LIFE DINALP BEAR

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

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Habitat selection, use of anthropogenic food sources for bears living in conflict area

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Abstract

For successful contemporary conservation, it is no longer enough just to know what the species' habitat requirements are. In densely populated Europe, where wilderness is almost non-existent, bears often come into contact with people, which triggers conflict. And conflicts are a key threat to long-term conservation of bears in Europe. If conservation is to be successful, it is necessary to know why such conflicts occur and how to mitigate or prevent them. The bulk of conflicts are the result of bears foraging for food, mainly from anthropogenic sources in the vicinity of human settlements. Major drivers of conflicts also include availability of natural food sources, structure of the environment (overlap of bear and human habitat), frequency of damage cases (in wilderness bears cannot cause “damage”), social interaction among bears, and bear population density and management.

Due to the importance of conflict management for successful conservation of bears in Slovenia, we conducted several studies in the framework of the Life DinAlp Bear project to identify the reasons for the occurrence of conflicts and how they differ between areas and bears. Using existing data, areas of higher conflict intensity were identified. They were divided into the wider conflict zone (ŠOK) and smaller hotspot areas (HS), where most of the conflict mitigation effort was directed. During the project 11 bears were equipped with telemetry collars. Potentially conflict-prone bears were selected preferentially. In addition, data on 33 bears equipped before 2012 were also used. Bear locations were used to:

- Analyse habitat selection in ŠOK and HS areas and distance from anthropogenic structures
- Search scats at daybeds for analysis of bear diet in combination with habitat use and distance from settlement
- Select random bear locations and control points for analysing presence of anthropogenic food sources at different distances from settlements
- Analyse the characteristics of settlements with conflict events and determine which landscape parameters have the greatest impact on conflict events

To identify differences in use of anthropogenic food sources between conflict and non-conflict bears, we also started collecting and analysing the stable isotope composition of bear tissues and their food. To study and track individual potential conflict bears we used genetic samples collected on damage and conflict sites as well as from bears removed as conflict bears.

Tracked bears were more likely to select forest and **avoided agricultural and urban areas**. Compared to ŠOK areas, HS areas had more locations in agricultural and urban areas but still fewer than expected if habitat selection was random. The probability of presence of fruits in scats increased with proximity to settlements, which confirms that anthropogenic sources (fruit) attract bears into settlements. Compared to locations collected before 2012, the bears were on average closer to settlements and roads, and they were recorded in agricultural and urban areas more frequently. Increased use of agricultural and urban areas and shorter distances to settlements are probably at least partly due to the pre-selection for potentially conflict-prone bears for this project.

Probability of conflict was found to increase the most with increasing bear density (on a 15 km^2 scale), length of settlement edge, and surface / edge coefficient. Probability of conflict in settlements decreases with increased **minimum distance from settlements to forest**. In the last few decades this distance has significantly decreased due to overgrowth, and in the core bear area it now averages only about 30 m. Apart from shorter distance to settlements, overgrowth has additional benefits for bears because it offers plenty of food and cover.

Shares of different types of food differ between habitats, seasons and individual bears. Interestingly, maize from feeding sites was detected in some scats very close to settlements and its share actually decreased with distance to settlement. There is an increasing body of research showing that feeding in general reduces the frequency of conflict – venturing into settlements. However, its effects are positive only if feeding sites are distant enough from settlements; in practice, therefore, improvements are possible and necessary.

The next major finding is that probability of bear presence near settlements is significantly affected by presence of anthropogenic food. It is important to distinguish between anthropogenic food at feeding places that are typically far from settlements from food sources that unintentionally attract bears (garbage, picnic residues, open compost). At locations with anthropogenic food sources, the likelihood of bear presence was 32% higher than on locations without. The most common category of anthropogenic food was food from orchards, fields and gardens, which together accounted for 76% of food sources near settlements. In the category Waste, garbage accounted for 63% of all anthropogenic food. Anthropogenic food was recorded at 41.5% of bear locations and only 26.8% of comparative (control) locations. Another major finding is that **the amount of anthropogenic food decreases with distance from settlement**. At a distance of over 300 m, the proportion of locations with anthropogenic food is less than 10%. Green plants and maize are dominant foods in all distance classes from settlement. Forest fruits are an important type in the nearest distance class and beech nuts in the farthest distance class. Apples and anthropogenic foods were recorded only in samples in the nearest distance class. The high degree of conflict is most probably the result of interaction of high population densities and presence of anthropogenic food sources in the vicinity of settlements, and the fact that settlements frequently have direct contact with forest (bear habitat).

A study on samples collected at damage sites suggests that **most bears cause damages only opportunistically** and only few bears are true problematic bears. Problem bears are removed in less than half of the cases and a problematic bear has higher chance of being part of regular mortality. This study also suggests that the **type of preventive measure does matter**. Electric nets seem to work better than fence with one to three electric wires.

Kazalo

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1 Introduction

Contemporary conservation requires much more than just knowledge about a species' habitat needs. In the densely populated Europe, which hardly has any wilderness left, bears necessarily come into contact with human, which often causes conflicts – and conflicts are one of the main threats to the sustainable conservation of the species. In order for bear conservation to be successful, it is therefore necessary to learn the causes of conflict and ways of preventing and resolving them. And even though the causes may vary depending on area, the basic characteristics thereof are similar: conflicts are often the consequence of bears foraging for food, in particular food from anthropogenic sources in the proximity of human settlements.

The biological characteristics of brown bear in Slovenia are relatively well researched, but the growing population size (Skrbinšek 2017) and new human interventions in the environment create situations that may intensify existing conflicts. Increasingly affordable new and developing methods, such as telemetry collars with cameras and analysis of stable isotopes, or new combinations of existing methods, such as scat analysis combined with spatial tools, have led to new findings and new potential solutions for resolving conflict cases. And addressing conflicts is key to conservation of the brown bear as a feature of Slovenia's fauna.

Bear distribution, location and behaviour are strongly affected by the quantity and accessibility of food, available habitat, and landscape structure. Food, in particular high-quality food, is one of the main factors affecting biological and behavioural features of animal species. Anthropogenic food is increasingly abundant and in densely settled parts of the world it is accessible to wild animals in great quantities. Its quality is often high, it is concentrated and predictable, for example at landfills, feeding sites and on agricultural land. Anthropogenic food typically has a positive impact on wild animals, but it may also lead to conflict.

Landscape structure determines species composition a well as use of space by individual species. Humans have profoundly changed the landscape to the extent that human-dominated landscape is the prevalent type of landscape in Europe. To ensure the long-term survival of brown bear in such a landscape, bears must be able to coexist with humans. Distribution of conflicts may be affected by infrastructure; knowing how landscape structure affects conflict may therefore improve bear conservation efforts.

Realising how important knowing triggers of conflict is for successful brown bear conservation in Slovenia, multiple studies were conducted in the Life DinAlp Bear project to examine the causes of conflicts and how they vary depending on area. The purpose of this report is to collect the knowledge about brown bear habitat selection and use of anthropogenic food sources in Slovenia, while also expanding on the knowledge with the study of latest data acquired in the course of the Life DinAlp Bear project.

2 Methods

Using past findings, areas of intense conflict were singled out in the central brown bear area (Jerina et al. 2015). They were divided into wider conflict zones (ŠOK) and smaller hotspot (HS) areas, where most of the conflict mitigation effort was directed (Stergar & Berce 2016). During the project 11 bears were equipped with telemetry collars. Potentially conflict-prone bears located at least in the wider conflict zone were selected preferentially (Figure 1). Two bears were collared in Trnovski Gozd, which is located north of the Ljubljana-Koper motorway. The remaining bears were tracked in the wider Kočevje area, western edge of the Javornik-Snežnik Plateau and in Brkini (Figure 1), where conflict intensity is highest (Figure 2).

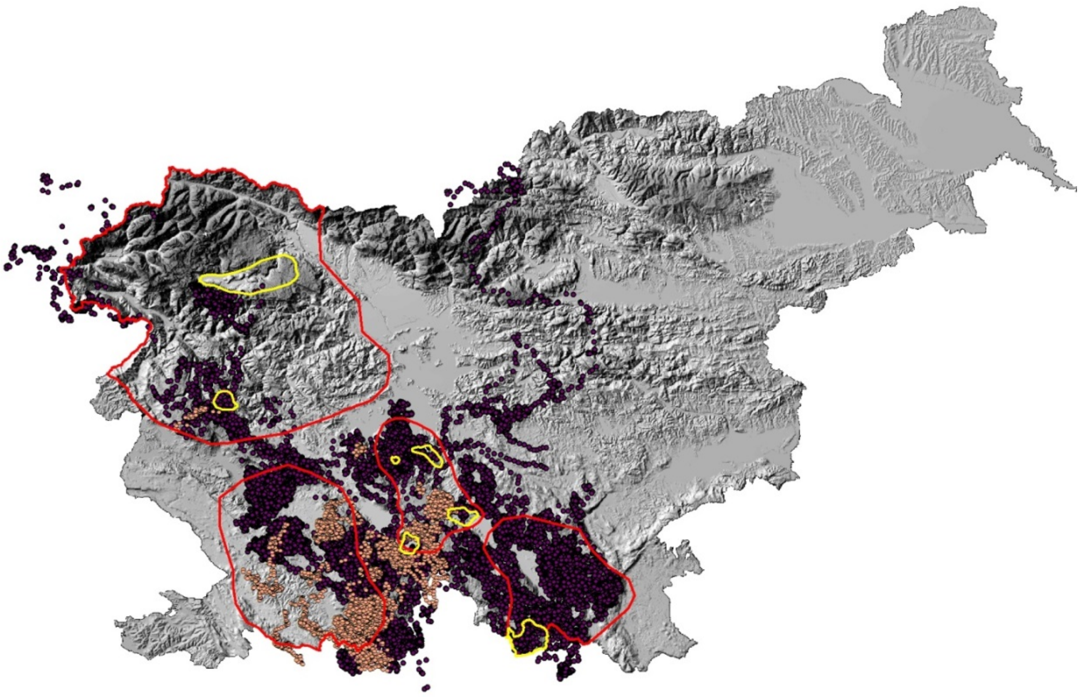

Figure 1: GPS-locations of bears tracked during Life DinAlp Bear project (light) and bears tracked in previous projects (dark) in broader conflict areas (red polygons) and conflict hot-spots (yellow polygons).

All bears were collared with Lotek GPS-GSM telemetry collars. Eight bears were tracked with the same type of collar (800MGU) and three with collars with built-in cameras to monitor behaviour. The first two bears were collared in early June 2016 and the last two in May 2019 (Table 1). The collars were programmed to record locations every hour, 24 hours a day, all days of the year. The data was transmitted via SMS, making direct observation possible. The collars tracked and saved location as well as data on animal activity (in 5-minute intervals) and external temperature (Jerina at el. 2012).

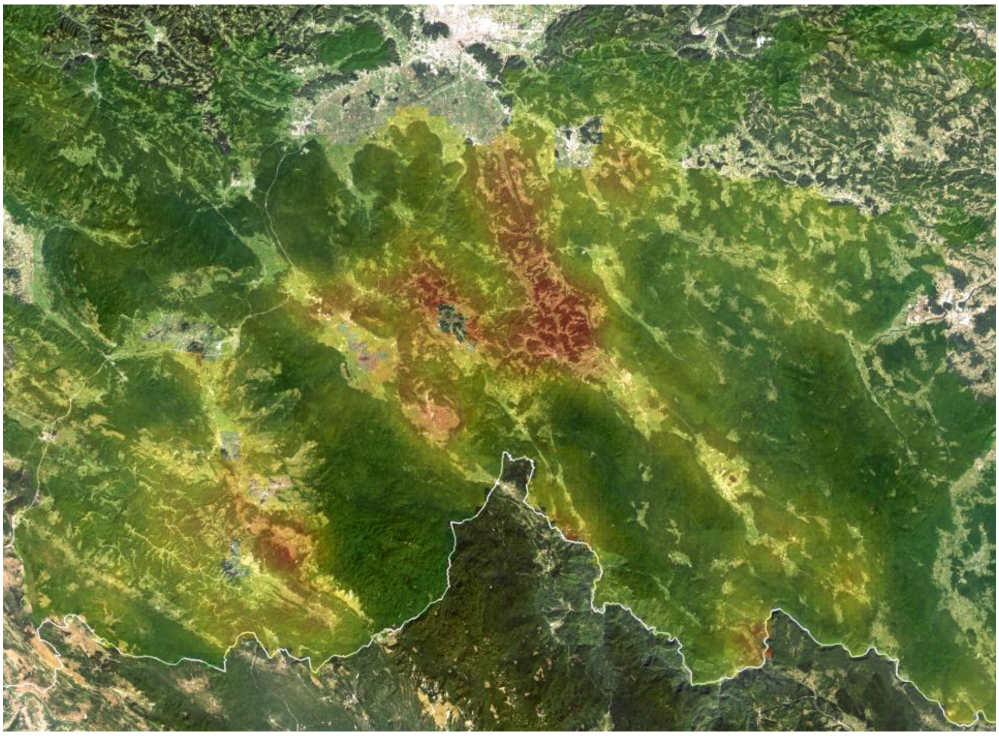

Figure 2: Intensity of human-bear conflict in bear core area. Green shows low intensity, yellow – medium and red – high intensity (Jerina in sod. 2015)

Using the data collected during the project and in the past (Jerina et al. 2012) we analysed the occurrence and causes of conflict over multiple studies (Bončina 2016, Kavčič 2016). The recorded bear locations were primarily used to track bear movement, but then we used this data to analyse habitat selection in areas with different conflict / damage strata, distance from settlement and several other spatial variables (Section 3.1). Location data was also used to: (i) analyse the characteristics of settlements where conflicts occur (Section 3.2); (ii) identify daybeds where, using the selected method, we searched for scats to analyse diet in combination with use of space (Kraft 2017) and distance from settlement (Štraus 2018; Section 4.1); (iii) select random bear locations and control points (computer-generated random points) for analysis of the causes of potentially conflict behaviour (Section 4.3).

To determine differences in use of anthropogenic food sources between conflict-prone and non-conflict bears, we started collecting data for analysis of stable isotope structure of bear tissue and food sources (Section 4.2). Using this method it is possible to estimate the share of individual food sources in digested food, in particular anthropogenic sources, which are easily distinguished from natural sources.

To study if individual bears are problematic bears or they just seize offered opportunities we used genetic samples collected on damage and conflict sites as well as from bears removed as conflict bears (Section 5). We also used genetic samples to study the effectiveness of implemented mitigation measures and to evaluate if conflict bears removal is effective.

Individual sections of this report correspond to studies conducted or conceived as part of Life DinAlp Bear. The studies are combined by type of factor affecting conflict behaviour, i.e.

habitat characteristics and anthropogenic food sources. The latter is further divided to intentional and non-intentional food sources: the first group includes food at feeding sites that hunters primarily use to divert bears from settlements and reduce damage to farmland; the second group is leftover food, incorrectly disposed garbage, unprotected compost heaps, crops and farm animals. This distinction is necessary because of how each type of food affects bear propensity for conflict. Even though incorrectly managed feeding sites may lead to habituation, they are primarily used to reduce conflict. Anthropogenic food sources as referenced in this report refer to the second type of food.

Table 1: GPS telemetry bears data from Life DinAlp Bear project.

Name	Start date	End date	Region	No. of localities	Days active	No. of visited locations			No. of scats
						Random	Control	Handpicked	
DinAlp1	2.6.2016	1.8.2016	Snežnik - Loška dolina	1444	60				47
DinAlp2	3.6.2016	2.9.2018	Snežnik - Ilirska bistrica	18733	821	33	13	2	63
DinAlp3	16.6.2016	25.7.2016	Velike lašče	1887	39				20
DinAlp4	24.10.2016	1.12.2016	Snežnik plateau	915	38				
DinAlp5	17.5.2017	12.8.2017	Loška dolina	3088	87	16	23	1	2
DinAlp6	19.6.2017	24.7.2017	Postojna	1631	35	13	15	5	4
DinAlp7	21.7.2017	1.6.2018	Sodražica	7808	315	58	14	2	6
DinAlp8	10.9.2017	24.10.2017	Snežnik - Brkini	1009	44	4			
DinAlp9	30.5.2018	2.6.2018	Menišija plateau	194	3				
DinAlp10	1.5.2019	10.5.2019	Trnovski gozd plateau	216	9				
DinAlp11	21.5.2019	30.5.2019	Trnovski gozd - Idrijsko	216	9				
All				37141	1460	124	65	10	142

3 Characteristics of brown bear habitat

The brown bear populates the majority of habitats in temperate zones of the northern hemisphere. While it tends to keep to open and semi-open areas in North America and Asia, in Europe it is predominantly a forest species often confined to mountainous and hilly areas. In Europe, where human-dominated landscapes prevail, bears often come into contact with settled areas and the cultural landscape. The resulting conflicts are clearly unevenly distributed (Jerina et al. 2015). Landscape structure may play a key role in bear movement and hence recurring conflicts. The purpose of this section is to analyse use of space in light of conflicts and how landscape affects their spatial distribution.

3.1 Brown bear habitat choice (analysis of telemetry locations)

A portion of the data used in this section had been acquired in previous projects and at least partially processed (e.g. Jerina et al. 2012). The purpose of this section is to present differences in habitat use between areas designated based on the occurrence of conflicts, and identify the differences between bears monitored pre-2012 and bears monitored post-2016.

3.1.1 Methods

In the project (Jerina et al. 2012) conducted prior to 2012 (hereinafter: pre-2012) 33 bears were equipped with telemetry collars and an additional 11 were collared during Life DinAlp Bear (hereinafter: Project). Two areas were designated in Life DinAlp Bear action C1 (Stergar & Berce 2016). Both were selected from areas of higher conflict intensity (Jerina et al. 2015; Figure 2). The areas where most of the conflict mitigation effort in proximity of settlements was directed are called hot spots (HS). Areas of increased conflict and larger bear density were designated as wider conflict zones (ŠOK). Bear locations outside these zones are identified as “Outside”. Bear locations and areas are shown in Figure 1.

Land use was defined based on MKGP (2013) data and classified into categories shown in Table 2. The categories represent individual sets of land use potentially significant for bears or humans. The category Overgrowth represents potential daybed areas, the category Agriculture food sources and the category Urban potential for conflict.

3.1.2 Results

Bears were recorded in more than just one type of area (Table 3). 14 bears were recorded in all three areas (outside, ŠOK and HS) and 22 in two of the three areas. Of the 43 tracked bears, only three were recorded only outside and two only inside ŠOK. None were recorded only inside HS.

Table 2: Land-use types used in chapter 3.1.1, with land-use after MKGP 2013.

Land-use types	Lan-use after MKGP 2013
Agriculture	Arable field, vineyard, intensive orchard, extensive orchard, meadows, marsh meadows
Forest	Forest
Urban area	Build-up and related land
Land in overgrowth	Abandoned arable land, tree plantation, mixture of shrubbery and trees, agricultural land with trees
Other	Unploughed arable land, other marsh land, dry open land, water,…

Table 3: Number of GPS telemetry bear locations in broader conflict area (ŠOK), Hot-spot area (HS) and in low conflict area (Outside).

	No. of locations	No. of bears
Outside	34.046	40
ŠOK	96.115	40
HS	2.516	16

The majority of bear locations were recorded in forest (Figure 3), the highest share in ŠOK (91.8%) and the lowest in HS (80.0%). The ratio between locations recorded in individual land use areas in Outside differed from that in ŠOK (X2 = 416.6, df = 4, p < 2.2e-16) and in HS (X2 = 850, df = 4, p < 2.2e-16). The ratio of land use differed between ŠOK and HS locations as well (X2 = 1129.3, df = 4, p < 2.2e-16). Compared to the other areas, in HS there were more locations on agricultural land, urban and overgrown areas. Within ŠOK there were more locations in forest and overgrown areas (Figure 3). Bears selected individual land use areas differently depending on how much of each was available, both in ŠOK (X2 = 1936.2, df = 4, p < 2.2e-16) and in HS (X2 = 128.1, df = 4, p < 2.2e-16). In ŠOK bears were significantly more likely to select forest than other areas (91.8% compared to 72.8%). In HS bears were more likely to select forest (79.7% compared to 71.5%) and urban areas (4.8% compared to 2.7%). They selected overgrown areas proportionately to the share of overgrown areas in the area (3.5%). In ŠOK, forest use was less likely in Project (pre-2012: 93.9%, Project: 84.6%) and agricultural land (pre-2012: 3.8%, Project: 9.7%) and overgrown areas (pre-2012: 1.7%, Project: 3.1% %; X2 = 2090.8, df = 4, p < 2.2e-16) more likely. Similarly, in HS areas Project bears were more likely than pre-2012 bears to be recorded in urban areas (pre- 2012: 0.8%, Project: 8.1%; X2 = 92.6, df = 4, p < < 2.2e-16).

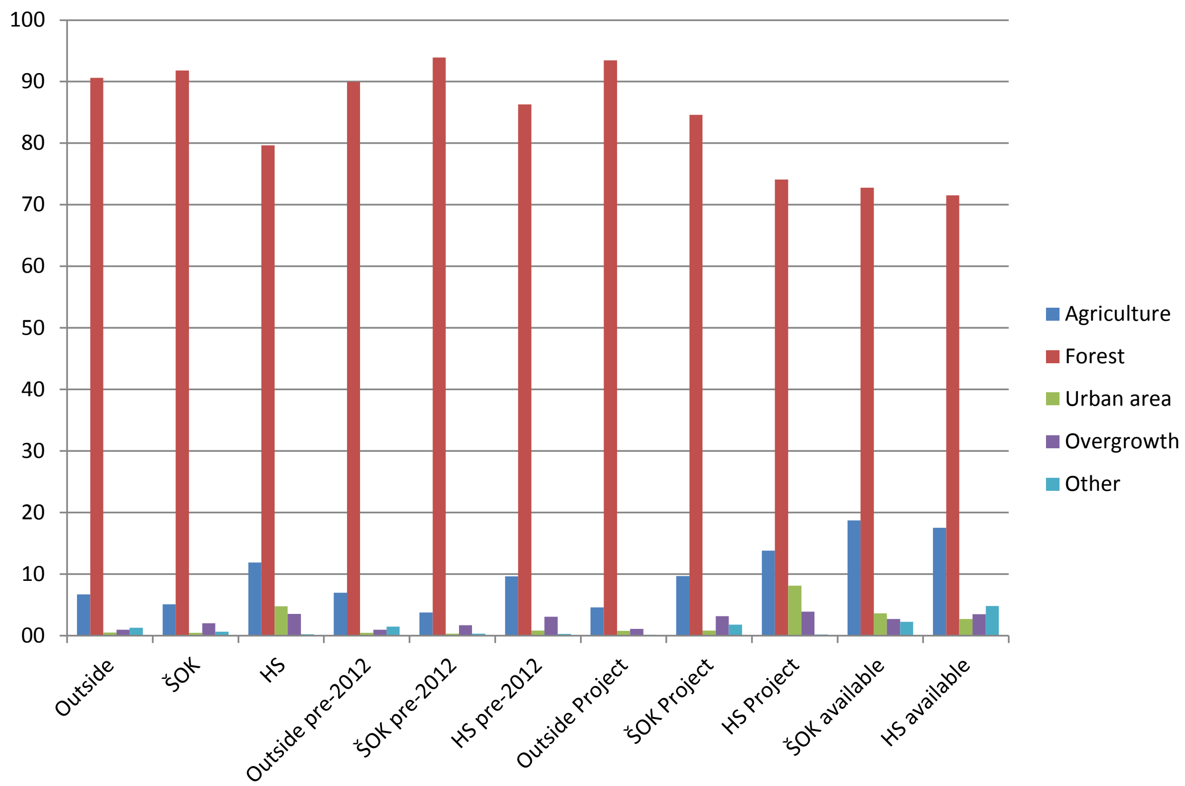

Figure 3: Percentage of GPS telemetry bear locations on different land-use types. ŠOK – broader conflict area, HS – conflict Hot-spot, before 2012 – data gathered before 2012, Project – data gathered within Life DINALP BEAR project

Bears were on average 856 metres from nearest settlement (Figure 4). Compared to locations Outside, distance to nearest settlement was significantly lower both in ŠOK ($t = 25.4$, $df = 60047$, $p < 0.001$) and in HS ($t = 99.0$, $df = 3715$, $p < 0.001$). Bears were significantly farther from settlements than randomly expected, both in ŠOK ($t = -129.6$, $df= 171550$, $p < 0.001$), and in HS ($t = -7.5$, $df = 5313$, $p < 0.001$). They were also significantly closer to settlements in the Project than pre-2012 (ŠOK from 893 m to 652 m, $t = 75.4$, $df = 40730$, $p < 0.001$; HS from 470 m to 224 m, $t = 24.9$, $df = 1601$, $p < 0.001$). For bears monitored in the Project, average distance to nearest house was 818 m (339-1686 m). Only two tracked bears had minimum measured distance to nearest house over 20 m (125 and 397 m) and both were tracked for less than a month.

Bears were on average 280 m from the nearest road (Figure 4). Distances in ŠOK ($t = -48.3$, $df = 80192$, $p < 0.001$) were higher and distances in HS were similar to distances in Outside ($t = 0.1$, $df = 3087$, $p = 0.909$). In ŠOK distance to road was similar to distance to random points ($t = 1.6$, $df = 129490$, $p = 0.131$). On the other hand, bears in HS were recorded significantly farther from roads than randomly expected ($t = -17.0$, $df = 5183$, $p < 0.001$). Distance to road was significantly lower for Project bears than for pre-2012 bears ($t = 10.7$, $df = 1862$, $p < 0.001$). In bears tracked in the Project, average distance to closest road was 456 m (136-1414 m).

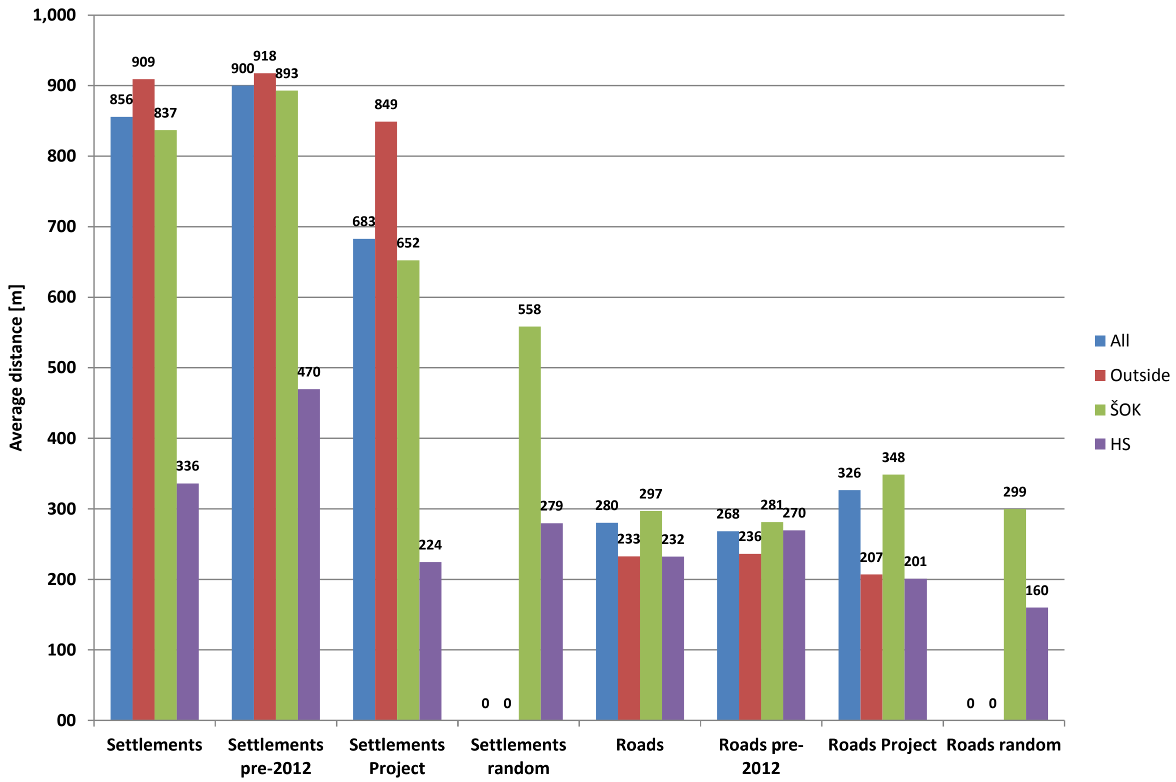

Figure 4: Average distance of bear locations from the nearest house (Settlement) and road for all bears tracked before 2012, within Life DinAlp Bear project and for random locations (Random).

3.1.3 Conclusions

The same bears appear in all three areas, which confirms the assumption that bear density at a larger spatial scale affects conflict (Bončina 2016) and challenges the effectiveness of emergency culling far from settlements.

Notwithstanding available land use area or home range, bears prefer forest. Even though bears in HS were more likely to use agricultural land, they tended to avoid these areas. On the other hand, they were more likely to select urban areas. In the central bear area there is an abundance of orchards between houses that are often classified as “built-up areas and related areas”. Fruit is one of the principal sources of anthropogenic food that attracts bears into proximity of settlements (Kavčič 2016, Kraft 2017). There are also compost heaps in the immediate proximity of gardens that appear at bear locations within urban areas (Kavčič 2016). On the other hand, bears on average remain at longer distances from settlements in all types of areas. Even though they avoid settlements, the majority of tracked bears appeared in close proximity to settlements at least once. In HS bears take advantage of overgrown areas, which has already been highlighted by Bončina (2016), and avoid roads.

The share of Project-bear locations in agricultural and urban areas is higher than the share of pre-2012 bears and distance to settlement and roads is smaller. This is probably largely the consequence of preferential selection of conflict bears for Project monitoring. Individual conflict bears often behave differently than other bears and may be responsible for a larger number of conflicts (Jerina et al. 2012). However, the higher number of locations in the proximity of settlements can also be explained with an increase in the overall brown bear population in Slovenia. Between 2007 and 2015, the population increased by 41.3% (Skrbinšek 2017), with the bulk of the population increase occurring after 2012 (Jerina & Polaina 2018).

3.2 Importance of landscape structure for brown bear

Data for analysing the impact of landscape structure on occurrence of human-bear conflicts in the central bear area was collected and processed for the doctoral dissertation Effects of Afforestation on Human-Bear Conflicts in Slovenia (Bončina 2016), which represents the bulk of the results presented herein. The purpose of this section is to present the impact of afforestation and other landscape characteristics on the occurrence and frequency of human-bear conflict, and to present those characteristics of settlements that increase the probability of conflict.

3.2.1 Methods

Emergency culling orders were the source of data for the human-bear conflicts selected for this analysis. Only orders that were the result of recurring damage by bears venturing into settlements in the central bear area were retained for analysis, a total of 70 orders. One order may refer to more than one conflict event and more than one settlement. There are 749 settlements in the central bear area, of which conflicts were recorded in 106. For the purposes of analysis, a forest edge was generated to best describe land use by bears (see Bončina 2016). In the next step distance of bear locations and random locations from the forest edge was calculated. A set of variables was selected for each category with potential impact on occurrence of conflict (settlement, bear density, distance from central bear area, forest edge, differences in hunting management). Since many of the variables are interdependent, only the most representative variables were included in the final model (Table 4) (Bončina 2016).

3.2.2 Results

Probability of conflict most strongly increases with bear density at 15 km2 spatial scale, distance from edge of study area, length of settlement edge and area/edge coefficient (Table 5). Probability of conflict decreases with increased minimum distance from settlement to forest. Distance of settlement from forest edge has the biggest impact among variables describing distance between forest and settlement. There are significant differences between settlements with registered human-bear conflicts and settlements without registered conflicts. Settlements with registered conflicts have more houses, more parts, larger settlement surface/edge coefficient and higher variability. Significant differences were also identified for minimum distance to forest and bear density (Bončina 2016).

From all possible models without categorical variable the best two include similar variables. The only difference is that model 1 doesn’t include surface/edge coefficient (Figure 6).

Table 4: Independent variables and their arithmetic mean in settlements with and without conflicts. Variables used in model are in bold. (after Bončina 2016)

Independent variable	Abbreviation	$\bar{X}$conflicts	$\bar{X}$no conflicts
Number of houses in a settlement	Hiše	56	35
Settlement size (ha)	Povr.	4,34	2,64
Edge of settlement (km)	Rob	2,20	1,40
Coefficient settlement-size/settlement edge	Povr./rob	15	13
No. of parts in a settlement	Del	8	6
Distance from core area (km)	Obm.	19,4	30,9
Bear density (5 km2) (n/km2)	G5	0,139	0,111
Bear density (10 km2) (n/km2)	G10	0,148	0,126
Bear density (15 km2) (n/km2)	G15	0,151	0,134
Hunting management area *	LOU		
Minimal distance to the modified forest edge (m)	L min	24	35
Average distance to the modified forest edge (m)	L povp.	116	124

* - categorical variable

Table 5: Comparison of settlements with (1) and without conflicts (0) using Mann-Whitney U-test (Bončina 2016)

Settlements		Hiše	Del	Rob	Povr.	Povr./rob	L povp.	L min	G5	G10	G15
	p	0,000	0,000	0,000	0,000	0,000	0,480	0,000	0,000	0,000	0,000
1	Min	1	1	65	284	4	10	0	0,037	0,111	0,112
	Max	1345	56	2877	119596	57	900	850	0,223	0,189	0,178
	$\bar{X}$	56	8	2213	43438	15	116	24	0,139	0,148	0,151
	Md	28	4	1105	17971	13	93	0	0,138	0,144	0,152
	Std	106	10	2941	93354	9	114	74	0,029	0,018	0,011
0	Min	1	1	65	250	4	0	0	0,008	0,019	0,046
	Max	908	56	1870	742300	64	1064	997	0,275	0,195	0,186
	$\bar{X}$	35	6	1395	26428	13	124	35	0,111	0,126	0,134
	Md	15	4	821	8649	11	91	0	0,114	0,130	0,140
	Std	77	6	1933	67709	8	120	86	0,053	0,039	0,026

Table 6: The best generalized linear models GLM (ΔAIC < 3) not using variable LOU (Bončina 2016)

Model	**Variables**	**sp**	**AIC**	**$\chi2$**	**p**	**ΔAIC**	**w_i**
1	Obm., Rob, L min, G15	4	1496,259	296,516	0,000	0,000	0,730
2	Obm., Rob, Povr./rob, L min, G15	5	1498,251	296,524	0,000	1,992	0,270

3.2.3 Conclusions

Multiple factors affect the probability of conflict within and in proximity of settlements. Two of the factors are related to the state of the bear population (population density and distance from edge of central bear area) and two with settlements (length of settlement edge and ratio between settlement area and edge). Probability of conflict declines with growing distance between settlement and forest edge. Overgrowth has made areas that are closer to settlements interesting to bears; in the last several decades the distance between forest edge and settlement has narrowed substantially. The forest edge area often comprises overgrowing areas with high species diversity that have high dietary potential for bears. In addition to food (i.e. fruit species) these areas also provide cover during bedding. In the central bear area in Slovenia average minimum distance from settlement (at least one house) to forest is 29.5 m (24 m in settlements with registered conflicts and 35 m in settlements without registered conflict). Taking into account bear speed and movement, these are very short distances. Bears may linger in proximity of settlements, where they bed and feed, while the distance to potential food is short. In particular in HS areas it is therefore important that availability of anthropogenic food be reduced to a minimum. Bear-proof compost bins and garbage cans, which reduce accessibility of food, may also help.

Settlement size does not deter bears. On the contrary, the probability of conflict is in fact higher in larger settlements. There are many potential reasons for that: more people means higher likelihood that someone will report a conflict; larger settlements have longer edges and hence more houses on the edge; houses on the edge that are at least slightly removed from neighbouring houses are more likely to attract bears; and if there is a larger number of houses, it is more likely some will be close to the forest.

One important finding is that the best bear density variable is density calculated at a larger spatial scale. This indicates that density in the wider surroundings is more important than local population size and that conflicts in settlements are caused by bears from the wider surroundings. This makes sense since the average bear home range is 350 km2 (Jerina et al. 2012). It is therefore more likely that bears will visit areas where food is easily accessible and cause conflicts there, and less likely that conflicts will occur where there are many bears.

4 Anthropogenic food sources

In many places wild animals have access to abundant food of anthropogenic origin, which is often concentrated, its availability spatially and temporally predictable. Consumption of anthropogenic food may lead to habituation and bears may start connecting food with people. The majority of anthropogenic food is energy-dense and easily available. Bears are believed to consume more anthropogenic food in areas where quality natural sources are limited. Anthropogenic food is also believed to be more important in years and seasons when natural food sources are scarcer. Bears consume a variety of anthropogenic food and in some bears it is believed to represent as much as 30% of total diet. Analysis of scats and stomach content has so far been the most common method of studying bear diet, but it does not provide a direct estimate of the share of assimilated food; it is also unreliable in determining the share of easily digestible food. Analysis of stable isotopes provides better insight, assuming that isotope composition of animal tissues reflects the isotope composition of consumed food sources. At the same time, analysis of stable isotopes may be used to estimate an animal's diet over longer time periods of different length since different elements transition to tissues at different rates (because of tissue-specific turnover rates). Nevertheless, scat analysis combined with other methods (e.g. telemetry) provides new insight into bears' use of space.

4.1 Analysis of scat samples of radio-collared bears

The data for analysis of bear scats in the wider conflict zone was collected and processed as part of two theses, a masters thesis (Kraft 2017) and a diploma work (Štraus 2018). The master's study focused on understanding the connection between environment and diet in brown bear (Kraft 2017). The research conducted as part of the diploma work focused on (i) seasonal and spatial variability of brown bear diet with an emphasis on anthropogenic food (from feeding sites and proximity of settlements), (ii) impact of corn feeding sites on bear diet, and (iii) dietary differences based on distance from settlement (Štraus 2018).

4.1.1 Methods

For both theses scats were collected and analysed in the same way. 105 scats were analysed in the first one (Kraft 2017) and an additional 16 in the second one (Štraus 2018). The number of scats from individual bears used in the analysis is recorded in Table 1. Collected location data was analysed for each animal separately on an ongoing basis and daybeds identified based on location clusters. At certain time intervals the last located daybeds were located in the field, where a 30-minute search was conducted spirally from the daybed outwards. Found scats were stored in sealed bags and later frozen. Before analysis, the scats were first thawed and then sieved through two sieves (4 mm and 0.8 mm). Content was identified and the volume share of each food type measured. Variables presented in Table 7 were used in analysis of habitat impact on diet.

To analyse seasonal variability in the presence of anthropogenic food in brown bear diet, spatial distribution of bear locations before visit to the daybed where the scat was found was analysed. This identified locations with and without prior visit to feeding site. Distance from settlement was assigned to each scat with the use of GPS location data (Štraus 2018).

Table 7: Abbreviations and descriptions of relevant variables used in modelling brown bear habitat-food analysis (after Kraft 2017)

Variable	Description
dist_feed	Distance to the nearest feeding site in m
dist_road	Distance to the nearest regional road in m
dist_settl	Distance to the nearest settlement in m
cnfr_prct	Mean of the conifer percentage coverage in a 50m radius

4.1.2 Results

Probability of presence of corn is higher the closer to a feeding site a scat is found (Table 8). The model explained more variability when using categoric variable that captured variability among individual bears. Other plants appear in almost all scats and none of the variables improves the basic model. Probability of presence of fruit increased with proximity to settlement and probability of insect presence with longer distance from feeding site and shorter distance from road. With each percentage increase of average share of conifers in stand the probability of presence of insects in scats increases nine-fold. Probability of vertebrates' presence in scats increased by a factor of 19.7 for each percentage increase in bear presence on grassland (Kraft 2017).

Corn on average represents 47% of total scat volume after feeding site visit; green plants dominate in scats of bears who did not visit a feeding site before defecating (Figure 5). Scats with and without prior feeding site visit differ significantly by volume share of corn (Mann-Whitney: Corn 525.0, Z: -6.846, $p < 0.001$) and beechnut (Figure 5; Mann-Whitney: beechnut 1292.5, Z: -3.378, $p < 0.001$) (Štraus 2018).

Scats collected at daybeds were divided into four equal bands of distance from settlement (165–1,537 m, average 973 m; 1,564–2,294 m, average 1,914 m; 2,313–3,460 m, average 2,710 m; 3,632–7,024 m, average 4,984 m). Corn (47% vol), green plant food (27% vol) and forest fruit (16% vol) were dominant scats found closest to settlements. In distance bands 2 and 3 green plant food (43% and 54% vol) and corn (28% and 25% vol) were dominant. In band 4 beechnut (37% vol), green plant food (35% vol) and corn (18% vol) were dominant. Share of corn declined with distance from settlement (Figure 6). Apples and anthropogenic food (other than corn) were recorded only in scats found closest to settlements. The strongest factor in increasing share of beechnut was distance from settlement (Figure 6) (Štraus 2018).

Table 8: Binary logistic regression model for the various response variables without and with the explanatory variable CollarID (B = regression coefficients; SE = Standard error; Sig. = Significance (α = 0.05); OR = Odds ratio) (after Kraft 2017)

	Variable	Model				Model with Collar ID			
Food type		B	SE	Sig.	OR	B	SE	Sig.	OR
Corn	Constant	,736	,597	,218	2,087	20,819	5786,2	,997	$11*10^8$
	dist_feed	-,001	,000	,001	,999	-,001	,001	,159	,999
	dist_road	,000	,000	,062	1,000	,001	,000	,054	1,001
Other plant material	Constant	2,145	,319	,000	8,545	2,145	,319	,000	8,545
Fruits	Constant	1,422	,749	,058	4,145	2,273	1,430	,112	9,705
	dist_feed	-,001	,001	,087	,999				
	dist_settl	-,002	,000	,001	,998	-,002	,001	,001	,998
Insects	Constant	-1,531	,733	,037	,216	-1,329	,692	,055	,265
	dist_feed	,001	,000	,001	1,001	,001	,000	,003	1,001
	dist_road	-,001	,000	,017	,999	-,001	,000	,074	,999
	cnfr_prct	2,225	1,268	,079	9,254				
Vertebrates	Constant	-1,011	,291	,001	,364	-1,287	,409	,002	,276
	Grassland	2,982	1,476	,043	19,729	3,384	1,568	,031	29,495

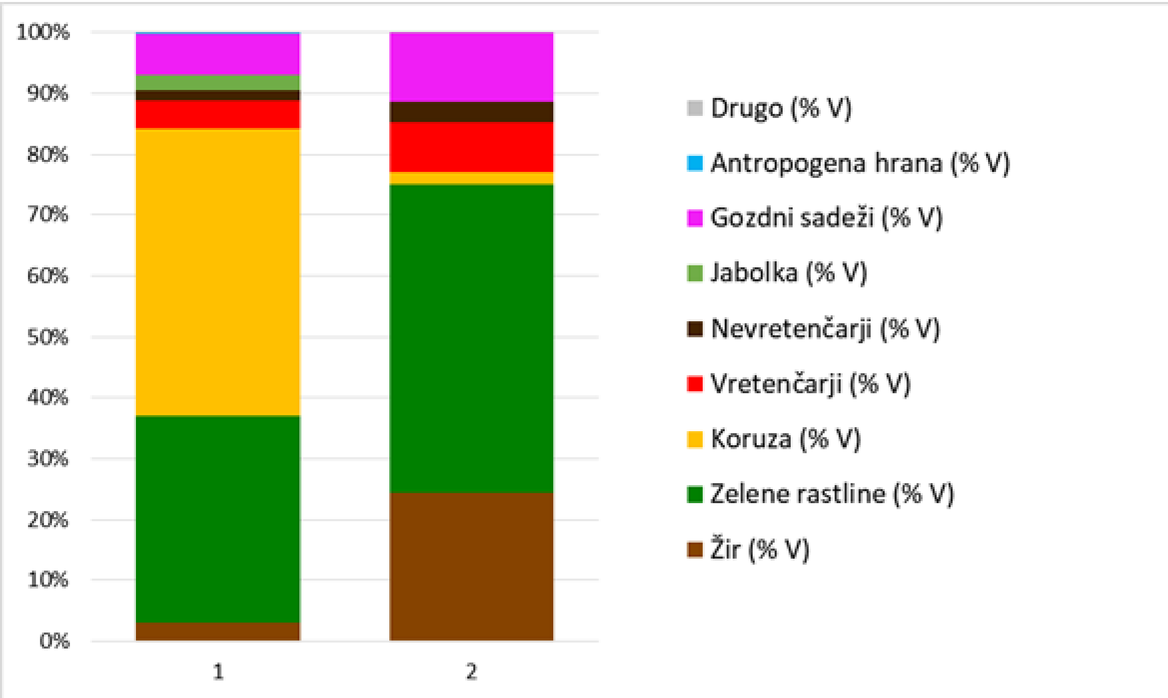

Figure 5: Food composition in bear scats after they visited feeding site the previous day (1) and when they didn't (2) (Štraus 2018)

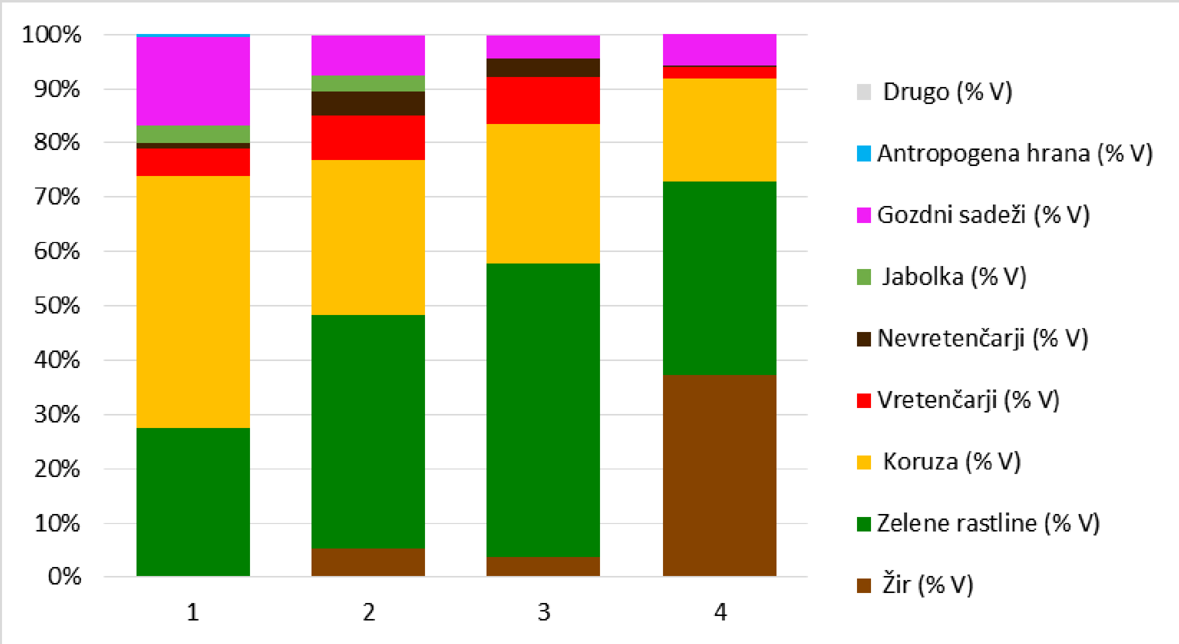

Figure 6: The volume share of different food types from bear scats collected at different distances to settlements – group 1: 165 – 1.537 m, group 2: 1.564 – 2.294 m, group 3: 2.313 – 3.460 m, group 4: 3.632 – 7.024 m) (Štraus 2018)

4.1.3 Conclusions

The share of individual type of food differs by habitat, season and animal. Both studies confirmed the impact of habitat on presence of individual types of food. The strongest connection between type of food and habitat was between corn and feeding site. The share of corn and probability of its presence in scat increase with proximity and prior visit to feeding site. This is not surprising given that corn is the most commonly available food at feeding sites. What is more surprising is that share of corn decreases with distance from settlement. Moreover, the share of corn was significant even in scats in the immediate proximity of settlement and since at that time bears were only venturing to the forest edge, it is highly probable that is where they visited feeding sites. It is recommended that feeding sites are located at least 2 km from the nearest settlement. Judging by scat location and content, and prior bear movement (telemetry data), individual feeding sites are probably located substantially closer to settlements than that. Feeding sites have a positive impact on conflict mitigation, but the effects are positive only when they are far enough from settlements. It would appear that improvements are needed in practice.

Regardless of habitat, bears fed on green plant parts, which are dominant in particular when bears do not visit feeding sites. The share of fruit in scats increases with proximity to settlement. This is understandable since in the wider conflict zone orchards are often located in settlements among houses. Other anthropogenic food was present only in proximity of settlements. The share of beechnut increases with distance from settlement, which leads to the conclusion that at times of abundant beech masting bears keep farther away from settlements. This reduces the probability of conflict, which has also been determined in analysis of conflicts in the Project area (Jerina et al. 2015).

4.2 Dietary analysis of stable isotopes of brown bear

Impact of anthropogenic food sources on brown bear is part of ongoing research for the doctoral dissertation Causes and Consequences of Brown Bear (Ursus arctos) Consumption of Food of Anthropogenic Sources in Anthropogenic Landscape, the first study in Europe to utilise analysis of stable isotopes to examine brown bear diet (Javornik unpublished).

The principal purpose of the study is to use stable isotope analysis to reconstruct brown bear diet in Slovenia over a longer time period at population and individual level, by focusing on anthropogenic food sources. The dissertation aims to study (i) to what extent bears in Slovenia consume anthropogenic food at the population level, what the variability between individual animals is, and whether there are annual, sex and age differences in consumption of anthropogenic sources; and (ii) to determine whether there are differences in diet between conflict-prone and non-conflict bears that would prove conflict behaviour is associated with specific dietary habits of individual animals (Javornik unpublished).

4.2.1 Methods

In Slovenia tissues of removed bears have been collected systematically since 2003. Data on sex, age and several morphological measurements are available for each bear. Additional data was acquired on annual beech masting. Bears shot under emergency culling orders which displayed conflict behaviour were designated as conflict-prone. By selecting samples taken in different years and time periods, and by combining their tissues with faster (liver) and longer (muscles and fur) turnover rates, we can study seasonal and annual differences in bear diet. All samples underwent special preparation and were then analysed for isotopic composition of carbon and nitrogen. Measurements of isotopic composition of sulphur will be conducted on a smaller subsample to determine whether $\delta^{34}S$ values can be used to isotopically distinguish additional groups of food sources. Based on previously performed analyses of brown bear diet in Slovenia, potential food sources were sampled for the purposes of stable isotope analysis. The results will be combined a priori into food groups based on their specific isotopic composition and biological importance. Using this data it will be possible to estimate the share of each food source in brown bear diet at population and individual level (Javornik unpublished).

4.2.2 Expected results

The doctoral dissertation will significantly contribute to the knowledge about the (dietary) ecology of brown bear and hence importantly affect management of brown bear populations in Slovenia, Europe and beyond. The dissertation examines how important anthropogenic food sources are in brown bear diet in Slovenia and the impact of these food sources on selected behavioural, biological an ecological characteristics of brown bear. The results are expected to provide very reliable answers to the question of how much anthropogenic food bears consume, and what the sex, age and individual differences are in terms of consumption of anthropogenic food. By analysing the isotopic composition of the tissues of the majority of culled conflict bears in Slovenia, it will be possible to comprehensively study the dietary habits of conflict-prone bears compared to other bears (Javornik unpublished).

4.3 Analysis of selected brown bear locations

For bears tracked prior to Life DinAlp Bear, data for analysis of brown bear location was analysed in the report (Jerina at el. 2012). During the Project the data was additionally analysed for a doctoral dissertation that more specifically focused on anthropogenic food sources in proximity of settlements (Kavčič 2016). One of the purposes of this section is to determine whether bears in proximity of settlements prefer locations with presence of anthropogenic food and whether there are differences between individual categories of anthropogenic food sources.

4.3.1 Methods

Random bear locations were selected from the range of locations acquired with telemetry collars using stratification method (locations closer to settlements and roads and locations outside forest have higher value). Random control points were generated for the same area (the method for both types of locations is explained in detail in Jerina et al. 2012). The selected locations were recorded in the field: spatial characteristics of locations and presence of anthropogenic food sources was described. Anthropogenic food was divided into three categories: feeding sites, waste and agriculture. Multiple types of food were separately classified within these categories. (Table 9). The data collected for Kavčič (2016) was additionally processed for the purposes of this report using the same method as the dissertation. The data is presented comparatively.

4.3.2 Results

Anthropogenic food (excluding feeding sites) was recorded at 41.5% of bear and 26.8% of control locations (Kavčič 2016: 32% of bear locations and 26% of controls; Life DinAlp Bear: 58.1%, 30.8%). Bears were more likely to visit locations where there was more food ($\chi2 = 4.229$, $n = 896$, $p = 0.04$; Kavčič 2016). The most frequent category of anthropogenic food was Agriculture (Table 9). Orchard and Field/Garden represented 76% of food sources in Agriculture. In the Waste category, the subcategory Garbage accounted for 63% of all anthropogenic food (Table 9).

It had already been previously determined that bears visit feeding sites more frequently than random (Jerina et al. 2012). However, that had not been established for the anthropogenic food category Agriculture (Kavčič 2016). In Life DinAlp Bear food from the category Agriculture was recorded more frequently at bear location than at control locations, but the difference was not statistically significant ($\chi2 = 3.31$, $df = 1$, $p = 0.07$). Two subcategories were excluded from the category Agriculture: Pasture, because it overlaps with domesticated animals, and Grassland, which may also appear far from settlements and does not represent a concentrated anthropogenic food source. After excluding these two sources, the difference between bear locations and control locations is statistically significant ($\chi2 = 7.06$, $df = 1$, $p = 0.008$). Excluding Pasture and Grassland, the difference in presence of food from the category Agriculture is significant even if both sets of data are combined ($\chi2 = 4.47$, $sp = 1$, $p = 0.034$).

Presence of anthropogenic food in the category Waste also differs between bear locations and controls ($\chi2 = 9.58$, df = 1, p = 0.002).

Table 9: Number of GPS bear locations with food from different anthropogenic sources (feeding sites, garbage and agriculture) compared to controlled locations

	Telemetry**		Life DinaAlp Bear			
Anthropogenic food source	Bears	Control	Bears	Control	Bears *	Control *
No. of locations	450	450	124	65	100	100
Feeding sites	**29**	**2**	**1**	**0**	**1**	**0**
Garbage bins	5	6	0	1	0	2
Garbage dump	3	5	10	0	8	0
Garbage	15	9	26	0	21	0
Picnic site	16	0	1	0	1	0
Animal remains	3	0	1	0	1	0
Compost	9	5	3	0	2	0
All garbage	**42**	**22**	**26**	**1**	**21**	**2**
Silage bale	12	8	3	3	2	5
Beehive	10	4	1	1	1	2
Domestic animals	8	28	10	5	8	8
Pasture	12	42	9	6	7	9
Animal feed	0	3	0	0	0	0
Orchard	81	38	32	4	26	6
Arable field/vegetable garden	23	41	48	11	39	17
Meadow	7	11	2	3	2	5
Other	12	4	3	2	2	3
All agriculture	**115**	**108**	**64**	**19**	**52**	**29**
ALL ANTHROPOGENIC FOOD	**166**	**118**	**72**	**20**	**58**	**31**

* Correction to 100 locations
** After Kavčič 2016 and Jerina et al. 2012

Quantity of anthropogenic food declines with distance from nearest house (Figure 7; Kavčič 2016). Waste declines with distance to settlements (Figure 8). At a distance of more than 200m the share of locations with waste as a food source is below 10%. At bear locations less than 100 m from the nearest permanently settled house there is more food than at control locations at the same distance ($\chi2 = 7.256$, n = 896, p = 0.007; Kavčič 2016).

Probability of bear presence at a certain visited location is affected by presence of anthropogenic food and cover. At locations with present anthropogenic food, probability of bear presence is 32% higher (Table 10). Total quantity of anthropogenic food at bear locations near settlements increases during the year and peaks in autumn. This is characteristic of anthropogenic food in the category Agriculture, as this is when the majority of fruit (fruit trees have been registered at 80% of locations with present anthropogenic food) vegetables and crops ripen. Presence of food from the category Waste peaks in summer (mostly leftovers at picnic places) (Kavčič 2016).

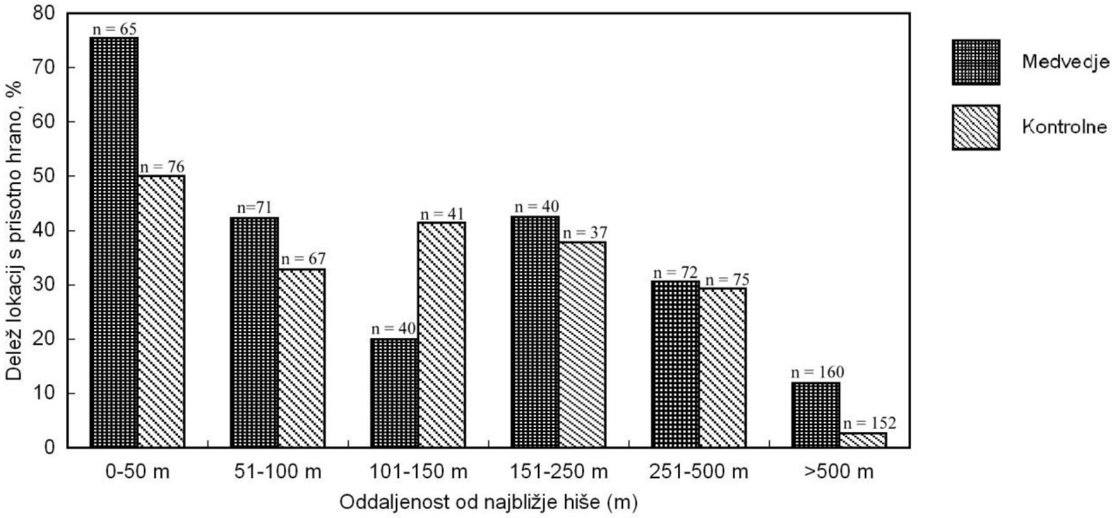

Figure 7: Percentage of bear and control location with anthropogenic food related to the distance from settlement (Kavčič 2016).

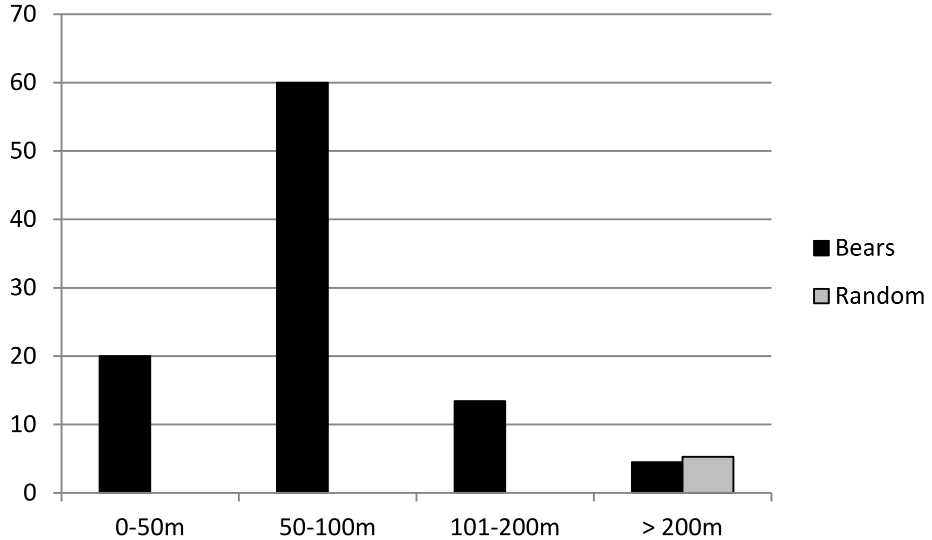

Figure 8: Percentage of locations with garbage on locations visited by bears compared to random locations.

Table 10: Variables and coefficients logistic regression model for probability of bear presence at certain location related to the presence of anthropogenic food and cover (Kavčič 2016)

Variable	Parameter estimate	Stand. error	Wald statistic	P-value.	Odds ratio
Constant	-0,18	0,109	2,7	0,099	
Anthropogenic food	0,28	0,084	10,8	0,001	1,32
Cover	0,01	0,002	9,5	0,002	1,01

4.3.3 Conclusions

In proximity of settlements, bears prefer locations with presence of anthropogenic food, in particular from the category Agriculture. In autumn the main source of anthropogenic food are ripe fruit in orchards; starting in summer, crops in gardens and fields are a major source as well. Larger volumes of anthropogenic food are also available in proximity of settlements in the form of waste. Both these categories of anthropogenic food decline with distance from settlement. The high degree of conflict in Slovenia is probably the result of an interplay of high population densities and presence of anthropogenic food sources in proximity of settlements.

5 Human-bear conflicts

Conflicts are one of the main threats to bear conservation, so measures must be taken to understand the reasons behind causation of conflicts and how to best mitigate them. Differently from previous chapters we used genetic data to tackle this problem. We used it to study the proportion of bears causing damage as well as the frequency of individual bear causing them. The aim of this chapter was to study if individual bears are problematic bears or they just seize offered opportunities. Mitigation measures are used to minimize and prevent potential damages caused by bears. Many were proposed or even distributed by Life DinAlp Bear project. People often use wrong measures or use then in an inappropriate way. Some measures are thought to be effective but they may prove ineffective in certain conditions. Effectiveness of the implemented mitigation measures is important so we can propose adaptation of measures and reduce further conflicts. As a last resort conflict bears are removed from the population and we aimed to study how often the correct bear is removed.

5.1 Methods

From 2015 to 2018 expert teams from Slovenian forest service collected samples from scats, saliva and hair found at or near damage sites. All samples were stored and analysed using protocol described in a report about results of non-invasive genetic sampling (Skrbinšek et al. 2017). Aside from samples gathered at damage sites, samples were gathered from conflict sites and from bears removed as conflict bears. Additionally, we used all data from samples gathered from non-invasive genetic sampling in 2015 or later and regular recorded mortality, if it was related to bears sampled at damage or conflict sites.

Altogether we collected 429 samples of bears that were at least once sampled at damages or conflicts. At several damage sites more than one sample was collected and thus 19 samples were duplicated and afterwards removed from the analysis. We were unable to identify individual bear from 122 samples and so they were used only in analysis types of damages sampled but not to analysis concerning individual bears. Few samples show an error in classifying individual bears (14 samples).

5.2 Results

276 genotyped samples were left after removal of problematic samples. From those 93 have been collected at damage sites, 13 were collected as conflict mortality and 4 at non-damage conflict events. Majority of samples are samples from non-invasive sampling (163). 77 different bears were sampled with connection to damages or conflicts between 2015 and 2018. Of those 30 were sampled only once, 22 on damages, two on non-damage conflicts and the rest were sampled as conflict mortality. Five bears were sampled more than 10 times with maximum of 22 samples. 11 bears were sampled more than once but were found on only one damage case. One bear was found at seven damage sites, one at five, three at four and two at three sites indicating that some individuals may be more problematic than most.

In the damage samples 62 different bears were identified and each was sampled at 1.5 damage sites, while 22 (35.5%) bears were sampled only once, suggesting that most bears cause damage only opportunistically. Damages and conflicts were spread throughout the bear territory in Slovenia (Figure 9) and often more than one bear was sampled at damage sites in most regions, for example at Mačkovec where three different bears were sampled at damages in that one village (red circle on Figure 10). We found 33 females on 50 and 29 males on 41 damage cases.

Figure 9: A map of bear samples collected from damages (yellow dot), conflicts (red dot), conflict mortality (red cross), regular mortality (blue cross) and non-invasive sampling (black dots). Samples from individual bear are connected with a line. Each colour represents an individual bear.

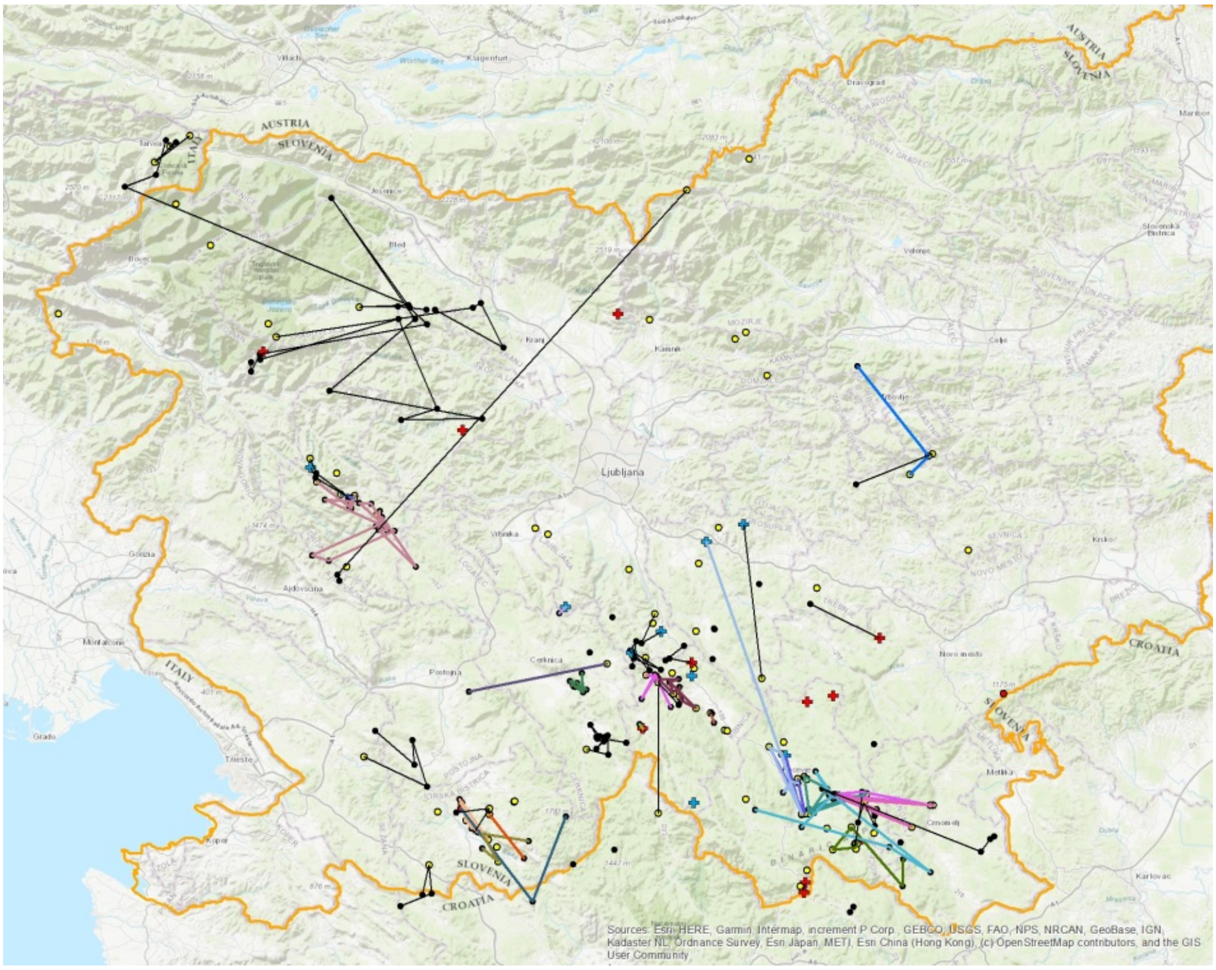

Figure 10: A map of bear samples collected from damages (yellow dot), conflicts (red dot), conflict mortality (red cross), regular mortality (blue cross) and non-invasive sampling (black dots). Samples from individual bear are connected with a line and bears sampled on more than one damage case are shown in bold colour.

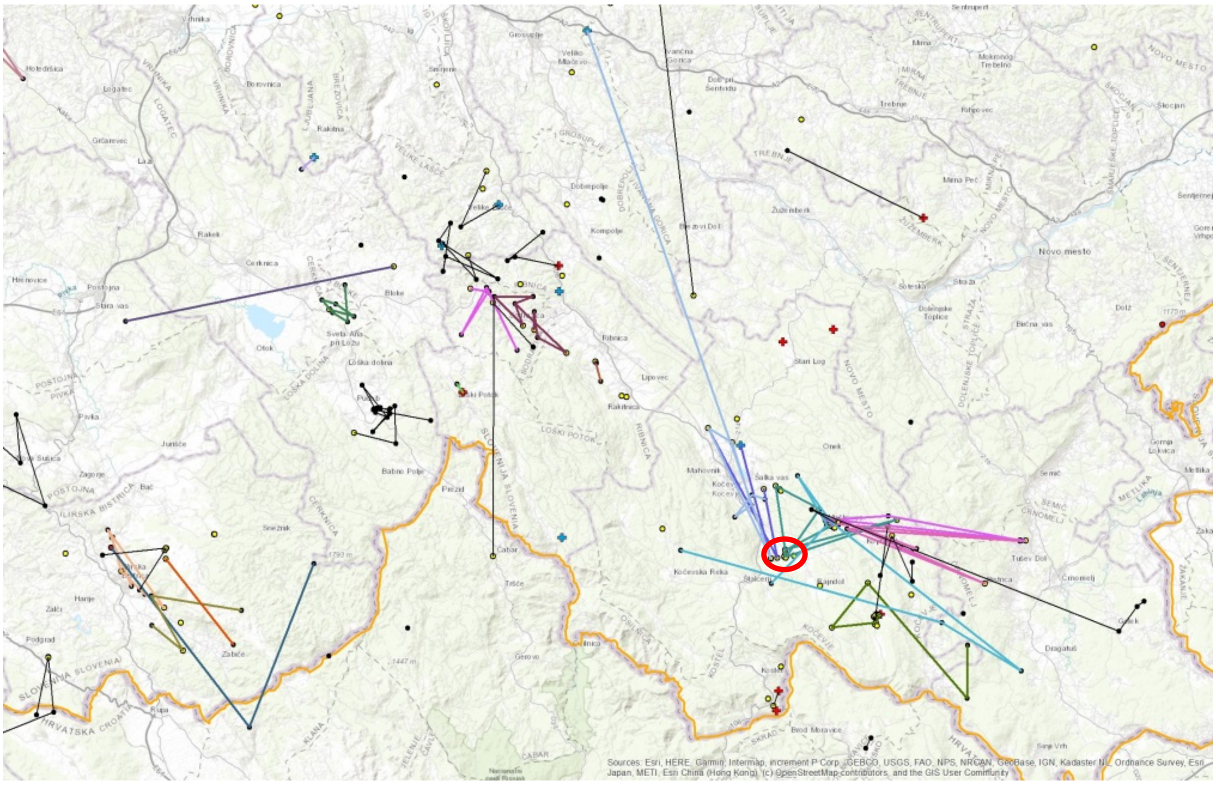

Table 11: Number of samples from individual bear in a year. Yellow marks damage cases (the first number refers to the damage cases), red marks conflict cases, red number a conflict mortality and blue number a regular mortality. Black numbers represent non-invasive sampling.

	2015	2016	2017
EX1JEK	5+2		2+1
M107E		1	1
M10AU	1	4	1
M10EK	1+6		
M10ET	1	1	1
M10HT		1	1+1
M1382	1		1
M1F7T	1+2	1	
M1FH7	1		1
M1KH5	3		1
M1PH6	1+1		1
M1PP4	14	3	4+1
M1T62	2+2		3
M1TF8	17		1
M1UFE	1	1	
M1UK6	3	1	2+1
M20LP	2	1	
M2150		1+11	
M21LX	2	2+3	1
M22H1	1	4	
M236K	1	1	
M280A			2
M2826	3	1	1
TM0001	3	11	1
TM001J	3	1	
TM001T	4	4+1	
TM003U	1	1	

Table 12: Number of samples from individual bear in a month. Yellow marks damage cases (the first number refers to the damage cases), red marks conflict cases, red number a conflict mortality and blue number a regular mortality. Black numbers represent non-invasive sampling.

	2015				2016												2017							
	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	3	4	5	6	7	8	9	10
EX1J8A	2+2	1	1+2																					
EX1JEK	5+1	1																				2	1	
EX1JJF	1	2																						
M06J6	2	1+2	1																					
M0PJ6														1	1									
M0T7J	1+1																							
M107E													1										1	
M10AU	1						2	2												1				
M10EK	1+2	3	1																					
M10ET	1											1										1		
M10HT															1		1						1	
M10J0	2	1+3	1																					
M1382			1																					1
M1EMH	1+7																							
M1F7T	1+2									1														
M1FF2	1		1																					
M1FH7	1																					1		
M1FMY	1+3																							
M1HM6	1+5																							
M1KH5	3																		1					
M1PH6	1		1																			1		
M1PP4	5	9											3									1	3+1	
M1T62	2+1	1															3							
M1T6A	1+1																							
M1T6L	1+1	3	2																					
M1TF8	6	7	2	2																		1		
M1UFE		1						1																
M1UK6	3												1									2+1		
M20LP	2											1												
M2150							6	1+4	1															
M21LX		1	1				2+1				2											1		
M21TX	1+1	2		1																				
M21UA	1+2	5+1																						
M22H1	1												3	1										
M22TM	1	1+1																						
M236K			1					1																
M280A																						1	1	
M2826	1	2					1														1			
M282A																							1	1
M282E																							2	
TM0001	1	2					4	1		1			1	3	1		1							
TM001J	1	1		1						1														
TM001T	4							4				1												
TM003U		1														1								
TM00F0	1																1							

Only seven bears were sampled in all three years and only four were sampled on damage cases in two different years and none in three (table 11). Four were removed as a conflicts with no prior samples on damages or conflicts and three were removed as conflict bears right after making damages, thus the conflict bear was removed in less than half of cases. On the other hand seven bears were removed during regular culling and were previously occurring on damages, suggesting that more problematic bears are removed trough regular than conflict mortality. Most (30) bears were sampled on damage case only in one month of the survey (table 12). Only three were sampled on damage sites in three months compared to 33 bears if all samples are included. So, even if bears were detected on more than one damage site, the odds are that happened in short period of time, e.g. one month.

Most samples of damage cases were collected on sheep (57%) and fruit trees (17%; table 13). We sampled 12 bears at multiple damage sites (Figure 9). From those only two were found on the same damage type in different years (table 14). In both cases, the type was sheep. The type sheep was also most repetitive within a single month.

Table 13: Number of samples collected on damage sites in Slovenia 2015 - 2017.

	No.
Sheep	51
Fruit trees	15
Beehive	6
Other animals	6
Corn	5
Other	7

In 158 damage cases with genetic samples taken roughly a quarter (23.4%) was without protection measures and roughly half (46.8%) had fence as a main protection with 32.3% cases including electric wires and 11.4% also including dogs. Roughly a quarter (24.7%) of cases included electric net fence.

Table 14: Number of damage cases done by individual bears between 2015 and 2017. Only bears with more than one damage case are shown.

	2015		2016				2017		
	Sheep	Fruit trees	Beehive	Sheep	Other animals	Other	Beehive	Sheep	Fruit trees
M10HT					1		1		
M1UK6								2	
M280A								2	
M282E									2
EX.1J8A	2	1							
M1T62	1	2							
M21LX			1		1			1	
M10J0	4								
M1PP4							2		2
TM001T				3		1			
M10AU	1			3		1			
EX.1JEK	4	1						2	

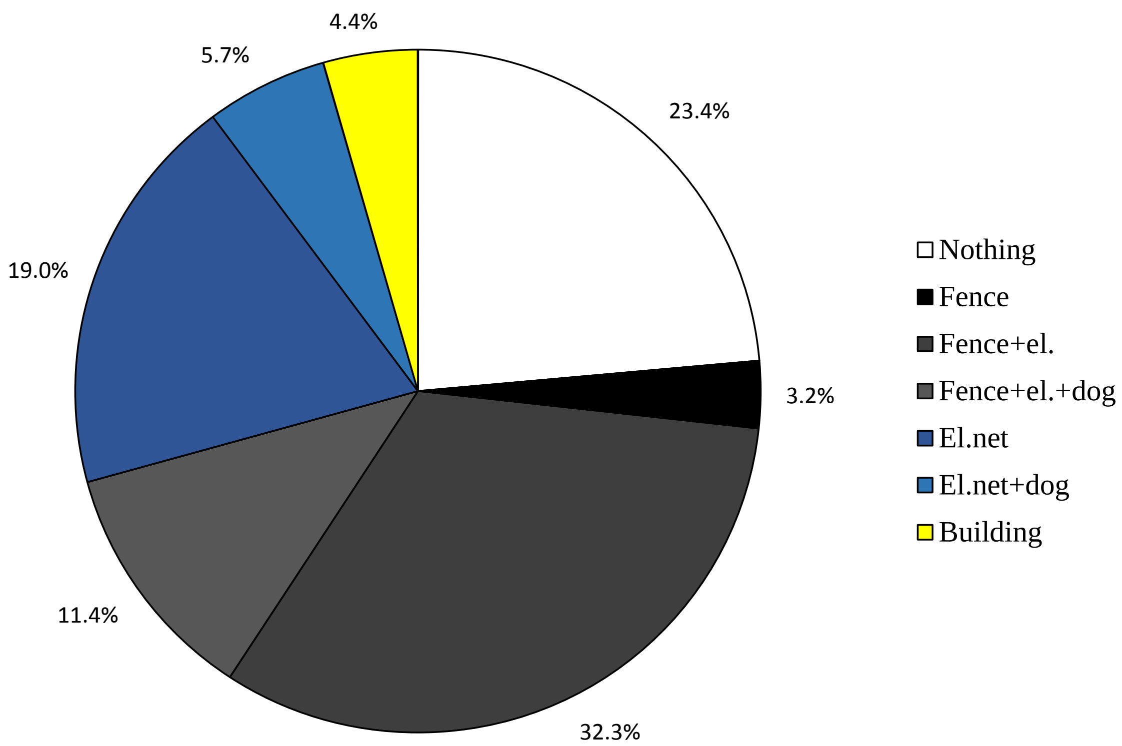

Figure 11: Percentage of different prevention measures in sampled damage cases.

5.3 Conclusions

Most bears were sampled on only one or two damage cases and mostly within one month and only few occur in multiple damage sites in larger time scale (a year). Also, bears causing more than one damage case are rarely found on the same damage type. This all suggests that most bears cause damages only opportunistically and only few bears are true problematic bears. Problem bears are removed in less than half of the cases and a problematic bear has more chance of being part of regular mortality. Type of preventive measure does matter and electric net seems to work better than wire electric fence.

6 Conclusions

- Bear preferentially uses forest and avoids arable and urban land.

- On average, bears stay further away from settlements and also avoids roads in hotspot areas.

- Share of different food types varies between habitat bear visits, seasons and individuals.

- Closer to urban areas bears use anthropogenic food sources, such as fruits, produce and organic refuse more often than further away.

- Anthropogenic food sources decline with the distance from settlements.

- Probability of conflicts in settlements and its vicinity is higher with higher bear density, length of edge of settlement and relationship between surface of the settlement and its edge length. Probability declines with the distance of settlement from the edge of forest.

- Density of bears on a larger scale has stronger effect on the number of conflicts than the number of locally present bears.

- Probability for conflict is higher in larger settlements.

- Most bears cause damages opportunistically and only few bears are true problematic bears.

- Problem bears are removed in less than half of the cases of conflict removal.

- Type of preventive measure does matter

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