ACTION A4. ANALYSIS AND MAPPING OF EXISTING CROSSING STRUCTURES FOR POTENTIAL USE BY THE TARGET SPECIES, AND OTHER INTERVENTIONS ON THE ROADS

ACTION REPORT/2020 – Abruzzo, Lazio and Molise National Park

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LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

NATURA 2000

Parco Nazionale d'Abruzzo, Lazio e Molise

***ACTION A.4*: Analysis and mapping of existing crossing structures for potential use by the target species, and other interventions on the roads**

Index

The aim of this preparatory action was to map existing transversal structures along the targeted road segments that could be adapted to crossing structures for Apennine brown bears and other medium to large sized mammal species. In the frame of this action one of the aims was also to identify potential attractants for the bears alongside the roads (i.e. fruit trees) in order to plan future mitigation intervention.

Methods

For all the targeted road segments we mapped and characterized all the mitigation structures found, following the standardized field form developed by the project partner Minuartia.

For each structure we recorded: the type of the transversal structure, the structure section, visibility of opposite entrance, the construction material, presence of water or dry ledges. We measured the height, width and length (all in meters). We verified the presence of potential obstacles, and the type and percentage of coverage of the vegetation at the two sides of the transversal structure, as well as the dominant environments. Finally, we noted the presence of safety barriers or fences. Each characterized structure was georeferenced. All data were archived in the database "transversal structure characterization", developed by the project partner Minuartia.

On the transversal structures suitable for adaptation to wildlife crossing we monitored the passage of species with a camera trap when possible.

Results

Characterization of the crossing structures

The road segment initially (prior to start monitoring actions) identified for this action were:

- National road S.S. 83 "Marsicana", km 35 – 41
- National road S.S. 83 "Marsicana", Km 46 – 58
- Regional road S.P. 17 "del Parco", Km 1- 30
- Regional road S.R. 509 "Forca d'acero" km 1-9

In the frame of the development of action A5, however, we decided to include other 2 road segments:

- Regional road S.R. 479 "Sannita", Km 20- 27
- National road S.S. 17 "dell'Appennino Abruzzese e Apulo Sannitica"- Km 146+5-147+2.

We decided to include a small segment of the National road SS17 even though it is not located inside the protected area but in the buffer zone surrounding it (which a lower degree protection) following the death of a female Apennine brown bear on the night of the 24th of December 2019, which was hit by a car while crossing the road with her cub (Km 146,7).

In the Abruzzo, Lazio and Molise National Park the identified roads are narrow (two lanes, one per direction of travel), typical mountain-environment roads. The existing transversal structures are all culvert and underpasses, except for an overpass we found along National road 17.

We characterized all features in June-November 2019, except for those along the National road SS17, which were characterized in summer 2020, since we decided to include also this road segment after the death of the female Apennine brown bear on the 24th of December 2019.

We mapped and characterized a total of 41 transversal structures: 7 on SS83, 4 on SP17, 29 on SP509 and 1 on the SS17 (table 1). All transversal structures were culvert or drainage. In SS17 we also mapped a multi-use overpass: a potential crossing structure above the road for movement of people or a single vehicle, that with modifications (i.e. addition to cover) could be turned in a wildlife crossing structure. In SP479 no transversal structures are available.

Following the "Guidelines to adapt transversal structures and increase use by large carnivores and other wildlife" produced by the project partner Minuartia in the frame of Action A4, we selected the transversal structures to monitor and adapt as wildlife crossing structure based on combined criteria: the width of the structure, the location (i.e. if it is located in a place that is important to enhance connectivity), the intensity of the use of the area by the target species. The selected structures are indicated in green in table 2, which provide details of each measurement.

According to the recommendation a suitable crossing structure for bears should be at least 15 m wide, with a height of at least 3.5 m and an openness index (section/length) ≥ 0,75 m. In PNALM most of the characterized structures were not suitable for the adaptation as a brown bear crossing structure, as the majority of the structures were less than 2 m width and less than 2 m high (table 1). However, bear have been reported to use also smaller structures if the structure is located in an environment useful for connectivity.

Table 1 Mean width, mean height and range (min-max) of existing transversal structures characterized in monitored roads.

		N structures per width class (m)			Width			Height			
Road Name	N	<2	2 -7	>15	Mean	Min	Max	Mean	Min	Max	Openess index
SP17	4	1	3	0	2.0	2.0	2.2	2.3	1.5	3.1	0.4
SR509	29	24	5	0	1.3	0.9	3.4	1.9	0.7	4.4	0.1
SS17	1		1	0	3.9			4.2			Not applicable
SS83 km 35 – 41	1	1	0	0	1			1.66			0.06
SS83 km 46 – 58	6	4	2	0	2.0	1.0	3.0	1.9	0.9	3.6	0.2

We excluded to act on transversal structures located along SP509, not only because all the culvert found were too small for adaptation but also because the monitoring activities performed in the frame of action A5 and the results of the analysis made in the action A3 indicated that this road is rarely crossed by bears, and also the surrounding of the road is not used (Figure 1).

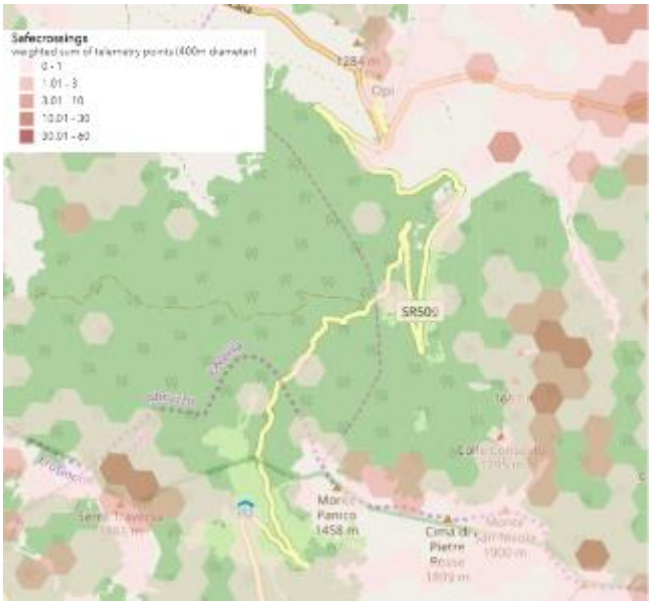

Figure 1 Results of the analysis performed in action A3 indicated that regional road SP509 is not used by bears: the picture shows the intensity of use of the area by bears with 400m wide hexagons: the deepest the colors the higher the intensity of use by bear. These results were confirmed with monitoring activities performed in action A5

Culverts characterized were excluded from adaptation work because of the characteristic of the culverts (too small), the little intensity of use of the surroundings, and the characteristics of the surroundings. In example along National road S.S. 83 "Marsicana", km 35 – 41 the terrain is open and flat, this means that there are no obstacles for wildlife to cross the road, and to invite a bear to use a really small culvert the only option would be to fence all the road. The best solution for mitigate animal vehicle collisions in this area is the AVCPS system, as described in the A5 report. Along National road S.S. 83 "Marsicana", Km 46 – 58, crossing of bears are frequent allover, but the transversal structures most suitable to be adapted as bear crossing are the culverts CUV_SS83_55+8 and CUV_SS83_54+6. From data acquired during the routine monitoring of brown bears we had evidences that bears occasionally use the culvert CUV_SS83_55+8, after the removal of some vegetation. Telemetry data and data acquired through camera traps indicated that also the areas beside CUV_SS83_54+6 were intensively used by bears (figures 4-5-6).

For National road SS17 we do not have the output of the analysis developed during action A3 since first it was not included in the analysis and because up to 2019 we do not have monitored bears in this area. As described in the report for action A5 in 2019 we equipped with a GPS collar a female bear and the data shows that the surroundings of this road are instead frequently used by this bear. Figures 2-4 shows the position of the culverts and the intensity of use of the surrounding areas as modelled in the frame of action A3.

Table 2 list of all the transversal structures (all culvert) characterized in PNALM in the frame of action A4. In green the 7 selected for further actions and monitoring

Transversal structure Identification code	Road code	Date inspection	Structure section	Visibility of opposite entrance (%)	Height (m)	Width (m)	Length	Substratum material	Land use e1	Vegetation coverage e1 (%)	Land use e2	Vegetation coverage e2 (%)
CUV_SS83_55+8 *	SS83	16/05/2019	Vault	100	3,60	3,00	9,00	Concrete	Forest	0-4	Riparian forest	0-4
CUV_SS83_54+6 *	SS83	16/05/2019	Vault	100	2,46	3,00	9,10	Natural Material	Forest	5-24	Riparian forest	25-49
CUV_SP17_29+9 *	SP17	23/10/2019	Rectangular	60	3,10	2,20	10,60	Concrete + Natural Mat	Meadow	70-100	Forest	70-100
CUV_SS17_146+125 *	SS17	27/08/2020	Vault	50%	4,20	3,90	16,00	Concrete	shrub	75-100	shrub	75-100
CUV_SP17_25+6 *	SP17	23/10/2019	Rectangular	100	1,89	2,00	11,70	Concrete + Natural Mat	Forest	70-100	Forest	70 100
CUV _SP17_25+5 *	SP17	23/10/2019	Rectangular	100	1,53	2,00	13,50	Concrete + Natural Mat	Forest	70-100	Forest	70-100
CUV _SP17_23+9 *	SP17	23/10/2019	Rectangular	100	2,58	1,98	9,00	Concrete + Natural Mat	Forest	70-100	Forest	70-100
CUV_SR509_0+1	SR509	21/11/19	Vault	50	2,50	1,90	7,50	Concrete	Urban	70-100	Urban	70-100
CUV_SR509_1+6	SR509	21/11/19	Vault	20	3,70	3,40	8,00	Concrete	Forest	70-100	Forest	70-100
CUV_SR509_2+3	SR509	21/11/19	Vault	80	4,00	2,70	12,00	Concrete	Forest	70-100	Forest	70-100
CUV_SR509_3+2	SR509	21/11/19	Rectangular	100	1,80	1,90	10,00	Concrete	Forest	70-100	Forest	70-100
CUV_SR509_4+4	SR509	21/11/19	Vault	80	4,40	2,90	8,00	Concrete	Forest	70-100	Forest	70-100
CUV_SR509_5+1	SR509	21/11/19	Vault	100	1,90	0,90	8,00	Concrete	Forest	70-100	Forest	70-100
CUV_SR509_5+3	SR509	21/11/19	Vault	100	1,15	0,90	7,00	Concrete	Forest	70-100	Forest	70-100
CUV_SR509_5+6	SR509	21/11/19	Vault	100	1,80	0,90	8,00	Concrete	Forest	70-100	Forest	70-100
CUV_SR509_5+7	SR509	21/11/19	Vault	100	1,80	1,90	7,00	Concrete	Forest	70-100	Forest	70-100
CUV_SR509_5+9	SR509	21/11/19	Vault	100	2,30	0,90	8,00	Concrete	Forest	70-100	Forest	70-100
CUV_SR509_6	SR509	21/11/19	Vault	100	4,20	2,90	8,00	Concrete	Forest	70-100	Forest	70-100
CUV_SR509_6+2	SR509	21/11/19	Vault	100	1,90	0,90	7,00	Concrete	Forest	70-100	Forest	70-100
CUV_SR509_6+4	SR509	21/11/19	Vault	100	1,00	0,90	7,00	Concrete	Forest	70-100	Forest	70-100
CUV_SR509_6+5	SR509	21/11/19	Vault	100	1,00	0,90	8,00	Concrete	Forest	70-100	Forest	70-100
CUV_SR509_6+6	SR509	21/11/19	Vault	100	1,00	0,90	8,00	Concrete	Forest	70-100	Forest	70-100

Transversal structure Identification code	Road code	Date inspection	Structure section	Visibility of opposite entrance (%)	Height (m)	Width (m)	Length	Substratum material	Land use e1	Vegetation coverage e1 (%)	Land use e2	Vegetation coverage e2 (%)
CUV_SR509_6+9	SR509	31/07/19	Vault	100	1,80	0,90	8,00	Concrete	Forest	70-100	Forest	70-100
CUV_SR509_7	SR509	31/07/19	Vault	100	1,30	0,90	8,00	Concrete	Forest	70-100	Forest	70-100
CUV_SR509_7+1	SR509	31/07/19	Vault	100	1,50	0,90	8,00	Concrete	Forest	70-100	Forest	70-100
CUV_SR508_7+3	SR508	21/11/19	Vault	100	1,70	0,90	7,00	Concrete	Forest	70-100	Forest	70-100
CUV_SR509_7+3	SR509	31/07/19	Vault	100	2,40	2,00	11,00	Concrete	Forest	70-100	Forest	70-100
CUV_SR509_7+4	SR509	31/07/19	Vault	100	1,18	0,98	8,00	Concrete	Forest	70-100	Forest	70-100
CUV_SR509_8	SR509	31/07/19	Vault	80	1,00	0,95	7,00	Concrete	Forest	70-100	Forest	70-100
CUV_SR509_8+3	SR509	31/07/19	Vault	50	1,20	0,90	7,00	Concrete	Forest	70-100	Forest	70-100
CUV_SR509_8+7	SR509	21/11/19	Vault	100	1,70	0,90	8,00	Concrete	Forest	70-100	Forest	70-100
CUV_SR509_8+8	SR509	21/11/19	Vault	100	1,05	0,90	8,00	Concrete	Forest	70-100	Forest	70-100
CUV_SR509_9	SR509	21/11/19	Vault	100	0,73	0,90	8,00	Concrete	Forest	70-100	Forest	70-100
CUV_SR509_9+2	SR509	31/07/19	Vault	100	1,40	0,90	7,00	Concrete	Forest	70-100	Forest	70-100
CUV_SR509_9+3	SR509	31/07/19	Vault	100	0,8	0,94	8,00	Concrete	Forest	70-100	Forest	70-100
CUV_SR509_9+4	SR509	31/07/19	Vault	100	3,00	0,85	7,00	Concrete	Forest	70-100	Forest	70-100
CUV_SS83_55+3	SS83	16/05/2019	Vault	5	0,95	1,00	7,50	Concrete	Forest	50-75	Forest	5-24
CUV_SS83_52+9	SS83	29/05/2019	Vault	70	1,75	2,80	6,00	Concrete	Riparian Forest	25-49	Riparian forest	25-49
CUV_SS83_52+3	SS83	04/06/2019	Vault	100	1,85	1,50	6,00	Concrete	Riparian Forest	70-100	Riparian forest	70-100
CUV _SS83_47+2	SS83	29/05/2019	Vault	100	1,10	1,00	6,00	Concrete	Meadow	50-75	Meadow	70-100
CUV_SS83_40+7	SS83	29/05/2019	Vault	100	1,66	1,00	6,00	Concrete	Riparian Forest	0-4	Meadow	0-4

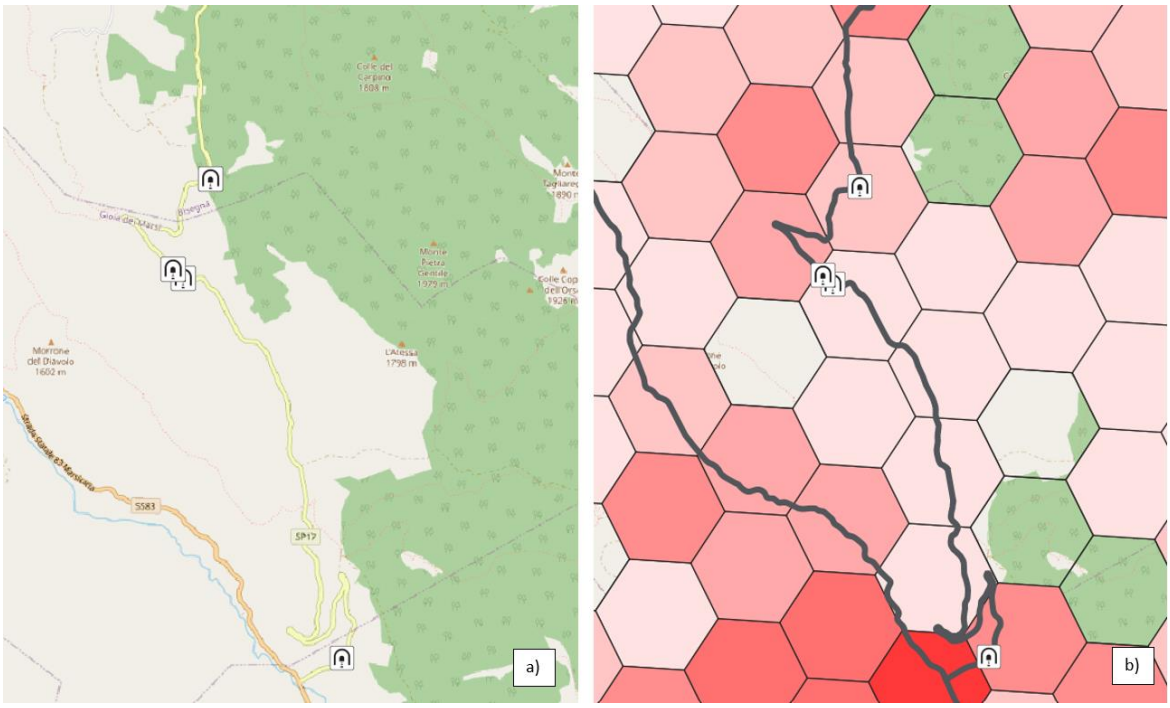

Figure 2 Transversal structures characterized along regional road SP17 (white dots). a) culverts identified for adaptations b)culverts in relation to the model developed in the frame of action A3: the 1 Km wide hexagons indicate the amount of time spent by monitored bears in the surrounding of the road. The deepest the red the more the area is intensively used by radiocollared bears

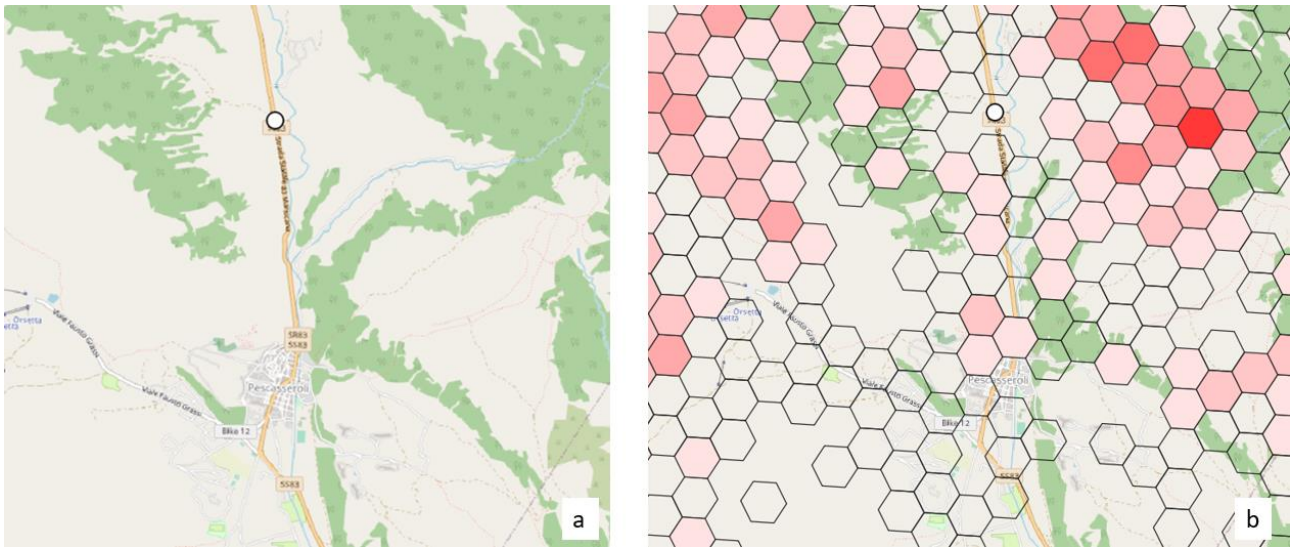

Figure 3 Transversal structures characterized along National road S.S. 83 "Marsicana", km 35 – 41 (white dots). a) culverts characterized b) culverts in relation to the model developed in the frame of action A3: the 400 m wide hexagons indicate the amount of time spent by monitored bears in the surrounding of the road. The deepest the red the more the area is intensively used by radiocollared bears

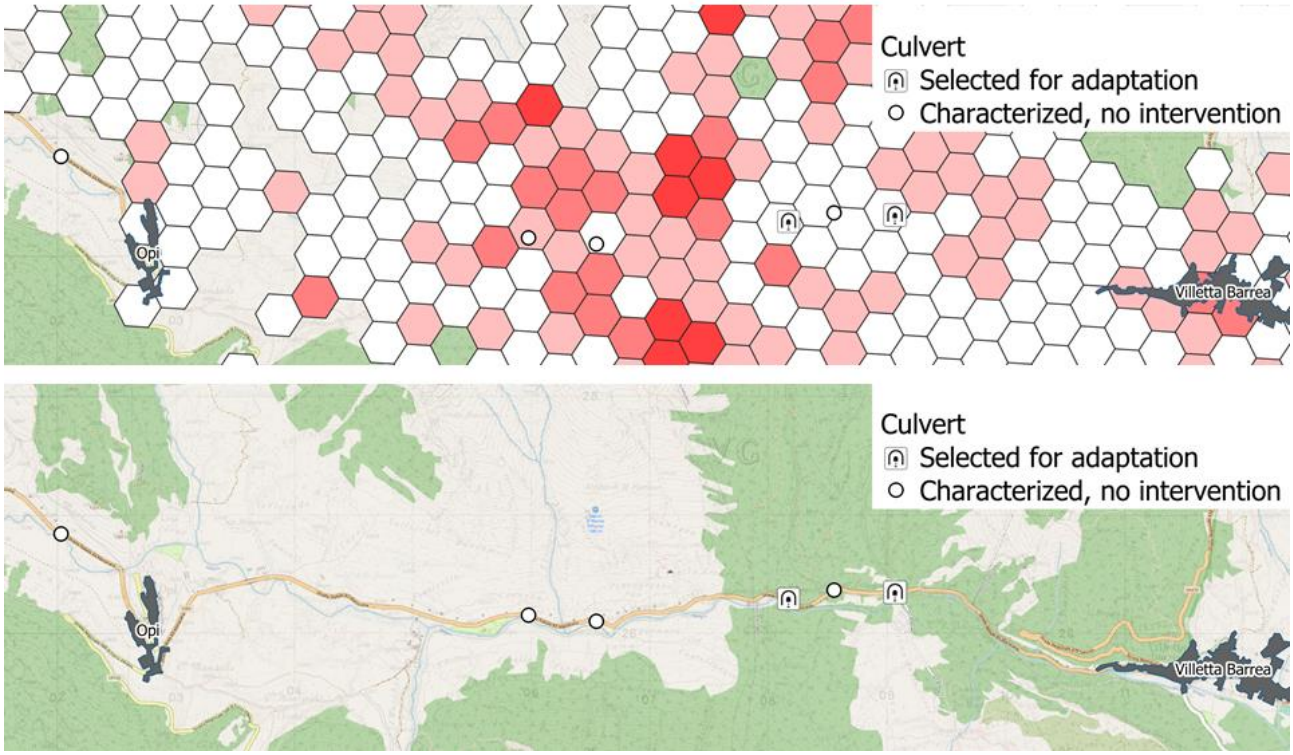

Figure 4 Transversal structures characterized along National road S.S. 83 "Marsicana", km 46– 58. a) culverts characterized b) culverts in relation to the model developed in the frame of action A3: the 400 m wide hexagons indicate the amount of time spent by monitored bears in the surrounding of the road. The deepest the red the more the area is intensively used by radiocollared bears

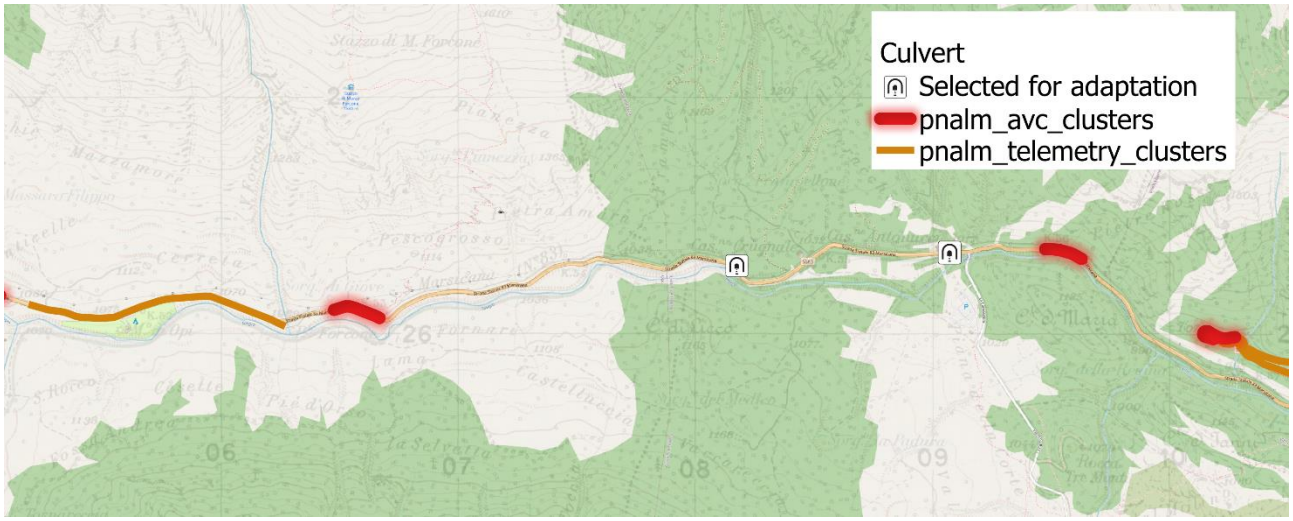

Figure 5 AVC cluster computed in the frame of action A3 and the location of the two targeted culvert that will be adapted to wildlife crossing

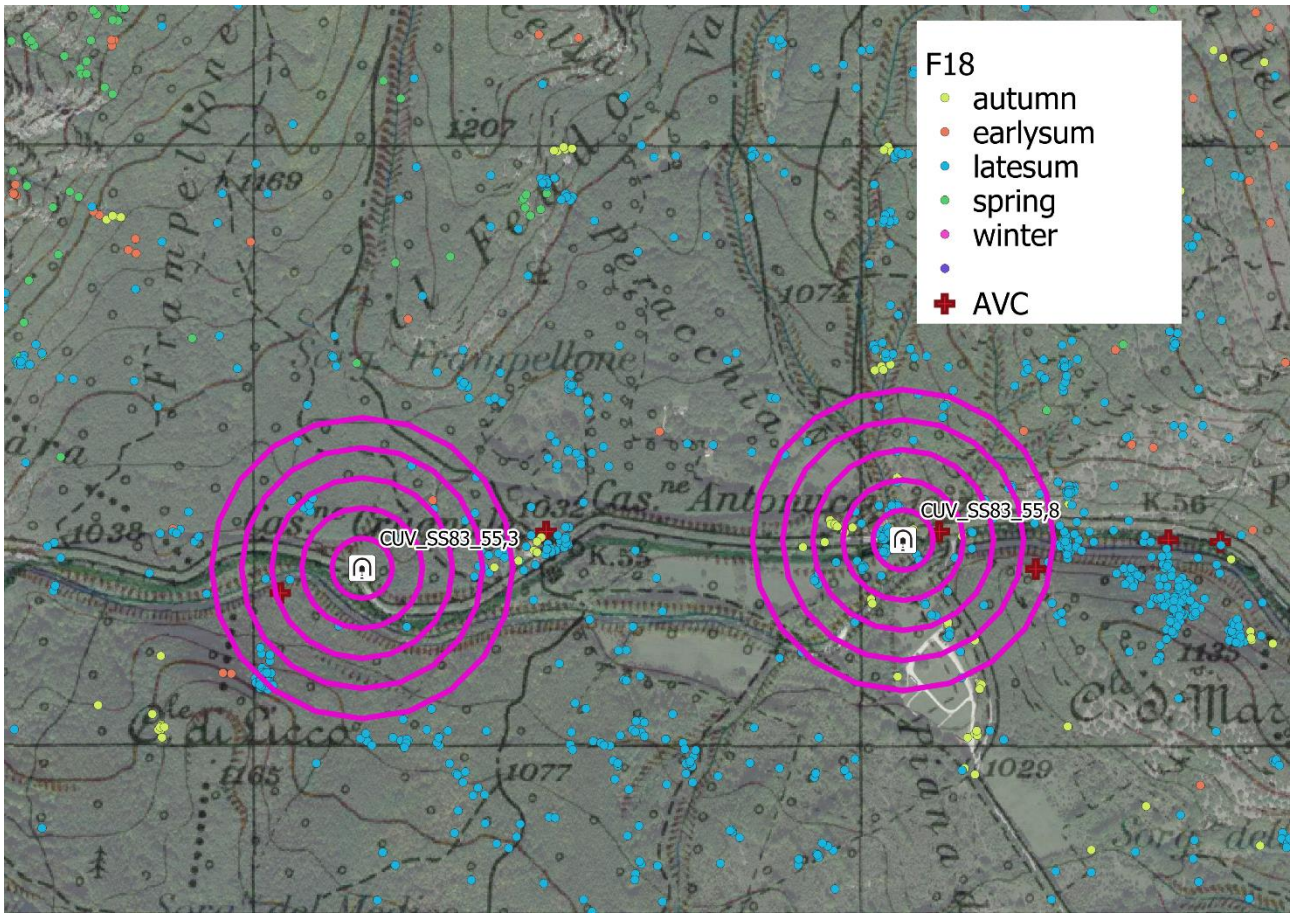

Figure 6 Location of culverts CUv_SS83_55+3 and CUV_SS83_55+8 in relation to animal vehicle collisions (red crosses) and locations of F18, a GPS collared female using the area which clearly confirm the ecological importance of this two crossing points. The circles around the culvert are buffers with an increasing radius: from 50 m around the structure to 250.

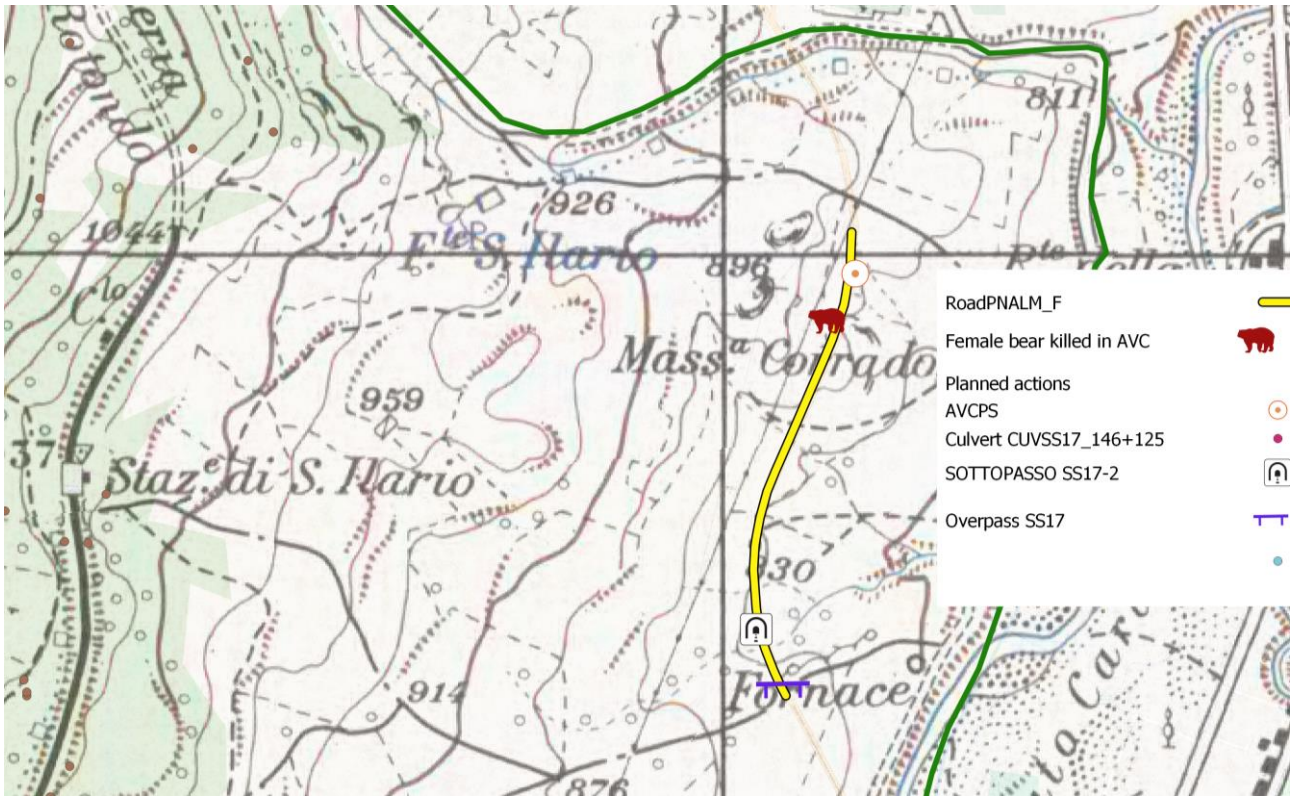

Figure 7 Transversal structures characterized along National road S.S. 17 "dell'Appennino Abruzzese e Apulo Sannitica"- Km 146+5-147+2. The map show the target segment, Road_PNALM_F, the location of the accident in wich a female bear with a cub of the year was killed on the 25 December 2019 and the structures that will be adapted in the frame of C2 action. An AVCPS is also planned.

Monitoring of the use of the crossing structures

We identified 7 transversal structures that can be adapted to crossing structure for Apennine brown bears. For 3 of them it was possible to install camera trap to monitor wildlife usage of the existing transversal structures. When this was not possible (i.e. when we verified a too high risk of thefts, or due to the lack of suitable places where to place the camera trap), we periodically checked for the presence of tracks and sign of presences in the surrounding of the transversal structure.

We employed Scout HD CAM 12 Mpx, set to acquire images as rapid photo sequencing or video (length 30 s).

Monitoring of the target underpasses started in June 2019 and is ongoing, although for the present report we analyze data collected up to the 1st September 2020.

Camera traps were used to monitor transversal structures that could be already potentially used by the bears: although the characterization indicated the need of further restoration to adapt the passage, by cutting the vegetation it was already possible that bears use the structure. In addition, it was not always possible for the environmental conditions (i.e. lack of trees in the immediate surrounding of the culvert, high visibility to people and risk of theft) to deploy the cameras. Therefore, we have monitored through camera traps the following transversal structures:

- CUV_SS83_55+8: “Casone Antonucci” (figure 7a)
- CUV_SS83_54+6: “Crugnale” (figure 7b)
- CUV_SP17_29+9 (figure 7c)
- CUV_SS17_146+125 (figure 7d)

Figure 8 a) CUV_SS83_55+8; b) CUV_SS83_54+6 C) CUV_SP17_29+9 d) CUV_SS17_146+125

CUV_SS83_55+8 we had the right conditions to monitor both the entrances, so we employed 2 camera traps, both set up to take 30seconds videos. On the 14 of May 2019 we cleaned up the vegetation on both entrances (figure 8), and this made the transversal structure more easily crossable for brown bears.

Figure 9 clean up of vegetation at culvert CUV_SS83_55+8 took place on the 14 of May 2019

Results of camera trapping show that this culvert is crossed by bears (table 3); in particular we identified and documented the passage of bear F18, a female equipped with a radiocollar. In 2019 the female used this transversal structure 4 times, all in summer: on 15th of July, and on the 1st, the 6th and the 12th of August (figure 10). In 2020, instead we recorded 5 passages, but only in 2 occasions the bear actually crossed the culvert (figure 11). Telemetry data and camera trapping performed for action A5 indicate that bear F18 regularly visit the area surrounding this culvert in summer and early autumn, this indicate that currently this transversal structure is underused by the bear, who still alternatively cross the road, in particular in nocturnal hours. In fact, all passages recorded in CUV_SS83_55+8 are diurnal. This result however is encouraging since bears typically cross roads when the traffic volume is very low (Chruszcz et al. 2003; Graham et al. 2010). The results of monitoring of action A5 indicate that also in PNALM bear cross roads during night, when the traffic volume is almost zero (also verified in the frame of action A5 by using the ViaCount traffic volume counter). Monitoring of the culvert indicate instead that these structures are employed by bears during daytime in summer, when the traffic volume is of about 1,000 vehicles/day.

Figure 10 2019: F18 crossing CUVSS8355+8. a)15/7 at 11:34; b) 1/08 at 17:45; c) 6/08 at 19:11; 12/08 at 18:15

Figure 11 2020 F18 at culvert CUVSS8355+8. a)08/8 at 18:23; b) 18/08 at 07:18; c) 26/08 at 20:20

Aside from the bear, the culvert is used mainly by medium sized mammals (pine and stone martens, foxes, wild cats, porcupines and badgers), although both in 2019 and 2020 we recorded the passage of a lone wolf, with a total of 7 occasions (table 4). We never detected ungulates using the culvert.

Most medium sized mammals cross the culvert during the night (time slot:21-5) in all months (table 5), except for the winter, when we recorded passages also in the time slot 18-20.

Table 3 list of all the recorded bear passages at the culvert CUV_SS83_55+8 monitored through camera traps

Camera trap code	Event N	CUV ID	Date	Time	Behaviour	N Bears	Bear ID (if marked)
LSC_FT001	1	CUV_SS83_55+8	15/07/2019	11:34:00	Cross the culvert	1	F18
LSC_FT002		CUV_SS83_55+8	15/07/2019	11:34:00	Cross the culvert	1	F18
LSC_FT001	2	CUV_SS83_55+8	01/08/2019	17:45:00	Cross the culvert	1	F18
LSC_FT002		CUV_SS83_55+8	01/08/2019	17:45:00	Cross the culvert	1	F18
LSC_FT001	3	CUV_SS83_55+8	06/08/2019	19:12:00	Cross the culvert	1	F18
LSC_FT002		CUV_SS83_55+8	06/08/2019	19:13:00	Cross the culvert	1	F18
LSC_FT001	4	CUV_SS83_55+8	12/08/2019	18:14:00	Cross the culvert	1	F18
LSC_FT002		CUV_SS83_55+8	12/08/2019	18:15:00	Cross the culvert	1	-
LSC_FT002	5	CUV_SS83_55+8	06/08/2020	06:17:00	Displacement (no crossing)	1	-
LSC_FT002	6	CUV_SS83_55+8	08/08/2020	18:23:00	Displacement (no crossing)	1	F18
LSC_FT002	7	CUV_SS83_55+8	12/08/2020	14:56:00	Displacement (no crossing)	1	-
LSC_FT002	8	CUV_SS83_55+8	18/08/2020	07:18:00	Cross the culvert	1	F18
LSC_FT002	9	CUV_SS83_55+8	26/08/2020	20:20:00	Cross the culvert	1	F18

Table 4 wolves recorded at the culvert CUV_SS83_55+8 in 2019 and 2020

Camera trap code	CUV ID	Date	Time	Behaviour	N of wolves
LSC_FT002	CUV_SS83_55+8	03/07/2020	20:45:00	Cross the culvert	1
LSC_FT002	CUV_SS83_55+8	14/09/2019	20:50:00	beve alla pozza, non attraversa	1
LSC_FT001	CUV_SS83_55+8	08/04/2020	00:52:00	Cross the culvert	1
LSC_FT001	CUV_SS83_55+8	05/07/2020	02:10:00	Cross the culvert	1
LSC_FT002	CUV_SS83_55+8	04/07/2020	02:00:00	Scared by the camera trap run away	1
LSC_FT002	CUV_SS83_55+8	04/07/2020	03:52:00	Cross the culvert	1
LSC_FT001	CUV_SS83_55+8	14/09/2019	04:58:00	Cross the culvert	1

Table 5 Number of passages (per season and time of the day) of medium sized mammals (pine and stone marten, fox, badger, porcupine, wild cat) recorded at the culvert CUV_SS83_55+8

Year	Season	Total number of passages	Time slot			
2019			**06-13**	**14-17**	**18-20**	**21-5**
	spring	15	6,7%	0,0%	0,0%	93,3%
	autumn	133	17,3%	9,8%	33,8%	39,1%
	summer	180	6,1%	2,2%	18,9%	72,8%
	winter	49	10,2%	6,1%	30,6%	53,1%
2020						
	spring	86	10,5%	12,8%	12,8%	64,0%
	summer	109	9,2%	14,7%	17,4%	58,7%

Culvert CUV_SS83_54+6 is not used as a crossing passage by mammals. However, camera trap reveal that this is an important crossing point on the road for mammals, both large and medium sized, indicating that with the adaptations this culvert would become an important crossing structure. In particular we recorded 7 bear passages in 2019 (figure 12), most of them, again, the bear was F18 (table 6). Number of passages of wolves, ungulates and medium sized mammals are provided in table 7 and 8. Most passages are recorded during late evening and night or early in the morning.

Figure 12 Bear crossing the road next to CUV_SS83_54+6. a) F18: 01/08 at 6:37; b) F18: 21/08 at 4:36; c) F18: 28/08 at 8:36; d) F18: 30/08 at 12:00; e) F18: 4/09 at 4:05; f) F18: 24/09 at 6:26; g) non-marked bear: 5/10/19 at 10:40

Table 6 list of all the recorded bear passages at the culvert CUV_SS83_54+6 monitored through camera traps

Camera trap code	CUV ID	Date	Time	Behaviour	N Bears	Bear ID (if marked)
LSC_FT012	CUV_SS83_54+6:	01/08/2019	06:37:00	Cross the road	1	F18
LSC_FT012	CUV_SS83_54+6:	21/08/2019	04:36:00	Cross the road	1	F18
LSC_FT012	CUV_SS83_54+6:	28/08/2019	20:36:00	Cross the road	1	F18
LSC_FT012	CUV_SS83_54+6:	30/08/2019	00:00:00	Cross the road	1	F18
LSC_FT012	CUV_SS83_54+6:	04/09/2019	04:05:00	Cross the road	1	F18
LSC_FT012	CUV_SS83_54+6:	24/09/2019	06:26:00	Cross the road	1	F18
LSC_FT012	CUV_SS83_54+6:	05/10/2019	10:40:00	Cross the road	1	-

Table 7 Number of passages (per season and time of the day) of wolves and ungulates (roe deer, red deer and wild boar) recorded at the culvert CUV_SS83_54+6

Year	Season	Total number of passages	Time slot			
			06-13	14-17	18-20	21-5
wolves						
2019	summer	2	0%	0%	50%	50%
	autumn	2	50%	0%	0%	50%
2020	summer	2	0%	0%	100%	0%
ungulates						
2019	summer	26	15%	0%	8%	77%
	autumn	50	20%	18%	12%	50%
	winter	3	0%	0%	33%	67%
2020	spring	20	25%	10%	30%	35%
	summer	15	29%	0%	0%	71%

Table 8 Number of passages (per season and time of the day) of medium sized mammals (pine and stone marten, fox, badger, porcupine, wild cat) recorded at the culvert CUV_SS83_54+6

Year	Season	Total number of passages	Time slot			
			06-13	14-17	18-20	21-5
	summer	12	8%	0%	25%	67%
	autumn	4	0%	0%	0%	100%
2019	winter	5	0%	0%	0%	100%
	spring	19	6%	6%	22%	67%
2020	summer	25	12%	4%	12%	72%

Monitoring at the other culverts revealed that the structures are not used. We recorded a really few passages of a fox (23) at CUV_SP17_29+9, but in none occasion the animal crossed the culvert, just passed in front of the camera trap (table 9). All passages were recorded during afternoon, and night.

Table 9 Foxes caught by camera trapping at culvert CUV_SP17_29+9. In none of the events the foxes crossed the culvert

Year	Season	Total number of passages	Time slot		
			14-17	18-20	21-5
2019	autumn	2	50%	50%	0%
	winter	18	22%	28%	50%
2020	spring	2	50%	50%	0%
	summer	1	100%	0%	0%

CUV_SS17_146+125 was instead monitored from 31/12/2019 to 8/05/2020 through a camera trap to check the presence of the orphaned cub, after the mother was killed in a car accident on the 24th December. No species used the passage, as expected since it needs a huge clean-up of the vegetation. Due to the high risk of theft we removed the camera trap.

Overall, among the monitored passages, the camera trap which performed better is one of the two camera trap at the entrance of CUV_SS83_55+8, followed by that at CUV_SS83_54+6 (table 9).

Table 10 Performance of the camera trap set to monitor 4 culverts

Camera Trap Code	CUV ID	Sampling (days)	N tot	N bears	N mesomam	N large mammals	tot Perf.	Perf. bears	Perf meso	Perf large
LSC_FT001	CUV_SS83_55+8	450	440	5	432	3	98%	1%	96%	1%
LSC_FT002		450	152	8	140	4	34%	5%	31%	3%
LSC_FT012	CUV_SS83_54+6	400	192	7	65	120	48%	4%	16%	63%
LSC_FT023	CUV_SP17_29+9	315	23	0	23	0	7%	0%	7%	0%
LSC_FT024	CUV_SS17_146+125	129	0	0	0	0	0%	0%	0%	0%

Regarding the performance of transversal structures, in terms of number of bear crossing/days of sampling, we can estimate such measure only for the culvert CUV_SS83_55+8, since for all other structures the number is 0. For measuring performance of bear crossing we consider as a sampling period 1-april- 31 November, in this way we exclude winter months when bears hibernate. In 2019 we recorded 4 passages in 173 days of sampling, therefore performance is 2.3%, in 2020 bear crossed the culvert 4 times in 154 days of sampling therefore performance is 2.5%.

We found no signs of crossing in the remaining structures, although we periodically checked for tracks or signs of presence. This indicate that at present none of the structures are not used by large mammals, including Apennine brown bears.

Other kind of intervention

Along National Road 83 an existing problem is the presence of attractants for bears such as fruit trees. During 2019 all the fruit located along the roads was removed, thanks to a fruit gathering campaign organized in collaboration with volunteers (figure 13). In 2020 due to Covid-19 social restrictions it was not possible to repeat the fruit campaign.

Figure 13 Fruit gathering campaign in 2019 along National road SS83 and villages-PNALM

Conclusions

Types of interventions foreseen in action C2

As described before in our study area there are not many structures that are suitable for adaptation to bear passages, according to literature, but we believe that those targeted could pride an opportunity for a safer crossing to bears and other large and medium sized mammals. Here after the previewed measures that will be adopted for the structures.

1. **CUV_SS83_55+8: "Casone Antonucci"**

This culvert is already occasionally used by at least one female bear. Vegetation has already being cleaned up. In the frame of action C2 we will built a fence leading to the entrance of transversal structures in order to funnel wildlife towards safe crossing path.

2 **CUV_SS83_54+6: "Crugnale**"

This culvert will first need an adaptation of the substratum, which is now made up by large stones which impede free movement. Camera trap monitoring infact indicate that no large mammals use this passage, although it is located in a crossing point frequently used by animals. Also in this case we will build a fence to invite bears and other animals to use the tunnel.

3 **CUV_SS17_146+125**

This culvert requires a huge clean up of vegetation to get free passage to animals. The substratum is flat and this structure is the biggest among the monitores, so it will need no further adaptations. In this case fencing will not only indicate the passage to animals but also preventing them to cross the highly trafficated national road.

4 **CUV_SP17_25+6, CUV _SP17_25+5, CUV _SP17_23+9**

For all these structures the adaptation will require a clean up of vegetation and fixing of the substratum. In particular CUV_SS17_146+125 will need a partial reconstruction of the wall and fixing of the substratum of the pavement.

5 **Overpass SS17_147II**

This is a small multi use overpass that can be easily adapted by fencing with vegetation on the borders.

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Annex 1: Example of characterization files elaborated for the PNALM

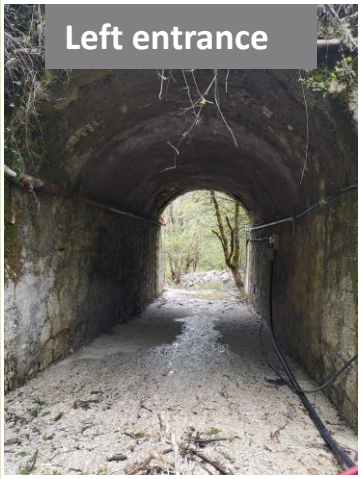
CUV_SS83_55VIII

Road code	SS83
Road stretch	Road_PNALM_B
PK (o+ooo)	55 + VIII
UTM X	409005
UTM Y	4626151
Type of crossing structure	Culvert/drainage

Road transversal section	Flat
Structure section	Vault
Composition of the structure	Simple
Visibility of opposite entrance (%)	100
Height (m)	3,60
Diameter (m)	Not applicable
Width (m)	3.00
Minimum width (m)	3.00
Section	3.53
Length	9.00
Openness index	0.39
Relation Width/Length	Not applicable
Structure construction material	Concrete
Substratum material	Concrete
Natural substratum (%)	0
Presence of water	Yes, temporal
Water layer depth(cm)	1.00
Surface covered by water(%)	0
Dry ledges	None

Entrance orientation 1 (e1)	S
Entrance orientation 2 (e2)	N
Type of obstacle_e1	None
Type of obstacle_e2	None
Dominant vegetation_e1	Herbaceous
Dominant vegetation_e2	Herbaceous
Vegetation coverage_e1 (%)	0-4
Vegetation coverage_e2 (%)	0-4
Activity disturbances at the vicinity	picnic area
Natural Habitat type /Land use_e1	Forest
Natural Habitat type /Land use_e2	Riparian forest
Distance to the entrance_e1 (m)	2,00
Distance to the entrance_e2 (m)	10,00
Type of fences_e1	*None*
Type of fences_e2	*None*
Safety barrier_e1	*None*
Safety barrier_e2	*None*

Left entrance



Right entrance

Vegetation