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Action plans for the monitoring of Brown bear in Trentino

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ABSTRACT

The extinction of an animal species results in the loss of an important component of the ecosystem and this is why a reintroduction program, carried out in the principle of the autochthony of the species, can bring the environment back to a greater naturalness. It should also be considered that the extinction of an animal species leads to an undoubted cultural impoverishment, which in other words results in the disappearance of a piece of human history. Trentino risked losing the Brown bear from its mountains, as a result of decades of severe persecution by man. Only after the realization of the 'Life Ursus' reintroduction project, the population was able to recover, counting a hundred individuals in the region at the end of 2020. The success of the re-establishment of the bear is also due to careful monitoring carried out by the Forestry and Wildlife Department of the Autonomous Province of Trento (PAT).

The content of this thesis aims to explain the action plans adopted by the province of Trento for the protection and monitoring of the Brown bears, reporting all the methodologies used, trying to highlight their peculiarities and transmit their importance, also analyzing and interpreting the data that each technique provides.

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INTRODUCTION

Following the massive persecution carried out by man during the nineteenth and early twentieth centuries which had eliminated most of the large predators from all over the Alps, the Trentino's bear population in the late 1990s was in a critical situation. Because of this between 1999 and 2002 in order to not lose the presence of this animal, a reintroduction project ('Life Ursus') was implemented, which saw the placement of some Slovenian bears in the territory. During the following years the monitoring of the population proved to be of fundamental importance both to control its growth and to study and deepen the knowledge on this species for a long time unjustly feared. Today Trentino can boast of a stable population of Brown bears made up of about a hundred individuals, mainly concentrated in the western part of the region. As a consequence, the population growth also leaded to an increase in human-bear interactions.

In recent years damage to economic activities, predation on farm animals, raids in apple orchards, road accidents have aroused more frequently concern and raised the question of whether the bear was still an animal to protect in the increasingly urbanized Alpine environment. However, the Brown bear represents a species that gives balance to ecosystem processes, which contributes to the stability of the ungulate populations, which represents an index of high environmental quality. The monitoring of this species therefore becomes a very important tool for their conservation and protection and to improve the relationship, which has always been considerably conflicting, with man. Moreover, the Brown bear is protected by the Framework Law of February 11th, 1992, n° 157 which includes it among the particularly protected species, by the Berne Convention which includes this carnivore among the strictly protected species and by the Community Directive 92/43/EEC which includes it among the species of community interest that require rigorous protection. The important task of monitoring the species has been carried out continuously for over 30 years by the Autonomous Province of Trento (PAT): over time, the traditional techniques of field survey have been joined by radio telemetry, automatic video control from remote stations, camera trapping and finally, in 2002 also genetic monitoring.

The goal of this thesis is to describe and evaluate all types of monitoring used in Trentino. The study is divided into seven chapters: the first chapter provides an introduction to the biology and ecology of the Brown bear. The second one is focused on the role and importance of monitoring and legislation. The remaining chapters will be dedicated to the description and deepening of each single method ordered as follow: genetic monitoring, the use of camera-traps, radio tracking monitoring, rub trees monitoring and finally some monitoring of minor importance will be considered.

1. BIOLOGY AND ECOLOGY OF THE BROWN BEAR

1.1. Taxonomy

The bear is a mammal belonging to the order Carnivora (Bowdich, 1821) and to the family Ursidae (Fisher, 1817). In the world, the Ursidae family includes 5 genera to which 8 species belong: the Brown bear (Ursus arctos - Linnaeus, 1758), the American black bear (Ursus americanus - Pallas, 1780), the polar bear (Ursus maritimus Phipps, 1774), the Asian black bear (Ursus thibetanus - G. Cuvier, 1823), the sloth bear (Melursus ursinus - Shaw, 1791), the sun bear (Helarctos malayanus - Raffles, 1822), the spectacled bear (Tremarctos ornatus - F. Cuvier, 1825) and the giant panda (Ailuripoda melanoleuca - David, 1869).

Figure 1.1 – Representation of the 8 bear species in the world
(Encyclopedia Britannica, 2007)

In Italy there is the species Ursus arctos (*Linnaeus, 1758*), of which two subspecies are present: the Marsican brown bear (*Ursus arctos marsicanus - Altobello, 1921*), limited to the Central Apennines and the Eurasian brown bear (*Ursus arctos arctos - Linnaeus, 1758*), distributed over the Central and Eastern Alps.

BROWN BEAR	
Class	Mammalia (Linnaeus, 1758)
Order	Carnivora (Bowdich, 1821)
Family	Ursidae (Gray, 1825)
Genus	Ursus (Linnaeus, 1758)
Species	Ursus arctos (Linnaeus, 1758)
Subspecies	Ursus arctos arctos (Linnaeus, 1758)

Table 1.1 – Taxonomy of the Eurasian Brown Bear

1.2. Distribution of the Brown bear in Italy

Figure 1.2 – Distribution of the subspecies of Ursus arctos in Italy. Vedovelli A., 2021

In Italy the Brown bear is present in two distinct sectors, the Central Eastern Alpine Arc and the Central Apennines. The Apennine population (*Ursus arctos marsicanus - Altobello, 1921*) is considered a subspecies by the scientific community: it has an extremely limited range, essentially reduced to the territory of the Abruzzo, Lazio and Molise National Park and the neighboring areas, visited erratically. The Apennine population is made up of a very small number of bears, approximately of 50 individuals (capable of reproducing), which are subjected to a high mortality of anthropogenic origin, in particular to acts of poaching that jeopardize their survival *("In Italia - Template PAT - Grandi carnivori in Trentino"* 1).

In the central Alps, especially in the western portion of the province of Trento, there is a Brown bear population estimated at the end of 2020 which exceeds 100 individuals (Groff et al., 2021). Considering the longer journeys made by young males, the Brown bear population of the central Alps was distributed during the year (2020) over a theoretical area of 38,445 km^2. The central nucleus of the population, that is the territory permanently occupied by the females, is more contained (1,131 km^2) and in slow expansion, in line with the characteristics of the species: females have a reduced tendency to make large exploratory/dispersive movements. At the end of 2020, the reproductive nucleus is still located entirely within the western sector of the Autonomous Province of Trento. However, the area occupied by the females is now not far from the borders with Lombardy, suggesting a probable future expansion of the same outside Trentino (Groff et al., 2021). For Italy, to the two vital bear nuclei described above, a third nucleus must be added, present in the eastern Alps, on the border with Austria and Slovenia. The Italian Eastern Alps have been affected, for more than 30 years now, by a phenomenon of spontaneous re-colonization by specimens that move from neighboring Slovenia to Friuli-Venezia Giulia and Carinthia (Austria). It is currently difficult to estimate the number of bears that frequent the Eastern Alps, as many of these animals make temporary trips to Italy and then return to Slovenia or Austria. Furthermore, between the Adige river and the Slovenian border no certain cases of reproduction have been recorded *("In Italia - Template PAT - Grandi carnivori in Trentino"* 1).

1.3. Morphology

The alpine Brown bear is an animal of very variable weight and size, depending on age, sex and, as regards weight, also on the time of year. Overall it has a sturdy and compact appearance with short limbs, round ears, and a massive head. The muzzle is elongated and ends with a large nose called black "truffle" with great mobility The eyes are small compared to the volume of the head (Osti, 1994), the coat has dark brown color with shades ranging from black to gray to beige. The Brown bear sheds its coat once a year. The moult takes place in the summer and the new hair will grow back towards the end of the season and then be ready at the beginning of winter (Mustoni, 2004). The bear is a plantigrade, its paws have a large palmar pad separated by a furrow, covered with short hair, and the 5 fingers are equipped with digital pads and robust non-retractable claws (Mustoni, 2004). The height at the withers in adults can vary between 75 and 120 cm, the total length (nose-tail) from 130 to 250 cm. Weight is the most variable parameter, with adult males ranging from 100 to 300 kg, while females, generally lighter, range from 70 to 180kg. The maximum weight peak is found in late autumn, the season in which the bear has already accumulated the fat necessary for winter hibernation. In spring there is a drop of 20-25% compared to autumn, but the minimum weight is reached at the beginning of summer. Newborn cubs weigh between 300 and 500 g, but at 5-6 months they can weigh up to 6 kg, they have a very fast growth in the first year of life at the end of which they can weigh 30-40 kg (Fattori et al., 2010). The bear is estimated to have a longevity of 15 - 20 years in the wild, while in captivity it can live up to 35-40 years (Osti, 1994).

Picture 1.1 – Brown bear in a standing position
Credit: Bavassano M.

1.4. Dietary habits

Although belonging to the order of Carnivores, the bear has an omnivorous diet defined by Mustoni (2004) as an ecological "intelligent" opportunist, who chooses what to eat from the wide range of food available following precise criteria such as energy content and seasonal needs. Its food spectrum includes vegetables (63%) such as sprouts, leaves, berries and fruits; insects, mainly hymenoptera (17%); mammals (6%); others (13%) [Fig. 3]. The diet tends to vary with the seasons according to the availability of resources and needs (Osti, 1994).

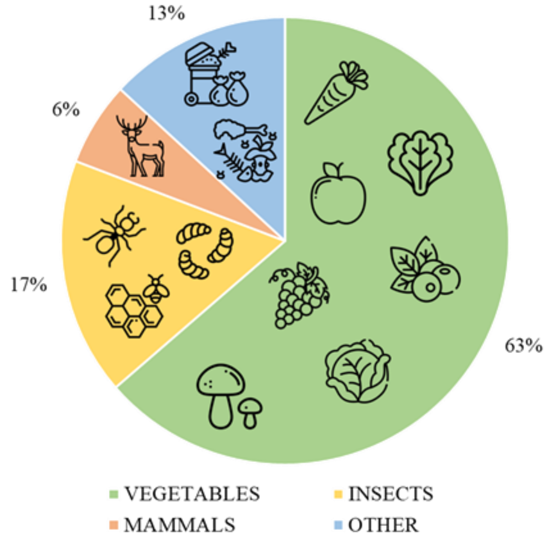


Figure 1.3 – Average volumetric composition of the bear's overall diet
Vedovelli A., 2021

1.5. Habitat, social habits and annual cycle

The Brown bear habitat can include various types of environments, as an animal that can adapt easily. However it prefers more rugged territories and complex forest ecosystems in the altitudinal range between 300 and 1,400 m asl, where it can find trophic resources throughout the year and where it can find "refuge areas" with an orography and vegetation cover such as to avoid contacts with humans (Mustoni, 2004). The Brown bear is a solitary animal, the only exceptions are the mating period and during the phase of parental care between female and cubs in which temporary social bonds develop. It is not strictly territorial and therefore the home range can overlap widely; interactions between individuals occur, according to various authors (for all Mustoni, 2004), through olfactory and visual stimuli such as urine, feces, scratches on "rub trees" and more. The information collected through these markers allows the single specimen to know the composition and distribution of the other individuals present in the territory.

Picture 1.2 - Bear breastfeeding two cubs in a puddle of water on Mount Gazza, from a camera trap video
Credit: F. Limelli and F. Cadonna - PAT Wildlife Service Archive)

The annual cycle of the Brown bear (Fig. 1.5) can be divided into two main phases: the activity phase and the winter rest phase. The winter rest period, concentrated in the Alpine environment mainly in the months between November and March, is believed to be subjected to variations depending on the climate and/or food availability. The inactivity phase during the winter season is defined as "hibernation" and consists in a conspicuous reduction of metabolism and body temperature of 4 -5 ° C compared to ordinary values (37 - 38 ° C) allowing the bear to maintain a good level of reactivity. For this reason sleep can be interrupted for short moments of activity in which the bear comes out of the den (Osti, 1994). The burrows are already set up in autumn and often consist of natural cavities and ravines with low entrances usually located on steep slopes, located between 1,000 and 2,000 m above sea level; females take particular care in preparing the 'bed' made up of leaves, branches and moss as it will have to welcome the pups of the year that will be born between January and February (Canziani, 2011). The mating season is between April and July, the only time of the year in which it is possible to see males and females together even for several days. In the population of the central Alps, females are often already sexually mature at 3 years of age, while males reach sexual maturity at around 4 years of age. Females give birth on average every two years from 1 to 3 cubs, which will remain with the mother for up to one and a half years of life. Gestation lasts 7 - 8 months. Such a long period is motivated by the fact that embryonic development stops until autumn (embryonic diapause) to resume in November approximately coinciding with the beginning of winter rest. The actual pregnancy therefore lasts about 4 months ("*Riproduzione - Template PAT - Grandi carnivori in Trentino*" 2).

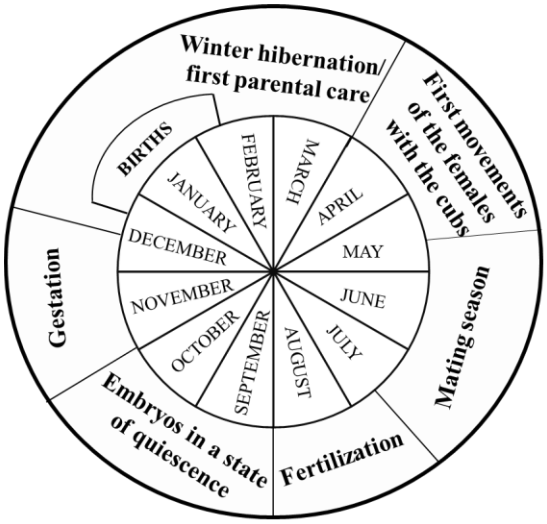


Figure 1.5 – Scheme of the annual cycle of Brown bears in the Alps.
Source: site
https://grandicarnivori.provincia.tn.it/L-orso
by the 'Servizio Faunistico PAT'

2. MONITORING

Through the action of monitoring there is the possibility to detect possible changes that occur in populations, communities and ecosystems. For the conservation of biodiversity it is of fundamental importance to detect them in order to decide which conservation measures to implement immediately and in the future. This approach to conservation falls within the framework of adaptive management of natural systems: given a certain system (at any level of the biological spectrum), starting from the basic knowledge of its current state and of the threat factors, a conservation strategy is established, it is then implemented and the status of the system is periodically measured by monitoring; the knowledge deriving from the monitoring is the starting point for reviewing the decisions made previously and, if necessary, making changes to the conservation strategies (feedback between monitoring, decisions and actions). There are different reasons behind a monitoring plan, it depends also on the initial situation considered. After a reintroduction projects for example, the animals are usually monitored to make sure everything is going well and eventually determine what needs to be reviewed. Another reason could be for game management, or the wild animal is considered an actual or potential pest, so knowing the population density, their distribution and home range can help with the control of them. In other situations the species may be endangered or threatened, and the population is being monitored to assess its progress or recovery. Sometimes also the effects of human management actions, land-use practices, or alternative activities are taken in consideration (Witmer, 2005). Large carnivores in particular attract conservation interest more than any other wild group: they are probably the most difficult (and most expensive) group of animals to preserve. According to Linnell et al. (1998), having established methods for monitoring the numbers and trends of these species is crucial for at least six reasons:

a) the size of the population is important to determine the appropriate level of protection that should be afforded it.
b) Repeated estimates of population size, or of an index, are vital to determine if the population is decreasing, increasing or stable.
c) Such estimates are vital to measure the success or failure of management strategies.
d) Interpreting research results without an estimate of population density is difficult.
e) Where large carnivores are harvested it is vital to set hunting quotas that can be supported by the population.
f) Where large carnivores cause conflict with livestock, measures of presence/absence and relative density may be important to ensure fair payment of compensation.

2.1. National and international regulatory framework

Recognizing the need to coordinate efforts for the conservation of Europe's biodiversity, the EU has put in place a series of wide-ranging laws which are now in force across all 27 countries. Together, they set the standard for nature conservation within Europe and enable Member States to work together towards the same goals and within the same
strong legal framework to protect valuable habitats and species across their entire natural range within Europe. The so-called 'Birds' Directive was the first such EU law to be adopted back in 1979. It provides a general protection regime for all birds that are naturally occurring in Europe. This Directive was complemented, 13 years later, by the adoption of the so-called 'Habitats' Directive which introduces similar legal measures but extends its coverage to a much wider range of rare, threatened or endemic plants and animals (Sundseth, 2008). Moreover every six years the Member States must report its implementation to the European Union (article 11); to do this, the national legislation (article 7 of the Decree of the President of the Republic September 8th,1997, n°357 modified by the Decree of the President of the Republic March 12th, 2003, n°120) provides that the results of monitoring, data on the conservation status of species and habitats and all that is necessary to verify the execution of the Directive are transmitted to the EU. At the heart of the two EU Nature Directives lies the creation of a coherent ecological network of protected sites: the Natura 2000 network.

Natura 2000 is a network of core breeding and resting sites for rare and threatened species, and some rare natural habitat types which are protected in their own right. It stretches across all 27 EU countries, both on land and at sea. The aim of the network is to ensure the long-term survival of Europe's most valuable and threatened species and habitats, listed under both the Birds Directive and the Habitats Directive (Sundseth, 2008).

The network consists of the Sites of Community Importance (SCI), identified by the Member States in accordance with the Habitats Directive, which are subsequently designated as Special Areas of Conservation (SAC), which also includes Special Protection Areas (SPAs) established by the Directive 2009/147 / EC "Birds" concerning the conservation of wild birds.

There are 155 Natura 2000 sites in Trentino that protect 57 types of habitats, 10 plant species, 72 species of animals of community interest (Cartografia Sistema aree protette del Trentino, 3).

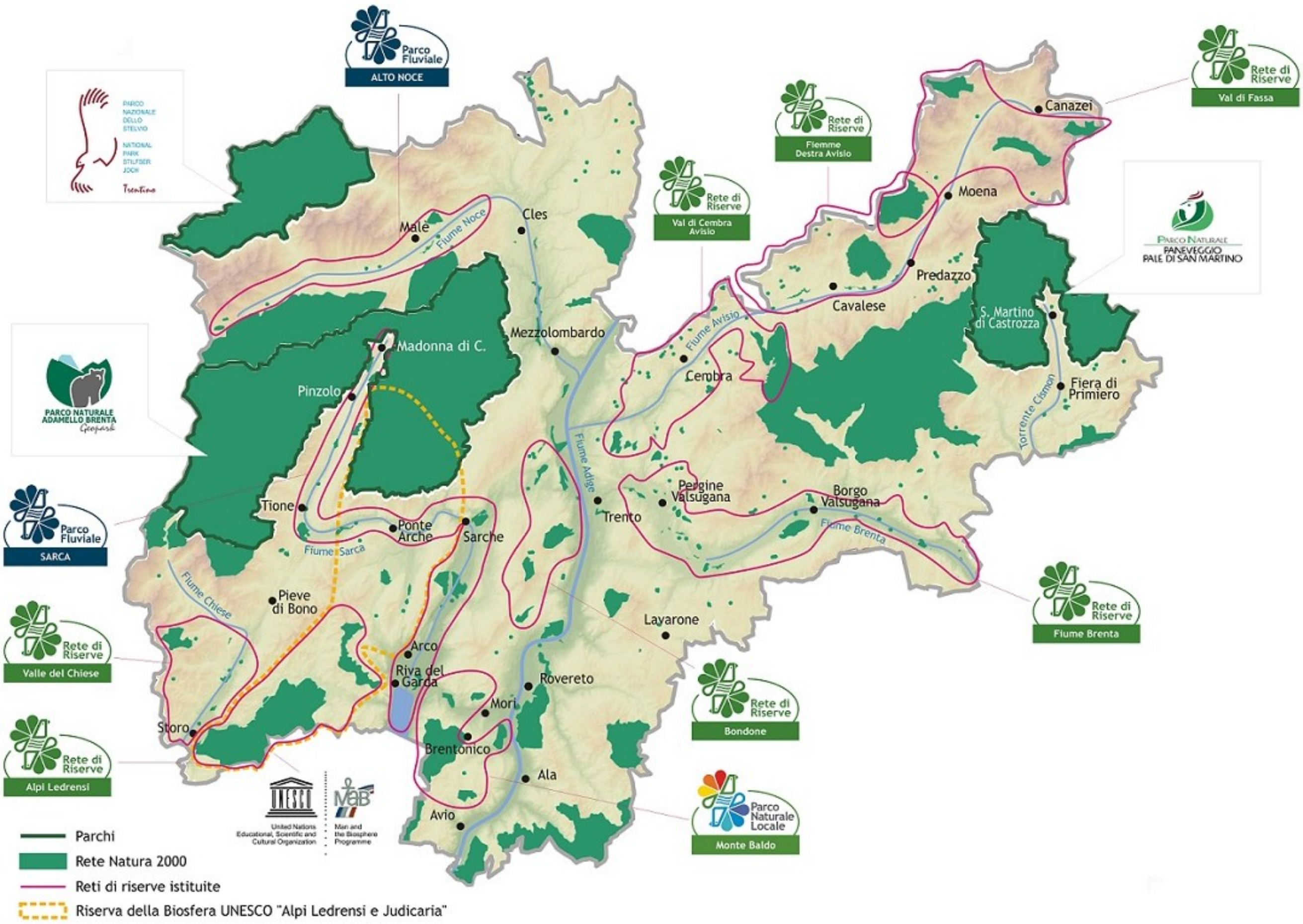


Figure 2.1 – Map of protected areas in Trentino

Source: http://www.areeprotette.provincia.tn.it/

2.2. Legal status of the Brown bear in Trentino

The Brown Bear is protected by the Framework Law of February 11th, 1992, n° 157 which includes it among the particularly protected species (art. 1 paragraph 1), by the Berne Convention which includes this carnivore among the strictly protected species and by the Community Directive 92/43 / EEC ("Habitat" Directive, implemented by Italy with DPR of September 8th, 1997, n° 357, modified and integrated by DPR of March 12th, 2003, n°120) which includes it among the species of community interest that require rigorous protection (AA.VV., 2010).

The regulatory framework summarized above provides for a strict ban on killing, capture, disturbance (in particular during the stages of the reproductive cycle and hibernation), possession and trade of specimens of Brown bears (Law 157/92 and Presidential Decree 357/97 art . 8). The Habitat Directive, and the related national regulations, have introduced obligations for the protection of populations and their habitats, which must be maintained in a satisfactory conservation status (DPR 357/97 art. 1 paragraph 2).

The DPR 357/97 has also introduced an obligation, for the regions and autonomous provinces, to guarantee the monitoring of the conservation status of the species on the basis of guidelines produced by the Ministry of the Environment and the Protection of the Territory and the Sea in contact with the Higher Institute for Environmental Protection and Research (ISPRA) (DPR 357, art.7 paragraphs 1 and 2; AA.VV., 2010).

Derogations from the prohibition of capture or killing may be granted for the purpose of preventing serious damage, in the interest of public safety or for research and reintroduction, as long as there are no alternative solutions, and that the application of the derogation does not affect the maintenance of the population in a satisfactory state of conservation (DPR 357/97 art. 11). The application of the exceptions requires a specific authorization from the Ministry of the Environment and the Protection of the Territory and the Sea, expressed on the basis of a technical assessment by ISPRA. The Ministry must send a report on the exemptions granted every two years to the European Commission (DPR 357/97 art. 11, paragraph 3; AA.VV., 2010).

Currently, to ensure the coexistence of bear with man, it is necessary to activate effective management policies by the competent local and state administrations. For this reason, the PACOBACE (interregional action plan for the conservation of the Brown bear in the central-eastern Alps) was drawn up. It is an action plan formally implemented by all the territorial administrations (Regions Lombardia, Veneto and Friuli Venezia Giulia and Autonomous Provinces of Trento and Bolzano) of the Central-Eastern Alps, by the Ministry of the Environment and by ISPRA. This document therefore represents the formal policy of the Italian State on the conservation and management of bears in the Alps. The plan contains detailed information on the measures to be taken to prevent and compensate the damage caused by the bear, the most appropriate intervention measures on problematic specimens, the structure of information and communication campaigns, staff training and population monitoring (AA.VV., 2010).

2.3. Invasive and non-invasive monitoring

In order to make informed decisions on the deployment of resources to protect endangered species it is necessary to have reliable data on their numbers and distributions that can be obtained through non-invasive and invasive monitoring.

Non-invasive monitoring means monitoring without disturbance to the normal behaviour, ecology or physiology of the animal. Noninvasive techniques include an increasing number of remote sensing approaches made possible by advances in technology and include camera trapping, in which an image of an animal is taken along a trail or grid, and biometric approaches, including footprint identification, coat pattern recognition, and vocalization identification. Noninvasive genetic sampling of feces and hair follicles is increasingly used and reliable.

Invasive monitoring relies on the fitting of instrumentation to the animal, such as a transmitter (e.g. radio-telemetry through a collar, tag, insert) or by marking, or capture to take biological samples, or close visual observation. Occasionally it is essential to use some of these techniques (for example in translocation, or veterinary treatment of injured animals) but deleterious effects from regular disturbance can occur. There is still no effective method for monitoring endangered species that does not cause some degree of interference to the individuals of that population. Human presence alone in the environment of free-ranging populations can cause physiological or behavioral modification, unwanted transmission of disease, and mortality (Lott & McCoy 1995; Green & Giese 2004).

Invasive monitoring techniques may require either physical or chemical immobilization. Physical traps create stresses similar to those of being caught by a predator, and the trapped individual may engage in a prolonged struggle to escape that causes pain, fear, and anxiety. Repeated stressors may induce chronic stress. Physical capture alone, without chemical immobilization, can result in capture myopathy, a syndrome in which extreme muscular activity and hyperthermia lead to death minutes to weeks after the inciting event. Chemical immobilization requires the delivery of potent sedative or anesthetic drugs, delivered after capture in a physical trap, or directly in the field. This method can present considerable risk for both operator and animal. Immobilizing drugs have the potential to disturb normal regulatory systems, particularly respiration and thermoregulation, which can lead to neurological or myocardial problems and multiple organ failure (Jewell, 2013).

In light of the above considerations, non-invasive monitoring is the most ethical and least disturbing one; however, not all information can be collected accurately in this way. In addition to situations where more direct actions are required (e.g. monitoring of 'problematic' bears), invasive monitoring allows us to obtain important data, such as the movements of a specimen thanks to the use of a radio collar. A good action plan of monitoring, therefore, should take into account the well-being of the individual animal as much as possible but still strive to ensure that the entire population benefits from it, using more invasive techniques when required.

2.4. Types of monitoring adopted in Trentino

The Wildlife Service of the Autonomous Province of Trento is the competent authority for the protection and conservation of wildlife and, together with the Forestry Department, is the reference structure for the management of the Brown bear population in the provincial territory. Bear monitoring has been carried out continuously since the 1970s. Over time, the traditional techniques of field survey have been joined by radio telemetry, automatic video control from remote stations, camera trapping and finally, in 2002 started genetic monitoring. Genetic monitoring is based on the collection of organic samples (hair, excrement, urine, saliva, tissues) that takes place in two ways:

- systematic monitoring, based on the use of traps with olfactory baits aimed at the "capture" of hair by barbed wire;
- opportunistic monitoring, based on the collection of organic samples found in the area during ordinary service activities and in correspondence with the assessment of damage and inspection of rub trees.

In the next chapters each methodology mentioned above will be explored in detail.

Picture 2.1 – A bear photo-trapped by a personal camera-trap in the Adamello-Brenta nature Park
Credit: Zanon N., 2019

Parameter	Indicator	Methods
1. Population distribution	Minimum range occupied (and trend) by the reproductive population and by the dispersers on a 10X10 km^2 grid	Opportunistic collection of signs of presence and organic samples, photos/videos Systematic collection of signs of presence/organic samples Camera traps on a systematic time grid
2. Population size	Minimum number of subjects present excluding cubs Estimate N individuals excluding cubs present in the population (by applying statistical methods of genetic capture and recapture) Estimate of the minimum number of cubs present at the end of summer	Opportunistic/systematic collection of organic samples and genetic *fingerprinting* Camera traps on systematic monitoring points Collection and validation of reports and images of females with cubs "Systematic" control of damage and predation reported and collection of organic samples
3. Mortality, Demographics	Population structure by sex and age N. bears found dead Estimation of survival rates	Opportunistic/systematic collection of organic samples and genetic *fingerprinting* Systematic collection of bears found dead
4. Conflict mitigation	Monitoring of human-bear interactions / encounters Road investments monitoring Monitoring of the outcomes of interventions on problematic bears Location, extent and type of damage (predation) Location, type, effectiveness of prevention works Type and number of information and dissemination activities Survey (5-10 years) on the level of knowledge and acceptance of the bear in local communities	Opportunistic collection of reports of human-bear encounters with the filled form Collection of investment reports and collection of organic samples Standardized collection of information relating to the monitoring/deterrence of problematic bears Systematic control of damage and predation on reported domestic workers Collection and storage Planning and control of the prevention works provided

Table 3.1 – Schematic review of the types of monitoring adopted in different situations

3. GENETIC MONITORING

Non-invasive genetic sampling methods, which are based on the analysis of DNA obtained from biological samples, using modern molecular biology techniques, allow to obtain and possibly estimate different population parameters. In particular, it is possible to (AA.VV., 2010):

1. determine the minimum number of animals present through the number of unique genotypes identified following the analyzes;
2. highlight the possible immigration of new individuals;
3. determine the sex of the individuals identified;
4. identify the newborn and reconstruct the kinship relations between the subjects;
5. estimate population size, growth rate, and survival rate;
6. identify the movements and distribution of animals on the territory;
7. monitor the genetic variability and the inbreeding rate of the population over time.

A coordinated Brown bear monitoring program with non-invasive genetic techniques should follow some principles allowing the correct collection of samples and interpretation of data. It is of fundamental importance that the samples are collected and preserved following precise standardized protocols as well as the use of an automated and centralized cataloging system and the construction of a single database for their consultation. The genetic analysis methods must be univocal, performed on the basis of standardized protocols, in order to allow the comparison between the samples collected in different areas and periods. Then, data must be stored in a centralized database that can be consulted and used by the Administrations involved, which allows for the comparison of results across the entire Alpine arc.

2020 was the 19th consecutive year that genetic analyzes were conducted on bear samples, coordinated by the Forestry and Wildlife Service, now the Wildlife Service, of the PAT (Large carnivores sector) with the collaboration of FEM, ISPRA, PNAB, MUSE, ACT and volunteers. Genetic analyzes were performed by the Genetics Research Unit of Conservation of the Edmund Mach Foundation for the samples of the Province of Trento and for some samples from the Autonomous Province of Bolzano, the Veneto Region and the Region Lombardy, in complete coordination (Groff et al., 2021).

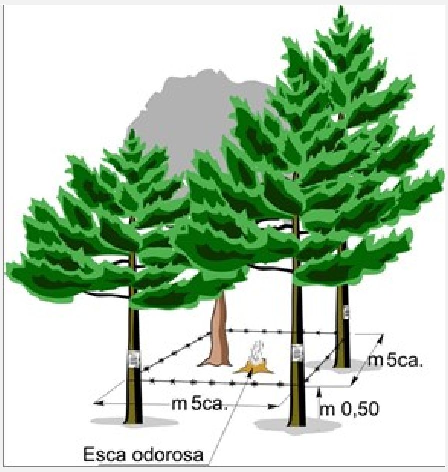
Organic samples can be collected using the following methodologies:

- **Opportunistic collection of samples**. This type of genetic sampling generally allows to obtain a high number of samples with a limited sampling effort because this collection can be done during the normal field activities of the technical staff. However, this methodology strongly reduces the possibility of applying population consistency estimation methods based on Capture-Mark-Recapture (CMR) due to the lack of a systematic design. Furthermore, the success rate of the analyzes of opportunistically collected organic samples can be compromised by the long exposure times of the samples to the external environment (AA.VV., 2010).
- **Collection of samples during the damage assessment and the activity of the emergency team**. During inspections aimed at ascertaining the damage, particular attention must be paid to the collection on site of any organic samples. In the case of the bear, genetic investigations are of particular importance in identifying harmful subjects. The methods of collection and conservation are the same as for opportunistic collection. The data relating to the organic samples collected on the site must be reported in the appropriate damage report sheets.

Picture 3.1 - Bee hives preyed on by the bear in Val di Sole, January 2019
Credit: Zanella S.

- **Systematic collection through hair traps**. The collection of hair samples with hair traps equipped with odorous baits allows the data to be used to estimate demographic parameters, as the sampling effort is homogeneously distributed and quantifiable (AA.VV., 2010). The territory taken into consideration is divided following a grid. Within each cell of the grid, the competent personnel must identify the suitable place in which to set up the trap. The purpose of the traps (*Box 1.*) is to attract the bear using a specific odorous bait; to reach it, the plantigrade must overcome a stretch of barbed wire on which it will most likely deposit some tufts of hair. The verification of the barbed wire with the collection of any samples is normally established by the Forestry and Wildlife Service through a specific calendar of site control and supply sessions (usually every two weeks).

Box 1 - The hair trap



Picture 3.2 – Hair caught in the wire
Credit: Alexander Kopatz

The traps consist of a ring of barbed wire stretched about 50 cm from the ground fixed to the tree trunk, which delimits an indicative area of 30 m2. For the placement of the traps, sites where previous presence indices have been detected will be chosen; other important characteristics for the location are the topography of the place and the distance from possible anthropogenic disturbances, less frequented areas are preferable. Tables (insert table) must be placed near the traps to indicate the structure and the possible risk to people represented by barbed wire. At the end of the monitoring season, the trap must be dismounted, the barbed wire removed, and the summary form of the sessions performed must be completed. To allow a more effective, rapid and accurate recognition when checking for the presence of hair, a white background (e.g. sheet of paper) is used placed at the height of the barbed wire and the entire perimeter of the trap is covered so that any hairs are best seen. After collecting the sample, the affected portion of wire must be made sterile by passing it under the flame of a lighter, in order to remove and burn any residue of the sample taken to avoid subsequent re-sampling.

It is advisable to equip each hair trap with a camera trap, so that through a comparison between images and organic material collected, it is possible to identify the organic samples to be analyzed avoiding the shipment of duplicate samples.

The methods of collecting and storing organic samples are fundamental to ensure the success of the genetic analysis. Each type of sample has its own specific collection and storage method which must be scrupulously observed. In general, it is preferable to collect fresh samples present in stable environmental conditions (for example not subjected to excessive humidity or sources of heat) and store them in a dry place at a temperature that varies between ambient and refrigeration depending on the type of sample.

Each sample is associated with its own sampling code, designed to be unique and to reconstruct the main information related to the individual sample. The table below shows the items that compose the code:

TEXT OF THE CODE	***DEFINITION***
E, S, U, H, T	*E=excrement, S=saliva, U=urine, H=hair, T=tissue*
YEAR	*2019, 2020, 2021, ecc*
MONTH	*01, 02, 03, 04, 05, 06, 07, 08, 09, 10, 11, 12*
DAY	*01, 02, ... 31*
FIRST THREE LETTER OF THE STRUCTURE OF BELONGING	*TIO=tione, VAL=vallelaghi, POZ=pozza di fassa, ALA=ala, RIV=riva del garda, LED=ledro, ecc*
INITIALS OF THE OPERATOR'S NAME AND SURNAME	*RD=riccardo dorna, PZ=paolo zanghellini, ecc*
PROGRESSIVE SAMPLE NUMBER	*01, 02, 03, ecc* *It is reset every time that the same operator collects different organic samples or of different species on the same day.*

It is important that the staff involved in the collection of organic samples participate in information meetings aimed at providing information on the techniques for recognizing, collecting and storing the samples. It is also advisable to prepare a kit for the collection and storage of samples, to be distributed to the personnel involved in this activity (personal communication by Large Carnivores Division, Bragalanti and Zeni, 2021).

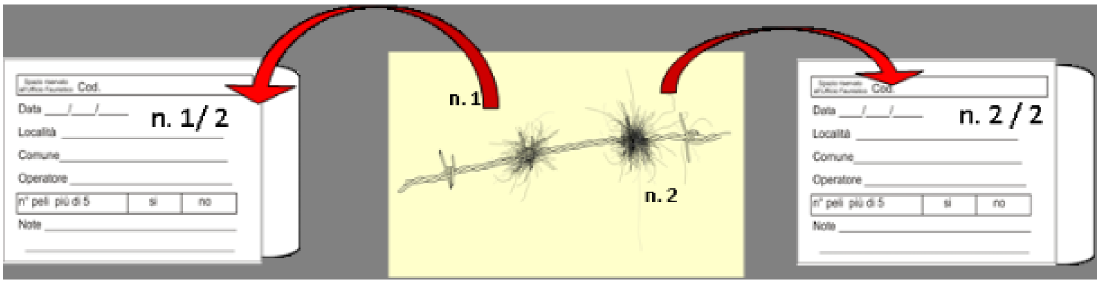
In 2020, genetic monitoring on bears was carried out limited to organic samples considered strictly necessary (e.g. emergencies and problematic specimens, dead animals, samples collected on damage of unclear attribution for the purposes of compensation, other). In fact, since 2020, intensive genetic monitoring, aimed at determining the main demographic parameters of the population, has been conducted in alternate years. The reason behind this managerial choice is to optimize the effort and costs of this activity in the medium-long term, but still maintaining a good level of monitoring. Also the economical/social situation created by the Covid-19 pandemic contributed to a rationalization of expenditures on all sectors.

In 2021, therefore, intensive monitoring (opportunistic and systematic) was again envisaged, which will make it possible to obtain updated data on population size and structure, survival rates, trends, distribution and dispersion (Groff et al., 2021). The data collected in 2021 will be analyzed and published with the next report (2022), not yet available during the writing of this thesis.

The specific methods of collecting and storing organic samples were explained personally by forestry agents Bragalanti and Zeni. After each sampling the reporting documents are also compiled.

HAIR

For hair collection, sterile tweezers or disposable gloves are used. The tweezers must be sterilized before and after each use through the flame of a lighter; the same goes for gloves, they must be changed when each new sample is collected. During the harvesting phase, it is essential to pay attention not to remove the hair follicle (the root) as it is the only source of DNA. The individual samples are then placed in paper bags, completing the information requested on the envelope.



Picture 3.3 – Example of how sampled hair must be stored

The envelope in turn must be placed in a hermetic plastic bag together with some silica grains which must then be monitored over time (replace it if it changes from yellow to green/blue).

Picture 3.4 – A plastic bag containing the collected hair sample with silica grains

The sample then needs to be placed in a cool, dry place, away from heat sources or direct sunlight. It is very important that the operator minimizes the risk of collecting hair from different subjects, since in the case of genetic analysis, it will be possible to define the species but not the individual subject. Therefore, hair that presumably belongs to different animals (for example tufts collected on different points of a barbed wire, a rub trees or a fence) must be collected and stored separately. It is advisable to sterilize the collection point with the use of a lighter or remove any residual hair in order to avoid resampling at the next check.

FECES

The sampling of excrements is carried out with the use of a "genotube" (picture 3.5) and takes place by rubbing the swab on the mucous part of the organic material. It is recommended to prefer the sampling of terminal portions (they are richer in cells from the intestinal tract) and of the external parts that have remained more protected from atmospheric agents. The genotube must be placed in the appropriate container; no preservative agent is needed. The sample then need to be placed in a cool, dry place, away from heat sources or direct sunlight. Stool freshness is a key element to ensure good DNA extraction from the organic sample. Those with a better outcome are fresh excrements preferably not older than 24 hours. In cases where feces are found in an area of sporadic presence or in contexts of doubtful damage, even older excrements can be sampled.

Picture 3.5 – The genotype used for sampling collection

SALIVA

Saliva is searched and collected in case of predation and finding of relatively fresh carcasses. Also in this case for sampling it is necessary to use the genotube; saliva is searched around the wound holes inflicted with the teeth, by passing and rubbing the swab around the holes themselves and trying to absorb the saliva left at the edges of the wound. A new genotube must be used for each bite. The genotube must be placed in the appropriate container; no preservative agent is needed. The sample then needs to be placed in a cool, dry place, away from heat sources or direct sunlight. When lacking a genotube, it is possible to use saliva swabs: the collection methods are the same, but the swab must be air dried first. The swab is then placed with the head facing upwards in the appropriate container, together with some silica grains and a cotton swab (picture 3.6).

Picture 3.6 – Correct storage of a saliva swab

TISSUE / BONES

1cm^3 of muscle tissue in an area where the state of decomposition seems less advanced is collected from a dead individual. In the case of a captured and, therefore alive, subject, the advisable portion to collect is of about 0.5cm^3 of tissue from the buccal epidermis. The collected sample can be stored in a plastic jar (like the one used for urine collection") or in a "Falcon" type test tube containing undenatured alcohol.

Blood and urine are not considered biological materials relevant for the genetic monitoring of the bear as the collection method is based on the sampling of a snowy substrate 'contaminated' by them. Since the bear usually hibernates during winter, finding samples of this type would be difficult.

4. CAMERA-TRAPS MONITORING

Camera-trapping is a useful and widely used tool to study wildlife. It is generally regarded as noninvasive, it can gather information on a range of species simultaneously and continuously, over large survey areas and for several months at a time. There are several types of camera traps, but all models have the same basic principle: a photo (and/or video) camera protected by some sort of weather proof housing, coupled to a mechanism that allows the camera to be triggered automatically when an animal moves in front of it (Ancrenaz et al., 2012). In recent years camera traps have become a mainstay in conservation management as they are (Molloy, 2018):

- relatively cheap to buy and deploy,
- highly reliable,
- able to be placed in the field for months at a time,
- low impact, i.e. they provide minimum disturbance to fauna and the environment,
- low skill, i.e. they do not require highly specialist skills to deploy,
- relatively safe for both fauna and project staff in comparison to animal handling,
- able to be used in situations which may be hazardous for people to work in,
- without a need for licensing (although landholders permission and, where applicable, ethics approvals are still required).

Camera traps are an ideal tool for remote areas since they do not need to be accessed daily this is because they have the advantage of working independently of an observer once they have been set up (as long as their batteries and picture storage allow). Another advantage is that they function 24 hours a day, this means that they make it possible to sample large areas over long periods of time with relatively low personnel demands. Nearly all modern camera traps are triggered by a combination of Passive infrared (PIR) and motion detectors. PIR sensors respond to heat signatures while motion sensors respond to the movement of animals and background objects, e.g. vegetation blowing in the wind. At default settings, most camera traps use a combination of both sensors (Molloy, 2018).

Picture 4.1 - Camera-trap placed on a tree

Credit: Zanghellini P. - Forests and Wildlife Department Archive PAT

In 2020, the multiannual program for monitoring the wildlife continued by systematic camera trapping. Launched in 2015, the project is part of the Convention between PAT and MUSE dedicated to large carnivores and since 2019 it has benefited from the scientific supervision of the University of Florence. The project provides for the monitoring during the summer season of 60 sites in an area of 220 km^2 in the southern sector of the Brenta Group and the adjacent Paganella-Gazza massif.

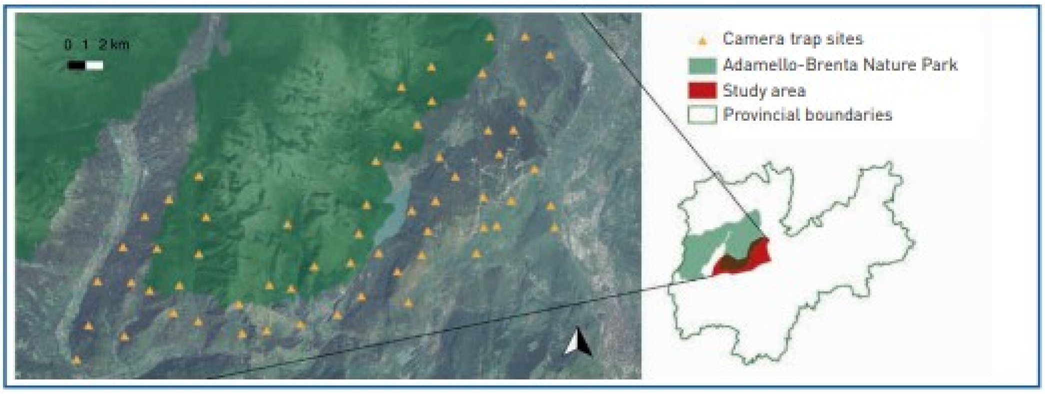


Figure 4.1 - Map of the 60 camera trapping sites in the study area in western Trentino
In green the territory of the Adamello-Brenta Natural Park
Source: ' 2020 Large Carnivores Report', (Groff et al., 2021)

The camera-trap must be located if possible in remote places, away from paths or routes heavily frequented by humans and in order to avoid vandalism against the instrumentation with possible damage or theft of the same, it is suggested the use of chains or steel cables. The positioning of the camera trap in order to avoid damage is particularly important in the case of the bear: it is recommended to position the camera at a certain height from the ground (at least 3 meters), in order to reduce the probability of contact with the plantigrade. It is also advisable to notify the landowners or other interested parties (e.g. rector of the hunting reserve) in advance of the location of the instrumentation. Then each camera trap must be equipped with an information card bearing the telephone number necessary to obtain information on the matter.
Artificial attraction to obtain photos/videos can only be used with authorization by the Forestry and Wildlife Service. In any case, olfactory attractants will be used, sufficient to keep the animal stationary for some time in the field of action of the camera trap, rather than food (personal communication by Large Carnivores Division, Bragalanti and Zeni, 2021).

Camera traps can collect data on a range of aspects of animal ecology, conservation and behaviour. Adequate project planning is essential to guarantee that you collect the right data you need in order to answer your research or management questions and involves planning on several levels (Ancrenaz et al., 2012). Some questions that a camera-trapping study may help to answer are:

a) **Is the species present in our study site?**
   The simplest way to look at camera-trapping data is to check the presence of the species: if the bear is present or absent in the photos/video recorded.
b) **Where in our study area/study landscape does my species of interest occur and which ecological factors influence its occurrence?**
   Information like habitat type, distance to water, distance to human settlement or anything that might be important to the species can be used to see whether any of these characteristics have an influence – positive or negative – on the bear being present at a sampled location.
c) **How abundant is the species? What is the population density?**
   The most refined measure for wildlife monitoring is abundance or density (abundance per unit area). Because the total counts of all individuals is not always possible there are different approaches to obtain an estimation, depending on whether or not individuals can be recognized based on camera trap photographs. In the case in which some records are difficult to be assigned to distinct bears, this information cannot be used to actually establish abundance. If instead there is the possibility to recognize the individual, capture-recapture models are used: they estimate the probability of detecting an individual and use this probability in conjunction with the number of observed individuals to estimate actual abundance (Ancrenaz et al., 2012).

Every 15 days camera traps used in the systematic monitoring are usually checked (correct functioning, data download). The presence of Brown bears in 2020 was recorded on 28 sites of the 60 total, through 62 independent events (considering an event as the set of all images of the species obtained within 15 minutes), with a maximum of 11 in a single site. These data show an increase in attendance compared to previous years, characterized by 15-23 sites with passage and a maximum number of independent events which so far has rarely exceeded 50. It is possible that this increase is partly an effect of the spring 2020 lockdown caused by the Covid-19 pandemic, which resulted in much lower average levels of human disturbance than normal in the months immediately preceding the sampling. In any case, only with appropriate statistical analyzes it will be possible to ascertain whether this variation reflects a real increase in numbers and/or in the distribution of the population (Groff et al., 2021).

5. RADIO TRACKING

Radio tracking technology can help determine exactly the location of an animal at any moment. The data collected from tracking devices can determine the day-to-day movements of an animal, the size of its home range and the types of habitats it uses. This information helps to control animal populations, determine what impact anthropogenic activities can have on an animal population, and determine if there are enough individuals in an area to allow for reproduction. In addition, another important function related to the use of the radio tracking technology is the monitoring of problematic bears, or of individuals that show a confident behavior towards humans and anthropogenic activities: knowing their movements and their current position allow a possible intervention in order to dissuade them from approaching and to prevent damage.

VHF Radio Tracking

Radio-transmitters have been deployed on wildlife monitoring since the 1960s. For the first few decades only very high frequency (VHF) radios were commonly available. Telemetry works in a manner similar to any radio system, in order to use VHF radio tracking, a radio transmitter (collar, ear tag, tail tag, implant) is placed on the animal. Usually, the animal is first sedated. While the animal is asleep, the personnel gather information about the health and condition of the animal. Once the radio transmitter is placed on the animal, it begins transmitting a signal to a radio antenna and receiver. In order to locate an animal using VHF radio tracking, the receiver must be close enough to the animal with the radio antenna so they can pick up the signal from the radio transmitter on the animal. The location of the animal can be ascertained by taking multiple bearings on the radio signal from different locations and triangulating the transmitter location.

Picture 5.1 - Traditional VHF telemetry uses a directional, hand-held antenna to receive transmissions.

Credit: U.S. Fish & Wildlife Service

GPS Tracking

Since the 1990s, with the advent and increased availability of global positioning system (GPS) technology, GPS radio-transmitters have been developed: they can be attached to individual animals and record multiple locations daily with much less labor cost per location than using VHF technology. This also allows for monitoring animals at night or when they are in inaccessible areas. In other words, the personnel does not need to be near the animal to record its location (Dahlgren et al., 2018). GPS is a system for locating a point thanks to a network of satellites that orbit around the Earth. The GPS of the radio receiver gets the signal of the best satellites positioned geometrically and, by hooking to them, allows the acquisition of three-dimensional coordinates relating to the position.

Picture 5.2 – Example of a radio collar
Source: https://www.vectronic-aerospace.com/

The bears are equipped with radio collars with both VHF and GPS technology. The radio collar is nothing more than a strap to which a battery is connected that makes all its components work. This tool is tied to the animal's neck, after the capture, and then left on it for the monitoring period or until the battery runs out. The interesting aspect of the radio collar lies in the ability to transmit and receive data via SMS (Short Messaging System), using the GSM cellular telephone network (Global System for Mobile Communications), to a station configured with it, called Ground Station (Mazzoni, 2016). In 2020, 3 bears, F20, JJ4 and M49, were monitored with satellite telemetry. Their home ranges, calculated with the Minimum Convex Polygon (MCP) method, are shown in figure n. 5.1.

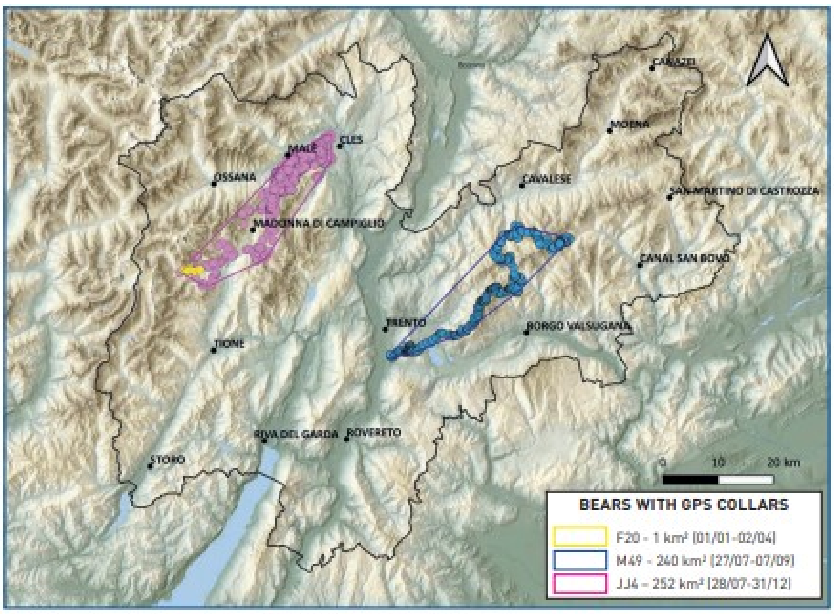


Figure 5.1- Home range of the three bears with GPS collars
Source: ' 2020 Large Carnivores Report', (Groff et al., 2021)

The models supplied to the PAT (Autonomous Province of Trento) are distributed by the company VECTRONIC Aerospace GmbH, based in Berlin, Germany, and have the following components (Mazzoni, 2016):

- *battery*: fundamental component for the working of the entire equipment. It has a variable duration depending on the number of daily localizations carried out by the collar, after which it can be regenerated. Depending on the body weight of the animal to be monitored and the number of positions to be obtained, the battery varies in size: large subjects such as bears can be equipped with heavier batteries which are more durable than lighter ones;
- *antenna*: allows better signal reception;
- *VHF emission system*: this system is independent; it has its own battery and its own signal frequency. This allows to locate the animal even in the field (specially equipped with radio and antenna). It also sends a mortality signal (if no activity is recorded for a certain time) and another emergency battery discharge signal;
- *drop-off mechanism*: this function allows to release the radio collar from the animal's neck automatically at the end of the monitoring period, after which it can be regenerated;
- *GSM communication*: it is the network that cell phones use to send or receive SMS. To allow it to work, it is necessary to equip the radio-collar with a SIM (Subscriber Identity Module) and connect the computer to a Ground Station. This system allows the user to communicate with the radio collar, receiving and sending information through the computer's special software. Basically it is what allows the archiving of data, which are then used with special databases;
- *internal sensors*: the position of the animal is represented by WGS84 coordinates. Each single data (fix or position) is stored with different information: date (dd/mm/yy format) and time of the survey, X, Y, Z coordinates (latitude, longitude and height), DOP[1] value, number of satellites used and their relative validity, channels of satellites used, voltage of the main battery and that used by the VHF system and temperature;
- *collar*: it is a strap of water-resistant, durable and smooth material to prevent dirt from infiltrating and damaging the components. It can be of different circumferences, depending on the size of the animal.

[1] DOP: to describe the contribution of the geometric configuration of the satellites to the accuracy of positioning, at a given point, the DOP index was defined (Diluition Of Precision): the lower its value, the greater the satellite configuration for positioning purposes (Mazzoni, 2016).

The collection of the data thus received by the radio-collars and the relative storage are carried out through a specific management software of the collars provided by the manufacturer Vectronic Aerospace.

The management of the radio collars is carried out by the Large Carnivores Division (LCD) which daily, through a special link for downloading the maps, transmits the position of the radiolabeled animals to the on-call coordinator and to the forest station territorially competent for the individual subject. The frequency rhythms of acquisition of the GPS-mediated localizations are defined and modified from time to time by the SGC in relation to the specific purposes of the monitoring (Mazzoni, 2016):

- **post release monitoring**: intensified fix frequency to allow operators to keep the animal under control in the period following release. It is greater than 7 fixes per day (usually one every 20-30 minutes);
- **ordinary monitoring**: ordinary fix frequency. 7 fixes are set a day, 3 hours apart from each other;
- **winter monitoring**: minimum fix frequency to avoid unnecessary battery waste as the bear in this period usually hibernates in the den and consequently the locations are strongly compromised. One fix is set per day;
- **emergency monitoring**: intensified frequency of fixes in cases of excessive proximity to inhabited areas or livestock activities and therefore to allow operators to know the position of the animal almost simultaneously (usually one every 15-20 min).

Picture 5.3 – A bear with a radio-collar

Credit: Forests and Wildlife Department Archive PAT

6. RUB TREES

The trees used continuously by bears to leave and acquire "information" between individuals in the same area are called rub trees. Where there is a greater concentration of bears, on the trunks of the trees it is possible to find marks left by claws and bites, usually together with the presence of hairs left on the bark with the typical energetic rubbing of the back carried out by the bear rising on the hind paws. In the Alpine environment it has been seen that resinous conifers are used much more than broad-leaved trees. The scratches that can be observed on trees tend to be produced at a height greater than one meter, usually superficial, rarely vertical, much more often placed obliquely, and are due to the "hugging" of the plant during the rubbing operations. Sometimes at the top, the marks of powerful bites can be found, left by adult males on the bark, probably as a visual as well as olfactory marking (Graffi e morsi su tronchi - Grandi carnivori in Trentino, 4).

Picture 6.1 - Bear marking on rub trees

Credit: C. Sartori - Forests and Wildlife Department Archive PAT

To date, it is not yet clear what the meaning of this behavior may be, in fact there are many conflicting opinions on the matter. Many studies carried out in North America, however, have highlighted the importance and potential of these sites both for the collection of organic samples and for the non-invasive monitoring of the bear population. In the Northern Continental Divide Ecosystem (Montana, USA) several authors (Kendall et al., 2008; Kendall et al., 2009; Stetz, 2008) have carried out studies on the distribution and density of ursine populations (grizzly and American black bear), using data collected with different sampling techniques, in particular hair traps with attractants, rub trees and captures of live specimens. From the results obtained, it seems clear that rub trees represent a promising complement, and a potential alternative, to sampling with bait traps (Tiso, 2010).

During 2010, the Forestry and Fauna Service, with the support of a graduate student (Tiso M., here cited for the results of the research) and in collaboration with the Adamello-Brenta Natural Park, coordinated the monitoring of rub trees for the first time. The study was carried out on a total of 73 rub trees distributed fairly evenly within the territory constantly frequented by bears (over an area of about 300 km^2). The sites have been equipped on some sections of barbed wire in order to facilitate the capture of the animal's hair while the bear rubs itself on the plant. Video surveillance was also carried out on some rub trees through the use of camera traps, in order to investigate the behavior of animals near these plants (Groff et al., 2011). Since bears are considered non-territorial animals, with a solitary life for most of the year, the marking of these particular plants could play a fundamental role for intraspecific communication, especially during a very delicate period such as the reproductive one. Some authors (Burst and Pelton, 1983) define them as "information places", suggesting that they may have the same function as the "urinals" of canines (Tiso, 2010). The results obtained through the genetic analysis of the samples showed a strong discrimination in the use of rub trees depending on the sex of the bear, its age class and the season. The use of rub trees occurs mainly during the spring - early summer period (coinciding with the reproductive period) for adult males, while the use by females seems to be much more sporadic and focused more in the autumn months. The younger classes actively use rub trees only marginally: all this suggests that through the use of them individuals can also establish a sort of social hierarchy, so as to avoid direct confrontations (Tiso, 2010).

Picture 6.2 – A rub trees equipped with barbed wire
Credit: Tiso M., 2010

The use of cameras on rub-trees sites made possible to obtain important data on the actual attendance of the same by bears, as well as a series of additional information (variations in the coat, daily pattern of activities, interactions between individuals and between species, congruence between genetic and morphological data, etc.) (Groff et al., 2013).

The monitoring of rub trees can therefore be considered an efficient, safe, flexible, non-invasive and relatively inexpensive method for collecting data useful for estimating the abundance and trend of the investigated population. Another point in favor of sampling carried out on rub trees is that it does not require particular skills or special tools and there are no major risks associated with it if not those of a normal mountain excursion. Currently, the control of rub trees in Trentino is done through opportunistic monitoring.

7. OTHER TYPES OF MONITORING

7.1. Monitoring through veterinary procedures

From 2020 veterinary assistance for bear and wolf captures is guaranteed, through a special agreement stipulated by the Provincial Health Services Agency, by a veterinarian freelance expert in the field of large carnivores.

On the occasion of each anesthesia, both for captures and for specific medical interventions, the bears are subjected to a complete medical examination, anesthesia monitoring and samples for laboratory tests. During the anesthetic surgery, biological samples of different nature are taken: tissue samples for genetic investigations, which will allow the identification of the subject; hair and skin to assess the health of the integumentary system and/or the presence of parasites; ear and rectal swabs to investigate the possible presence of pathogens. A stool sample is also taken for coprological investigations. Also important is the blood sampling which, through a hematological-serological screening, allows to highlight the general metabolic conditions of the animal. The urine analysis completes the medical protocol for managing the bear, both in the wild and in captivity.

Picture 7.1 - Veterinarians at work during a catch
Credit: Zeni M. - Forests and Wildlife Department Archive PAT

The primary task of the veterinarian is to ensure the best possible well-being during all operations, before, during and after anesthesia. Veterinarians must take utmost care in handling bears (reducing tactile, visual and auditory sensitivity of the patient), as well as check that he is not injured during the capture phases. All the maneuvers and the collections of organic material take place without any pain for the animal and without complication on recovery after anesthesia. After a period of monitoring under strict medical supervision, in which the animal regains all its organic functions and full psycho-physical faculties, it is released again in nature. Over the course of 2020, all anesthetic procedures had a favorable outcome and in none of them any problems were reported (Guadagnini R., for '2020 Large Carnivores Report').

7.2. Opportunistic monitoring of predation or damage

The damage done by large carnivores is a good opportunity to collect the organic samples for genetic investigations; they can be fundamental in the damage assessment phase, especially in cases where the operator has doubts regarding the attribution of the animal responsible for the damage. In case of the bear, genetic investigations are also of particular importance in the identification of harmful/problem individuals. The search for organic material, collected and stored in appropriate conditions is therefore to be considered fundamental in the damage assessment phase.

Picture 7.2 - Predation on sheep in Val Ambiez
Credit: Baldessari M. –
Forests and Wildlife Department Archive PAT

The data relating to the organic samples collected on the damage site must be reported in the appropriate damage report sheets.

7.3. Monitoring of reproductive rates by observation of females with cubs

Any report concerning family groups is of considerable importance for the understanding of the dynamics of the populations of large carnivores. In relation to the above, any communication, information or news relating to the observation of family groups must be checked and thorough, as well as promptly communicated to the Wildlife Service (LCD); the compilation of the appropriate form will follow. In any case, it is necessary to carry out an inspection in the sighting /reporting area in order to ascertain the possible presence of organic samples. In these cases, the possible involvement of the bear-dogs team should be evaluated with particular attention to facilitate the search for the samples themselves.

Picture 7.3 - The F20 bear with cub photographed in Val Genova
Credit: Panelatti N. - Forests and Wildlife Department Archive PAT

7.4. Use of 'bear dogs'

The use of bear dogs is also recommended for monitoring activities. Dogs are cared for by specific handlers who take care of their training mainly as deterrent dogs, used for the aversive conditioning of problem bears; they can be used for monitoring purposes and specific research of organic samples at the discretion of the conductor, compatible with the training and according to the criteria contained in the appropriate operating instructions.

Picture 7.4 - Four anti-bear dogs (Russo-European Laika) with conductors
Credit: Groff C., Forests and Wildlife Department Archive PAT

7.5. Monitoring of encounters and interactions between humans and bears

For all cases of reporting of encounters between man and bear in which a direct behavioral interaction takes place (from the escape of the bear to the bluff charge, up to the aggression) and which are reported to the on-call coordinator, the appropriate form is filled in. The coordinator also evaluates the opportunity to carry out an on-site check through the involvement of the emergency team or the staff of the bear-dog team for a detailed reconstruction of the event and for the search for organic samples. This opportunity is a must in case of aggressive bear behavior.

CONCLUSIONS

The procedures used for the monitoring of the Brown bear population has so far allowed to obtain satisfactory and reliable results. The study carried out in this thesis aimed to analyze the application of traditional and non-invasive methodologies used to achieve what, at the moment, are the main objectives of a monitoring campaign: verify the constant presence and define the occupied area, estimate the minimum number of individuals present, ascertain reproductive success, genetically identify the newborn and monitor of problematic behavior, especially when it occurs to the detriment of anthropogenic activities.

The systematic monitoring carried out mainly by using hair traps technique made possible during the last decade to estimate with a good degree of approximation the minimum number of individuals present in the Trentino area. In 2020, specifically, the presence of about a hundred specimens was estimated, once again confirming the success of the reintroduction project and the effectiveness of the monitoring and management carried out so far.

With the help of opportunistic monitoring techniques such as direct sightings, the use of camera traps and the genetic analysis conducted on the biological samples collected, it was possible to ascertain the genetic identification of the newborn bears year after year. Knowing the genetic identity of individuals is also fundamental for the managing of all those bears who are too much confident towards human activities; the intervention of qualified personnel on the site of predation or damage therefore represents a good opportunity for the collection of biological samples that can be used for the identification of these bears that need to be monitored with more attention. The monitoring of these problematic interactions (damage and predation) over time has also made it possible to quantify the bear's influence on economic activities and to undertake a consequent prevention campaign, applying appropriate measures according to specific needs.

In addition to the data collected thanks to opportunistic monitoring, the implementation of a systematic monitoring allows not only to collect useful information for the study of the population at a local level, but also to have standardized data, therefore comparable with those collected in other situations in the Alps.

Therefore the data collected during the monitoring plans conducted so far, results to be effective and adequate to follow and monitor the trend of the Brown bear population in Trentino.

BIBLIOGRAPHY

AA.VV. (2010) - *Piano d'Azione interregionale per la Conservazione dell'Orso Bruno sulle Alpi Centro-Orientali* (PACOBACE). Quad. Cons. Natura, 33, Min. Ambiente – ISPRA.

ANCRENAZ, M., HEARN, A. J., ROSS, J., SOLLMANN, R., WILTING, A. (2012) - *Handbook for wildlife monitoring using camera-traps*.

CANZIANI M. 2011 - *GRANDI CARNIVORI E SPAZIO ALPINO. Il rapporto con le comunità locali al centro della strategia di conservazione*. Report 1/2011. Federazione Nazionale Pro Natura, Torino, 40 pp.

DAHLGREN, D., KOHL, M., & MESSMER, T. (2018) - *What wildlife managers should know when using radio-telemetry data*. Utah State University Extension. Natural Resources. 2018-02pr.

EUROPEAN COMMISSION, DIRECTORATE-GENERAL FOR ENVIRONMENT, SUNDSETH, K. 2008 - *Natura 2000: protecting Europe's biodiversity.* European Commission

FATTORI U., RUCLI A., ZANETTI M. (a cura di) 2010 - *Grandi carnivori ed ungulati nell'area confinaria italo-slovena. Stato di conservazione*. Regione Autonoma Friuli-Venezia Giulia, seconda edizione rivista, Udine: 1-80.

GROFF C., BRAGALANTI N., RIZZOLI R., ZANGHELLINI P. (editors) 2011 - *2010 Bear Report,* Forestry and Wildlife Department of the Autonomous Province of Trento.

GROFF C., BRAGALANTI N., RIZZOLI R., ZANGHELLINI P. (editors), 2013 - *2012 Bear Report*, Forestry and Wildlife Department of the Autonomous Province of Trento.

GROFF C., ANGELI F., BRAGALANTI N., PEDROTTI L., ZANGHELLINI P., ZENI M. (editors), 2021 - *2020 Large Carnivores Report*, Autonomous Province of Trento's Forestry and Wildlife Department.

LINNELL, J.D.C., SWENSON, J.E., LANDA, A. & KVAM, T. 1998 - *Methods for monitoring European large carnivores - A worldwide review of relevant experience*. NINA Oppdragsmelding 549: 1-38.

MAZZONI, N. – 2016: Tesi di laurea in Tecnologie Forestali e Ambientali. "*Risultati preliminari relativi all'utilizzo di collari GPS per il monitoraggio degli orsi in Trentino*." Università degli Studi di Padova, dip. Territorio e sistemi agro-forestali a.a. 2015-2016

MOLLOY, S. W. 2018 - *A Practical Guide to Using Camera Traps for Wildlife Monitoring in Natural Resource Management Projects*.

MUSTONI A. 2004 - **"***l'Orso bruno sulle alpi. Biologia comportamento e rapporti con l'uomo.*" Nitida immagine Ed., Cles (TN), 236 pp.

OSTI F. 1994 - *L'orso bruno. Per quanto tempo ancora in trentino?* Ed. Arca, Trento, 279 pp.

TISO M. - 2011: Tesi di laurea in scienze forestali e ambientali "*I grattatoi (rub trees): sperimentazione di una nuova metodologia per il monitoraggio genetico dell'orso bruno (Ursus arctos L.) In Trentino."* Università degli studi di Padova facoltà di agraria tesi di laurea in scienze forestali e ambientali a.a. 2010-2011.

WITMER, GARY W. 2005 - *Wildlife population monitoring: some practical considerations*. USDA National Wildlife Research Center - Staff Publications. 70.

SITOGRAPHY

http://www.grandicarnivori.it/

- "*Distribuzione dell'Orso bruno in Italia*"
- "*Modello riproduttivo dell'Orso bruno*"
- "*Graffi e morsi su tronchi*"

http://www.territorio.provincia.tn.it/

- "*Cartografia Sistema aree protette del Trentino*"