AUTOCESTA RIJEKA-ZAGREB d.d.
DRUŠTVO ZA GRAĐENJE I GOSPODARENJE AUTOCESTOM

LIFE DINALP BEAR

LIFE13 NAT/SI/000550

REPORT ON THE BROWN BEAR MOVEMENTS AROUND OR OVER THE HIGHWAY RIJEKA-ZAGREB

Action D.2: Report on brown bear movement around or over the highway Rijeka - Zagreb with the evaluation of the effectiveness of the implemented measures - the confirmation and demonstration of the best practice method.

Prepared by: Bojan Vivoda, Đuro Huber, Daniele De Angelis and Slaven Reljić

Zagreb, 2019

Table of Contents

GPS-collared bears crossing the Rijeka-Zagreb highway

1. Introduction

Connectivity is the single most important factor determining habitat quality (Taylor et al. 1993). On the other hand, transportation routes are the single strongest fragmenting factor of the habitat (Shepard et al. 2008). In Croatia there are over 1000 km of fenced highways, and about 319 km fall within the brown bear range. Due to the topography and to the specific mitigation measures 43.6 km (13.6%) are considered permeable to bears and other ground dwelling animals, as the highway is passing through tunnels, over viaducts or bridges, or under specifically constructed wildlife crossing (i.e. green bridges). However, despite the existing mitigation measures, bears can occasionally overpass the wire mesh fence that surrounds most exposed traits of the highway and do get on the lane. Collisions between brown bears and human vehicles are one of the most relevant causes of human-induced bear mortality in Slovenia and Croatia (Huber et al. 1998; Kaczensky et al. 2003), and more than 200 bears killed by collisions with human vehicles and trains have been recorded between 2004 and 2017 only in Croatia. Studying how bears interact with road infrastructures can provide useful indications to guide management actions aimed at limiting both human and bear fatalities. In particular, using high-resolution Global Positioning System (GPS) transmitters to track bears during their movements makes possible not only to evaluate locations and frequency of road crossing events for GPS-tracked bears, but also to develop statistical models based on habitat selection analyses to estimate the probability of bear passage between habitat patches across the landscape.

2. Methods

In the framework of LIFE DINALP BEAR project, seven male bears were captured in Croatia in the area surrounding the Rijeka-Zagreb highway (between 2015-2018) and were equipped with GPS-collars (Vectronic Aerospace GmbH). To be able to determine as close as possible the location where bears crossed the highway, the Virtual fence tool implemented in Vectronic collars was used to define a buffer of 1000 m on each side of the highway. Within this buffer, the temporal resolution of data collected through GPS collars increased from one bear localization per hour to one every 15 minutes. By visualizing such highly detailed movement data in a Geographic Information System (GIS) environment, we were able to assess the number of bear crossings occurred over or under the highway lane, identifying the type of crossing structure used by bears when crossing the highway. This was also possible thanks to manual mapping of all potential crossing structures along the Rijeka-Zagreb highway (see Kusak et al. 2009). To identify most probable locations of bear crossing events, we linearly interpolated bear GPS relocations of each animal, creating individual bear tracks (Figure 1).

We analyzed high-resolution steps (lines between two consecutive GPS locations acquired every 15 minutes) aiming at discerning between bear crossings occurred through crossing structures (i.e. those avoiding direct passage of bears on the highway lane) and those occurred through fence overstepping. We assumed that bear steps falling in the surrounding of a crossing structure occurred on that crossing structure, as despite the high resolution of bear GPS relocations the angle of a bear trajectory might cause bear steps falling on the highway lane. For this reason we created a 200-m buffer around all the structures that bears could have used to walk above or under the highway lane. We then classified bear crossing events as occurred on crossing structures, if i) bear GPS locations were located on the very crossing structure; ii) a

high-resolution step intersected the highway on the crossing structure; iii) a high-resolution step intersected highway within a 200-m buffer around crossing structure. Conversely, we classified bear crossings as occurred on the highway lane (i.e. fence overstepping) if bear trajectory intersected the highway further than the 200-m buffer around crossing structures.

Figure 1 Setting foot snares for capturing brown bears to be marked for Geographic Positioning System (GPS) telemetry tracking

3. Results

3.1. Bears tracked

Table 1. GPS tracked bears in LIFE DINALP BEAR project. As the "added value" shown are also the GPS tracked bears within Plitvice Lakes National Park project in 2016.

Animal ID	Name	Collar ID	Deployed	End	N days	Fate	Comment about status and symptoms
B43	B43-Slavko Male 170 kg	17067	20.05.2015	09.08.2016	447	Worked OK	13190 fixes
B44	B44-Bojan Male 186 kg	17069	28.05.2015	28.02.2016	276	Stopped	Shed collar was dead when found by hunters. 4834 fixes. VECTRONIC replaced collar free of charge.
B45	B45-Matej Male 178 kg	17068	30.05.2015	31.05.2015	1	Shed collar	Found and used again on bear Slaven2

Animal ID	Name	Collar ID	Deployed	End	N days	Fate	Comment about status and symptoms
B46	B46-Slaven2 Male 100 kg	17068	12.06.2015	05.02.2016	238	Stopped	Drop off remotely by visual location as collar was dead. Made 4333 fixes. Wires that connect battery were broken;
B47	B47-Vedran Male 73 kg	17066	12.06.2015	13.11.2015	154	Malfunctioned	Collar retrieved from a legally hunted bear.
B58	Miro Male 68 kg	17067	05.06.2018.	01.07.2018.	26	Shed the collar	640 fixes
B59	Simon Male 49 kg	17066 ex Vedran	09.06.2018.	01.07.2018.	22	Shed the collar	714 fixes
B60	Miljenko Male 220 kg	22053	16.06.2018.	29.04.2019,	318	Trtain killed	7881 fixes
Plitvice Lakes NP collars							
B48	B48-Lana Female, 80kg	17075	08.05.2016	09.08.2016	93	Active and OK	3626 fix attempts
B49	B49-Runja Male, 184 kg	17076	09.05.2016	19.05.2016	10	Shed collar	Collar picked and placed on Nikola
B50	B50-Nikola Male, 109 kg	17076	19.05.2016	09.08.2016	82	Shed collar	Collar picked and placed on Daniel
B51	B51-Jakov Male, 39 kg	9485	26.05.2016	09.06.2016	14	Illegally shot	WOLF COLLAR placed on a bear cub, 385 fixes.
B52	B52-Daniel recapture, Male, 176 kg	21873	09.05.2016	16.08.2016	99	Active	1582 fixes.
B53	B54-Jasna Female, 101 kg	21872	26.05.2016	09.06.2016	14	Stopped	No VHF signal, no data coming in! (161 fixes)

Figure 2 Radiocollared bear B43 "Slavko" for Geographic Positioning System (GPS) telemetry tracking

Figure 3 Bear B43 "Slavko" with the GPS radicollar

3.2. Results of tracking

During the study period (2015-2018) we classified 64 crossings, of which 61 were attributed to crossing structures, and three to the highway lane. Over seven GPS-tracked bears, five crossed the highway multiple times (B43-Slavko, B44-Bojan, B46-Slaven2, B47-Vedran, B60-Miljenko), whereas two bears (B58-Miro and B59-Simon) were never observed on the southern part of the highway (Figure 2). Forty-nine bear crossings occurred in areas where the highway is in tunnels, 10 where it is on viaducts, one occurred under a small underpass, and only three possible crossings likely occurred over the fence (Figure 3). Crossing events never occurred on the green bridge “Dedin”, although one bear approached it, eventually preferring a larger crossing spot located over a tunnel (Figure 4).

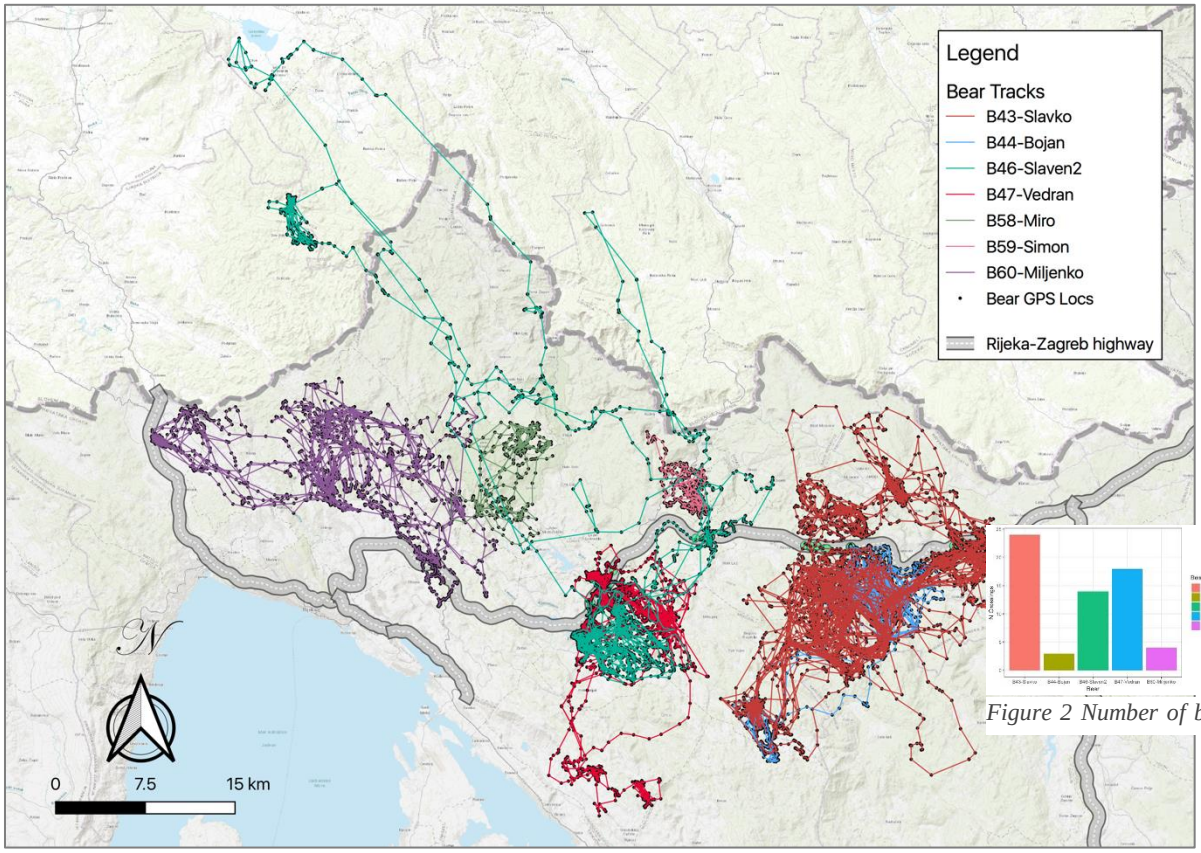

Figure 2 Number of bear

Figure 4. Geographic Positioning System (GPS) locations of seven male bears captured between 2015 and 2018 in Croatia.

Each colored track represents the path followed by a bear.

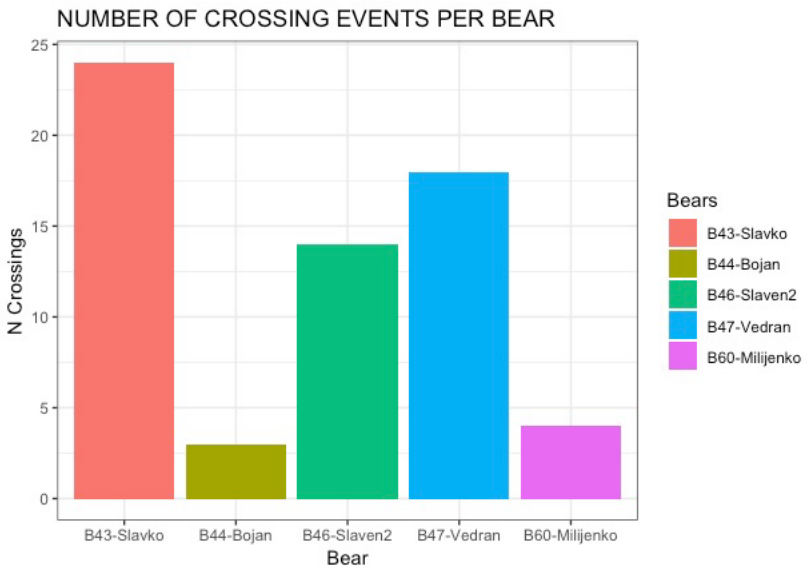

Figure 5. Number of bear crossing events per bear. Bears B58-Miro and B59-Simon never crossed the highway.

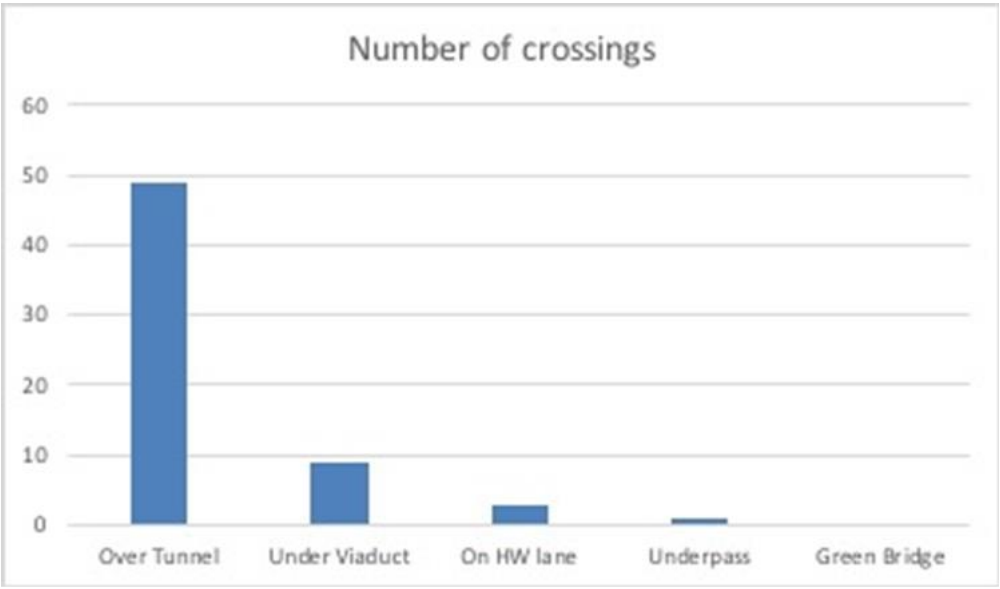

Figure 3 Number of bear crossing events occurred over tunnels, under viaducts, beneath underpasses,

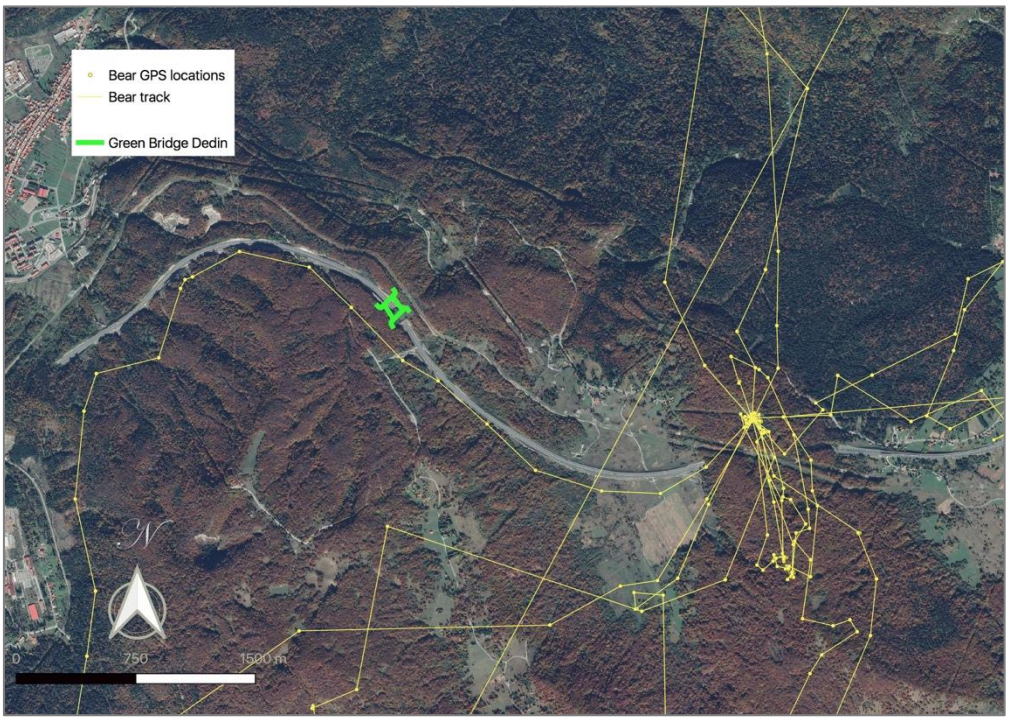

Figure 7 Movements of bear BXX "Slaven2" along the highway fence for about 7 kilometres is search for a crossing place. He passed the green bridge "Dedin" (in green) without using it for crossing. A few kilometres later he crossed the highway over the forested tunnel "Sleme", that he also used multiple times before and after

4. Discussion

Although the Rijeka-Zagreb is largely located in a core area for bear presence (i.e. Gorski kotar), we observed multiple bear movements across the highway, with bears moving especially through those traits where the highway passes either under tunnels or over viaducts (Figures 1,4). In these areas, in facts, the habitat between both sides of the highway is continuous and probably bears perceive very little or no traffic-related disturbance, likely also thanks to the relatively large width of the structure (about 850 m in length). On the other hand, green bridges were never used by bears collared in the framework of LIFE DINALP BEAR project, although previous studies based on both bear tracks and GPS locations demonstrated bear use of green bridge "Dedin" (Kusak et al. 2009). Nevertheless, green bridges did not seem to be among the preferred crossing structures used by the bears GPS-tracked in our study for moving between the two sides of the highway. Arguably, the greater width of tunnels and viaducts, as compared to the 100-m width of "Dedin" green bridge, played an important role in supporting multiple bear passages. Habitat cover over green bridges might be another important factor influencing the probability of bear use, as arguably bears are less prone to traverse poorly covered areas. Bear 'B60' moved repeatedly nearby the north-west side of the highway without crossing it, which suggests that electric fences in that part of the highway correctly worked in keeping the bear out of the lane, but might also suggest that that trait of the highway is not sufficiently permeable to bear movement, as the animal was never observed on the other side (Figure 1). Overall, our findings are relevant, as on one hand they show that the Rijeka-Zagreb highway is not

completely impermeable to bear passages, as bears can move between both sides benefitting of those enough large traits where the lanes are under tunnels or over viaducts; on the other hand, they also provide some indications that the currently available green bridges might not be sufficiently suitable to be frequently used by bears, due to their width or to the composition of the vegetation cover.

5. References

Huber, D., Kusak, J., and Frkovic, A. 1998. Traffic Kills of Brown Bears in Gorski Kotar, Croatia. Ursus **10**: 167–171. doi:10.2307/3873124.

Kaczensky, P., Gossow, H., Knauer, F., Krze, B., Jonozovic, M., and Adamic, M. 2003. The impact of high speed, high volume traffic axes on brown bears in Slovenia. Biol. Conserv. **111**: 191–204.

Kusak, J., Huber, D., Gomerčić, T., Schwaderer, G., and Gužvica, G. 2009. The permeability of highway in Gorski kotar (Croatia) for large mammals. Eur. J. Wildl. Res. **55**(1): 7–21. doi:10.1007/s10344-008-0208-5.

Shepard, D.B., Kuhns, A.R., Dreslik, M.J., and Phillips, C.A. 2008. Roads as barriers to animal movement in fragmented landscapes. Anim. Conserv. **11**(4): 288–296. doi:10.1111/j.1469-1795.2008.00183.x.

Taylor, P.D., Fahrig, L., Henein, K., and Merriam, G. 1993. Connectivity is a vital element of landscape structure. Oikos **68**(3): 571–573. doi:10.2307/3544927.