

ACTION A5. DESCRIPTION OF TARGET ROAD SEGMENTS, IDENTIFICATION OF CROSSING POINTS USED BY ANIMALS AND ANALYSIS OF TRAFFIC VOLUME AND SPEED

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

AUTHORS: Laura Scillitani, Roberta Latini



Action A5- Description of target road segments, identification of crossing points used by animals and analysis of traffic volume and speed – Parco Nazionale d’Abruzzo Lazio e Molise.

Index

Methods.....	2
Results.....	3
Road segments characterization.....	3
Traffic Volume.....	10
Road_PNALM_A.....	10
Road_PNALM_B.....	14
Road_PNALM_C.....	17
Road_PNALM_D.....	20
Road_PNALM_E.....	22
Identification and monitoring of crossing points.....	25
Bear sightings on the road.....	30
Road mortality.....	33
Road accidents involving Apennine brown bears.....	35
GPS monitoring of bears: bear spatial behavior in relation to roads.....	37
Conclusions.....	44
Literature cited.....	46

This preparatory action aims at characterizing and monitoring road segments, finding and monitoring crossing points and animal-vehicle collisions. The purpose was to identify the most critical points to apply the mitigation measures in the actions C1, C2 and C3.

Methods

Road segments characterization

All selected road segments were characterized traveling along each road on foot and taking GPS waypoints to map:

- ✓ Speed limit road signs
- ✓ Wildlife crossing road signs
- ✓ Potential barriers to animal movements: safety barriers, walls, fences, natural barriers (i.e. steep rocky slopes) for each line.

All the gathered information was georeferenced by using a GIS software (Q GIS 2.18). By using a landcover shapefile we identify the characteristics of the landscape surrounding the road segments, by creating a buffer of 400 m on both side of the road segments.

Traffic Volume

We measured for each season in each road segment traffic volume the number of vehicles, their speed and vehicle type. For measurement we employed the traffic counter *Viacount II* (<https://www.viatraffic.de/en/products/viacount-ii-traffic-counter/>). The traffic counter was set along straight-line segments of the targeted road, and left at the spot for one week in each season, in order to be able to compare working days and weekends, and to measure seasonal variations in traffic volume.

Identification of crossing points

Potential crossing point were first identified on GIS software combining information obtained through models developed in action A3, animal vehicle collisions, GPS locations of radiocollared bears. For each accident in which a medium (mesocarnivores) or large sized (ungulates, Apennine brown bears and wolves) was run out by a vehicle, we identified a 200 m buffer. We then walked along the road to find out the exact location of wildlife passages on the road. When the conditions were suitable (presence of adequate location, not too visible from the road by people traveling on the road) we placed a camera trap to identify the species of wild mammals (with particular interest at the target species) which use the passage and the frequency of utilization. We employed Scout HD CAM 12 Mpx set to take picture

sequences for each occasion in which an animal pass by the trail and trigger the camera trap. All data were archived in an Access database. For each passage we recorded date, time, species, number of individuals and behaviour.

Road mortality and sightings

We registered all animals found dead along the selected road segments. Each road was traveled twice a month on foot or by car at a slow pace, in order to record the presence of animals hit by cars. We also gathered all the warnings from park rangers. We considered only vehicle collisions involving mesocarnivores and large mammals.

Finally, we collected all warnings of sightings reported to the National Park or found on social media of bears crossing the road.

Data were stored in a Access database.

GPS telemetry tracking

GPS telemetry was not a previewed SAFE CROSSING action, but PNALM staff routinely monitor bears through radiotelemetry. GPS tracking provide a unique opportunity to have real time information on bear movements in relation to roads and identify crossing points and dangerous road segments. During 2019 two females bears who have been sought along road SS83 were captured and equipped with a GPS collar. One of the bears, F18, is a habituated bear who has been monitored since 2016, and which home range encompass 3 villages located along National road SS83. We analyzed bear location in relation to roads by identifying bear location within a 100 m wide buffer around the road.

Results

Road segments characterization

All road segment within PNALM are two lane roads, one lane per direction of travel. Prior to the start of monitoring activities of Life Safe Crossing, the road segment targeted were 4, but monitoring activities of animal crossings, together with the results of the models developed in action A3, and telemetry data of

bears, indicated that the regional road SP509, code Road_PNALM_D is not frequently crossed by bears, therefore we decided to change the target roads and substitute Road_PNALM_D with other road segments that were non included at first, but need interventions. We decided instead to add other two road segments, ROAD_PNALM_E, SR 479 as the results of the A3 action, together with the analysis of telemetry data indicated a major probability of accident in this road segment. In two occasions, in the past ten years, bears were involved in car accident in this tract, in one case the bear died. In 2020 we added also Road_PNALM_F, a small road segment on National road SS17. We decided to include it 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). Therefore, we characterized a total of 6 road segments (Table 1). All road segment but Road_PNALM_F have been characterized in june-july 2020 (a total of 15 days in the field). Road_PNALM_F was added later so the characterization was made in June 2020 (3 days of fieldwork).

Table 1 List of road segments characterized and monitored inside the PNALM. For each road segment are indicated the number of speed limit road signs and wildlife crossing road signs.

ID ROAD SEGMENT	Description	X start	Y start	X end	Y end	N Speed Limit road signs	N wildlife crossing road signs	Action C previewed
Road_PNALM_A	SS83 Km 35-41	399502	4630751	395948	4636742	4	4	C1-C2-C3
Road_PNALM_B	SS83 Km 46-58	400964	4627162	410767	4625486	14	8	C1-C2-C3
Road_PNALM_C	SP17 Km 15-31	398554	4634007	396689	4645647	10	14	C1
Road_PNALM_D	SP509 Km 1-9	402715	4625494	401622	4622881	13	10	no
Road_PNALM_E	SR479 Km 24-29	407032	4640546	404103	4643172	4	2	C3
Road_PNALM_F	SS 17 Km 145-147II	425006	4626208	425104	4626799	5	0	C1-C2-C3

All road segments were travelled on foot in order to measure all potential road barriers along the road. We did not include in the measurement of the potential barriers road segment inside villages.

We considered a full barrier for bear crossing the presence of walls higher than 3 m or rocky and steep slopes. To classify presence to barriers to bear movements across the two sides of the road we considered 4 classes:

- ✓ No barriers: absence of any kind of structure, or presence of guard rail or walls lower than 1 m;

- ✓ Low: 1 to 1.5 m high barriers
- ✓ Medium: 1.5 to 2 m high barriers
- ✓ High: 2 to 3 m high barriers;
- ✓ Full barrier: higher than 3 m barriers.

Most of the characterized road segment were permeable to bear movements: most of the features found do not represent a barrier for bears.

Along Road_PNALM_A there was almost no barrier with the exception of a really small tract (about 100 m) with a wall higher than 3 m along the left lane. The landscape along this road is characterized by the presence of open areas, pastures and bushes (Figure1). The road segment is flat. There are no hotspot wildlife crossing, since in the absence of barriers, animals can cross the road wherever.

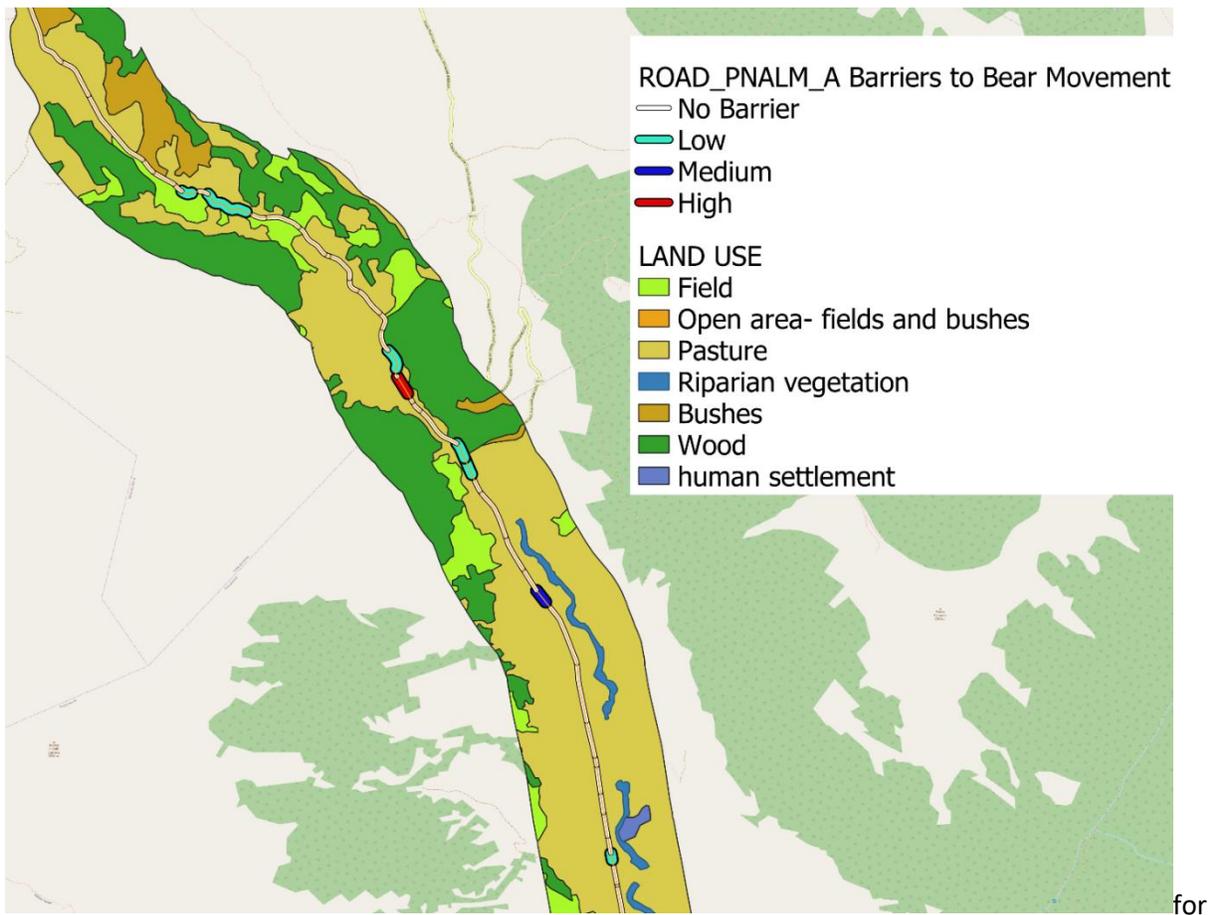


Figure 1 Road_PNALM_A, National road SS83, Km 35-41 have almost no barrier to bear movements, with the exception of very short segments. The landscape surrounding this road segment is open, with presence of fields and pastures, and an almost flat terrain

Road_PNALM_B is mostly flat, with the exception of the segment Km 55-Km 57 in which the transversal section is a slope combination. Along this road segment 5.1 Km have no barriers to animal movement, 1.6 have a low barrier and only 0.8 Km are a medium barrier for bears movement. 1.9 Km are instead difficult to cross, for the presence on the left lane of a rocky steep side. The first 8 km of this road segment are almost free from barriers (figure 2a), with the exception of very small segments with walls lower than 2 m. The road here is surrounded by open habitats: fields and pastures mainly. Along all the road there are fences of barbed wires, which bears can easily climb by. The last 4 km (figure 2b) are instead surrounded by woods, and there is on the right side a stream, Sangro river, while on the left side of the road, there are steep rocky sides that impede crossing to large mammals.

Road_PNALM_C is mostly flat, and the prevalent habitat along this road is wood (figure 3) Along this road segment there are several tracts characterized by steep rocky slopes (3.5 Km precisely) in which wildlife crossing is not possible, so we defined these segments as “full barriers”. Most of the road segment (about 12 Km) are instead easily crossable for a bear. We did not consider the road segment within the villages (Bisegna and San Sebastiano), since there are already speed limits and it is not possible to adopt the measures previewed for the Life Safe Crossing project, although from radiotelemetry we know that bears sometimes enter inside the villages at night. In particular since 2016 a habituated female, F17, use to enter within the villages located along SP17 searching for fruit tree. The PNALM has a campaign since 2016 to inform people about how to behave with habituated bear, including reducing speed limit and be careful at driving.

The small road segment (5 Km) Road_PNALM_D (figure 4) lies on the lake of Scanno shore. This road segment lies within the buffer area around the PNALM (with a lesser degree of protection of the environment). Here the crossing of bear is impeded by the presence of a rocky steep slope on the left lane of the road, except really small passages that we individuated through telemetry and camera trapping. In this road segment a bear was injured in a car accident in 2012 and one was killed in 2013. 730 m are full barrier to bear crossing due to the presence of rocky slopes, and 700m contain barriers that are difficult to cross (mostly 2 m high walls).

Also Road_PNALM_F is outside the border of the National Park, and lies in the buffer area. This road segment is a National road, SS17. Even if it is a two lanes road, this National road connect towns so it is characterized by a more frequent passage of vehicles at high speed. The road section is flat, and the road is surrounded by open habitats as fields and pastures. In the targeted segment there are no barriers to wildlife crossing, only guard rails, which are not a barrier for bears.

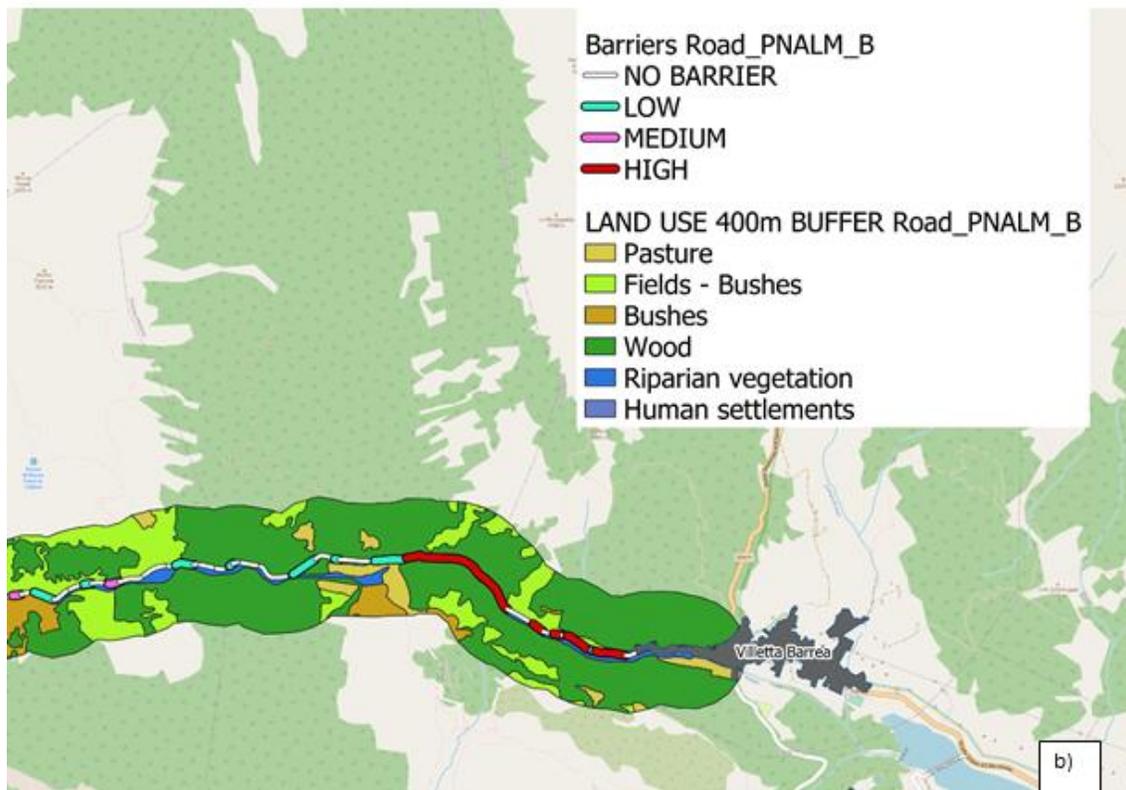
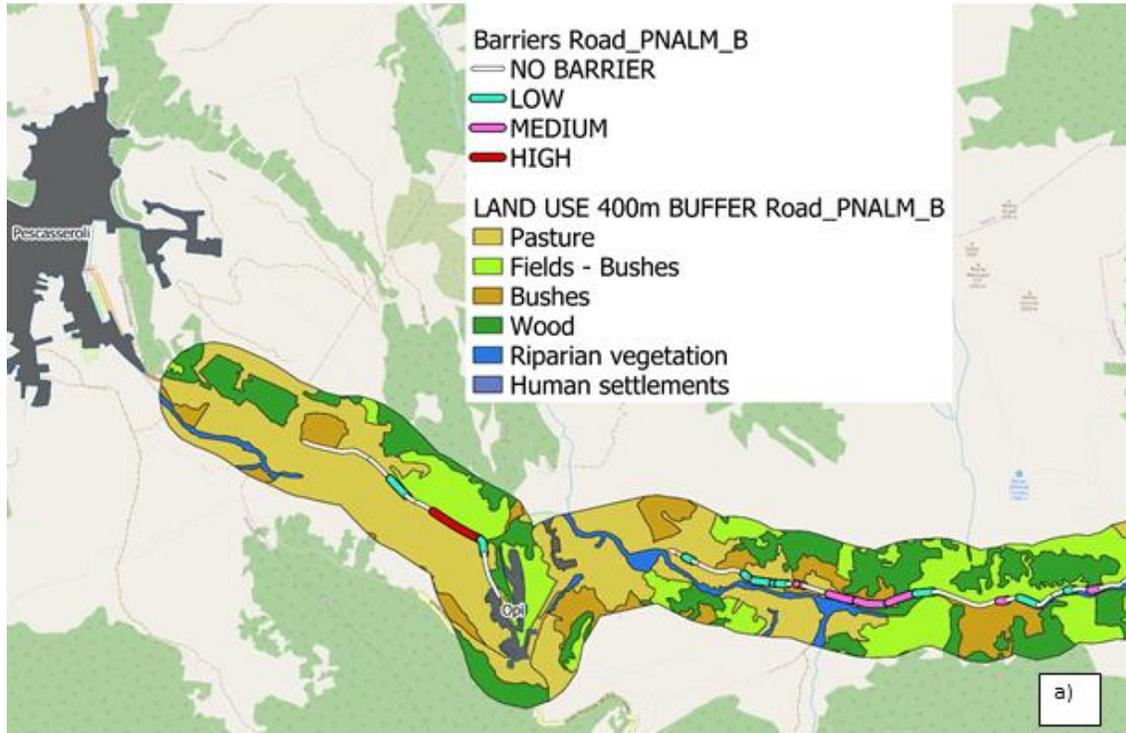


Figure 2 Road_PNALM_B, National road SS83, a) Km 46-52 have almost no barrier to bear movements, with the exception of very short segments. The landscape surrounding this road segment is open b) Km 52-58 here the last two km are characterized by steep rocky slopes on the left lane, which are barriers to crossing. The habitat surrounding the road here is a forested habitat

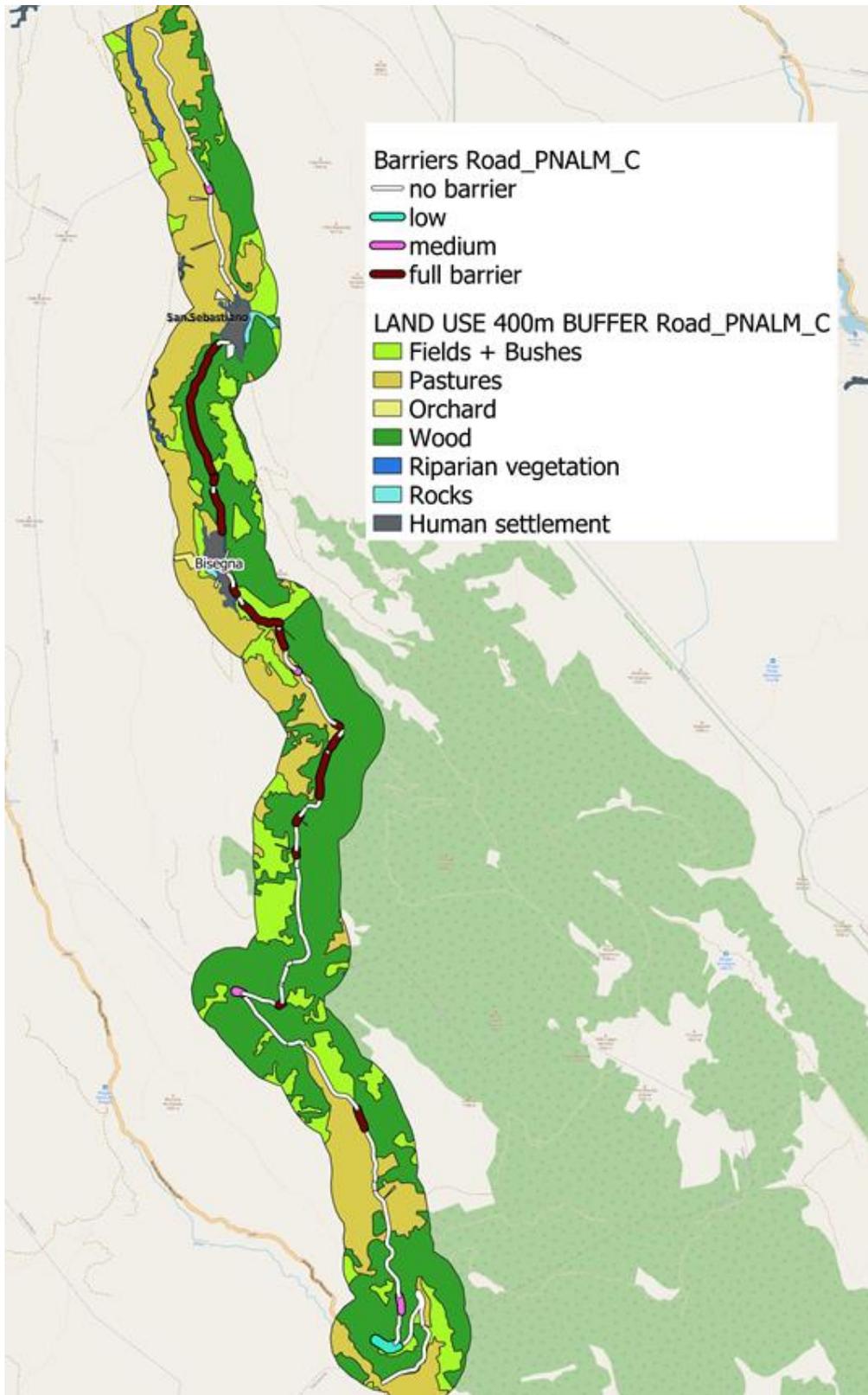


Figure 3 Road_PNALM_C, Regional road SP17. The landscape surrounding this road segment is mostly wooded. The presence of rocky steep slopes creates barrier to bear crossing.

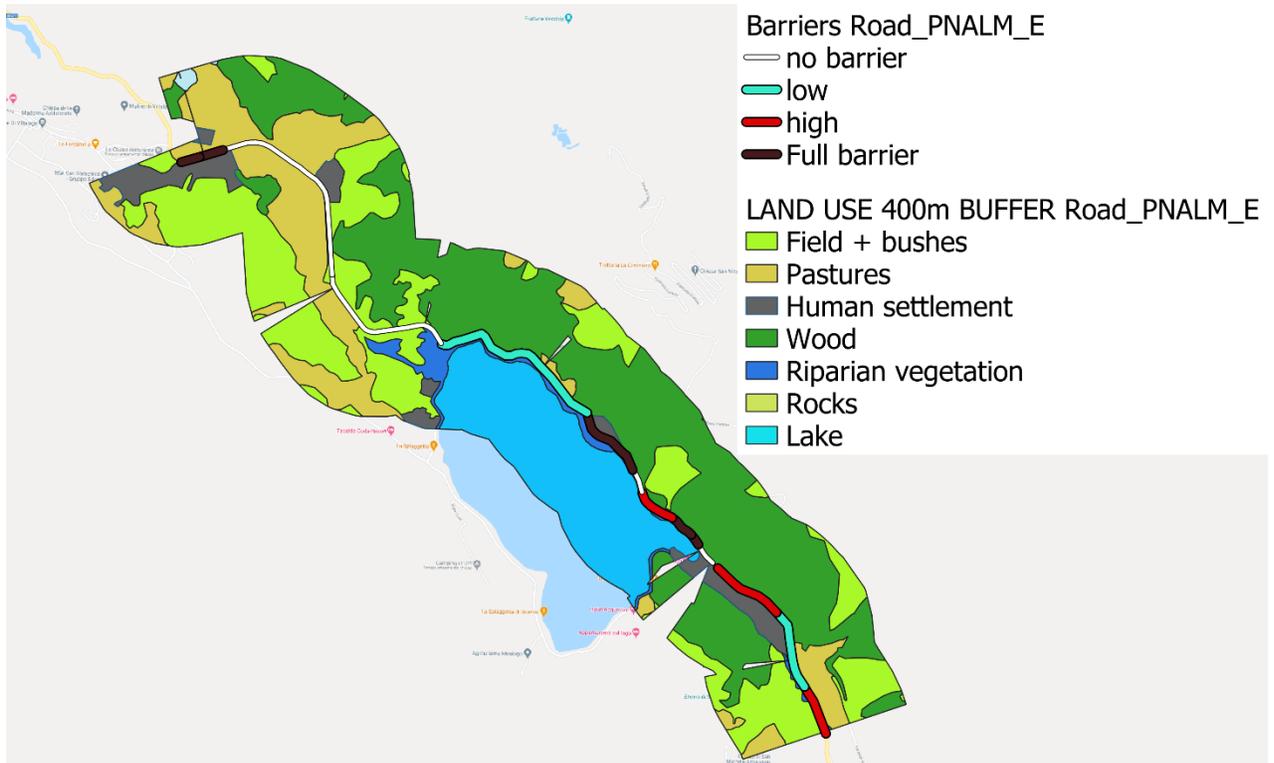


Figure 4 Road_PNALM_E, Regional road SR479. The landscape surrounding this road segment is mostly wooded. The presence of rocky steep slopes creates barrier to bear crossing.

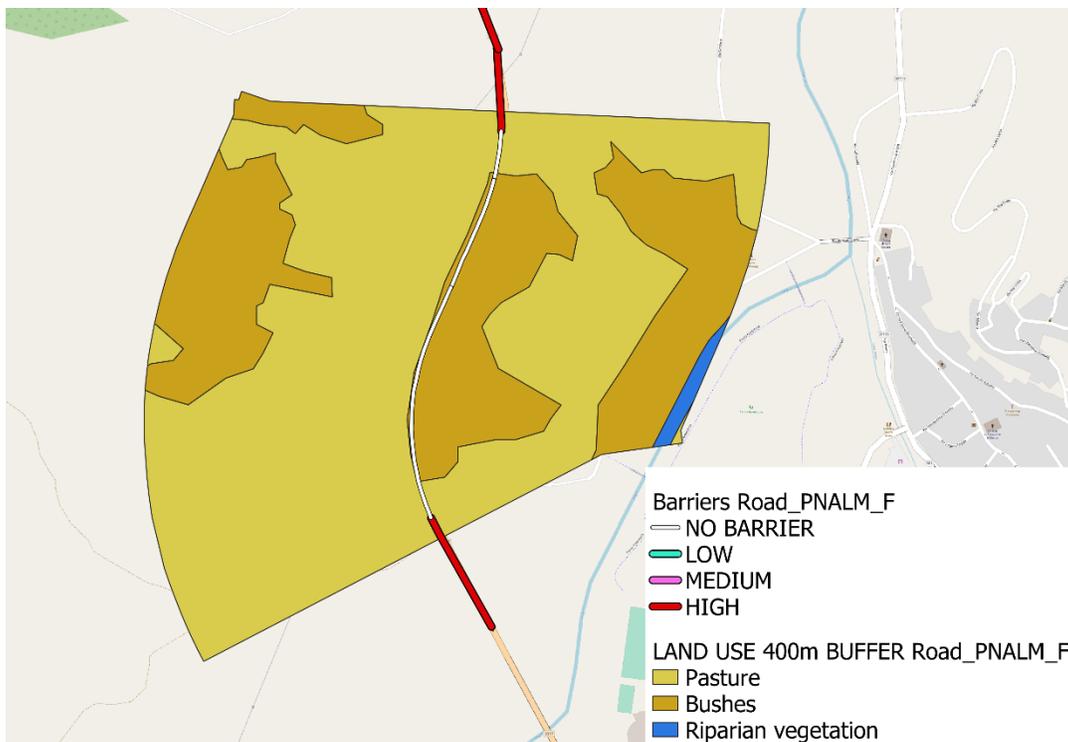


Figure 5 Road_PNALM_F National road SS17. The landscape surrounding this road segment is open. The targeted segment has no barrier to bear crossing.

Traffic Volume

We monitored through the traffic counter Viacount II (figure 6) the traffic on the targeted road segments at least 1 week for each season. We were not able to place Viacount II along Road_PNALM_F since in this small road segment there was no suitable location to place it. Anyway, we agreed with Anas, the enterprise responsible of National road management in Italy, to get data on traffic volume from their traffic counter positioned on this area.

Results of traffic monitoring overall indicate that the targeted road segments are subject to seasonal and weekly fluctuations in traffic volume. Summer and weekends are the period in which traffic volume increase. There is also a daily pattern as during the night the traffic decrease significantly. Cars are the main component of traffic volume, although heavy vehicles travel daily on all road segments.

Overall, speed limits are not respected, with a high percentage of vehicle which exceeds speed limits. Hereafter the details for each road segment.



Figure 6 Traffic counter Viacount II placed along Road_PNALM_B

Road_PNALM_A

Along this road segment the greatest issue is the high speed recorded. Almost all vehicles exceed speed limits (50 km/h), in all seasons (table 2). In summer 2019 49% of vehicles exceed 80 Km/h, in autumn the 43% and in winter the 71%.

Traffic volume was higher during weekend in all seasons but spring 2020 (table 2). In particular this is true for cars and motorbike, while is less pronounced for heavy vehicles. In spring 2020 the traffic volume was

lower during weekend, but this result is probably linked to the Covid-19 restrictions. The traffic counter was placed along the road at the end of May and until June in Italy it was still not possible to travel in other regions except for working reasons. Since this road segment is highly used by visitors to the National park, it is likely that the lockdown had caused a reduced traffic volume. In all seasons there is a daily pattern in traffic volume: traffic is higher in diurnal hours and almost absent during the night.

Table 2 Road_PNALM_A: average values of cars and motorbikes and heavy vehicles in working days (WD:monday-Friday) and weekend. Average speed, percentage of vehicles that exceed speed limits and maximum speed recorded are provided. Speed limit on this road segment is 50Km/h.

Start	End	year	Season	Cars & Moto		Heavy vehicles		Average speed	% over speed limits	Max speed
				WD	WE	WD	WE			
19/07	26/07	2019	Summer	828	1687	306	424	82	95%	212
21/10	28/10	2019	Autumn	437	804	233	237	77	92%	184
30/01	05/02	2020	Winter	259	400	257	335	92	95%	202
28/05	05/06	2020	Spring	227	44	170	16	83	89%	156
29/07	06/08	2020	Summer	775	1126	270	289	65	87%	165

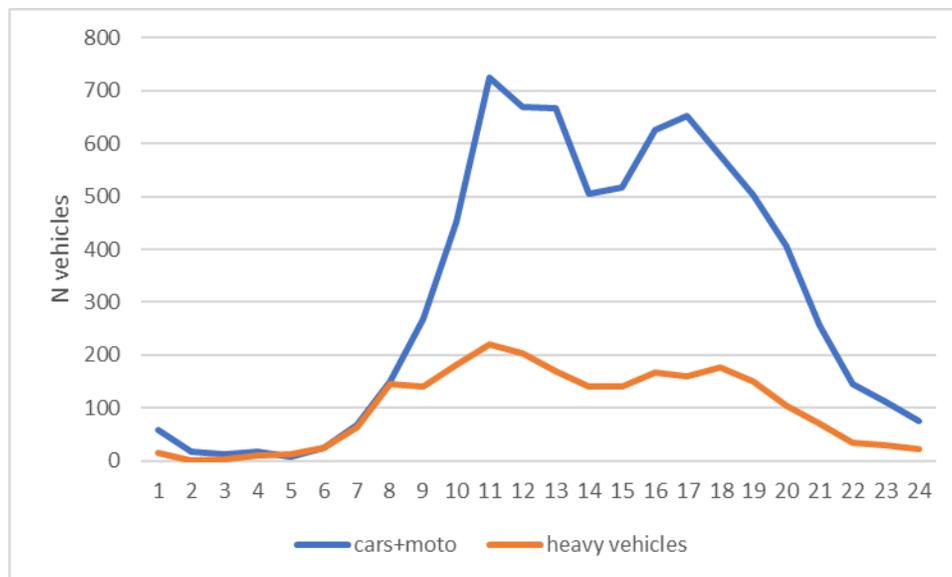


Figure 7 Daily traffic volume (average values) per time slot. Road_PNALM_A, summer 2019 (19/07-26/07)

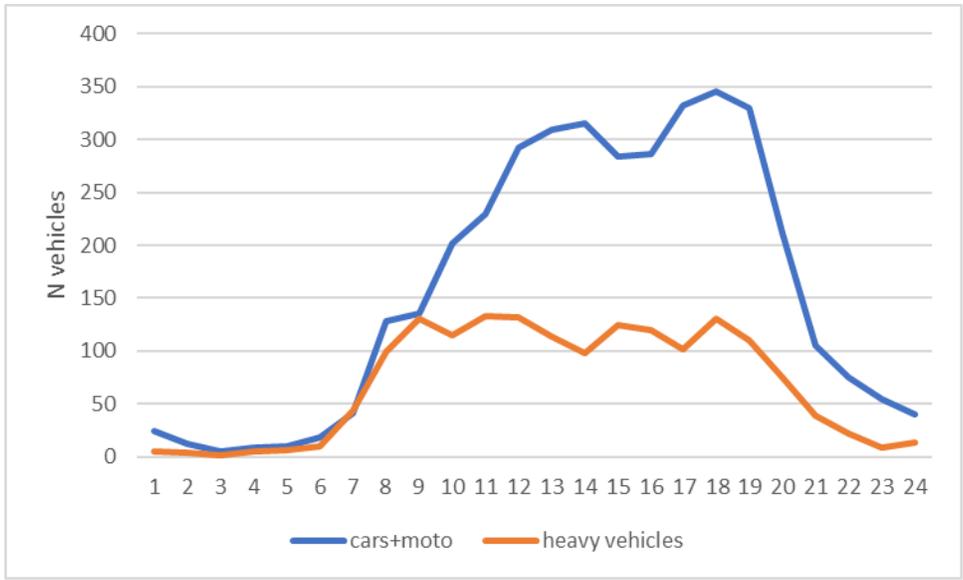


Figure 8 Daily traffic volume (average values) per time slot. Road_PNALM_A, autumn 2019 (21/10-28/10)

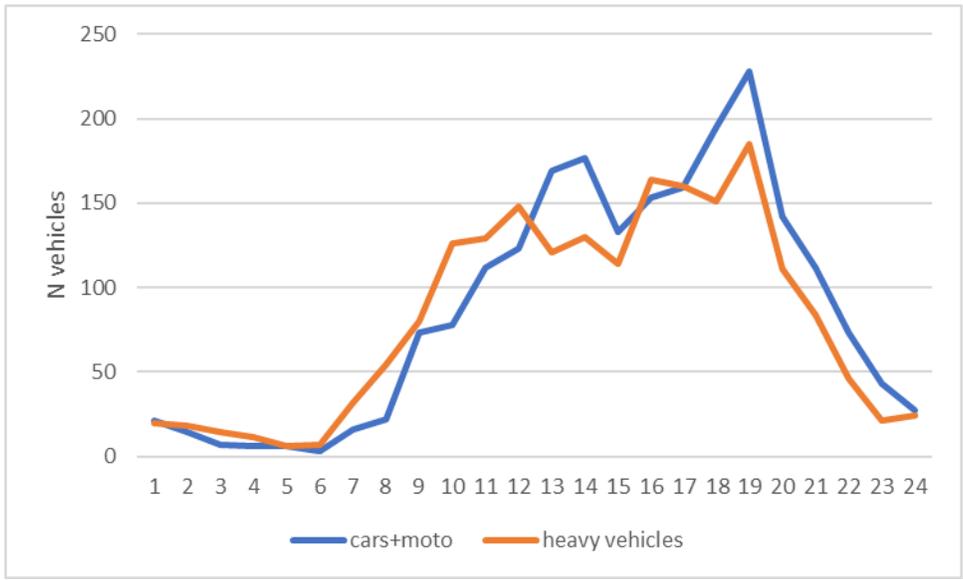


Figure 9 Daily traffic volume (average values) per time slot. Road_PNALM_A winter 2020 (30/01-05/02)

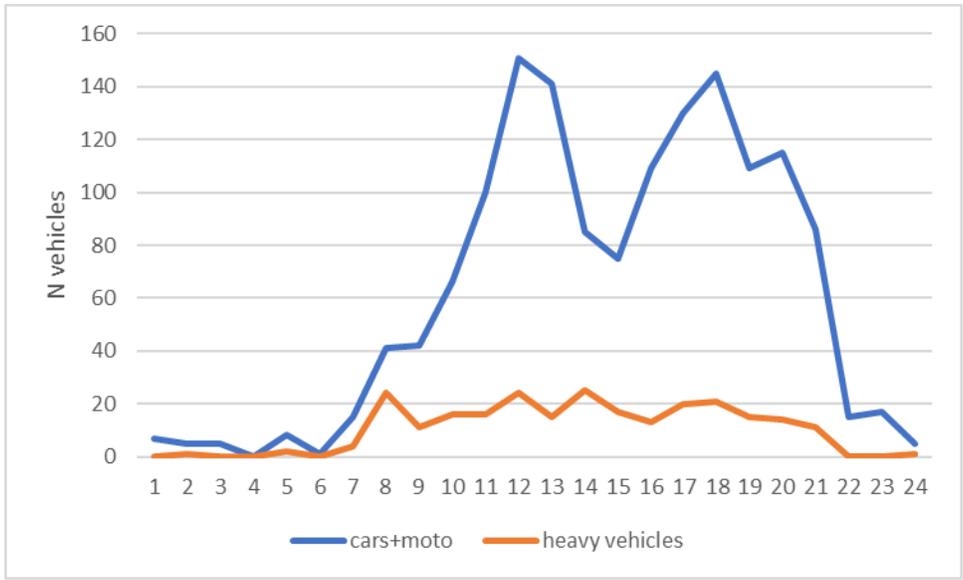


Figure 10 Daily traffic volume (average values) per time slot. Road_PNALM_A, spring 2020 (28/05-05/06)

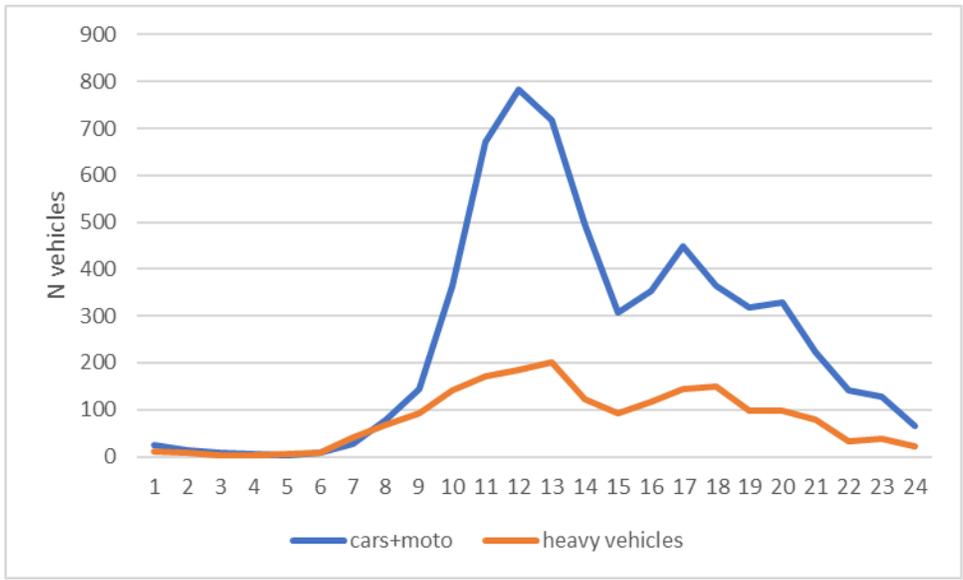


Figure 11 Daily traffic volume (average values) per time slot. Road_PNALM_A, summer 2020 (29/07-06/08)

Road_PNALM_B

This road segments lies within the core of the protected area and connect Pescasseroli, which is the most important village in the Sangro valley, so this road segment is used by commuters. Also in this road segment most drivers exceed speed limits (especially outside the touristic season because in this period the traffic is lower), but the average speed is lower than that recorded in Road_PNALM_A, and about 10 km/h higher than the speed limits. About 5% of drivers exceed 80 Km/h. Also in this case, in all seasons, the traffic is higher during diurnal hours, while during the night traffic volume is strongly reduced (figures 12-17).

Table 3 Road_PNALM_B: average values of cars and motorbikes and heavy vehicles in working days (WD:monday-Friday) and weekend. Average speed, percentage of vehicles that exceed speed limits and maximum speed recorded are provided. Speed limit on this road segment is 50Km/h.

				Cars & Moto		Heavy vehicles				
Start	End	year	Season	WD	WE	WD	WE	Average speed	% over speed limits	Max speed
12/07	19/07	2019	Summer	1084	2241	501	637	54	60%	130
10/10	17/10	2019	Autumn	599	1423	305	436	58	71%	140
21/01	29/01	2020	Winter	575	558	295	65	67	90%	122
2/03	9/03	2020	Spring	311	397	143	81	62	85%	123
19/5	28/5	2020	Spring	220	348	98	79	67	87%	130
17/07	24/07	2020	Summer	788	1589	441	431	60	79%	151

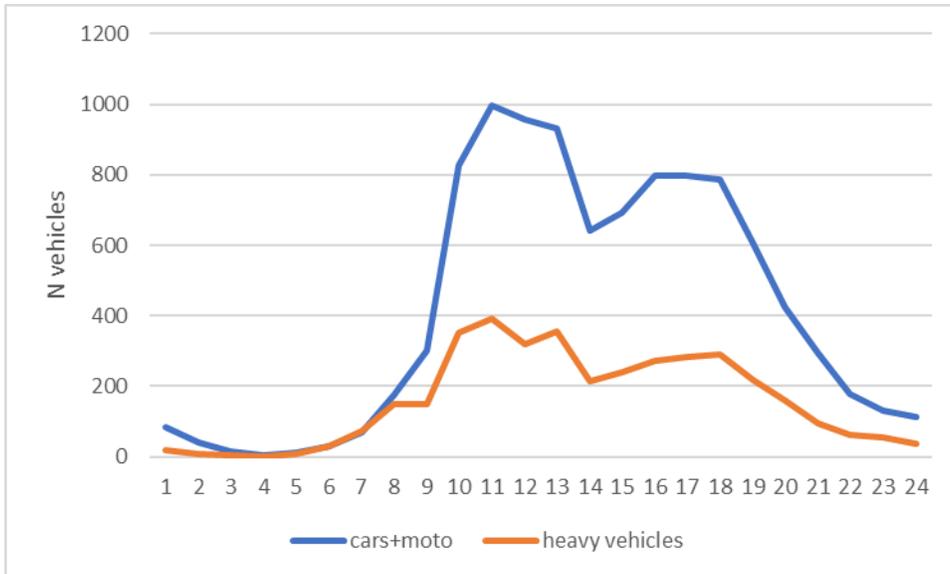


Figure 12 Daily traffic volume (average values) per time slot. Road_PNALM_B, summer 2019 (12/07-19/07)

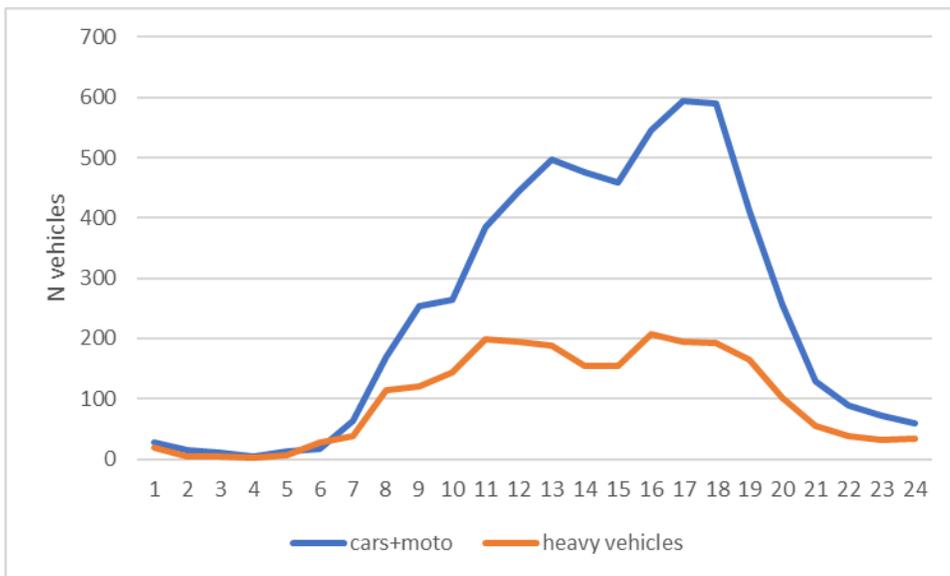


Figure 13 Daily traffic volume (average values) per time slot. Road_PNALM_B, autumn 2019 (10/10-17/10)

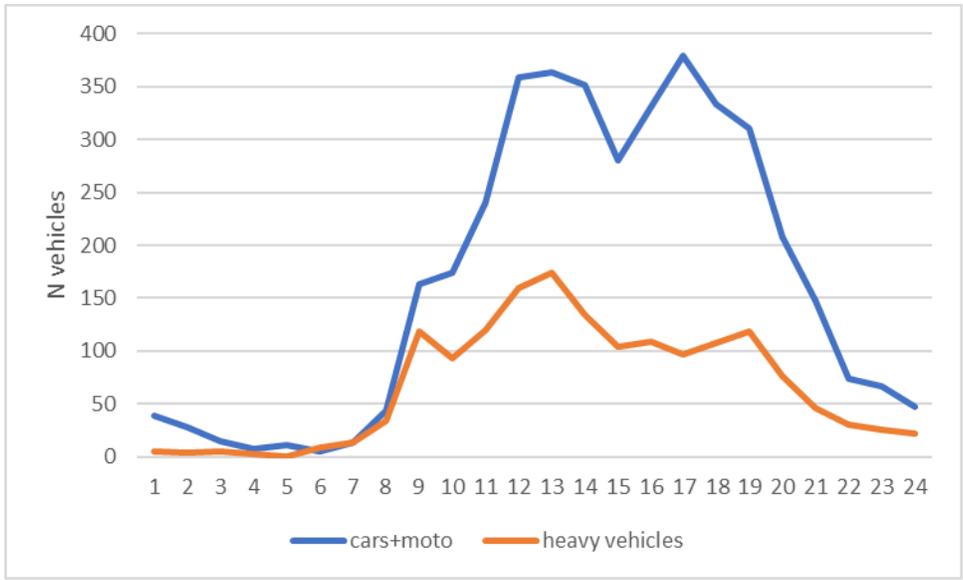


Figure 14 Daily traffic volume (average values) per time slot. Road_PNALM_B, winter 2020 (21/01-29/01)

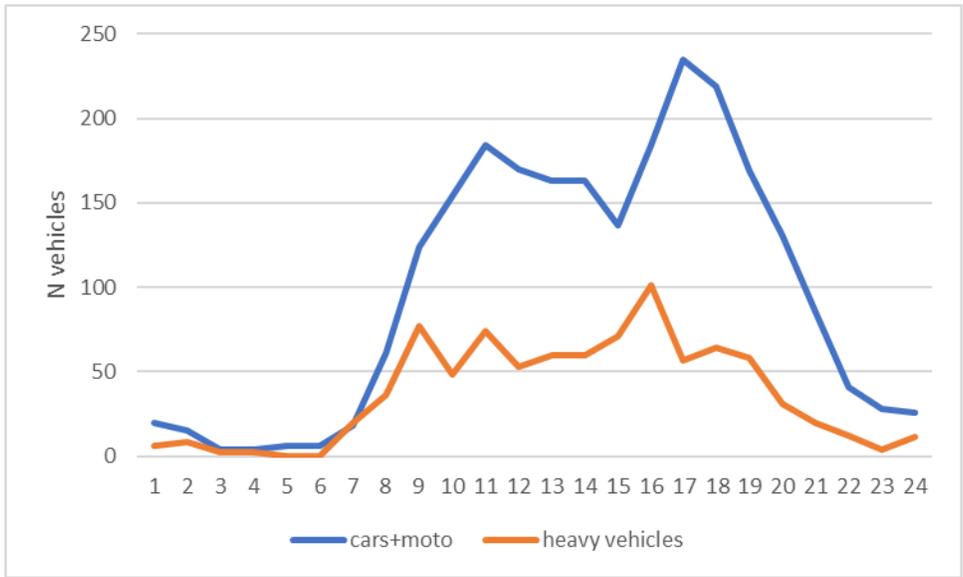


Figure 15 Daily traffic volume (average values) per time slot. Road_PNALM_B, spring 2020(2/3-9/3)

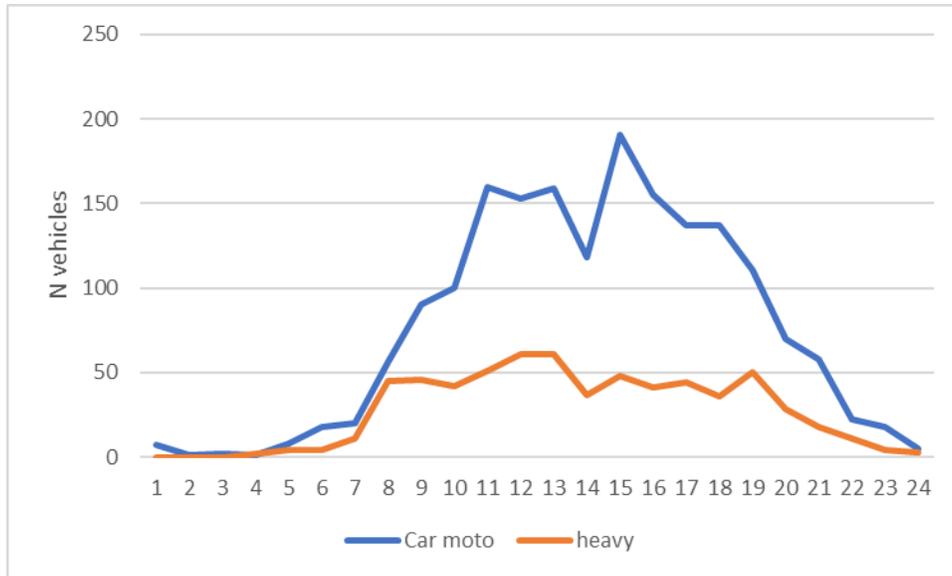


Figure 16 Daily traffic volume (average values) per time slot. Road_PNALM_B, spring 2020(19/5-28/5)

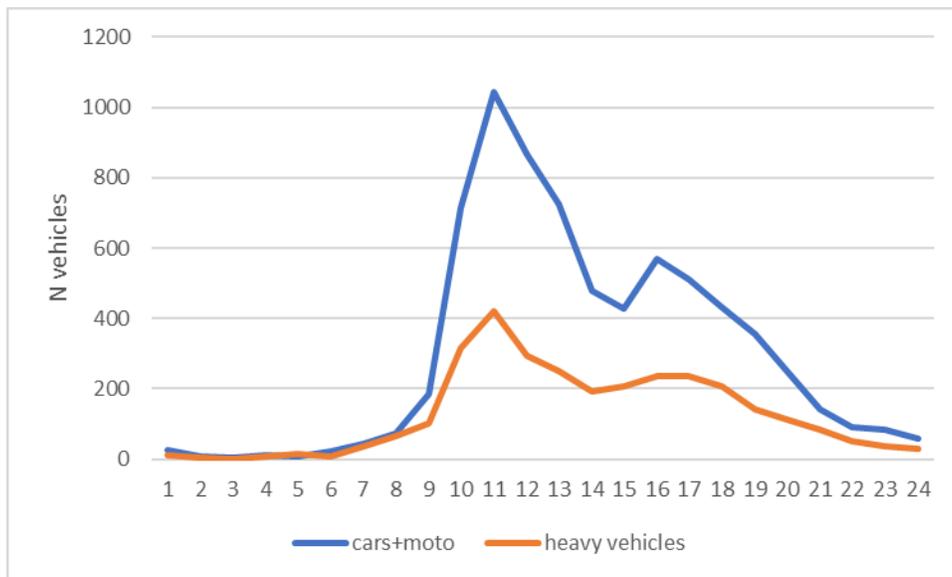


Figure 17 Daily traffic volume (average values) per time slot. Road_PNALM_B, summer 2020 (17/07-24/07)

Road_PNALM_C

For this road we lack the measurement for spring because of the lockdown and movement restrictions due to the Covid-19 pandemic. In summer 2020 we recorded a higher level of traffic, due to the 15th of August which in Italy is an important holiday occasion. Except for summer 2020 the traffic volume in this road segment is generally lower than for segments A and B. However, telemetry data indicate that is road is crossed by bears, and PNALM monitor since 2016 a habituated female who frequently cross this

road segment, so despite the low traffic volume it is important to reduce the possibility of car accident on this road segment. About 23% of vehicles in winter go faster than 80 Km/h. Also in this road segment traffic is concentrated in diurnal hours.

Table 4 Road_PNALM_C: average values of cars and motorbikes and heavy vehicles in working days (WD:monday-Friday) and weekend. Average speed, percentage of vehicles that exceed speed limits and maximum speed recorded are provided. Speed limit on this road segment

Start	End	year	Season	Cars & Moto		Heavy vehicles		Average speed	% over speed limits	Max speed
				WD	WE	WD	WE			
31/07	03/08	2019	Summer	165	239	75	79	63	82%	152
30/10	05/11	2019	Autumn	159	202	83	81	58	73%	112
11/02	19/02	2020	Winter	99	115	42	19	61	68%	119
12/08	20/08	2020	Summer	388	385	156	127	47	36%	119

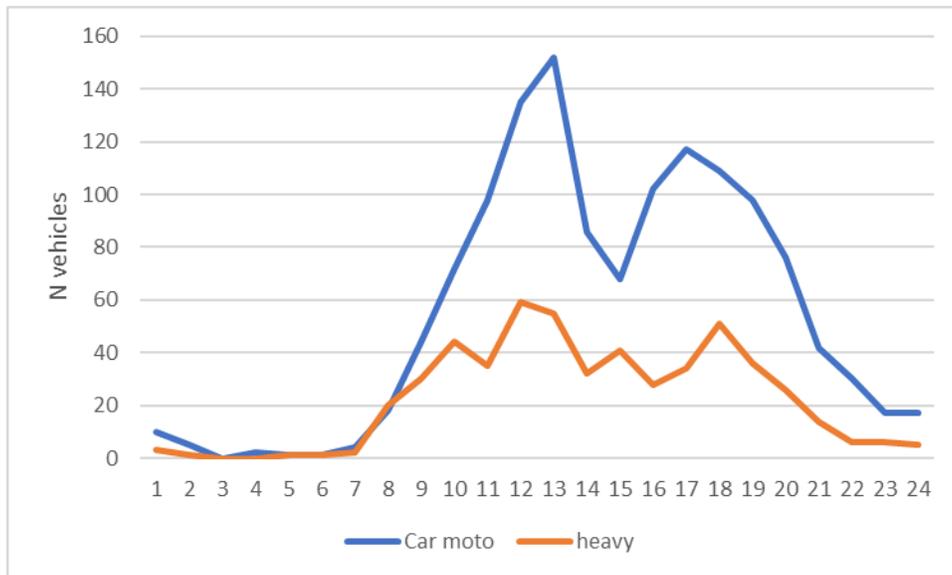


Figure 18 Daily traffic volume (average values) per time slot. Road_PNALM_C, summer 2019 (31/07-3/08)

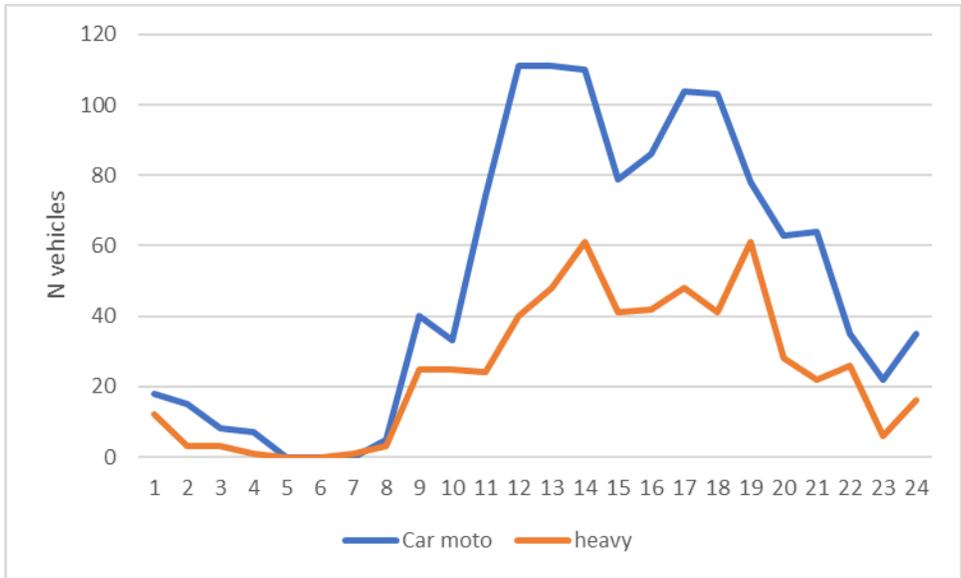


Figure 19 Daily traffic volume (average values) per time slot. Road_PNALM_C, autumn (30/10-5/11)

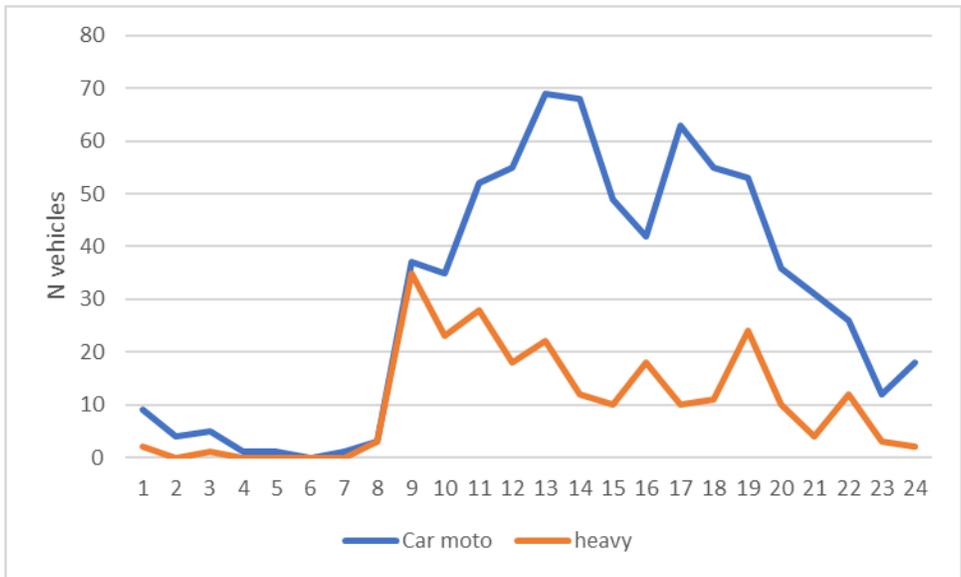


Figure 20 Daily traffic volume (average values) per time slot. Road_PNALM_C, winter (11/02-19/02)

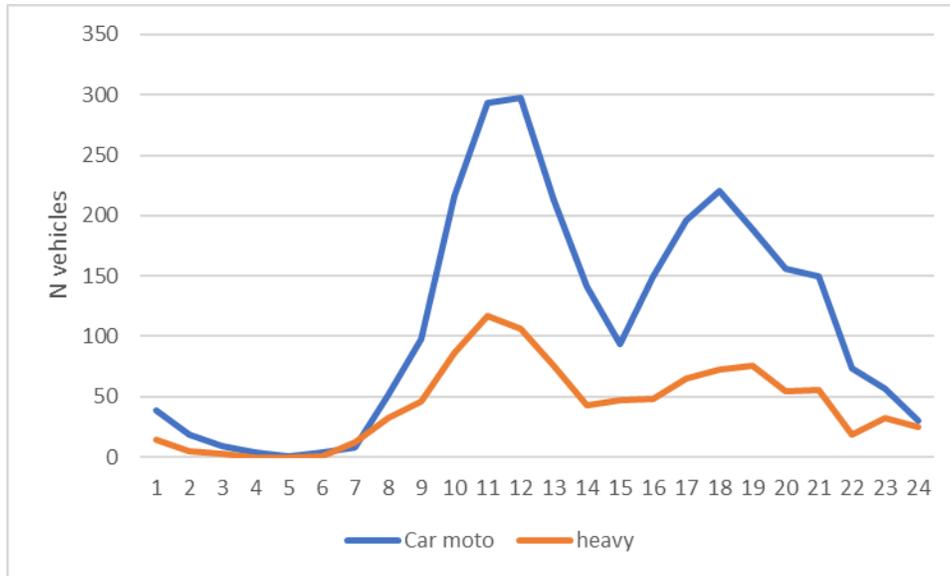


Figure 21 Daily traffic volume (average values) per time slot. Road_PNALM_C, summer 2020 (12/08-20/08)

Road_PNALM_D

The traffic on this road segment was monitored up to winter 2019/2020. Monitoring and models developed in action A3 revealed in fact that this road is not frequently crossed by bears. Therefore, we decided to interrupt monitoring of traffic on this road segment. As for the other road segments in PNALM, traffic is higher during weekends and during diurnal hours.

Table 5 Road_PNALM_D: average values of cars and motorbikes and heavy vehicles in working days (WD:monday-Friday) and weekend. Average speed, percentage of vehicles that exceed speed limits and maximum speed recorded are provided. Speed limit on this road segment

Start	End	year	Season	Cars & Moto		Heavy vehicles		Average speed	% over speed limits	Max speed
				WD	WE	WD	WE			
22/8	29/8	2019	Summer	780	1334	301	413	57	71%	139
20/11	27/11	2019	Autumn	89,2	113	113	107	73	95%	149
20/2	27/2	2020	Winter	118	352	32	68	72	95%	195

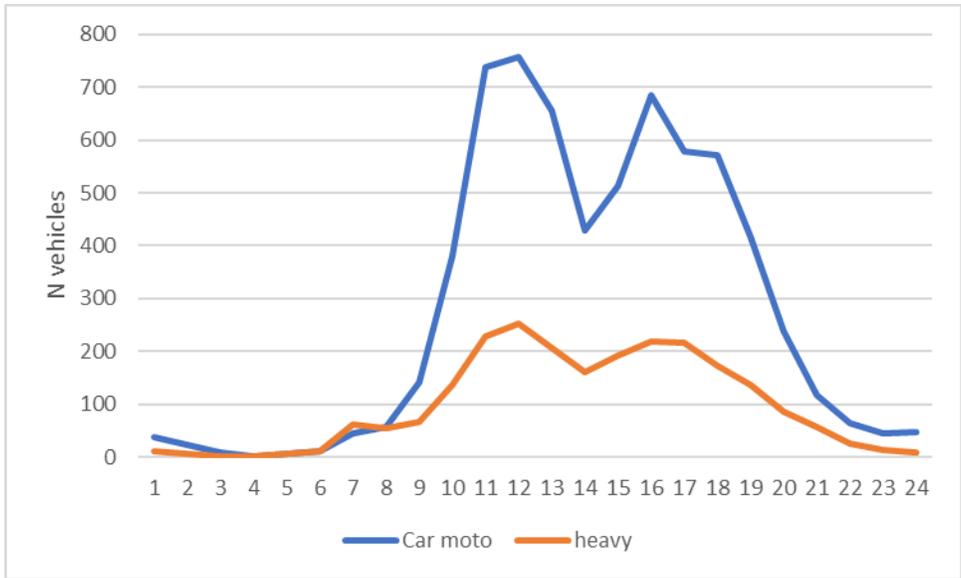


Figure 22 Daily traffic volume (average values) per time slot. Road_PNALM_D, summer 2019 (22/08-29/08)

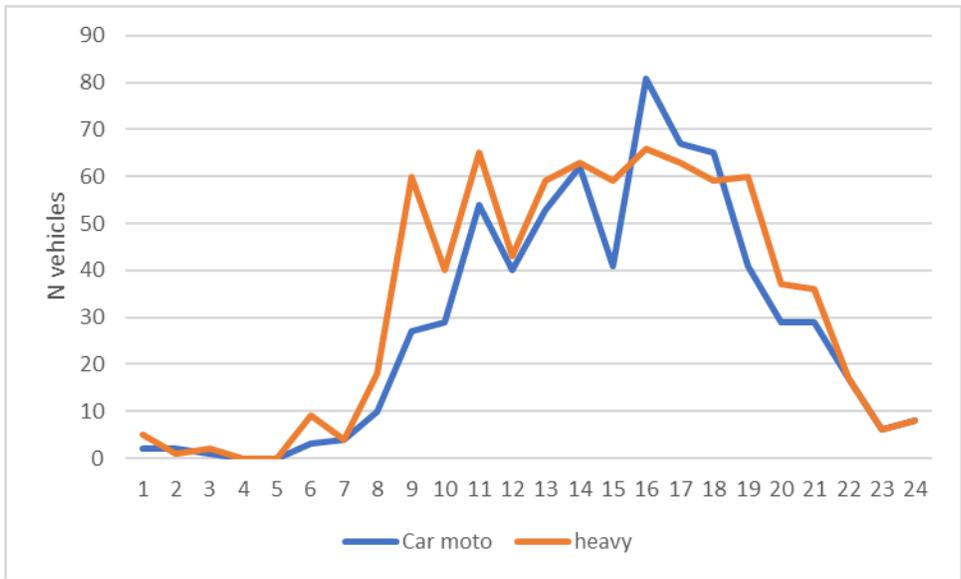


Figure 23 Daily traffic volume (average values) per time slot. Road_PNALM_D, autumn 2019 (20/11-27/11)

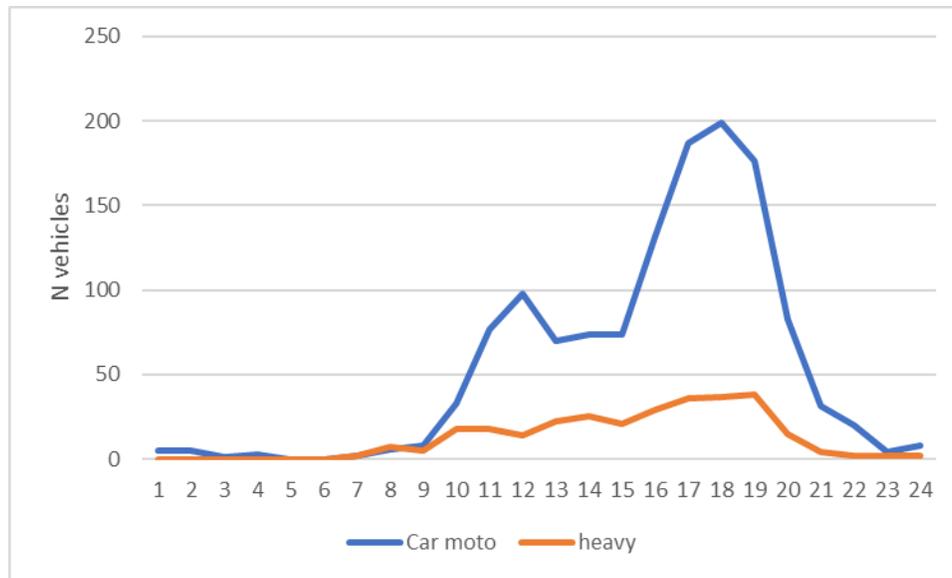


Figure 24 Daily traffic volume (average values) per time slot. Road_PNALM_D, winter 2020 (20/02-27/02)

Road_PNALM_E

Monitoring of traffic volume on this road segment begun in autumn 2019, when, based on monitoring results we decided to substitute Road_PNALM_D with this road segment, which is not located inside the protected area, but in the buffer area, but is more dangerous for car accidents involving bears. Due to lockdown and restriction to movement due to the Covid-19 pandemic we did not monitor this road in spring 2020. In summer we got two different measurements indicating not only that the traffic is higher in summer and in weekends (table 6), but also that it is higher in late summer (August-beginning of September). Traffic is higher during daylight, but in summer it is higher in the afternoon.

Table 6 Road_PNALM_E: average values of cars and motorbikes and heavy vehicles in working days (WD: Monday-Friday) and weekend. Average speed, percentage of vehicles that exceed speed limits and maximum speed recorded are provided. Speed limit on this road segment

Start	End	year	Season	Cars & Moto		Heavy vehicles		Average speed	% over speed limits	Max speed
				WD	WE	WD	WE			
10/12	18/12	2019	Winter	541	515	313	175	61	84%	111
23/6	2/7	2020	Summer	220	241	264	265	58	73%	135
25/8	3/9	2020	Summer	1089	1493	697	906	56	73%	112

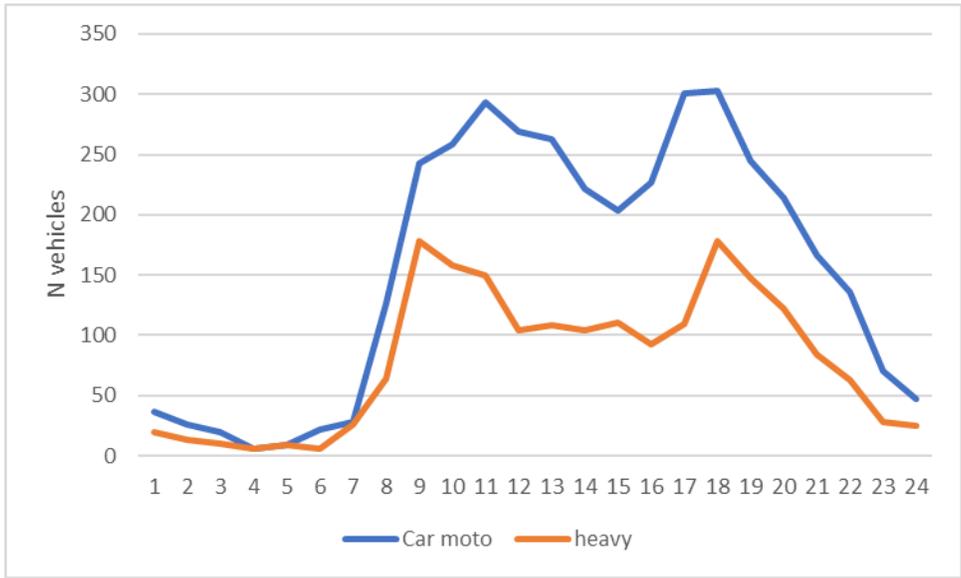


Figure 25 Daily traffic volume (average values) per time slot. Road_PNALM_E, winter 2019 (10/12-18/12)

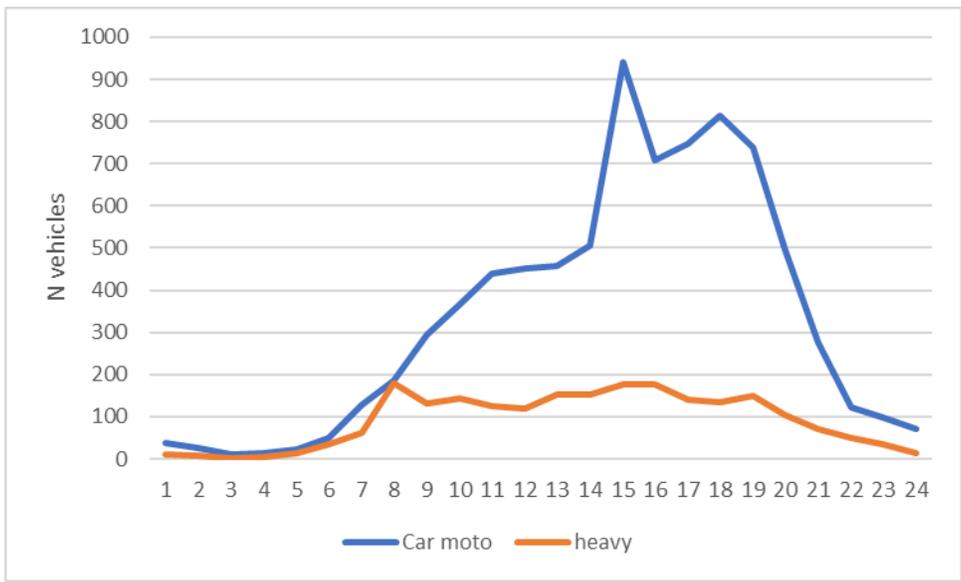


Figure 26 Daily traffic volume (average values) per time slot. Road_PNALM_E, summer 2020 (23/06-2/07)

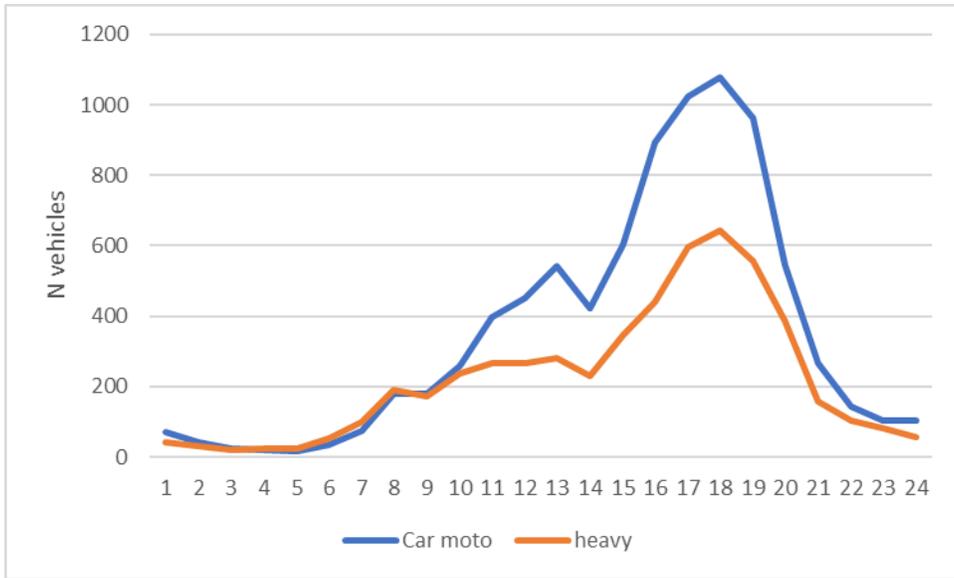


Figure 27 Daily traffic volume (average values) per time slot. Road_PNALM_E, summer 2020 (25/08-3/09)

Identification and monitoring of crossing points

Combining information acquired from radiocollared bears and the model developed in the frame of action A3, and thanks to the foot transect along the targeted road segments, we identified several potential crossing points for bears and other large or medium sized mammals. In 19 crossing points we placed a camera trap in 2019 (table 7 and figure 28), 3 in 2020. We dismissed all sites during winter when the bears hibernate, to avoid damages due to snow, which normally is amassed at road borders when paved road are cleaned by snowploughs. In 2020, due to the lockdown we were unable to place camera trap until the end of May, due to movement restrictions.

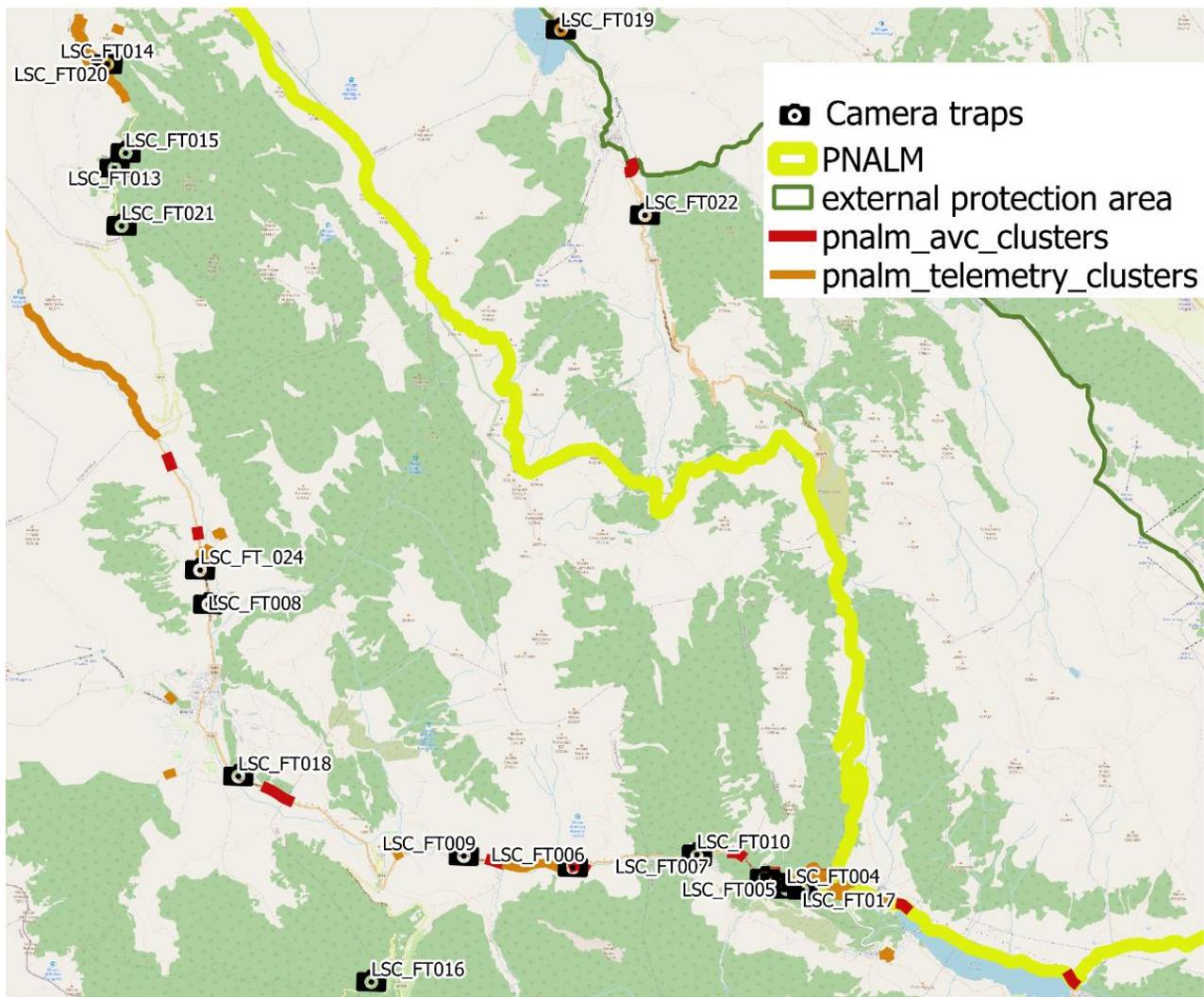


Figure 28 Map of the camera traps placed at crossing points in the frame of action A5. In orange telemetry clusters and in red AVC clusters identified in the frame of action A3

Table 7 list of the camera traps placed along the targeted road segments in the Abruzzo, Lazio and Molise National Park 2019-2020

Camera trap at crossing point ID	ID road segment	Start of Monitoring	End of Monitoring	Trapping period (days)	Notes
LSC_FT003	ROAD_PNALM_B	26/06/2019	18/07/2019	22	
LSC_FT004	ROAD_PNALM_B	26/06/2019	22/11/2019	149	
LSC_FT005	ROAD_PNALM_B	26/06/2019	21/10/2019	117	Stolen
LSC_FT006	ROAD_PNALM_B	27/06/2019	22/11/2019	148	
LSC_FT007	ROAD_PNALM_A	27/06/2019	22/11/2019	148	
LSC_FT008	ROAD_PNALM_B	02/07/2019	21/10/2019	111	
LSC_FT009	ROAD_PNALM_B	02/07/2019	22/10/2019	112	
LSC_FT010	ROAD_PNALM_B	03/07/2019	28/08/2019	56	
LSC_FT011	ROAD_PNALM_B	18/07/2019	02/08/2019	15	Stolen
LSC_FT013	ROAD_PNALM_C	01/08/2019	23/10/2019	83	Stolen
LSC_FT014	ROAD_PNALM_C	01/08/2019	20/08/2019	19	Stolen
LSC_FT015	ROAD_PNALM_C	06/08/2019	21/11/2019	107	
LSC_FT016	ROAD_PNALM_D	06/08/2019	05/09/2019	30	
LSC_FT017	ROAD_PNALM_B	28/08/2019	21/10/2019	54	Stolen
LSC_FT018	ROAD_PNALM_B	03/09/2019	01/10/2019	28	
LSC_FT019	ROAD_PNALM_E	06/09/2019	24/11/2019	79	
LSC_FT020	ROAD_PNALM_C	04/09/2019	21/11/2019	78	
LSC_FT021	ROAD_PNALM_C	17/09/2019	21/11/2019	65	
LSC_FT022	ROAD_PNALM_E	27/09/2019	24/11/2019	58	
LSC_FT004B	ROAD_PNALM_B	29/05/2020	20/07/2020	52	
LSC_FT019B	ROAD_PNALM_E	29/05/2020	20/07/2020	52	
LSC_FT0024	ROAD_PNALM_A	01/06/2020	1/09/2020	92	

It was not always possible to monitor all the wildlife passages individuated through camera trapping, unfortunately, due to logistic problems. For example, Road_PNALM_A is surrounded by open fields, with almost no barriers for animal passage. In such an open habitat, wild animals are free to pass and cross the road wherever, there are no obligatory passages. In addition in the absence of trees it is really hard to set a camera trap without risking a theft, as the visibility is too high. We were able to set only two camera traps along this road segment, but the performance was really low (table 8).

Another problem encountered was the risk of theft. In 2019 we monitored 19 different crossing point and 5 camera traps were stolen (26%). Theft and damaging occurred very often in Road_PNALM_C, were 2 of

the 4 camera traps set along the road were stolen. The problem along this road is that most wildlife crossing points are located in trails that are frequently visited by people. In one case it was possible to find an alternative location for the camera trap in the same spot, in the remaining cases there were no other options available so we were forced to dismiss the monitoring of the passage through camera trap to avoid another theft.

Table 8 Performance of camera trap (number of events/sampling days). The sites in bold are those where Apennine brown bears were camera trapped

Camera trap at crossing point ID	Number of camera trap events	Sampling (days)	Performance
LSC_FT009	354	112	3.16
LSC_FT007	240	148	1.62
LSC_FT011	22	15	1.47
LSC_FT017	60	54	1.11
LSC_FT006	136	148	0.92
LSC_FT004	135	149	0.91
LSC_FT005	90	117	0.77
LSC_FT019B	50	92	0.54
LSC_FT013	43	83	0.52
LSC_FT018	14	28	0.50
LSC_FT019	39	79	0.49
LSC_FT015	30	107	0.28
LSC_FT021	18	65	0.28
LSC_FT003	6	22	0.27
LSC_FT010	14	56	0.25
LSC_FT014	3	19	0.16
LSC_FT004B	8	52	0.15
LSC_FT008	15	111	0.14
LSC_FT020	8	78	0.10
LSC_FT016	2	30	0.07
LSC_FT024	4	52	0.07
LSC_FT022	2	58	0.03

Overall, considering all wild mammal species, the camera trap sessions with a higher performance (number of passages/trapping period) were: LSC_FT009, LSC_FT007, LSC_FT011 e LSC_FT017 (table 8).

In 2019 we recorded a total of 1,231 crossings by large mammals or medium sized mammals. We recorded the passage of bears on 7 crossing points (37% of monitored sites). In 1 more crossing point we obtained a picture of an animal that was likely a bear but the quality of the picture is not enough to state it with certainty. The total of recorded bear crossing is 16. The crossing point with more recorded passages by Apennine brown bears is LSC_FT006, where we recorded 5 bear crossings. The road segments in which we camera trapped bear crossings are located along Road_PNALM_B, Road_PNALM_C and Road_PNALM_E (figure 29). Most trapping events occurred along the segment Road_PNALM_B (table 9). Results of the model developed in Action A3 also indicated a high density of crossing points in this road segment, as well as GPS monitoring. In 5 out of the 16 recorded bear passages the bear was F18, a radiocollared female. In one occasion we recorded the passage of a family group, a female and one cub of the year. Almost all bear passages were recorded at night or dusk. In one case we caught F18 in the afternoon (17:43) on the 1st of August 2019. The same day we got also a picture of F18 crossing the road through the culvert CUV_SP83_55+8, which was at about 50 m from this crossing point on the road.

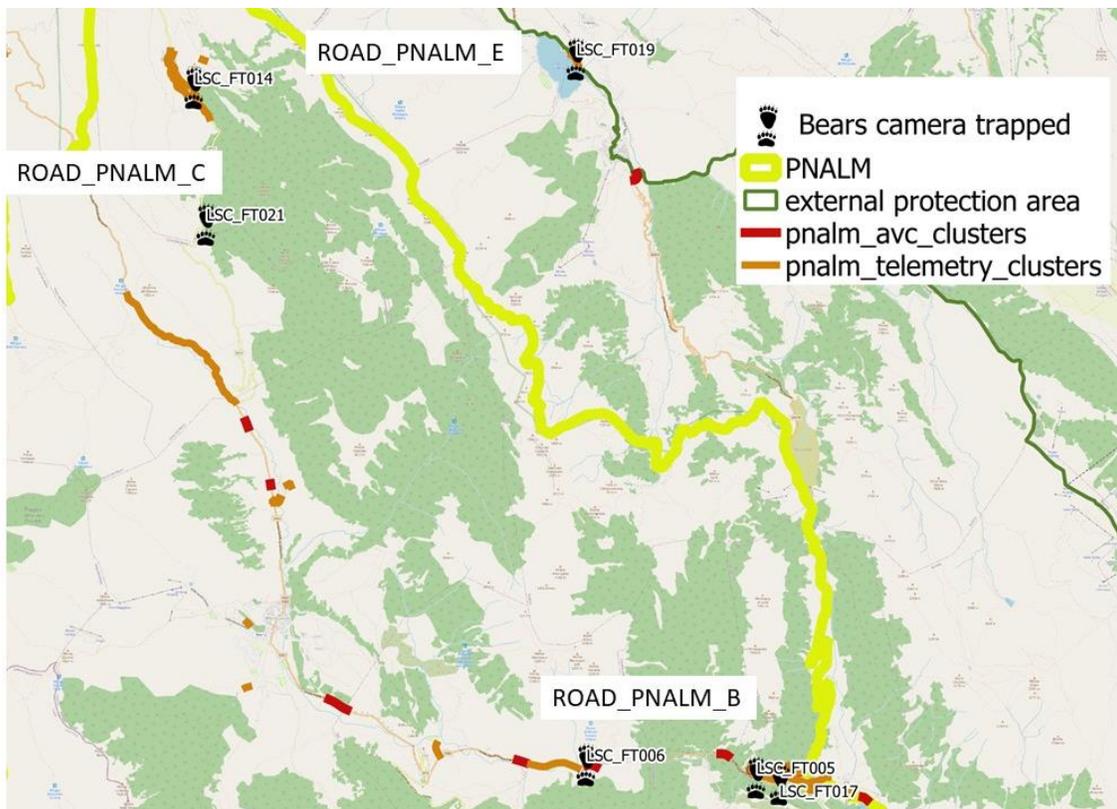


Figure 29 Camera traps which recorded bear crossing the road. In orange telemetry clusters and in red AVC clusters identified with the models developed in action A3

Table 9 Bear crossing camera trapped at crossing points in the frame of action A5-PNALM

Camera trap at crossing point ID	Date	Time	N bears	Bear Code (if recognizable)
LSC_FT011	31/07/2019	02:26:00	1	
LSC_FT011	01/08/2019	17:43:00	1	F18
LSC_FT017	28/08/2019	22:20:00	1	
LSC_FT017	06/09/2019	23:25:00	1	F18
LSC_FT017	14/09/2019	04:06:00	1	
LSC_FT005	14/09/2019	07:20:00	1	
LSC_FT014	19/09/2019	05:00:00	1	
LSC_FT017	24/09/2019	04:21:00	1	F18
LSC_FT019	26/09/2019	04:22:00	1	F18
LSC_FT021	02/10/2019	03:26:47	1	
LSC_FT021	18/10/2019	01:57:00	2	
LSC_FT006	28/10/2019	20:43:00	1	
LSC_FT006	02/11/2019	00:43:00	1	
LSC_FT006	03/11/2019	08:38:00	1	F18
LSC_FT006	06/11/2019	09:43:00	1	
LSC_FT006	12/11/2019	02:42:00	1	

Besides the bears, camera trap recorded the crossing of ungulates, wolves and mesocarnivores (foxes, pine and stone martens, badgers). The species more frequently recorded were foxes (29% of total camera trapping events) and wild boars (24%). Wolves crossing are the 13% of total events recorded and red deer 9%, while badgers represent the 11% of total cases. We observe all other species in less than 5% of all recorded events. We recorded wolves crossing the road in 15 out of 22 camera traps; ungulates and mesocarnivores in 20 out of 22.

The passage LSC_FT_009 was really frequently used by a group of 3 wolves, indicating a recurrent passage at this point. In this crossing point we recorded as well a high percentage of wild boars crossing, indicating that, although bears were never recorded at this site, it could be an important spot for mitigation measures due to the high frequency of large mammals using this crossing point.

Table 10 Number of passages of wolves, ungulates and mesocarnivores at the monitored crossing points

Etichette di riga	Total events recorded	Wolves	Ungulates	Mesocarnivores
LSC_FT003	6	0	1 (17%)	5 (84%)
LSC_FT004	134	10 (7%)	36 (27%)	88 (66%)
LSC_FT004b	8	2 (25%)	4 (50%)	2 (25%)
LSC_FT005	85	14 (16%)	18 (21%)	53 (62%)
LSC_FT006	127	8 (6%)	52 (41%)	67 (53%)
LSC_FT007	227	14 (6%)	122 (54%)	91 (40%)
LSC_FT008	11	1 (9%)	6 (54%)	4 (36%)
LSC_FT009	348	84 (24%)	131 (38%)	133 (38%)
LSC_FT010	13	0	7 (54%)	6 (46%)
LSC_FT011	18	1 (6%)	1 (56%)	16 (89%)
LSC_FT013	34	2 (6%)	20 (59%)	12 (35%)
LSC_FT014	2	0	2 (100%)	0
LSC_FT015	24	0	14 (58%)	10 (42%)
LSC_FT016	2	1 (50%)		1 (50%)
LSC_FT017	56	11 (20%)	4 (7%)	41 (73%)
LSC_FT018	14	2 (14%)	6 (43%)	6 (43%)
LSC_FT019	38	3 (8%)	1 (3%)	34 (89%)
LSC_FT019b	50	1 (2%)	13 (26%)	36 (72%)
LSC_FT020	8	0	4 (50%)	4 (50%)
LSC_FT021	16	2 (12%)	7 (44%)	7 (44%)
LSC_FT022	2	0	0	2 (100%)
LSC_FT024	4	0	4 (100%)	0

Bear sightings on the road

We collected a total of 36 sightings of bears crossing the road, 20 in 2019 and 16 in 2020. In 33 cases we got the coordinates of the exact site of the sighting (figure 30). 19 sightings were collected as shared photos or videos on social media, and it was not always possible to find the people who take the picture, so it was not always possible to get the exact place where the bear was sought. Most of the sighting are in National road SS83, in both targeted segments, but especially in ROAD_PNALM_B. Most bear were seen crossing the road in correspondence of sites that have been identified as potential crossing sites by the model developed in action A3 and by the monitoring of crossing points.

16 sightings are of marked and recognizable individuals, in 10 cases the bear sought was F18. In 2019 the female F08 and her 3 cubs were seen 4 times along the road, and unfortunately this family group was chased by a car with a dramatic outcome. During the night 24-25 August 2019 in fact the family group was chased and split: 2 of the cubs remained alone. The Park personnel got the warning by finding the video

of the chasing on social network on the morning of the 25 August. Thanks to a careful monitoring it was possible to verify that one of the cubs was able to rejoin the mother, but one of the cubs was never found. Unfortunately, the chasing of bears along the road is not an isolated case, we collected on social media other episodes, even if luckily the outcome was not dramatic all times. People who meet bears on the road chase them to film them and post the video on social media. We believe that this bad habit should be addressed in the educational campaign for the Life Safe Crossing.

In August 2019 a solitary cub was found alone along Road_PNALM_A. The Scientific staff of PNALM successfully captured the cub and release it in a natural environment where a family group was sought. The cub successfully joined the family group.

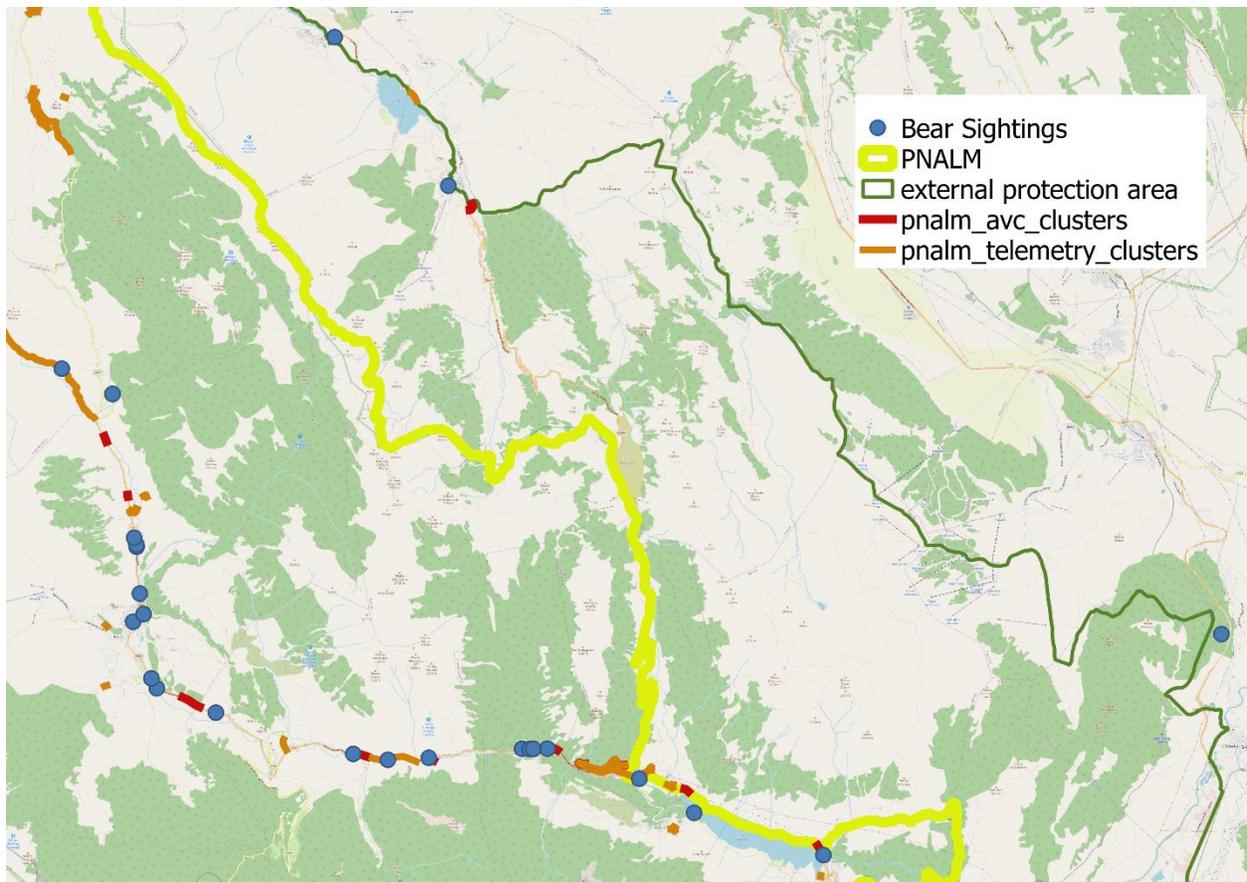


Figure 30 Map of bear sightings on the road in 2019-2020 _PNALM

Table 11 list of bear sighted on the road in 2019-2020. PNALM

Sighting_code	Road code	Date_obs	Hour_obs	N	Age	Family Group	Bear ID (if marked)
Sight_2019_001	Road_PNALM_B	16/06/2019	01:50:00	4	Adult +cubs	yes	F08
Sight_2019_002	Road_PNALM_B	14/07/2019	20:00:00	1	Adult		F18
Sight_2019_003	Road_PNALM_A	17/07/2019	18:00:00	2	Adult +cubs	yes	
Sight_2019_004		28/07/2019	18:36:00	1	Juvenile		
Sight_2019_005	Road_PNALM_B	06/08/2019	08:00:00	1	Adult		F18
Sight_2019_006	Road_PNALM_B	10/08/2019	20:45:00	1	Adult		F18
Sight_2019_007	Road_PNALM_B	25/08/2019		2	Adult +cubs	yes	F08
Sight_2019_008	Road_PNALM_B	25/08/2019		2	Cub		
Sight_2019_009	Road_PNALM_B	01/09/2019		3	Adult +cubs	yes	F08
Sight_2019_010	Road_PNALM_B	17/09/2019		1	Adult		
Sight_2019_011	Road_PNALM_E	17/09/2019		1	Adult		
Sight_2019_012	SS83	17/09/2019	21:40:00	1	Adult		
Sight_2019_013	Road_PNALM_B	06/10/2019	20:15:00	3	Adult +cubs	yes	F08
Sight_2019_014	Road_PNALM_B	10/10/2019	23:00:00	1	Adult		F18
Sight_2019_015	Road_PNALM_B	17/10/2019	20:22:00	1	Adult		F18
Sight_2019_016	Road_PNALM_B	18/10/2019	00:45:00	1	Adult		F18
Sight_2019_017	Road_PNALM_A	08/08/2019	17:30:00	3	Adult +cubs	yes	
Sight_2019_018	Road_PNALM_A	09/08/2019	07:30:00	1	Cub		
Sight_2019_019	Road_PNALM_A	10/08/2019	07:30:00	1	Cub		
Sight_2019_020	Road_PNALM_A	13/08/2019	15:00:00	1	Cub		
Sight_2019_021	Road_PNALM_A	14/08/2019	12:30:00	1	Cub		
Sight_2019_022	Road_PNALM_B	22/11/2019	23:00:00	1	Adult		
Sight_2020_001	Road_PNALM_A	28/05/2020	11:30:00	1	Juvenile		
Sight_2020_002	Road_PNALM_A	03/06/2020		1	Juvenile		
Sight_2020_003	Road_PNALM_A	04/06/2020	15:00:00	1	Juvenile		
Sight_2020_004	Road_PNALM_B	23/06/2020	20:30:00	1	Adult		F18
Sight_2020_005	Road_PNALM_A	09/07/2020		1	Juvenile		
Sight_2020_006	Road_PNALM_B	03/08/2020	22:00:00	1	Adult		
Sight_2020_007	Road_PNALM_B	16/08/2020	18:00:00	1	Adult		F18
Sight_2020_008	Road_PNALM_B	18/08/2020		1	Adult		F18
Sight_2020_009	Road_PNALM_B	17/08/2020		1	Adult		F18
Sight_2020_010		13/08/2020		1	Adult		
Sight_2020_011	Road_PNALM_B	06/08/2020		1	Adult		
Sight_2020_012	Road_PNALM_F	11/05/2020		1	Adult		
Sight_2020_013		27/08/2020		1	Adult		
Sight_2020_014	Road_PNALM_E	24/09/2020		5	Adult +cubs		F17

Road mortality

Twice a month we walked or drove at a walking pace along the targeted road segments to measure road mortality along it. We recorded only data on medium and large sized mammals, although we found frequently dead amphibians. In fact, we considered that mitigation measures that will be employed for brown bear will benefit also other large mammals and medium sized one, and therefore road mortality of these species provide a good proxy for evaluating the effectiveness of action C in future. All year long all car accident involving wildlife are reported by the park rangers and stored in a database. Park staff act to rescue injured animals and collect carcasses of dead animals. Therefore, we also employed and analyzed this data.

Up to 6 September 2020 We performed a total of 107 transects (table 12). Transects started in June 2019 for road segments Road_PNALM_A, Road_PNALM_B, Road_PNALM_C, Road_PNALM_D. We started to collect mortality data along Road_PNALM_E in Autumn 2019, when we decided to include this road in the project. At the end of August 2019 instead we stopped the monitoring of Road_PNALM_D, as we substitute this road segment with Road_PNALM_E. Finally, we included Road_PNALM_F in 2020, and we recorded casualties starting from June 2020.

During 11 March -30 May 2020 it was not possible to regularly perform transects, due to the lockdown restrictions to movement. In this time period we were able only to perform once the transects along SS83 (Road_PNALM_A, Road_PNALM_B).

During the transect we found two dead mammals: on Road_PNALM_B Km 55 , on the 9th July 2020 a male pine marten, and on the 29th of July another marten on Road_PNALM_F, Km 146 (from the condition of the carcass it was not possible to identify if it was a pine or a stone marten).

Table 12 Transects performed along targeted road segments in PNALM, start and end of monitoring, and mammals (medium and large sized) found dead Due to movement restrictions in response to Covid-19 during spring 2020 (March-May) the transects were not performed

**monitoring is ongoing*

Road segment ID	Monitoring start	Monitoring end	Transects 2019	Transects 2020	Total N transects	N mammals found dead	Species
Road_PNALM_A	25/06/2019	06/09/2020*	13	13	26		
Road_PNALM_B	26/06/2019	06/09/2020*	14	13	27	1	pine marten (Martes martes)
Road_PNALM_C	17/07/2019	06/09/2020*	11	12	23		
Road_PNALM_D	25/07/2019	28/08/2019	4		4		
Road_PNALM_E	07/09/2019	06/09/2020*	8	11	19		
Road_PNALM_F	26/06/2020	07/09/2020*		6	6	1	Martes sp

Inside the protected area from January 2019 to July 2020, 26 cases of dead mammals were recorded foxes (9 cases) and roe deer (7 cases) are the animals more involved in vehicle collisions. In the same period, in the buffer of the protected area (with a lesser extent of protection) 19 deaths were recorded; in most cases the animals killed were badgers (5 cases) and roe deers (4 cases). Outside the protected area 2 deaths were recorded, one of a wolf and the other of a female Apennine brown bear. In respect to the targeted road segments, we recorded a total of 18 collisions, 13 in 2019 and 5 in 2020. The road segment in which in total we recorded more accidents was Road_PNALM_B, followed by Road_PNALM_A. No carcasses were collected along Road_PNALM_E. We have one record along Road_PNALM_F, but it is of high importance because the involved animal was a female Apennine brown bear. The species most frequently killed by a collision was roe deer, with 6 cases all recorded along Road_PNALM_B. Recorded AVCs also highlighted the need to carefully survey also the segment of National road SS83 connecting Villetta Barrea with Barrea (from Km 59 to Km 69) where 8 AVC were recorded. Including this Road segment (hereafter Road_PNALM_B2) the total of AVC is therefore 26. Overall, most AVC occurred in summer (5 cases in 2019 and 2 in 2020) and autumn (6 cases in 2019).

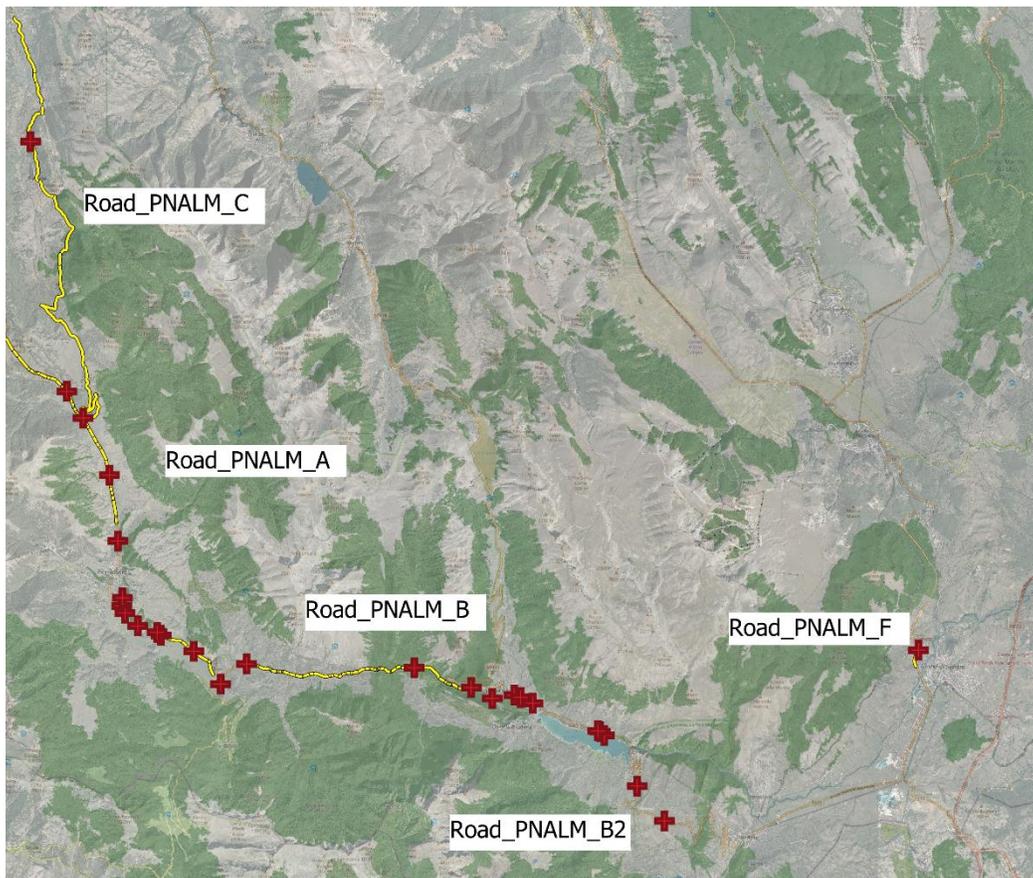


Figure 31 Location of the AVC recorded along the target road segments in PNALM in 2019 and 2020

Table 13 AVC recorded in 2019 and 2020 along the targeted segments in PNALM (ungulates=red deer and roe deer; mesocarnivores=fox, badger, pine marten, stone marten; other medium sized mammals: porcupine and European hare)

	Apennine brown bear	Ungulates	Mesocarnivores	Other medium sized mammals	Total
2019					
Road_PNALM_A					2
autumn				1	1
winter				1	1
Road_PNALM_B					9
autumn			2		2
spring		1	1		2
summer		1	3		4
winter			1		1
Road_PNALM_B2					7
autumn		2			2
spring		2			2
winter			3		3
Road_PNALM_C					1
summer		1			1
Road_PNALM_F					1
autumn	1				1
Total 2019	1	7	10	2	20
2020					
Road_PNALM_A					2
spring		1			1
summer		1			1
Road_PNALM_B					3
summer		1			1
winter			1	1	2
Road_PNALM_B2					1
spring			1		1
Total 2020		3	2	1	6
Grand Total	1	12	3	10	26

Road accidents involving Apennine brown bears

In 2019 two female Apennine brown bears were killed in a vehicle collision (figure 32). The first accident occurred on the 22th of august. A young female (age estimated: 4 years old) was hit by a car along National road SS652, at km 157. Although this road is outside the protected area and the buffer area, the Veterinary Park staff was alerted and intervened. The female was dead and the corpse was taken for the necropsy, which confirmed that the trauma caused by the vehicle was the cause of death. The

following genetic analysis revealed that the female was F20 a young female that during 2018 was monitored by the park, and showed habituated behavior going inside villages in the neighborhood of the SS652.

On the night of the 25th of December, a female with a cub of the year was hit by a car along National road SS17, Km 146+7. This stretch of the road SS17 lies within the buffer zone of the PNALM. Also in this case the park staff was alerted and intervened. The female, estimated 9 years old of age, was dead. The cub was not directly involved in the accident so it was still alive and healthy, but since it was a cub younger than a year the risk was that the cub remained in the neighboring area looking for its mother, and get hit by a vehicle. During the following days the PNALM staff in cooperation with the PNM staff monitored the area in search for the cub, by using camera traps and transects. The cub was observed in the following days. To reduce the possibility that the cub was hit on the same road while searching for his mother, along this tract, in agreement with road authorities, warning flashing light signals were temporarily positioned and patrol controlled the situation.

Following this car accident, the road segment along SS17 was included in Life Safe Crossing monitoring.

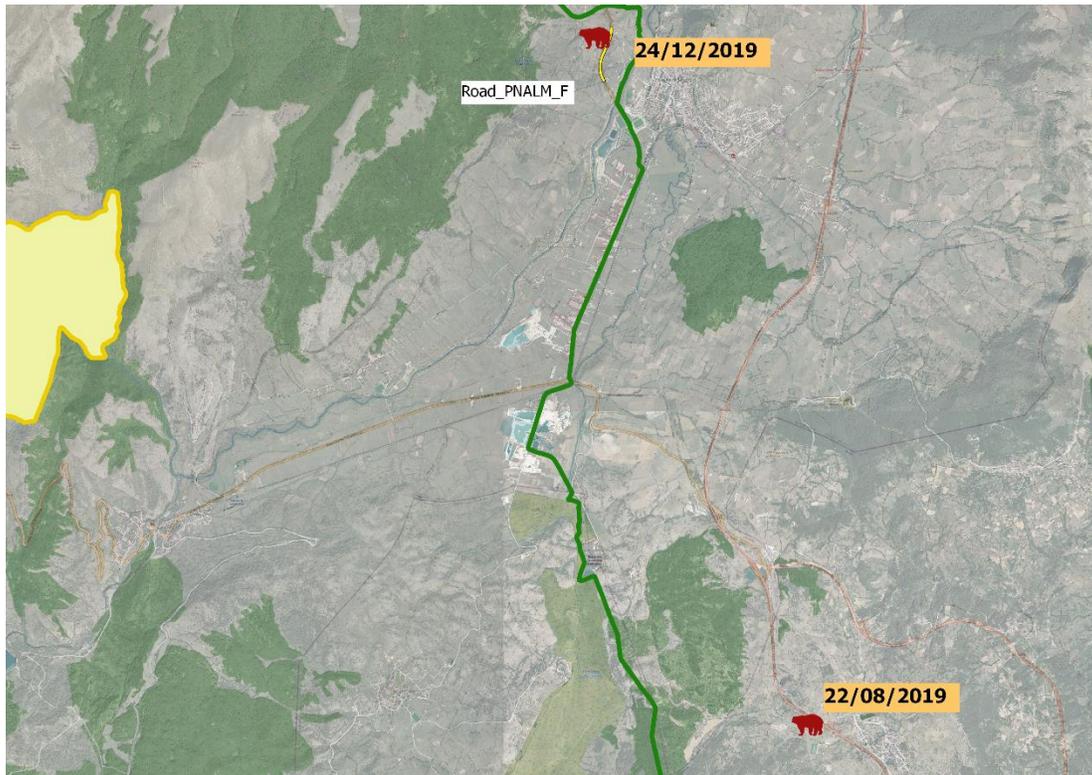


Figure 32 The two car accidents occurred in 2019 in which 2 females Apennine brown bears were involved. In yellow PNALM, green line: buffer zone

GPS monitoring of bears: bear spatial behavior in relation to roads

Aim of the extra-Life action was to analyze the spatial behavior in relation to the targeted road segments. In 2019 in fact, the PNALM staff captured two females that were frequently seen along roads. One of them was F18, which is monitored by the Park staff since 2016. The other bear, F21, was frequently seen along SS83.

For each bear and in each monitoring years we calculated the seasonal core area (as a 50% adaptive kernel) to estimate the areas more intensively used by the bears. In order to understand the intensity of use of the roads we created with QGIS a 200 m wide buffer around the road (100 m buffer around each lane) and we computed the number of locations of the bears inside this buffer.

Hereafter follows a detailed description of the results for each marked individual.

F18

This female has been monitored through GPS radiotelemetry by the Scientific staff of PNALM since 2016. F18 is a habituated female which, in late summer and autumn, is used to get inside villages (Villetta Barrea, Civitella Alfedena, Opi and occasionally Pescasseroli) and has been frequently signaled crossing the National road SS83. On the 22th of August 2019 the female has been recaptured and a radiocollared (as the previous one had run out of battery in 2018). The collar was programmed with the following schedule:

- 22 August-30 October 2019: 1 location/hour from 14:00 to 6:00 LMT and 1 location at 9:00 LMT; once a week the collar was scheduled to obtain 1 location/half an hour since 13:00 LMT of day X to 13:00 LMT of day X+1
- 1st November-7 August 2020: 1 location/3 hours.
- 7 August 2020 -ongoing: 1 location/half an hour.

In 2019 we collected 6 intensive monitoring sessions in with we got a location each half an hour in 24 hours. In 2020 intensive monitoring sessions started in August and will last until the beginning of November.

Both the summer and the autumn core areas in 2019 include Road_PNALM_B, indicating that in both season the bear home range encompass this road segment (figure 33), and that F18 frequently cross the National road SS83 to reach different site within her home range. A very similar result was found for 2020.

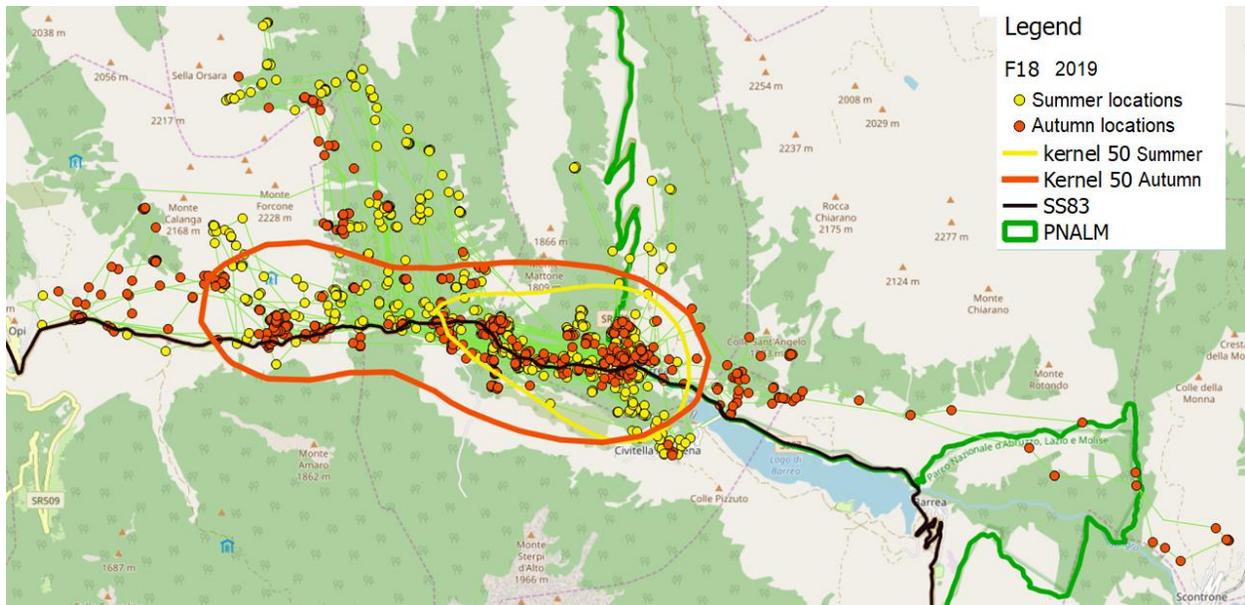


Figure 33 Seasonal core areas (Kernel 50%) of female F18 in 2019. In yellow summer and in orange autumn. Both core areas encompass Road_PNALM_B.

22% of locations of F18 obtained in 2019 (340 on a total of 1535) fall into the buffer of 200m around the road (figure 34). 25% of these locations is diurnal, in particular in late summer (August and September). As the data obtained from the traffic counter demonstrates, the fact that F18 cross the road or walk nearby in diurnal hour is of particular concern, as traffic volume is high. F18 uses areas nearby Road_PNALM_B, the road stretches of National road SS83 connecting Opi to Villetta Barrea. Most of locations in summer are in the area of Casone Antonucci, where there are two targeted culvert that have been monitored in action A4 and will be adapted as wildlife crossing structures in action CX. Data obtained in action A4 reveal that F18 already use one of the culvert CUV_SP83_55+8.

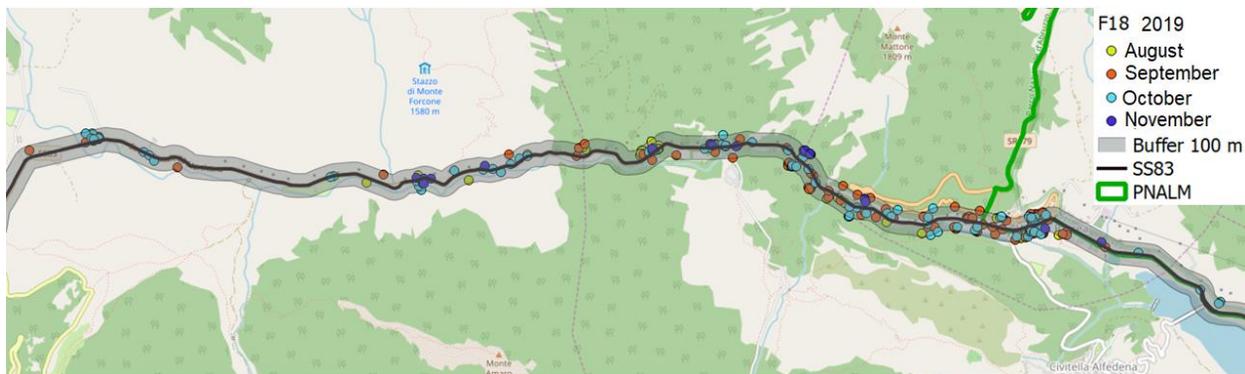


Figure 34 Monthly locations of F18 (2019) that are contained in the buffer of 200 m (100 m in each lane) around Road_PNALM_B



Figure 35 Monthly locations of F18 (2020) that are contained in the buffer of 200 m (100 m in each lane) around Road_PNALM_B

On 5 out of 6 intensive monitoring sessions obtained in 2019, F18 was located on both side of the road indicating that she crossed it. We connected with a polyline consecutive points to roughly estimate the path made by the bear. Although we acknowledge that straight lines are not a truly estimation of the path made from the bear, these segments help to get an idea of the minimum number of times the bear crossed the road (some examples are given in figures 36-38). The same behavior was observed in 2020.

Most crossing occur in the immediate proximity or inside the village Villetta Barrea, that this habituated female frequently visit. Thanks to camera trapping sessions we found the exact spot were the bear cross the river and the road. Although speed limits are usually more respected within villages, it is still a concern the fact that the bear walk along the road at any hours. Data obtained from intensive monitoring sessions also indicate that F18 never used in these occasions the culvert CUV_SP83_55+8, since the camera traps set at both entrance in the frame of action A4 never got a video of the bear in these days. Instead we obtained pictures nearby the culvert CUV_SP83_54+6 (5/10/2019 10:40 a.m.) confirming that the bear did not use this culvert to cross the road but it is still an important crossing point.

F18 is active and move mainly in dark hours, when traffic volume is lower. However, vehicle speed is even higher in nocturnal hours, indicating the need to adapt the road for a safer wildlife crossing.

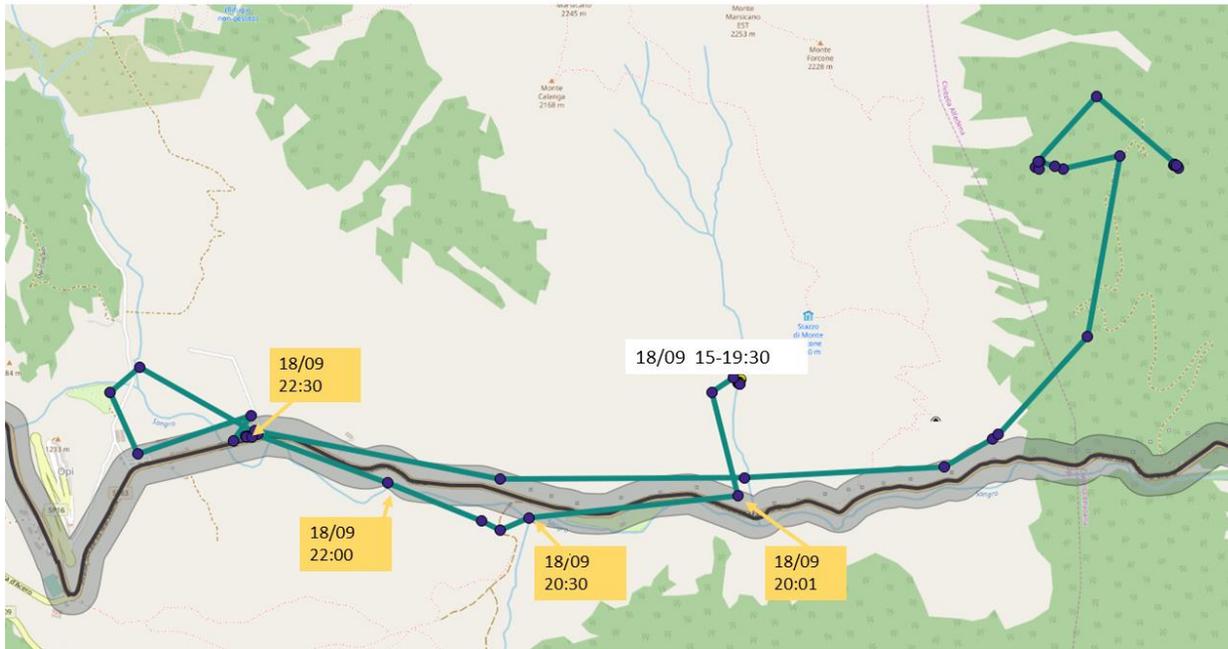


Figure 36 Estimated path of the bear F18 during the night 18/09/2019- 19/09/2019 along Road_PNALM_B

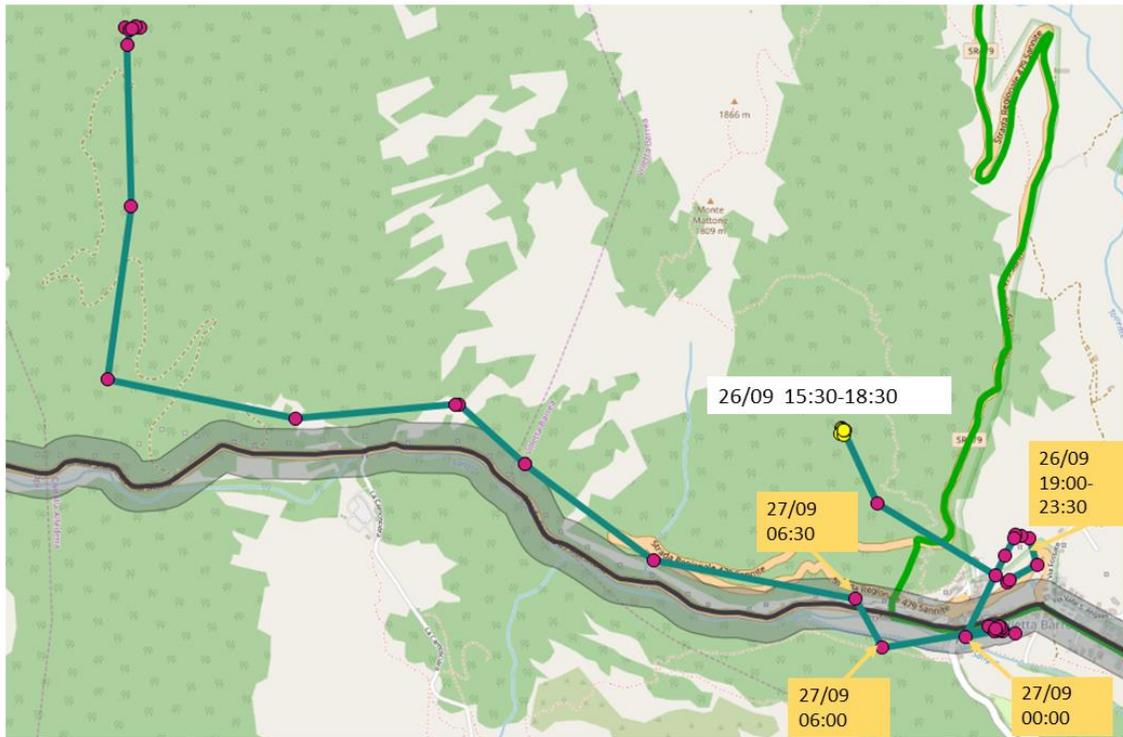


Figure 37 Estimated path of the bear F18 during the night 26/09/2019- 27/09/2019 along Road_PNALM_B

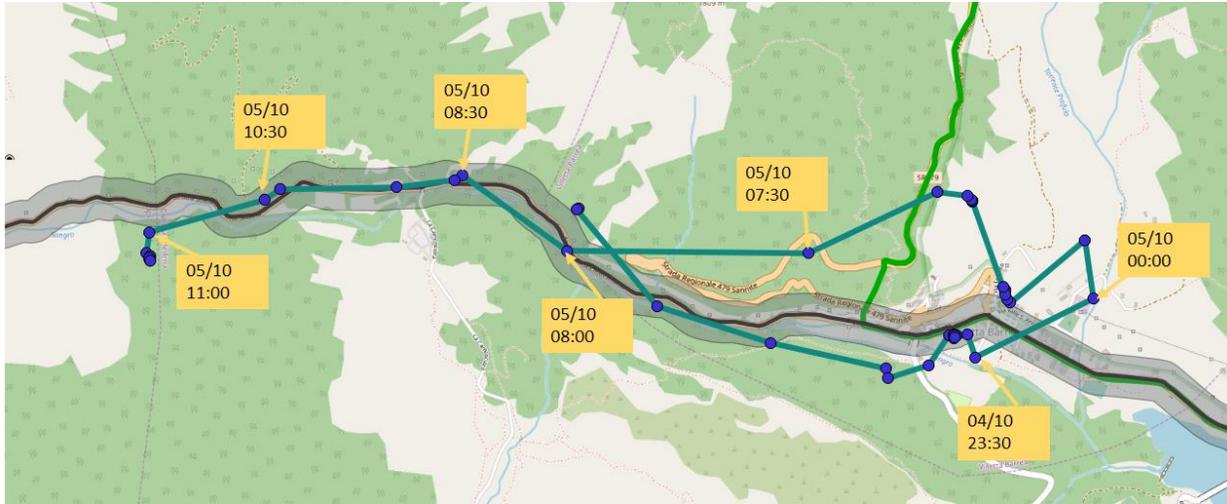


Figure 38 Estimated path of the bear F18 during the night 04/10/2019- 05/10/2019 along Road_PNALM_B

In 2020 we collected 298 locations of F18 inside the buffer of Road_PNALM_B. 98% of this locations were collected in late summer (August and September). Only 5 locations belong to June and July. The late summer home range of F18 encompass the National road SS83, since the bears feed upon the fruit trees that are located in the Sangro valley and enter inside the villages in search for orchards. In late summer 2020 therefore, the locations inside the buffer represent 19% of locations (295 out of 1549), a proportion comparable to that obtained in 2019, although slightly lower.

F21

This young female (estimated age at capture 4-5 years old) was captured and equipped with a GPS radiocollar on the 10/09/2019. The bear was repeatedly sought on the road, therefore the Park staff decided to capture her to better monitor her movements. Since in the spot where the bear was seen on the road there was an apple tree, the PNALM staff removed all available fruit to eliminate attractants. The collar was programmed with the following schedule:

- 11 September 2019 -30 October 2019: 1 location/hour from 14:00 to 6:00 LMT and 1 location at 9:00 LMT;
- 1^o November 2019- 7 August 2020: 1 location/3 hours.
- 7 August 2020 -ongoing: 1 location/half an hour

The home range of F21 encompasses 3 different roads, all at least partially included in the Life Safe Crossing project: SS83, SR479 and SS17 (figure 39). While F18 uses the area surrounding Road_PNALM_B only in late summer and autumn, F21 has seasonal home ranges that encompass the road in all seasons but winter (as expected of course due to the hibernation).

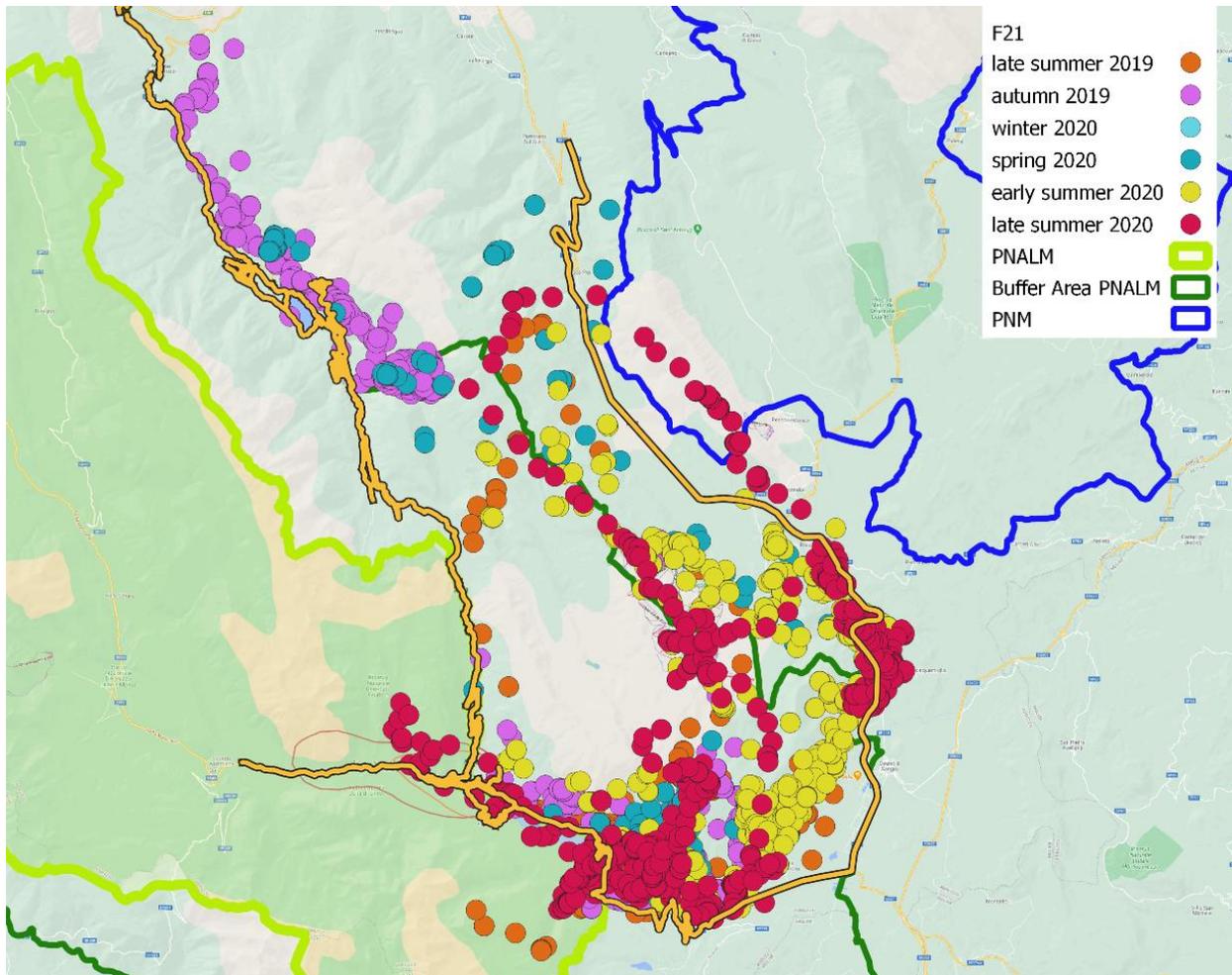


Figure 39 Locations of F21 (different colors indicate different seasons) in relation to roads. The female uses area surrounding 3 roads, all at least partially included in Life Safe Crossing: SS83, SR479 and SS17.

We performed surveys to verify clusters of the bear nearby the roads. Luckily in most cases she was feeding on fruit trees that were not on the road. Still, F21 uses both sides of the road and in each season there are location which fell in the buffer created around road segments (figure 40 and 41), although only in late summer 2019 and in early summer 2020 the core area encompass the road (figure 41), while in other season although road were visited the density and therefore the frequency of use was lesser.

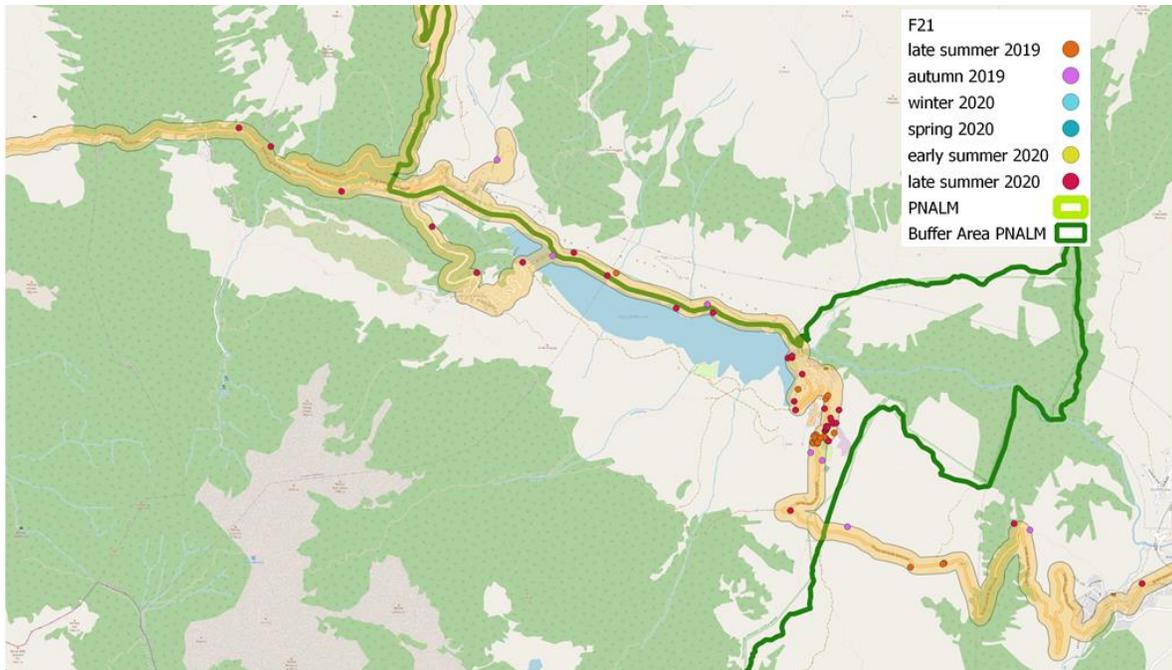


Figure 40 locations of F21 falling inside the buffer of national road SS83 (Road_PNALM_B)

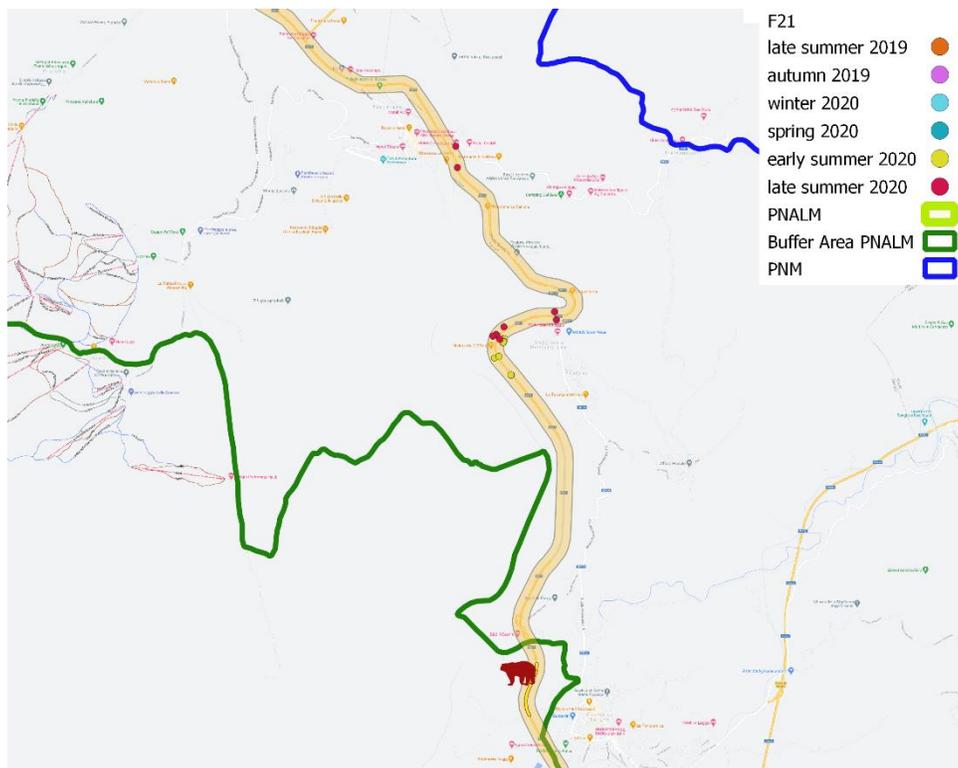


Figure 41 locations of F21 falling inside the buffer of national road SS17 (Road_PNALM_F). The bear symbol indicate the road accident in which a female was killed on the 25 December 2019, about 1,5 Km southern of the locations on the road of F21.

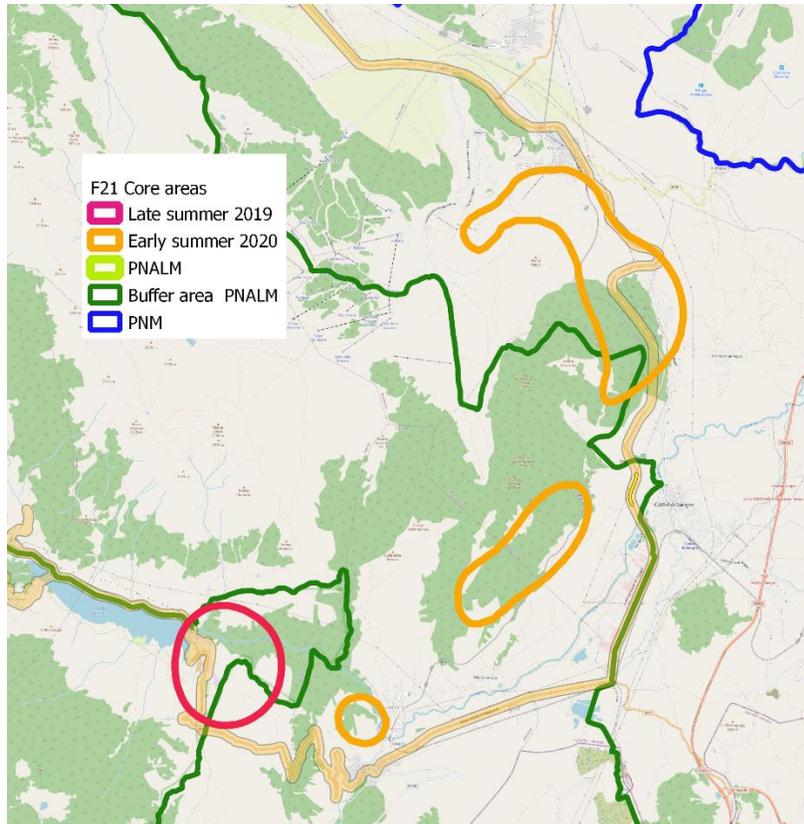


Figure 42 F21: core area (kernel 50%) of late summer 2019 encompass National road SS83, while in nearly summer 2020 it contain SS17.

Conclusions

Putting together information acquired in the development of Action A5, allow us to derive conclusion on the action to implement in the concrete action of the project. Monitoring of crossing points and telemetry data indicate that bears cross the road when the traffic volume is lower, during nocturnal hours. These results are confirmed from data available in literature, indicating that bears favor road with a lower traffic volume (Chruszcz et al. 2003; Graham et al. 2010; Waller 2005), and crossing is influenced by the kind of habitat surrounding the road, in particular the distance from wooded areas (Findo et al. 2018) Another problem is the presence of attractants on the road (Pollock et al. 2017; Roever et al. 2010) which can strongly influence bears movements and create a danger. Road within the PNALM are typical mountain roads, which crosses natural environments and along the road, especially in proximity of villages, there are several fruit trees. GPS data from bears F21 and F18 confirm that bears can feed on this tree, even on the ripe fruit fallen on the pavement. One of the prevention measures developed by Park staff is fruit gathering, which help reducing this problem. Unfortunately, the Covid-19 pandemic

and the rules emanated by Italian government on social distancing impede the development of this activity in 2020.

GPS data collected on female F18 indicate that this bear cross the road also in daylight, when traffic volume is higher, and traffic jams due to the presence of the bear were reported (figure 43). We hypothesize that habituated bears can be less sensitive to traffic volume, and a study performed in Banff National Park confirm this hypothesis (Chruszcz et al. 2003).



Figure 43 Screenshot of a video appeared on social media on the 10/08/2019: a traffic jam caused by people stopping to observe female F18 crossing the road

Although we did not find a high frequency of AVC, given the conservation status of the little population of Apennine brown bears, it is mandatory to prevent any casualties. GPS data and camera trapping indicate that bears risk to be run over by cars, that must be prevented, as especially females are of great importance for the survival of this endangered subspecies.

Monitoring indicate the need for the future conservation actions:

- ✓ ROAD_PNALM_A is critical for the high vehicle speed, in all seasons. Almost all vehicles exceed speed limits and a half exceed 80 Km/h. This road is surrounded by open habitats, with no barriers

for wildlife crossing. No adaptable transversal structures are available. Therefore, it will be important here to act with C1, adopting innovative prevention measures, AVCPS and virtual fence, combined by the installation of road panels to motivate drivers to reduce speed (C3).

- ✓ In ROAD_PNALM_B the main problem is the presence of a high traffic volume, especially in summer. This road segment is frequently crossed by wildlife, and there are natural barriers that impede movements. Along this segment we identified two culverts that are suitable to be adapted as wildlife crossing structures, and monitoring performed in A4 and A5 confirm that this adaptation can be suitable to increase safe crossing for bears (action C2). Telemetry monitoring of female F21 allowed to identify the Valico di Barrea (km 66-68 of SS83) as a danger for bear crossing. Here the habitat is open at the two sides of the road, and there are no transversal structures. Therefore, even if this road segment of SS83 was not initially included in the project, we will use here conservation action C1, by installing a AVCPS and virtual fence, together with road panels to increase drivers attention.
- ✓ Road_PNALM_C is characterized by a lower traffic volume, but the road is frequently crossed by bears. Here we will act by adapting available transversal structures (C2), and placing virtual fences (C1), together with road panels (C3).
- ✓ Road_PNALM_E has no transversal structures, and it is no suitable for the placement of a AVCPS, but we will place in strategic crossing points virtual fences (C1) and work on communication by installing road panels (C3) since here the problem is the high speed of vehicles.
- ✓ Road_PNALM_F is critical because of the high traffic volume and speed of vehicles. Last Christmas the death of a female confirms the danger of this National road. Also, telemetry data of F21, together with sighting of bears in tunnels indicate the need for the adoption of different preventive measures. So here PNALM will combine the adoption of innovative preventive measures (C1), the AVCPS, as well as road panels (C3) and the adaptation of a culvert and a overpass.

Literature cited

- Chruszcz, B., Clevenger, A. P., Gunson, K. E., & Gibeau, M. L. (2003). Relationships among grizzly bears, highways, and habitat in the Banff-Bow Valley, Alberta, Canada. *Canadian journal of zoology*, 81(8), 1378-1391.
- Find'ò, S., Skuban, M., Kajba, M., Chalmers, J., & Kalaš, M. (2019). Identifying attributes associated with brown bear (*Ursus arctos*) road-crossing and roadkill sites. *Canadian Journal of Zoology*, 97(2), 156-164.
- Graham, K., Boulanger, J., Duval, J., & Stenhouse, G. (2010). Spatial and temporal use of roads by grizzly bears in west-central Alberta. *Ursus*, 21(1), 43-56.

Pollock, S. Z., S. E. Nielsen, and C. C. St. Clair. 2017. A railway increases the abundance and accelerates the phenology of bear-attracting plants in a forested, mountain park. *Ecosphere* 8(10):e01985.

Roever, C. L., Boyce, M. S., & Stenhouse, G. B. (2010). Grizzly bear movements relative to roads: application of step selection functions. *Ecography*, 33(6), 1113-1122.

Waller, J.S., and Servheen, C. 2005. Effects of transportation infrastructure on grizzly bears in north-western Montana. *J. Wildl. Manage.* 69: 985–1000.