



LIFE  
DINALP  
BEAR

Population level management and  
conservation of brown bears in northern  
Dinaric Mountains and the Alps



# MONITORING OF THE EFFECTIVENESS OF MITIGATION MEASURES IN SLOVENIA

*Action D.2: Evaluation (monitoring) of the  
effectiveness of mitigation measures  
implemented to prevent traffic related  
bear mortality*

August, 2017



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## 1 INTRODUCTION

Highways, roads and railways can have negative impacts on bears and many other species of wildlife. Bears killed by motor vehicles and trains are a significant part of the total documented bear mortality in Slovenia (Al Sayegh Petkovšek *et al.*, 2015a; Figure 1). Additionally, bear-vehicle collisions represent an important risk to drivers and passengers. Overall, vehicle-related mortality of bears represents a risk to long term viability of bear population in Slovenia; moreover, highways represents barriers to bear movement and can reduce connectivity of population(s). Therefore, mitigation measures were implemented along the main road Ljubljana – Kočevje (installation of dynamic signs and acoustic deterrents) and along the railway Ljubljana – Postojna (Rakek) and Postojna - Prestranek (installation of acoustic deterrents) to reduce traffic related bear mortality in Slovenia.

With the aim to monitor the effectiveness of mitigation measures along the selected road sections of the main road Ljubljana – Kočevje and the selected railway sections between Ljubljana – Postojna (Rakek) and Postojna - Prestranek, the following activities were performed in years from 2015 to 2017: (i) monitoring of wildlife (including brown bear) in the very close vicinity of dynamics signs with the use of camera traps; (ii) measuring the speed of vehicles along the road section between Dolenja vas and Gornje Ložine (Jasnica) and between Ortnek and Žlebič; and (iii) collecting data regarding traffic mortality of brown bear at selected road and railway sections, respectively.

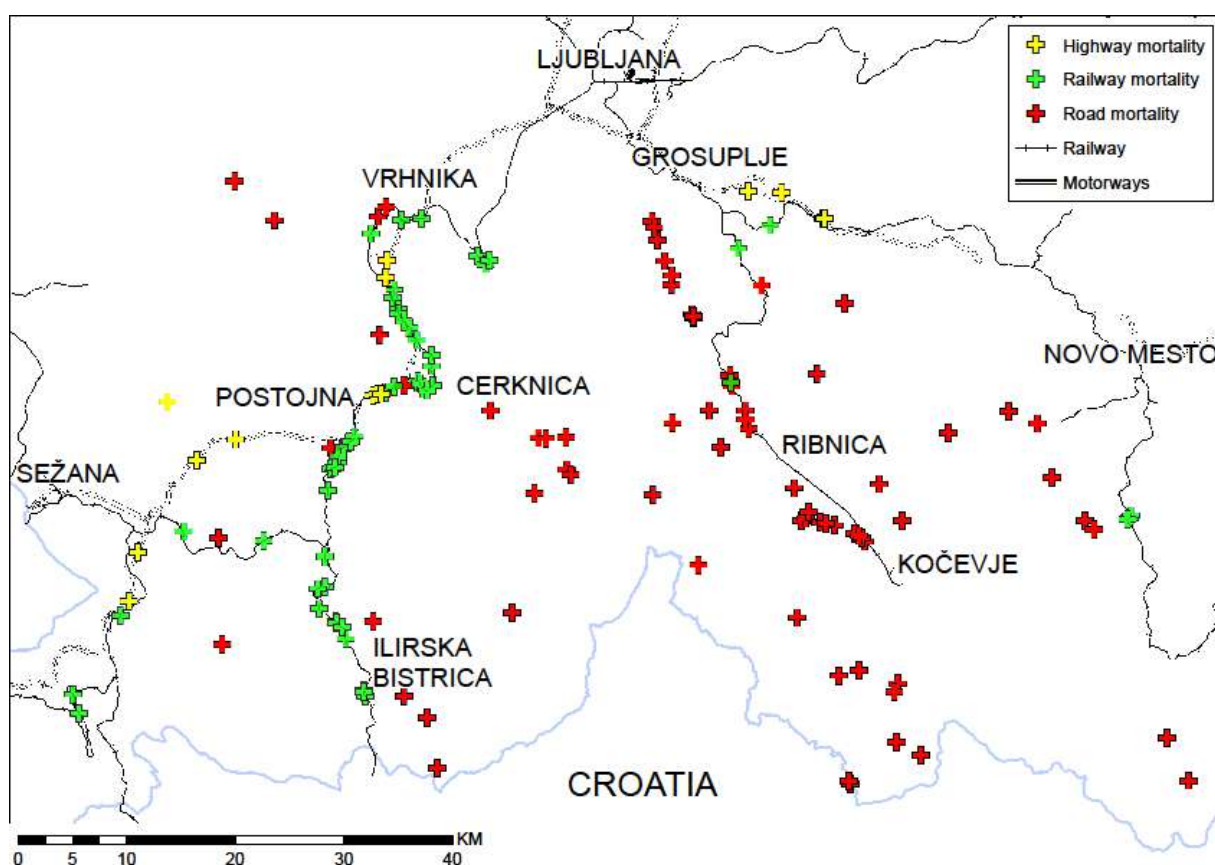


Figure 1: Map of locations of reported brown bear mortality on highways, roads and railways in Slovenia for the period 2004 – 2014 (Al Sayegh Petkovšek *et al.*, 2015a).



## 2 MITIGATION MEASURES IMPLEMENTED TO PREVENT TRAFFIC RELATED BEAR MORTALITY

### 2.1 DYNAMIC TRAFFIC SIGNS ALONG THE MAIN ROAD LJUBLJANA – KOČEVJE

Dynamic traffic signs were placed along two sections of the main road Ljubljana – Kočevje (between Zgornje Lozine and Dolenja vas (Jasnica) and between Ortnek and Žlebič) to alert and slow down drivers in order to avoid potential collisions with wildlife, including bears. Dynamic signs are coupled to sensors capable to detect large animals approaching to the roadways (see Figure 2). In the case of approaching bear (or ungulates), the signs light on and send the message to the driver that an animal is approaching the road. Since the sensors are not bear-specific, they provide also higher road-safety considering collisions with other large mammals, particularly ungulates.

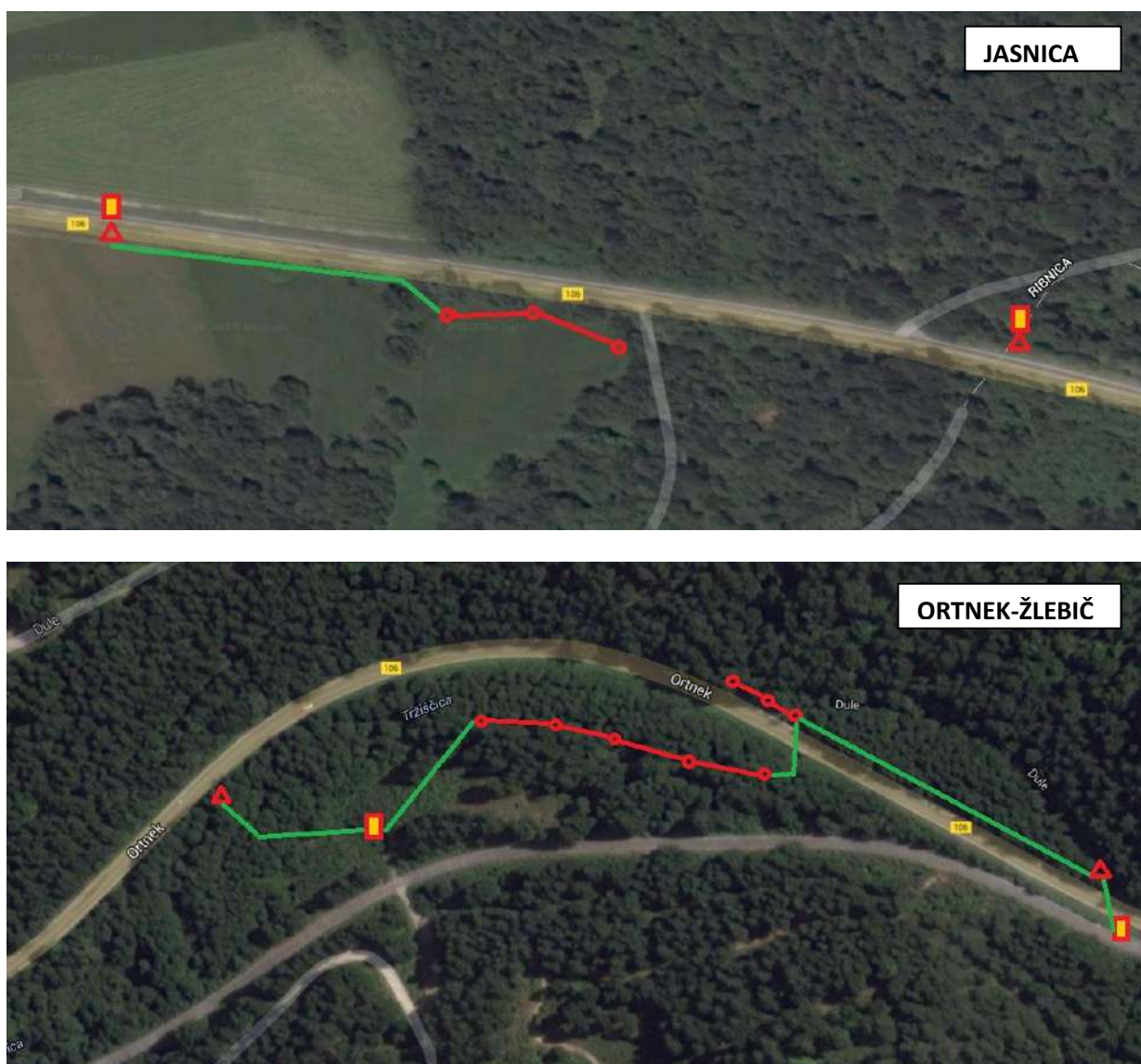


Figure 2: Dynamic traffic signs are coupled to sensors (red line), power lines (green line), solar cells (yellow rectangle) and traffic signs (triangle).





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Figure 3: Dynamic traffic signs were placed along two sections of the main road Ljubljana – Kočevje (above: Ortnek; below: Jasnica) (photo: Z. Pavšek, 2016).



## 2.2 INSTALATION OF ACUSTIC DETERRENTS ALONG SELECTED RAILWAY SECTIONS

Acoustic deterrents were installed on electric poles along the railway sections Rakek – Postojna and Postojna – Prestranek, where it was stated by field inspection that crossing of wildlife (especially brown bear) is possible (see Figures 5, 6, 7).



Figure 4: Two types of electric poles to which we installed acoustic deterrents (photo: Z. Pavšek, 2015).





Figure 5: Installation of acoustic deterrents on electric poles along railway sections (photo: M. Zaluberšek, 2015).



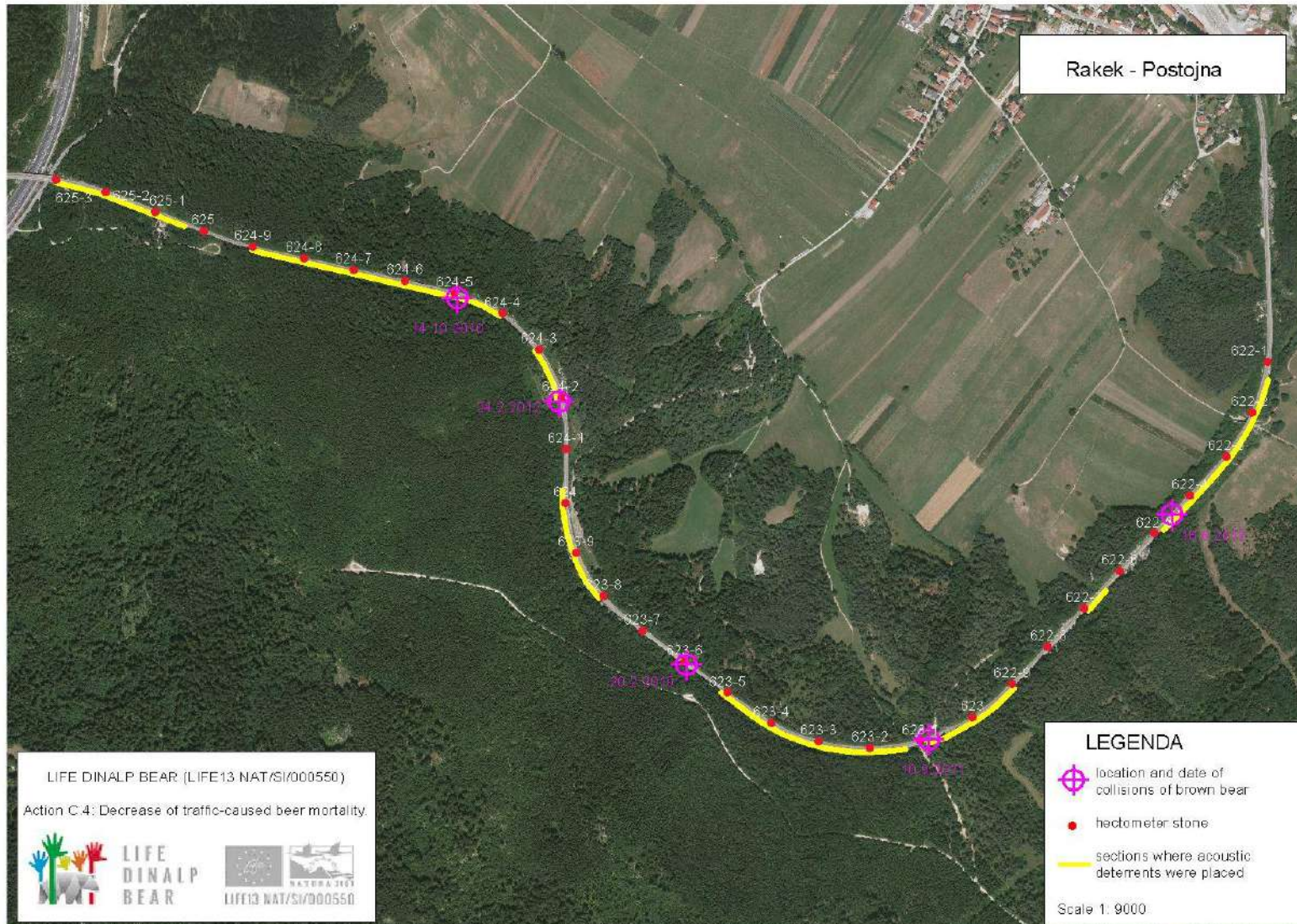


Figure 6: Selected section of the railway Rakek - Postojna with locations of the traffic related bear mortality, dates of collisions and sections where acoustic deterrents were placed.



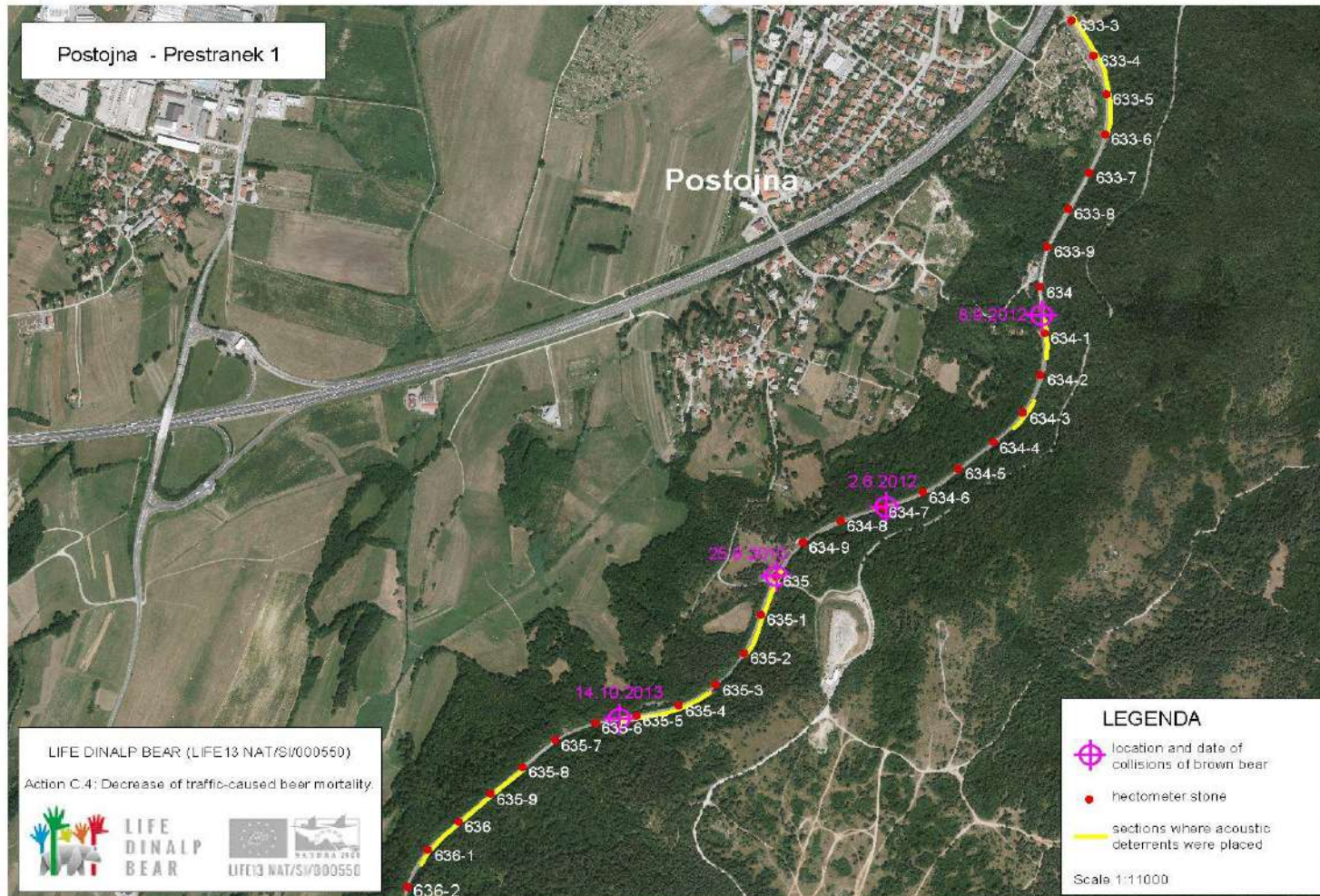


Figure 7: Selected section of the railway Postojna - Prestranek with locations of the traffic related bear mortality, dates of collisions and sections where acoustic deterrents were placed.



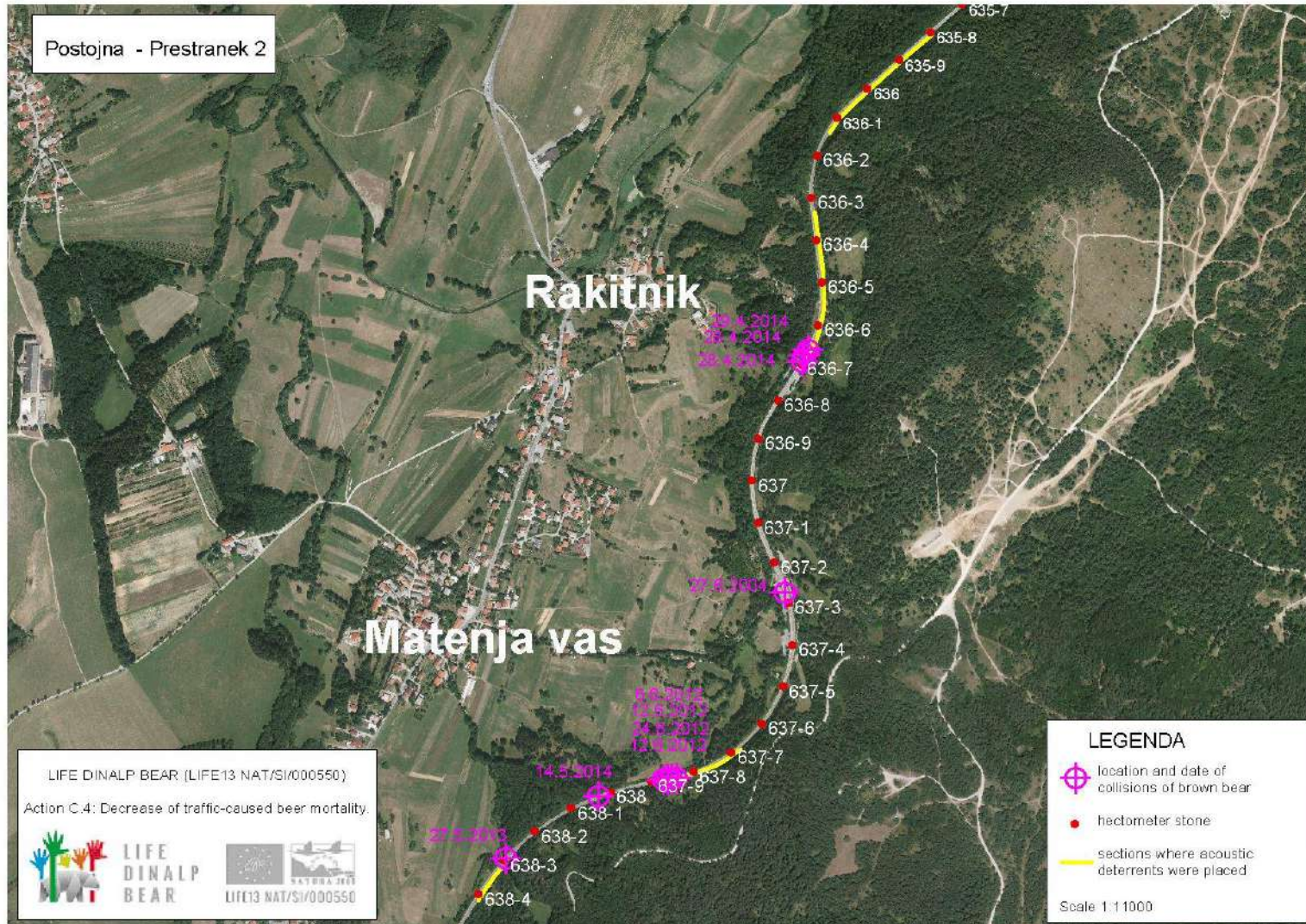


Figure 8: Selected section of the railway Postojna – Prestranek with locations of the traffic related bear mortality, dates of collisions and sections where acoustic deterrents were placed.



### 2.3 INSTALATION OF ACUSTIC DETERRENTS ALONG SELECTED MAIN ROAD SECTIONS

Acoustic deterrents (ultra- and infrasound emitting electronic devices coupled with sensors activating the sound by the approaching vehicle) were installed directly into the roadside trafficators/pillars along the 'black-spots' considering bear-vehicle collisions along the main road Ljubljana – Kočevje (Figures 10-13). In total, app. 6 km of roads are protected by 240 acoustic deterrents.



Figure 9: Acoustic deterrents were installed along the main road Ljubljana – Kočevje (photo: M. Zaluberšek, 2016).



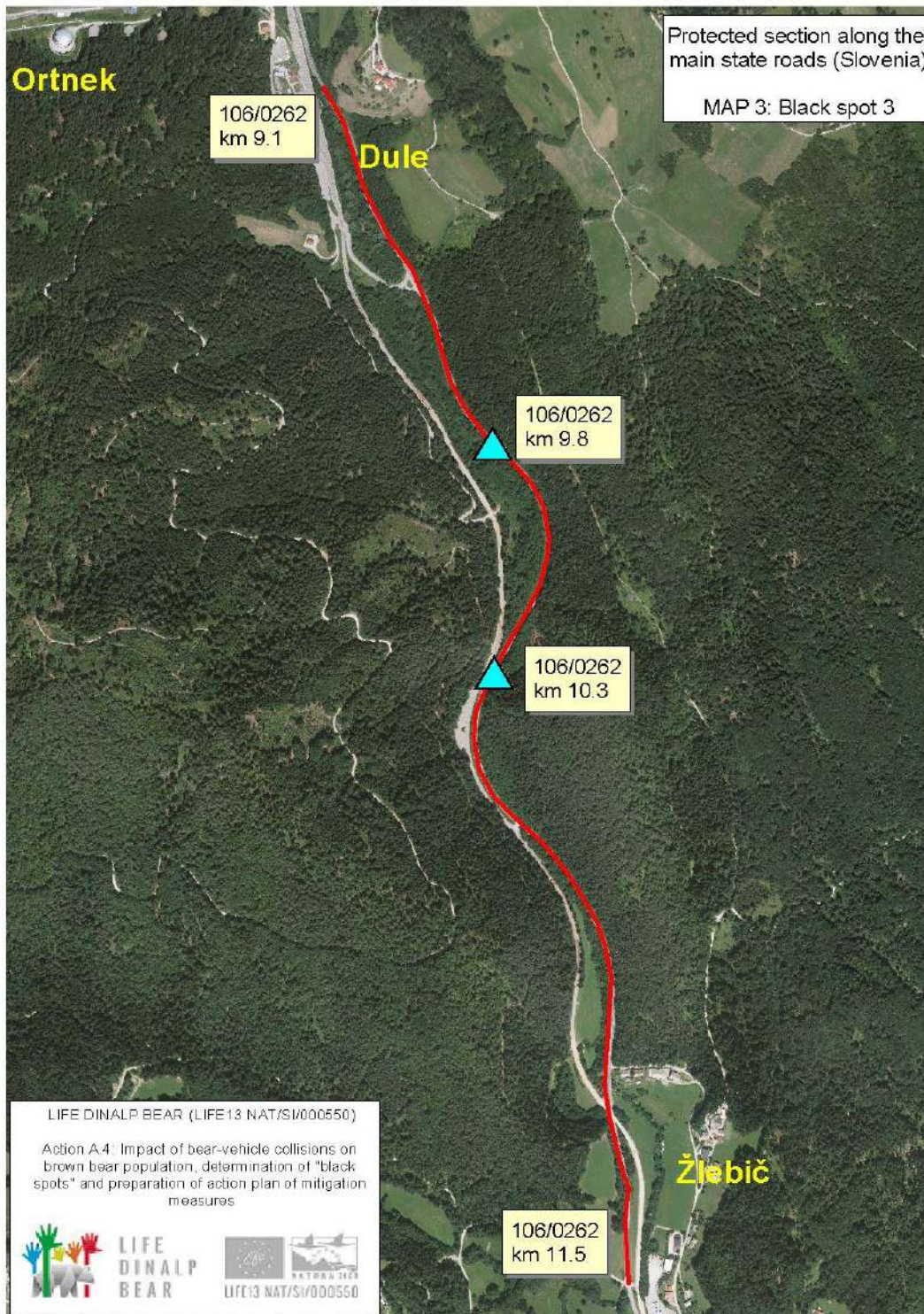


Figure 10: Selected road section along main road Ljubljana – Kočevje (between Ortnek and Žlebič), where acoustic deterrents were installed.



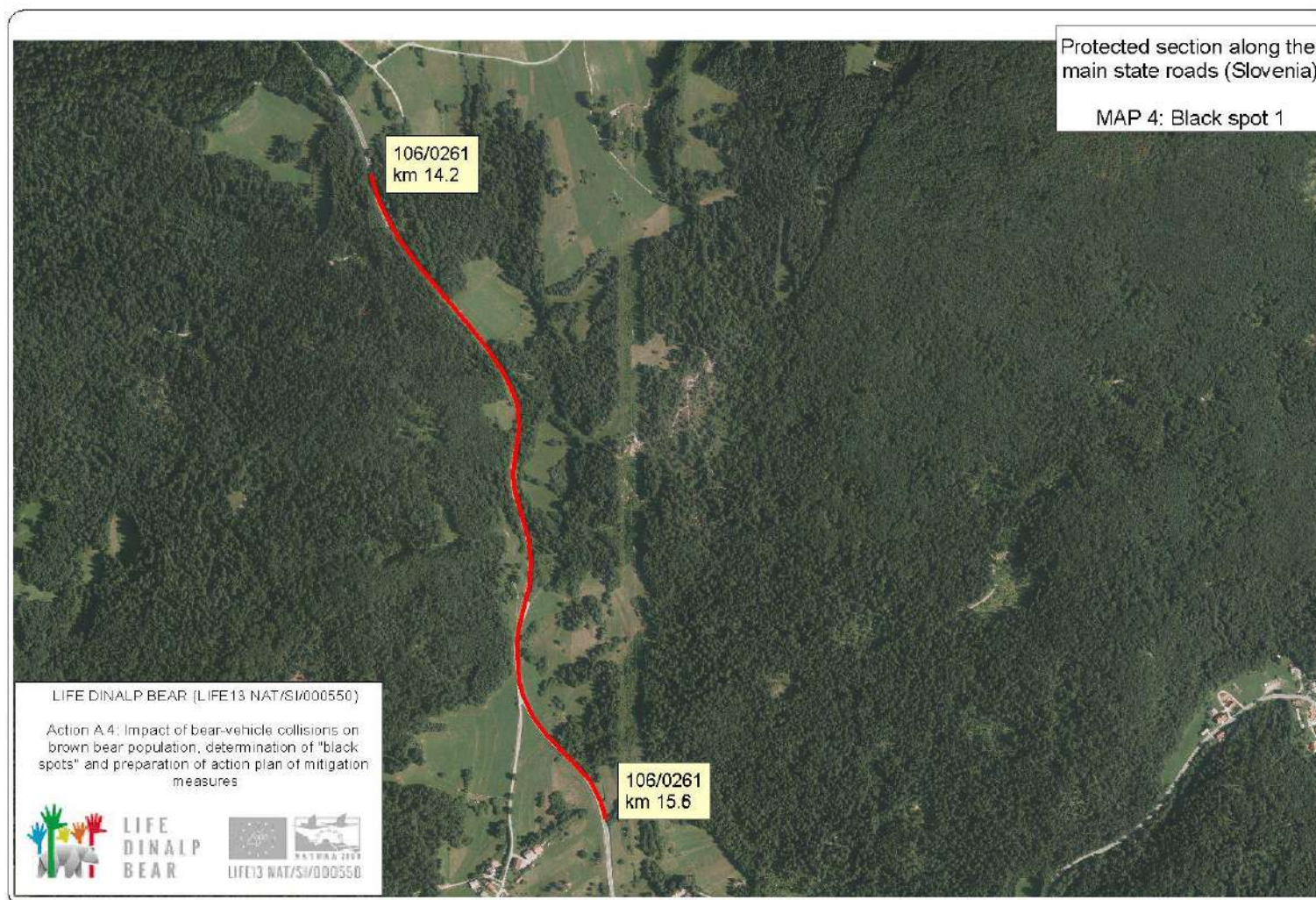


Figure 11: Selected road section along main road Ljubljana – Kočevje (near Rašica and Turjak), where acoustic deterrents were installed.



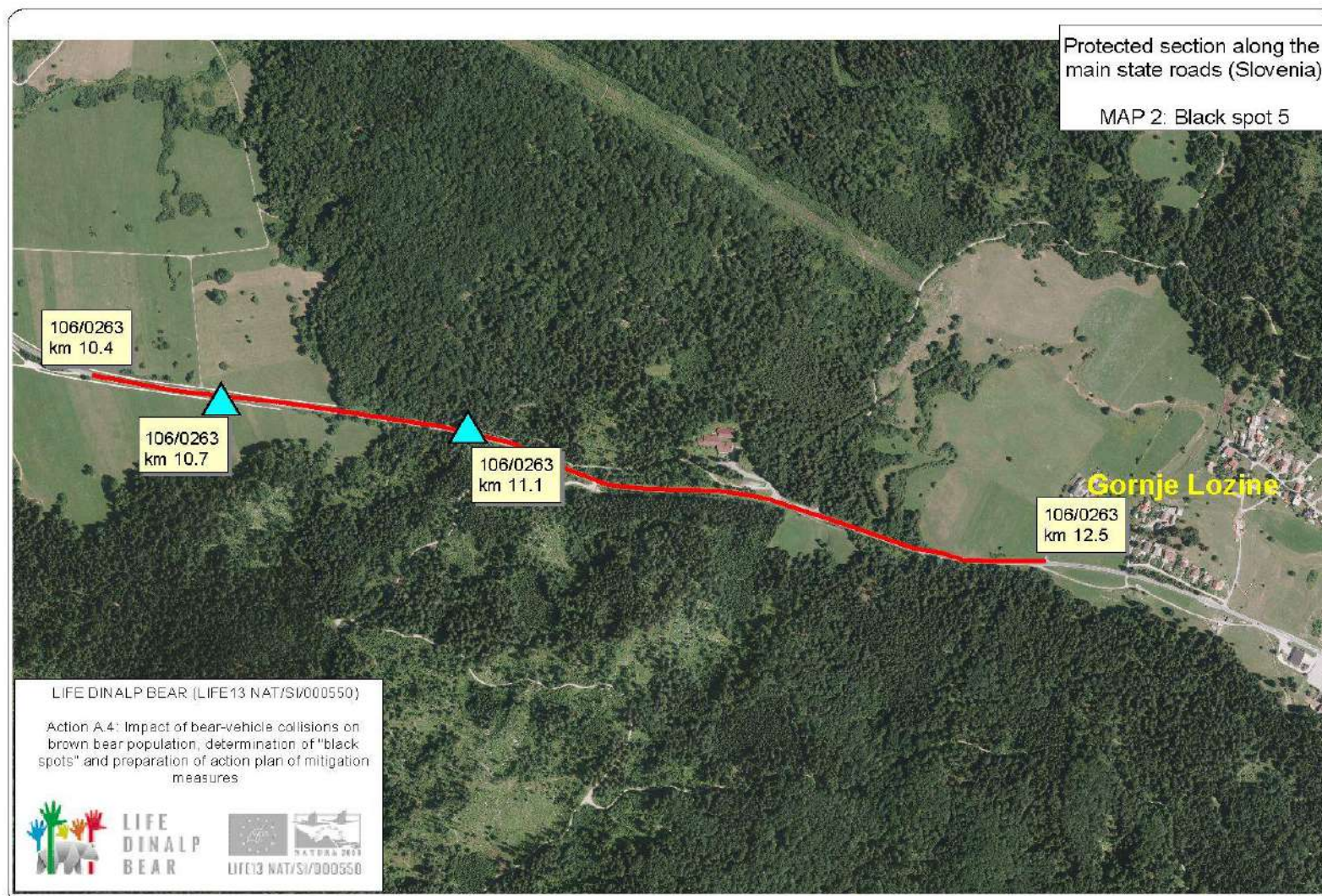


Figure 12: Selected road section along main road Ljubljana – Kočevje (Jasnica), where acoustic deterrents were installed.



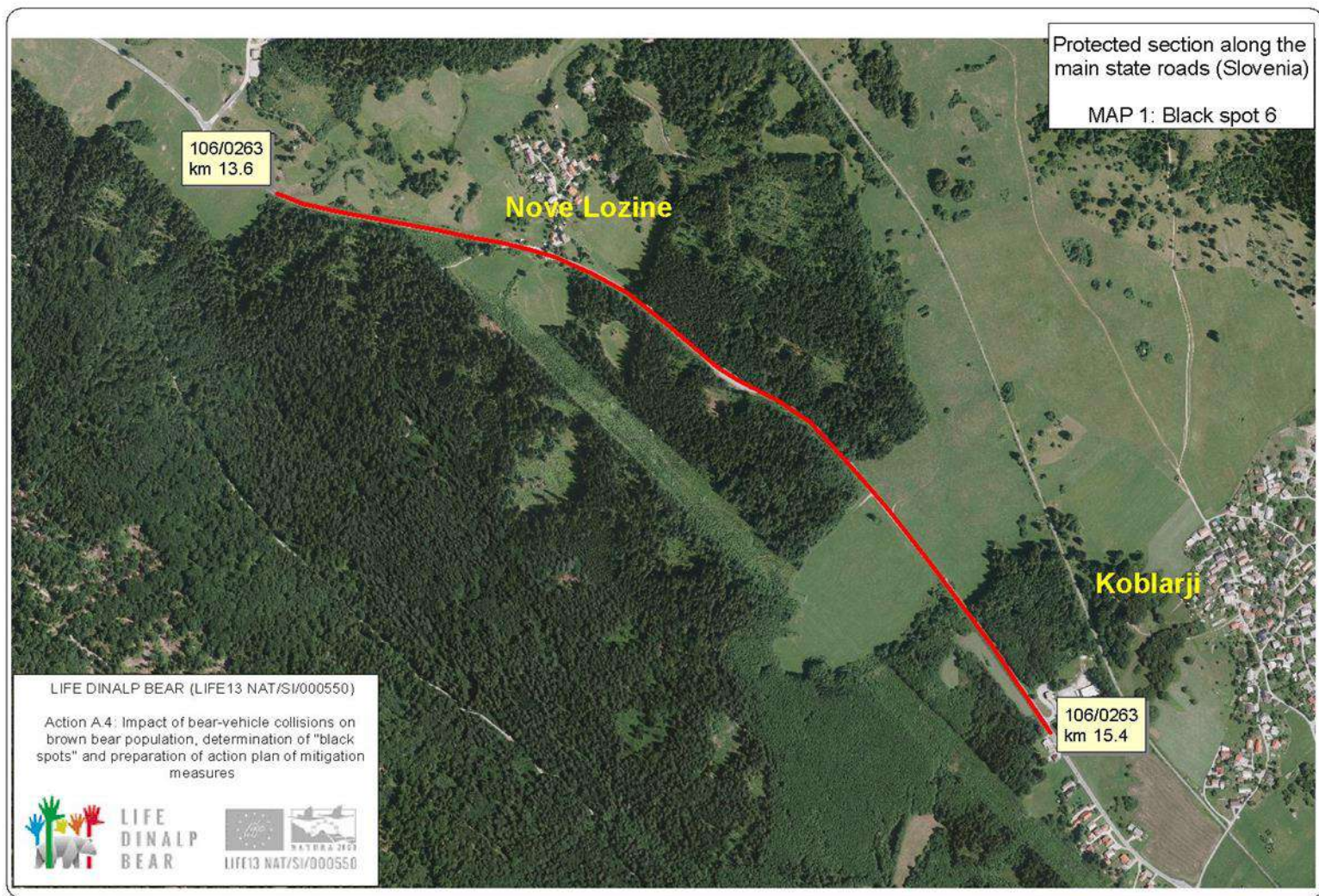


Figure 13: Selected road section along main road Ljubljana – Kočevje (near Nove Lozine), where acoustic deterrents were installed.



### 3 MONITORING OF THE EFFECTIVENESS OF MITIGATION MEASURES

#### 3.1 MEASURING OF THE SPEED OF VEHICLES IN 2015

We have measured the speed of vehicles to allow comparison of speed of different type of vehicles before installation of dynamic traffic signs and after installation. The measuring device Viacount II or traffic counter was placed on the main road Ljubljana - Kočevje between the villages Dolenja vas and Gornje Ložine (Jasnica) in the period between 9 November 2015 (12:00) and 23 November 2015 (12:00) (before installation of dynamic traffic signs on this road section) (Grebenc, 2015). Driving direction and location of measuring device are shown on the map below (see Figures 14, 15).



Figure 14: Map of location of traffic counter and driving direction along the main road Ljubljana – Kočevje (Jasnica) near Dolenja vas.

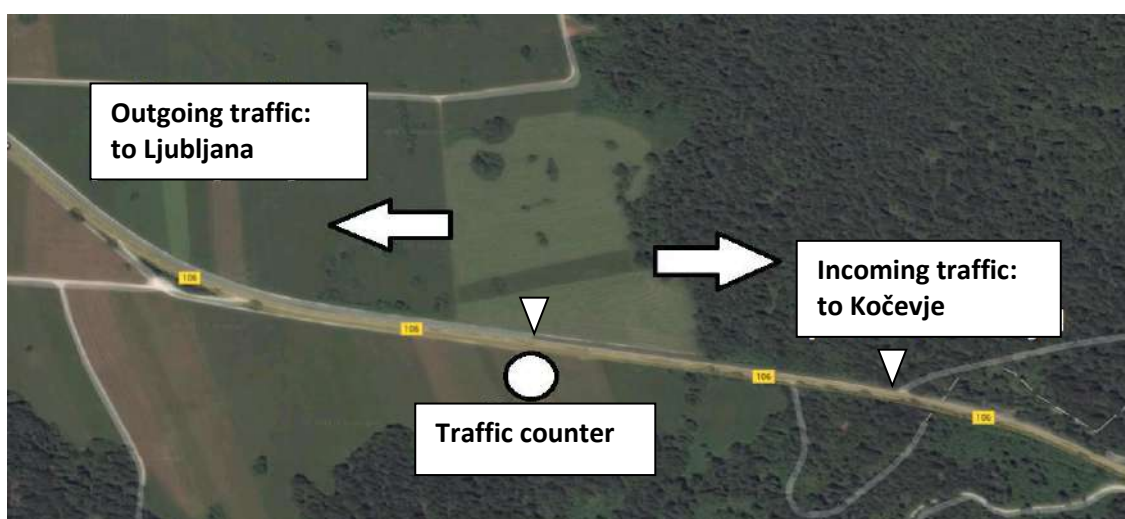


Figure 15: Location of traffic counter and direction of incoming (to Kočevje) and outgoing traffic (to Ljubljana) and location of dynamic signs (triangle), which were installed afterwards

Traffic counter Viacount II is radar device for counting and classification of vehicles according to the type of vehicle. Based on the Doppler method of measurement it provides accurate and reliable measurements. The device enables the counting and measurement of the speed of vehicles in both directions, e.g. incoming and outgoing traffic. Traffic counter was placed on the pole of traffic sign at a height of 2.3 m and 1.9 m away from the road (Figure 16). Speed limit in this section of the main road is 90 km/h.



Figure 16: Traffic counter placed on the pole of traffic sign near Dolenja vas (Jasnica).

Vehicles were divided into motors, cars, combined vehicles, trucks and semi-trailer. Characteristics of traffic for both directions (incoming and outgoing) are listed in the Table 1.

Table 1: Characteristics of traffic for both directions (incoming and outgoing).

Type	No. of vehicles	Average speed (km/h)	Max. of speed (km/h)	V85 (km/h)*
motors	293	62	141	96
cars	55.387	96	226	111
combined vehicles	15.120	94	186	109
trucks	3.518	84	109	96
semi-trailer	2.285	82	109	92
<b>SUM</b>	<b>76.603</b>	<b>95</b>	<b>226</b>	<b>110</b>

\*The 85% percentile speed.



76.603 vehicles drove past the traffic counter within two weeks. The majority of them were cars (72%); the combined vehicles were 20 %, while percentages of remaining types of vehicles were significantly lower.

The average speed of all vehicles was 95 km/h, and maximum speed was 226 km/h. 60% of all vehicles exceeded the speed limit (90 km/h), 31% of all vehicles have speed above 100 km/h and 6% above 120 km/h (Figure 18).

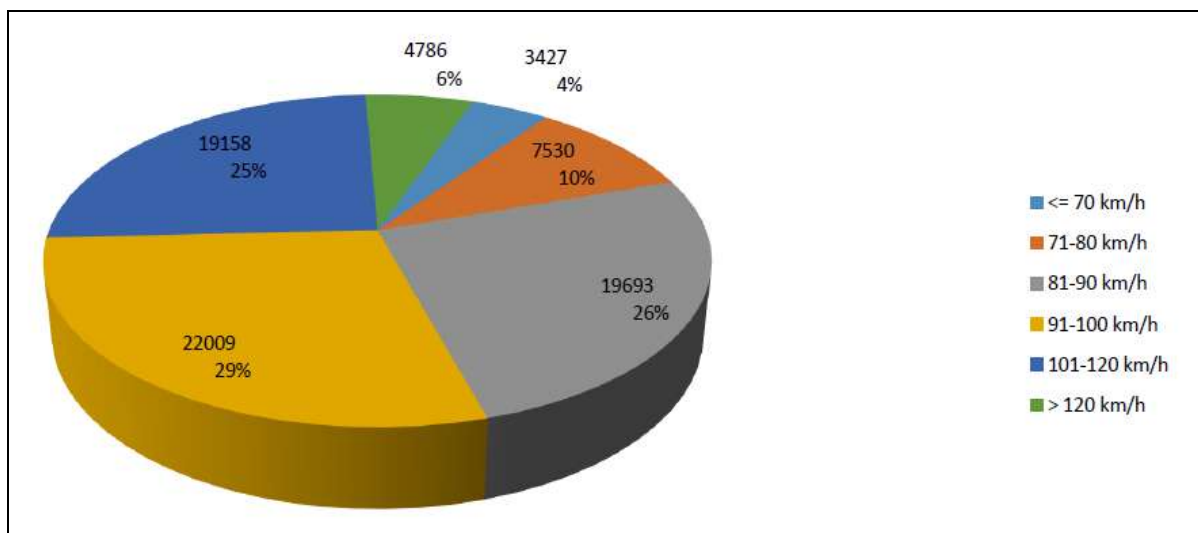


Figure 17: Percentages of vehicles which were classified in different speed classes.

Table 2: Characteristics of incoming traffic.

Type	No. of vehicles	Average speed (km/h)	Max of speed (km/h)	V85 (km/h)*
motors	98	43	115	87
cars	28.151	95	216	108
combined vehicles	7.486	95	186	111
trucks	1.667	87	102	97
semi-trailer	1.151	85	92	92
<b>SUM</b>	<b>38.553</b>	<b>94</b>	<b>216</b>	<b>108</b>

\*The 85% percentile speed.

The average speed of vehicles of incoming traffic (to Kočevje, up the hill) was 94 km/h, and maximum speed was 216 km/h. 56.6% of all vehicles exceeded the speed limit (90 km/h).

Table 3: Characteristics of outgoing traffic.

Type	No. of vehicles	Average speed (km/h)	Max of speed (km/h)	V85 (km/h)*
motors	195	66	141	99
cars	27.236	98	226	114
combined vehicles	7.634	93	184	107
trucks	1.851	82	109	95
semi-trailer	1.134	79	109	91
<b>SUM</b>	<b>38.050</b>	<b>95</b>	<b>226</b>	<b>112</b>

\*The 85% percentile speed.

The average speed of vehicles of incoming traffic (to Ljubljana, down the hill) was 95 km/h, and maximum speed was 226 km/h. 63.4% of all vehicles exceeded the speed limit (90 km/h).

### 3.2 MEASURING OF THE SPEED OF VEHICLES IN 2016

In year 2016, we monitored the impact of the activation of dynamic signs on the speed of vehicles of incoming traffic at protected sections on the main road Ljubljana - Kočevje between the villages Dolenja vas and Gornje Ložine (Jasnica) and between Ortnek and Žlebič. Traffic counter was placed on the pole with dynamics sign. The comparison between average speed during activation and inactivation of dynamic signs was done (Table 4, 5). We determined that at both locations (Jasnica and Ortnek) speed of vehicles, which passing the active dynamic signs, was significantly lower in comparison with average speed of vehicles, which passing the inactive dynamic signs. This finding was confirmed in all periods of measuring speed during inactive and active dynamics signs (Table 4 and Table 5). The reduction of speed was for app. 8 km/h (Ortnek: 77.1 km/h vs. 69.4 km/h and Jasnica: 87.6 km/h vs. 79.4 km). The reduction of speed of vehicle in year 2016 confirm the positive impact of activation of dynamic signs on driver's behaviour.



Table 4: Average speed of traffic at Ortnek when dynamic signs were active vs. inactive in 2016.

Period	Average speed (km/h)	Average speed during inactive dynamic signs (km/h)	Average speed during active dynamic signs (km/h)
27.5. - 3.6.2016	69.8	78.1	69.6
3.6. - 10.6.2016	74.9	81.2	68.8
17.6. -24.6. 016	70.4	77.8	69.6
24.6. - 1.7.2016	73.1	76.6	71.7
16.7. - 24.7.2016	71.6	77.3	70.6
24.7. - 31.7.2016	70.9	76.7	70.4
31.7. - 5. 8.2016	70.4	76.6	69.8
5.8. - 14.8.2016	71.3	77.0	70.9
26.8. - 2.9.2016	71.4	77.3	70.5
2.9 - 9. 9.2016	74.7	76.2	65.6
9.9. - 16.9.2016	73.9	76.9	71.3
16.9. - 26.9.2016	72.6	77.0	68.7
30.9. - 21.10.2016	72.2	75.9	65.0
21.10. - 16.11.2016	72.7	75.6	70.5
23.11. - 25.11.2016	74.6	76.6	69.1
2.12.-12.12. 2016	72.6	76.4	69.0
<b>SUM</b>	<b>72.3</b>	<b>77.1</b>	<b>69.4</b>

Table 5: Average speed of traffic at Jasnica when dynamic signs were active vs. inactive in 2016.

Period	Average speed (km/h)	Average speed during inactive dynamic signs (km/h)	Average speed during active dynamic signs (km/h)
30.5. - 3.6.2016	83.3	92.8	83.2
4.6. - 10.6.2016	81.5	85.4	81.4
18.6. - 24.6.2016	83.3	89.2	82.6
24.6. - 1.7.2016	83.0	86.7	81.3
1.7. - 8.7.2016	82.5	83.8	81.9
8.7. - 15.7.2016	80.5	86.6	79.6
16.7. - 24.7.2016	81.1	87.3	79.3
24.7. - 31.7.2016	85.5	85.7	74.4
31.7. - 5.8.2016	86.3	86.9	85.0
5.8. - 16.8. 2016	80.2	87.6	78.5
26.8. - 2.9.2016	76.8	85.7	75.3
2.9. - 9.9.2016	79.9	87.7	77.7
9.9. - 16.9.2016	79.6	85.7	76.1
16.9. - 26.9.2016	86.6	88.9	76.0
30.9. - 21.10.2016	89.6	91.6	79.3
21.10. - 4.11.2016	85.9	90.0	78.1
<b>SUM</b>	<b>82.9</b>	<b>87.6</b>	<b>79.4</b>

### 3.3 MEASURING OF THE SPEED OF VEHICLES IN 2017

In year 2017, we continued with monitoring of the impact of the activation of dynamic signs on the speed of vehicles of incoming traffic at protected sections on the main road Ljubljana - Kočevje between the villages Dolenja vas and Gornje Ložine (Jasnica) and between Ortnek and Žlebič. Traffic counter was placed on the pole with dynamics sign. The comparison between average speed during activation and inactivation of dynamic signs was done. We determined that at both locations (Jasnica and Ortnek) speed of vehicles, which passing the active dynamic signs, was significantly lower in comparison with average speed of vehicles, which passing the inactive dynamic signs. The reduction of speed was from 7 km/h to 15 km/h (Ortnek: 75.9 km/h vs. 69.1 km/h and Jasnica: 83.9 km/h vs. 68.9 km/h). The reduction of speed of vehicle in year 2017 confirm the positive impact of activation of dynamic signs on driver's behaviour.

Table 6: Average speed of traffic at Ortnek and Jasnica when dynamic signs were active vs. inactive in 2017.

Location / Period	Average speed (km/h)	Average speed during inactive dynamic signs (km/h)	Average speed during active dynamic signs (km/h)
Ortnek: 7.2. – 3.6.2017	71.8	75.9	69.1
Jasnica: 8.3. – 1.8.2017	77.0	83.9	68.9



Figure 18: Active dynamic sign at Jasnica (photo: Z. Pavšek, 2016).



### 3.4 MONITORING OF WILDLIFE USING CAMERA-TRAPS

#### 3.4.1 VIDEO SURVEILLANCE IN YEAR 2015

IR cameras were placed at Ortnek and Jasnica before dynamic signalizations were set up in the period between 2 November 2015 and 15 December 2015.

Table 7: Wildlife filmed during video surveillance at Jasnica between 2 November 2015 and 15 December 2015.

Latin name	Name	Date	Time of recording	No. of observed animals
<i>Ursus arctos</i>	brown bear	/	/	0
<i>Sus scrofa</i>	wild boar	12. 11. 2015	20:03:25	1
<i>Cervus elaphus</i>	red deer	26. 11.2015	03:04:44	1
		1. 12.2015	01:12:25	1
		13. 12.2015	08:14:05	2
<i>Capreolus capreolus</i>	roe deer	8. 11. 2015	18:23:49	2

Table 8: Wildlife filmed during video surveillance at Ortnek between 2 November 2015 and 15 December 2015.

Latin name	Name	Date	Time of recording	No. of observed animals
<i>Ursus arctos</i>	brown bear	17.11.2015	19:48:25	1
<i>Sus scrofa</i>	wild boar	/	/	0
<i>Cervus elaphus</i>	red deer	/	/	0
<i>Capreolus capreolus</i>	roe deer	5.12.2015	16:18:19	1
		9.12.2015	19:55:50	1
		15.12.2015	01:38:00	1
<i>Vulpes vulpes</i>	red fox	8.12.2015	20:51:01	1

Monitoring of wildlife in the period of six weeks had been done with the aim to record the occurrence of brown bear and other wildlife species in the area where sensors of dynamics signs were installed afterwards. The following wildlife species were observed/recorded: brown bear and roe deer at Ortnek; wild boar, red deer and roe deer at Jasnica, respectively. Brown bear was observed very close to the main road Ortnek – Žlebič. On the basis of this first, relatively short-lasting video surveillance in year 2015, we concluded that the selected sections of the main road had been properly selected. Therefore, the mitigation measures (implementation of dynamics signs) are expected to have positive impact on drives behaviour and will hopefully prevent traffic related mortality of large wildlife, including brown bear.

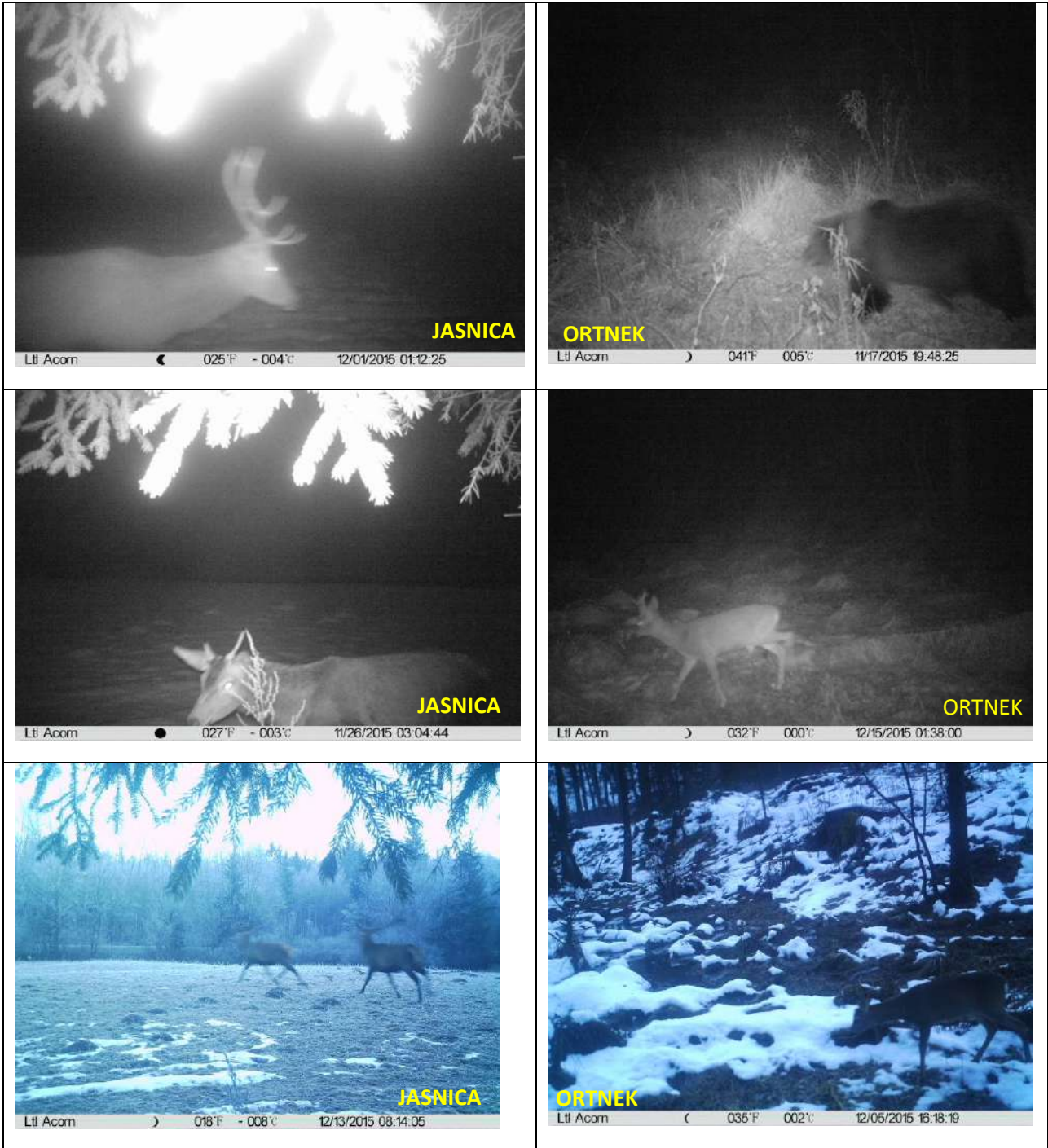


Figure 19: Photos of red deer, brown bear and roe deer, approaching the road sections on which dynamic traffic signs were implemented.



### 3.4.2 VIDEO SURVEILLANCE IN YEAR 2016

IR cameras were placed at Ortnek and Jasnica in the vicinity of sensors in the period of five months from March to October 2016. The following wildlife species were observed/recorded: roe deer and red fox at Ortnek; brown bear, wild boar, red deer, roe deer, red fox, European badger and European hare at Jasnica, respectively (Table 8 and 9; Figures 23-30). Brown bear was observed twice very close to the main road at Jasnica (Table 8, 9; Figure 23). Video surveillance in year 2016 additionally confirmed that the selected sections of the main road and locations, where dynamics signs were placed, had been properly selected. Especially in Jasnica we filmed several individuals of different wildlife species in the vicinity of road; therefore, there is significant possibility for crossing the road and for causing vehicle collisions.



Figure 20: Meadow near main road at Jasnica, where camera was placed and frequently filmed wildlife (arrows indicate sensors in wooden stumps capable to detect large animals approaching the roadways) (foto: S. Al Sayegh Petkovšek, 2016).



Figure 21: Images captured by the camera at Jasnica (left) and Ortnek (right) (arrows indicate sensors).

Table 9: Wildlife filmed during video surveillance at Jasnica in 2016 (17 March 2016 to 16 June 2016; 13 July 2016 to 12 September 2016).

Latin name	Name	Date	Time of recording	No. of observed animals
<i>Ursus arctos</i>	brown bear	15.8.2016	21:54:42 - 22:19:08	1
		4.9.2016	21:25:49	1
<i>Sus scrofa</i>	wild boar	19.8.2016	22: 28:17	1
<i>Cervus elaphus</i>	red deer	21.3.2016	21:50:48	1 hind
		22.3.2016	02:54:05 - 12''	1 stag
		22.3.2016	04:12:43	1 stag
		28.3.2016	00:16:51 - 55''	1
		29.3.2016	03:23:17 - 03:26:28	1 stag
		30.3.2016	00:49:00	1 stag
		14.7.2016	03:51:52 - 56''	1 stag
		16.7.2016	02:47:24 - 02:48:32	1 stag
		16.7.2016	04:25:56 - 04:27:05	1 stag
		19.7.2016	23:05:41 - 23:09:37	1 stag
		23.7.2016	22:28:53 - 22:29:57	1 stag
		26.7.2016	02:15:49 - 01:30:21	3 (1 hind + 2 calf)
		28.7.2016	21:24:45	2 hind + calf
		3.8.2016	00:53:04 - 02:11:17	2 hind
		3.8.2016	23:27:03 - 10''	2 hind
		4.8.2016	00:08:06 - 00:09:18	1 hind
		4.8.2016	00:11:10 - 01:41:12	2 hind + calf
		4.8.2016	02:36:46	2 hind
		9.8.2016	00:18:00 - 03''	1 hind
		10.8.2016	21:39:46 - 21:40:53	1 hind
		13.8.2016	00:43:39 - 42''	1 hind
		18.8.2016	01:13:00 - 01:15:23	1 hind
		20.8.2016	22:40:21 - 22:41:40	1 stag
		22.8.2016	23:32:37 - 23:42:23	3 (hind, stag, calf)
23.8.2016	23:37:10 - 23:39:3	2 hind		
24.8.2016	01:02:01 - 08''	2 hind		
<i>Capreolus capreolus</i>	roe deer	19.3.2016	05:47:33 - 36''	1 doe
		27.3.2016	05:39:17	1 buck
		30.3.2016	22:33:10 - 22:40:32	1 doe
		5.4.2016	19:17:06 - 33''	1 buck
		10.4.2016	21:07:48 - 21:08:07	1 buck
		17.4.2016	04:47:27	1 buck
		17.4.2016	20:11:01	1 buck
		18.4.2016	19:21:19	1
		20.4.2016	06:14:11 - 13''	1 doe
		26.4.2016	23:42:14	1
		28.4.2016	01:20:43 - 47''	1 buck
		28.4.2016	do 02:53:48	1 buck
		19.6.2016	22:00:17	1 doe
		29.6.2016	21:45:56	1 doe
		9.7.2016	21:46:00	1
		15.7.2016	20:51:22 - 20:54:30	1 doe
		15.7.2016	22:08:27 - 31''	1 buck



continuation

Latin name	Name	Date	Time of recording	No. of observed animals
<i>Capreolus capreolus</i>	roe deer	18.7.2016	06:05:26 - 28''	1 doe
		24.7.2016	06:04:01 - 03''	2 doe
		29.7.2016	05:49:22	1 buck
		30.7.2016	20:16:19	1 buck
		31.7.2016	05:38:20	1 doe
		31.7.2016	07:31:00	1 doe
		1.8.2016	05:33:24	2 (buck + )
		2.8.2016	20:23:49	1 doe
		2.8.2016	20:34:39 - 45''	2 doe + buck
		5.8.2016	06:39:33 - 06:49:12	1 doe
		7.8.2016	06:16:19 - 22''	1 doe
		7.8.2016	07:54:40 - 45''	1 buck
		9.8.2016	06:17:39	1 buck
		12.8.2016	05:48:02 - 05''	1 doe
		12.8.2016	06:10:23	1 doe
13.8.2016	04:51:54 - 04:52:01	1 buck		
10.9.2016	06:26:54	1 buck		
<i>Vulpes vulpes</i>	red fox	20.3.2016	00:04:17 - 00:27:19	1
		23.3.2016	21:46:41	1
		26.3.2016	22:40:41 - 22:44:47	1
		28.3.2016	19:12:41	1
		1.4.2016	03:25:19 - 54''	1
		7.4.2016	01:05:43	1
		15.8.2016	04:27:55	1
		16.8.2016	21:00:21	1
		17.8.2016	04:56:41	1
		10.9.2016	05:58:35	1
<i>Meles meles</i>	European badger	19.3.2016	04:26:02	1
		22.3.2016	19:22:04	1
		24.3.2016	23:15:23 - 26''	1
		2.4.2016	22:24:47 - 54''	1
		10.4.2016	20:58:05	1
		16.4.2016	19:12:06	1
		21.4.2016?	04:13:17	1
		22.4.2016	03:53:04	1
		22.4.2016	22:18:31	1
26.4.2016	22:23:11	1		
<i>Martes sp.</i>	marten	8.4.2016	03:09:17 - 20''	1
<i>Lepus europeus</i>	European hare	21.7.2016	00:59:14	1



Figure 22: Data collection from cameras at Ortnek (photo: S. Al Sayegh Petkovšek, 2016).

Table 10: Wildlife filmed during video surveillance at Ortnek in 2016 (17 March 2016 to 16 June 2016; 13 July 2016 to 12 September 2016).

Latin name	Name	Date	Time of recording	No. of observed animals
<i>Ursus arctos</i>	brown bear	/	/	/
<i>Sus scrofa</i>	wild boar	/	/	/
<i>Cervus elaphus</i>	red deer	/	/	/
<i>Capreolus capreolus</i>	roe deer	21.4-14.6.2016*	no data available	3 (doe with fawns)
		21.4-14.6.2016*	no data available	2 (doe with fawn)
		24.3.2016	21:21:33	1 buck
		18.8.2016	21:38:28	1 buck
		19.8.2016	23:26:00 - 07''	1 buck
		20.8.2016	06:13:05	1 buck
		20.8.2016	22:24:32	1 buck
		21.8.2016	02:49:32	1 buck
		23.8.2016	06:05:52	1 buck
		23.8.2016	00:12:59	1 buck
		24.8.2016	03:42:30	1 buck
<i>Vulpes vulpes</i>	red fox	2.4.2016	20:05:34	1
		4.4.2016	19:59:59	1
		6.4.2016	20:22:03	1
<i>Meles meles</i>	European badger	/	/	/
<i>Martes sp.</i>	mink	/	/	/
<i>Lepus europeus</i>	European hare	/	/	/

Note: \*: no data.





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Figure 23: Brown bear filmed at Jasnica on 15 August 2016 and on 4 September 2016.



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Figure 24: Wild boar filmed on 19 August 2016 (above) and European badger (below) filmed on 19 March 2016 at Jasnica.





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Figure 25: Red deer hinds filmed on 16 July 2016 and 20 August 2016 at Jasnica.



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Figure 26: Red deer hinds filmed on 3 August 2016 and 4 August 2016 at Jasnica.





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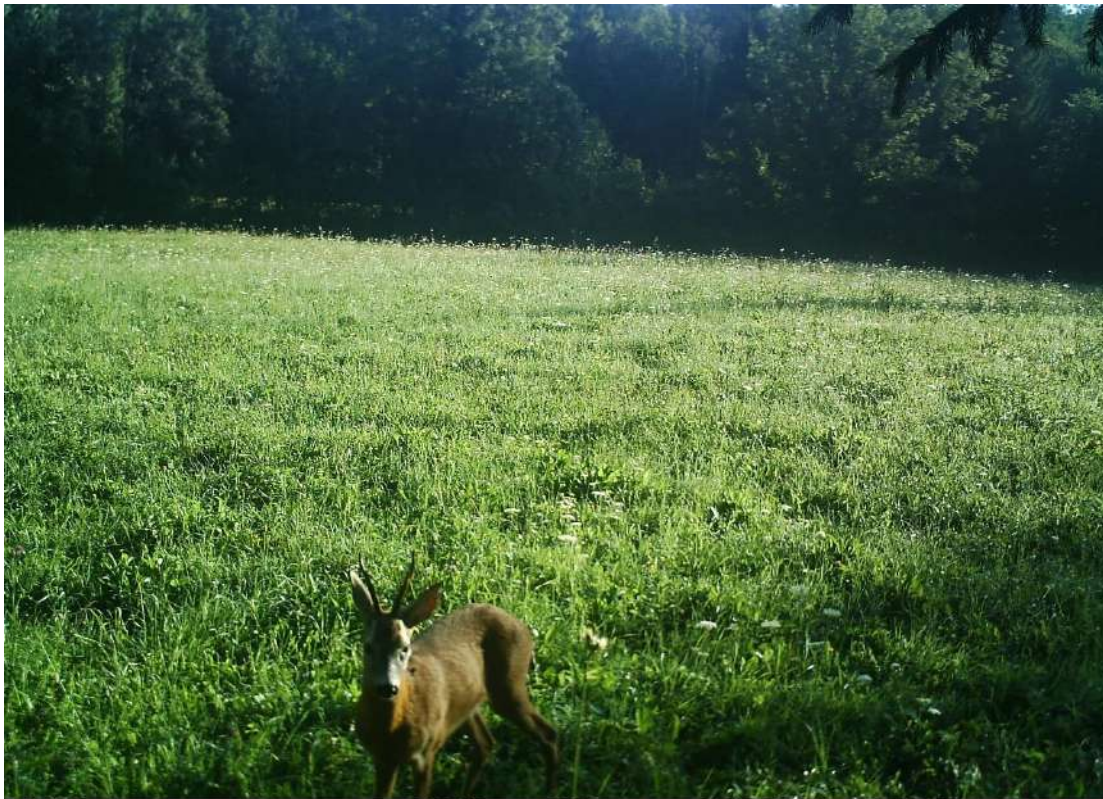
Figure 27: Red deer hinds with calves filmed on 4 August 2016 at Jasnica.



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Figure 28: Roe deer filmed on 7 August 2016 and on 18 July 2016 at Jasnica.





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Figure 29: Red fox and marten filmed on 15 August 2018 and 8 April 2016 at Jasnica.





Figure 30: Roe deer doe with fawn filmed at Ortnek (data on photo are not correct).



### 3.4.3 VIDEO SURVEILLANCE IN YEAR 2017

IR cameras were placed at Ortnek and Jasnica in the vicinity of sensors in the period of five months from April to August 2017. In year 2016, we filmed large number of individuals of different wildlife species in the vicinity of road at Jasnica; therefore, we selected another location in 2017 in very close vicinity of first IR camera (Jasnica II: forest). The following wildlife species were observed/recorded at Jasnica in 2017: wild boar, red deer, roe deer, red fox, European badger, European hare and squirrel (Table 10 and 11; Figures 31-35). On the other hand, at Ortnek we did not record wildlife during video surveillance in 2017 due to technical problems with IR camera.

Table 11: Wildlife filmed during video surveillance at Jasnica II (forest) in 2017 (4 April 2017 to 8 August 2017).

Latin name	Name	Date	Time of recording	No. of observed animals
<i>Sus scrofa</i>	wild boar	12.5.2017	03:14:03	1
		19.5.2017	23:26:40 – 47''	1
<i>Cervus elaphus</i>	red deer	18.4.2017	21:56:31-39''	1 stag
		19.4.2017	17:23:18 – 21''	1 stag
		19.4.2017	19:14:08 – 11''	1 stag
		22.4.2017	02:27:02 – 06''	1 stag
		22.4.2017	02:34:21 – 27''	1 hind
		22.4.2017	02:38: 57 till 02:39:91	1 stag
		24.4.2017	00:04:30 – 38''	1 hind
		24.4.2017	21:12:10 – 13''	1 hind
		10.5.2017	23:45:11 – 15''	1 hind
		11.5.2017	21:41:20 – 27''	1 hind
		19.5.2017	01:16:57	1 hind
		21.5.2017	01:37:31 – 38''	1 stag
		23.5.2017	21:26:43 – 47''	1 stag
		24.5.2017	20:43:50; 20:44:29 – 36''	1 stag
		1.6.2017	21:27:50 – 57''	1 stag
		1.6.2017	21:28:10 – 58''	1 stag
		7.7.2017	23:36:36	1 stag
		9.7.2017	02:42:05 – 12''	1 hind
		14.7.2017	02:24:09 –18''	1 stag
		24.7.2017	04:13:15 – 22''	1 stag
31.7.2017	02:00:29 – 36''	1 stag		
1.8.2017	01:00:52 – 59''	1 stag		
2.8.2017	02:00:43 – 51''	1 stag		
4.8.2017	03:32:02 – 09''	1 stag		
5.8.2017	01.25.12 – 16''	1 stag		
<i>Capreolus capreolus</i>	roe deer	9.4.2017	20:53:41 – 45''	1 buck
		10.4.2017	23:02:16 – 20''	1 buck
		15.4.2017	19:36:42 – 46''	1 doe
		23.4.2017	20:28:13 – 16''	1 buck
		26.4.2017	06:18:00 – 04''	1 buck
		26.4.2017	23:15:35 – 38''	1 buck
		28.4.2017	19:43:20 – 26''	1 doe
		28.4.2017	19:45:10 – 43''	1 doe
		29.4.2017	05:28:59	1 doe
		30.4.2017	02:14:32	1 doe
		11.5.2017	01:20:55 – 15''	1 doe

continuation

Latin name	Name	Date	Time of recording	No. of observed animals
<i>Capreolus capreolus</i>	roe deer	11.5.2017	06:24:26	1 doe
		15.5.2017	16:48:58	1 doe
		17.5.2017	21:37:17 – 24''	1 doe
		18.5.2017	21:03:09	1 doe
		26.5.2017	05:18:39	1 doe
		26.5.2017	09:07:51 – 54''	1 doe
		27.5.2017	07:32:04	1 doe + 1 buck
		1.6.2017	20:43:33 – 36''	1
		6.6.2017	06:28:47 – 52''	1 doe
		6.7.2017	00:44:56 do 00:45:00	1 doe
		21.7.2017	06:57:44 – 46''	1 buck
		28.7.2017	05:25: 20	1 doe
		31.7.2017	21:26:09 – 12''	1 buck
		4.8.2017	18:38:48 – 50''	1 doe
		6.8.2017	09:53.52 – 54''	1 buck
		6.8.2017	19:57:51	1 doe



Figure 31: Installation of IR cameras at Ortnek and sensors in wooden stumps capable to detect large animals approaching the roadway (photo: Z. Pavšek, 2017).



Table 12: Wildlife filmed during video surveillance at Jasnica I (meadow) in 2017 (7 April 2017 to 3 June 2017).

Latin name	Name	Date	Time of recording	No. of observed animals
<i>Sus scrofa</i>	wild boar	19.5.2017	22:57:04 – 08''	1
<i>Cervus elaphus</i>	red deer	24.4.2017	03:25:13 – 21''	1 stag + 1
		25.4.2017	00:51:21 – 24''	1 stag
		11.5.2017	21:50:32	1 stag
		12.5.2017	02:06:19 – 23''	1 hind
		17.5.2017	22:25:01	1 hind
		3.6.2017	02:15:38	1 stag
<i>Capreolus capreolus</i>	roe deer	7.4.2017	23:11:16 – 19''	1 doe
		13.4.2017	20:32:28 – 32''	1 doe
		14.4.2017	03:57:06 – 10''	1 doe
		23.4.2017	21:29:39 – 42''	1 doe
		25.4.2017	21:19:10	1 buck
		1.5.2017	02:18:48	1 doe
		5.5.2017	05:39:57 till 05:40:04	1 doe
		5.5.2017	20:07:44 – 50''	1 doe
		6.5.2017	04:50:37	1 doe
		11.5.2017	06:34:30 – 35''	1 doe
		11.5.2017	20:34:39 – 45''	1 doe
		12.5.2017	01:27:34 – 37''	1 doe
		18.5.2017	04:53:18 – 26''	1
		18.5.2017	05:03:28 – 32''	1 doe
		20.5.2017	05:37:38 – 44''	1 doe
30.5.2017	12:07:02 – 05''	1 buck		
<i>Vulpes vulpes</i>	red fox	21.4.2017	20:52:11	1
		24.4.2017	01:22:14	1
		30.4.2017	01:23:30	1
		14.5.2017	23:25:07 – 10''	1
<i>Meles meles</i>	European badger	27.4.2017	20:09:18	1
		18.5.2017	20:28:52	1
<i>Martes sp.</i>	Marten	25.5.2017	01:50:13	1
		31.5.2017	02:15:38	1
<i>Lepus europeus</i>	European hare	7.4.2017	19:57:54	1
		6.5.2017	05:35:23 – 26''	1
		7.5.2017	06:44:33	1
		8.5.2017	07:17:29	1
		10.5.2017	06:06:50 – 55''	1
<i>Sciurus vulgaris</i>	Squirrel	23.4.2017	22:57:09 – 49''	1



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Figure 32: Red deer hinds filmed on 2 May 2017 and 3 June 2017 at Jasnica I (year on photo is not correct).





Figure 33: Roe deer doe and European hare filmed on 5 and 10 May 2017 at Jasnica I (year on photo is not correct).





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Figure 34: Red deer hind and roe deer doe filmed on 19 April and 28 April 2017 at Jasnica II.





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Figure 35: Red deer hind and roe deer buck filmed on 31 July 2017 at Jasnica II.



Figure 36: Wild boar filmed on 15 May at Jasnica I (above) and Jasnica II (below).



### 3.5 TRAFFIC RELATED WILDLIFE MORTALITY AT SELECTED MAIN ROAD AND RAILWAY SECTIONS

Table 13: Traffic related bear mortality at protected section of main road Ljubljana – Kočevje (Al Sayegh Petkovšek *et al.* 2015; OSLIS).

	2011	2012	2013	2014	2015	2016	2017
Rašica -Turjak (Figure 11)	0	1	0	1	0	0	0
Ortnek - Žlebič (Figure 10)	0	1	0	0	0	1	0
Jasnica (Figure 12)	1	1	0	0	1	0	0
Novo Lozine - Kobljarji (Figure 13)	0	1	0	2	0	0	0
SUM	1	4	0	3	1	1	0

Table 14: Traffic related bear mortality at selected section of railway Rakek - Postojna and Postojna - Prestranek (Al Sayegh Petkovšek *et al.*, 2015; OSLIS).

	2011	2012	2013	2014	2015	2016	2017
Postojna - Prestranek (Figure 7, 8)	0	6	2	4	0	0	0
Rakek - Postojna (Figure 6)	1	2	0	0	0	2	1
SUM	1	8	2	4	0	2	1

Three traffic related bear mortalities were recorded in year 2016 at protected sections, where acoustic deterrents were installed, namely one at the main road Ljubljana - Kočevje between Ortnek and Žlebič and two at selected section of railway Rakek – Postojna (Table 10, 11). In year 2017 (till 31.7.2017) only one traffic related mortalities were recorded at selected section of railway Rakek – Postojna (Table 10, 11). In the period before installation of acoustic deterrents (from 2011 to 2015) 9 mortality cases (1.8 per year) of brown bear were registered at relevant sections of main road Ljubljana - Kočevje and 15 mortality cases (3.0 per year) of brown bear at relevant railway sections between Ljubljana and Pivka.

For now, it is not possible to adequately evaluate the effectiveness of mitigation measures according to mortality data, because it is necessary to compare longer period of mitigation measures operating.

## 4 CONCLUSIONS

On the basis of monitoring of the effectiveness of mitigation measures the following conclusions can be made:

- (i) In year 2017 the reduction of speed of vehicles, which pass activated dynamics signs, was from 7 km/h to 15 km/h (Ortnek: 75.9 km/h vs. 69.1 km/h and Jasnica: 83.9 km/h vs. 68.9 km). The reduction of speed of vehicles in year 2016 was app. 8 km/h at both locations (Ortnek: 77.1 km/h vs. 69.4 km/h and Jasnica: 87.6 km/h vs. 79.4 km/h). The observed reduction of speed of vehicles in years 2016 and 2017 confirms the positive impact of activated dynamic signs on driver's behaviour.
- (ii) IR cameras were placed at Ortnek and Jasnica in the vicinity of sensors coupled with dynamic signs from March to October 2016 and from April to August 2017. The following wildlife species were recorded: brown bear, wild boar, red deer, roe deer, red fox, European badger, marten, European hare and squirrel. Brown bear was not observed in 2017. However, in 2016 was observed twice very close to the main road at Jasnica and in year 2015 (before installation of dynamic signs) once at Ortnek. Video surveillance in last three years (2015, 2016, 2017) confirmed that the selected sections of the main road and locations, where dynamics signs were placed, had been properly selected. Especially in Jasnica we filmed a high number of wildlife in the vicinity of road.
- (iii) All together three traffic related bear mortality were recorded at selected section of railway Rakek – Postojna; namely two in year 2016 and one in year 2017. In year 2016 one traffic related bear mortality was recorded at the main road Ljubljana Kočevje (near Ortnek) in and none in 2017. In the period before installation of acoustic deterrents (from 2011 to 2015) 9 mortality cases (1.8 per year) of brown bear were registered at relevant sections of main road Ljubljana - Kočevje and 15 mortality cases (3 per year) of brown bear at relevant railway sections between Ljubljana and Pivka. For now, it is not possible to adequately evaluate the effectiveness of mitigation measure according to mortality data, because it is necessary to compare longer period of mitigation measures operating.

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