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PILOT ACTION IMPLEMENTED IN THE TATRA MOUNTAINS ON THE MONITORING, POACHING PREVENTION AND CONFLICT PREVENTION OF BEARS

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PILOT ACTION IMPLEMENTED IN THE TATRA MOUNTAINS ON THE MONITORING, POACHING PREVENTION AND CONFLICT PREVENTION OF BEARS

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Content

1. Introduction

The Tatra Mountains, forming a natural border between Slovakia and Poland, represent the highest and one of the most ecologically valuable parts of the Western Carpathians. This transboundary mountain range serves as a key stronghold for large carnivore conservation, particularly for the brown bear (*Ursus arctos*), which maintains a stable and reproducing population on both sides of the border. Together with the grey wolf (*Canis lupus*) and the Eurasian lynx (*Lynx lynx*), the brown bear plays a crucial role in maintaining the ecological balance and natural processes of the Carpathian ecosystems.

However, the Tatra region also faces significant challenges associated with intensive human presence. Millions of tourists visit the Tatras every year, creating high recreational pressure and generating potential for human–bear conflicts, particularly in and around the foothill settlements and tourist resorts. Although the bear population remains one of the best-protected in the Carpathians, the increasing overlap between human and bear habitats leads to recurring conflict situations, such as damage to property, attraction to garbage, and occasional threats to public safety. At the same time, illegal killing, although rare, still poses a latent risk to the population.

The pilot action implemented under the LECA project in the Tatra Mountains focused on three interrelated pillars:

1. **Monitoring harmonisation**, including advanced telemetry of bears, analysis of spatio-temporal behaviour, habitat selection and innovative use of video collars to better understand bear ecology and interactions with humans;

2. **Conflict prevention**, addressing the underlying causes of human–bear conflicts through behavioural studies, including hormonal and diet analysis using metabarcoding, testing of preventive tools (e.g. electric fences, bear-proof containers), and cooperation with local farmers and tourism operators;

3. **Poaching prevention**, strengthening cross-border cooperation between law enforcement agencies through dedicated seminars and capacity-building activities, promoting effective response to wildlife crime in the Carpathian region.

Monitoring efforts combined complementary approaches such as GPS telemetry and field verification of GPS clusters. Collared bears provided high-resolution data on movement patterns, habitat use, denning behaviour, and feeding habits, helping to identify key areas of human–bear interactions and to understand the drivers of conflict. The innovative use of video collars provided unique insights into natural bear behaviour in the alpine environment, enriching both scientific knowledge and educational resources.

Conflict prevention activities built upon these ecological insights, linking bear behaviour to anthropogenic attractants and testing practical mitigation measures. Hormonal analyses helped assess stress responses associated with deterrent methods, while DNA metabarcoding revealed differences in the diets of “conflict” and non-conflict bears, showing a higher proportion of anthropogenic food in individuals frequently visiting settlements. Preventive tools such as electric fences and bear-proof containers were installed in cooperation with local stakeholders, significantly reducing bear-related damage and improving coexistence between people and bears.

Poaching prevention was addressed through an international seminar for law enforcement agencies from Poland, Slovakia, and the Czech Republic, which fostered knowledge exchange and highlighted the importance of reporting and investigating all suspected cases of wildlife crime. The seminar strengthened cooperation between environmental authorities, police, and prosecutors, and emphasized the role of forensic genetics and telemetry as modern tools in combating poaching.

By integrating advanced ecological monitoring, targeted conflict mitigation, and enhanced law enforcement cooperation, the Tatra Mountains pilot action demonstrates a comprehensive and transboundary approach to managing human–bear coexistence in one of the most intensively used mountain landscapes of the Carpathians. The results and experiences gained provide a valuable foundation for scaling up coordinated conservation actions across the Carpathian range and beyond.

2. Description of pilot area

The area is characterized by a diverse altitudinal zonation of ecosystems: foothill forests dominated by beech (*Fagus sylvatica*) and fir (*Abies alba*), montane forests of Norway spruce (*Picea abies*), subalpine dwarf pine (*Pinus mugo*) stands, alpine grasslands, and rocky habitats above the tree line. Forests cover a large proportion of the area, but extensive alpine and subalpine zones form a unique feature of the Tatra landscape. Most of the area is included in protected territories, namely Tatra National Park (TANAP in Slovakia, TPN in Poland), and parts are designated as strict nature reserves.

The Tatras are among the most important centers of tourism in Central Europe, with millions of visitors annually, resulting in high recreational pressure, ski resort development, and infrastructure expansion. Traditional activities such as forestry and grazing are largely restricted by protection regimes but still occur in peripheral zones. Human settlement density is concentrated in valleys and basins around the mountain range, while the high-mountain core remains uninhabited.

All three large carnivores — brown bear (*Ursus arctos*), grey wolf (*Canis lupus*), and Eurasian lynx (*Lynx lynx*) — have a permanent presence in the Tatras, with confirmed long-term reproduction of all species. The area functions as one of the key strongholds for their conservation in the Western Carpathians.

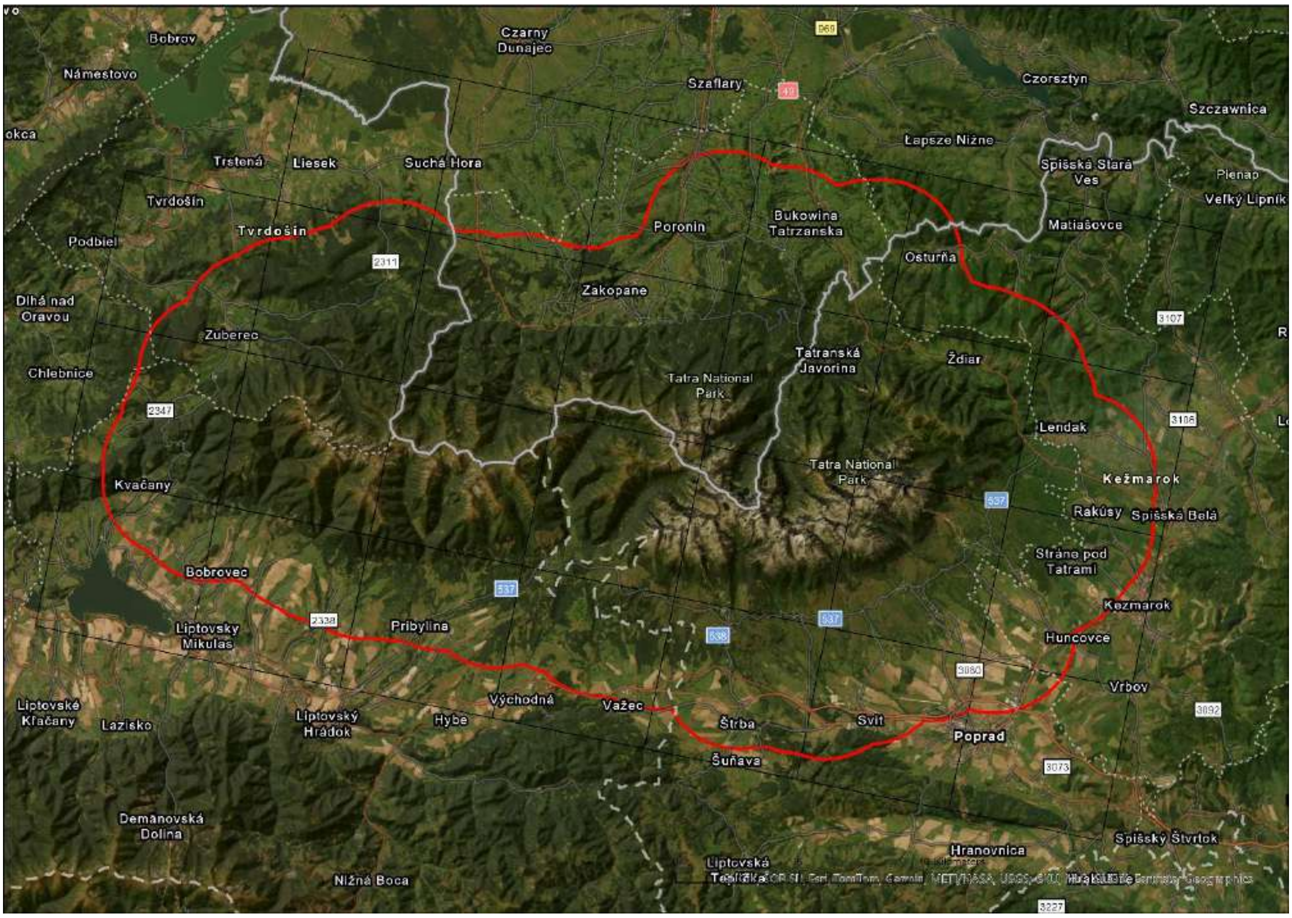

Figure 1. The cross-border study area Tatra Mountains situated on the edge of the Western Carpathians with pre-defined pilot border (red) and 42 mapping grids (EEA 10×10 km).

3. Pilot activities: Monitoring harmonisation

3.1 GPS Telemetry: Spatio-temporal activity and home range estimates

Data collection and analyses

Bear trapping for telemetry purposes was carried out on the Polish as well as Slovak side of the pilot area, specifically in the Tatra Mountains (PL), Podhale (PL), and Liptov (SK). Based on the experiences gained from intensive bear monitoring conducted by TPN, TANAP and SNC SK professional staff, emergency teams, and rangers, the most suitable capture sites were identified. Foot snares and box traps were used for trapping bears. Permits for bear capturing were issued by the Polish Ministry of the Environment, and the State Nature Conservancy of SK. The TNP (PP7) carried out five bear trapping sessions (spring 2023, autumn 2023, spring 2024, autumn 2024, and spring 2025) and SNC SK (PP8) carried out two bear trapping sessions (spring 2025, summer 2025), to capture and collar bears for telemetry purposes.

Two female bears were fitted with GPS collars on the Slovak side of the Tatra pilot area during implementation of pilot activities within the LECA project (Blazka and Marta). On the Polish side, a total of 23 bears were captured during the project period. Collars were fitted or replaced on 14 of them (the remaining bears were either too young or were recaptures of individuals that had recently been collared). During the project, telemetric monitoring of five previously caught bears was also carried out.

Figure 2. Telemetry collars (left), bear collaring in TPN (middle) and Marta female bear collared in Slovakia in Tatra Mountains pilot area (right).

The GPS schedule of the collars was set to fix positions every 30 minutes to two hours (12–48 fixes per day). Depending on the social status of the individual, the monitoring period, or the need to track interactions with human activity, the GPS schedule was remotely adjusted in order to collect more detailed spatio-temporal data or spare batteries in winter. By applying the virtual fence mode, a more intensive GPS schedule was activated, and alert messages were received whenever a collared individual entered a specific area of interest (e.g. towns or human settlements). Location data from GPS collars was obtained automatically from the storage server via the Inventa application or by retrieving data directly from the collar after it was dropped-off and recover. The evaluation of spatio-temporal activity (including home range size estimation) was carried out in a GIS environment.

Clusters of GPS positions were intensively checked in the field to determine habitat preferences or feeding behaviour in relation to human activities. At these sites, faecal samples were collected and subsequently analysed to assess the diet of conflict bears, cortisol levels as indicators of stress, and the efficacy of aversive conditioning in combination with the spatio-temporal behaviour recorded after interventions.

Telemetry monitoring, however, allowed us to identify the reasons for the appearance of bears in the vicinity of settlements. These include not only garbage bins directly next to buildings, but also throwing away the remains of farm animals in neighbouring woodlands and deliberate attracting, e.g. for the purpose of photographing animals.

Throughout the entire period, faecal samples of telemetry monitored bears were collected. In total, 85 samples were collected for dietary analyses, 85 for hormonal analyses, and 139 for genetic analyses. All samples were submitted to the Institute of Nature Conservation of Polish Academy of Sciences for analysis.

In total, more than 20 000 GPS fixes were obtained from 18 monitored individuals, of which 16 were captured as part of the LECA project activities. The dataset was dominated by adult individuals, particularly females accompanied by cubs.

The longest monitoring periods were recorded for the reproductive females Dziurka and Tekla, whereas the shortest monitoring duration was observed for the male Bazyl.

Figure 3. Bear trapping area in Slovakia (left) and box-trap used there (right).

Table 1. Bears captured and collared as part of the LECA project.

Individual	Sex	Status	Cubs	Tracking period	Tracking days
P1701_Danka	F	adult leading	3 COY	22.10.2024-9.03.2026*	502
P2301_Dziurka	F	adult leading	2Y	29.4.2023-27.4.2025	728
P2403_Łucja	F	adult single	—	13.10.2024-25.5.2025	223
P2406_Wiola	F	adult single	—	30.10.2024-7.11.2024	8
P1807_Iga	F	adult single/leading	—/3 COY	29.9.2023-8.7.2024	282
P1806_Jaga	F	leading/adult single	3 COY/—	26.9.2022-3.9.2024	707
P1902_Tekla	F	adult leading	2 COY/Y	14.10.2022-10.10.2024	728
P2304_Gaja	F	yearling	—	27.9.2023-17.10.2023	20
P2305_Maja	F	yearling	—	12.10.2023-16.4.2024	187
P2405_Areta	F	yearling	—	24.10.2024-21.12.2024	58
47019_Blazka	F	adult leading	3 Y	22.3.2025-7.8.2025	138
47017_Marta	F	adult leading	3 COY	29.7.2025-9.3.2026*	214
P2402_Cesiek	M	adult	—	30.4.2024-13.3.2025	317
P2501_Jarek	M	adult	—	25.4.2025-30.7.2025	96
P2502_Szon	M	subadult	—	15.5.2025-2.9.2025	111
P2401_Michał	M	adult	—	12.4.2024-22.4.2024	10
P2303_Bazyl	M	subadult	—	30.5.2023-7.6.2023	7
P2503_Maks	M	subadult	—	29.5.2025-6.6.2025	8

Results: Detailed description of spatio-temporal activity of GPS monitored individuals

<u>Female bear “P1701”</u>

The female bear “P1701” was captured and collared for the first time in October 2017 at the age of nine, which was determined based on the annual cement layers on her premolars. The capture was carried out as part of the protection activities intensively conducted since 2015 by the Tatra National Park. These captures and bear-collaring efforts aimed to reduce conflict situations involving bears. The captures took place near settlements visited by conflict bears. Subsequently, for collared individuals appearing near human settlements, intensive deterrence and aversive conditioning campaigns were conducted, including the use of rubber bullets and smoothbore firearms.

At the time of her first capture, the female bear P1701 was accompanied by three cubs born that year. She weighed 121 kg. Until mid-November, the entire bear family stayed along the border of the Tatra National Park and nearby villages, foraging in household garbage bins, compost piles, and fruit orchards. Intensive deterrence and aversive conditioning had rather limited effects. After one of the deterrence actions, P1701 and her cubs crossed into Slovakia for three days, visiting wildlife feeding sites in the Oravice area. On November 16, she settled in a den located in a hard-to-reach strict protection area of the Tatra National Park, which she left only in mid-April 2018.

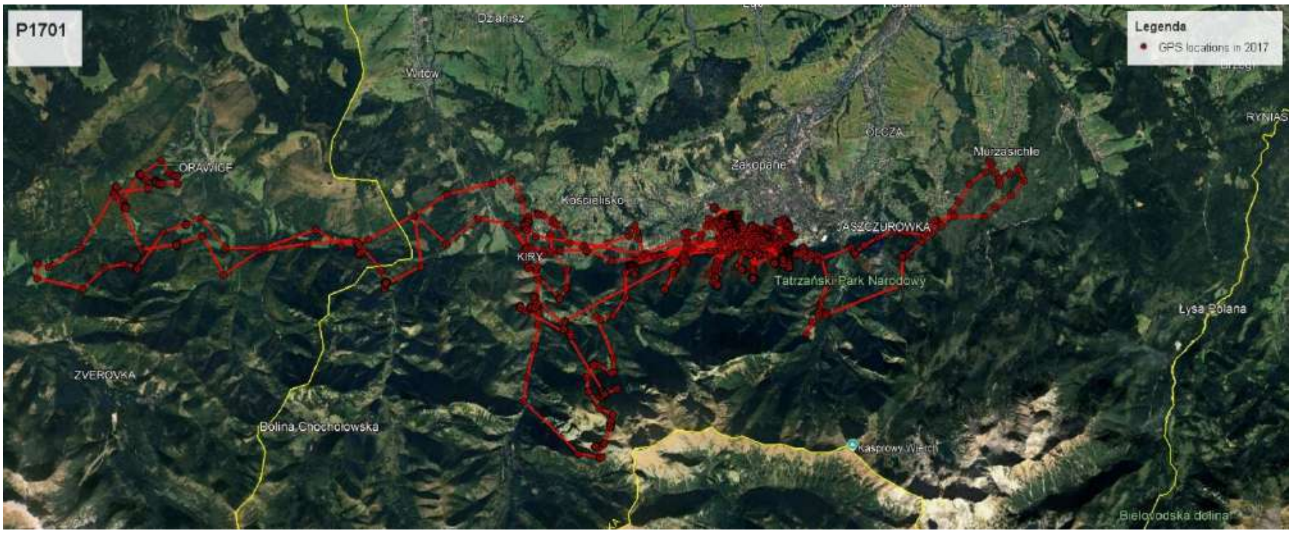

Figure 4. GPS location of female bear P1701 in 2017 (since October).

Over the following months, she roamed within a relatively small area between the Kościeliska and Bystra Valleys, crossing the main Tatra ridge into Slovakia twice (August 20–22). On September 13, she was captured again due to a malfunction of the VHF module in her collar. After fitting a new collar, it became easier to deter her from human settlements in Zakopane and Kościelisko, which she visited almost every night with her three cubs born in the winter of 2016/2017. It is possible that this deterrence prompted P1701's November journey westward to the Molkówka and Oravice areas, where she fed on bait laid out by hunters on both the Polish and Slovak sides of the border. By the end of November, however, the entire bear family returned to the Zakopane foothills. On November 30, she made a den on the northern slope of Mały Giewont, at an altitude of about 1,550 meters, where she hibernated with her cubs until March 23.

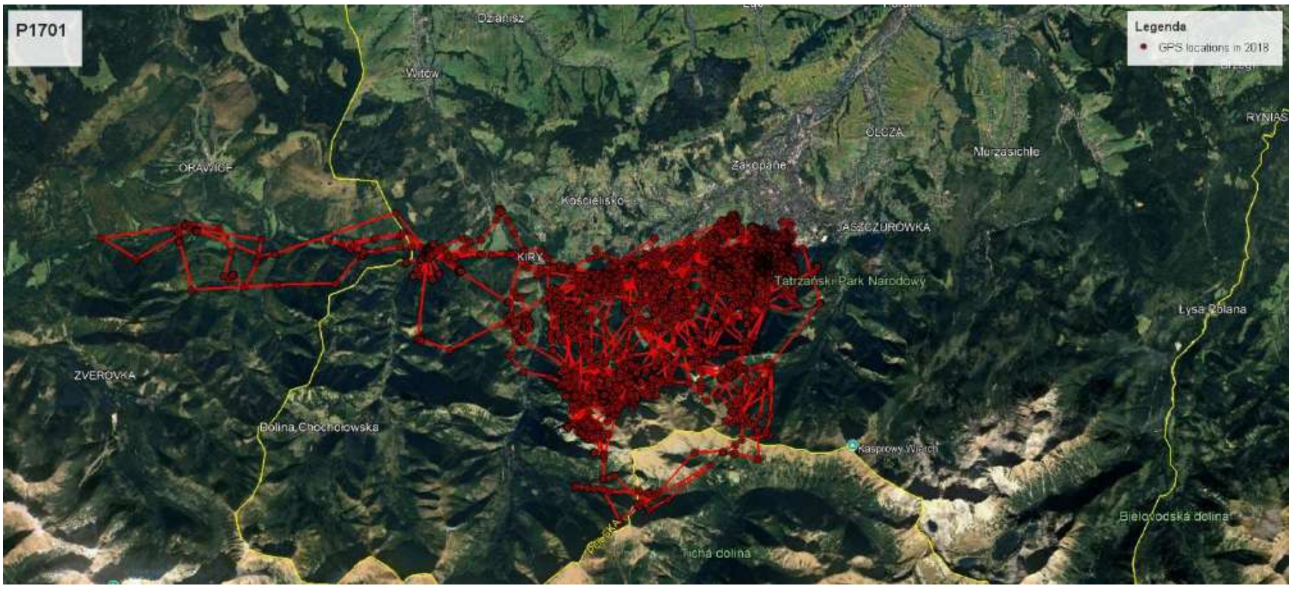

Figure 5. GPS location of female bear P1701 in 2018.

After leaving the den, the bear family moved down the Strążyska Valley toward the nearest Zakopane buildings. Throughout 2019, this female bear remained within a relatively small area of about 5,000 hectares, spending most of her time on approximately 3,000 hectares between the Białego and Kościeliska Valleys. Only in May did she appear in the Jaworzynka and Olczyska Valleys, reaching as far east as Mały Kopieniec. She never crossed the Slovak border but frequently left the Tatra National Park during the periods of March 30–April 19, June 26–July 15, August 6–23, and September 7–October 7. At those times, she ventured into the areas of Kościelisko and Zakopane, but never more than a few hundred meters beyond the park's boundary. She most frequently visited Gronik and Bogdańskiego Street and was the most common cause of interventions by Tatra National Park patrols (firearms and non-lethal ammunition were used four times).

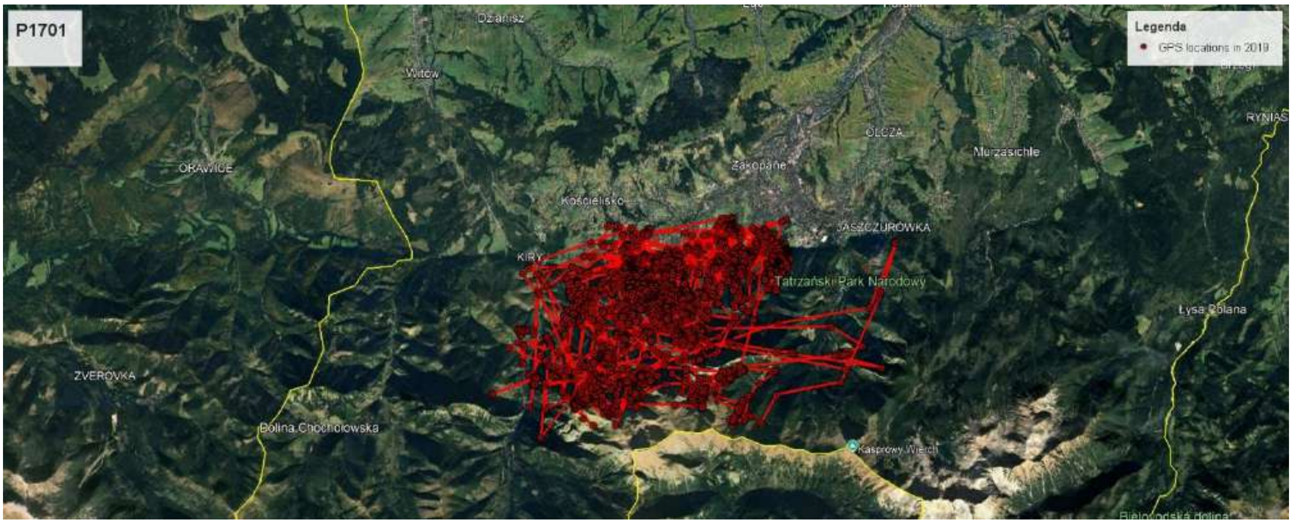

Figure 6. GPS location of female bear P1701 in 2019.

This bear received her third collar on September 17, 2019. At that time, she was no longer accompanied by cubs. Probably thanks to having weaned them earlier, she managed to reach a weight of 166 kg, over 40 kg more than the previous year. In the second decade of October, she most likely began searching for a wintering site, visiting, among others, the Miętusia Valley, where she had hibernated in the winter of 2017/2018. Ultimately, on October 29, 2019, she settled on the northern slope of Łysanki, in Mały Żlebek, below Pośredni Wierszyk, at an altitude of 1,175 meters above sea level — relatively low compared to the dens used in previous years.

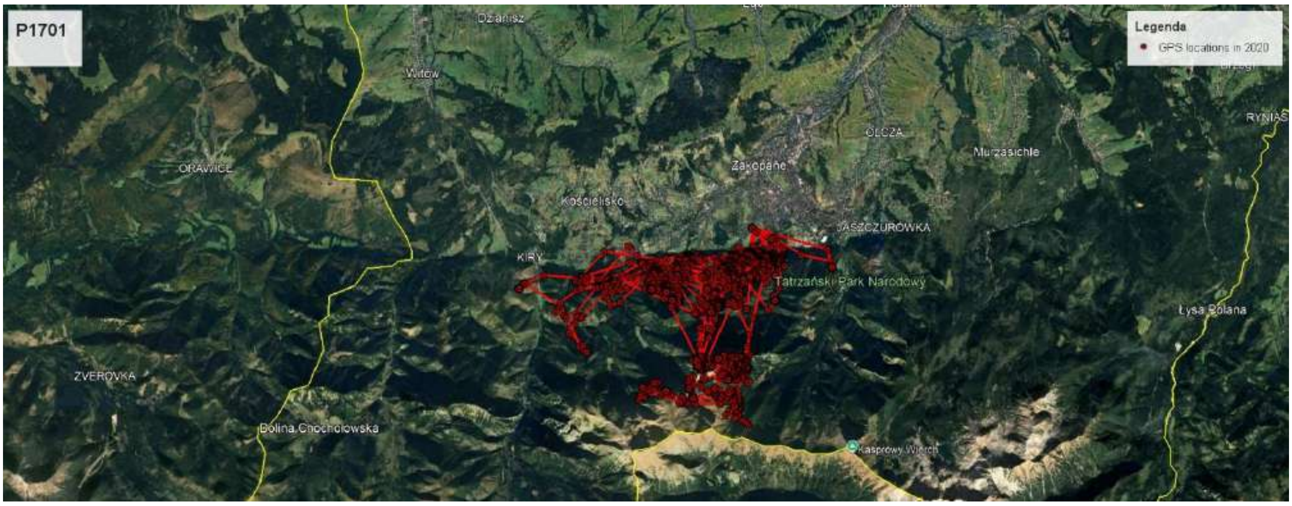

Figure 7. GPS location of female bear P1701 in 2020 (till July, and since 23 of September).

She left this site only on April 27, 2020, moving slightly lower, near Zakopane. Tracks indicated that she was accompanied by one recently born cub.

The collar fitted on female bear P1701 in September 2019 unfortunately malfunctioned at the beginning of July 2020. On September 23, 2020, she was successfully captured again and received her fourth collar. During this capture, she weighed 103 kilograms and was accompanied by one cub born that year. Unfortunately, we do not have a complete set of data on this bear's behavior for 2020. In the autumn, as in previous years, she rummaged through garbage bins in the southern parts of Zakopane and Kościelisko, where she was intensively deterred and subjected to aversive conditioning by Tatra National Park staff. In December, she made her den on the steep slopes of Mały Giewont and left it on March 30, 2021, but remained in the area until April 20, sometimes staying for longer periods in one spot, in what is known as a transitional resting site. She then moved toward Zakopane.

She left the national park area for the first time on the evening of May 17, visiting the vicinity of Mała Łąka Street in Kościelisko and Gronik, where, unfortunately, she was being fed by people. She was last seen there on September 30. On October 20, 2021, she hid in the windthrow area under Łysanki, where she made her den. She was already alone and pregnant, having likely weaned last year's cub during the mating season.

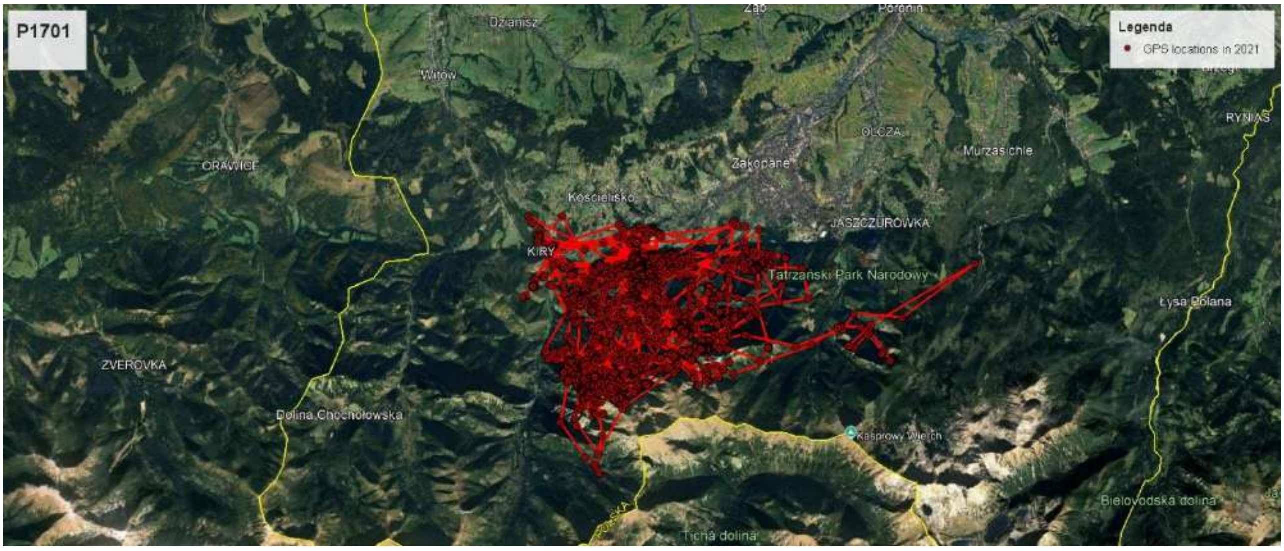

Figure 8. GPS location of female bear P1701 in 2021.

At the end of April 2022, she left the denning area, leading with her three cubs born there during the winter of 2021/2022. Unfortunately, this collar was not recovered, so we do not have a complete picture of her behavior that year. However, it appears that her habits did not change significantly compared to previous years—she continued to frequent the foothill settlements, especially the areas of Kiry, Gronik, Mała Łąka, and Bogdańskiego Street. On the evening of September 16, she made a longer trip to Molkówka. The last GPS position in 2022 from her collar was received on the evening of October 1, from between the buildings in Gronik.

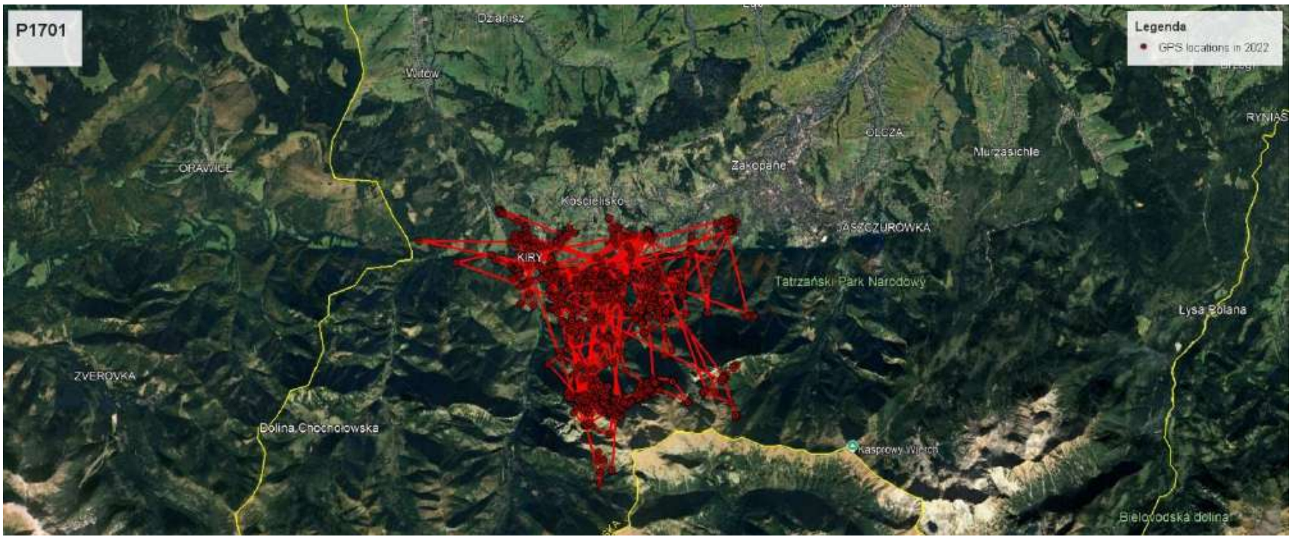

Figure 9. GPS location of female bear P1701 in 2022 (till 1st of Oct.).

The collar was partially damaged, but its VHF signal could still occasionally be detected until April 2023. In 2023 and 2024, female P1701 was captured several times by surveillance cameras near residential properties in Zakopane while raiding garbage bins. However, no deterrence measures were successfully implemented against her. Thanks to these recordings, it is known that she gave birth to three cubs during the winter of 2023/2024.

Attempts to capture female P1701 in the autumn of 2023 and spring of 2024, already under the LECA project, were unsuccessful. This was only achieved on October 22, 2024. At that time, she weighed 126 kg and was accompanied by two of the three cubs born the previous winter. The third cub had likely been killed a few days earlier after being hit by a car on its way from the Tatra National Park to garbage bins in Kościelisko.

Figure 10. GPS location of female bear P1701 in late Autumn 2024.

Thanks to her new — fifth — collar, it is known that she remained in the border area between Kościelisko, Zakopane, and the Tatra National Park until November 22. She denned high in the mountains but reappeared in Kościelisko and Zakopane as early as March 12, 2025, raiding garbage bins, compost heaps, and wildlife feeding sites together with her two yearlings. Throughout 2025, her behavior remained similar to that of previous years. In the summer and autumn, she was frequently recorded by surveillance cameras near residential properties in Zakopane and Kościelisko. By that time, she was already alone, having weaned her cubs during the mating season.

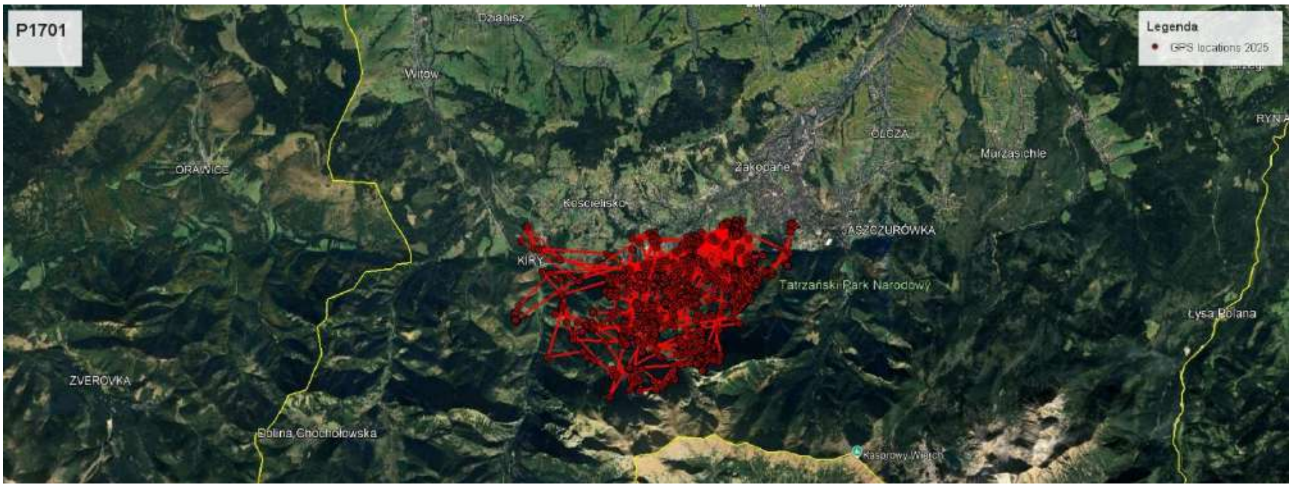

Figure 11. GPS location of female bear P1701 in 2025.

Female bears “P1806” and her daughter “P2304”

Solitary female bear “P1806” was captured and collared for the first time by TNP (PP7) on the 15 of October, 2018. At the time of capture she was 3 years old, and she weighed 116,6 kg. The capture was carried out as part of the protection activities intensively conducted since 2015 by the Tatra National Park. Until November

4, she visited the foothill settlements every night. Later, she started searching for a den and found one on November 13 on the steep slopes of Mały Giewont, were she lost the collar.

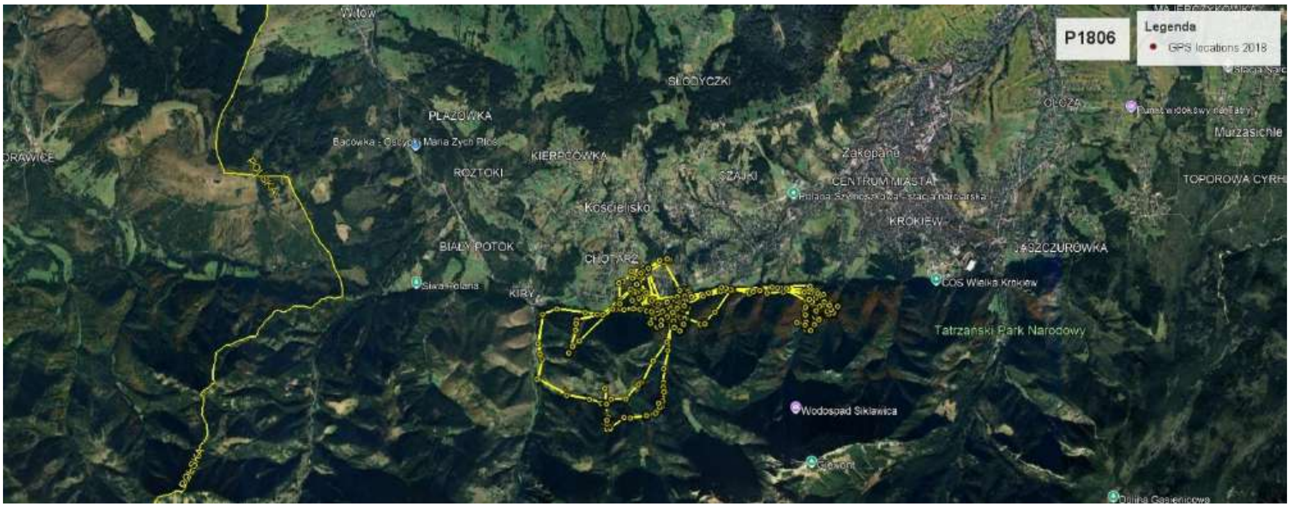

Figure 12. GPS location of female bear P1806 in 2018.

On September 26, 2022, the female bear "P1806" was recaptured, again as part of the Tatra National Park's preventive measures. She was accompanied by 3 cubs of the year, weighting 92,2 kg. Until winter, whole family stayed mainly in the area of the Ku Dziurze Valley or near Gronik village. She also made several longer excursions across the Podtatrze region, visiting many villages. On November 29, just after midnight, she was still near Kościelisko village, and twelve hours later she settled for hibernation in high mountain valley, which led Tatra National Park to close this area to speleological activity. She, and her cubs remained there until March 15, 2023.

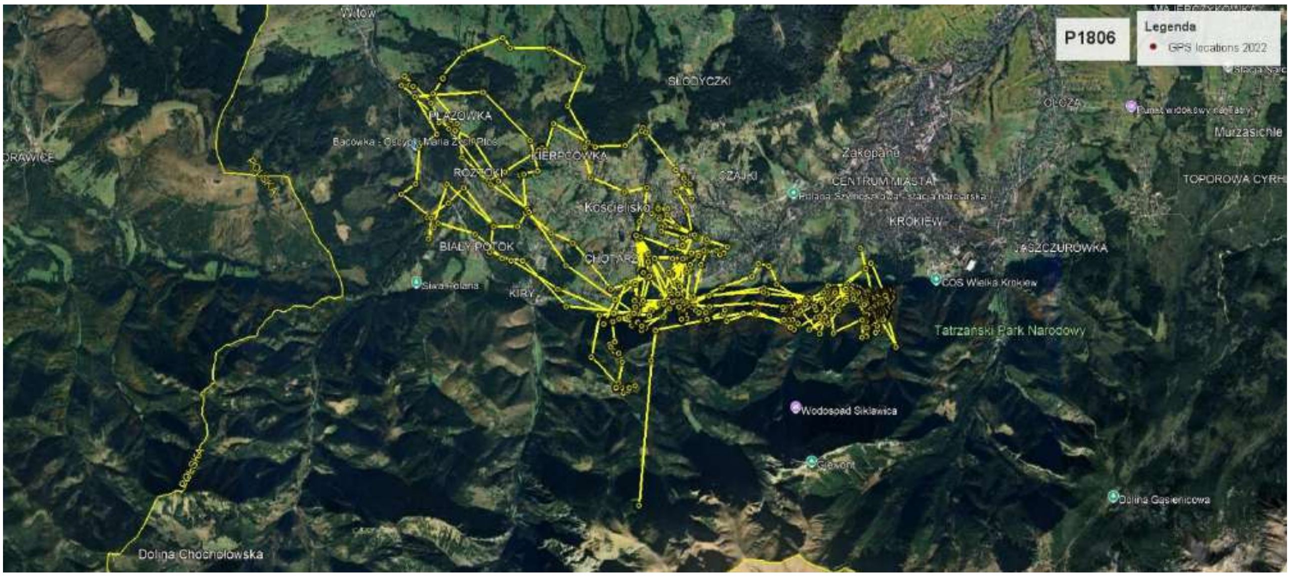

Figure 13. GPS location of female bear P1806 in 2022 (since September, 26).

After leaving the den, the entire bear family spent a long time among the alpine meadows and rocky peaks. It was only at the end of April that they descended to the foothills of the Tatras. Until June 20, however, they remained within the boundaries of the Tatra National Park. From that time on, they regularly visited the foothill settlements. On November 7, 2023, she made a den in a small cave deep in the Kościeliska Valley. It is not clear if whole family were wintering together.

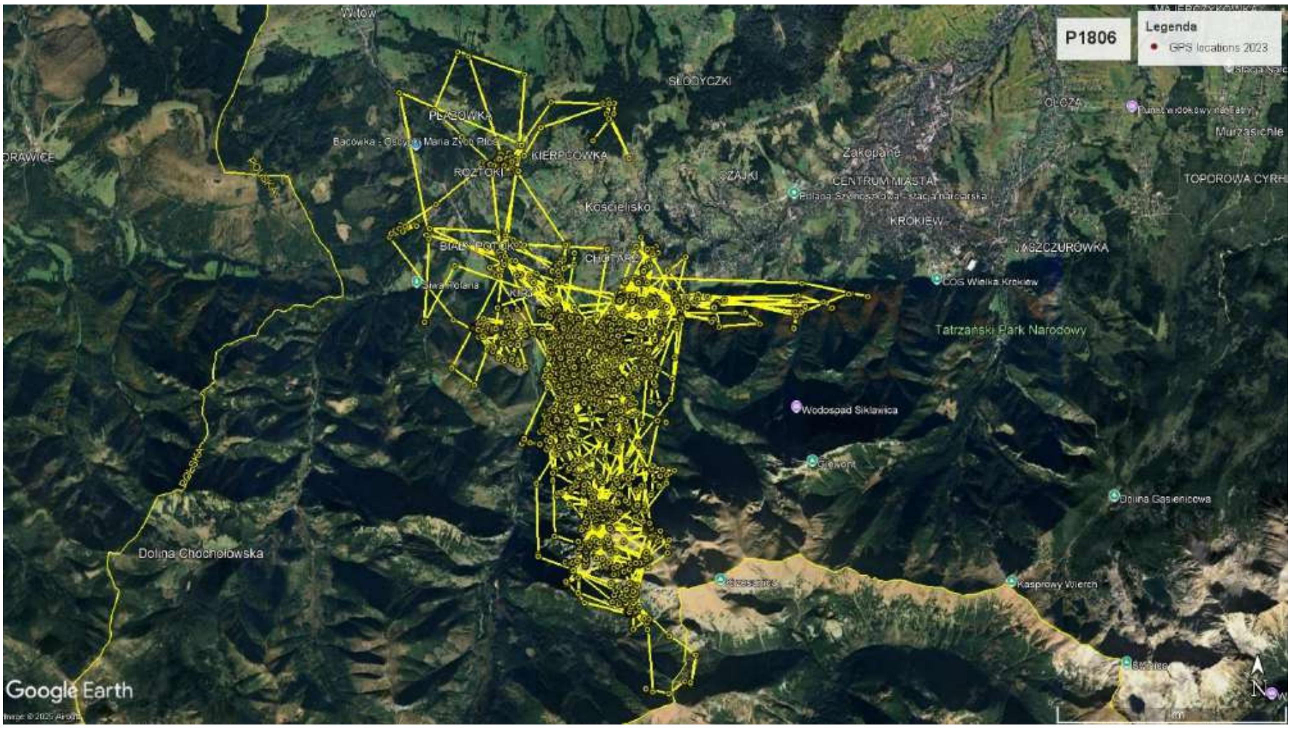

Figure 14. GPS location of female bear P1806 in 2023.

One of her yearlings, female named later P2304, was captured and equipped with video collar on 27 of September, 2023. Collar felt of on 17 of October, when whole family was still together (recorded on video). Very first videos recorded by bears under LECA were obtained.

Figure 15. GPS location of female bear P2304 in 2023 (since 27th of September till 17th of October).

Female P1806 left den alone, which was determined based on tracking on snow. Until 19 of June 2024 she stayed inside TNP. After that date, she was frequently visiting neighboring villages. In September 2024, the collar stopped transmitting GPS locations. Using a VHF antenna, a radio signal was detected in “mortality” mode, and the collar was eventually found in the current of the Kirowa Woda River. It turned out that the collar had been mechanically torn apart in a way suggesting human interference. Therefore, it is likely that the bear P1806 was poached. Due to a lack of concrete evidence, the case was not reported to law enforcement authorities. However, this incident was discussed during a seminar for law enforcement agencies organized in Zakopane as part of the LECA project, where it was concluded that this had been a mistake — all such cases should be reported, even when evidence is scarce.

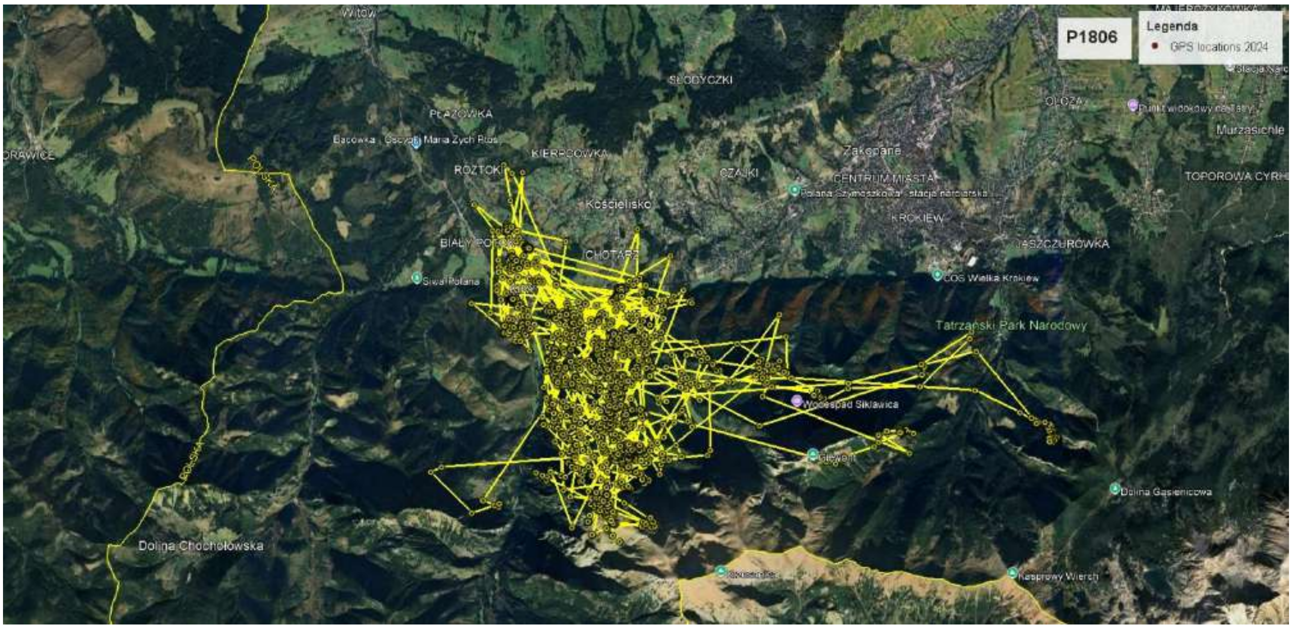

Figure 16. GPS location of female bear P1806 in 2024 (till September, 3).

Female bear “P2402”

Solitary female bear “P1807” was captured and collared for the first time by TNP (PP7) on the 18 of October, 2018. At the time of capture she was 3 or 4 years old, and she weighed 93 kg. The capture was carried out as part of the protection activities intensively conducted since 2015 by the Tatra National Park. After being collared, she ventured several times north of the Droga pod Reglami, into areas near human settlements. On November 10, she settled down among the windthrows in the Miętusia Valley, were she lost the collar.

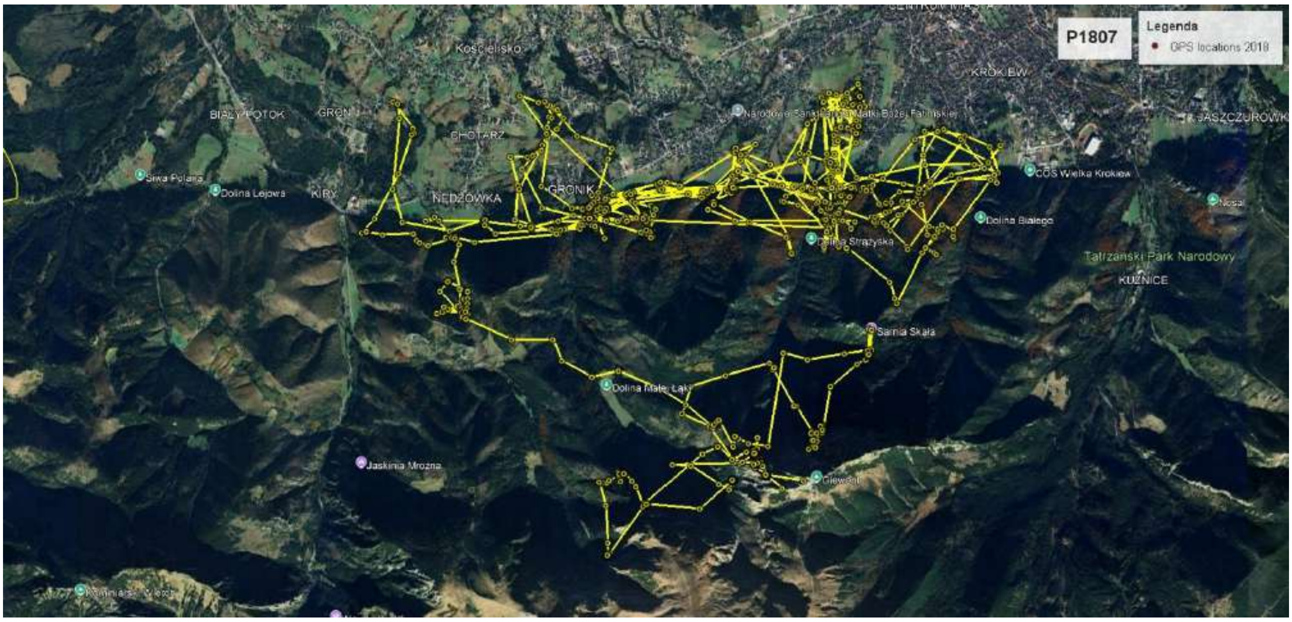

Figure 17. GPS location of female bear P1807 in 2018 (since October, 16).

On September 30, 2023, the female bear “P1807” was recaptured under LECA project, by TNP (PP7). She was solitary, weighting 133 kg. After being captured near a village, she moved high into the mountains, where on October 20 she made a den on the inaccessible slopes of Giewont. During the winter, she gave birth to three cubs, with whom she left the den at the end of April.

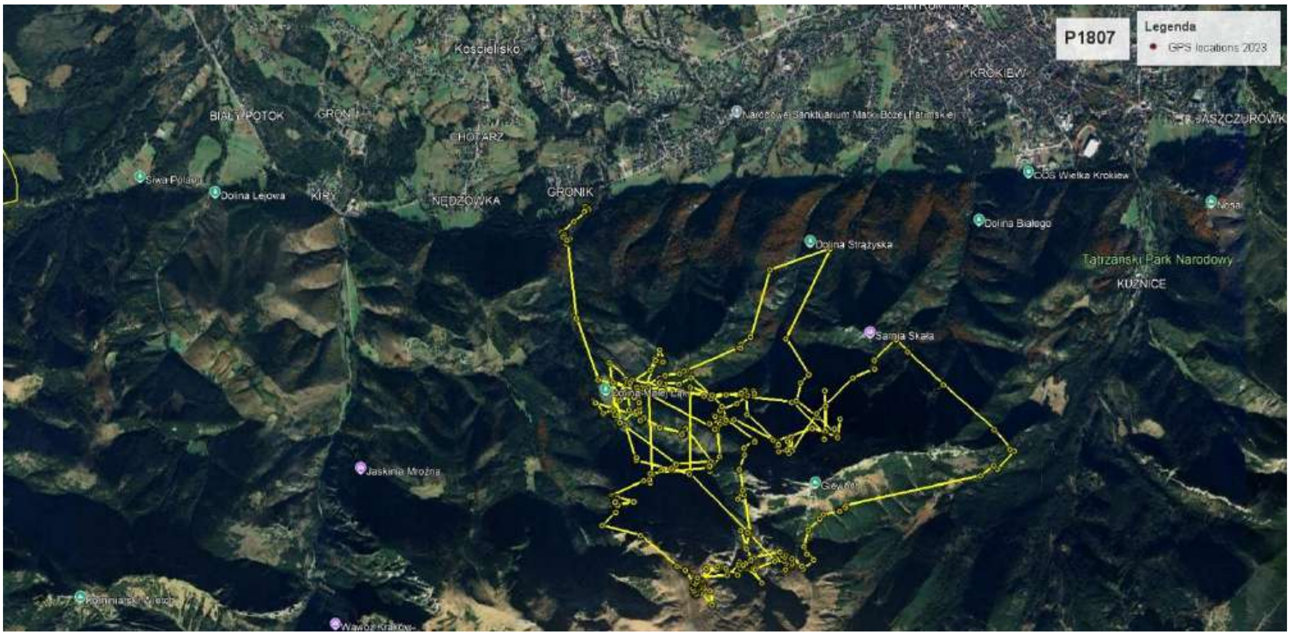

Figure 18. GPS location of female bear P1807 in 2023 (since September, 30).

The family stayed among the rocky peaks for another month before descending into the forested foothills in early June. On July 24, 2024, the female P1807 lost her collar in that area. No conflict situations involving her were recorded in 2023–2024.

Figure 19. GPS location of female bear P1807 in 2024 (till July, 7).

<u>Female bears “P1902” and her daughter “P2305”</u>

Solitary female bear “P1902” was captured and collared for the first time by TNP (PP7) on the 23 of September, 2019. At the time of capture she was 5 or 6 years old, and she weighed 115 kg. Before denning high in the mountains (around 1,400 m a.s.l.) on November 28, she divided her activity between the forests of the Tatra foothills, and the Gubałówka Hills forests, on the other side of Zakopane. Several times, she used the ecological corridor leading from Gronik down to the Cicha Woda valley and along the Butorowski Stream ravine, passing through increasingly urbanized clearings toward the Gubałówka Range. The collar fell off the female during hibernation; however, it was determined that she gave birth to at least two cubs that winter.

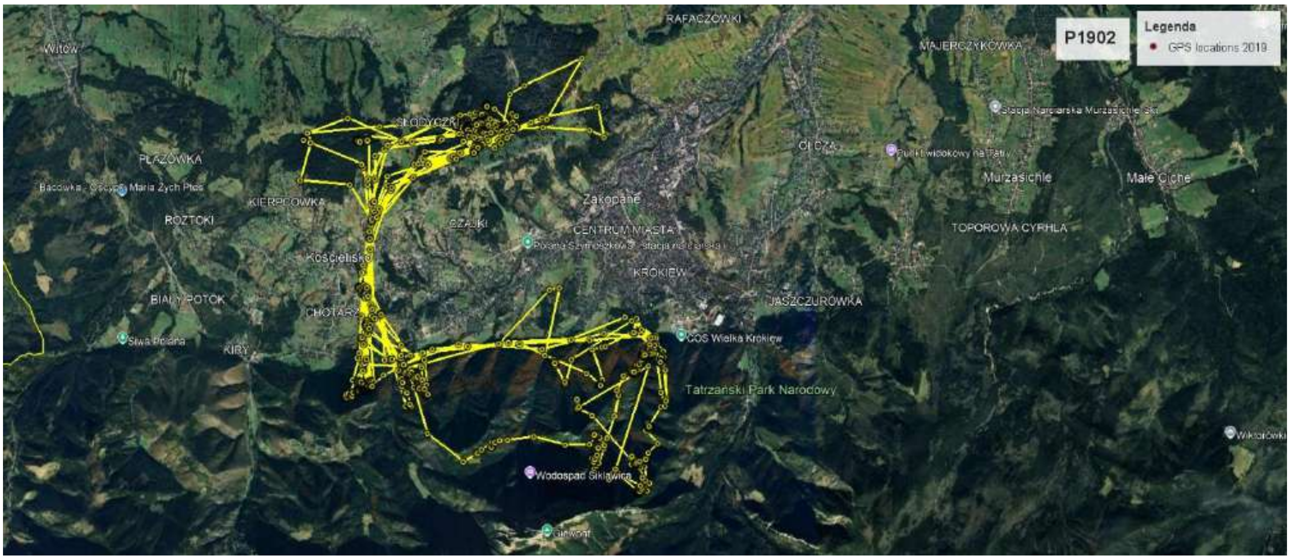

Figure 20. GPS location of female bear P1902 in 2019 (since September, 23).

The female bear P1902 was recaptured on September 27, 2021. At the time of capture, she was alone and weighed 131 kilograms. After being collared, P1902 made one trip to Butorowy and Gubałówka, following the same route she had used in 2019 through the village near the coal depot. On October 23, she retreated to a den on the northern slope of Długi Giewont, were she gave birth to at least two cubs.

Figure 21. GPS location of female bear P1902 in 2021 (since September, 27).

The entire family stayed within the Giewont massif until the end of May 2022. On May 29, the female lost her collar on the northern slope of Długi Giewont. The subsequent fate of bear “P1902” can be followed from her recapture on October 14, 2022. Afterward, she remained in the Zakopane foothill forests (Regle Zakopiańskie) until December 21, without leaving the park or approaching human settlements. At noon that day, she appeared on the ridge of Długi Giewont, where she denned again—this time on the southern slope. She was accompanied by two cubs born in the winter of 2021/2022.

Figure 22. GPS location of female bear P1902 in 2022 (till May, 29 and since November, 1).

The entire bear family left the den very early, on March 22, 2023, and moved to the forests near Zakopane. They remained within the Tatra National Park area until the second half of September. In October 2023, the family resumed their familiar wanderings through Kościelisko toward Gubałówka, where they fed at wildlife feeding sites, compost heaps, and fruit trees, before returning to the Tatra Mountains. In mid-November, the entire family climbed the northern face of Giewont, where they began searching for a suitable denning site.

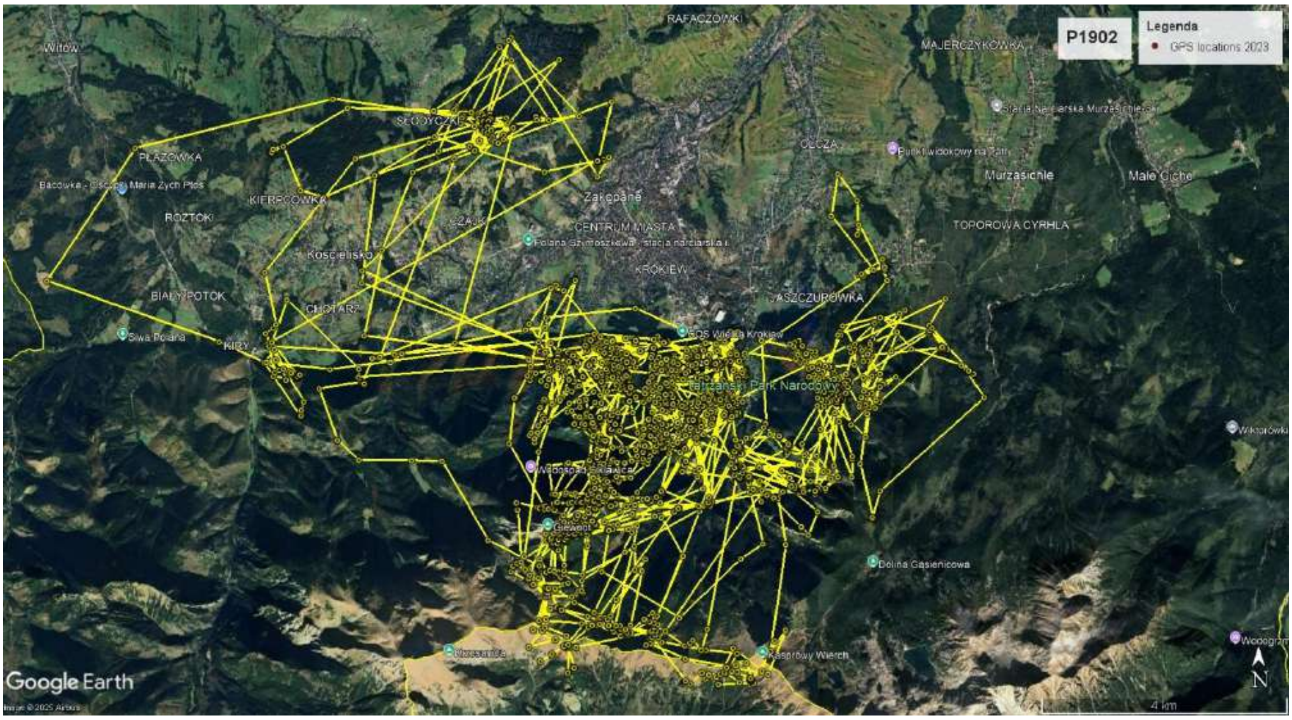

Figure 23. GPS location of female bear P1902 in 2023.

One of her yearlings, female named later P2305, was captured and equipped with video collar on 12 of October, 2023. Collar felt of on 16 of April, 2024, but stopped recording in Autumn 20223.

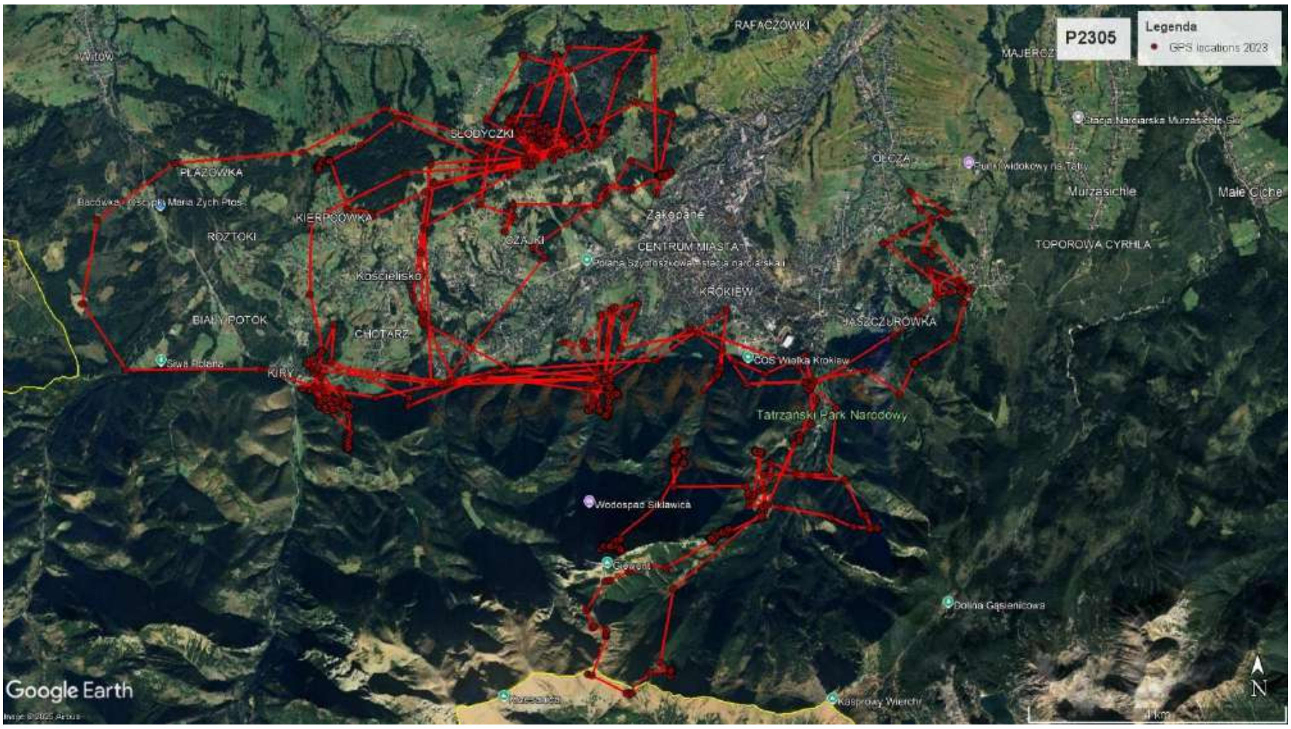

Figure 24. GPS location of female bear P2305 in 2023 (since October, 12).

The bears descended from Giewont at the beginning of April. Until early July, they remained within the Tatra National Park area. Later, they began visiting garbage bins and compost heaps in Zakopane and Kościelisko, as well as roaming across the Gubałówka range, where they were recorded raiding a hidden pigsty near a shepherd's hut and feeding on pig slops. On October 10, 2024, the collar of the female P1902 automatically detached after two years of operation and was recovered by the Tatra National Park staff.

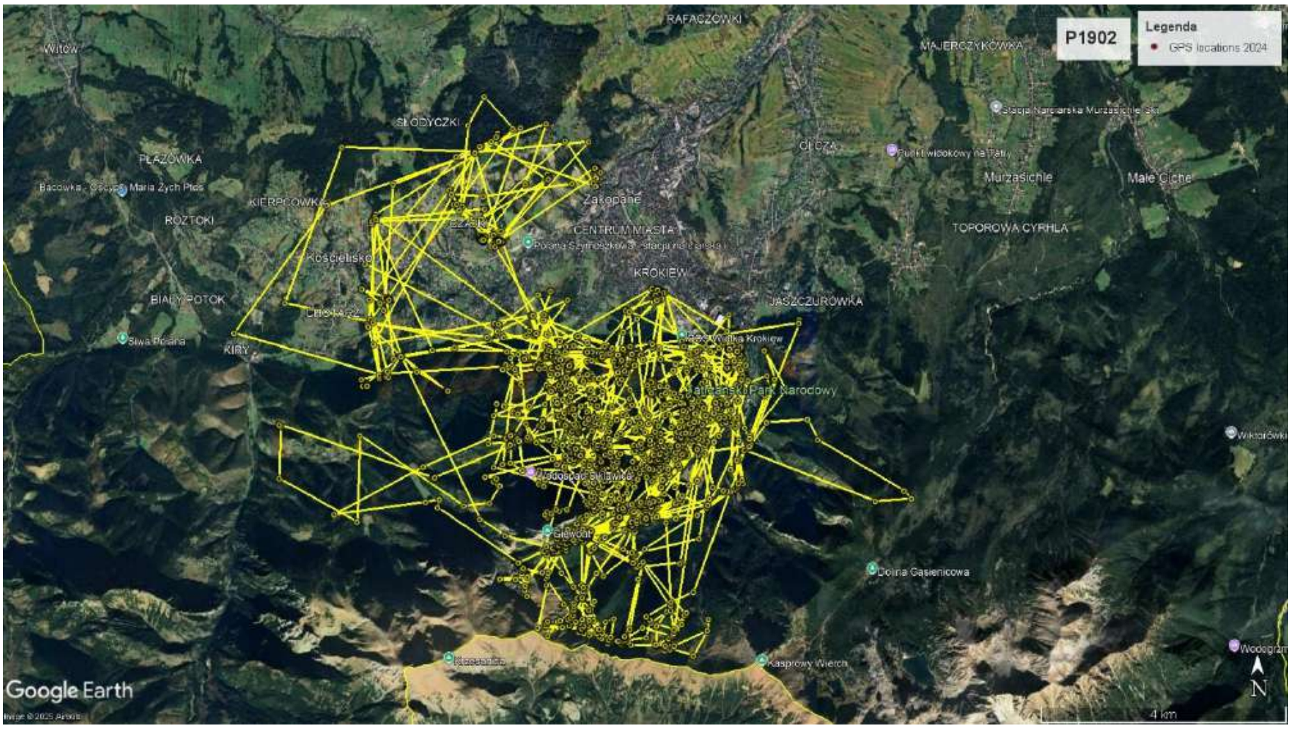

Figure 25. GPS location of female bear P1902 in 2024 (till October, 10).

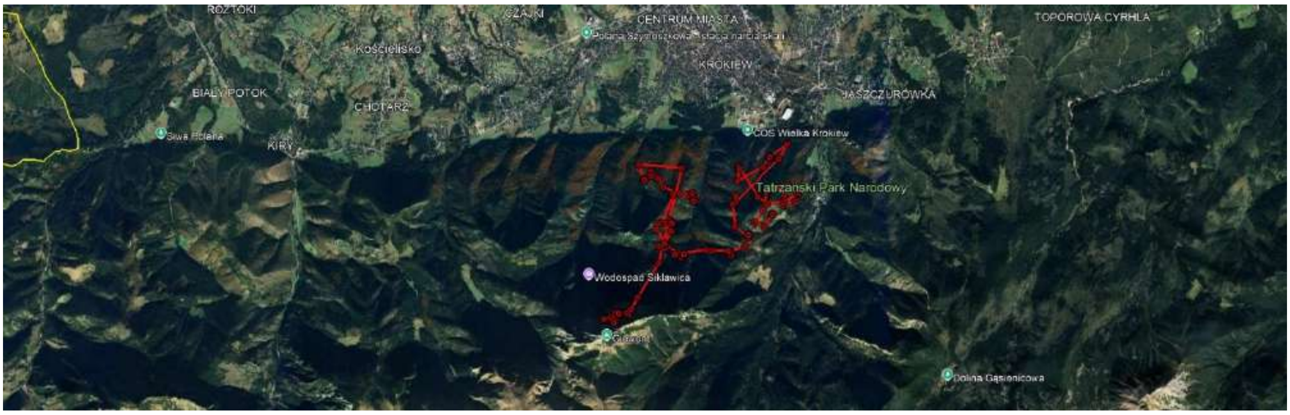

Figure 26. GPS location of female bear P2305 in 2024 (till May, 16).

Female bear “P2106”

Solitary female bear “P2106” was captured and collared by TNP (PP7) on the 10 of May, 2021, before LECA project started. At the time of capture she was 7 years old, and she weighed 87 kg. The capture was carried out as part of the protection activities intensively conducted since 2015 by the Tatra National Park. Until autumn, she remained within a relatively small area of about 60 square kilometers on the eastern side of the Tatra National Park. She quite often left the park boundaries, approaching human settlements, but did not cause any conflict situations. She was recaptured on September 28. The collar was not replaced, but her weight was measured — she weighed 136 kg, which means she increased her body mass by 56.3% over three and a half months. In the first days of October, she made her den high in the mountains, above the tree line in the Pańszczyca Valley, just above the junction of the black and green trails, which led to the decision to close that section of the trail.

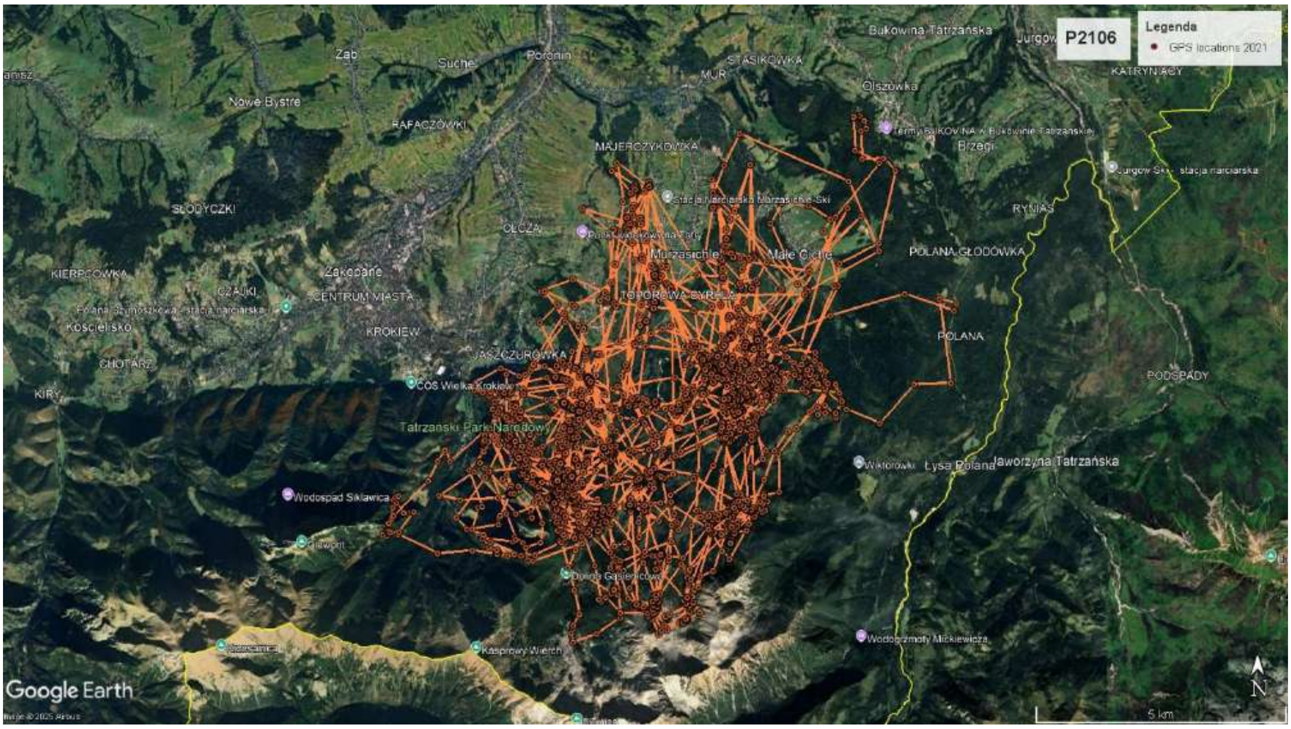

Figure 27. GPS location of female bear P2106 in 2021 (since May, 21).

During the winter of 2021/2022, the female P2106 gave birth to two cubs, with whom she remained in the den until April 10, 2022. Afterwards, the entire family moved to another resting site for two weeks, and by the end of April they descended to the lower parts of the Tatras. Compared to 2021, her home range in

2022 expanded slightly to the west and east. Her behavior remained quite similar — she often stayed near the villages of Małe Ciche and Murzasichle, but the satellite data never showed her in direct proximity to human settlements. On November 19, she left the foothills and moved into the Tatras, toward Hala Gąsienicowa. Between November 21 and December 13, 2022, she denned near the upper tree line, but eventually, around December 19, she settled for winter hibernation lower down in the Sucha Woda Valley, in a quiet area among windthrows and uprooted trees, far from tourist trails.

Figure 28. GPS location of female bear P2106 in 2022.

On March 19, 2023, together with her two cubs, she left the den. She wore the collar until May 8, 2023, behaving in a similar way as in previous years.

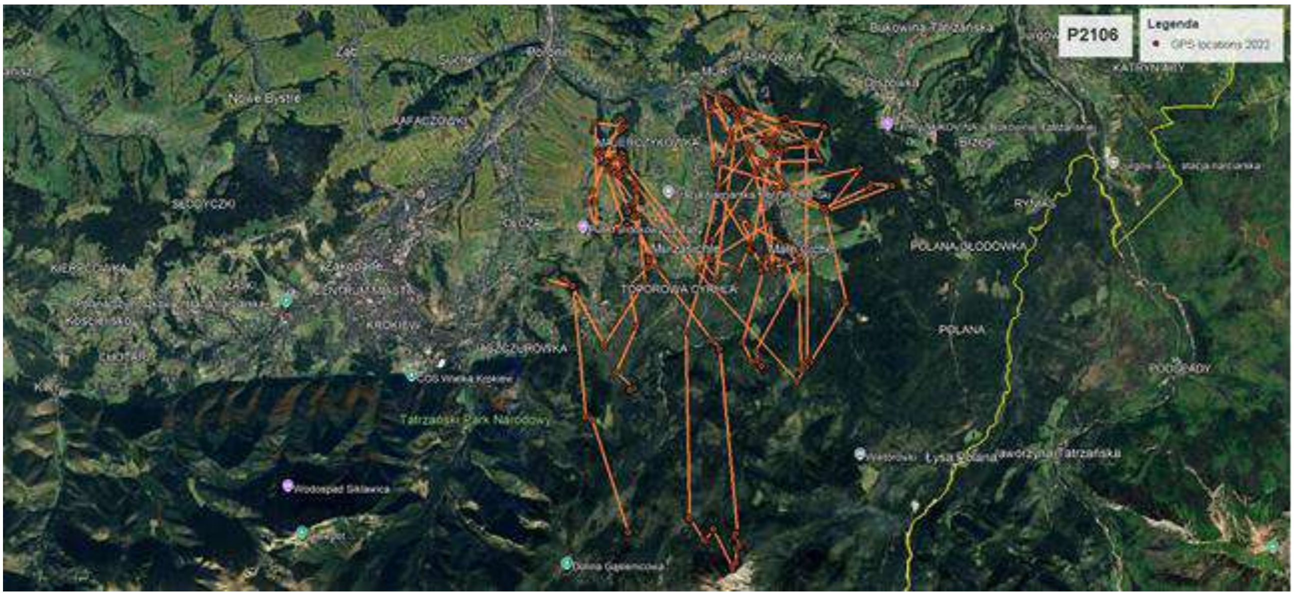

Figure 29. GPS location of female bear P2106 in 2021 (till May, 8).

Male bear "P2203"

Subdult male bear "P2203" was captured and collared before LECA project by TNP (PP7) on the 31 of October, 2022. At the time of capture, he weighed 73 kg. He established his den at the end of November 2022 in the area of the upper tree line. Until that time, he had been moving between the Polish and Slovak national parks.

Figure 30. GPS location of male bear P2203 in 2022 (since October, 31).

He left the den at the end of March 2023 and moved toward the foothills of the Tatras, visiting the villages of Murzasichle, Małe Ciche, Brzegi, and Bukowina Tatrzańska. However, he did so discreetly enough not to cause any conflict situations. He lost his collar on May 27, 2023.

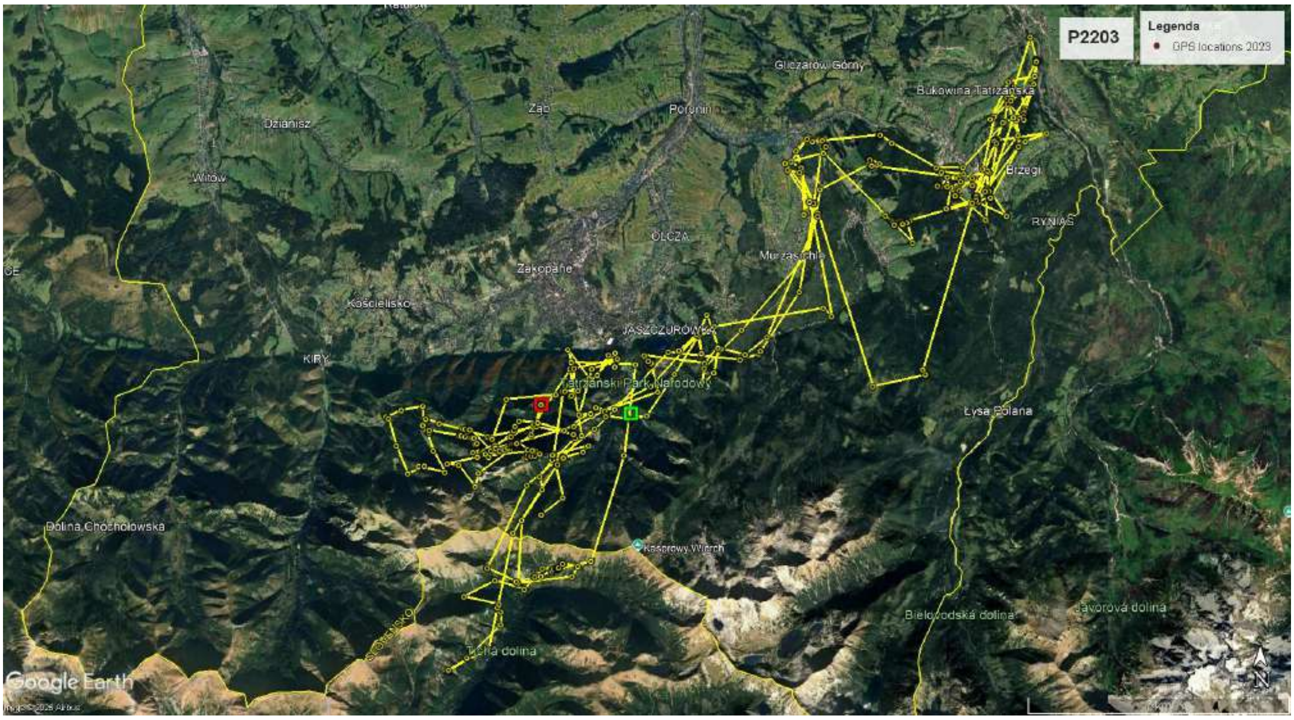

Figure 31. GPS location of male bear P2203 in 2022 (till May, 27).

Female bear "P2301"

Female "P2301" was the first bear captured and collared under LECA project by TNP (PP7) on the 29 of April, 2023. This was the only capture carried out deep within the Tatra National Park, near the tourist bar on Polana Włosienica, on the road leading close to Morskie Oko — the most popular trail in the Tatras. The purpose of this capture was to fit a collar on a distinctive female bear with a visible scar on her nose, who had been observed in this area for several years and had repeatedly approached mountain hotels, attempting to access garbage bins. This time, bags of trash were used as bait. During the capture, she was accompanied by two cubs from the previous year and weighed 64 kg. After fitting the collar, it became clear that this female behaved very differently from the others. She spent most of her time in high-mountain areas, occasionally attempting to access garbage bins at mountain shelters. These were rarely conflict situations, however. Most attempts to access garbage bins were unsuccessful due to protective measures, including electric fences. On one occasion, she was deterred using firecrackers.

However, she primarily relied on natural plant food and carrion. The entire family was also observed hunting marmots. She frequently crossed the main Tatra ridge into Slovakia, where she visited, among other places, the ski resort at Štrbské Pleso. She established her den at the end of November 2023 on the Polish side, in the area of the upper tree line.

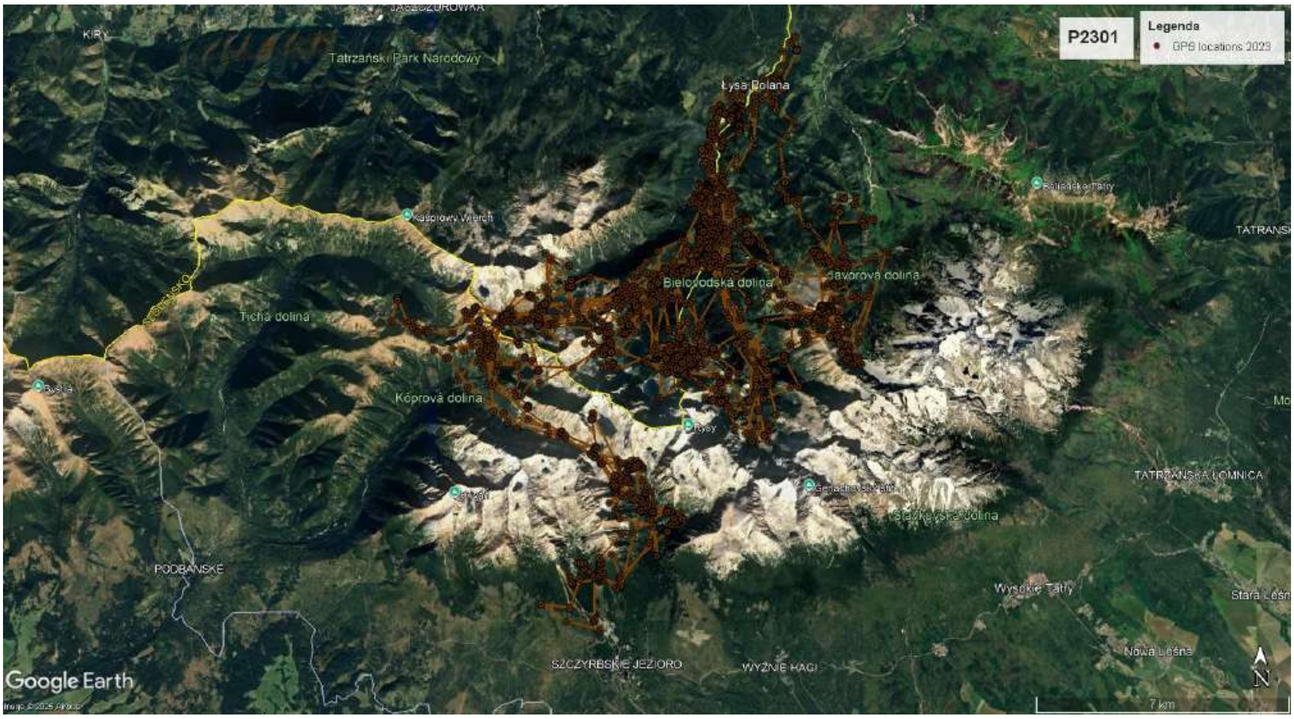

Figure 32. GPS location of female bear P2301 in 2023 (since April, 29).

In the second half of March 2024, the entire family left the den and remained together, behaving similarly to the previous year. In the second half of November 2024, the female P2201 established another den, this time in the high-mountain zone on the Slovak side, at 1,745 m a.s.l. It is not certain whether her cubs were still with her. She left this den in the second half of April 2025 but remained in the vicinity. On April 27, the collar automatically detached, ending its two-year service.

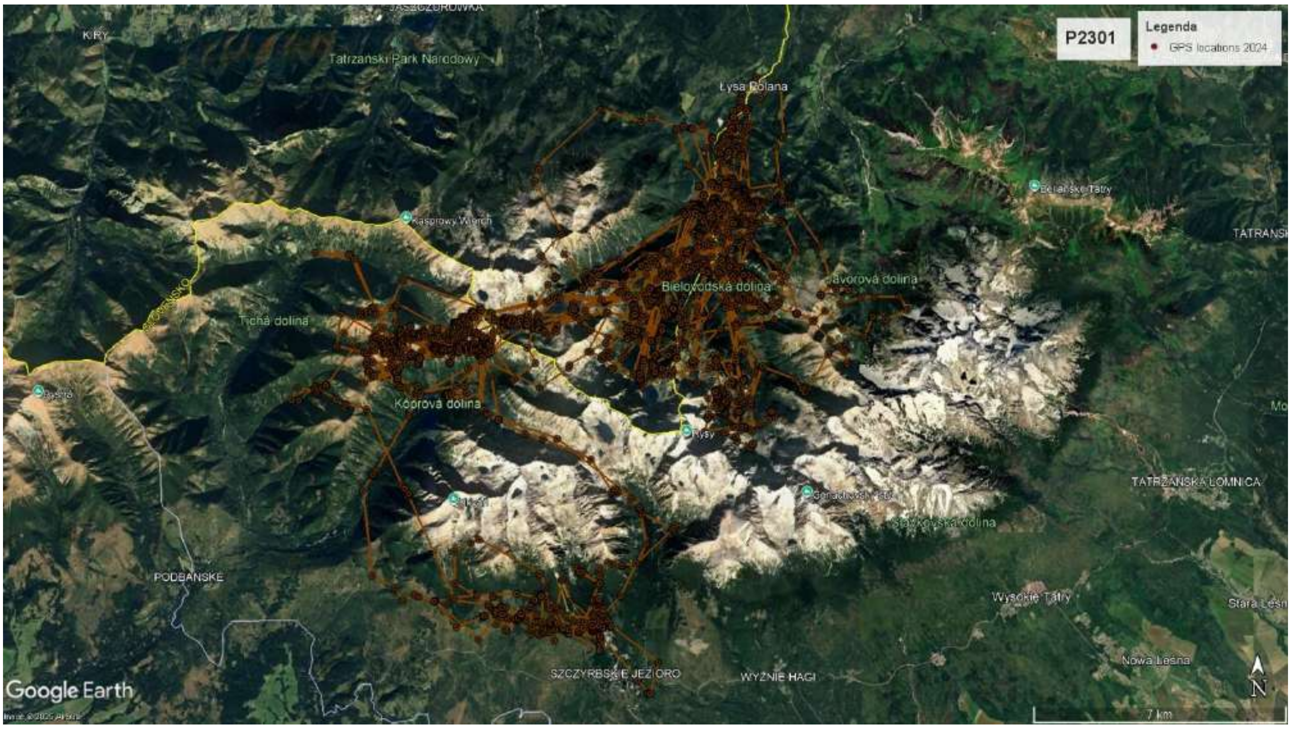

Figure 33. GPS location of female bear P2301 in 2024.

Male bear "P2303"

Subdult male bear "P2401" was captured and collared under LECA project by TNP (PP7) on the 31 of May, 2023. At the time of capture, he weighed 56 kg. He lost the collar after seven days. No conflict situations were observed, although he appeared near buildings.

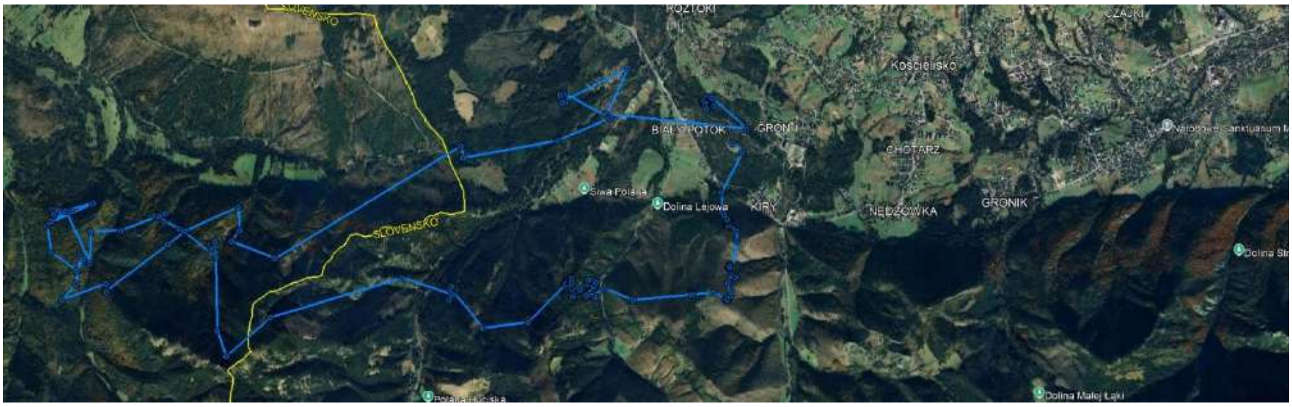

Figure 34. GPS location of male bear P2303 in 2023 (since May, 31 till June, 9).

Male bear "P2401"

Adult male bear "P2401" was captured and collared under LECA project by TNP (PP7) on the 12 of April, 2024. At the time of capture, he weighed 293 kg. He wore the collar for only 10 days, but during that time he managed to visit a chicken coop at the mouth of the Mała Łąka Valley, where he ate feed prepared for the poultry.

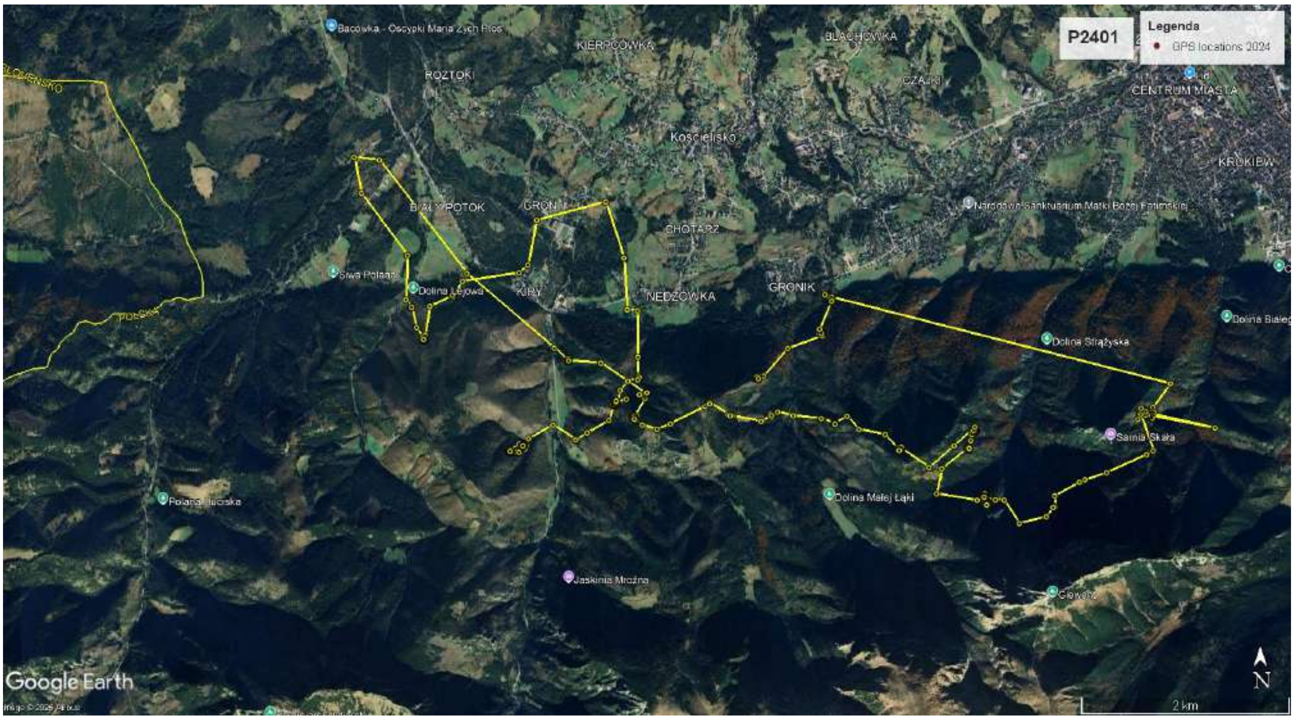

Figure 35. GPS location of male bear P2401 in 2024 (since April, 12 till April, 22).

Male bear “P2402”

Adult male bear “P2402” was captured and collared under LECA project by TNP (PP7) on the 30 of April, 2024. At the time of capture, he weighed 120,5 kg. Until the end of the year, he remained in the Polish-Slovak border area in the Białka Valley, both in the Tatra and foothill parts. He foraged in fields near villages very often but did not directly approach people and did not cause any conflict situations. However, he frequently used hunting devices and wildlife feeding sites. At the turn of November and December, he began searching for a suitable denning site, resting in various locations for several to several dozen days, high on Wołoszyn Mountain. The longest denning period lasted from December 18, 2024, to February 21, 2025. At the beginning of March, he left the denning area and returned to activity patterns similar to the previous year. The last GPS location was recorded on March 13, 2025, near Polana Rynias. Later, he was detected by camera traps, which revealed serious damage to his collar (missing GPS module). There was no evidence that he caused any conflict situations.

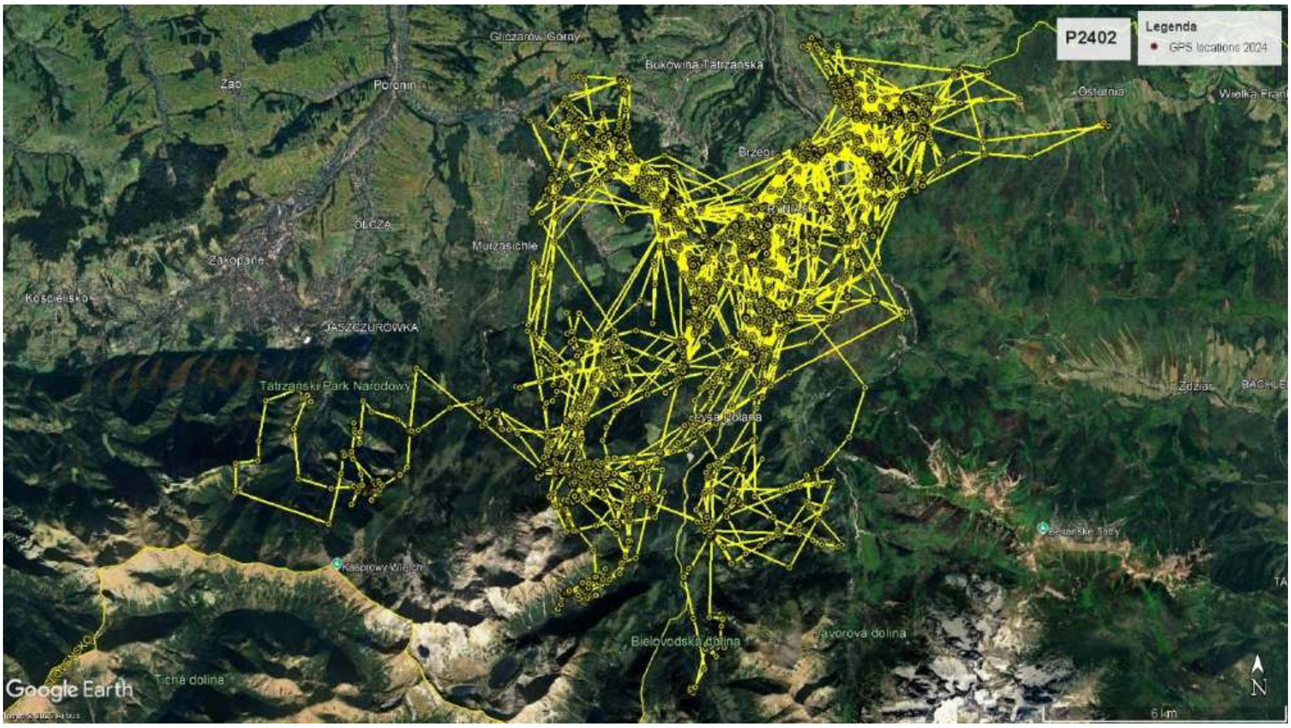

Figure 36. GPS location of male bear P2402 in 2024 (since April, 30).

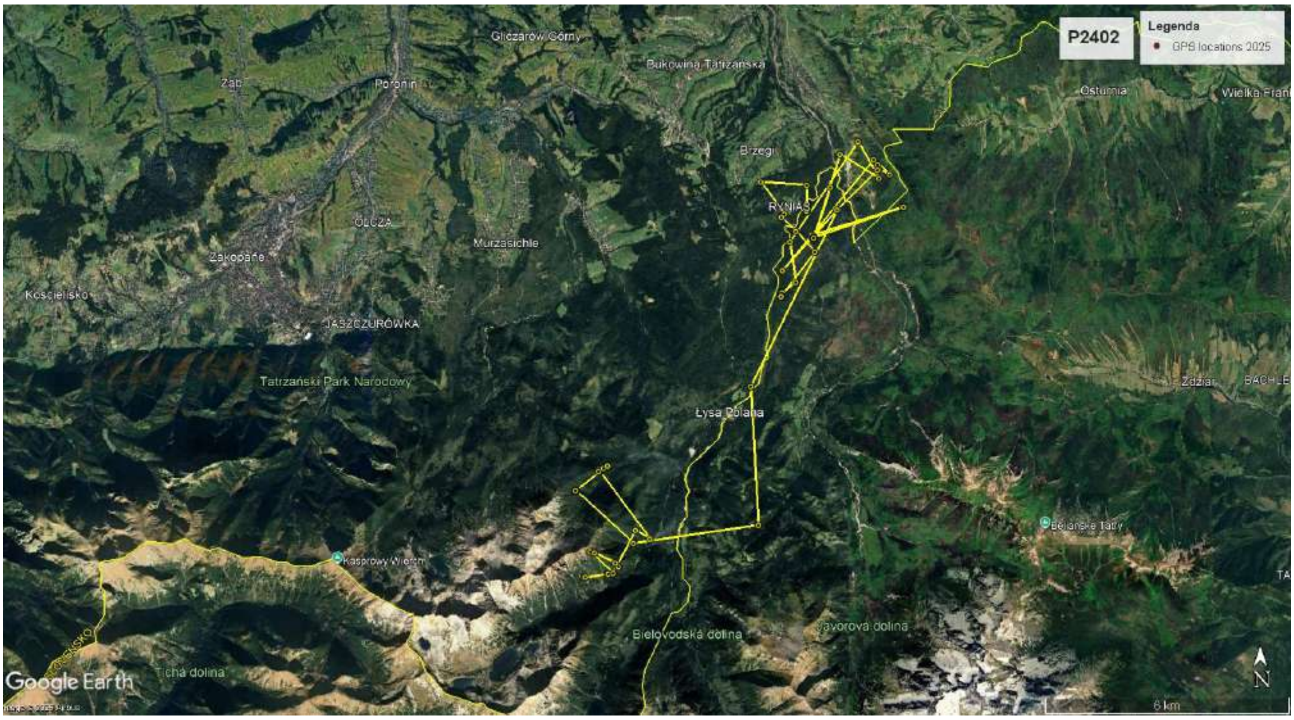

Figure 37. GPS location of male bear P2402 in 2025 (till March, 13).

Female bear "P2403"

Solitary adult female bear "P2403" was captured and collared under LECA project by TNP (PP7) on the 13 of October, 2024. At the time of capture, he weighed 70 kg. After spending two weeks in the beech forests of the Tatra National Park near Zakopane, she moved to Slovakia, looking for a den in the Tatranská Javorina region. On November 8, 2024, she established a den in a small cave, which she left on April 19, 2025. Over the following month, she remained in the Szeroka Jaworzyńska area, crossing briefly to the Polish side via the Białka River. In mid-May, her collar malfunctioned. After long and challenging work using VHF telemetry, it was possible to remotely detach the collar and recover it, with the assistance of staff from the Slovak National Park. No conflict situations involving her were observed.

Figure 38. GPS location of female bear P2403 in 2024 (since October, 13).

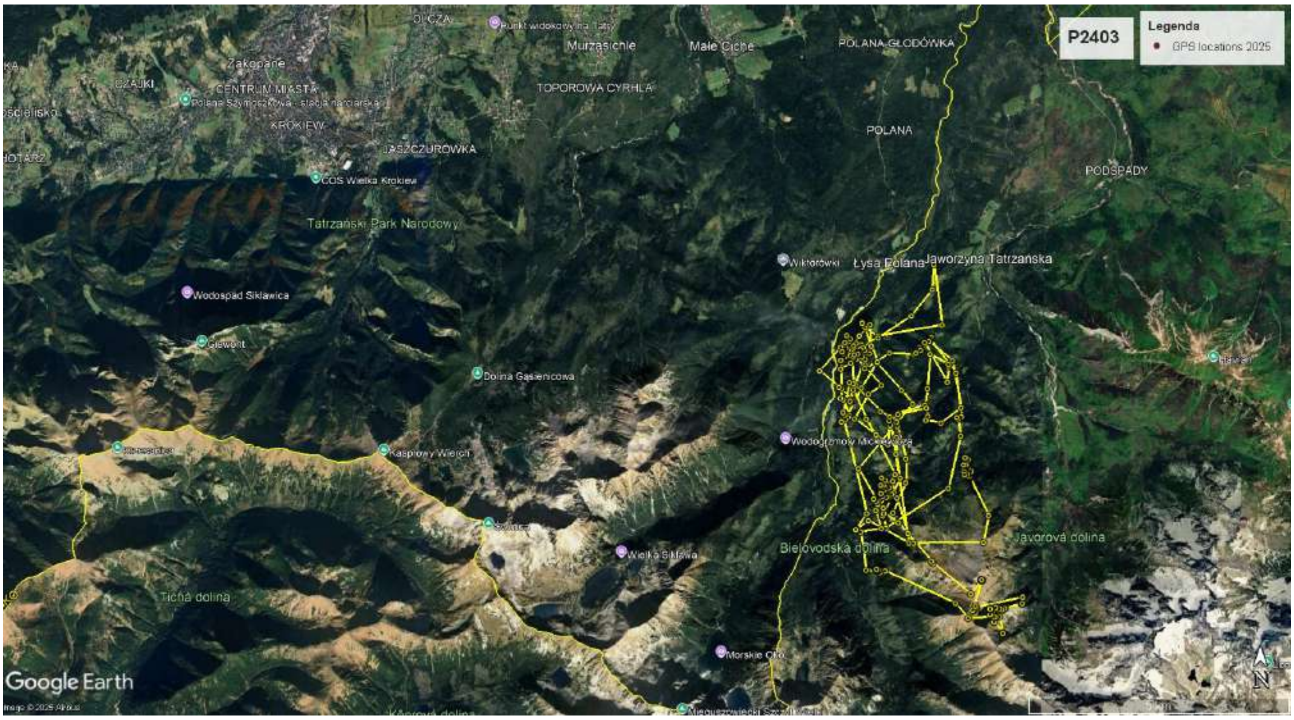

Figure 39. GPS location of female bear P2403 in 2025 (till May, 25).

Female bear "P2405"

Subadul female bear "P2405" was captured and equipped with the video collar under LECA project by the TNP (PP7) on the 24 of October, 2024. At the time of capture, she was still with her mother and the other sibling. After spending a few days in the beech forests of the Tatra National Park near Zakopane, the entire bear family left the Tatras and moved toward the Czorsztyn Reservoir (Pieniny), foraging in small woodlands and fields. After about a week, they returned to the Polish High Tatras, briefly passing through the Slovak foothills. On November 4, they crossed the Wołoszyn Ridge (over 2,000 m a.s.l.), where they found a denning site on its slopes. From November 8, the whole family remained together in the den (unique video recordings). Unfortunately, the collar came off during the denning period.

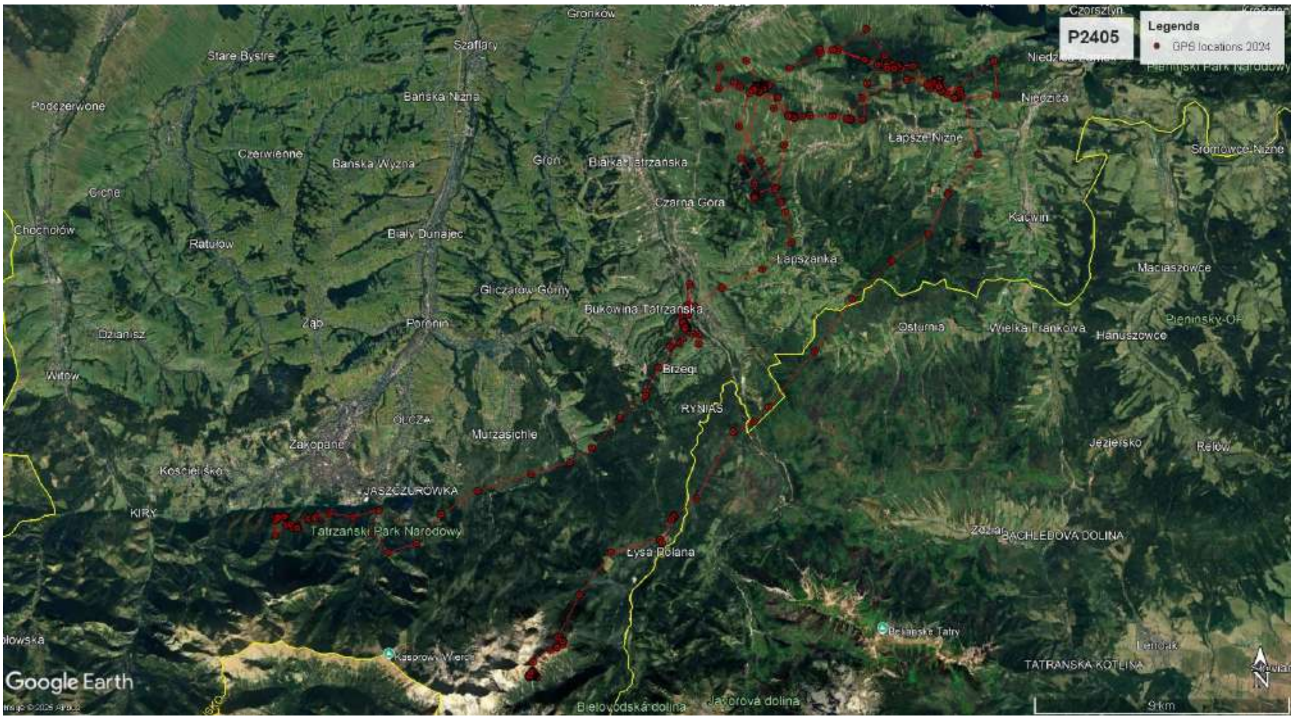

Figure 40. GPS location of female bear P2405 in 2024 (since October, 24).

Female bear "P2406"

Solitary adult female bear "P2406" was captured and collared under LECA project by TNP (PP7) on the 30 of October, 2024. At the time of capture, he weighed 111 kg. She lost her collar after eight days. During that time, she moved near the foothill settlements; however, there was no evidence that she caused any conflict situations.

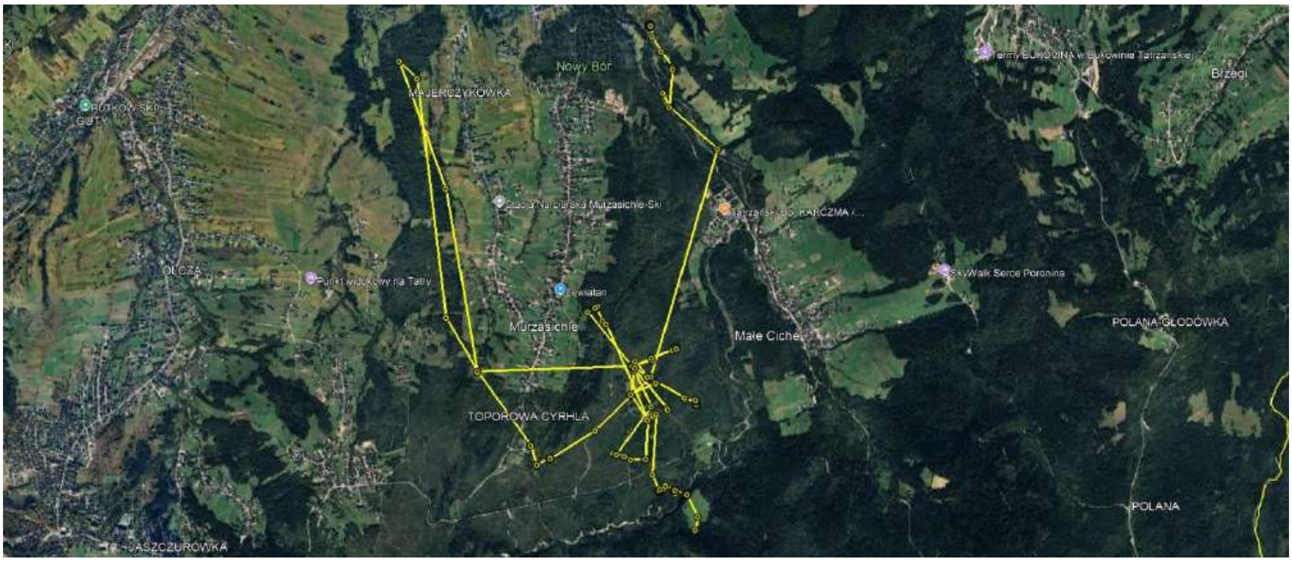

Figure 41. GPS location of female bear P2406 in 2024 (since October, 30 till November, 7).

<u>Male bear “P2501”</u>

Adult male bear “P2501” was captured and collared under LECA project by TNP (PP7) on the 25 of April, 2025. At the time of capture, he weighed 244 kg. In May and June, he remained within the Tatra National Park area, where he likely participated in the mating season. On July 1, he crossed to the Slovak side along the foothills of the Tatras and stopped in the forests of the Slovak Spiš region. There, he lost his collar, which was found at the beginning of August in cooperation with SNC SR (PP8). There was no evidence that he caused any conflict situations.

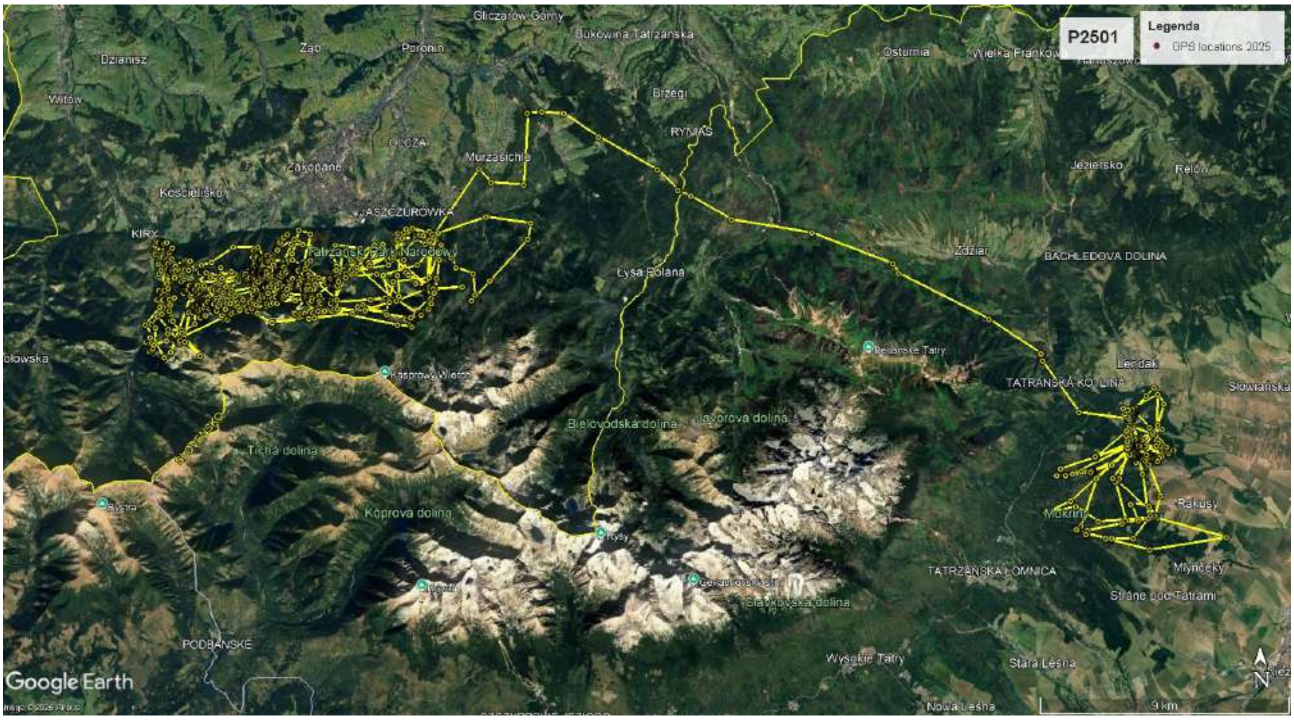

Figure 42. GPS location of male bear P2501 in 2025 (since April, 25 till July, 30).

Male bear "P2502"

Subadult male bear "P2502" was captured and equipped with video collar under LECA project by TNP (PP7) on the 17 of May, 2025. At the time of capture, he weighed 94 kg. In May and June, he caused several conflict situations by appearing near buildings and raiding garbage bins in Zakopane. After the mating season, in which he participated despite his young age (as recorded by the camera collar), he crossed the main Tatra ridge on June 29 and moved into Slovakia, where he stayed among the cornfields in the Liptov region. There, on September 2, he lost his collar, which was later recovered by SNC SR (PP8).

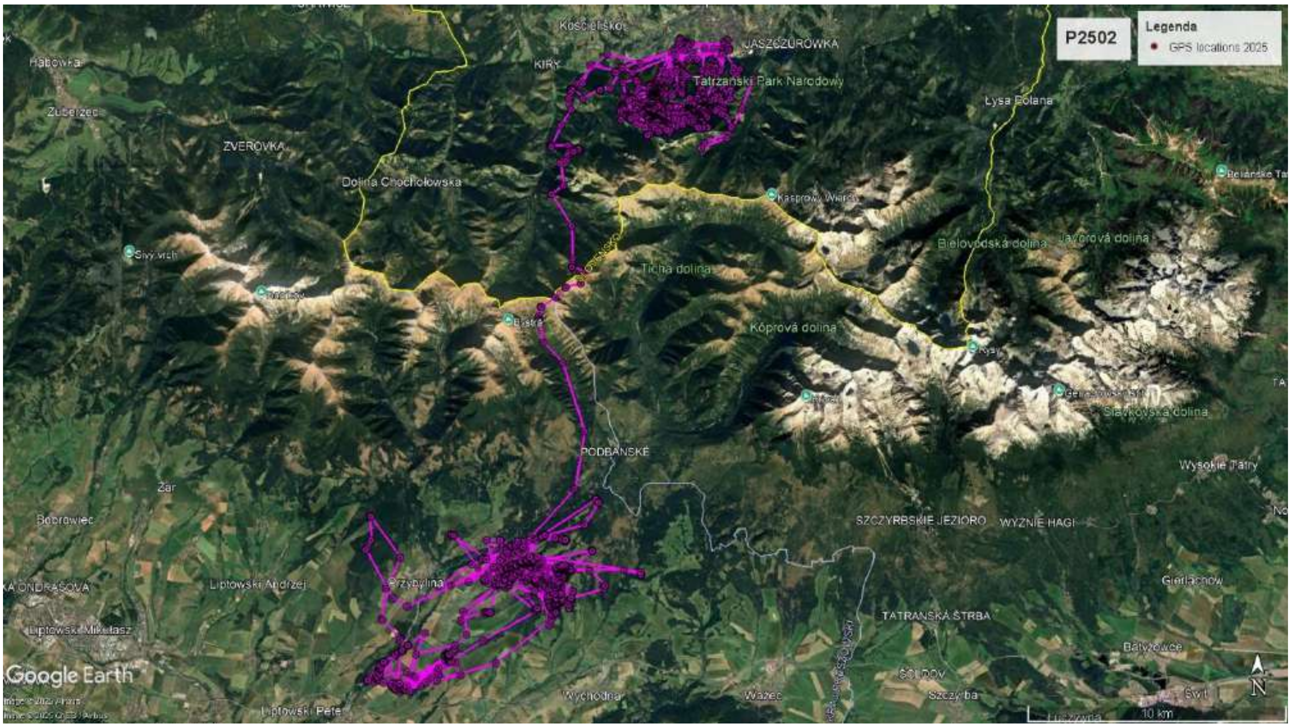

Figure 43: GPS location of male bear P2502 in 2025 (since May, 17 till September, 2).

Male bear "P2503"

Subadult male bear "P2503" was captured and equipped with video collar under LECA project by TNP (PP7) on the 29 of May, 2025. At the time of capture, he weighed 85 kg. After eight days, he lost his collar. During that time, he made a loop through the Slovak Spiš region before returning to the Polish High Tatras. There was no evidence that he caused any conflict situations during that time, although he moved near villages.

Female bear "47019" (Blažka)

The female was captured on 21 March 2025 in the cadastral territory of the village of Liptovská Kokava. When captured, she had three cubs from last year with her. The home range of the female and her three cubs was located in the foothills of the Tatras, where the outskirts of the village of Liptovská Kokava were also part of the range, and in the west the home range was bordered by the Belá River and in the east by the horse farm in Východná, which the female frequently visited due to unsecured waste from cheese production. The female moved independently from the second half of the rut and the last coordinates were from 7 of August, when we believe that the female was poached. (Fig 45).

Female bear "47017" (Marta)

The female was captured on 29 July 2025 in the cadastral area of the village of Liptovská Kokava. When captured, she had three cubs of this year's with her. The home range of the female and her three cubs was located in the foothills of the Tatras, including the outskirts of the village of Priblina, where she frequently stayed because of the main source of food, which was corn in the summer. The home range of the female was bordered to the east by the home range of the female Blažka (Fig 45).

Figure 44. Locations of subadult male bear P2503 between 29.05.2025 and 6.06.2025.

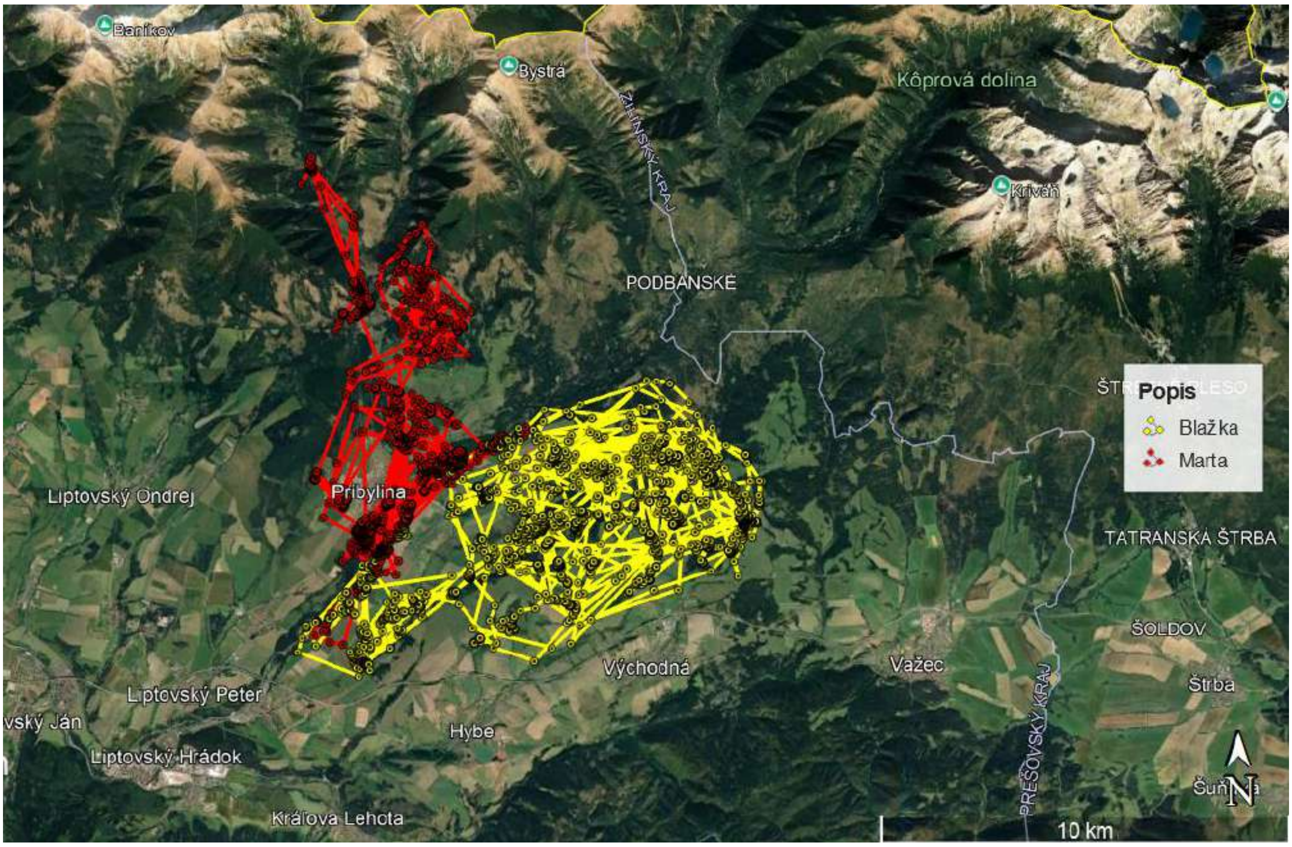

Figure 45. GPS location of female bears Blažka and Marta in 2025.

Results: Spatial activity and home range estimates

Four of the monitored individuals (two females and two males) exhibited substantial cross-border spatial activity, with home ranges extending across national boundaries. Among the nine adult females included in the study, seven were accompanied by cubs. Males showed markedly higher spatial mobility compared to females. Estimates of home range size for adult individuals, calculated using multiple methods (KDE_95, MCP_95, dBBMM_99), ranged on average from 39.7 to 54.1 km² for females and from 88.8 to 247.6 km² for males (Fig. 46, Fig. 47).

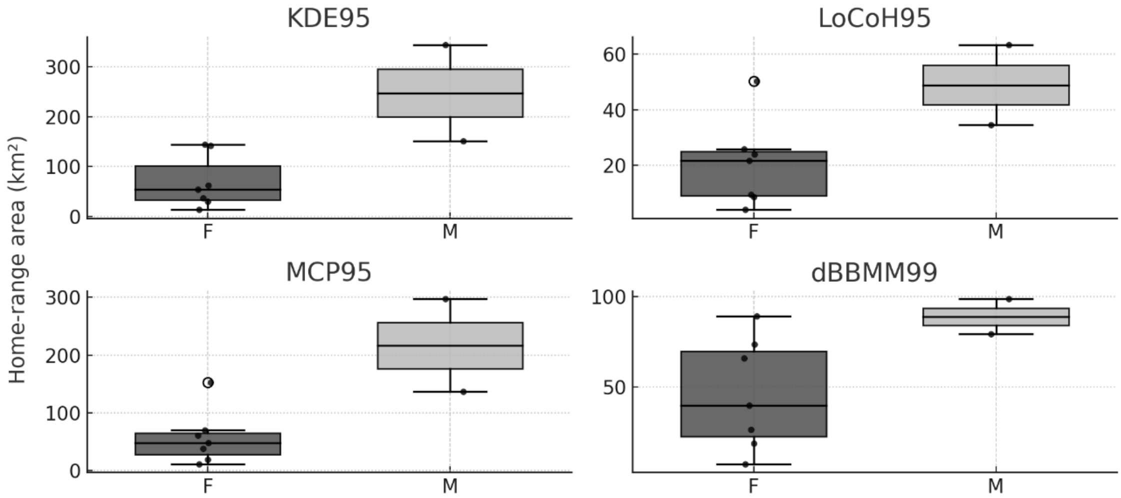

Figure 46. Home range size for females (F) and male (M) bears.

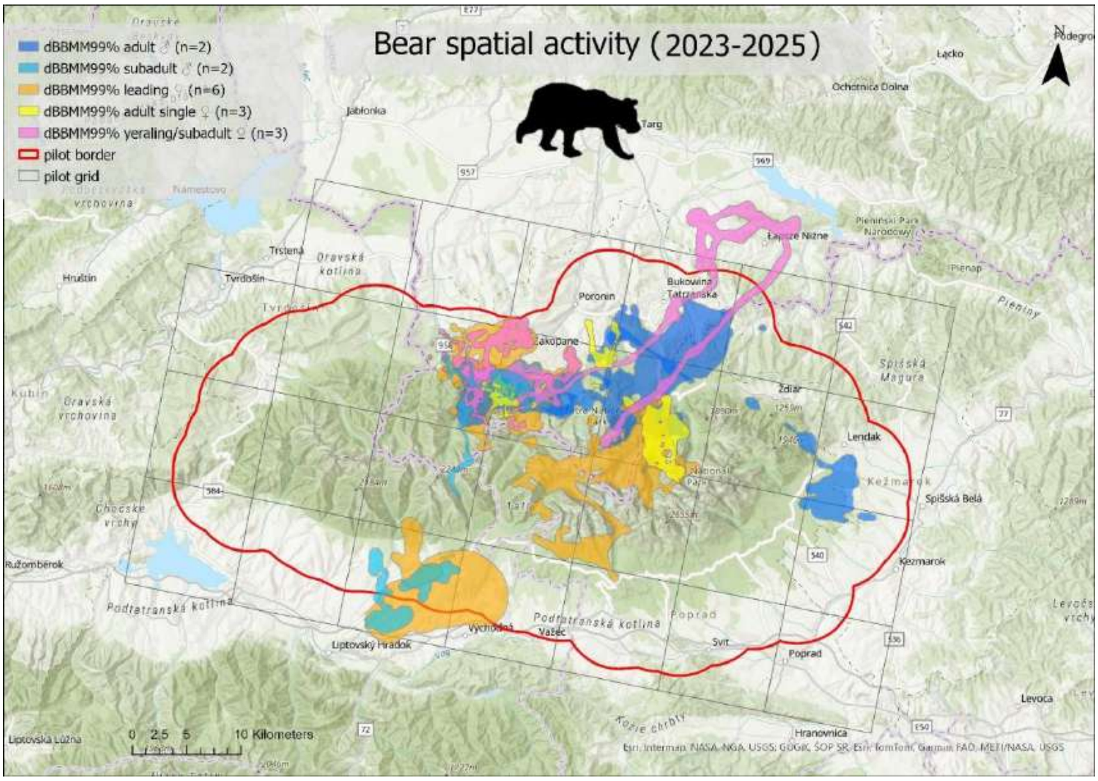

Figure 47.Home ranges of selected bears determined using Dynamic Brownian Bridge Movement Model.

3.2 GPS Telemetry: Habitat selection

Data collection and analyses

We quantified habitat selection of bears using a resource selection framework, comparing used locations derived from GPS telemetry with randomly generated available locations. Specifically, we aimed to (i) quantify relative selection strength among habitat types, (ii) assess sex-specific differences in habitat use, (iii) evaluate the influence of distance to built-up areas, and (iv) investigate inter-individual variability in habitat selection

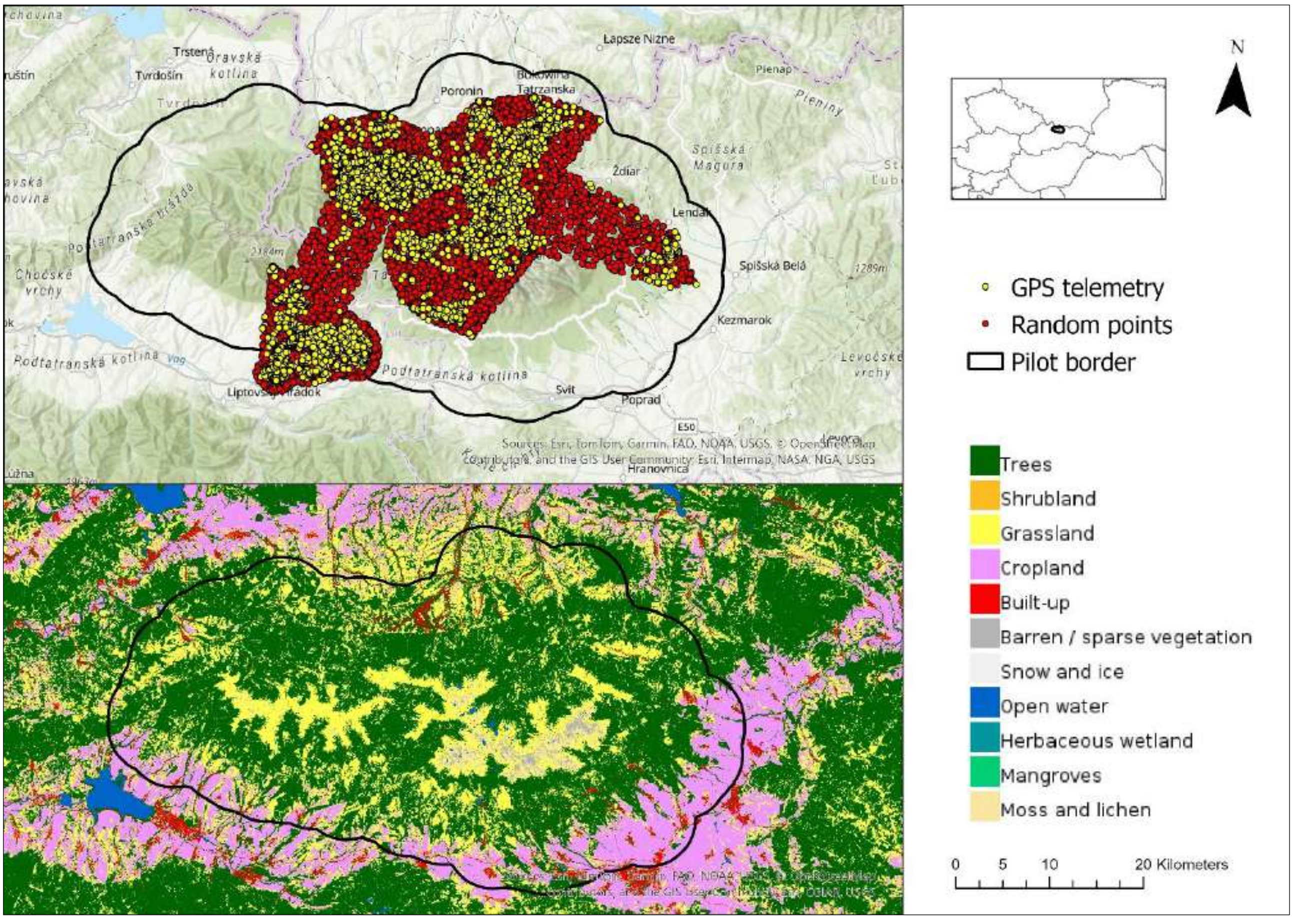

Figure 48. Spatial distribution of telemetry data and habitat composition within the study area. Distribution of GPS telemetry locations (yellow points) and randomly generated available points (red points) used in the resource selection analysis. Land cover classification of the study area based on remote sensing data. Habitat types are shown according to the legend, including forest (trees), shrubland, grassland, cropland, built-up areas, and other land cover categories.

We analysed spatial data from selected 11 individual bears, consisting of GPS-derived used locations and randomly generated available locations representing habitat availability within the accessible area. Habitat types were classified into five categories: forest, open habitats, cropland, built-up areas, and other habitats. Forest was used as the reference category.

To quantify habitat selection, we fitted a generalized linear mixed model (GLMM) with binomial error distribution, where the response variable distinguished used (GPS) and available (random) locations. The model included habitat type, sex, and distance to built-up areas (standardized) as fixed effects, as well as interactions between habitat and sex. Individual identity was included as a random intercept to account for repeated observations.

Model coefficients were exponentiated to obtain Relative Selection Strength (RSS), allowing direct interpretation of habitat preference relative to the reference category. Values greater than one indicate selection, whereas values below one indicate avoidance.

In addition to model-based inference, we quantified habitat availability and use for each individual as proportional composition and visualized these patterns using stacked bar plots.

Results: Sex-specific and individual habitat selection

Habitat selection differed strongly among habitat types. Relative to forest, all other habitat categories exhibited lower selection strength (RSS < 1), indicating that forest represents the dominant habitat. Among alternative habitats, open habitats and cropland showed moderate use, whereas built-up areas and other habitats were strongly avoided (Fig. 52).

Sex-specific differences were pronounced. Females exhibited higher relative use of open habitats and cropland compared to males, while males showed stronger avoidance of these habitats. This pattern was supported by significant interaction terms, particularly for open habitats, indicating that habitat selection is sex-dependent. Predicted probabilities confirmed that forest habitats had the highest probability of use, followed by open habitats and cropland, while built-up and other habitats were used least frequently. These patterns were consistent across sexes, although their magnitude differed (Fig. 50).

Overall, these results demonstrate that population-level patterns obscure pronounced individual-level differences in habitat selection, highlighting the importance of accounting for behavioural heterogeneity in resource selection analyses.

While population-level models indicated general avoidance of anthropogenic habitats, individual-based estimates of relative selection strength (RSS) showed considerable heterogeneity in habitat preferences. Several individuals (e.g. Iga and Dziurka) exhibited clear selection for open habitats (RSS > 1), whereas others (e.g. Blazka, Ciesek, and Jarek) avoided these habitats (RSS < 1; Fig. 51, 52).

Built-up areas were consistently avoided across most individuals, indicating a strong and relatively uniform negative response to human-associated environments. In contrast, cropland and other habitat types showed more variable patterns, with some individuals displaying moderate avoidance and others showing neutral responses. Confidence intervals varied widely among individuals, suggesting differences in sample size or movement variability, with some estimates (e.g. Marta) exhibiting high uncertainty (Fig. 51).

Distance to built-up areas had a significant negative effect on habitat use, with the probability of use decreasing as distance increased. This suggests that bears are not strictly avoiding areas near human infrastructure, but rather tend to occur closer to built-up areas than expected under random availability. Substantial inter-individual variability in habitat selection was observed (Fig. 52).

Some individuals exhibited strong selection for open habitats, whereas others avoided them, indicating considerable behavioural heterogeneity. The large variance associated with the random intercept further supports strong individual differences in habitat use. Comparison of habitat availability and use revealed that forest dominated both availability and use across individuals. However, built-up and other habitats were consistently underrepresented in used locations, whereas open habitats showed variable but generally moderate use (Fig. 51).

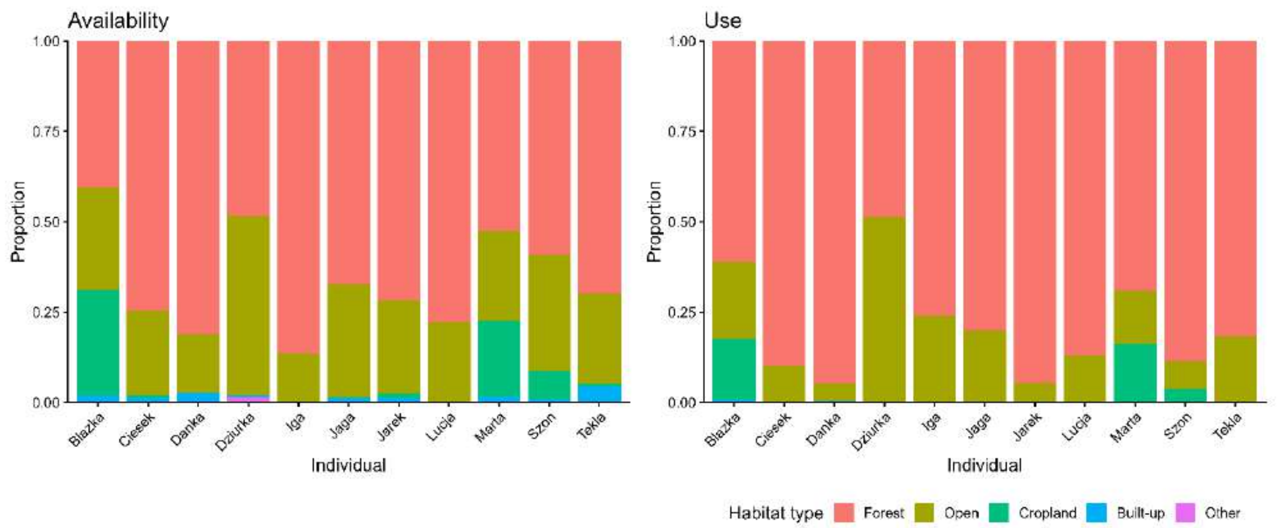

Figure 49. Comparison of habitat availability (random points; left panel) and habitat use (GPS points; right panel) for individual bears. Bars represent proportional habitat composition for each individual, with colours indicating habitat categories. Differences between panels illustrate selection patterns at the individual level.

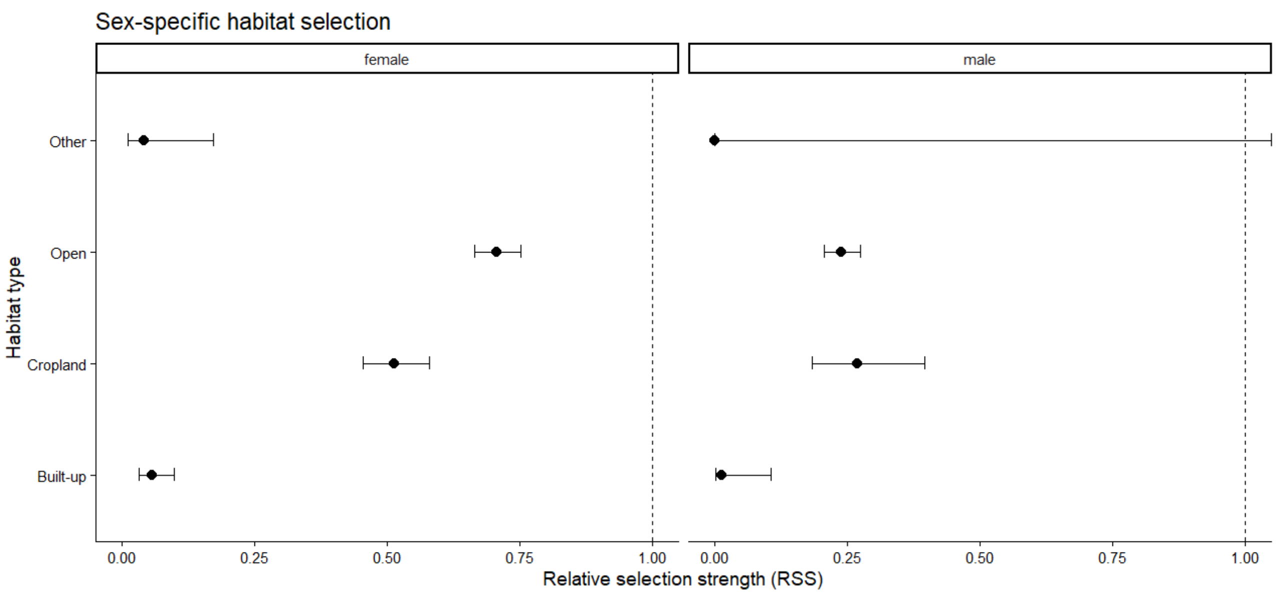

Figure 50. Sex-specific habitat selection expressed as relative selection strength (RSS) for female and male bears. RSS values were calculated from model coefficients including interaction terms between habitat type and sex. Points represent estimated RSS and error bars indicate 95% confidence intervals. The dashed line at RSS = 1 denotes neutral selection relative to forest. Differences between panels reflect sex-specific variation in habitat use.

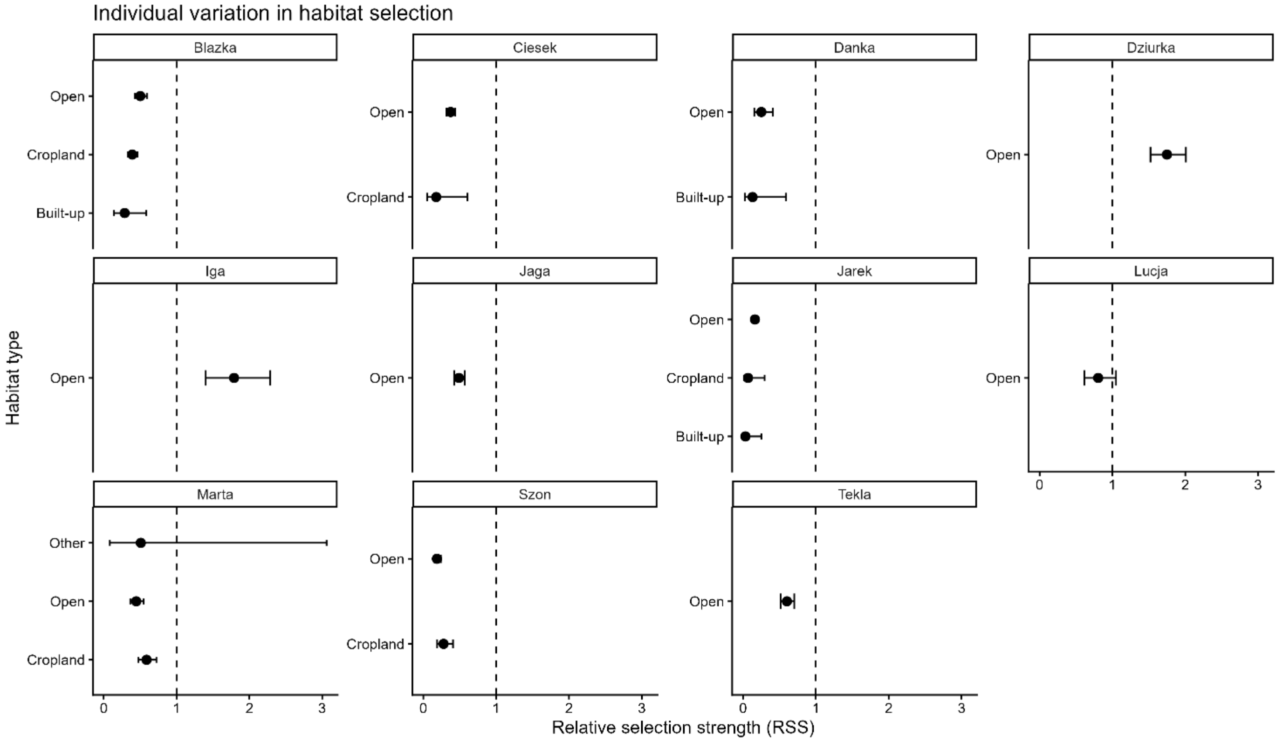

Figure 51. Individual variation in habitat selection expressed as relative selection strength (RSS) for each bear. Points represent RSS estimates from individual-level models and horizontal error bars indicate 95% confidence intervals. The dashed vertical line at RSS=1 indicates neutral selection. Variation among individuals highlights behavioural heterogeneity in habitat use.

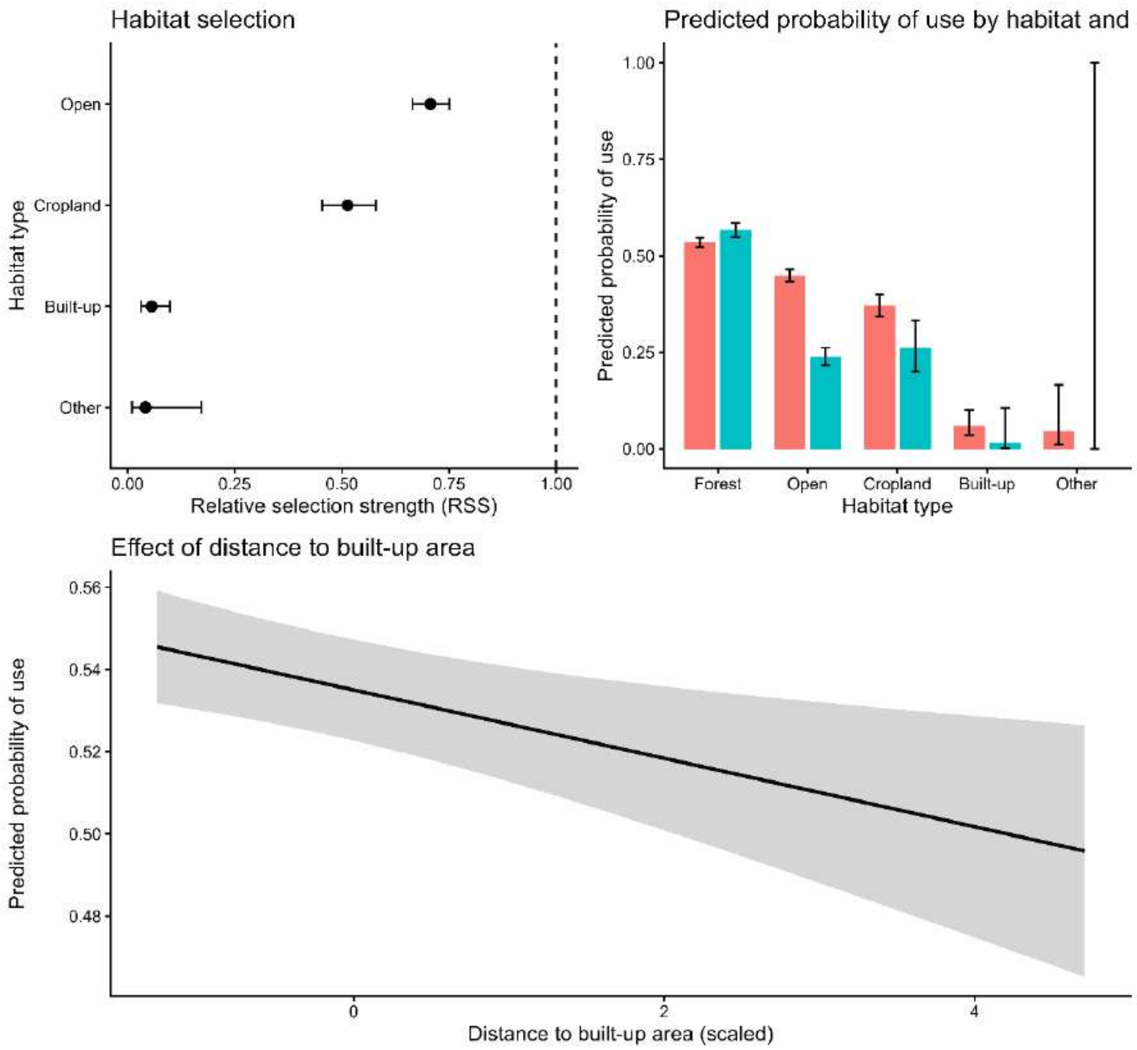

Figure 52. Habitat selection and environmental drivers of space use by bears based on generalized linear mixed models. (A) Habitat selection expressed as relative selection strength (RSS). Points represent exponentiated model coefficients relative to the reference habitat (forest), with horizontal error bars indicating 95% confidence intervals. The dashed vertical line at RSS = 1 denotes neutral selection; values below 1 indicate avoidance. (B) Predicted probability of habitat use across habitat types and sexes. Bars represent model predictions (on the response scale) at mean distance to built-up areas, with error bars showing 95% confidence intervals. Differences between sexes reflect interaction effects between habitat type and sex. (C) Effect of distance to built-up areas on the predicted probability of use. The solid line represents model predictions for the reference habitat and baseline sex, while the shaded area indicates 95% confidence intervals. The negative relationship indicates decreasing probability of use with increasing distance from built-up areas.

3.3 GPS Telemetry: Video collars

For the purposes of the pilot action in the Tatra Mountains, two collars equipped with video cameras were purchased by TNP (PP7). The aim was to capture the bears' reactions to deterrent measures applied against them. Unfortunately, this objective was not achieved for several reasons. One of them was a significant reduction in conflict situations on the Polish side. While in previous years (before the launch of the LECA project) smoothbore weapons and rubber bullets were frequently used to deter bears, during the project's implementation no such incidents occurred. On rare occasions, firecrackers were used for deterrence.

Technical limitations also proved to be a significant obstacle. Currently, there are no collars on the market with video cameras capable of recording at night. The available models must be programmed in advance (without the possibility of remote activation at any chosen moment) in a way that conserves both battery power and the storage capacity of the built-in memory card (both components must be small and lightweight, which limits their capacity). When programming a collar camera, it is impossible to predict the animal's activity or the time it will occur. As a result, most of the footage recorded during the project consists of static images captured while the bears were resting. Often, the screen is simply black, as the camera lens was pressed against the body of a sleeping bear.

Nevertheless, the use of collars with video cameras should be considered a valuable element of the project. They were deployed on five individuals, and more than 2,600 files were collected (approximately 216 GB of video material). Among the recordings were unique scenes documenting rare bear behaviors in their natural habitat (e.g., feeding on a variety of food sources, nursing by cubs, climbing in difficult mountainous terrain, and play, hibernating together). These materials represent not only a valuable resource for the production of educational films but also an important contribution to research.

Video recordings from the collars were analyzed and used to create four educational videos, which were shared on social media and websites:

- BEAR DENNING: https://youtu.be/jbN9gg7JIJs
- BEAR WANDERING: https://youtu.be/-H1vbCqcCpM
- BEAR LOVE: https://youtu.be/mB62hcN1yok
- BEAR FEAST: https://youtu.be/XByAg1KnJy0

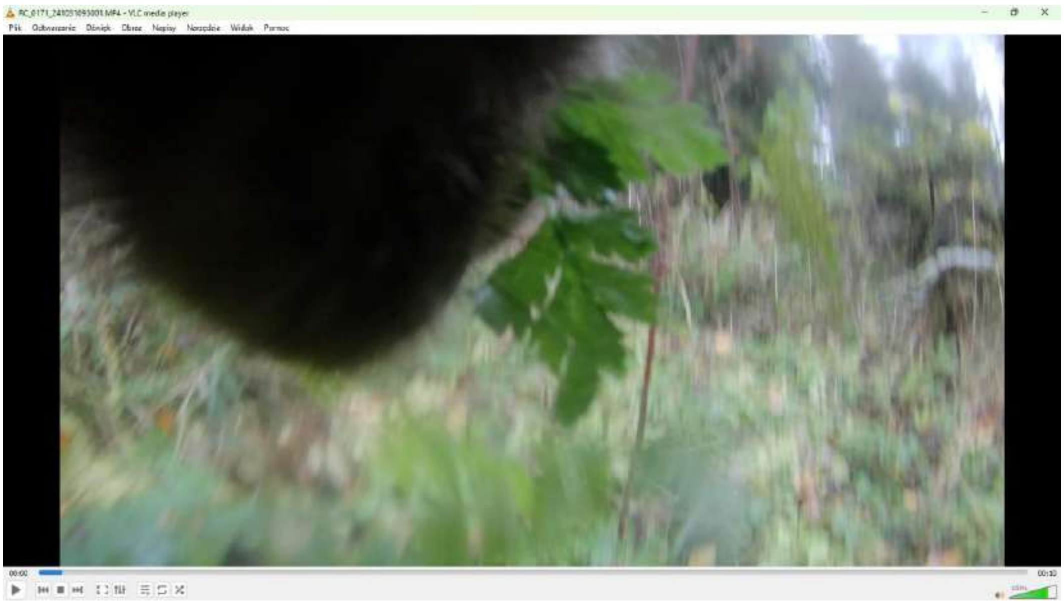

Figure 53. Screenshot from video recorded by female bear P2405 during feeding on plants.

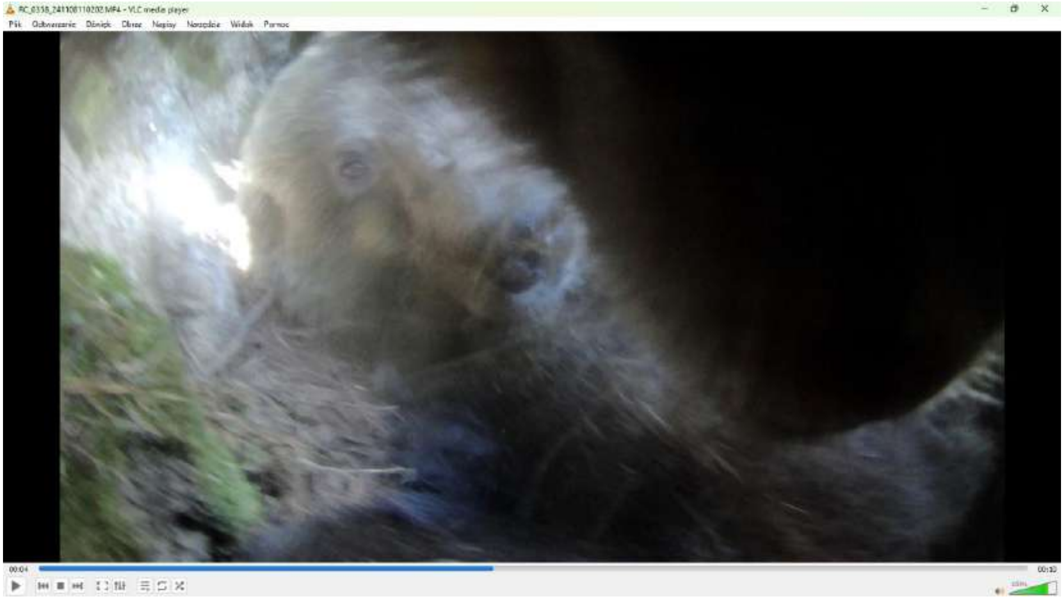

Figure 54. Screenshot from video recorded by female bear P2405 while in den with her mother.

4. Pilot activities: Conflict prevention

4.1 Hormonal analyses

Aversive conditioning and hazing involves the use of negative stimuli to create aversion to specific places, objects, or behaviors (Gillin et al., 1995; Found et al., 2018), often with the aim of preventing conflict situations or reducing existing problems such as bears entering human settlements and exploiting anthropogenic food sources (Majić Skrbinšek et al., 2015). Factors such as the animal's personality, age, health condition, and the specific context of conditioning can influence the outcome and effectiveness (Geoffroy et al., 2020; Majić Skrbinšek et al., 2015; Rauer et al., 2003). Although properly applied aversive conditioning of bears is considered effective (Majić Skrbinšek et al., 2015), it is important to also consider the potential for stress and long-term behavioral changes.

At the time of preparing the project proposal, staff of the Tatra National Park were conducting intensive aversive conditioning actions targeting conflict bears in Zakopane and the surrounding areas. However, these measures had limited effect – despite the repeated use of rubber bullets from smoothbore firearms, the conflict bears continued to return near human settlements. Therefore, a concept was developed within the project to test the actual effectiveness of this measure by examining the physiological response of bears deterred using various preventive methods. This led to an innovative idea to employ hormonal analyses. Measuring cortisol metabolite concentrations in the faeces of conflict individuals subjected to aversive conditioning aimed to assess the short-term stress response to deterrence activities.

However, the aversive conditioning carried out in 2023–2024 was much less intense and did not involve individuals from which faecal samples were collected. Therefore, the study also included samples from collared individuals from 2014–2015, when aversive conditioning was intensively conducted against conflict bears, and the faecal samples collected at that time—archived in the biobank—had not yet been analysed for this purpose.

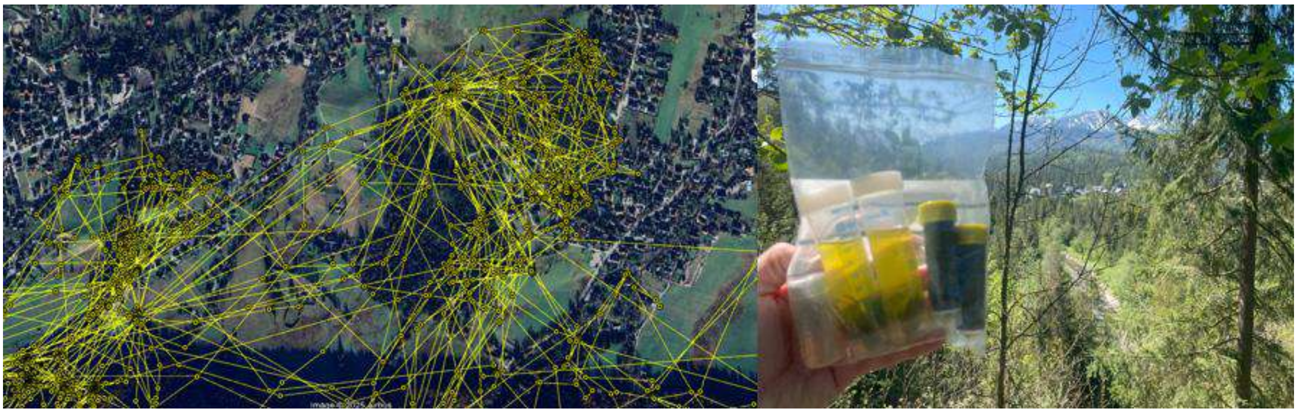

Figure 55: GPS location of conflict bear P1701 (left) and set of samples collected on one of clusters (right).

Of the 83 samples collected in 2023–2024 for cortisol metabolite analysis, 11 belonged to unidentified individuals. A total of 72 samples were selected for analysis, of which three yielded results below the detection threshold. Ultimately, 69 cortisol metabolite concentration readings were obtained. Due to the small number of samples collected from individual bears, the study also included 115 cortisol metabolite measurements from samples collected from collared individuals in 2014–2015.

Table 2. List of individuals collared in 2014–2015, including female P1507 with her cubs, who was regularly deterred between October 13 and November 2, 2015.

Individual ID	No of samples
P1401 (male)	23
P1402 (male)	18
P1403 (male)	14
P1404 (male)	10
P1505 (male)	18
P1506 (female)	5
P1507 (female)	14
Cub the Year of P1507 (CoYR)	13

Results: cortisol metabolites concentrations and individual variability

The following table and figure present a summary of the mean concentrations of cortisol metabolites in faecal samples collected from individuals exhibiting different levels of conflict behavior (assigned to categories 1 and 2) and studied in 2023–2024. Due to the small number of samples, the summary also includes results from analyses of samples collected from cubs accompanying females. Below, we also present a summary of cortisol metabolite concentration results from samples collected before 2023 from collared individuals monitored in 2014–2015.

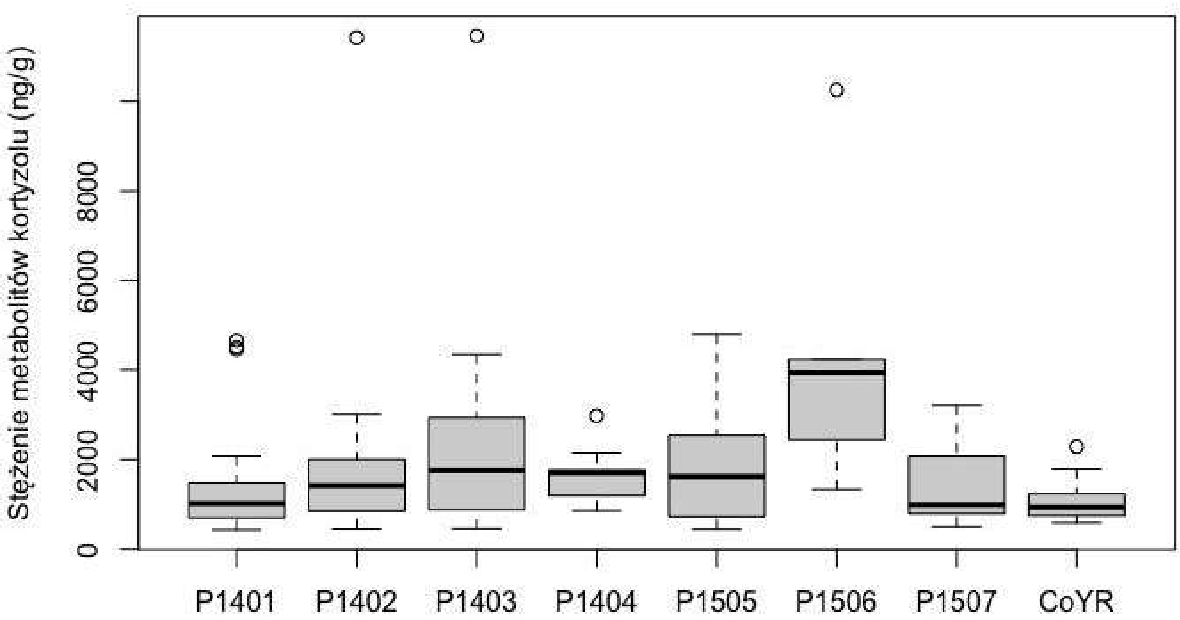

Figure 56. Box plot of cortisol metabolite concentrations (ng/g) in brown bear fecal samples collected in 2014–2016.

Table 3. Mean concentrations and standard deviations of cortisol metabolites (ng/g) in faecal samples collected from identified individuals (N=12) in 2023-2024. Individuals belonging to category 2 of conflict behaviour are marked in light grey; unmarked individuals belong to category 1.

Individual ID	No of samples	Mean concentrations of cortisol metabolites (ng/g)
P2203 (male)	4	45,49 (±30,51)
P2301 (female)	10	316,38 (±367,90)
COY of P2301 (CoYDz)	5	275,21 (±233,31)
P2401 (male)	2	152,32 (±19,73)
P2402 (male)	14	70,22 (±54,43)
P1701 (female)	2	47,03 (±2)
COY of P1507 (CoYDa)	2	79,79 (±14,04)
P1806 (female)	8	119,05 (±109,27)
COY of P1806 (CoYJ)	4	76,92 (±53,57)
P1902 (female)	9	148,76 (±73,28)
Coy of P1902 (CoYT)	4	178,97 (±111,37)
P2106 (female)	5	28,67 (±15,96)

Table 4. Mean concentrations and standard deviations of cortisol metabolites (ng/g) in fecal samples collected from identified individuals (N=8) in 2014-2016.

Individual ID	No of samples	Mean concentrations of cortisol metabolites (ng/g)
P1401 (male)	23	1482,7 (±1279,65)
P1402 (male)	18	2040,1 (±2457,35)
P1403 (male)	14	2545,1 (±2826,2)
P1404 (male)	10	1665,2 (±607,78)
P1505 (male)	18	1908,6 (±1297,34)
P1506 (female)	5	4438,9 (±3454,67)
P1507 (female)	14	1317,6 (±817,51)
Cub the Year of P1507 (CoYR)	13	1143,1 (±518,16)

The figure below illustrates the cortisol metabolite concentrations in fecal samples collected regularly after aversive conditioning sessions of female bear P1507 with her cubs. The concentration values fluctuate in relation to the deterrence activities; however, the mean concentration of stress hormone metabolites in this female and her cubs is generally lower than that observed in most other collared bears from 2014-2015.

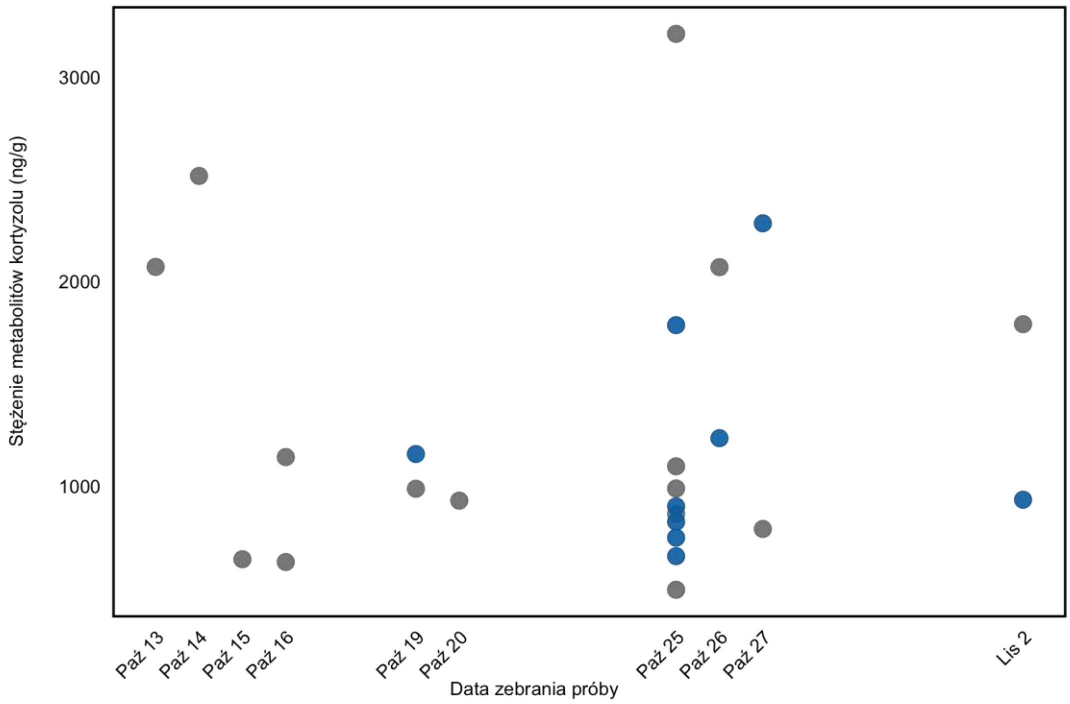

Figure 57. Cortisol metabolite concentrations in samples collected from female P1507 (gray) and her cubs (blue) after days of aversive conditioning.

Due to differences between the laboratories performing the analyses, the results from 2014-2015 and 2014-2015 are not directly comparable, and conclusions can only be drawn separately for individuals studied in 2023–2024 and those studied in 2014–2015. The mean cortisol metabolite concentration in bears from category 2 (those frequently visiting human settlements) was generally lower, which may suggest habituation to the proximity of human settlements and reduced stress, possibly associated with the benefits of easily accessible anthropogenic food sources. This issue requires further investigation, including the use of additional indicators (e.g., cortisol concentrations in the hair of collared individuals).

In summary: although it was not possible to fully achieve the objective formulated in the project proposal—namely, to determine the effectiveness of different deterrent methods based on hormonal analyses—this part of the study yielded a very interesting result. In individuals that more frequently visited human settlements, generally lower mean concentrations of cortisol metabolites in feces were observed. This may indicate behavioral adaptation and overall lower sensitivity to stress stimuli.

4.2 Metabarcoding

Data collection and analyses

The number of interactions between humans and bears has increased as a result of population recovery and expansion into highly anthropized environments, which is also accompanied by the use of anthropogenic food sources. The search for easily accessible food is one of the presumed reasons brown bears approach human settlements. This phenomenon is referred to as food conditioning and is an active learning process. Bears learn that by overcoming their fear of humans, they are rewarded with food (Selva et al., 2012). Consequently, they will actively seek areas near humans or settlements in search of food. However, near human settlements, bears may also include young, naïve individuals, as well as females using them as protection against infanticide committed by adult males (Elfström et al., 2014a, 2014b; Steyaert et al., 2016). In all cases, the presence of bears can increase fear among local residents. When such conflict situations occur repeatedly, these individuals are referred to as “problem/conflict bears” (Berezowska-Cnota et al., 2023).

Studies conducted in Scandinavia (Elfström et al., 2014b) provided evidence against food-seeking as the main explanation for the presence of brown bears near settlements. Instead, the authors suggest that bears susceptible to intraspecific predation use settlements as cover, without being food-conditioned. The results of these studies showed that the diet composition of individual bears did not differ between times spent near settlements and times spent away from them. However, the number and density of human settlements and potential anthropogenic food sources in the Polish Carpathians is much higher than in Scandinavia. Despite the high level of landscape anthropization, Tatra bears still maintain a very diverse and natural diet (García-Rodríguez et al., 2021). Nevertheless, its analysis may help to understand the mechanisms underlying the occurrence of conflict bears near human settlements in the Tatras.

The aim of this study was to analyze the individual diet of conflict bears. The research was conducted using DNA metabarcoding.

Based on the available telemetry data, a two-level scale of conflict behaviors exhibited by the studied bears was established, based on the frequency of visits near buildings and human settlements: occasional visits near buildings (category 1) and frequent visits near buildings (category 2). The table below provides information on the category assigned to each individual.

Figure 58. A wildlife feeding site identified using telemetry data.

Based on the available telemetry data, a two-level scale of conflict behaviors exhibited by the studied bears was established, based on the frequency of visits near buildings and human settlements: occasional visits near buildings (category 1) and frequent visits near buildings (category 2). Table below provides information on the category assigned to each individual.

Table 5. Division of the analyzed bears into categories.

Individual ID	Conflict behavior scale	Total monitoring time using a telemetry collar (months)
P2203 (male)	Category 1	6,8 mo
P2301 (female)		23,9 mo
P2401 (male)		0,3 mo
P2402 (male)		10,4 mo
P1701 (female)	Category 2	57,3 mo
P1806 (female)		28,8 mo
P1902 (female)		38,4 mo
P2106 (female)		24 mo

Results: diet composition of "conflict" and "non-conflict" bears

After sequence analysis and filtering, seven DNA extracts did not yield sequence reads for the target taxonomic groups (plants, vertebrates, and insects). Consequently, 69 out of 76 analyzed samples (90.7%) were used to assess the bears' dietary taxonomic composition. Based on these samples, a total of 127 molecular operational taxonomic units (MOTUs) were detected. Additionally, three samples from unidentified bears were excluded (N=66). The diet of eight individuals was analyzed: five females (four of which had cubs) and three males. Regarding conflict behavior, half of the studied individuals were classified as category 1 (N fecal samples = 32), and the other half as category 2 (N fecal samples = 34).

The number of taxa detected per fecal sample from brown bears (N=66) ranged from one to 16 (Table 2; mean ± standard deviation = 5.6 ± 3.06). A total of 96% and 58% of samples contained more than one and more than five taxa, respectively. Overall, 88 different taxa were identified, corresponding to 56 plant taxa, 24 insect taxa, and six vertebrate taxa, indicating that plants were the most frequently consumed, followed by insects, and then vertebrates. Plants from the subfamily Apioideae and the family Asteraceae were present in over half of the samples. Among taxa identified to the species level, the most frequently consumed were common nettle (*Urtica dioica*; 24% of samples), bilberry (*Vaccinium myrtillus*; 15%), and great wood-rush (*Luzula sylvatica*; 14%). The most frequently consumed insects, present in over 5% of samples, were carpenter ants (*Camponotus herculeanus*) and common wasps (*Vespula vulgaris*). Among vertebrates, taxa present in over 5% of samples included wild boar (Sus scrofa; 10.61%), Caprinae (*Rupicapra rupicapra* or domestic goat; 7.58%), red deer (*Cervus elaphus*; 6.06%), and domestic chicken (*Gallus gallus*; 6.06%).

The average number of taxa identified in samples from category 1 bears (occasionally visiting human settlements) was higher (5.9 taxa) than in category 2 bears (frequently visiting human settlements; 4.9 taxa). Table below presents the total number of taxa detected and the total number of unique taxa identified in samples from each individual. On average, 92.4% of samples from category 1 individuals contained at least one naturally occurring taxon, whereas this percentage dropped to 84.9% in category 2 bears.

Table 6. Summary of brown bear diet analysis results in Tatra National Park. The table provides information on the sex of each studied individual ("+C" indicates that the female had at least one cub during the study period). For each individual, the table also includes the total number of fecal samples collected (and the number of samples with detected taxa/with specific food types identified using DNA metabarcoding techniques), as well as the maximum, minimum, mean, and standard deviation of detected taxa. Rows shaded in gray represent individuals assigned to category 2 on the conflict behavior scale; unshaded individuals belong to category 1.

Individual	No of samples (Total/with detected taxa)	Number of taxa detected per sample: Max	Min	Mean ± SD.
♂ P2203	4 / 4	10	8	9.5 ± 1
♀ P2301+C	14 / 14	12	2	6.86 ± 2.48
♂ P2401	2 / 1	2	2	NA
♂ P2402	14 / 13	9	2	5.15 ± 2.41
♀ P1701+C	4 / 3	8	1	4.33 ± 3.52
♀ P1806+C	15 / 12	8	1	3.83 ± 2.41
♀ P1902+C	15 / 14	16	2	5.36 ± 4.07
♀ P2106	5 / 5	7	4	6 ± 1.58

The difference was more pronounced for the percentage of samples containing at least one anthropogenic taxon, which averaged 19.6% for category 1 bears compared to 48.3% for category 2 bears. While the proportion of samples containing natural food was similar between the two categories, the proportion of samples containing anthropogenic taxa was substantially higher in category 2 bears.

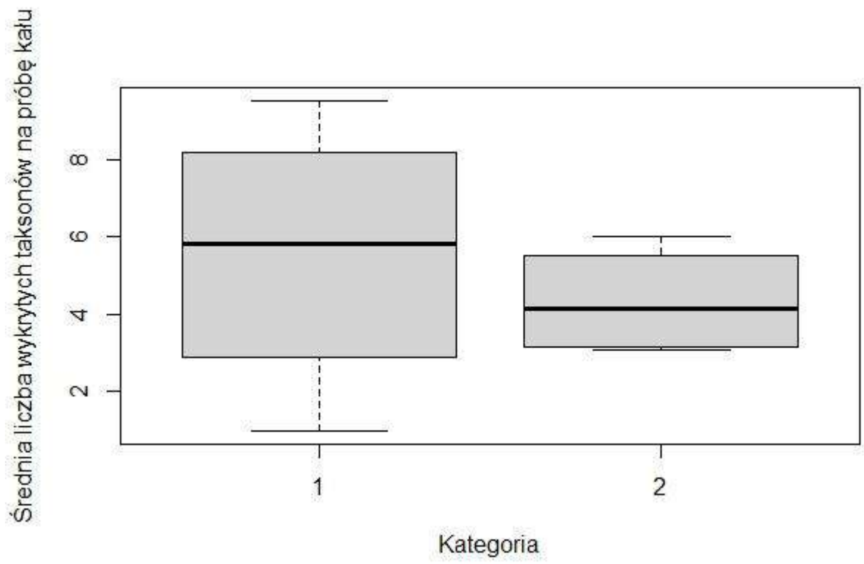

Figure 59. Box plot showing the number of taxa identified in fecal samples from category 1 bears (occasionally visiting human settlements) and category 2 bears (frequently visiting human settlements).

The ratio of natural to anthropogenic taxa (number of distinct taxa of confirmed natural origin divided by the number of unique taxa of confirmed anthropogenic origin detected in all samples from a given bear) ranged from 0 to 0.27 in category 1 bears and from 0.05 to 1.33 in category 2 bears. Similarly, the ratio of detected anthropogenic to natural taxa (total number of taxa of confirmed anthropogenic origin divided by the total number of taxa of confirmed natural origin in all samples from the same individual) was generally higher in category 2 bears (0.07–1) than in category 1 bears (0–0.3).

Table 7. Total number of taxa detected using DNA metabarcoding in fecal samples from brown bears. It should be noted that a single taxon may appear in more than one sample from the same individual. The number of each taxon detected in the feces of each studied individual is also provided in parentheses. The total number of detected and unique taxa is given separately for plants, insects, and vertebrates. "+C" indicates that the female had at least one cub during the study period, while the number in parentheses next to the individual ID represents the number of fecal samples analyzed for that individual. Rows shaded in gray represent individuals assigned to category 2 on the conflict behavior scale; unshaded individuals belong to category 1.

	Number of taxa detections (and number of distinct taxa)			
ID (no of samples)	Total	Plants	Insects	Vertebrates
♂ P2203 (4)	38 (24)	36 (22)	0 (0)	2 (2)
♀ P2301+C (14)	96 (35)	82 (25)	11(7)	3 (3)
♂ P2401 (1)	2 (2)	2 (2)	0 (0)	0 (0)
♂ P2402 (13)	67 (33)	50 (24)	12 (6)	5 (3)
♀ P1701+C (3)	13 (12)	8 (8)	3 (2)	2 (2)
♀ P1806+C (12)	46 (25)	33 (15)	10 (8)	3 (2)
♀ P1902+C (14)	75 (35)	62 (25)	13 (10)	0 (0)
♀ P2106 (5)	32 (20)	24 (16)	0 (0)	8 (4)

Table 8. Percentage of brown bear fecal samples containing taxa (1) belonging to the three main food groups (plants, insects, vertebrates) and (2) of natural and anthropogenic origin. The table also provides information on the sex of each studied individual. The number of fecal samples used to calculate these percentages is given in parentheses. "+C" indicates that the female had at least one cub during the study period. Rows shaded in gray represent individuals assigned to category 2 on the conflict behavior scale; unshaded individuals belong to category 1.

	Percentage of samples containing each taxon (%)					
	Taxa			Natural vs. anthropogenic origin		
ID (no of samples)	Plants	Insects	Vertebrates	Natural	Anthropogenic	Both origins possible
♂ P2203 (4)	100	0	25	100	25	100
♀ P2301+C (14)	100	57.14	14.29	92.86	7.14	100
♂ P2401 (1)	100	0	0	100	0	100
♂ P2402 (13)	100	53.85	30.77	76.92	46.15	84.62
♀ P1701+C (3)	100	66.67	33.33	66.67	66.67	66.67
♀ P1806+C (12)	91.67	41.67	25	100	16.67	66.67
♀ P1902+C (14)	100	35.71	0	92.86	50	92.86
♀ P2106 (5)	100	0	100	80	60	100

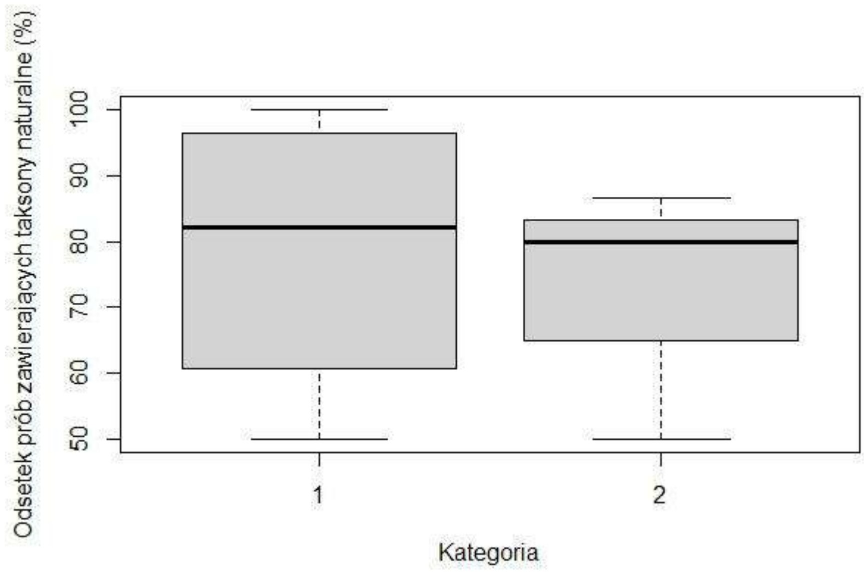

Figure 60. Box plot showing the percentage of fecal samples containing taxa of natural origin in category 1 bears (occasionally visiting human settlements) and category 2 bears (frequently visiting human settlements).

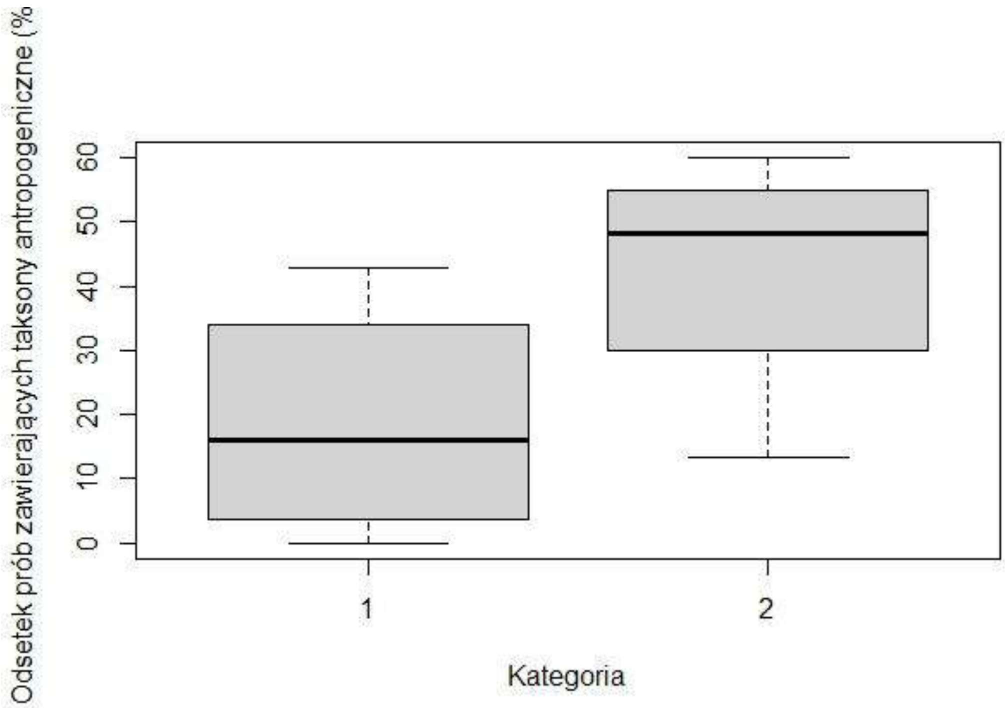

Figure 61. Box plots showing the percentage of samples containing taxa of anthropogenic origin in category 1 bears (occasionally visiting human settlements) and category 2 bears (frequently visiting human settlements).

Table 9. Total number of taxa detected using DNA metabarcoding in fecal samples from brown bears. It should be noted that a single taxon may appear in more than one sample from the same brown bear. The number of each taxon detected in the feces of each monitored bear is also provided in parentheses. The total number of detections and unique taxa is given separately for food of natural and anthropogenic origin, as well as for food items for which the taxonomic resolution does not allow precise determination of origin (for these items, both natural and anthropogenic origins are possible). "+C" indicates that the female had at least one cub during the study period, while the number in parentheses next to each individual ID represents the number of fecal samples analyzed for that individual. Rows shaded in gray represent individuals assigned to category 2 on the conflict behavior scale; unshaded individuals belong to category 1.

	Number of taxa detections (and number of distinct taxa)			
ID (no of samples))	Total	Natural food	Anthropogenic food	Both origins possible
♂ P2203 (4)	38 (24)	16 (11)	3 (3)	19 (10)
♀ P2301+C (14)	96 (35)	57 (23)	1 (1)	38 (11)
♂ P2401 (1)	2 (2)	1 (1)	0 (0)	1 (1)
♂ P2402 (13)	67 (33)	30 (18)	9 (4)	28 (11)
♀ P1701+C (3)	13 (12)	4 (3)	4 (4)	5 (5)
♀ P1806+C (12)	46 (25)	30 (20)	2 (1)	14 (4)
♀ P1902+C (14)	75 (35)	36 (23)	7 (2)	32 (10)
♀ P2106 (5)	32 (20)	8 (6)	6 (4)	18 (10)

Of the 88 identified taxa (Table S1), eight (9%) represented food of anthropogenic origin, such as chickens, *Avena* spp., or the PACMAD clade (which includes C4 plants, e.g., maize, *Zea mays*). Twenty-two taxa (25% of detected taxa) include both wild and domesticated taxa and could potentially also originate from human activities. This mainly occurs when taxa can only be identified at the family or subfamily level. For example, the subfamily Caprinae includes both chamois (*Rupicapra rupicapra*) and domestic goats.

In a previous diet study conducted in Tatra National Park between 2017 and 2019 using the same DNA metabarcoding method on a much larger number of samples from unidentified bears (N=246, García-Rodríguez et al., 2021), the number of taxa potentially originating from human activities (including taxa whose wild counterparts are present in the study area) was 14 (5.7% of samples). However, in the present study, focused on conflict bears, the proportion of taxa of potential anthropogenic origin was much higher (34%, 30 out of 88 detected taxa). Although the smaller sample size and slightly different primers used in this study may limit direct comparability, the large difference observed between the two studies suggests a greater contribution of anthropogenic food in conflict bears. The results of this study are also consistent with this trend. Category 2 bears (frequently visiting human settlements) had a higher percentage of samples containing anthropogenic taxa and a less diverse diet (fewer detected taxa) than category 1 bears. Nevertheless, category 2 bears still maintained a relatively natural diet, similar to that of category 1 individuals.

Bilberry (*Vaccinium myrtillus*) deserves particular attention, as it is a key food for bears in the Tatras, and its presence can be considered an indicator of "naturalness" in the diet. It was detected in 41.9% of samples in the previous study (García-Rodríguez et al., 2021) but only in 15.15% of samples in this study. Although only 56% of samples in this study were collected during the hyperphagic period—when bilberries are available—compared to 82.9% in the previous study, the contribution of bilberry in the diet of conflict bears appears lower.

The only domesticated insect, the honeybee (*Apis mellifera*), detected in 0.41% of samples in García-Rodríguez et al. (2021), was not detected in this study. Among vertebrates of potential anthropogenic origin, the only species detected in the diet of brown bears in both studies was wild boar/domestic pig (*Sus scrofa*), which may include both wild and domestic individuals. This species had a higher contribution in the diet of conflict bears (10.61%) than in the general population diet (2.44%, García-Rodríguez et al., 2021).

Table 10. Frequency of occurrence (percentage of fecal samples containing a given taxon) of foods likely originating from human activities detected in the feces of studied brown bears (n=66). An asterisk (*) indicates taxa whose wild counterparts are also present in the study area, meaning that the origin of these foods in the bears' diet cannot be unambiguously classified as natural or anthropogenic

	Taxa	Taxonomic rank	Frequency of occurrence (%)
PLANTS			
	Apioideae*	Subfamily	65.15
	Asteraceae*	Family	53.03
	Pooideae*	Subfamily	16.67
	Poeae Chloroplast Group 2 (Poeae type)*	Informal grouping	15.15
	PACMAD Clade	Clade	13.64
	Poaceae*	Family	13.64
	Maleae*	Tribe	12.12
	Poeae Chloroplast Group 1 (Aveneae type)*	Informal grouping	12.12
	Solanales	Order	7.58
	Fragariinae*	Subtribe	6.06
	Poeae*	Tribe	6.06
	Campanulids*	Clade	4.55
	Allium spp.*	Genus	3.03
	Brassicaceae*	Family	3.03
	Scandiceae*	Tribe	3.03
	Solanoideae	Subfamily	3.03
	Apioid superclade*	Suoerclade	1.52
	Avena spp.	Genus	1.52
	*Cynosurus cristatus**	Gatunek	1.52
	Dysphania aristata	Gatnek	1.52
	Holcus spp.*	Genus	1.52
	Impatiens spp.*	Genus	1.52
	Indigoferoid/millettioid clade	Clade	1.52
	Mesangiospermae*	Clade	1.52
	Musaceae	Family	1.52
	Trifolium spp.*	Genus	1.52
VERTEBRATES			
	*Sus scrofa**	Species	10.61
	Caprinae*	Subfamily	7.58
	Gallus gallus	Species	6.06
	Bovidae*	Family	1.52

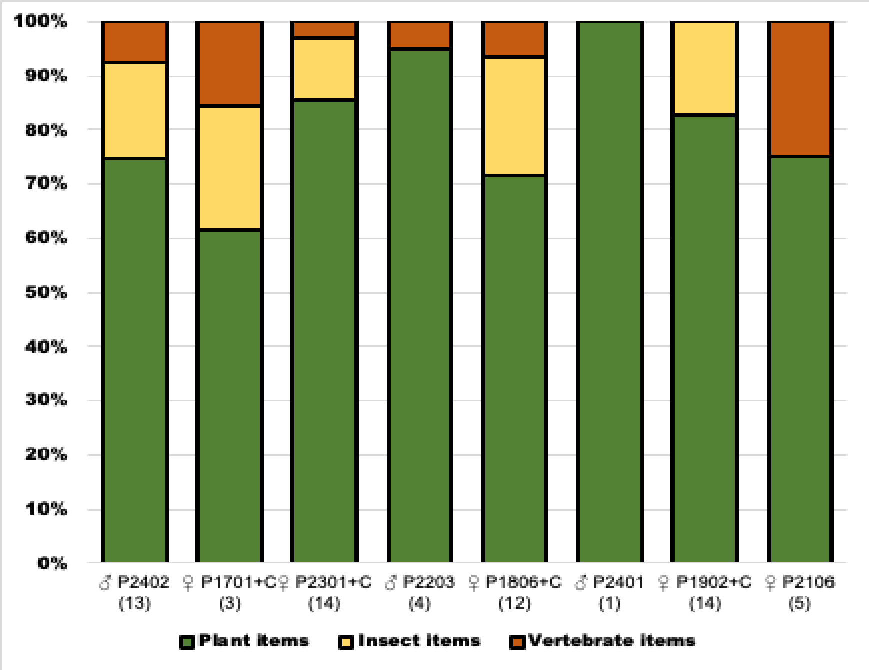

Figure 62. Percentage of plant, insect, and vertebrate foods detected in the feces of the studied bears. Each bar represents an individual, with the sex indicated to the left of the individual ID, and “+C” denoting females that had cubs during the sample collection period. The number in parentheses indicates the number of samples analyzed per individual. Plant foods are shown in green, insects in light yellow, and vertebrates in orange.

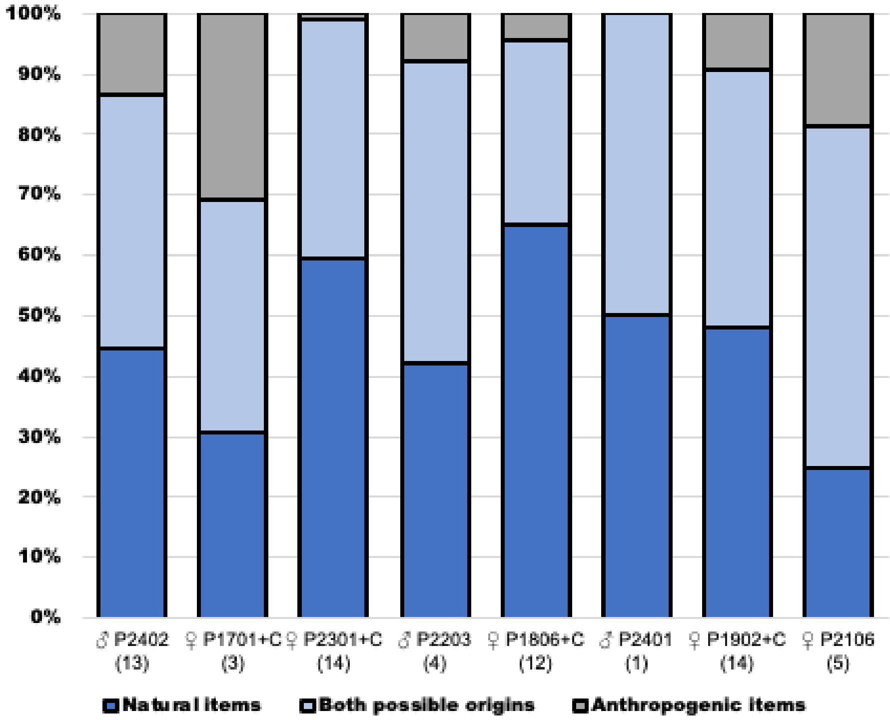

Figure 63. Percentage of foods of natural, anthropogenic, or ambiguous origin (i.e., foods that may come from either natural or anthropogenic sources) detected in the feces of the studied bears. Each bar represents an individual, with the sex indicated to the left of the individual ID, and “+C” denoting females that had cubs during the sample collection period. The number in parentheses indicates the number of samples analyzed per individual. Natural foods are shown in dark blue, foods of ambiguous origin in light blue, and anthropogenic foods in gray.

In summary:

1. The diet of conflict bears, like that of the general population, was primarily based on plant foods; however, the proportion of taxa potentially of anthropogenic origin was higher in conflict bears.

2. Among conflict bears, individuals frequently visiting human settlements had a less diverse diet—reflected in a lower number of detected taxa—and a higher proportion of taxa of anthropogenic origin compared to those visiting settlements only occasionally.

4.3 Monitoring/identification of bear damages

Data on bear-related damage on the Polish side were obtained from the Regional Directorate for Environmental Protection and the Tatra National Park, which are the institutions responsible for administering compensation payments. These data include only verified cases for which financial compensation was officially granted.

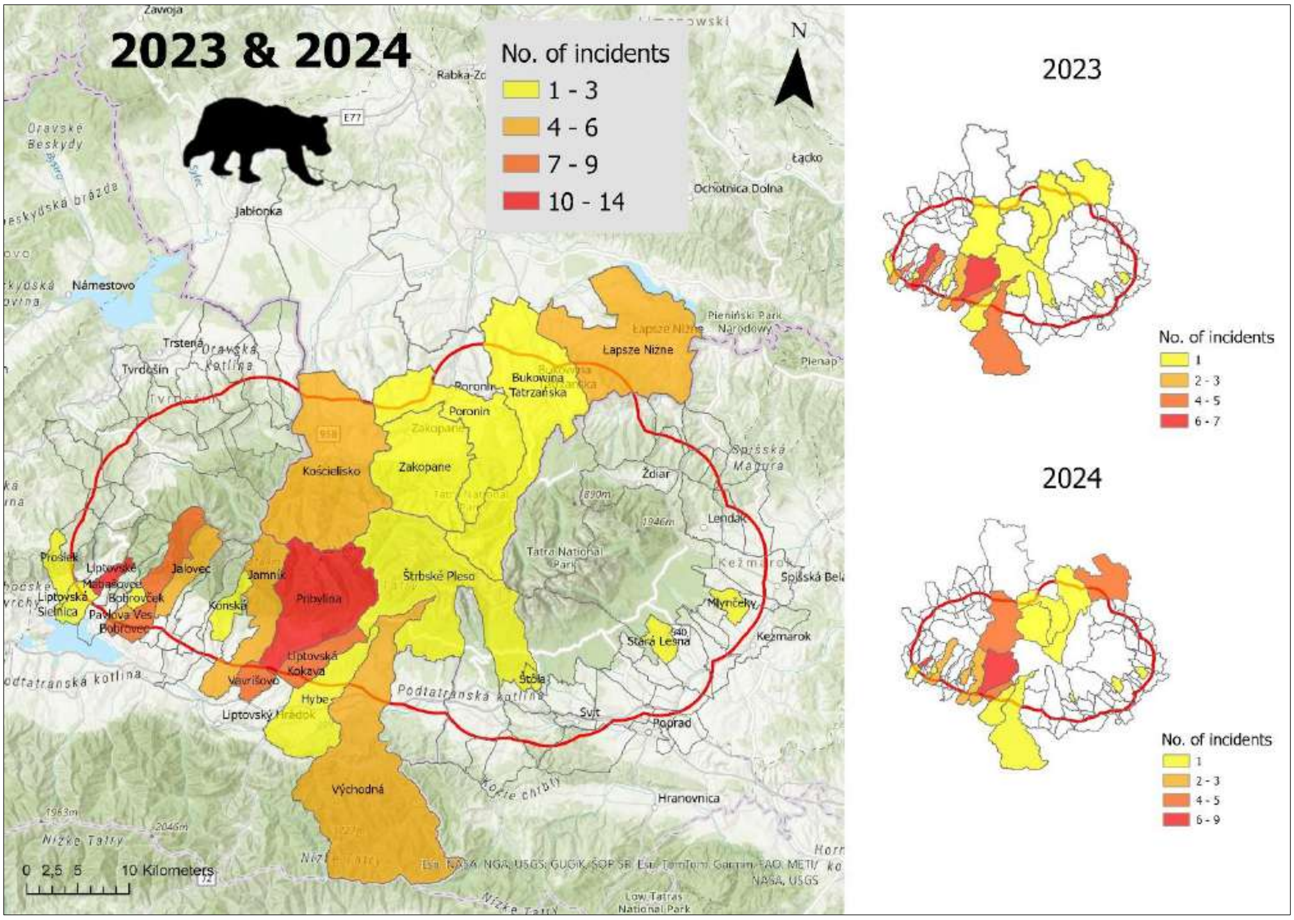

Figure 64. Number of bear-related damages in municipalities of the Tatra pilot area.

On the Slovak side, damage data were compiled from the State Nature Conservancy as well as from an internal database developed within the LECA project. The dataset therefore includes both officially reported damage events that were part of the compensation assessment process and additional cases that were not formally reported but were communicated to staff of the State Nature Conservancy or the bear intervention team and subsequently verified in the field.

In total, at least 111 bear-related damage events were recorded at the level of cadastral units on the Slovak side and administrative districts (gminy) on the Polish side. Of these, approximately 85% occurred within the Slovak part of the pilot area in the Tatras. The highest frequency of damage events during both years was recorded in the cadastral areas of Liptovské Matiašovce and Pribylina.

Most damage incidents involved livestock, agricultural crops, and beehives or beekeeping infrastructure. Less frequent were damages to fruit trees and other property, such as compost bins, fences, or silage bags. The majority of damage events occurred at sites where livestock or beehives were either unsecured or insufficiently protected. A similar pattern was observed for agricultural crops, particularly maize.

According to available data from both the Slovak and Polish sides, total compensation payments for bear-related damage reached approximately 72 000 EUR over the two-year period. The largest proportion of compensation was paid for damages to livestock and maize.

4.4 Identification of attractants and application of preventive measures

During the project, a variety of attractant types were identified within the pilot area, with a clear dominance of anthropogenic attractants. These primarily consisted of food resources such as unsecured agricultural crops, particularly maize, improperly secured waste containers, and beehives. Additional attractants included bait remains near hunting facilities, fruit orchards, and agricultural by-products associated with cheese production, specifically unsecured slurry pits and whey effluent discharge (Fig. 65, 66). TNP (PP7) conducted several consultations and meetings with cattle farmers and tourism operators who could potentially be involved in testing the preventive measures. In April 2024 the leaseholder of a bar destroyed by bears in the Strążyska Valley was equipped with an electric fence (Fig. 67).

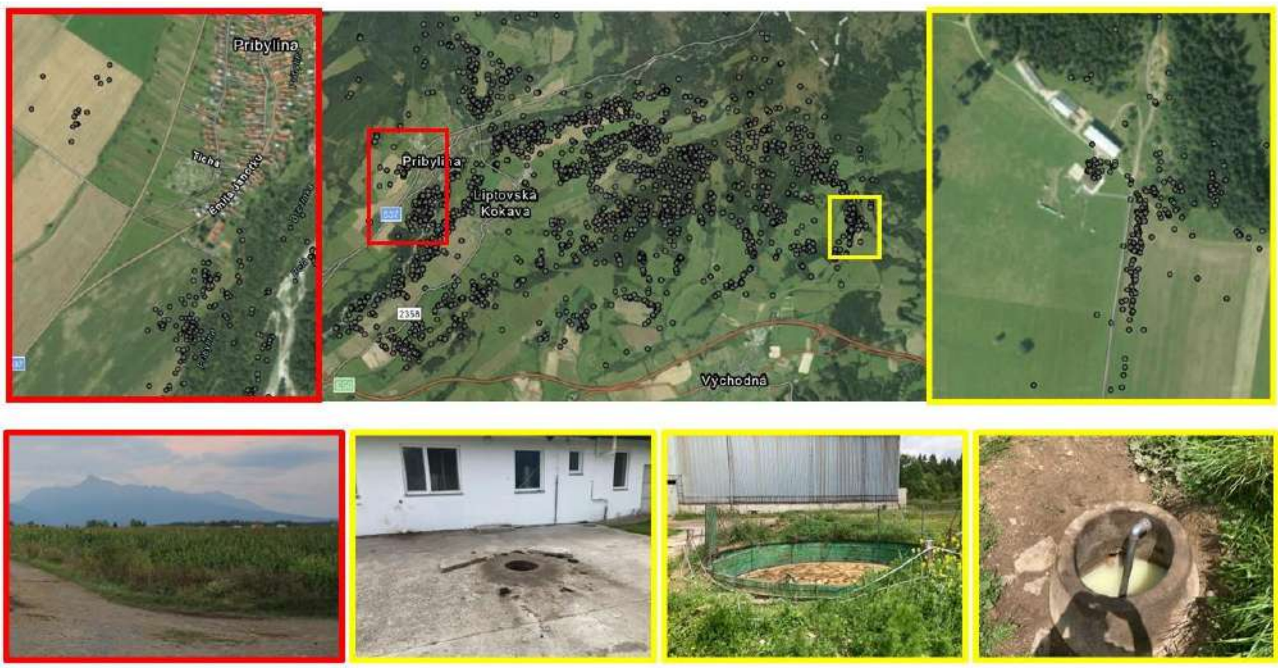

Figure 64. Human provided attractants identified in Liptov area.

Figure 65. Human provided attractants identified in Zakopane area (bottom in the middle: natural beach forest, natural food resources at the border of Zakopane).

Figure 67. Bar in the Strążyska Valley (T{N PL) equipped with an electric fence.

The use of deterrents turned out to be possible in the case of the bear P2301 who regularly approached one of the bars in TNP. SNC SR (PP8) successfully used several preventive measures several consultations and meetings with relevant stakeholders, especially livestock breeders. We used electric fences for direct protection of property to prevent unwanted entry onto the land, and we used acoustic repellents with variable sound frequencies. An integral part of these measures were MMS camera traps, which provided us with more detailed information about what was happening at a given location. Based on the MMS, we received information about the presence of the species at the site (often family gardens) and not only about its presence but also its abundance (a female bear with cubs). We had such a case in the village of Štôla, where a female bear with two cubs visited the garden of a family home. After installing an electric fence and acoustic repellents, the unwanted visits ceased. This location was also monitored by camera traps, which sent real-time images to the brown bear intervention team, which was prepared to intervene in an aversive manner (with light, noise from a service vehicle, or firearms with non-lethal ammunition - cartridges (gas), rubber bullets).

Figure 66. Electric fencing in the Liptov region.

Another positive example of preventive measures was when ŠOP SR lent an electric fence free of charge to a novice cattle farmer in the village of Liptovská Kokava in the Liptov region, which is locally known for its high incidence of brown bears in its cadastral area. After finding signs of bears (footprints, droppings) in the vicinity of the farm, he contacted us with a request to solve this problem. After analyzing the situation, ŠOP SR decided to lend an electric fence, which proved to be an effective measure, as there were no incidents of damage throughout the year, despite the fact that signs of presence (droppings, tracks) indicated the permanent presence of brown bears in the vicinity of the farm.

Another positive example of preventive measures was when ŠOP SR lent an electric fence free of charge to a novice cattle farmer in the village of Liptovská Kokava in the Liptov region, which is locally known for its high incidence of brown bears in its cadastral area. After finding signs of bears (footprints, droppings) in the vicinity of the farm, he contacted us with a request to solve this problem. After analyzing the situation, ŠOP SR decided to lend an electric fence, which proved to be an effective measure, as there were no incidents of damage throughout the year, despite the fact that signs of presence (droppings, tracks) indicated the permanent presence of brown bears in the vicinity of the farm.

SNC SR also installed bear-proof containers in two foothill villages where brown bears are present (Liptovská Kokava, Pribylina).

Within the Slovak part of the pilot area, several preventive measures (listed below) were implemented, and their effectiveness was monitored using camera traps.

- Acoustic deterrents – These were installed at locations where conflict individuals accessed undesirable areas, such as gardens, orchards, and apiaries.
- Bear-proof waste containers – Secured waste containers were installed to prevent access by brown bears.
- Electric fencing – This measure was applied in locations where acoustic deterrents proved insufficient, not due to their effectiveness, but due to multiple access points used by one or more bears in combination with a limited number of deterrent devices.
- Active deterrence – In cases where animals showed low responsiveness to the above preventive measures, active deterrence was implemented. Individuals were deterred using various methods, including vehicle headlights, flares, gas-powered expansion guns, shotguns with rubber bullets, noise, and shouting.

Figure 67. Bear-proof waste containers in Liptovská Kokava in the Liptov region.

Based on the experience gained from the LECA project, the State Nature Conservancy of the Slovak Republic concludes that there is no single universal preventive measure effective against brown bears. Each situation must be addressed individually, using a comprehensive and carefully considered approach.

The most effective strategy has proven to be the combination of multiple preventive measures. For example, electric fencing can prevent bears from entering a property, acoustic deterrents can reduce the likelihood of approaching the area, and MMS camera traps provide real-time information on bear activity, enabling timely and targeted intervention by response teams.

The removal of attractants (i.e., resources that attract bears) should be considered a standard measure; however, this is not always feasible due to practical or economic constraints. For instance, bears frequently visit gardens with ripening fruit, where early harvesting may not be practical or economically justified, and beekeepers are often unwilling or unable to relocate their hives.

Figure 68. Preventive measures in the Liptov region.

Nevertheless, where possible, reducing or eliminating attractants can significantly decrease conflict situations. This may include measures such as relocating or removing compost heaps, eliminating bait, and raising awareness among local residents to modify inappropriate practices (e.g., improper disposal of organic or animal waste).

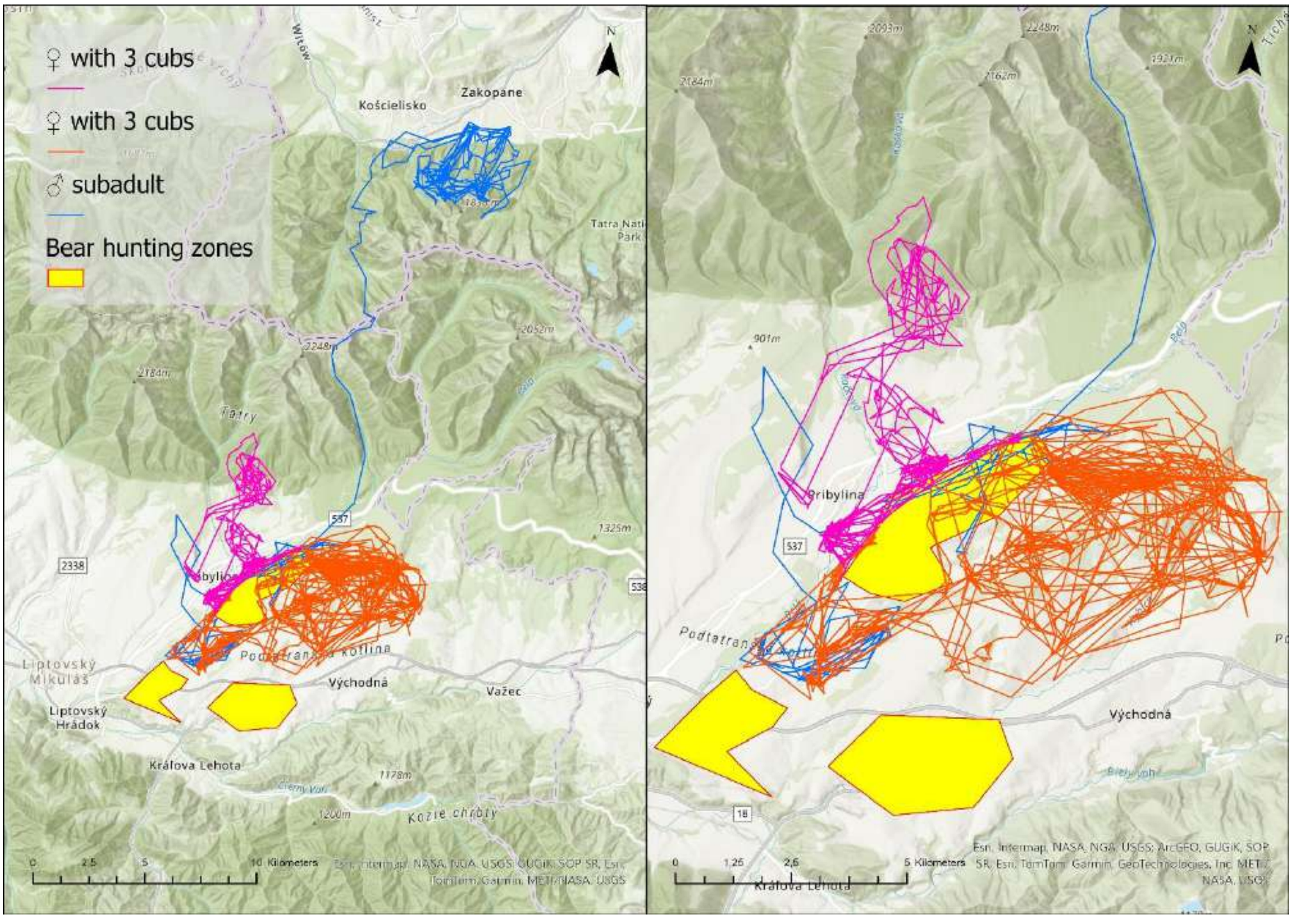

Figure 71. Bear movement around and in bear hunting zones in the Liptov region.

The successful implementation of preventive measures requires a case-by-case, responsible approach, including the selection of the most appropriate combination of measures in close cooperation with the brown bear intervention teams. Currently, three intervention teams have been established across national parks in Slovakia, along with an additional team within the State Nature Conservancy of the Slovak Republic.

These observations indicate that not all individuals occurring in close proximity to human-modified environments can be classified as conflict individuals. Instead, their spatial behaviour and foraging strategies appear to reflect adaptive responses to locally available resources (e.g. rather than inherently problematic behaviour.

Three monitored individuals on the Slovak side of the study area also moved within zones where culling is permitted under current management regulations. These included two adult females with cubs (Marta and Blažka) and one subadult male that dispersed from the Polish territory during the summer. Despite their presence in these management-sensitive areas, none of these individuals exhibited overtly conflict-prone behaviour.

The females with cubs utilized easily accessible, unsecured food resources such as maize fields and whey effluent ponds associated with agricultural production. However, they did not cause damage to beehives nor did they enter urban areas to exploit waste or other anthropogenic food sources.

5. Pilot activities: Poaching prevention

5.1 Seminars for police investigators

On January 16–17, 2025, a cross-border seminar for law enforcement authorities was held at the REWITA Center in Kościelisko, organized as part of the project **“Supporting the Coexistence and Conservation of Carpathian Large Carnivores (LECA)”**. The event brought together representatives of law enforcement agencies, nature conservation institutions, non-governmental organizations, and experts from Poland, Slovakia, and the Czech Republic. The aim of the meeting was to strengthen international cooperation in combating poaching and other environmental crimes, as well as to enhance the protection of large carnivores such as wolves, lynxes, and brown bears.

Figure 69. Seminar for police investigators in Kościelisko (2025.01.16)

During the two-day seminar, participants had the opportunity to hear presentations from experts on the challenges related to the protection of endangered species, with a particular focus on the issue of poaching. The program included an overview of the LECA project, national reports on illegal activities targeting protected species, and analyses of large carnivore population dynamics in the Carpathian region. Special attention was given to the legal aspects of environmental protection and to opportunities for improving legal systems in this field.

With the participation of representatives from the police and prosecution services, the seminar also covered practical methods for prosecuting environmental crimes. Speakers from Slovakia, Poland, and the Czech Republic presented specific cases of actions taken against crimes targeting protected animal species, as well as tools supporting the detection and prevention of such offenses, including genetic and telemetry monitoring of large carnivores.

The seminar concluded with a final discussion, during which participants exchanged experiences and formulated recommendations for future actions. The need for better information exchange between countries, the organization of joint training sessions, and the development of tools supporting law enforcement authorities was emphasized. **An important conclusion highlighted during the discussion was the necessity of reporting all suspected cases of environmental crimes to law enforcement authorities**. It was summarized that effective protection of large carnivores requires both intensive cross-border cooperation and active involvement of local communities.

6. Conclusion

The Tatra pilot action has provided valuable insights into the monitoring, conflict prevention, and poaching prevention of brown bears in a transboundary high-mountain region of the Western Carpathians. By combining advanced ecological research, practical field measures, and international cooperation, the project demonstrated how coexistence with large carnivores can be effectively managed in a densely visited and human-influenced alpine landscape.

A harmonised monitoring framework integrating GPS telemetry, genetic and hormonal analyses, and field verification substantially improved the understanding of bear ecology, space use, and behaviour in the Tatra region. In total, several bears were equipped with GPS collars, providing high-resolution data on seasonal movements, denning sites, and habitat use in relation to human infrastructure. Telemetry revealed strong spatial and temporal variation in bear activity, with clear differences between natural and human-modified areas. The innovative use of video collars provided unique visual data on bear behaviour and feeding ecology, revealing detailed information on natural foraging and interactions with anthropogenic food sources. Non-invasive genetic sampling and camera trapping enabled the identification of individuals and contributed to the development of harmonised SCALP and occurrence maps, forming a solid basis for long-term monitoring and trend analysis.

Conflict prevention measures addressed the key sources of human–bear interactions, particularly access to waste and attractants around settlements and tourist areas. Dietary analysis using DNA metabarcoding confirmed that bears repeatedly visiting human areas consumed a significantly higher proportion of anthropogenic food compared to non-conflict individuals. Hormonal studies further revealed elevated stress levels associated with increased human activity and management interventions. Several preventive tools were tested and implemented in cooperation with local communities and park authorities, including bear-proof waste containers, electric fencing for beehives and livestock, and awareness campaigns targeting tourists and local residents. These interventions proved effective in reducing property damage and bear visits to human settlements. Public education activities, supported by visual materials from telemetry and video collars, significantly improved awareness of proper waste management and safe behaviour in bear habitats.

Poaching prevention was addressed through a dedicated international seminar involving law enforcement officers, customs representatives, and conservation experts from Slovakia, Poland, and the Czech Republic. The event enhanced cooperation across borders, improved understanding of wildlife crime in the Carpathians, and promoted the use of forensic genetics and telemetry data as critical tools in wildlife law enforcement. The seminar also emphasised the importance of coordinated reporting systems and data sharing between institutions to detect and respond to illegal activities effectively.

The Tatra pilot action demonstrated that brown bear management in Central Europe must be transboundary, science-based, and adaptive. Combining telemetry, genetic, and behavioural data provides a powerful foundation for understanding population dynamics and guiding evidence-based management. Preventive measures, if implemented consistently and supported by local communities, can significantly reduce conflict levels and foster long-term coexistence. Strengthening cooperation between environmental institutions and law enforcement agencies has proven essential for addressing both conservation and crime-related challenges.

Overall, the pilot action delivered practical solutions, strengthened institutional partnerships, and generated comprehensive knowledge applicable to large carnivore management across the Carpathians. The experience gained in the Tatras highlights the need for continued monitoring, regular assessment of mitigation tools, and sustained cross-border cooperation to ensure the effective conservation of brown bears and the harmonious coexistence of people and wildlife in this emblematic mountain landscape.

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