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RESEARCH ARTICLE

Sharing Landscapes with Wildlife: Conflict and Coexistence of Extensive Grazing Systems with Large Carnivores

What does coexistence mean? Insight from place-based trajectories of pastoralists and bears encounters in the Pyrenees

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Abstract

1. The recovery of large carnivores in Europe raises issues related to sharing landscape with humans. Beyond technical solutions, it is widely recognized that social factors also contribute to shaping coexistence. In this context, scholars increasingly stress the need to adopt place-based approaches by analysing how humans and wildlife interact and co-adapt in specific landscapes. In the burgeoning field of 'more-than-human' geography, both humans and non-humans are considered as co-constitutive of places. According to this tradition, animals should not simply be seen as objects under human control but approached as powerful actors in multi-species landscapes.
2. By tracking how brown bear recovery in the French Pyrenees has shaped different places of encounters with pastoralists (i.e. farmers and shepherds in extensive sheep farming in mountain pastures during summer), this paper discusses what coexistence means when viewed through the lens of more-than-human geography. We use an in-depth, retrospective and multi-sources approach to describe the inter-relationships of bears and pastoralists on three mountain pastures since the return of bears at the end of the 1990s. Semi structured interviews, participant observation, administrative and institutional data about bear depredation and genetics, as well as pastoral practices form the basis of an integrated narrative analysis.
3. Our study reveals how the return of a large carnivore has produced three different, singular, context-specific coexistence 'patches'. Each of these three pastures represent a distinct landscape dynamically shaped over time by bears, pastoralists and the rest of biotic and abiotic environment.

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4. Specifically, we demonstrate how various factors—the individual behaviour of bears, their movement and reproduction capacity, the number of depredations, the pastoralists' histories, their collective organization, the choices they made, the pastures' features, the available resources and surrounding vegetation—cumulatively intertwine in complex, place-specific entanglements.
5. *Policy implications.* Our results suggest that coexistence should not be conceptualized as global, top down and standardized. Instead it is shaped by patches in which humans and non-humans interact in specific ways. Therefore, fostering coexistence means acknowledging the full diversity of situations in which people and wildlife write their own place-based, more-than-human histories.

KEYWORDS

bears, coexistence with large carnivores, extensive sheep farming, more-than-human geographies, place-based trajectories

1 | INTRODUCTION

On the 19 of May 1996, Ziva, a 6-year-old brown bear *Ursus arctos* female captured the day before in Slovenia, was released in Melles, a municipality in the central part of the French Pyrenees. As a starting point of an ambitious population reinforcement program promoted by the European Union, this event followed a dramatic decline of the species in the area during the 20th century (de Marliave, 2008). Almost 30 years later, and after 10 more translocations of Slovenian individuals in France and 1 in Spain (Quenette et al., 2019), the bear population in the Pyrenees is now estimated at about 80 individuals and shows an increasing dynamic which offers optimistic perspectives to conservationists (Sentilles et al., 2024). The recovery of the bears, however, is not without challenges. As in other parts of Europe, the return of large carnivores, whether reintroduced or not, has been associated with conflicts with humans, particularly with livestock husbandry practices (Bautista et al., 2017). Indeed, bears, wolves *Canis lupus*, wolverines *Gulo gulo* or lynxes *Lynx lynx* do not care about borders. Beyond protected areas, they also spread in human dominated landscapes (Chapron et al., 2014). Through the incursion of the wild into human and domesticated territory, large carnivores transgress the nature-culture divide, and question our ability to share common spaces with other beings (Morizot, 2016).

Large carnivores pose perceived or real threats to human life and livelihood (Bombieri et al., 2023; Dorresteijn et al., 2016; Lamb et al., 2020). Over the past decades, scholars have made important efforts into understanding how to reduce human-wildlife conflicts as well as to foster coexistence (Hovardas, 2018; IUCN SSC Guidelines on Human-Wildlife Conflict and Coexistence, 2023; Lorand et al., 2022). Coexistence has been defined as 'a dynamic but sustainable state in which humans and large carnivores co-adapt to living in shared landscapes' (Carter & Linnell, 2016). It is not only about ensuring long-term carnivore population persistence but also requires building social

legitimacy (Sandström et al., 2018) and tolerable levels of risk and damage for humans (Skogen et al., 2017). Beyond technical solutions to mitigate carnivore-related risks, scholars in the field stress the need to understand the complexity of the social and cultural factors shaping coexistence (Pooley et al., 2017). Human tolerance towards carnivores is not only related to the experience of damage, but also to social, cultural, cognitive and emotional factors (Dickman et al., 2014; Kansky et al., 2014; Sjölander-Lindqvist et al., 2018).

In line with this, recent studies argue that coexistence strategies need to be addressed at the landscape level to account for the context-specific conditions in which cultural values and environmental conditions intertwine (Durant et al., 2022; Gao & Clark, 2023; Killion et al., 2021). As suggested by Pooley (2016), 'it is not sufficient to take a generic technical view "from nowhere," but it is rather essential to take a place-based view "from somewhere"'. Places, however, are not simply physical spaces. They are contact zones (Haraway, 2008) where humans and non-humans overlap along biological, cultural and political dimensions (Aisher & Damodaran, 2016), and whose specificities must inform place-based conservation (Williams et al., 2013).

By tracking how the return of bears in the Pyrenees has shaped different places of encounters with pastoralists, this study aims to discuss what coexistence means through the lens of 'more-than-human geographies' (Whatmore, 2008). Within the realm of the social sciences, researchers have analysed the relationships between humans and bears in the Pyrenees, comparing for example the divergent impact of bear recovery on pastoral practices in Spanish and French areas (e.g. Pons-Raga et al., 2021). Benhammou and Coquet (2008) discussed the impact of bears on humans in light of other socio-economical constraints. Quite a few have also focused on the meanings, opinions and perceptions attributed to bears by different social groups, in particular farmers (Ballarín et al., 2023; Herrero et al., 2021; Piédallu et al., 2016).

The challenge is to assess human-wildlife coexistence in a way that does not render invisible the animals themselves. By revealing how

individuals of bears and humans interact and intertwine along place-specific trajectories (i.e. each place follows its own evolutionary path, influenced by a combination of local and global factors and shaped by its unique set of circumstances), we believe that more-than-human geography can offer complementary insights to these human-dominated perspectives. Indeed, more-than-human approaches acknowledge that humans interact not only with individuals of their own species but also with plants, animals and objects. This of course does not mean that non-humans have agency in an intentional or rational way, but rather that they contribute to shape the world through the relational networks in which they are involved (Arnold, 2020; Latour, 2005).

Following this 'more-than-human' turn (Barua, 2016), animal geographers have begun to view animals as active participants in the production of interactions that constitute places (Bear et al., 2017). Building on Philo and Wilbert (2000) insights, they have acknowledged that prior research has mainly concentrated on 'animal spaces', where humans organize and oversee animal life and stressed the need to emphasize the 'bestly places', where animals exist not as mere objects under human control but as entities with their own lived geographies and experiences of the world.

However, a key challenge remains in finding empirical ways to study such co-produced multispecies landscapes (Hodgetts & Lorimer, 2015; Pooley, 2016). Animal geographers have thus proposed cross-disciplinary approaches that combine social research methods, such as multispecies ethnography, which take lives beyond the human sphere into consideration, with natural science research tools that provide opportunities to track animal spatialities (Doubleday, 2018; Evans & Adams, 2018; Van Patter, 2022).

This article focuses on three distinct summer pastures in the French Pyrenees, as landscape units in which bears and pastoralists came to interact in the wake of the bear population reinforcement program. Combining different sources of information including individual identification of bears with genetic, administrative data on farming practices, depredation reports and interviews, we adopt a narrative approach to highlight more-than-human histories. We describe the trajectories of the three pastures over the last 20 years as singular, complex and dynamic entanglements involving different bears, pastoralists (i.e. shepherds and sheep farmers) and sheep in their environments. Based on these findings, we discuss the importance of considering how localized patches where humans and non-humans interact in distinct ways, can illuminate the emerging concept of human-wildlife coexistence.

2 | MATERIALS AND METHODS

2.1 | Human and bear relationships in the French Pyrenees

While being one of the last refuges of brown bears in south-western Europe over the last centuries (de Marliave, 2008), the Pyrenees mountains have also long hosted traditional pastoral activities (Eychenne, 2006). Beyond their cultural and economic importance,

these activities, have contributed to shape most of the current Pyrenean landscapes (Chandivert, 2010; Gibon & Balent, 2005). Although bears and humans in the Pyrenees have a long history of sharing landscapes, this relationship has never been peaceful. After decades of systematic killing of bears coupled with habitat loss, the bear population plummeted from an estimated 400 individuals at the beginning of the 20th century to near extinction at the end of the 1990's (de Marliave, 2008).

However, with the rise of environmental concerns, the status of large carnivores changed. Considered critically endangered in France, the brown bear is listed in the European Union's Habitats Directive as a species that requires strict protection, and which requires Member States to take actions to return the species to 'Favourable Conservation Status' (Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora). When the French population reinforcement program started in 1996, only five relict individuals, including one last female, remained in the western part of the Pyrenees (Taberlet et al., 1997). In total, 12 individuals have been released between 1996 and 2018, mostly in the central part of the French Pyrenees (Quenette et al., 2019). In 2023, the Pyrenean bear population was estimated at a minimum of 83 bears (Sentilles et al., 2024).

Despite this relative success however, the return of bears in France did not follow a peaceful pathway. Often perceived as a top-down policy imposed by the EU and the centralized French State, it is still subject to multiple controversies, mainly confronting farming organizations with environmental NGOs and/or the French Ministry of the Environment (Benhammou & Coquet, 2008). Bear depredation on sheep within the summer season is the cornerstone of the conflict (Ballarín et al., 2023; Gastineau et al., 2019; Herrero et al., 2021). In the French Pyrenees, from the end of the spring until early autumn, pastoralists, collectively organized through officially recognized pastoral groups (PG), move their cattle and sheep to medium and high-altitude mountain pastures ('Pasture' here refers to an officially delimited landscape units used by a given pastoral group during the summer season). After several decades with a near total absence of predators, the return of bears automatically required far-reaching adaptations which imposed serious constraints on pastoralists.

2.2 | The study areas

This study is part of a four-year research project called 'Pastoralism and Bears in the Pyrenees' that aims to focus on the concrete, micro scale of three summer pastures to understand how bears and pastoralists co-adapt following different trajectories.

Our study focuses on three pastures located in the central part of the Pyrenees (Figure 1) within the Regional Natural Park of 'Pyrénées Ariégeoises' and overlapping with sites within the EU Natura 2000 network. While farming practices in the area are mainly oriented towards raising sheep for their meat, the region also hosts the core Pyrenean population of brown bears and is particularly impacted by sheep depredation (Gastineau et al., 2019).

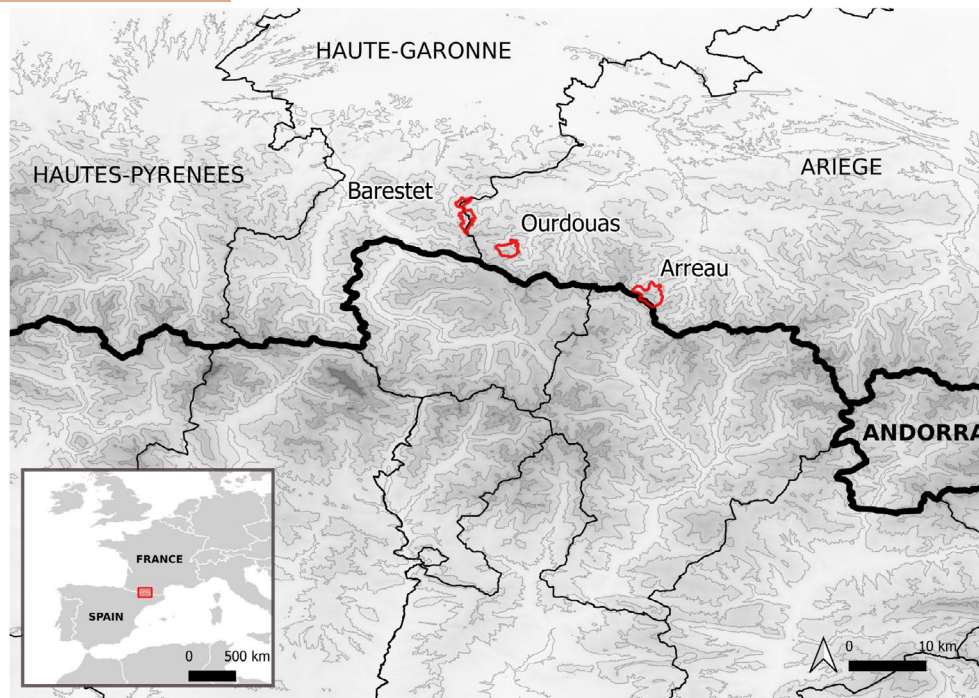


FIGURE 1 Location of the three study sites in France close to the Spanish border. The map also shows districts delimitation of both countries.

All three pastures belong to the State and are used by pastoralists during summer season only. Pastoralists have a collective management through PGs. PGs are mainly composed by farmers who own flocks and employ one or more shepherds to take care of the herd during the summer season. The pastures were selected based on their location, the confirmed presence of bears, and the motivation of the PG to participate in our study. In the three PGs, farmers mainly raise sheep of local *Tarasconnaise* breed. Although we acknowledge that these pastures are obviously not fully representative of the entire diversity of bears-farmers interactions within the Pyrenees, our point here is rather to build on their specific trajectories to illustrate the need for a place-based approach of coexistence.

Located at the lowest altitude, the Barestet summer pasture has an area of 670ha. It has a relatively elongated shape along a ridge linking the two highest points at respectively 2150 and 1670m. The lowest areas of the pastures are located at around 1100m. Although heaths *Erica* sp. dominate the landscape, this pasture is the most forested among our three study sites, with the presence of deciduous (dominant beech *Fagus sylvatica* and oaks *Quercus* sp.) and coniferous (dominant silver fir *Abies alba*) trees. In addition to 900 sheep, a herd of 60 horses also graze most of the area. Nearby vehicle tracks, accessible terrain, open cabins and hiking trails result in the pasture being regularly frequented by both hikers and hunters.

With 530ha, Ourdouas is the smallest selected summer pasture. Its altitude ranges from 1050 to 2420m. Dominated by one summit in particular, the rather steep landscape includes large scree and heaths areas but also beech and hazel *Corylus* sp. forests and grassy meadows. In addition to 700 sheep, 25 cows, a few horses

and donkeys usually graze this area. Infrequently used by hikers, the pasture is nevertheless valued by hunters who appreciate its wilderness and the availability of an open cabin.

Arreau is located next to the Spanish border. With 890ha, it stands as the largest summer pasture among our study sites. It ranges from 1350 to 2470m in altitude with several summits exceeding 2000m above the sea. The relief is varied, with rocky bars, scree, and sometimes very steep slopes but also creeks and rivers with variable flow and a permanent pond. Landscapes are dominated by heaths and grassy meadows with almost no forest. In addition to 1800 sheep, around 100 horses, donkeys and cows also graze most of the area. Hiking and mountain biking are quite frequent activities due to a vehicle track crossing the pasture, the presence of open cabins and a Trans-Pyrenean hiking trail passing through.

2.3 | Data and analysis

More-than-human geographies necessitate methodologies that enable geographers to approach animals more closely (Hovorka, 2020) and to investigate how they co-constitute the world alongside humans. In this study, we address this challenge by mobilizing different sources of information collected through a range of approaches spanning from social to ecological sciences. The focus is on the shared human/bear histories of the three pastures since the return of the carnivore, particularly between 2000 and 2021.

Three complementary types of data were collected. First, qualitative information regarding historical operational decisions made by pastoralists on the three pastures as well as their experience

of bear population development and individual habits were collected through an ethnographic study from 2019 to 2023. Within the framework of the 'Pastoralism and Bears in the Pyrenees' research project, it encompassed participant observation of herding practices within the three pastures, pastoral group organizational meetings, bear scaring missions conducted by the *Office français de la biodiversité* (OFB), annual meetings of the Brown Bear Network driven by the OFB, as well semi-structured interviews with 8 livestock owners, 6 employed shepherds and the OFB expert in charge of the bear monitoring program. In particular, the survey exhaustively included all shepherds from the pastures as well as all livestock farmers who are presidents of PGs. Other farmers were also interviewed based on their significant involvement in PGs. The OFB expert was chosen for his long-standing experience both in terms of field observation and data analysis. In particular, he knows each of the three pastures very well and has followed individual bears in the study area for the last 20 years. Participants gave informed consent to participate, and the *Centre National de la Recherche Scientifique* (CNRS) has formally approved the study. For ethical reasons, the informants have been pseudonymized. Using an iterative process to engage deeply with such qualitative material, the fully transcribed interviews and the field notes from participant observation were subjected to a thematic analysis (Aronson, 1995). This means that we identified themes that allowed mapping chronological specificities and divergences among the three pastures regarding bears and pastoralists interactions and adaptations.

Second, based on the Common Agricultural Policy farmers declaration, administrative data from the Ministry of Agriculture allowed us to retrace, for each of the three pastures, the annual development of the numbers of pastoralists and sheep present, of the surface area grazed as well as the implementation of the different EU funded protection measures such as shepherds, guarding dogs of the traditional and local breed *Montagne des Pyrénées* and night-time enclosures.

Third, information on bear depredation was extracted from the national database on depredations held by the Ministry of Environment in charge of compensating livestock damages to farmers in case of bear attack (database Géopred/DREAL AuRA/ASP). Information on the bears' individual identities was extracted from the database of the French bear monitoring program (database BDROB). Despite records of bear presence, this program also includes genetic identifications of individual bears based on biological samples (hairs, scats) collected from transects and sites where attacks occur (Vanpé et al., 2022). It is important to note, however, that not all collected samples have been analysed due to funding issues. Such data were thus used to identify some of the bears passing through each pasture rather than to estimate their full numbers.

All data were combined to construct narratives that retrace the distinct trajectories of each pasture. Following recent studies such as the one conducted on coyotes *Canis latrans* by Van Patter (2022), this storytelling approach was intended to reveal how the human and bear histories specific to each pasture have shaped distinct patches of coexistence. The spatial data (e.g. depredations, delimitation of pasture areas, certain protection measures) were mapped

using the Geographic Information System QGIS, version 3.26 (QGIS Development Team, 2022).

3 | RESULTS

3.1 | Pastures as places for sheep, humans and bears

Except when he left the area for a couple of years, Gustave has always been the president of the Barestet PG since its official creation in the 1990s. And like his parents before him, this septuagenarian sheep farmer moves his herds every summer to this mountain pasture.

Gustave still remembers when he first understood that bears passed through 'his' pasture. It was in 1996, just after Pyros, Melba and Ziva, one male and two females from Slovenia, were released a few kilometres from there. From that point onward, the presence of bears steadily increased and became permanent.

It used to happen sometimes. There was at least one passage in September, it was passing through in September. One passage. Well, it was doing damage when it passed, but it was not like now. Now it is constantly around.

(Gustave, farmer and president of the PG, Barestet, 2022)

Indeed, according to the various field signs found by Victor, an expert in charge of the bear monitoring program for the OFB, bears started to be regularly present in the area after the second translocation in 2006 (Figure 2). Since then, a total of four females and six males have been detected on Barestet. Among them is Hvala, a Slovenian female first detected in the year of its release in 2006, and followed by its cubs, Pollen, Callisto and Gaïa, born in 2007, 2011 and 2013, respectively. Others include the translocated males Pyros, Balou, Goiat, as well as Néré, Bonabé and Boet, the direct offspring of the first translocated females, and their own cubs (Figure 2).

The number of individual bears detected in Barestet is lower than in Arreau and Ourdouas. According to Victor, together with the fact that the pasture is situated at the edge of the bear's Pyrenean range, this can be attributed to the unfavourable habitat conditions on this pasture, especially for females with cubs. Indeed, while tranquil areas like forests on steep slopes are situated at the periphery of the pasture itself, the only feeding areas are a blueberry *Vaccinium myrtillus* patch and an oak *Quercus* sp. grove on the low-altitude eastern and western parts of the pasture. Ultimately, as expressed by one of the latest employed shepherds, Louis, the Barestet is more 'a transitional area, a crossroad' (Louis, shepherd, Barestet, 2022), due to the high density of forests surrounding it.

Over the last decade, the PG's dynamic began to decline. The number of sheep farmers using the pasture decreased from 11 in 2015 to 5 in 2021. Simultaneously, the size of the herd declined from 1500

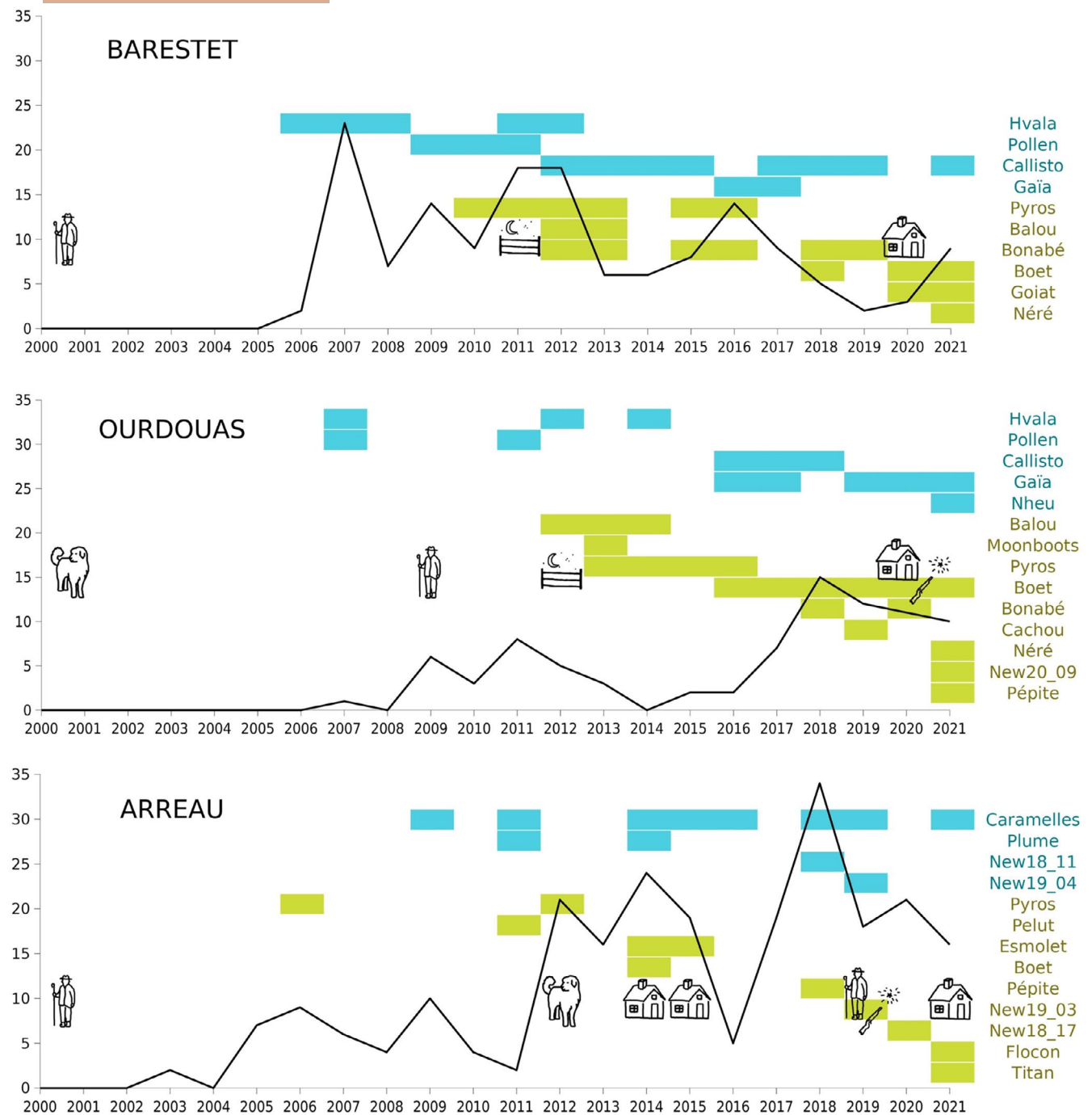


FIGURE 2 Development of bear depredation, individual bears detected, and implementation of herd protection measures on the three pastures. The number of bear attacks is represented by the black line (non-confirmed depredation events were not considered here) and indicated in the y axis. Bear names are written on the right, in blue for females and in green for males, and their presence is shown by coloured years. Pictograms represent the introduction of the herd protection measures: Shepherds/night guards, livestock guarding dogs, night-time enclosure, scaring team from the OFB and huts. Pictograms on the extreme left of the graph mean that the given protection measures were already present at the start of our study period.

sheep in 2012 to 940 in 2021. The PG had to adapt to a regular turnover with a high number of non-local farmers coming from the lowland plains. Today, Gustave acknowledges that the forage resource would be sufficient to support a bigger herd and more farmers. But, because of the presence of bears, he does not advocate for that development.

If I move one thousand sheep up there, it's because they can live correctly. Why should I move 500 more? To bring back dead bodies? It's not worth it.

(Gustave, farmer and president of the PG, Barestet, 2022)

Long before the arrival of bears, the PG had always employed a shepherd to supervise the herds on the pasture, and the turnover of shepherds has always been a major issue. As Gustave mentioned, it takes time to get to know 'the mountain', making it a challenge when a shepherd leaves after only 2 or 3 years. This might explain why the PG tried to hire a second shepherd in 2021, benefiting from new public funds directly linked to bear presence. The idea was to make Louis, the shepherd of the PG from 2018 to 2022, more comfortable, by allowing him to take days off as well as to feel less alone in the daily work. However, this did not work mainly because the pasture was then equipped with only one pastoral hut unsuitable for accommodating two people.

A few kilometres south, the dynamic of the Ourdouas PG, established in 1993, was quite different. In this area, the number of farmers has always been stable at around 8 and the herd size increased from 390 in 2007 to 690 sheep in 2015 before fluctuating around 600 until 2021. Sheep farmers know each other well and value more than others a collective management of the pasture. In this regard, Léandre and Eliane, a couple living next to the pasture and moving their sheep there for more than 40 years, played a key role by ensuring experience transmission and continuity despite the natural turnover of farmers in the PG. And this is not only true regarding the daily use of the mountain, but also in terms of the herd composition itself. Indeed, all young farmers that joined the collective over the last decade, bought part of their cattle from Léandre and Eliane. As many of them testified, such continuity, ensures to keep a herd that is united and familiar with the area.

Bears appeared on the pasture the year of the second release in the Pyrenees, in 2006 (Figure 2). Although nearly all individual bears detected in Barestet have also been found in Ourdouas, one additional female and four additional males were identified here, including two descendants from Caramelles (a female born in 1997 from the first bears translocated to France, also detected in the Arreau pasture) and three from Hvala (a female Slovenian bear released in 2006 in France). Among our three study sites, Ourdouas is thus the pasture with the largest number of bears detected (Figure 2). And this, according to Victor, can be explained by different factors. Firstly, the presence of steep and inaccessible slopes and the high density of blueberry fields makes this pasture a particularly suitable place for bear reproduction and explains why Hvala resided there between 2007 and 2014 followed by Callisto and Gaïa who also raised their cubs in this area since 2016 (Figure 2). Second, due to its position near two mountain passes, the pasture is also a transition area, that enables bears, especially males with much larger territories than females, to cross from one place to the other.

Compared with the two other pastures, Ourdouas PG did not have any resident shepherd before the return of the bears. Rather, the farmers took turns to regularly visit their cattle that were freely ranging on the mountain. However, soon after the arrival of bears in 2006, such practices rapidly became unsustainable. The PG first called on the temporary shepherds provided by the 'Pastorale Pyrénéenne', an NGO entirely funded by the Ministry

of the Environment to help pastoralists protect their flocks. But in 2009, they finally hired their first permanent shepherd (Figure 2). Aurélien kept the position for 7 years before he joined the PG as a sheep farmer in 2017. This was just after a new hut, exclusively designated for shepherds, was built next to the historical one which also serves hikers. After a short period with a shepherdess for one season, Alex, a shepherd who had experienced wolf depredation in the Alps, arrived in 2018 and stayed until 2022. Alex, like his predecessors, could count on the full support of the sheep farmers when he needed help or days off. Indeed, they all knew well the mountain and how to herd.

Further to the east, the Arreau pasture provides a very different perspective. Since the 1990's, the sheep herd has always been guarded by an employed shepherd. Georges was one of them and, following his arrival, the size of the flock rapidly increased, from 700 sheep in 2002 to 1800 in 2007.

Located in the core of the Pyrenean brown bear range, the large surface area of the pasture brings together all characteristics associated with the presence of bears including a low level of human presence on some parts, a high density of foraging habitats, resting areas and steep forests, as well as several mountain passes towards the Val d'Aran in Spain and neighbouring pastures. When talking to farmers and shepherds in Arreau, one bear in particular seems to have made quite an impact: Caramelles, the female born in 1997 from the first bears translocated to France. It was detected for the first time in Arreau in 1999 and, of the total of 12 bears detected on the pasture since then, eight were its descendants (Figure 2). According to Victor, thanks to the philopatric lifestyle of bears, the reproduction of this single female explains the rapid increase in local bear density in the area. After 22 years of presence in Arreau, late in the Autumn of 2021 Caramelles was killed by a hunter close to the pasture, during a wild boar *Sus scrofa* hunting.

Over this time period, the size of the flock constantly decreased from 1800 sheep in 2007 to less than 800 in 2016. But things changed when Arthur, a sheep and cow farmer living in the valley, took the lead of the PG in 2016. Arthur's approach was to welcome new young farmers and to expand the PG: 'My conviction is that I don't want to limit access to the mountain to others, because I have been fighting to make this mountain accessible' (Arthur, farmer and president of the PG, Arreau, 2021). This strategy might also be directly related to a major change in the EU's Common Agricultural Policy which, since 2015, started to take into account the surface of the collective summer pastures used by farmers when calculating their annual financial support. Thus, as a possible consequence, the number of farmers increased from 11 in 2015 to 15 in 2021, the grazing area increased from 1000 to 1400 ha and the flock size more than doubled to reach 1600 sheep in 2021. A progressive turnover has led the PG to be now composed of both old and young farmers, some of which come from quite far away from the area.

Due to the combined effect of a larger herd and the increased presence of bears, Arthur also pushed to reinforce the shepherd team. When Georges left in 2019, the PG directly hired Anna and Julián, a couple from Spain, and then created a third position in 2022.

3.2 | Frictions and adaptations

Inevitably, the arrivals of bears led to the first depredations on sheep, which were observed in 1996 in Barestet, in 2007 in Ourdouas and in 2003 in Arreau. Since then, following the official report from the French Ministry of Environment, at least 237 attacks (resulting in 353 dead sheep) were recorded in Arreau, 85 (112 dead sheep) in Ourdouas and 155 (183 dead sheep) in Barestet. However, the annual pattern of attacks is highly unpredictable for each pasture (Figure 2). As Lucas, one of the pastoralists from Ourdouas PG, mentioned:

For me, there is no rule. The bear can attack you anytime and leave you in peace anytime: there's no rule. Among the seasons that I have experienced as a shepherd with the bears, there's not one that looked alike.
(Lucas, farmer, Ourdouas, 2021)

Such depredations have inevitably forced the different PGs to adapt their herding practices. Beyond the recruitment of shepherds in some of the pastures, overall, pastoralists made efforts to be closer to their flocks. Herding practices have changed from what they called *en escabot*, where several small units of sheep freely graze in separate areas, to *à bâton planté*, where a consolidated flock is constantly herded by a shepherd. Each PG has also established weekly health monitoring sessions in which shepherds and farmers get together to count the sheep, to treat them, to cure foot rot, to isolate ewes with newly born lambs but also to discuss general issues related to their work.

Despite these common dynamics, each pasture has also followed its own trajectory. In Barestet, the PG has faced a sudden increase of depredations in 2007, a level that stayed quite high until 2012 (Figure 2). For Victor, this could be due to the presence, in that time period, of Hvala and Pollen with their litters. According to him, females with offspring tend to be more predatory than females without cubs. They may attack more often, but also kill more sheep per attack.

The expert also assumes that the decrease in terms of depredations in 2012 could be explained by a change in bear presence. He remembers that Pollen lost her cub in 2011, then disappeared and was never detected anymore in the entire Pyrenees. Other factors may also come into play. For example, 2011 was the year where the PG installed a night-time enclosure as its main strategy to protect the flock (Figure 2). This 2-ha area is surrounded by electrified fences and placed next to the main historical sleeping area for sheep, which was also the most predated zone since the return of bears. It is located close to the shepherd hut, under a ridge, protected from the wind and includes a small area of woodland where the sheep can take refuge in case of bad weather (Figure 3). Although its particularly large size remains a challenge in terms of fence maintenance, the PG members justify it by the need to avoid soil degradation and preserve the grazing resource inside, and to prevent foot rot. Since then, as expressed by Gustave, 'as long as they [the sheep] were in

the enclosure, there wasn't any trouble' (Gustave, farmer and president of the PG, Barestet, 2022).

Despite a decrease from 2013 onwards, depredations have not stopped entirely (Figure 2). They have shifted spatially and largely spread to the non-protected sleeping places of the Barestet pasture in Bazet and Cap de Gauch respectively at the north and south of the pasture (Figure 3). In these areas, and especially in the latter due to the rugged terrain, the construction of a fenced enclosure was not feasible. However, an alternative recently arose when, in 2020, the Ministry of Agriculture offered PGs in the bear range the opportunity to instal temporary wooden shelters on the pastures entirely funded by the State and helicoptered at the beginning of each summer season (Figure 2). The Barestet PG installed one of them in each of the two unprotected sleeping places (Figure 3). Such equipment allows a night shepherd's presence close to the herd but also improves his working conditions by reducing walking time every day and/or replacing the camping tent he used to pitch there.

Other parts of the Barestet pasture can be considered of high risk in terms of depredation but are still utilized because of their high value in terms of foraging resources. For instance, the area in the western part of the pasture (Figure 3) is often used at the start and end of the season because of its rich meadow. But the flock must pass through a forest to reach it and when the weather is bad, isolated groups of sheep that have been separated from the flock have to spend the night there, facing a higher risk of attack.

Until now, the Barestet PG has not wanted to introduce livestock guarding dogs. The farmers consider them ineffective for protecting the herds and think they can pose risks to other mountain users, such as hikers and hunters. They have furthermore refrained from seeking assistance from the OFB's bear scaring team that has been available since 2019 for the most heavily predated pastures. Beyond the poor relationship between the Barestet PG and the OFB, mainly because the farmers believe that the scent baits used by the OFB to monitor bears could increase their presence on the pasture, Gustave also doubts the efficiency of the bear scaring team. In his own words, he does not want to 'send' bears to his neighbours' pastures.

Thanks to Léandre and Eliane, the Ourdouas PG has been using *Montagne des Pyrénées* livestock guarding dogs long before the first bear depredation events, mainly to protect the herd against stray dogs. Soon after the first depredations in 2007, however (Figure 2), pastoralists understood that dogs alone could not be fully efficient. As Eliane reported: 'Since there wasn't any shepherd, the sheep were not guarded, they were not gathered every night. The dog was staying with only a part of them. It was not necessarily where the attack was' (Eliane, farmer, Ourdouas, 2019).

Hired in 2009, Aurélien clearly remembers he had a hard time protecting the herd and identifies one female bear in particular as responsible: 'On a particular period, we had Hvala. For all my depredations, it was Hvala with her cubs. We knew it. My first years, it was very clear. She was the one making the mess' (Aurélien, former shepherd, Ourdouas, 2019).

Aurélien had to teach the flock to be gathered. This involved in particular to create daily herd trajectories over the pastures and

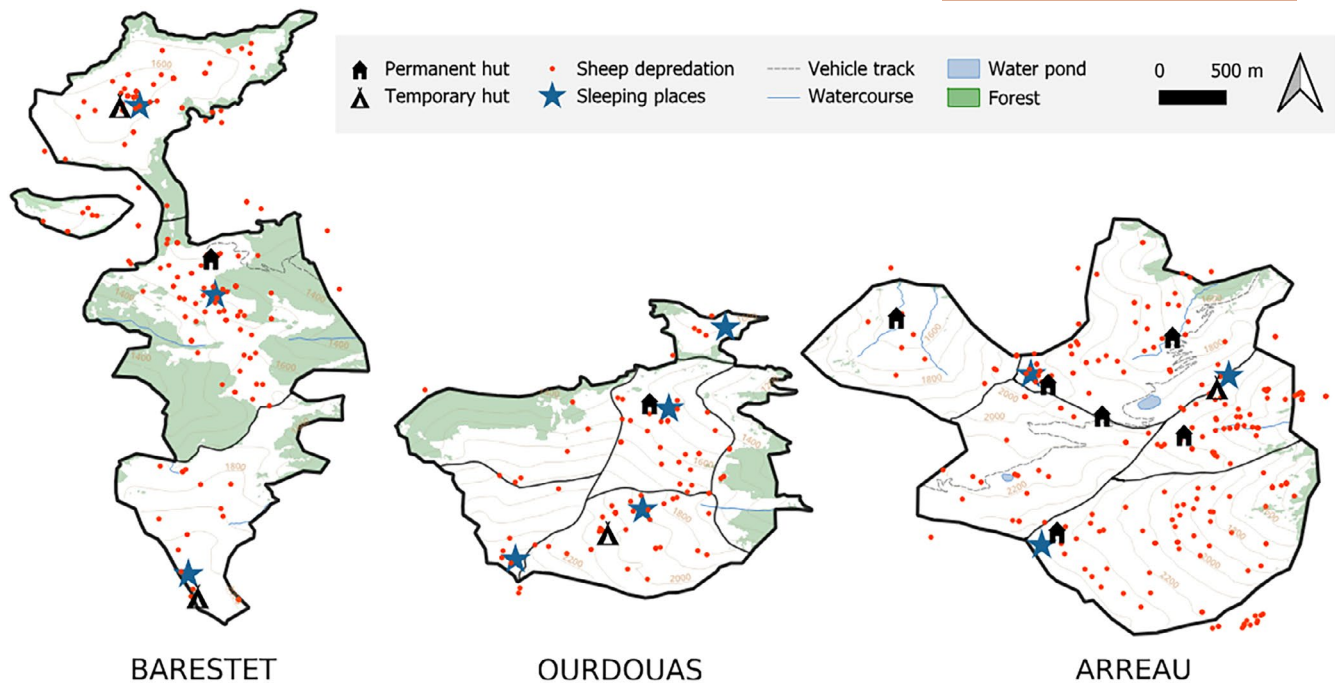


FIGURE 3 Spatial distribution of bear attacks, pastoral huts and sleeping places among the three pastures. Limits within the pastures indicate the different sections as used by the pastoralists.

ensure the sheep slept in the same area to facilitate the herd management according to the season and the available grazing resources.

He created one sleeping place in Col des Cos, where the pastoral hut was, but also maintained those in Pic de l'Har, Léat and Coume d'Ourdouas that were used 'naturally' by the sheep. Aurélien remembers that, at that time, he also tried two additional places in two different sections of the pasture but finally had to give up because of the high number of bear attacks. In 2012, the PG decided to instal a fence next to the hut to help to concentrate the sheep at night (Figures 2 and 3). Designed to constrain the natural behaviour of sheep to walk uphill while eating, this crescent shaped fence is only closed on the upper part and is fully open on the lower part from where the sheep enter.

After a constant decrease between 2011 and 2014, the number of attacks went up again and reached its maximum in 2018 (Figure 2). This roughly corresponds to the period when Pollen and Hvala were succeeded by Callisto and Gaïa with their cubs in the area (Figure 2). Alex, the shepherd between 2018 and 2022, remembers that night in 2021, when a female bear killed seven sheep at once, and assumes that it was Gaïa 'training' her cubs.

During this period, the PG implemented several new strategies to prevent depredations. The night-time enclosure was electrified in 2019 and the number of guardian dogs increased from 3 in 2015 to 6 in 2023. As in Barestet, from 2020, an annual helicopter-transported shelter was installed halfway between the pastoral hut and the highest sleeping place in Pic de l'Har in the south-west part of the pasture. This arrangement enabled the shepherd to stay longer with the herd, ensuring its surveillance at night (Figure 3). Finally, the PG also called upon the OFB bear scaring team for 21 nights between 2020 and 2021 (Figure 2).

Beyond such active protection of the flock, the PG members also adapted their spatial use of the pasture. Situated in the north of the pasture and surrounded by forests, the sleeping place of Léat has been progressively abandoned since 2018 because of the high risk of attacks. Low-altitude sections in the East and North parts of the pasture—such as Prés des Azias, Jos, Souel, Besset and Coulédoux that were generally used during bad weather and at the beginning and end of the season—were used less. The high density of visual obstacles such as forest edges, dense vegetation or topographic features with 'blind spots' rendered the effective herding of the flock too complicated.

Given the large surface area of the pasture, the level of depredation was relatively low in Arreau between 2003, the year of the first attack, and 2011 (Figure 2). But things changed in 2012 when more than 20 attacks were recorded. Both the OFB expert Victor and the PG president Arthur agree on the particular role played by Caramelles since her arrival in 2009 (Figure 2). While Victor associates the responsibility of this female and her cubs in a large number of attacks according to the DNA samples he collected, Arthur related the damages she caused to her strong territorial attachment—comparing her to previous males that were mainly just passing through.

Montagne des Pyrénées livestock guarding dogs were introduced on the pasture in 2012 (Figure 2) at the initiative of Georges, who was at that time both a farmer and a shepherd. Since then, the pack has rarely exceeded four dogs. The PG members know that this number is quite insufficient given the size of the herd, but several reasons make them reluctant to bring in more dogs. Beyond the risk of accidents with the many other users of the area such as hikers and bikers, the pastoralists are especially afraid of losing their dogs. Indeed, on this pasture, three guarding dogs were killed by bears in 2017 and 2021.

Given the large surface area of the pasture, the PG has instead opted to increase the human presence to ensure that the shepherds can always be close to the herd, especially at night. In 2014, another cabin was built 15 min' drive from the historical one, next to the high-altitude predated areas (Figure 3). Soon after, a second one was built in Berbégué, in the south-east section of the pasture, to allow the shepherd to stay permanently in the area when using this section every other week during the summer. Despite its reputation for being highly predated, this area remains a key foraging resource for sheep grazing and needs to be protected, as other livestock such as cows, horses and donkeys prioritize the flatter areas in the western part of the pasture. Additionally, in 2015, three small wooden shelters were added close to the three sheep sleeping places to allow the shepherds to sleep right next to the herds (Figures 2 and 3). One of them was replaced by a helicopter-transported hut provided by the Ministry of Agriculture after it was destroyed by an avalanche in 2021. In these sleeping places, sheep are never enclosed at night. Aside from a linear electrified fence close to the Courbe's sleeping place in the eastern section of the pasture to dissuade the sheep from spreading out towards the cliffs, night-time enclosures are avoided by pastoralists because of the constraint they represent for sheep grazing at night and the potential risk they pose for creating panic movements.

Following a catastrophic season in 2018 with 34 attacks (Figure 2), the Arreau PG distinguished itself from the other PGs in the Pyrenees by establishing a dedicated night-time guard position in 2019 to support the two existing shepherds (Figure 2). Using the shelters next to the sleeping places, this guard is responsible for monitoring the herd every night and employing simple deterrent methods, such as light and firecrackers, if necessary. Obviously, this move raised questions regarding working conditions and security and the PG rapidly encountered difficulties in recruiting motivated people. In response to the need for supporting this employee and lighten his work, the PG also called upon the OFB scaring team for 29 actions between 2019 and 2021 (Figure 2).

As confirmed by one of the shepherds, except for two *dérochements*, that is accidents where around 20 sheep fell from a cliff following a bear attack in 2020 and 2021, the level of depredations seemed to have somewhat slowed down since 2018 (Figure 2). However, on top of making huge investments to protect the herd, the PG also had to progressively abandon some sections of the pasture, such as Bibet, Aula and the low elevation parts of Berbégué, located in the north-west and eastern parts of the pasture (Figure 3). Their distance from existing sleeping places, proximity to forest edges and steepness make them difficult for humans to access while also being favourable habitats for bears.

4 | DISCUSSION

This study demonstrate how the return of a large carnivore to a specific region has produced new patterns of human-wildlife interactions following distinct, local-scale, place-based trajectories. While

conservation strategies tend to homogenize the world and to render animals inert, we argue that recognizing the full diversity of places or patches where both humans and non-humans co-adapt is key to improving coexistence.

Studying humans-bears interactions at the micro-local scale of three summer pastures represents a great methodological challenge and particularly since each data (genetic, interviews, administrative, etc.), remains quite sporadic. We believe however that, combining different sources of information, the narrative approach proved appropriate for revealing the trajectories of the pastures. When examined through the layers of non-human and human traces, experiences and meanings, these places appears not just as empty shells where different species come to adapt uniformly but rather emerge as complex landscape units, dynamically shaped over time by the interaction between specific individuals—bears, pastoralists and other humans—and their environment.

In the case of bear recovery in the French Pyrenees, the behaviours of individual bears, their movements and reproduction status, the number of depredations, the composition and history of the pastoral groups, their collective organization, the choices they have made, the topography of the pastures, the available resources and the surrounding vegetation have all become cumulatively intertwined in complex entanglements specific to each place. For instance, bears did not arrive at the same time in each pasture, and while they do not seem to stay and reproduce in Barestet, Hvala and Caramelles have played a key role in the bear population dynamics in Ourdouas and Arreau precisely due to their reproduction.

Moreover, while shepherds were already present in Barestet and Arreau when the first bears arrived, only guarding dogs were staying with the flock in Ourdouas. As a protection strategy, the Arreau PG clearly counted on increasing human presence over time. In contrast, the Barestet PG made the choice early on for a fully sealed electric night enclosure, while in Ourdouas, similar fences were left partly open, but fortified by guardian dogs. Additionally, whereas the use of the pasture did not really change over time in Barestet, low-altitude areas surrounded by forest have been progressively abandoned in Arreau, and in Ourdouas, the PG ceased to utilize several sleeping places that were deemed too risky.

This, of course, does not mean that the different pastures have nothing in common. A notable similarity in each pasture's trajectory is the growing use of technical equipment. Cabins, fences, scaring tools, or genetic samples, to name but a few, all contribute to shape coexistence as an 'anthrozootechnical agencement' (Doré & Michalon, 2017), where people, animals, nature and technologies become interconnected in making things happen—simply exerting each their own agency.

Aiming to get a better grip on the global environmental crisis, Tsing et al. (2019) suggested that we should trace how human and non-human histories and socialities shape and become shaped by landscape differences. While the framing of the environmental crisis within the idea of the Anthropocene tends to position the environmental debate as planetary (Bonneuil & Fressoz, 2016), descaling to 'patches' offers an opportunity to observe socio-ecological enactments embedded

within local contexts (Tsing et al., 2024). On that ground, we propose that coexistence be designed and conceptualized as 'patchy'.

Just like conservation strategies, reintroduction projects are too often designed as global, top down and place-less approaches, making it difficult for regional stakeholders to define how a given biodiversity issue should be managed in practice and to provide generic directives to be applied 'in the field'. Our results, in contrast, underline the need for a place-based approach to coexistence, where both humans and non-humans are considered as co-constitutive actors of the spaces they occupy (Pooley, 2016).

Indeed, coexistence is not a universal concept to be imposed on localities as an injunction to cooperate in a peaceful way; rather it is shaped by the specific interactions between humans and non-humans in distinct places. By way of example, depredations, which are often considered to be the key driver of human-wildlife conflicts (Lozano et al., 2019), are never the result of any single isolated factor, be it bear predatory behaviour or an assumed deficiency in farmer adaptation. Instead, depredations are always context-specific and intrinsically caused by a multiplicity of factors (Gibbs, 2020). Understanding how human-carnivore relationships are embodied within specific landscapes is thus key to reducing human-wildlife conflict and improve coexistence.

Thinking with patches does not mean focusing only on micro scale interactions. In our study, the narratives of each pasture revealed how bear-human interactions were also shaped by factors operating at larger scales (funding from the EU, national rules, equipment from the Ministry of Agriculture, the Pyrenean bear's population dynamic, the species conservation status). It is furthermore obvious that the coexistence between Pyrenean pastoralists and bears also relies on processes involving regional, national and continental scale actors.

But thinking with patches does facilitate changing paradigms by increasing a focus on both human and non-human individuals as agents of change. Just as pastoralists are not simply actors in charge of applying broad animal husbandry solutions in order to limit bear depredation, bears are not just objects to be managed but active participants with distinct behaviours and habits (Berezowska-Cnota et al., 2023; Evans & Adams, 2018; Taylor & Carter, 2013). An important point here is that the way bears and humans display agency at the pastures level is quite different. While human individuals' actions within each pasture take place throughout the collective organization of the PGs, bears as roughly solitary animals act much more on their own. Acknowledging the more-than-human agency means paying less attention to communities such as 'species' or 'populations' and focusing more on individual histories and behaviour (Bear, 2011; de Azevedo & Young, 2021; Van Patter, 2022). In short, through their adaptive, context-specific, and complex behaviours, animals themselves contribute to their own conservation (Ampumuza & Driessen, 2021). Of course, individual of bears as well as pastoralists cannot be considered as insulated, but our result shows that within the three Pyrenean pastures, through their specific interactions, they co-produced new geographies and shaped different patches of coexistence (Tsing, 2015). Thinking with patches is thus also a way to highlight the importance

of considering and accepting the world as heterogeneous and diverse. Coexistence is made possible precisely because of the combination of divergent place-based stories. And these stories must be considered as dynamic, never-ending pathways. In the words of Tsing (2015), 'The question of how the varied species in a species assemblage influence each other, if at all, is never settled'.

AUTHOR CONTRIBUTIONS

Alice Ouvrier and Ruppert Vimal conceived the ideas. Alice Ouvrier and Ruppert Vimal designed the methodology. Alice Ouvrier collected and analysed the data; Alice Ouvrier and Manon Culos prepared the figures. Alice Ouvrier and Ruppert Vimal led the writing of the manuscript. All authors contributed critically to the drafts and gave final approval for publication.

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CONFLICT OF INTEREST STATEMENT




The authors indicated that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

DATA AVAILABILITY STATEMENT

This study relies on two main types of data: social survey data (semi-structured interviews and participant observation) and institutional data (bears survey, compensation records for predation and pastoral practices). The social survey data were collected under confidentiality agreements to protect the anonymity of participants and the sensitive

nature of their contributions. Researchers seeking further information about this data are encouraged to contact the corresponding author. Institutional data were provided under specific agreements that prohibit public dissemination.

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