figure 8. Representative photos from local mammal fauna captured by trail cameras on the monitored locations.

The survey of the mammal fauna conducted for the purpose of this project is the first of this type in the biocorridor German-Osogovo and its adjacent area. Monitoring results (collected by both methodologies – camera trapping and transect tracking) from this project helped to get an insight in of the status of part of the mammalian fauna in the biocorridor. With few records of wolf and no previous studies in the area, we can't say how much the biocorridor is used for movement by large carnivores. As mentioned, the monitoring methodologies used in this project could provide only preliminary data, which cant reveal if specific individuals are crossing the expressway route and the existing regional road and move from one core area to another (Osogovo Mts. and German Mt.) because they are not suitable to track and identify separate individuals across the study area (like radiotelemetry and genetic study which are complex and haven't been conducted even in the wider area).

4. Impact Assessment

This chapter summarises the general understanding of impacts on large carnivores from road construction as found in various literature and continues with impact assessment from the construction of the expressway A2, LOT 2: Subsection Kriva Palanka – Dlabocica.

4.1 Impact of road construction on large carnivores

Road construction is an essential component of modern infrastructure development, facilitating economic growth, connectivity, and accessibility. However, the expansion of road networks can have significant consequences on the natural environment, particularly on large carnivore populations. They become victims of traffic accidents, and the traffic network itself causes loss and degradation of their natural habitats, pollution and increases human activity in the neighbouring areas that were previously less or not accessible for people at all. All this leads to great losses and disturbances in the natural environment. In addition, roads and railways represent obstacles to the movement of many animals, which leads into isolation and eventually their local extinction. Habitat fragmentation, and partitioning of natural ecosystems into smaller, isolated pieces of land, is globally recognized as one of the greatest threats to the preservation of biodiversity (Hubert et al. 2023). Large carnivores play a crucial role in maintaining ecosystem balance and biodiversity, making it imperative to understand and address the impacts of road construction on these apex predators.

According to literature (Kusak, Huber, and Frkovic 2000; Passoni et al, 2017; Ferrão da Costa et al, 2018) large carnivores as a top predators require large and relatively undisturbed areas to successfully trace and hunt their prey, reproduce and raise their offspring. An important biological characteristic of all mammals and especially of the large carnivores is that they need vast natural habitats in order to avoid contact with humans which often end in a conflict critical for the large carnivores.

Some of the well-known impacts from road construction are following:

Habitat Fragmentation: The most immediate and direct consequences of road construction for large carnivores is habitat fragmentation. Roads act as barriers, dividing once contiguous habitats into smaller, isolated patches. This fragmentation poses a considerable threat to the roaming patterns and territorial behaviour of large carnivores, disrupting their ability to access vital resources such as food, water, and mates. Fragmented habitats also increase the risk of inbreeding, leading to a decline in genetic diversity and the overall health of carnivore populations.

Mortality Risk: Collisions between vehicles and carnivores can result in injuries or fatalities for both humans and animals. Large carnivores, such as bears, big cats, and wolves, are often unable to navigate through the expanding road networks quickly enough, resulting in increased mortality rates. These accidents not only contribute to the decline of carnivore populations but also pose risks to human safety.

Barriers to Movement: Roads act as formidable barriers, limiting the movement of large carnivores. These barriers impede natural migration routes, essential for finding new territories, establishing home ranges, and accessing seasonal resources. As a result, large carnivores may become isolated in smaller habitats, leading to increased competition for resources, conflicts with humans, and reduced chances of successful reproduction. However, some of the supporting infrastructure like viaducts and culverts contribute to permeability of roads for large mammals.

Human-Wildlife Conflict: The encroachment of roads into carnivore habitats brings an increased human-wildlife conflicts. As large carnivores are pushed into closer proximity to human settlements due to road construction, incidents of livestock predation and attacks on domestic animals may rise. In retaliation, humans may resort to lethal measures, exacerbating the already precarious situation for these species.

Research done on wolves show that the impact on reproduction sites is effective in radius of 2 km around construction sites. Some wolf individuals and their prey avoided the area of construction sites up to 4 km. Concerning the proximity of construction sites to the wolf breeding sites and the potential impact it was noted that packs that had their breeding sites on a distance more than 3 km from the construction sites had only minor changes in the breeding site and reproduction success Packs that had their territories less than 3 km away from the project location showed a decrease in breeding success during construction and initial operation phase, as well as shifts in denning sites, which were located progressively further to resume regular reproduction (Álvares et al, 2017). The same research in Portugal showed that after 3 years of operation most of the wolf packs around project site would resume reproduction but with notable shifts in denning locations. Consequently, when breeding sites shift to more unsuitable areas, it may result in decreasing survival and pack viability in the short term (da Costa et al, 2018). On the long run, wolves can adapt to human activities and disturbance only to a certain level. Therefore, in the area of the biocorridor the analysis of the different habitat loss was made in the 2km buffer (zone of expected impact).

4.2 Impact assessment on large carnivores from construction of express way Kriva Palanka – Dlabocica.

Habitat loss and fragmentation

In principal habitat loss can be considered as a direct impact as a result of opening construction grounds, Depo Areas, access roads and removing vegetation; and indirect impact where habitats are relatively physically un-damaged but due to disturbance their quality is degraded to a point where they are not considered (temporary or longer) anymore as suitable for large carnivores.

Direct habitat loss due to land use conversion can be considered a long-term impact. The largest areas of direct habitat loss occurs during construction phase, while after construction certain parts (Depo Areas, parking and areas for construction materials) can reversibly be converted back to its natural state by natural succession or remediation process. Results from the third drone imagery are showing that the total area of direct habitat loss during construction (till July 2023) is 90,61 ha or less than 1 km^2. From that area, 46,63 ha (51,47%) falls under route of the express way and can be considered as permanent loss while the rest is accounted for Depo Areas for excess dirt material and access roads which can be used in a later stage from local wildlife as explained above. Having in mind the large home ranges large carnivores have, it appears that the direct habitat loss in the project area (during construction) will have/had insignificant impact. The impact of indirect habitat loss is mostly relevant for the construction phase. The presence of construction workers, use of heavy construction machines, transport of construction materials etc. are causing disturbance beyond the construction sites in the previously relatively undisturbed area and the effect is avoidance or displacement (usually temporal) as a reaction from the local fauna of large mammals. This type of impact is usually temporary but with relatively high intensity. However, most of the impact in construction phase is happening during the day (work hours) while the ecology of most wild mammal species registered in the project area is that they are mostly active during the night hours or crepuscular (dusk and dawn). Another specific of the construction work is the one that its not constant along entire construction zone but is conducted in segments, meaning that while it is focused in one area the rest of the project area is relatively undisturbed so the animals could use it (at least for movement). All the previously said can be supported by the results of the monitoring. The presence and frequency of habitat use of most of the registered species is relatively homogeneous in the study area during entire monitoring period (no significant fluctuations). The only exception was the wolf which was recorded in the first months of the study by the camera traps and haven't reappeared later. However its tracks were discovered in the period November 2019 – January 2020 and March 2022, which indicates that wolf might used the vicinity of the construction zone of the expressway during the entire construction period. Altogether, the impact of habitat loss (direct and indirect) should be considered as temporal issue with moderate (focused construction activities) to minor intensity and extent.

Fragmentation is the most expected impact from construction of linear infrastructures such as motor ways (especially fenced highways). Therefore, partial local fragmentation can be expected in the construction phase of the express way Kriva Palanka – Dlabocica. However, the landscape in the biocorridor and its vicinity in the impact area of 2 km of the expressway route is already fragmented due to the local land use. In addition, the habitat composition affected by construction activities mostly include low quality habitats for large carnivores like transitional woodlands and shrubs, arable land and hilly pastures. As stated in the previous reports (Geonatura d.o.o. 2020) narrow valleys between hills are the most likely landscape features that local fauna would use for movement in the project area or biocorridor area. Those landscape features are significantly less impacted by the construction activities (overall) because viaducts are planned for overbridging this landscape features which are recognised in general as a potential passages even more in the post construction phase. In total 11 viaducts have been constructed in the area where the expressway intersects with the biocorridor German – Osogovo. In that regard it is relatively safe to say that the construction of the express way didn't contribute significantly on the fragmentation and did not posed a strong barrier for movement of local mammal fauna.

The recent construction activities in the area of the biocorridor (2 km buffer) did not significantly increase the habitat loss in the period between second and third drone records. As explained in the Initial findings from the first impact assessment (Fig. 6 from Geonatura d.o.o. 2020) the Depo Areas should not represent a significant impact on the movement of the large mammals mainly because animals are using depressions in the terrain with dense vegetation to move in the area. In addition, the main expected movement routes – the depressions at the viaducts number 10, 11, 12, 14, 15 and 16 will not be affected by the Depo Areas so the animals can use the depressions with dense vegetation for movement (migration) in the broader landscape (Fig. 7). Since the habitat loss related to the Depo Areas practically did not increased in the past years of construction activities (results from the third drone imagery) and the impact from Depo Areas was previously assessed as non-significant, we can assume that the Depo Areas did not represent a threat to large carnivore movement. After the construction is completed and Depo Areas remediated or successionally overgrown they can be used as natural habitats by local mammal species.

A general conclusion regarding impact on the large mammals due to habitat loss after the third and final drone imagery is that the direct and overall habitat loss due to construction activities is not significant, thus should not be expected to obstruct the permeability of the biocorridor. Areas where the vegetation was removed are mostly situated in the western end of the expressway route where the ruggedness of the terrain will allow animals to use the narrow valleys for moving in south-north directions (Fig. 6). Moreover and important is that the direct habitat loss is even less significant within the borders of the biocorridor and the area of Depo Areas is barely increased, again not affecting the narrow valleys as important landscape features for animal movement. Given the fact that large carnivores are territorial and occupy large areas as their individual home range or wolf pack territory (few to several hundred km^2) the expected total habitat loss as a result of the road construction of the expressway Kriva Palanka – Rankovce (**90,61** ha) is assessed as insignificant. Furthermore, some of the areas after the construction are planned for remediation so part of the habitat loss will be returned to natural habitat and used by local fauna.

Direct disturbance from construction activities

It is not fully clear how large carnivores react on disturbance. The most obvious and expected reaction would be avoidance. Results from wolf monitoring in Portugal (da Costa et al. 2018) showed that wolves avoid affected areas during construction phase. There is evidence that newly formed packs, which have recently recolonized areas with already built infrastructure, have shown relative tolerance, choosing breeding sites at distances of less than 3 km from the infrastructure. This example and other literature suggest that impact from construction activities is affecting large carnivores and their prey which in general try to avoid human contact or disturbed areas, but this type of impact is temporal, intensive only locally (construction segments) and mostly during the daytime. The width of the biocorridor and its imminent vicinity is relatively wide enough for animals with large movement capabilities to avoid the source of disturbance. According to construction reports, in total 4 events where explosives where used were inside the borders of the bio-corridor German-Osogovo. Three events were in the early spring period (2020) as recommended in the Biodiversity management plan report while one event was in late summer (2020) which could have potential and temporary impact concerning that wolfs are raising their pups in that period. Since the wolf was not detected in the period when mining evets took place, we could not confirm if the suspected mining event (or any other) has some impact on the frequency of using the bio-corridor by wolves.

Visual disturbance (occurrence of artificial construction elements in nature)

It is not clear enough how large carnivores react on visual disturbance. Since the visual disturbance around construction site is usually coupled with human presence, some individuals might avoid the artificial elements but other (bold or curious) might find it attractive to check the area for possible food leftovers. Overall, such behaviour can not be predicted and therefore the impact is hard to predict. Helldin et al. 2012 and other similar literature suggest that noise and visual disturbance from infrastructure constructed in nature can be masked by vegetation and wind and that animals can adapt with time. From all three large carnivores, lynx is the least sensitive to human infrastructure and wolf is usually the most avoiding such areas as potentially risky. Light emissions (pollution) is also impactful but mostly for other group of animals like bats and insects.

Access roads

The impact of opening new access roads for construction purposes can be considered from two aspects. One is related to construction of those roads that eventually results in habitat loss and disturbance in the natural areas which were not accessible previously (both addressed in the text above), and the other aspect is using the access roads for transportation of construction materials and people during the construction phase and eventual use of those roads by public after the construction phase. The impact from using the access roads during construction have already been discussed in the previous reports and adequate mitigation measures were suggested. Basically speaking, this impact has relatively moderate intensity but is also temporary (while construction lasts and during daytime). Use of the access roads after construction is finished, mostly by locals might have strong impact on local mammal fauna if the roads are used for poaching, steeling wood, dumping hard litter etc. Therefore, it is recommendable the new access roads to be closed (with ramps) after construction of the expressway is finished which prevents abuse of such infrastructure. On the other side, unpaved roads, which is case with most of the access roads in the project area are not contributing to fragmentation and can be beneficial for large carnivores and are frequently used by them for movement. Anyway, the newly constructed access roads do not penetrate deep in the biocorridor but are adjacent to the expressway route so the impact from them is not significant especially on the long period.

Cumulative impact assessment

The assessment of cumulative impacts considers the impact from construction of the expressway Kriva Palanka – Dlabocica with other existing infrastructure that causes fragmentation, degradation, disturbance or any other significant negative impact on the wider project area. In order to assess the cumulative impacts, it is important to include the survey analysis as well as other spatial data on the movement corridor and the area in general (Google Maps, 2024).

Due to the reason that the rural part of the region is poorly developed the only major infrastructure that should be considered is the existing regional road that connects the towns Kriva Palanka and Kumanovo which at the same time is used as the main connection with Bulgaria. The route of the existing regional road follows the valley of Kriva Reka and is situated at lower elevation than the route of the new expressway. Beside the few river bridges the route of the regional road is basically without suitable passages for larger wildlife in the section between Kriva Palanka and Dlabocica and the biocorridor area German-Osogovo. Taking the previous into consideration, it is clear that the existing regional road is the source of potential impact on fragmentation and interruption of animal migration. During the construction phase of the expressway route the cumulative impact from both infrastructures is emphasized and imminent. However, after the construction of the expressway most of the traffic would switch from the regional road and the regional road will serve as a local road (if not closed for use) with low traffic and lower traffic speed. In the following period it should be expected that the expressway will lower the cumulative impact of both routes due to many wildlife passages and redirection of the traffic from the regional road.

4.3 Effectiveness of mitigation measures.

During the different processes of planning and construction of the expressway Kriva Palanka – Dlabocica a comprehensive list of mitigation measures have been listed and suggested for implementation (ESIA, Biodiversity Management Plan, Impact Assessment analysis, etc.). The mitigation measures have been developed to target Landscape, Flora, Fauna and Habitats as well as specific sensitive species or periods in their life cycle (ex. reproduction).

The conducted study of the project area (with focus on the biocorridor German – Osogovo) monitoring the wildlife through field visits and using monitoring techniques like camera traps and transect tracking and monitoring of habitat loss through remote drone imagery have not revealed significant impact from the construction activities on the species and habitats of interest as also mentioned previously in this report. The most common impact during construction phase mentioned in the field reports (to improve implementation) was occasional littering found along the construction site, addressed as an issue also during the training of the construction staff.

Other mitigation measures like remediation of Depo Areas for excessive material are yet to be finished after the construction is completed. Another important set of mitigation measures is foreseen for the operation phase when the permeability of the expressway must be ensured for un-obstructed movement of terrestrial fauna on both sides of the road.

Table 9. List of mitigation measures targeting different impact at different phases and the effects from their implementation

Mitigation measure	Effects from implementation
Mitigation measures for flora (habitats)	
Along the road section, the vegetation clearing area will be limited to the road section and adjacent working ground	No significant impact (habitat loss) detected through drone imagery.
the construction of access roads, warehouses, parking lots and useful service areas, clearing of vegetation land will be limited to the area occupied by these facilities	No significant impact (habitat loss) detected through drone imagery.
The access roads for accessing the working areas will be constructed with width of 3,5 m, only at certain important points of crossing and maneuvering they will be wider	No significant impact (habitat loss) detected through drone imagery.
Any area affected by the construction works that is not going to be permanently occupied by the road structures should be restored to a state as close to the original conditions as possible through reinstatement activities, using native plant species from the surrounding areas	Action to be further completed.

Workers will be trained prior to construction work and during construction to increase their awareness and responsibility for the value of the surrounding natural environment, including vegetation	Trainings for the construction workers conducted.
Mitigation measures for fauna	
Construction activities will be scheduled to avoid mating season and other sensitive seasons or parts of the day, especially in areas where more sensitive species are associated in common habitats	Field survey did not discover presence of sensitive species in the study area.
All equipment and personnel movements will occur within the established construction works site and access roads	Field survey did not detect significant equipment and personnel movements in the natural habitats beyond the construction site.
Hunting of wildlife in the area of the construction works by workers will be prohibited	Field survey did not detect any sign of construction workers hunting/poaching.
The waste generated during the feeding of the workers from the construction site to be collected every day and to be properly disposed of in appropriate locations for communal waste	Field visits of the survey area could detect very occasional littering in the construction zone with unknown origin, however it had no significant impact.
To prohibit keeping and free movement of stray dogs in the area of the construction site and to prohibit the feeding of stray dogs by construction workers.	The field survey managed to detect presence of dogs at almost all camera trapping sites, but these events could not be related to the construction workers due to general presence of stray dogs in the wider area.

5. Conclusions and recommendations

- The construction of Expressway A2, LOT 2: Sub-section Kriva Palanka – Dlabocica" is a national strategic priority. The construction of large linear infrastructure projects inevitably impacts the natural environment, with the severity varying in intensity, duration, and extent. Implementing appropriate mitigation measures and strategies is crucial to achieve a balance between development needs and environmental preservation.
- The route of the expressway is transecting the landscape corridor German-Osogovo identified for movement of large carnivores, especially brown bear. Large carnivores are known to have large home ranges and low reproduction rate, therefore are susceptible on large scale fragmentation and disturbance of their suitable habitats.
- Although the biocorridor is identified based on brown bear requirements for movement, its presence was not confirmed through more than 3 years of constant monitoring of the area adjacent to the route. Wolf was the only large carnivore species detected, occurring at few locations and events. Although poorly recorded, the identified corridor is of big importance for large carnivores and their prey species on a regional scale but also transborder because all three large carnivores are found to be present (permanently or temporary) in one or both transboundary sites (German Mt. and Osogovo Mts.) that the biocorridor connects.
- The impact from construction of the expressway on large mammals and their habitats was assessed at different phases of the project based on the existing data and reports, literature data, and data obtained from two monitoring techniques (tracking and camera trapping) as well as drone imagery of the survey area.
- The initial impact assessment resulted in production of a Biodiversity management plan and a set of mitigation measures proposed for implementation.
- Results from our survey (periodic and final) showed that the construction of the expressway haven't created a significant impact on large mammals including large carnivores. This could be concluded through several points: a) direct habitat loss (heavily disturbed or areas cleared of vegetation) were only a small portion (1%) from the available habitats within the biocorridor area; b) Disturbance did not caused avoidance of the impacted area but rather the species composition and frequency of occurrence were relatively constant with the exception of wolf which was present in the study area only in the first months of the monitoring. Its absence in the rest of the study could not be tightly related to impacts although it is possible. The methods used are mostly suitable to detect presence, but absence is hard to confirm; c) The biocorridor did not suffer complete fragmentation because as mentioned above the most important landscape features for mammal movement are the narrow valleys with shrub or forest which were not blocked but the road goes above, so these viaducts and many other passages along the route provided the permeability of the biocorridor during construction but afterwards as well (operation).
- The mitigation measures suggested were mostly implemented with some remarks for littering (food package leftovers) noted on several occasions. Remediation is yet to be implemented resulting with returning some of the lost habitats due to opening Depo Areas and access roads back to its natural state.
- Finally, when the expressway will be finished and used, we recommend to plan a further monitoring of its permeability. Many reports of the state of highways in the Balkan countries are pointing to permeability structures (viaducts, culverts, underpasses, overpasses) being blocked or structures damaged or used inappropriately by locals causing disturbance and obstructing the permeability of those structures for large mammals known to be shy and cautious avoiding risky contact with humans. We suggest a periodic inspections of these

permeability infrastructures and periodic monitoring on certain spots to obtain information if the local terrestrial mammals are using these passages and if the biocorridor have kept its function.

6. Literature

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