Environmental Sciences and Policy Department,
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FROM CONFLICT TO COEXISTENCE: Human-wolf conflict and management solutions in the Western Carpathians of Transylvania - *reinterpreting conflicts as drivers of change and inherent regulating mechanisms of coexistence*

In partial fulfilment of the requirements for the degree of Doctor of Philosophy

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ABSTRACT OF DISSERTATION submitted by:
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The recent global expansion of human population has led to an unprecedented increase in human-wolf interactions in a wide variety of landscapes where their activities overlap. Within and across such interfaces, management of human-wolf interactions became one of the most pressing conservation issues of the 21st century. Human-wolf interactions, including human-wolf conflicts are multifaceted and impose complex cost-benefit tradeoffs to both humans and wolf populations. Thus, understanding these interactions holistically is essential for facilitating positive outcomes of management and conservation strategies and for securing human-wolf coexistence in human dominated landscapes.

The conflict with human economies, generated largely by wolf predation on livestock and game species, represents one of the main reasons for wolf control, and it is still today one of the most important causes of wolf mortality. Analyzing what management and husbandry factors may be related to wolf predation on livestock and showing how these factors can influence predation is an essential way of gaining more baseline information providing useful insight into choosing appropriate preventative measures. It is also important to consider the role of Traditional Ecological Knowledge (TEK) of livestock producers and local communities related to husbandry systems and individual management practices in mitigating conflicts. In addition, empirical research examining the *human aspects* of wildlife conflicts contributes to our knowledge on the multitude of socio-political and governance aspects that drive, maintain, amplify and/or reduce conflicts. All this knowledge is essential for the process of co-designing and implementing sound mitigation strategies.

Thus, this research analyzes the wide array of biophysical, husbandry, management, and social-institutional factors that influence and drive direct and indirect (both visible and subtle) conflicts around wolves in the Western Carpathians of Romania and identifies solutions that would aid in mitigating conflict. In order to grasp the full complexity of this subject, this research takes on *a novel holistic and interdisciplinary approach* that sees the human and natural components of the complex and dynamic human-influenced landscape of the Western Carpathians of Transylvania as coupled rather than separate. By further developing and adapting the *Integrated Coupled Human-Natural Systems* (CHANS), the Complex Adaptive Systems (CAS) and the *Coexistence as a Continuum* approaches, this research adopts *a comprehensive, integrative and multi-science framework* to capture the intricate web of interactions and back-

and-forth feedback between the various components of this fundamentally integrated system (wolves and their natural environment; livestock, livestock guarding dogs and shepherds; local communities; stakeholders and managing institutions at both local, national and international level).

First, in order to determine what *spatial biophysical* factors are associated with the risk of wolf predation on livestock, a predictive model of where predation is more likely to occur was built through a complex Risk Modelling Analysis, and the predicted risk was visually represented through a detailed risk map of wolf predation patterns that can help identify conflict hot-spots and focus management efforts. Next, 78 *non-spatial biophysical and husbandry* factors were analyzed statistically in order to identify which of these factors also profoundly influence the outcome of predation events, thus introducing the role of humans and human-wildlife interactions in this spatial food web. TEK of livestock producers on the topic was also investigated and described for this purpose. People's concerns and perceptions were also assessed, and the resulting map of the Perceived Risk of predation was compared to the calculated risk. Lastly, moving completely into the realm of *human* influence on conflict, the role of interhuman conflict and decision making at the institutional level was investigated by analyzing existing policies and practices concerning wolves and their management, identifying actors involved in wolf governance and HWC and their roles in the conflict, mapping institutional processes, defining problems and schematically representing processes and issues. This allowed identifying potential measures and offering evidence-based recommendations on ways to overcome the identified issues.

The results suggest to managers and livestock producers that livestock flocks in the study area are at a higher risk of predation by wolves in the remote natural high alpine pastures (situated in the core area of the park) where they graze during the warm months of their seasonal migration. While grazing in these areas, livestock are most vulnerable in the open grasslands and pastures near the edge of the forest, where dense and tall vegetation minimizes sensorial detection. The element cover appears to be a very important factor affecting predation success on livestock for wolves in our study, suggesting that wolves in this landscape demonstrate stalking-hiding and ambush-like behavior as part of their hunting tactics. This study suggests that livestock owners aiming to reduce livestock losses should be aware of these hunting strategies and increase vigilance and preventative behavior when finding themselves and their flocks in higher risk areas and situations such as the middle of the night, in the cold seasons, and during harsh weather conditions. The results suggest that the vulnerability of livestock to wolf attacks depends on flock size, density and composition, with enclosed flocks attacked more when in larger numbers and free grazing flocks attacked more when in smaller numbers, while juvenile individuals seem to be at highest risk of predation. At the same time, the findings of this research reemphasize the urgency of well-thought-out management policies that take into account both the calculated and the perceived risk, TEK, and the value of preventative measures, and emphasize the need to incorporate nation-wide data on wolf and prey populations into the decision-making process. Tensions and disputes revolving around various interests of the many stakeholders involved in wolf management influence wolf governance at a local but also national and even international level, leading to a situation where wolf management becomes as much of a socio-political issue as a biological one, resulting in less-than-ideal management strategies and their poor implementation at both local and national levels and compromised human interests and conservation goals. There is a need to reform policies and institutions, while also changing attitudes.

In the context of a centuries-long coexistence, wolves, livestock and people in the Romanian Carpathians constantly interact, responding to each other's strategies in the form of a never-ending process of *co-adaptation*. Capturing these interactions, and the influence of social and governance factors on wildlife conflict development, is a novel socioecological framework for *operationalizing coexistence*, rarely employed until now. The unique combination of methods adopted in the framework of this research and adapted to the specific context of this ancient case of coexistence, can offer broader insight into what factors make functional coexistence and co-adaptation possible. This stands in contrast to other studies focusing solely on aspects that hinder conservation and coexistence. This approach is essential for designing functional *landscapes of coexistence* in areas prone to human-wildlife conflicts. Thus, this research represents one small step forward towards advancing the interdisciplinary theory and practice of coexistence in an increasingly human-dominated world.

Founded on the aforementioned approaches, this dissertation introduces concepts, such as the "*Integrated Adaptive Response System*" (IARS) of the coupled *Human-Dog-Livestock* trio, tailors "*Adaptive Participatory Governance" to* HWC studies; discusses an adapted framework of "*Coexistence viewed as a continuum*" and "*Coexistence interpreted as Co-adaptation"* between people and wildlife in complex socio-ecological systems, that focuses on reinterpreting conflicts as "*drivers of change"* and intrinsic self-regulating mechanisms of coexistence. Under the acronym of CASES (*Complex Adaptive Socio-Ecological Systems*), this framework promises to become a helpful baseline, starting-point study framework to guide the choice of theoretical and methodological approaches for specific research contexts on the basis of a set of fundamental principles that assemble the state-of-the-art understanding on HWC matters in SES and CAS systems into one comprehensive, multi-dimensional, flexible and broadly applicable blueprint. In short, CASES – a framework for HWI cases.

This socio-ecological approach has rarely been undertaken and thus, this analysis helps fill an important research gap while also laying the ground for improving the interoperability of different scientific approaches that scientists and managers can undertake in the field to gather richer data on, and successfully mitigate, human-wolf conflicts.

Keywords

Human-wolf conflicts; Coupled Socioecological Systems; Complex Adaptive Systems; Wolf management; Conflict drivers; Conflict mitigation; Predation Risk Mapping; Perceived Risk; Prevention; Traditional Ecological Knowledge; Social/Institutional mapping; Interdisciplinary approach; Multi-science framework; Canis lupus.

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List of Abbreviations

AIC – Akaike Information Criteria
ANP - Apuseni Natural Park
APIA - National Agency for Payments and Interventions in Agriculture
AUC – Area under the ROC Curve
CAS – Complex Adaptive Systems
CASES – Complex Adaptive Socio-Ecological Systems
CHANS - Integrated Coupled Human-Natural Systems
DCA – Damage Causing Animal(s)
EAFRD - European Agricultural Fund for Rural Development
EU – European Union
FFI – Flora and Fauna International
GLM – Generalized Linear Model
HDW – Human Dimensions of Wildlife
HDL – Human-Dog-Livestock
HWC – Human Wolf Conflict/ Human Wildlife Conflict
IAR – Integrated Antipredator Response
IARS – Integrated Adaptive Response System
LC – Large Carnivore
NEPA – National Environmental Protection Agency
NGO – Non-Governmental Organization
PA – Protected Area(s)
PAM – Participatory Adaptive Management
ROC – Receiver Operating Characteristic
RQ – Research Question
RSF – Resource Selection Function
SES – Socioecological Systems
TEK – Traditional Ecological Knowledge
VIF – Variance Inflation Factor

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For the wolves. And for my wolf pack.

1. Introduction

1.1. Outline

This study aims to examine the complex nature of human-wolf conflicts (HWC) in the specific context of the Apuseni Natural Park (ANP) in the Western Carpathians, Romania, which harbors one of the last remnants in the world of ancestral coexistence between people and wolves. However, this coexistence is increasingly under threat. This special case of threatened coexistence provides important lessons for wolf conservation and HWC management worldwide.

In order to grasp the full complexity of this subject, this research takes on a novel interdisciplinary approach, founded on the *Integrated Coupled Human-Natural Systems* (CHANS) framework, also defined as *Coupled Socioecological Systems* (Carter *et al.*, 2014), and inspired by the *Complex Adaptive Systems* (CAS) approach (Peiser *et al.*, 2018) for Socioecological Systems (SES) (Berkes *et al.,* 2000; Berkes *et al.,* 2003).

By adopting and adapting some of the ideas put forward by these frameworks, this research views the human and natural components of the complex and dynamic human-influenced landscape of the ANP as closely interlinked rather than separate, and therefore uses a comprehensive, integrative and multidisciplinary approach (Redman *et al.,* 2004) to capture the intricate web of interactions and mutual feedback between the various components of this system (wolves and their natural environment, livestock, livestock guarding dogs, local people and managing institutions). This approach represents a novel socioecological framework for operationalizing coexistence (Lute and Carter, 2020), rarely employed until now (McInturff *et al.*, 2021).

The research combines insight from both natural and social sciences to analyze both dimensions of the conflict: the *human-animal conflict* (the biophysical environment that influences the risk of predation and the socio-ecological dynamics of the conflict) and the *human-human conflict* (the social environment and governance systems), thus allowing an enhanced understanding of the overall scope of the conflict. It proposes to do this through a twofold “mapping” exercise of both the physical and social conflict that entails a broad cross-scale analysis (spatial, temporal, management and organizational) of influential factors.

The focus is also on people’s attitudes and their perceptions both towards wolves and their management, their local and professional know-how in dealing with wolves and their knowledge of the species – what literature in the field defines as “Traditional Ecological Knowledge” (TEK) (Berkes, 1993). This helps identifying the complex range of non-spatial bio-physical and husbandry factors that can influence success of predation while also allowing for the quantifying of the perceived risk of living with wolves and its comparison with the physical risk, thus adding a final, important dimension to the complexity of these conflicts and bridging the multiple dimensions of the research. Thus, this additional analysis acts as a complementary element, bridging the various dimensions of the research and rounding up the knowledge on the web of processes and interactions that lead to conflict, but also to co-adaptation and coexistence.

The unique combination of novel methods adopted in the framework of this research and adapted to the specific context of this ancient case of coexistence, can offer broader insight into what factors make functional coexistence and co-adaptation possible. This stands in contrast to other peer studies focusing solely on aspects that hinder conservation and coexistence. Thus, this research represents one of the first steps towards advancing the interdisciplinary theory and practice of coexistence (Carter and Linnell, 2016) in an increasingly human-dominated world.

1.2. Problem statement

The gray wolf (*Canis lupus*) is a key predator, a large carnivore that plays an important role in maintaining viable wildlife populations and healthy ecosystems. Wolves have a long history of association with humans and have always been present in various ways in human discourse, from long forgotten myths and fairytales to more recent scientific studies, and to emerging practical conservation issues. Whether in a positive or negative sense, people have consistently expressed strong emotions connected to wolves (Boitani, 1995). Due to misconceptions and fear, wolves have often been viewed in a negative light, depicted as villains, pests and beasts (Jesse, 2000). Since the Early Middle Ages, this negative attitude towards wolves has led to a prolonged persecution of this species causing a significant decrease in its numbers and its almost complete disappearance from various parts of the world (Boitani, 1995). The main reasons for killing wolves were for fur, the protection of livestock and wild ungulates, disease control, and out of fear (Musiani and Paquet, 2004). In the European continent wolves were subject to extreme hunting pressure during the 18th and 19th centuries (Blanco and Sundseth, 2023) and became extinct in most Western European countries (Enserink and Vogel, 2006; Dalerum *et al.,* 2009). Small but healthy populations survived in some Eastern European and Balkan countries (Boitani, 2000; Linnel *et al.,* 2001; Chapron *et al.,* 2014; Sin *et al.,* 2019), including Romania.

However, the future of these remaining populations is uncertain. Due to the intensely anthropogenic European landscapes, a product of millennia of human modification, there are little pure pristine areas left in Europe where large carnivores and their natural habitats remain undisturbed and free of human impacts. Habitat loss and fragmentation contribute to increased isolation and patchy distribution of wolf populations (De Groot *et al.,* 2016). Under an accelerated loss of suitable habitats, large carnivores populating these areas find themselves sharing a multiple-use, human-dominated landscape (Linnell *et al.,* 2005) in which their populations and habitat are intensely managed. Wolf predation on livestock, one of the main direct causes of conflict, occurs more frequently in the more transformed and densely inhabited areas of Europe where wolf habitats are fragmented and adjacent to areas of livestock farming (Boitani, 2000; Jêdrzejewski *et al.,* 2004). In the Carpathians, livestock still have only a marginal importance in wolves diet (Nowak *et al.,* 2005; Sin *et al.,* 2019). However, despite a "*relatively high degree of coexistence*" (Linnell *et al.,* 2001, p.348), characteristic especially to Southern and Eastern Europe, conflicts between people and large-carnivores (and wildlife in general) are increasing in recent years (Mishra 1997; Graham *et al.,* 2005; Decker *et al.,* 2006; Wang and Macdonald, 2006; Blanco and Sundseth, 2023) including in Romania (Maanen *et al.,* 2006; Berde *et al.,* 2016), threatening this fragile coexistence.

Predation on livestock appears to be further aggravated by the problematic implementation of several management strategies (compensation for damage, wolf and prey population control, etc.) due to growing concerns with the institutional processes surrounding wolf management (Salvatori *et al.,* 2002; Iojă *et al.,* 2010; Duncan, 2011; Knorn *et al.,* 2012; Szabo and Anthony, 2012; Berde *et al.,* 2016; Popescu *et al.,* 2016; Sin et al., 2019). This poor conflict management leads to stronger negative views of both the wolves themselves, and towards conservation authorities and between other stakeholder groups (section 9.2. in Chapter 9).

Finding sound management strategies to mitigate these conflicts thus becomes an increasingly important task. But it is a task that must be carried out with careful consideration. As large carnivores are vulnerable and often controversial taxa, any poorly designed management intervention could rapidly deteriorate the success of their long-term survival (Mattson, 2004; Dalerum *et al.,* 2009; Can *et al.,* 2014). Moreover, it is noteworthy that management decisions can affect temporal horizons in that the consequences of past management decisions can have cascading effects, leading to less-than-optimum solutions for managing current and/or future HWC (Anthony and Szabo, 2011). Failure to effectively respond and mitigate conflicts may reduce society's tolerance and thus hinder future conservation efforts (Hewitt and Messmer, 1997; Anderson and Pariela 2005; Anthony *et al.,* 2010). Even more, the effects of current strategies can reflect upon a large array of actors and thus conflicts can lead to other larger societal conflicts, and vice versa. This is even more evident when considering that these conflicts are often interwoven with a variety of unresolved problems many local communities are struggling with such as poverty, social and political exclusion, isolation, and social unrest (Gherghinescu, 2008; Anthony *et al.,* 2010; Barua *et al.,* 2013).

These afore-mentioned considerations are just some of the many trade-offs which need to be fully recognized and articulated if human-wolf conflict is to be fully understood and mitigated. Madden (2004, p. 250) recognizes that "*the conflict about wildlife is between people with historical wounds, cultural misunderstandings, socioeconomic needs, as well as gaps in trust and communication over how to conserve wildlife and ensure the well-being of people at the same time.*"

It already becomes clear that managing wildlife, and particularly large carnivores, is a very complex affair and finding successful solutions that serve both people and wildlife can be a monumental challenge (Kareiva and Marvie, 2012; Linnell, 2013; Leslie *et al.,* 2015). Management strategies must be built on specific sets of aims and objectives defined and tailored for each case, based on a thorough understanding of the carnivore species itself, its relationship with the biophysical environment and of all the issues implied (Simonic, 2003). The challenge resides in the need to tackle the diversity of all associated issues: human interests and the relevant biophysical, socio-economic, political and emotional aspects.

1.3. Significance of the study: originality and relevance

Romania is significant to the European wolf population (Mech and Boitani, 2003) as it represents one of the last islands of wilderness and biodiversity in Europe and presently has one of the largest wolf populations on the continent (except Russia) (Linnell *et al.,* 2003; Kaczensky *et al.,* 2012; Sin *et al.,* 2019; Blanco and Sundseth, 2023; Kaczensky *et al.,* 2024). Wolves occupy the top of the trophic pyramid in the Romanian Carpathians and are considered an umbrella species for Carpathian biodiversity (Rozylowicz *et al.,* 2010). One aspect that makes Romania so important for wolf conservation is the fact that wolves have never been completely extirpated from this region, maintaining continuous viable populations over time (Boitani, 2000; Breitenmoser *et al.,* 2000; Swenson *et al.,* 2000; Van Maanen *et al.,* 2006) in these well-preserved, densely-forested landscapes (Biris and Veen, 2005) and, as such, is one of the last wolf populations of this kind remaining in Europe and even the world (Hulva *et al.,* 2018). This rare and valuable example of ancestral coexistence is in need of special protection and conservation. But the specific context of contemporary Romania threatens this coexistence and the future of wolf and other protected large carnivore populations. The unstable political and economic situation of the country fostered over the past decades following the fall of the communist regime, and the accession to the EU, resulted in major changes in land ownership, policy, as well as forest and wildlife management. These include land privatization; modernization and industrialization of agriculture; intensive forestry under increasing demand of a new consumerist economy; rapid and erratic urban development and infrastructure expansion; rapid loss of traditional practices and customs; new-born conflict among various stakeholders in forest and wildlife management (due to swift policy changes). In addition, inefficiently regulated grazing and increasing touristic activities lead to a continuous decrease of the ecological integrity of these historically preserved forested habitats (Van Maanen *et al.,* 2006; Rozylowicz *et al.,* 2011).

This has led to increased pressure on natural resources and now fosters a weak institutional system and incoherent governance that hinders the proper implementation of policies and conservation strategies. This influences local attitudes, the intensity of the conflicts and the way they are managed and, therefore, affects both humans and wildlife.

This research can inform and assist local and national management agencies in understanding the sources and solutions to the problems it faces, by providing adequate and evidence-based recommendations and sound scientific baseline data on several aspects of the conflict. The main aim is to contribute to improved management of HWC that would benefit both local communities and wolf populations alike.

This is even more relevant when considering that few systematic studies of the factors that influence HWC and wolf conservation and management have been undertaken in Romania until now. Very few studies have attempted to combine ecological assessments with socio-political investigations despite the pressing need of an interdisciplinary approach to address these problems (Treves *et al.,* 2006). Further, no studies performing spatial modeling of the risk of predation have been carried out in Romania, nor in surrounding countries, even though the need of such studies in this part of the world (Eastern Europe) has been demonstrated by the fact that the highest levels of potential livestock predation in Europe are found here (Miller, 2015). Miller (2015, p. 2900) has shown that "*comparing study locations against areas of potential livestock losses revealed a lack of studies in areas with the greatest potential human–carnivore conflict … distributed across a contiguous belt stretching through Eastern Europe, western Asia and southern and eastern Asia*."

Almost no investigations of wolf hunting behavior and ecology have been carried out in the Apuseni Natural Park or the Romanian Western Carpathians until now (Cristescu *et al.,* 2019; Sin *et al.,* 2019). Only recently have EU funded projects started investigating the subject of human-wolf conflicts in the area, but their extent is only local, their aims don't encompass a holistic view of conflict drivers, and their results are yet to be taken into consideration by official state managers. The very few state projects/studies gathering data on predation events in the past have had the sole purpose of quantifying the amount of predation with the purpose of communicating this to management authorities for determining hunting quotas and, rarely, for compensation. Wolf research at the country-wide extent has therefore narrowly focused mostly on assessing population size and distribution patterns only from raw footprint tracking data, with little consideration of other essential population or habitat parameters (Cristescu *et al.,* 2019).

None of these studies have systematically and holistically looked into the key mechanisms of how biophysical attributes influence livestock vulnerability to predation and how these landscape features are associated with wolf predation success and hunting behavior and strategies in the study area. Examining these mechanisms and obtaining key insights into these relationships represents the purpose of the spatial risk analysis performed within this research.

Quantifying and mapping people's perception on wolves and wolf predation and the perceived risk, while also describing the institutional arena for wolf management and pinpointing the issues in the institutional processes that lead to conflict, is also first performed by this research, as is integrating all these aspects into a holistic assessment of the human-wolf conflict. The Complex Adaptive Socio-Ecological Systems (CASES) framework for HWI, born from the study of this specific case of uninterrupted coexistence, assembles the state-of-the-art understanding on HWC matters in complex coupled socio-ecological systems into one comprehensive, multi-dimensional, flexible and broadly applicable framework that promises to become a baseline guiding blueprint for studies engaging in this topic.

Therefore, there is great relevance in an in-depth investigation of these aspects in the Romanian Carpathians.

1.4. Research questions, aims and objectives

Hypothesis and research question

The general assumption this study is predicated on is that HWC can be greatly influenced by several biophysical and social/institutional factors. The rationale is that proper management based on careful consideration of these influential factors can reduce wolf predation on livestock and other manifestations of the conflict; can ameliorate the human-human conflict and improve people's perceptions of both wolves and the park by reducing losses, addressing concerns and involving stakeholders. This increases positive outcomes and ensures improved coexistence between people and wolves in the park.

For this, there is a need for knowledge and understanding of the local dimensions of the conflict. The scope of this research is to provide this knowledge.

Therefore, the overarching research question of this study, based on the needs and gaps previously identified is:

How do biophysical, social and institutional factors influence the occurrence and management of human-wolf conflicts in Apuseni Natural Park, Romania?

In order to answer this question, several other questions must be investigated:

2. *How are human-wolf conflicts manifested in the study area?*

a) *What landscape attributes influence wolf predation of livestock?*

b) *What non-spatial and husbandry factors influence wolf predation on livestock?*

c) *How do social and institutional factors influence conflicts on a local and national level?*

3. *Based on the biophysical, social and institutional factors identified, what management practices and/or institutional arrangements are most likely to mitigate human-wolf conflicts in the ANP and beyond?*

Due to the complexity of this combined multidisciplinary methodological approach, the methods, design considerations and results are presented separately for each of the three major parts of this research: the analysis of spatial landscape attributes (Chapter 6), analysis of non-spatial and husbandry factors (Chapter 7), and analysis of social and institutional factors (Chapter 8). These three parts correspond to the three central research questions, RQ 1, a, b, and c.

Chapter 6 focuses on predator prey interactions in a purely spatial context analyzing the spatial biophysical factors that are associated with the risk of wolf predation on livestock. It describes the Risk Mapping Analysis in a stepwise narration of all the design and statistical procedures that were undertaken and, finally, the results of the modeling process. Chapter 7 moves the focus on to non-spatial factors and the husbandry and human management measures that also profoundly influence the outcome of predation events, introducing the role of humans and human-wildlife interactions in this spatial food web. Last, chapters 8 and 9 move completely into the realm of human influence on conflict, investigating the role of management and decision making at the institutional level. Chapter 10 zooms out to bridge all of these aspects and give a holistic understanding of the overall picture of conflicts and their unfolding in the context of this ancestral landscape of coexistence and proposes a comprehensive framework to act as a guideline for HWC studies in complex socioecological systems worldwide.

Aim and objectives

Under the guidance of these research questions, this study aims to shed light on the complexity of HWC by investigating the main aspects to be targeted by mitigation efforts, with a major role in improving coexistence. Moving beyond the classic approach that focuses solely on factors that hinder conservation and coexistence, this study delves into understanding what makes functional coexistence possible in this ancestral coexistence landscape where the coadaptation between people and wolves over centuries has shaped a complex coupled socioecological system, a classic case of a CAS that can provide many important lessons tailored to the field of HWC. Therefore, the main objectives set forth for this study are to:

Q1

1. Obtain background information on the conflict context and create a database on influential factors and predation events in the study area.

Q1a

2. Assess the relationship between an array of spatial biophysical and husbandry factors and the selection of certain sites by depredating wolves.
3. Build a predictive model of where predation is more likely to occur (spatial risk model);
4. Visually represent the risk of predation: risk maps and complex, multilayered maps of wolf predation patterns that can help identify conflict hot-spots and focus management efforts.

Q1b

5. Assess how several non-spatial biophysical and husbandry factors are associated with wolf predation.
6. Investigate and describe traditional ecological knowledge in the topic of wolves and wolf predation on livestock.
7. Assess people's concerns and perceptions, quantify and map the perceived risk.
8. Compare the perceived risk to the calculated risk.

Q1c

9. Analyze existing policies and practices concerning wolves and their management.
10. Identify actors involved in wolf governance and HWC and their roles in the conflict.
11. Investigate and map institutional processes, define problems and schematically represent processes and issues.

Q2

12. Identify potential measures and offer evidence-based recommendations on ways to overcome the identified issues and therefore improve the workflow of the respective processes with the aim of improving conflict mitigation.
13. Identify key features that contribute to the vulnerability of livestock to wolf attacks and find solutions to lower the risk of predation.
14. Define and describe a holistic approach to HWC research, a new study framework that advances research methods and approaches to responds to the current needs of a more and more human dominated world where the human and the natural components need

to be interpreted and understood as integrated in the form of dynamic socioecological systems that require an interdisciplinary approach in order to grasp the full context of such complex adaptive systems.

1.5. Research design and structure

To reach these objectives, the research chooses a specific set of methods under a multidisciplinary analytical framework tailored to best fit the context and needs of this study. Linnell (2013) stipulates that these methods must be chosen to fit the specific context and identifies three elements to consider when doing so:

(1) the conservation context – background information on the area, wolf population and threats.
(2) the nature of the conflict – understanding the specific context and shape of the conflict; and
(3) the human environment – the wide range of stakeholders and their roles in the conflict.

Following these recommendations, this research designs the analytical framework along the lines of these three elements included in the research questions as follows:

(a) the first research question in its holistic form ("*How are human wolf conflicts manifested in the study area?*") examines the context, in an attempt to obtain background information on the area and the conflict (specific context and shape of the conflict);

(b) the underlying three sub-questions (1a, 1b and 1c) analyze the nature of the conflict in detail, aiming to understand distribution, intensity and the environing factors that shape the conflict, belonging to both the biophysical environment (RQ 1.a. "*What landscape attributes influence wolf predation of livestock?*" and RQ 1.b. *"What non-spatial and husbandry attributes influence the risk of predation"*), and the human environment (RQ 1.c. "*How do institutional factors influence the conflict on a local and national level?*"). Finally, (c) the last research question ("*Based on the physical and institutional factors identified, what management practices and/or institutional arrangements are most likely to mitigate human-wolf conflicts in the ANP and beyond?*") intends to propose measures and recommendations for the identified problems and integrate all the acquired knowledge to describe new research framework for HWC studies.

The complex nature of this undertaking is reflected in the multidisciplinary design of the research. The analysis of the ***'biophysical factors'*** that influence risk of predation – the context - will largely draw on natural sciences while the analysis of the human and ***'institutional factors'*** - the human environment – will draw on social sciences.

A key concept in this research is that of '***influential factors'*** that can be distinguished as proximal and distal factors (Mattson, 2004). '*Proximal Factors'* constitute "direct sources of mortality" and are closer in time and space while '*Distal Factors'* are "*those features of the landscape and human community that increase the likelihood of carnivore–human conflict*" (Mattson 2004, p. 157). The study mostly deals with distal factors, as it analyzes several features of the landscape, social context, management, and governance that influence the conflicts. Identifying and examining these distal factors is critical because they determine the frequency and intensity of proximal factors (e.g. retaliation for predation, killing of problem animals, population control, loss of native prey) with direct effects on wolf populations.

All these key biophysical and institutional factors are identified and mapped. The design of this research revolves around this central concept of ***'mapping'***, taking place from different perspectives (the biophysical and the social) and employing different techniques (spatial modelling of the risk of predation, an analysis of traditional and husbandry practices that influence predation outcome and institutional process mapping). Mapping in this case is therefore seen as a cognitive process (Aligica, 2006) intending to simplify the complex reality of the conflicts by schematically representing them in a form that is much easier to grasp. This mapping process aims to describe the main *actors* on the stage of the conflict, the *arena* in which they manifest, and the complex set of *interactions* and *chains of action* that finally shape the conflicts (Figure 1). Just like any geographic map, the maps and Figures resulting from this process will act as predictive tools to guide the users to action. They can represent practical, useful tools for practitioners.

The element that ties the different parts of this research together is the common purpose: understanding the entire framework of the conflict. This is an extremely difficult and complex task, sometimes also very controversial and sensitive. The mapping process is therefore intended to simplify and create a schematic understanding of the complexity entailed by HWC.

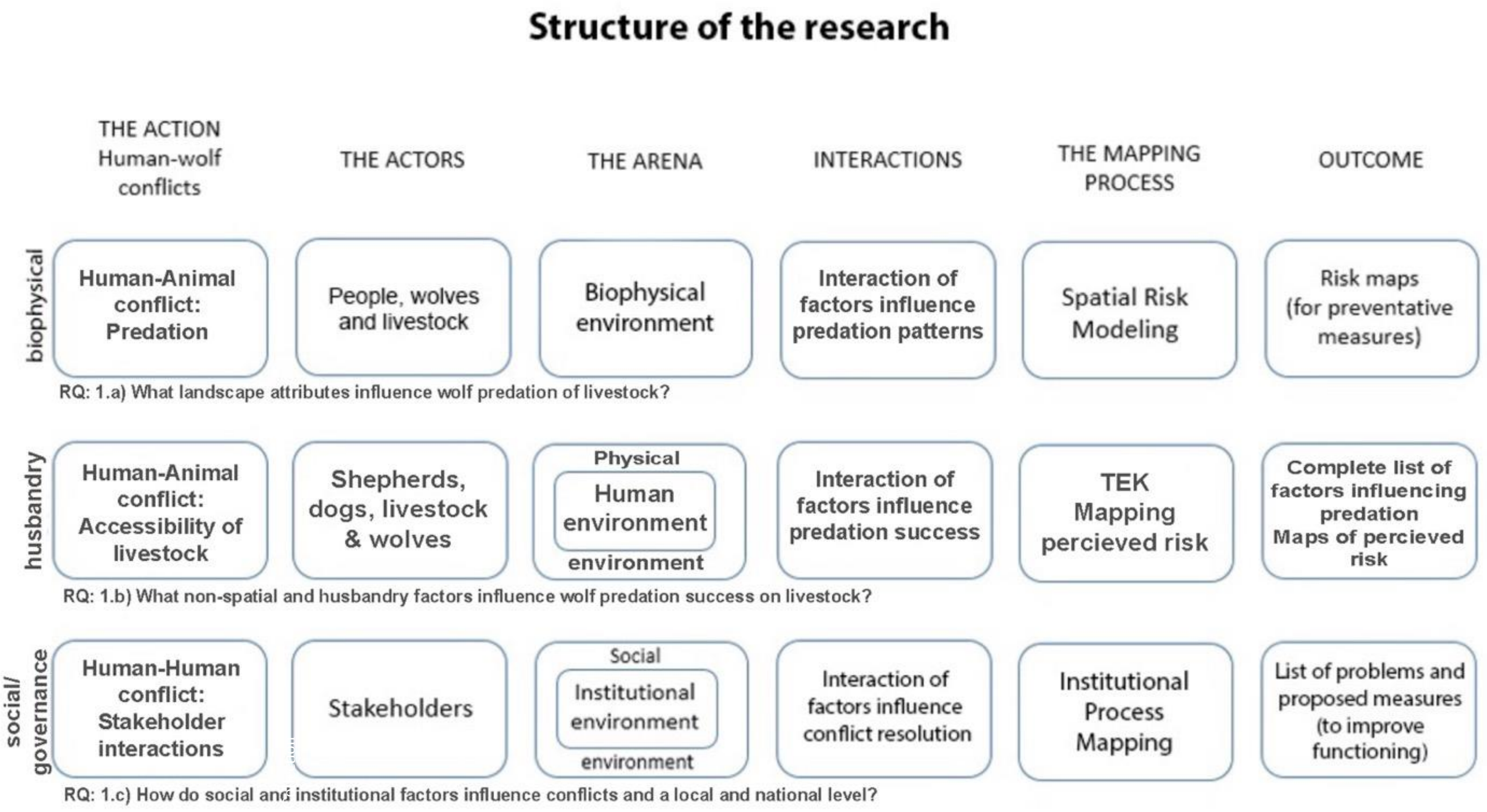

Figure 1. A schematic representation of the research structure.

2. Background

2.1. Human dimensions of wildlife

Human Dimensions of Wildlife (HDW) is a field that has gained the attention of the scientific community and is best defined as "*how people value wildlife, how they want wildlife to be managed, and how they affect or are affected by wildlife and wildlife management decisions*" (Decker *et al.,* 2002, p. 5). In Europe, HDW is currently neither an established concept nor recognized as a formal research field (Glikman and Frank, 2011). It is much more commonly discussed under the term of '*human–wildlife interactions*' (Peterson *et al.,* 2010; Johansson *et al.,* 2016). When these interactions lead to clashes between people and wildlife we refer to them increasingly in terms of *human–wildlife conflicts* (Peterson *et al.,* 2010). But regardless of how it is referred to, this field is gaining more importance as it implies a practical issue that affects both human and wildlife well-being.

Human-wildlife conflicts may be rooted in, and are often manifestations of, underlying *human–human conflicts* (Knight, 2000; Madden, 2004; Dickman, 2010; White and Ward, 2010; Cooney *et al.,* 2015), generated by a clash between different views of different groups of people on conservation issues and on wildlife governance. Such conflicts appear, for example, between local people and authorities (Anthony *et al.,* 2010), between landowners and wildlife managers (Hewitt and Messmer, 1997) or between people of different cultural backgrounds, especially in labor relationships (Rust *et al.,* 2016). Therefore, there are two dimensions of human-wildlife conflicts (Herda-Rapp and Goedeke, 2005): one represented by conflicts between people and wildlife and one between people and people *over* wildlife.

Due to the complexity brought by the manifestation of these two dimensions, there is a need to address HWC with an integrative interdisciplinary approach (Mascia *et al.,* 2003; Manfredo and Dayer, 2004; Bruskotter and Shelby, 2010; Dickman, 2010; White and Ward, 2010; McInturff *et al.,* 2020) capable of grasping the entire scope of these conflicts. As more and more studies focus on human-wildlife relations, it is more widely understood that wildlife conservation and management programs need a multilevel approach that entails the integration of knowledge from multiple disciplines (especially natural sciences and social sciences but also psychology and sociology) to be able to grasp the complexity of the interaction between the societal and environmental systems.

In the context of a continuously growing human population, human-influenced landscapes predominate in today's world. In such "*coupled human-natural systems*" (CHANS) (Turner *et al.,* 2003; Walker *et al.,* 2004; Carter *et al.,* 2014; Liu et al., 2021), people, through management and their presence (Oriol-Cotterill *et al.,* 2015), shape how animals interact and use the landscape. Thus, the social and the ecological components are seen as integrated, interacting with each other (Liu *et al.,* 2007). Meeting human resource needs while simultaneously maintaining proper conservation of wildlife becomes an increasingly challenging sustainability issue in this context. This growing concern led to the birth of a new concept, that of an *Integrated* CHANS, "*an approach for analyzing the patterns, causes and consequences of changes in wildlife population and habitat, human population and land use, and their interactions*" (Carter *et al.,* 2014, p. 1). This new approach for studying human-wildlife interactions and conflicts warns of the fact that, in today's complex and dynamic human-influenced landscapes, human and natural components are inextricably linked (Berkes *et al.,* 2003; Summers *et al.*, 2012; Wu, 2013; Díaz *et al.,* 2015) through continuous interactions and feedback mechanisms. Thus, they cannot - and should not - be studied and understood independently of each other. Engaging such Socioecological Systems as Complex Adaptive Systems (Preiser *et al.,* 2018) serves in advancing research methods and approaches to better capture the dynamic nature of the intertwined social-ecological relations in the real world.

It therefore becomes essential to collate the knowledge on the complex web of processes and interactions that lead to conflict, but also to co-adaptation and coexistence. This approach represents a novel socioecological framework for operationalizing coexistence (Lute and Carter, 2020) and has rarely been employed until now (McInturff *et al.,* 2021). We are thus today witnessing the very first steps towards advancing the interdisciplinary theory and practice of coexistence (Carter and Linnell, 2016) in an increasingly human-dominated world, filling an important research gap (Dickman, 2010). This novel approach lays the ground for improving the interoperability of different scientific approaches that managers can undertake in the field to gather richer data on, and successfully mitigate predation risk, thus facilitating positive outcomes of management and conservation strategies and for maintaining functional human-wolf coexistence in human dominated landscapes.

2.2. Human-large carnivore conflicts

Large carnivores are especially affected by conflicts as they are more susceptible to allee effects[1] and are more "extinction prone" due to their relatively small population sizes, slow growth rates, large home ranges, and dietary requirements (Linnell *et al.,* 2001; Mattson, 2004; Dalerum *et al.,* 2009). Also, conflicts with large carnivores are especially controversial due to the threat they pose to people's lives, the economic value of losses generated from their interaction with human populations, and also the conservation status that these species usually have (Graham *et al.,* 2005).

Large carnivores need large areas to survive, but as human activities are expanding and habitat fragmentation and habitat loss increase, they are drawn closer to human settlements, where they compete for resources and their interactions with people generate conflicts. Carnivores are specialized in hunting wild ungulates, but when these become scarce and become increasingly energy costly to find and hunt, carnivores may also hunt domesticated livestock (Treves and Karanth, 2003; Graham *et al.,* 2005). Thus, predation on livestock becomes one of the main causes of conflicts between people and large carnivores.

Factors contributing to large carnivore conflicts

Conflicts arise whenever large carnivore territories overlap with human activities and when there is a clash with human interests. Treves and Karanth (2003) describe the situation as a competition between humans and carnivores due to their similar needs: protein-rich diet and large home ranges. It is a competition over "*space, food and life*" (Manfredo *et al.,* 2009, p. 215).

But humans and large carnivores have coexisted for thousands of years, and yet the frequency of conflicts has shown an increasing trend in recent years (Conover, 2002; Graham *et al.,* 2005; Woodroffe *et al.,* 2005; Inskip, 2009). One of the explanations for this is the growth in

[1] *Allee effects* are broadly defined as "a decline in individual fitness at low population size or density, that can result in critical population thresholds below which populations crash to extinction" (Courchamp *et al.*, 2004)

human populations and concomitant expansion of human activities that lead to increasing fragmentation of wildlife habitats. Reduction of native prey and introduction of vulnerable livestock can also represent clear triggers for conflict (Mattson, 2004; Hiller *et al.,* 2015; Khorozyan *et al.,* 2015; Nelson *et al.,* 2016). Recent reports show that livestock predation by wolves can also be influenced by social disruption of packs (Imbert *et al.,* 2016), especially due to hunting.

Wildlife expansion is also a source of conflict. In Europe, under the wing of the Habitat Directive and the Bern Convention, the re-establishment of locally extinct native species is being encouraged (Blanco and Sundseth, 2023), particularly that of the wolf (*Canis lupus*) and the Iberian lynx (*Lynx pardinus*) (White and Ward, 2010). The re-establishment of such predators in areas of livestock farming can lead to high levels of conflict due to poor husbandry (Linnell *et al.,* 1996; Meriggi and Lovari, 1996; Ciucci and Boitani, 1998). In areas where people have always coexisted with predators, there is usually a specific *know-how* in how to protect livestock and other property from predator damage (Durá-Alemañ *et al.,* 2024), and an intrinsic acceptance and respect towards these animals (Boitani, 1995; Linnell *et al.,* 2001; Boitani, 2003). But in areas where carnivores have been led to extinction and are now recovering after even a century of absence, this know-how and tolerance can be lost. People in these areas are less experienced in knowing how to defend themselves and often turn to the government and local authorities at the slightest appearance of conflict (Fritts *et al.,* 2003; Anthony and Tarr, 2019). The intolerance of people towards predators in these areas gives rise to negative attitudes both towards the animals themselves, but also towards any reintroduction efforts and the institutions responsible for managing wildlife. These negative attitudes are the main drivers of conflict in these areas.

Wildlife conflicts can also arise as a consequence of conservation efforts but also due to the incapacity of responsible institutions to effectively respond to and mitigate conflicts. Flaws in institutional processes (e.g. ambiguity concerning species, poor reporting, inflexibility, inadequate response times, overlapping responsibilities, and corruption) can further exacerbate conflicts (Hewitt and Messmer, 1997; Anthony *et al.,* 2010; May, 2022).

In some cases, conflicts can lead to other conflicts, with a snowball effect. Multiple actors involved in the conflict are affected in a myriad of ways both by historical conflicts, the initial impacts of the conflict, and also by consequences of management measures (Cheldelin *et al.,* 2003; Anthony and Swemmer, 2015; Anthony, 2021) and this affects their attitudes and perceptions and behavior (Dickman, 2010). For example, people experiencing frequent predation events in areas with poor management of the conflict were shown to be more likely to take the matter into their own hands and kill or harm the problem animal or even destroy the habitat in the area as a retaliatory action or as a preventative measure (Mishra, 1997; Woodroffe, 2001; Hazzah *et al.,* 2009; Linnell *et al.,* 2010; St John *et al.,* 2012; Kahler *et al.,* 2013; Mariki *et al.,* 2015).

The complexity of the biophysical, socio-cultural and institutional factors that influence the outcome of a conflict situation is very difficult to fully grasp, yet what becomes obvious is that the human factor plays a major role in human-large carnivore conflicts.

Impacts

Human-carnivore conflicts can have many direct and indirect *impacts on large carnivores*, especially when attitudes are strongly negative towards the animal causing the damage: retaliatory responses such as killing problem animals, destroying the habitat, poaching, negative attitude towards managers and conservations, can all hinder and undermine conservation processes (Dickman, 2010; Linnell *et al.,* 2010).

Conflicts also *impact human populations* in a variety of ways including livestock and crop losses, property damage, health effects, and even a host of indirect effects (Linnell *et al.,* 2010; Barua *et al.,* 2013; Galley and Anthony, 2024). Further, how the impact is evaluated largely depends on attitudes and perception, and on the victim, with different stakeholders having different evaluations of the same impact (Decker *et al.,* 2002). These are all very important considerations for management. Knowing what are the impacts that matter the most and to whom is ultimately crucial in order to target measures and bring about positive outcomes.

Large carnivore management and conflict mitigation

Achieving and maintaining coexistence is generally considered to be the main goal of large carnivore conservation policies (Nyhus, 2016). '*Coexistence'* can be viewed as an interactive process through which people and wildlife have adapted to live close to each other, a process of co-adaptation through certain mechanisms that allow them to share the same landscape (Linnell, 2013). It is a set of behaviors that allow for the negotiation of compromises that foster mutual adaptation (Frank, 2015). If we understand coexistence as this mutual adaptation process, then we can see that coexistence can be achieved not necessarily by completely eliminating conflict, but by maintaining interactions within *acceptable limits* (both to people and wolf populations). This means that coexistence can be secured by reducing conflicts to a limit that both people and wolves can *tolerate* and by finding ways for wolves and people to share the landscape (Miquelle *et al.,* 2005; Linnell, 2013).

Until recently, conservation management concerning large carnivore populations has focused mainly on aspects of biology and ecology of the species, looking at large carnivore populations, their prey populations and habitats. Although these are all fundamental elements in large carnivore conservation and management (Giles, 1978), it disregards critical social, political and cultural conditions that, in many cases, are the main drivers of conflict and source of population decline (Clark *et al.,* 1996; Bruskotter and Shelby, 2010). The traditional approach to managing large carnivores was primarily based on direct interventions for population control, such as killing problem animals, and population regulation through hunting and relocation which, in many cases, only further increased the severity of the conflicts because they did not address the cause of the conflict. But the increasing recognition of the need for a new, interdisciplinary approach has encouraged alternative management strategies targeted more at the conflict itself by addressing the causes rather than directly controlling the carnivore populations. This process of conflict management is often referred to as '*environmental conflict resolution'* (Emerson *et al.,* 2009).

There are several essential elements important for an effective conflict resolution process:

- having high quality baseline information on the conflict environment (rich, sound valid data on conflict distribution and intensity, conflict hot-spots, population status and dynamics, amount of damage and value of economic losses, etc.) (Redman 2004; Treves *et al.,* 2006; White and Ward, 2010; Anthony and Szabo, 2011; Szemethy *et al.,* 2016; Sin *et al.,* 2019);
- determining what management and husbandry factors may be related to predation on livestock (both through scientific research and local Traditional Ecological Knowledge) and showing how these factors can influence predation (Oriol-Cotterill *et al.,* 2015; Janeiro-Otero *et al.,* 2020; McInturff *et al.,* 2020; Volski 2021);

- fully identifying and understanding the problems arising in the process of mitigation and management (Lasswell, 1971; Clark *et al.,* 1996; Anthony *et al.,* 2010);
- identifying the entire array of stakeholders' views affected by the conflict (Redpath *et al.,* 2013; KU Work Group for Community Health and Development, 2016);
- assuring stakeholder and public participation (Decker *et al.,* 2002; Treves *et al.,* 2006; Linnell, 2013; Preiser *et al.,* 2018)
- building trust among stakeholders (Young *et al.,* 2013; Young *et al.,* 2016, Anthony, 2021);
- having coherent policies and institutional framework (Linnell *et al.,* 2001; Anthony *et al.,* 2010); and
- instating an adaptive management approach (Stringer *et al.,* 2006; Rist *et al.,* 2013; Westgate *et al.,* 2013; Preiser *et al.,* 2018; May, 2022).

It therefore becomes evident that conflict mitigation strategies require complex planning and design, and proper implementation based on a thorough understanding of both biophysical and social factors shaping the conflicts. In an effort to operationalize coexistence in shared landscapes, Carter and Linnell (2016, p. 575) reconceptualize coexistence to include management actions as a "*dynamic but sustainable state in which humans and large carnivores co-adapt to living in shared landscapes where human interactions with carnivores are governed by effective institutions that ensure long-term carnivore population persistence, social legitimacy, and tolerable levels of risk*".

The current research seeks to adopt such an interdisciplinary approach, further develops these ideas and contributes to understanding the conflict framework by examining multiple factors that shape the conflict(s).

2.3. Human-wolf conflicts (HWC)

Wolf biology and ecology

The gray wolf (*Canis lupus*) is the largest member of the Canidae family, composed of 38 extant species (IUCN, 2018), of which it differs by its larger size and less pointed features, especially ears and muzzle (Young and Goldmann, 1944). The geographic distribution of this species makes its physical characteristics oscillate according to the part of the world that it inhabits: weight, size and color variation tend to increase proportionally with latitude (Figure 2).

Figure 2. Wolf pack in the Apuseni Natural Park (Source: APN).

Because it is a highly adaptable animal and mostly depends on the availability of its prey, the wolf can survive in almost any type of habitat with extremely different ecological characteristics as long as it can find prey (Boitani, 2000). The wolf used to have a much more extended distribution, but its range shrank considerably mostly due to human pressure and persecution, which has led to its extirpation in many parts of the world including a number of European countries.

The global wolf population is now stable and estimated to be at around 3-400,000 individuals (2022), listed as Least Concern (Boitani *et al.,* 2018). With an approximate estimate of about 23.000 individuals in geographic Europe (excluding Belarus and the Russian Federation) in 2023 (Kaczensky *et al.,* 2024), wolves in Europe are also listed as Least Concern (Boitani *et al.,* 2018) and the population trend is believed to be generally increasing in number and expanding its distribution range (Blanco and Sundseth, 2023). Following the bottleneck of the 1960s and 1970s, wolves are now recovering and even expanding back to their former ranges (Promberger and Schroder, 1993, Boitani, 2000; Deinet *et al.,* 2013; Chapron *et al.,* 2014; Boitani *et al.,* 2022;

Blanco and Sundseth, 2023) (Figure 3), showing an increase of over 25% of wolf range (Cimatti *et al.,* 2021). Yet, several European populations are still small and haven't reached the threshold that would advance them from the 'Vulnerable' (VU) status, according to the Red List criterion (IUCN, 2018), and only three out of the nine European wolf populations are large enough to be labeled as 'Least Concern' (LC). The Carpathian population is one of these three, with an estimated 3,460 - 3,849 individuals (Kaczensky *et al.,* 2024).

Romania is home to the vast majority of this population, sheltering ~2500-3000 individuals as part of a stable continuous population over time, which has never been completely extirpated from this region.

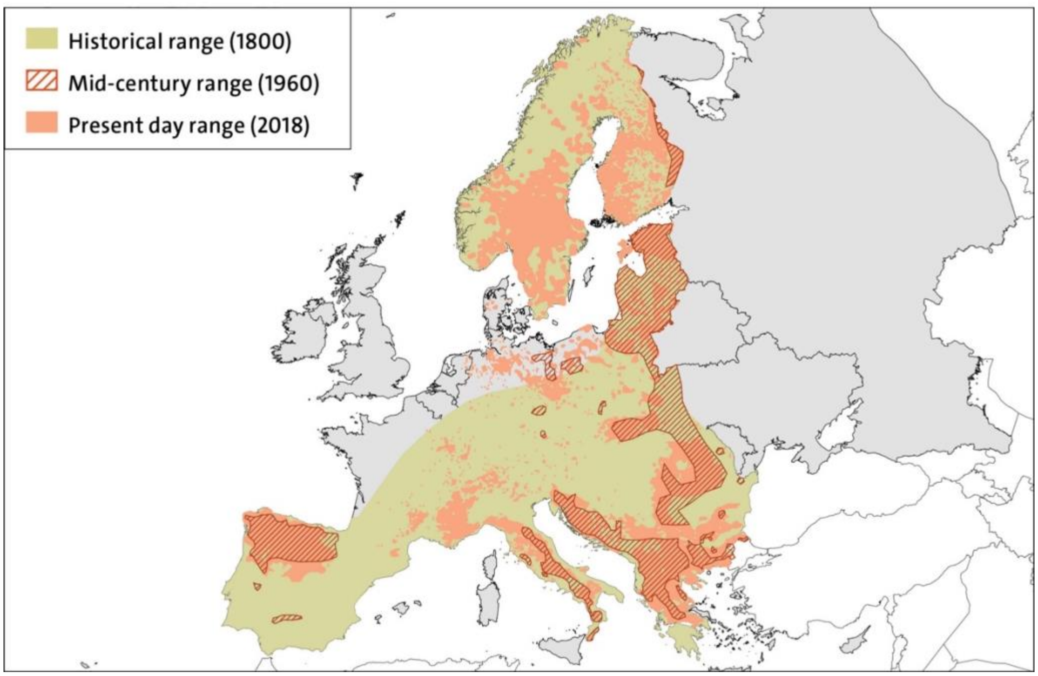

Figure 3. The evolution of wolf range over time (Ledger et al., 2022)

Wolves are social animals living in nuclear families with basic social units called "packs" formed of a breeding pair and their offspring from previous years (Mech, 1970). In his book "The Wolf: Ecology and Behavior of an Endangered Species", published in 1970, David Mech used the term of "*Alpha wolf*" to describe the breeding male or female. But the scientific world, and David Mech included, has since dropped this term (Pappas, 2023) that is now considered misleading and inappropriate for wolf packs. "Alpha" implies that individuals compete with each other and win the dominant or top position through contest or battle, while in wolf packs leading wolves achieve their position merely by mating and producing pups. Wolf packs are simply families led by the "parent" pair and all members of the pack defer to the leading male and female who care for the rest of the pack. Fights for supremacy are extremely rare. Therefore, this dissertation will, from here on, refer to the alpha pair as the breeding or leading wolves.

The number of individuals in a pack can vary, but the average is between 3.6 – 11.5 wolves (Mech and Boitani, 2003). This number varies also according to the time of the year, with a maximum after the breeding season, in spring, and a minimum in late winter. Each pack occupies a well-defined territory that is comprised of the hunting and feeding grounds, grounds for breeding, rest and travel routes (Mech, 1970). Also, partly due to the wolf's large distribution and versatility, the size of a pack's territory can vary from less than 100 to several thousand km^2 (Mech and Boitani, 2003; Jêdrzejewski *et al.,* 2007).

The packs mark their territories through a combination of visual and scent markings (urination, defecation, ground scratching and glandular secretions) and audio markings (howling). Wolf packs travel constantly in search of prey, covering an average of 25 km (about 10% of their territory) per day.

Sexual maturity is reached in the second year of life. After a nine-week gestation period, the female gives birth to 2-10 pups in a den that the female found or built three weeks earlier (Jordan, 1967; Fuller, 1989). The activity of the pack during this season is reduced to a smaller territory called a "*rendezvous site*", where the pups are raised. At the beginning of the fall, the pups already have the capacity to follow their parents on long distances (Mech and Boitani, 2003).

The wolf is a top predator and is directly threatened only by humans and their activities. Due to its need for large territories, it acts as an umbrella species and plays an essential role in biodiversity maintenance (Kaczensky *et al.,* 2012). The wolf is a large carnivore, opportunistic and adaptable (Mech, 1970). It is in fact the most adaptive and opportunistic of Europe's large carnivores (Maanen *et al.,* 2006). It mainly preys on wild ungulates (Red deer *Cervus elaphus*, roe deer *Capreolus capreolus* and wild boar *Sus scrofa*) (Nowak *et al.,* 2005) but its diet can vary, including other smaller animals, carrion, fruits, and in certain areas where human pressure is higher, livestock and human refuse (Mech and Boitani, 2003). In Europe, wolves diet varies from large wild ungulates (reindeer and elk) in Northern Europe (Scandinavia) to medium size wild ungulates (roe deer and boar) in southern Europe (the Alps, Italy), with a mixture of large and medium size wild ungulates (red deer and elk) in Central Europe (Newsome *et al.,* 2016). In

Romania, the wild prey available to wolves consists of red deer, roe deer, wild boar and chamois (*Rupicapra rupicapra*), plus a range of other small and medium sized mammals. During warm months, domestic prey (mainly sheep, dogs, pigs and goats) can become part of their diet given their presence in wolf habitats.

Prey availability is one of the main factors that determine wolf distribution. Being a very versatile and adaptive animal, wolves can live almost anywhere they can find food. They even wander very close to human activities where their interaction can cause conflicts. Wolf predation on livestock is one of the most important problems arising from these interactions (Mech and Boitani, 2003).

Predation on livestock

The conflict with human economies generated by wolf predation on livestock represents one of the main reasons for wolf control and it is still today the single most important cause of wolf mortality (Boitani, 2000). Where human activities and wolf territories overlap and where there is a depletion of their wild prey, wolves – particularly dispersing/recolonizing non-resident individuals (Mayer *et al.,* 2022) – can cause serious economic damage and increase negative attitudes (Meriggi and Lovari, 1996; Sidorovich *et al.,* 2003; Imbert *et al.,* 2016).

The impacts of these conflicts are felt by both parties. But the extent of these impacts is highly dependent on a series of environmental and social factors that intervene to create a complicated web of perceived and actual cost of the conflict that, in turn, generates varied responses of the affected communities, with resultant direct and indirect consequences on wolves (Dickman, 2010).

Conflict mitigation in case of predation usually consists of the following stages (Boitani, 2003): prevention (based on incentives to encourage protection); compensation of livestock owners through compensation and insurance programs; and elimination of individual problem animals. But all these three stages require, first of all, a sound understanding of the predation patterns and conditions. Much effort has been put into understanding the biological and ecological factors that influence carnivore predation on livestock, and into finding alternative methods for mitigating problems. The factors most commonly found to be associated with carnivore attacks are related to the species (carnivore and prey), environment (e.g. habitat, elevation), human infrastructure (e.g. roads, human settlements) and management interventions (e.g. husbandry practices, preventative measures, park boundaries) (Miller, 2015).

Analyzing what factors may be related to wolf predation on livestock and showing how these factors can influence predation is an essential way of gaining more baseline information, providing useful insight into choosing appropriate preventative measures. This data can also help quantify the costs of losses and help explain the behavior of the problem animal(s).

But in many cases, conflict mitigation proves to be a much more complex process due to all the socio-economic, political and emotional aspects that are woven in the conflict environment. All associated issues must also be addressed in order to efficiently mitigate conflicts. As we have already seen, poor management of the conflict may lead to strong negative, opposing attitudes towards the conservation authorities and therefore support for general conservation declines (Madden, 2004). People's attitudes and perceptions can be influenced by a series of factors and therefore careful consideration of these factors is also essential for conflict mitigation.

Wildlife acceptance capacity (WAC) - the maximum wildlife population level in an area that is acceptable to people – was shown to be influenced by both positive values relative to a species, such as aesthetic, ecological, economic, or educational values, and acceptance thresholds for negative factors, such as damage and nuisance associated with the species, fear regulated by social and environmental factors (Johansson, 2016), perceived competition of the species with other desirable species, or disease transmission (Decker and Purdy, 1988). As conditions vary in time and space, the perceptions of the positive and negative factors can also greatly vary among individuals and among groups (Zin *et al.,* 2000).

People's perceptions of risk may not mirror actual conditions (Hill, 2004; Anthony and Moldovan, 2008; McInturff *et al.,* 2021). The same level of damage can be perceived differently according to a series of economic, social, and cultural factors (Hill, 2004) but also according to their satisfaction with the process of conflict resolution and trust in the institutions involved in the process (Decker and Purdy, 1988; Zin *et al.,* 2000; Hill, 2004; Dickman *et al.,* 2010).

High perceived risk can generate misconceptions, for example wolves being blamed for most predation, even when evidence shows other predators are responsible (Fritts *et al.,* 2003). Inflated perceptions of risk can lead to retaliatory responses (Graham *et al.,* 2005) such as: killing of problem animals; population control and habitat destruction; opposition to conservation activities and protected areas; negative attitudes towards authorities and managers; opposition to maintaining or increasing wolf populations, and even opposition to reintroduction campaigns.

In protected areas, increased perceptions of risk alongside distrust in management authorities can lead to arson within protected areas (Ayivor *et al.,* 2013); carnivore poaching (John *et al.,* 2012); lowered tolerance for wildlife (Kansky *et al.,* 2021), particularly for those species for which there is less knowledge (Siegrist and Cvetkovich, 2000; Bruskotter and Wilson, 2014); and even to protected area closures (Thondhlana *et al.,* 2016). These responses all affect the management process, increase risk to wolf populations and undermine conservation sustainability and human well-being.

Therefore, economic loss alone is a poor indication of the impact of human-wildlife conflict on farmers. In order to effectively mitigate conflicts, there is a need to quantify both the real and the perceived risk (Dickman, 2010; McIntruff *et al.,* 2021; Volski, 2021). Delineating between perceived and calculated risk demands accurate information on the attributes contributing to wolf attacks, and investigation of this aspect in the Western Carpathians where wolves have been extant for centuries, is one focus of this research.

3. Local context and study area

3.1. Human-wolf conflicts in Romania

A sanctuary for the European wolves

Historically wolves populated all suitable habitats throughout the entire Northern Hemisphere (Young and Goldman, 1944). After long persecution campaigns, wolf distribution decreased significantly (Boitani, 2003; Fritts *et al.,* 2003), wolves becoming mostly extinct from most of Western and Central Europe in the 19th century. Small but healthy populations of wolves still survived in some Eastern European and Balkan countries (Boitani, 2000; Sin *et al.,* 2019). Due to raising awareness and a better understanding of the role of the species in the ecosystems, timid, continental scale come-back has been observed in recent decades (Chapron *et al.,* 2014; Boitani, 2022; Blanco and Sundseth, 2023). All throughout, Romania has held viable wolf populations of great importance at a European level (Sin *et al.,* 2019). With an estimated 2500-3000 individuals (Kaczensky *et al.,* 2014; Blanco and Sundseth, 2023) covering an area of approximately 154,500 km^2 (Sin *et al.,* 2019) in the Carpathian Mountains and the Transylvanian Plateau (Figure 4), Romania presently has one of the largest stable wolf populations on the continent outside of Russia.

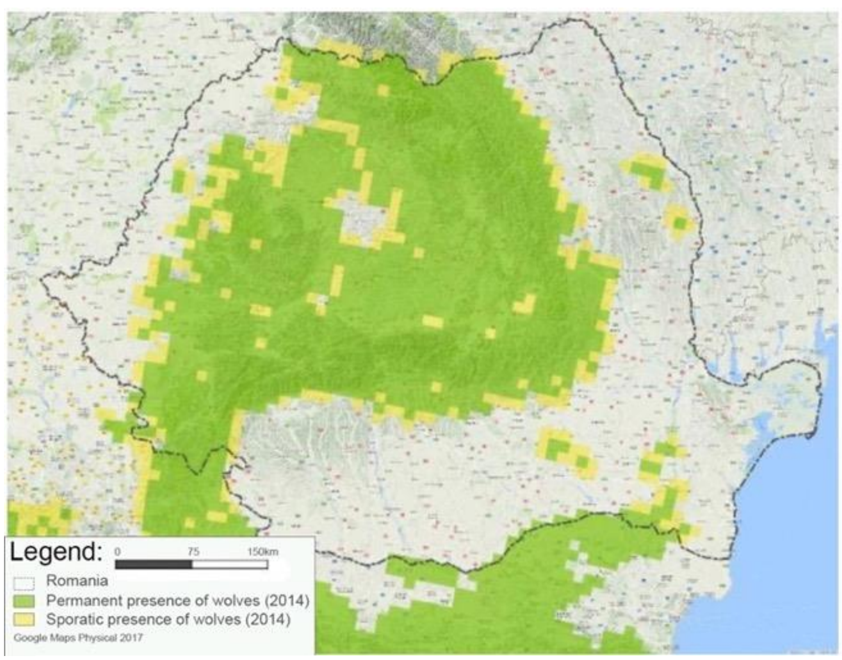

Figure 4.Wolf distribution in Romania in 2014 (NAPW, 2018)

The Romanian wolf population, representing more than 80% of the entire Carpathian wolf population (Kaczensky *et al.,* 2012), is distributed across a variety of landscapes, but is present predominantly in remote, densely forested mountains (more than 70% of the population, Figure 5).

Figure 5. Endless forests covering most of Western Carpathians represent the ideal wolf habitat.

The most recent assessment of the conservation status of wolves in Europe (Kaczensky *et al.*, 2024) shows a similar distribution (Figure 6).

Wolves in Romania benefited from the proximity to the vast populations of Russia, from the protection of the Carpathian Mountains and the specific mixture of local culture and traditional lifestyle. Arching through Eastern and Central Europe, the Carpathian Mountains cradle the Transylvanian Plateau, representing a vital biogeographical corridor for European wolves and other large carnivores. Wolves here are predominantly found on rugged forested terrain and pastures (Cristescu *et al.,* 2019). Several still intact forested habitats, areas of low-level human influence and a wide range of wild prey make the Carpathians one of the last sanctuaries for three European large carnivores (wolf *Canis Lupus*, brown bear *Ursus arctos* and

Eurasian lynx *Lynx lynx*), being home to half of Europe's large carnivores (Kaczensky *et al.,* 2012) and harboring one of the highest densities of these carnivores in the world (Zibordi *et al.,* 2012).

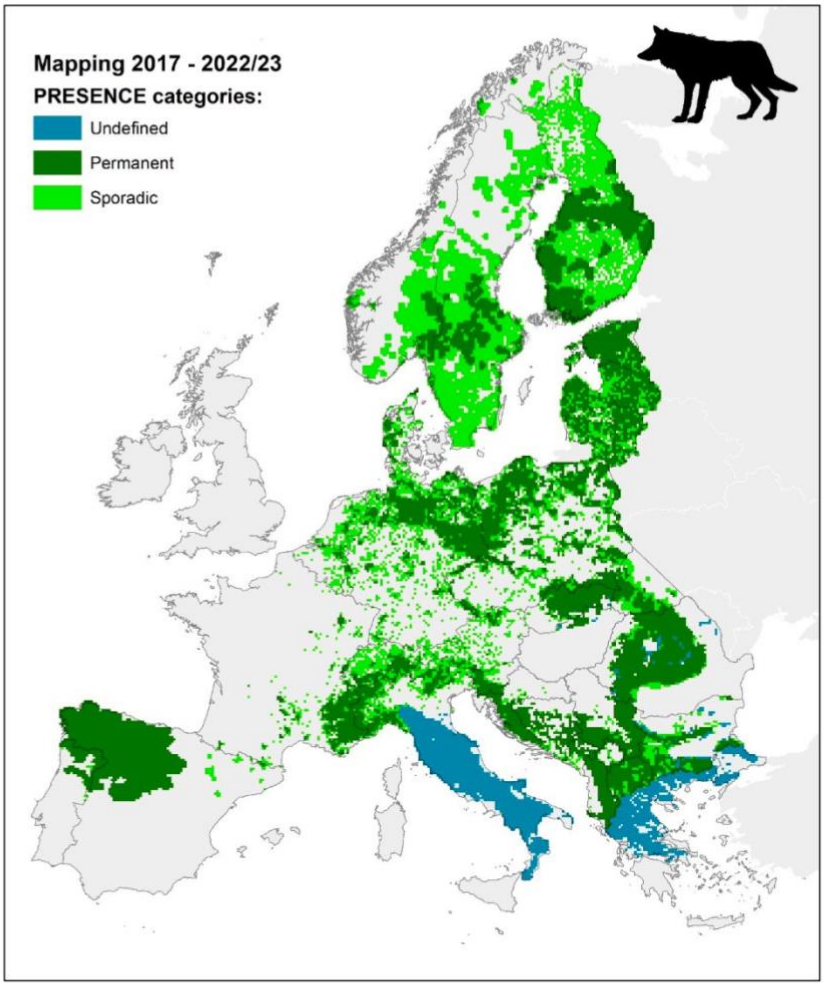

Figure 6. Wolf population distribution in Europe as of 2023, as reported to the EC in 2024 (Kaczensky et al., 2024).

Within a habitat suitability modelling exercise, Cristescu *et al.* (2019) made predictions of potential favorable wolf habitat (Figure 7) and show where conservation efforts could focus in order to improve habitat suitability and establish/maintain ecological connectivity for gray wolf.

As we can see from this projection, the entire Romanian Carpathian range represents ideal wolf habitat. Designating and preserving suitable habitats in key areas as ecological corridors, would ensure the connectivity of various mountainous groups, thus promoting a continuous and robust wolf population throughout the entire Carpathian Range. Maintaining a strong coexistence between people and wolves in this landscape is also essential in this regard.

Rooted in ancestral legends (Vulcanescu, 1987; Eliade, 1995; Neculae, 2005) and in a pastoral traditional way of living close to nature, the Romanian culture and spirituality has played a significant role in conserving the centuries-long coexistence of people and wolves in the pristine landscapes of the Carpathian Mountains (Boitani, 1995) until now. Understanding key mechanisms that promote coexistence and finding ways to maintain and enhance coexistence in the context of today's quickly changing world, represents the most important challenge we are faced with.

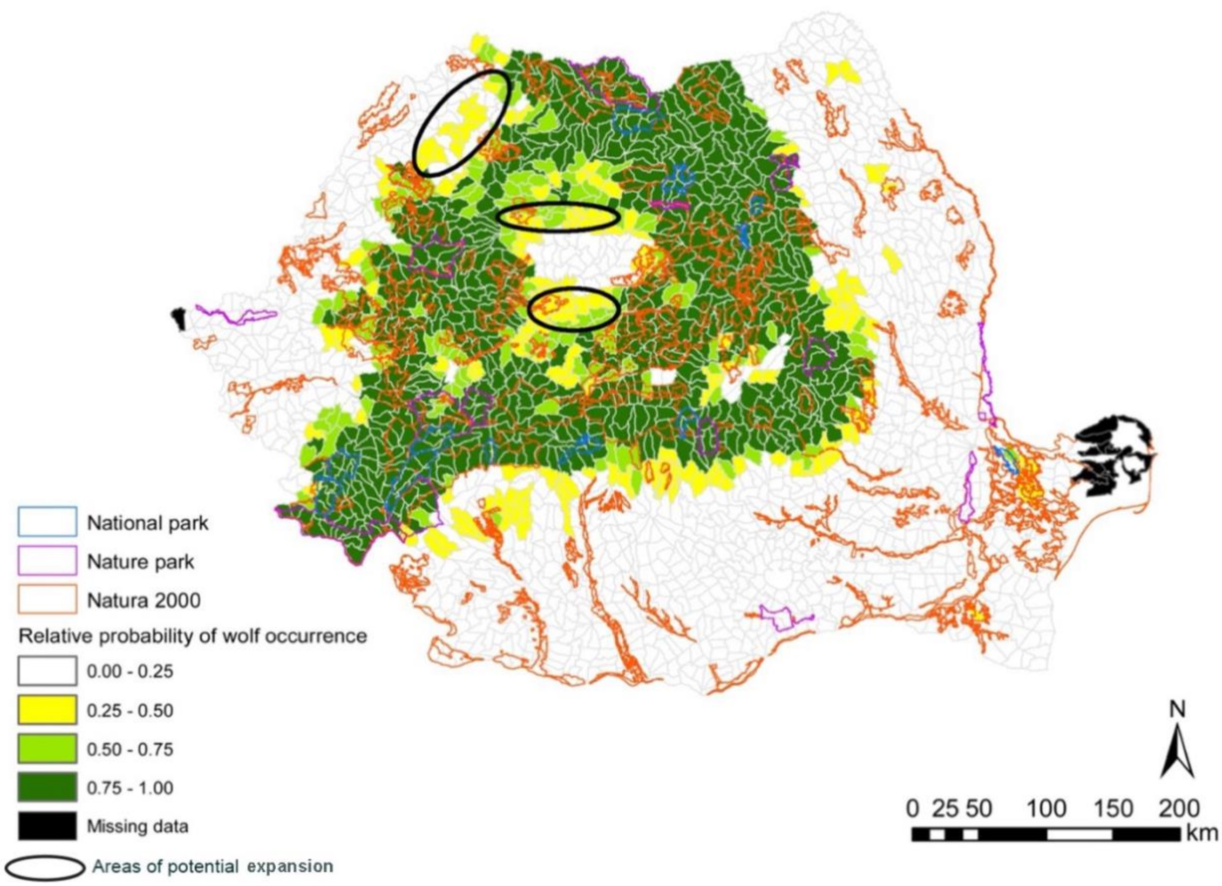

Figure 7. Predictions of potential suitable wolf habitat (Cristescu et al., 2019).

A threatened coexistence

Wolves used to be more widespread in Romania, but after World War II, in line with worldwide trends, control campaigns severely reduced wolf populations (Almăşan and Ionescu, 1993; Kecskes, 2008). However, the power of these campaigns wasn't as strong as in western European countries, wolves maintaining a stronghold in the vast forests of the Carpathians (Sin *et al.,* 2019). Thus, Romania has historically housed large and stable populations of these species

(Boitani, 2000; Breitenmoser *et al.,* 2000; Swenson *et al.,* 2000; Van Maanen *et al.,* 2006). The restriction of hunting during the communist regime encouraged the recovery of wolf populations, but their stability was not yet established. The fall of the communist regime then brought major changes in land ownership, land use, forest and wildlife management, sustained by political and economic instability. Today, these changes, combined with increasing human-wolf conflicts, negative attitudes and a general lack of reliable population-wide scientific data, threaten this historical coexistence (Van Maanen *et al.,* 2006).

There are several factors that represent potential threats to the conservation of Romanian wolves (Salvatori and Linnell, 2005; Van Maanen *et al.,* 2006; Iojă *et al.,* 2010; Knorn *et al.,* 2012; Kaczensky *et al.*, 2012; Szabo and Anthony, 2012; Berde *et al.,* 2016; Hulva *et al.,* 2018; NAPW, 2018; Cristescu *et al.,* 2019):

- Poor law enforcement;
- incoherent institutional framework;
- reduced capacity for science-based sustainable population management;
- general lack of reliable and robust monitoring and knowledge of basic population parameters and habitat suitability;
- negative attitudes towards wolves (specifically those of hunters and livestock producers);
- conflicts with livestock producers and competition with hunters over game species;
- population isolation;
- habitat fragmentation caused by urban and agricultural expansion and the proposed construction of two major motorways along with a general expansion of road development;
- habitat degradation due to land privatization, agriculture and intensive forestry;
- prey population reduction;
- hunting and population control;
- poaching (of wolves and prey populations);
- human-caused mortality;
- invasive species and competitor replacement (feral dogs; jackals); and
- hybridization.

Livestock grazing in wolf habitat

Deeply embedded in Romanian culture and folklore, livestock grazing has played an essential role in the history of the Romanian people and the pastoral way of living has been present for millennia, surviving even today in rural areas. Romania is home to one of Europe's rarest natural environments, a landscape where biodiversity thrives alongside traditional, low-impact agriculture in semi-subsistence farms and small-scale grazing (Figure 8).

Figure 8. Traditional semi-subsistence way of living of local communities in the ANP

This is a landscape that Europe has mostly lost, one that could serve as a “blueprint” for many more industrialized nations. The legendary ‘transhumance’ – the practice of moving livestock from one grazing ground to another in a seasonal cycle, typically to lowlands in winter and highlands in summer (Arnold and Greenfield, 2006) – is still practiced today in the Romanian Carpathians. In long distance transhumance, shepherds and their herds can cover, only one way, distances of up to 300 km in as much as six weeks (Juler, 2014). But as modern world intrudes more and more (due to the need to avoid main roads and built-up areas), short-distance transhumance, “pendulare” (the Romanian idiom for “pendulation”) – the moving of flocks between producers in summer (Arnold and Greenfield, 2006) – is becoming more predominant (Huband *et al.,* 2010) and continues to survive as it is vital for local communities and mountainous areas (Figure 9). Small sheep flocks (10 to 30 individuals) belonging to individual owners are usually amalgamated for the summer grazing season to create flocks of 300-500 (up to 1000) individuals, which are walked up to the mountains in May by shepherds together with their LGDs (Promberger, 1999; Goodwin *et al.,* 2000).

Figure 9. Left: typical sheepfold in the Apuseni Mountains. Right: A sheep flock grazing in the alpine meadows.

Stimulated by subsidies offered by the state from EU funding to livestock producers, the number of livestock has seen a significant increase in recent years, with the number of sheep more than doubling in the last two decades. Romania now has the third largest flock in EU, estimated in 2020 at ~10 million sheep and ~1.7 million goats (Popescu *et al.,* 2023) and also 11.4% of the sheep in the EU (Petek and Marinšek*,* 2021). Despite this fact, the average density of livestock grazing in Romania is one of the lowest in the EU and most sheep farms are not (yet) massive agribusinesses (Juler, 2014). Raising sheep is an important source of income for small-scale producers that own 70% of the national sheep flocks. These subsistence and semi-subsistence family farms raise sheep and goat for their milk, meat and wool, as a source of income but also as part of the pastoralism tradition in rural mountainous regions (Popescu *et al.,* 2023). Preserving this tradition and the cultural heritage of pastoralism in Romania is one of the main purposes of subsidies offered to producers. The role of incentives is also to sustain the grazing sector in order to maintain a stable income and food security of producers (Figure 10).

In large part, subsidies for grazing in alpine areas are also offered as a measure to maintain the biodiversity of certain valuable semi-natural grassland habitats, as grazing (alongside mowing) plays a vital role in the fine balance of arresting successional processes and maintaining the condition of the swards (Huband *et al.,* 2010).

The future of the remaining semi-natural grasslands in Europe is dependent upon maintaining low-intensity pastoralism that is, at the same time, socially and economically viable.

Figure 10. Subsistence agriculture in the high altitudes of the park. Left: the inside of a temporary sheepfold shack, bags full of coagulated curds are hung on the walls to separate de liquid that drips in containers underneath. Then the curd is pressed in wooden boxes until the cheese is ready. Right: small temporary establishments in the alpine areas where people bring their livestock to graze in the summer months.

Shepherding in the Romanian Carpathians continues to be a very low-intensity form of livestock production (Huband *et al.,* 2010) that, at the same time, support the livelihoods of thousands of small-scale producers in rural areas and dominates the European market, with Romania even possibly soon becoming the European leader in sheep milk production (Rancourt and Carrère, 2011). Currently, Romania is second (15.3%) only to Greece (32.1%) in the EU27, and fifth in the world, producing roughly 633.000 metric tons of sheep milk a year (Misachi, 2020). But will the subsidy system indeed fulfill its role in supporting the continuation of this rare traditional low-impact pastoral system in the context of the rapid social and economic changes?

Manifestation of human-wolf conflicts

EU subsidies greatly encourage the presence of sheep in the alpine areas, pushing livestock into wolf habitats. Naturally, wolf predation on livestock is not an uncommon phenomenon in this landscape (Figure 11). Predation can then be exacerbated by several natural pack related factors (small size of packs, dispersing packs, packs containing an injured individual, breeding female raising pups alone) and anthropogenic factors (habitat fragmentation and degradation, reduction of prey population, inefficient preventative measures, flocks located close to forest edge and tall vegetation, choice of grazing areas, carcass disposal methods) (NAPW, 2018).

Figure 11. Shepherd dragging goat carcasses after a wolf attack.

Predation on livestock and dogs, and wolves' impact on game species represent only one of two dimensions of conflict: the direct damage caused by wolves to human interests. The indirect effects of the dispute between humans over wolves emerges as a second, much more complex, dimension.

3.2. Apuseni Natural Park[2]

Originally declared a national park in 1990, the Apuseni Natural Park (ANP) was later declared a natural park in 2000 and now represents a key area for large carnivore conservation

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[2] this section is based on the official Management Plans for Apuseni Natural Park and the additional protected areas under the same administration (2008, 2016 and 2023).

situated in the heart of the Western Carpathians, Romania, covering an area of 75,784 ha on the territory of three counties.

Starting in 2014, the ANP administration has undertaken the management of three additional protected areas (Natura 2000 sites) that partly overlap with the territory of the park (ROSCI0002 Apuseni, ROSCI0016 Buteasa and ROSPA0081 Munții Apuseni Vlădeasa) and that of 55 natural reserves and nature monuments present in the park, the combined surface of the joint protected areas being 96,051 ha (Figures 12 and 13).

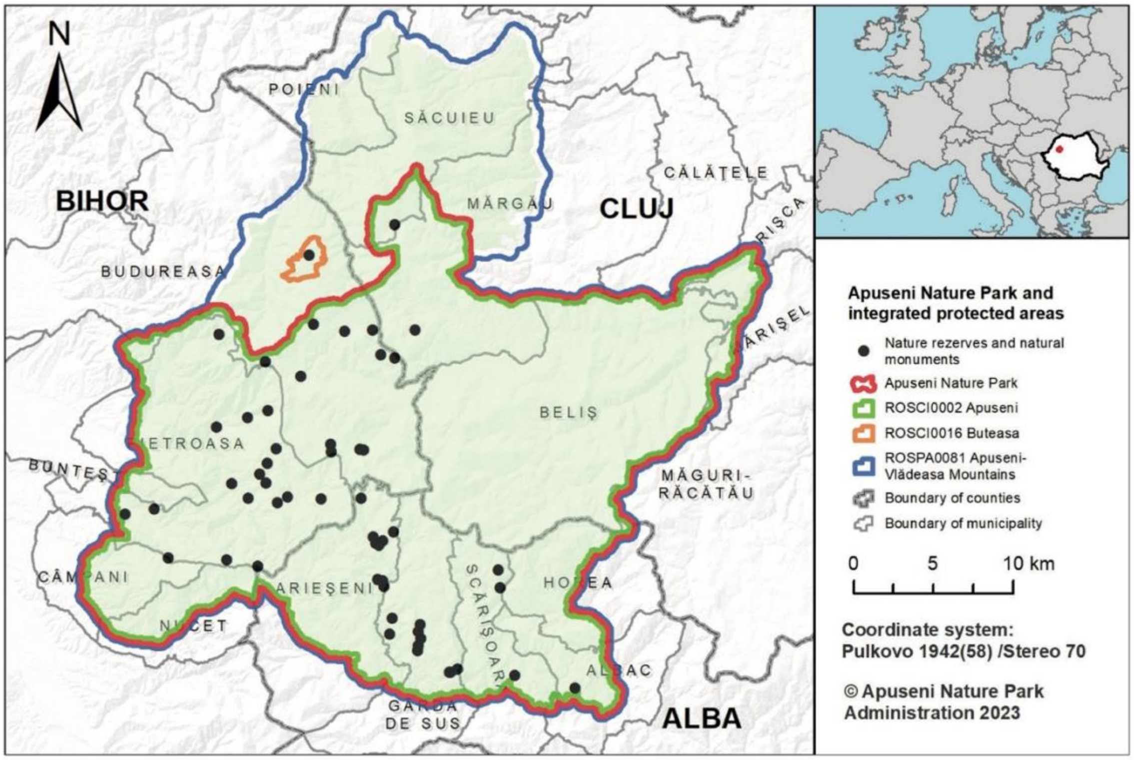

Figure 12. Location of Apuseni Natural Park and integrated protected areas in the Western Carpathians, Romania (Moş and Brînzan, 2024).

The ANP administration is held by the National Forestry Association (Romsilva) according to Emergency Government Ordinance OUG 57/2007. The main role of the park administration is to ensure the unitary management of ANP with the purpose of protecting and conserving the biological diversity and the sustainable use of the natural capital in conformity with the stipulations of the ANP management plan and internal regulations. The administration of ANP is guided and supervised in this quest by a Scientific Council and a Consultative Council.

Figure 13. Apuseni Natural Park, Romania (source: Apuseni Natural Park management plan 2008).

On the territory of the ANP there are 55 permanent settlements comprising approximately 9000 inhabitants. The local communities living in the ANP have preserved their traditional values and lifestyle for centuries and their long-term interaction with their environment has created a distinctive landscape (Figure 14), known as the Land of the Moți (Moş and Brînzan, 2024). The main economic activities of these local communities are the exploiting and processing of wood, agriculture (especially raising livestock), commerce, small industry and touristic activities. The lack of modern utilities and natural gas supply outlets leads to a total dependence of local communities on wood resources originating from the protected natural area.

Figure 14. Traditional lifestyle in the Apuseni Natural Park.

The surface of ANP is dominated by forested habitats (over 70% of the area) followed by areas covered by alpine meadows and grasslands (14.59%) (Figure 15). These particularities make wood exploitation and animal husbandry dominant economic activities at the local level and, implicitly, major sources of anthropogenic impacts. The complex and diverse habitats on the territory of the park are used by several migratory species of birds and bats for nesting and hibernation, and also by large carnivore populations and herbivores that need extensive unaltered natural areas. Grazing livestock is a very important activity in the park, with livestock being brought here even from settlements in the near vicinity of the park. Grazing can have negative effects on biodiversity both from overgrazing (Hogan, 2009) and under-grazing (in relation to conservation grazing) (WallisDeVries *et al.,* 1998).

Figure 15. Typical Apuseni landscapes of rolling hills covered by forests intertwined with meadows and grasslands (Source of picture on the left: APN).

Over time, intensive grazing, especially in the context of climate change, leads to the homogenization of the habitat and to a decrease in biodiversity (Jarque-Bascuñana, 2021) affecting the vegetation, insect species and implicitly bird species that feed on them (Sartorello *et al.,* 2020). The presence of shepherds, livestock and dogs near bird colonies populating these habitats disturbs nesting and can even lead to the total compromise of the brood. On the other hand, the abandonment of agropastoral practices leads to the destruction of these rare and protected alpine grassland habitats through the slow invasion of forest pioneer species, such as *Carpinus betulus*, *Populus tremula*, *Betula verrucosa*, affecting plant species, invertebrates, amphibians and reptiles (Cislaghi *et al.,* 2019). Grazing also directly affects wolf population and its prey species (*Cervus elaphus, Capreolus capreolus* and *Rupicapra rupicapra)* in forested habitats near the grazing areas and in herd transit points to pastures. Both direct and indirect effects on wolf populations are widely discussed within this research.

Due to its role in arresting successional processes and maintaining the high biodiversity of certain grassland habitats, traditionally used as pastures, grazing is necessary in such habitats (Cislaghi *et al.,* 2019). Incentives are therefore awarded for raising livestock in these areas. Grazing areas are amended by the park administration and grazing livestock in these areas can only be done by livestock producers that have secured the legal rights of using the pastures within specific regulated limits (spatial, temporal, species composition and size of flocks) preapproved by the park. Grazing is strictly forbidden in forested habitats and the transit of flocks through these habitats can only be done on preapproved routes during the transhumance of flocks. The temporary summer sheepfolds need to be placed only in locations approved by the park administration, 1 to 3 m away from water sources and livestock producers need to comply with legal regulation regarding maintaining livestock health, preventative measures, limiting numbers of livestock guarding dogs and equipping these dogs with yokes.

According to the latest data from the National Institute of Statistics (2020) on the dynamics of the pastoral sector, there has been a moderate, but constant increase in sheep and goat numbers grazing in the areas overlapping and adjacent to the park. Based on data from same study, in 2020, a total of 27,600 sheep and 3600 goats was estimated to graze on the surface of the park and the immediate adjacent areas (Nitu, 2022). This number comes in contrast with the Figures put forward by the park managers, who estimate approximately 9300 sheep grazing in the park in the same year. Yet, findings of this study show an approximate number of

16,500 sheep on the surface of the park during the time of the research (2017). Despite the fact that the park administration approves the numbers of livestock individuals to be grazed on the surface of the park, there is still confusion, a wide range of approximations and a lack of concrete scientific data on the total number of livestock grazing in the park each year. The same lack of data applies to livestock distribution and the only indicator of where livestock could be grazing on the surface of the park is the distribution of alpine pasture habitats (Figure 16) that represent 14,649 ha of the total park surface.

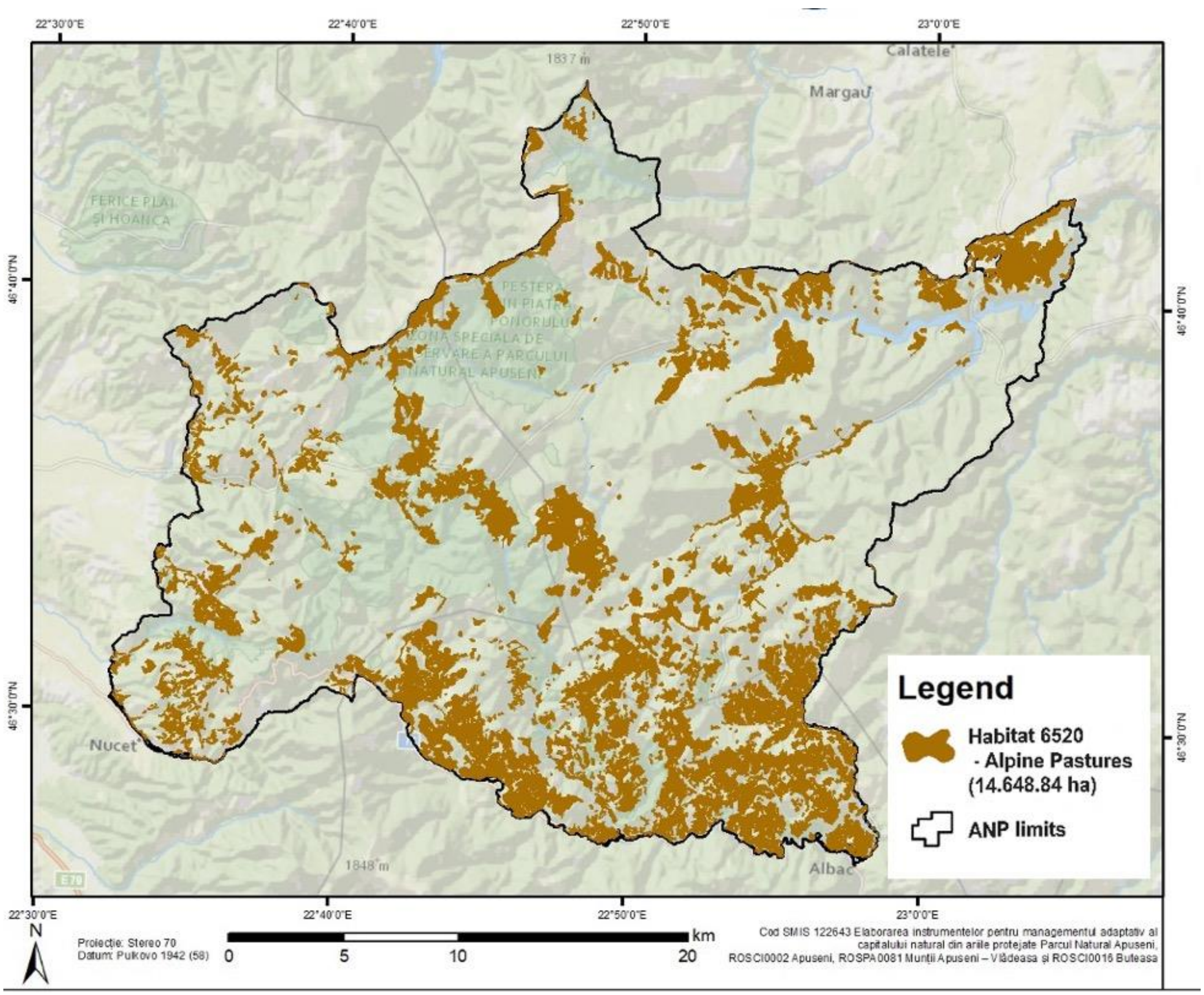

Figure 16. Distribution of the Alpine Pasture habitat 6520 on the surface of the Apuseni Natural Park (ANPMP, 2023).

Of the over 180 species of vertebrates identified on the territory of the ANP, 121 are protected species, listed by various national and international normative acts, as well as in the Red Book of Vertebrates from Romania (Botnariuc and Tatole, 2005). The protected large mammal fauna of the park (Figure 17) consists of well represented, consolidated populations of wolves, lynx, brown bear, roe deer, red deer, wild boar, wild cat (*Felis silvestris*), ferret (*Mustela Linnaeus*), and otter (*Lutra lutra)*.

Figure 17. Large mammals protected in the park. Upper left: brown bear. Upper right: red deer. Lower left: lynx. Lower right: roe deer (Source: APN).

According to the management plan of ANP (ANPMP, 2016), as of 2016 (when the field work for this research took place), there were 26 wolves living on the territory of the park, divided into 4 packs (according to scientific studies realized previous to 2008). There was a very well represented lynx population of 12 individuals and only 21 bears (much below the carrying capacity of the habitat). The most recent (yet to be approved by the Ministry) management plan of ANP (ANPMP, 2023) estimates a stable wolf population of 25-38 individuals of favorable conservation status, occupying 66,800 ha, equal to the surface assessed as suitable for the species. This surface represents 88% of the territory of the park (Figure 18). These wolf individuals cross the park borders and also move in the specific habitats outside the protected natural area. These recent numbers (and the park managers) suggest an increase in wolf numbers (and pack size) in the last decade, similar to the trend of other large carnivore populations, with lynx currently at an approximate population of 19-32 individuals and bears ranging between 48-65 individuals. At the same time, the difference in numbers can be attributed to a difference in assessment methodology.

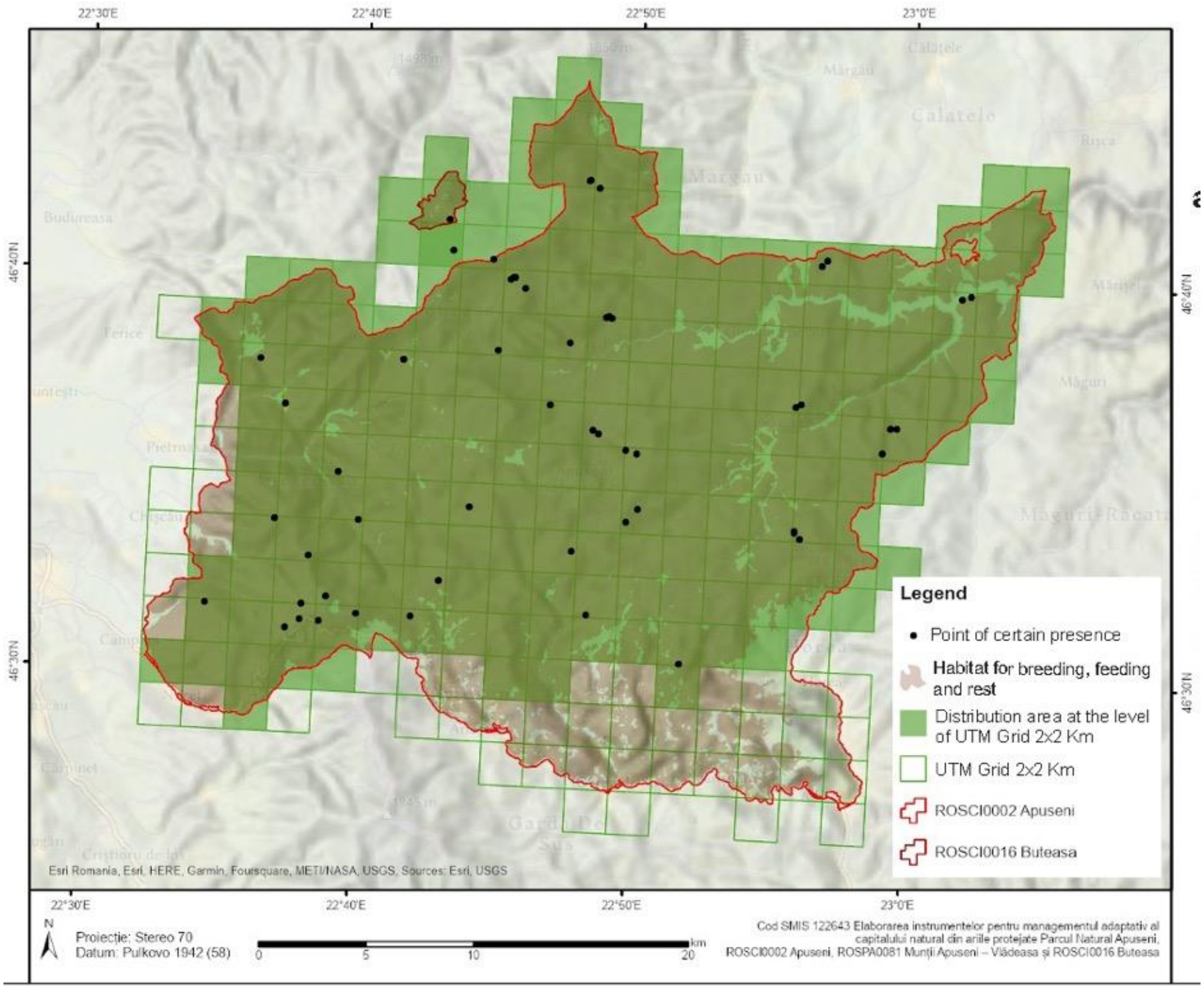

Figure 18. Wolf (Canis lupus) and favorable habitat distribution on the surface of the Apuseni Natural Park (ANPMP, 2023).

Hunting in the park is carried out in compliance with the principle of sustainability, based on evaluation studies and hunting management plans by the 18 hunting grounds that partially overlap with the territory of the park. ANP Administration assesses and approves the hunting management plans put forward by the hunting associations, at the request of the beneficiaries based on the submitted documentation. The yearly evaluation studies are carried out by the same hunting associations in collaboration with the park administration. Hunting is fully forbidden in the Strict Protection and the Integral Protection Areas of the park (Figure 19).

Because the Western Carpathians are geographically partially separated from the Southern and Eastern Carpathians, they have the appearance of an island, isolated by lowlands dominated by human inhabitance and infrastructure. Due to reduced connectivity among wildlife populations, the Western Carpathians are possibly more vulnerable (Moş and Brînzan, 2024), particularly in the case of large carnivores that need communication among gene pools in order to remain viable.

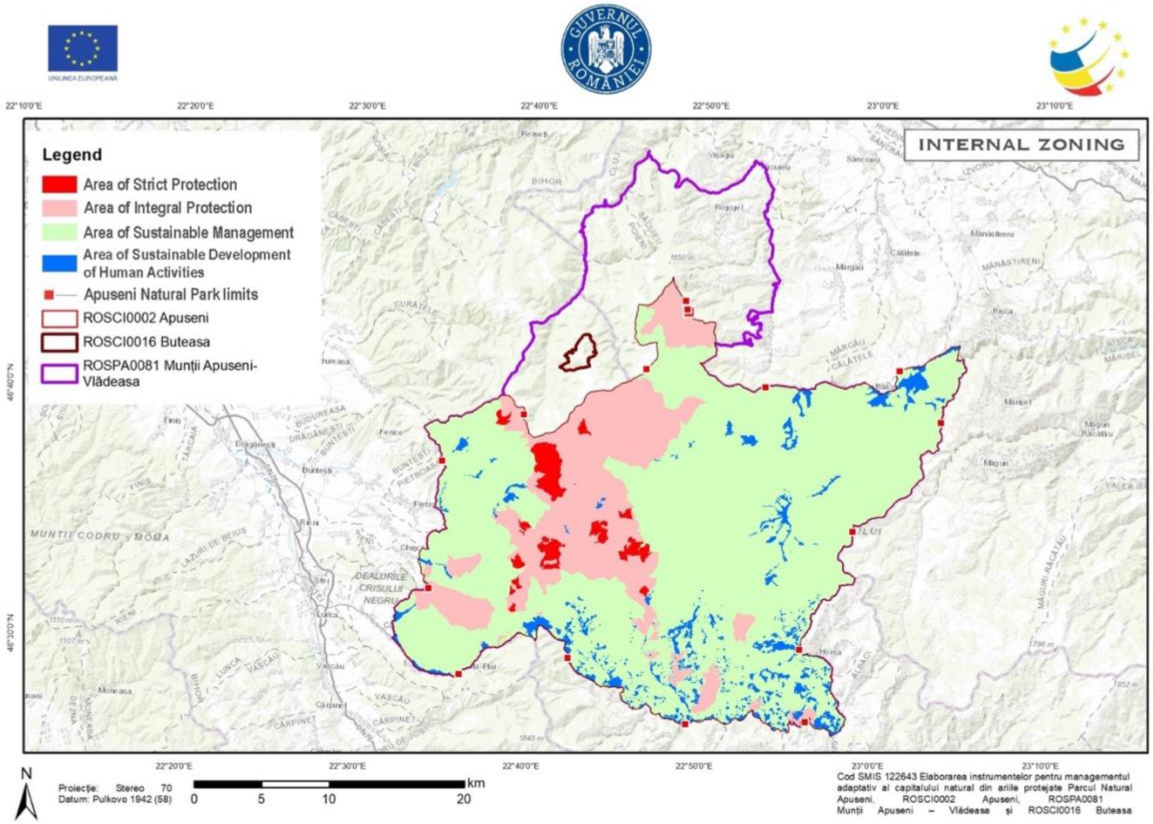

Figure 19. Management zoning of Apuseni Natural Park (ANPMP, 2023)

Therefore, the area covered by the natural park is seen as a core area that is now included in a national ecological network of Nature 2000 sites (Figure 20), critical for overcoming the potential threats of this pressing connectivity issue. In order to ensure that large carnivore populations do not become demographically, genetically or ecologically isolated, and that a favorable state of conservation of these species is achieved and maintained, the LIFE Connect Carpathians EU funded project, coordinated by Flora and Fauna International (FFI), contributed to increase the functional connectivity of the ecological corridor that connects the Western and the Southern Carpathians – the so called "Apuseni Link" – through securing and restoring of critical habitat (LCC report, no date). Additionally, the project contributed, within the extent of the corridor, to reducing predator damages, increasing monitoring, raising awareness and creating several important structures such as an Intervention Team for predation events, anti-poaching units and regional action plans for bears and wolves.

Despite this fact, the populations of large carnivores living here still represent separate population centers. Maintaining strong healthy populations in such core areas and assuring connectivity with other subpopulations are critical to sustaining large carnivores.

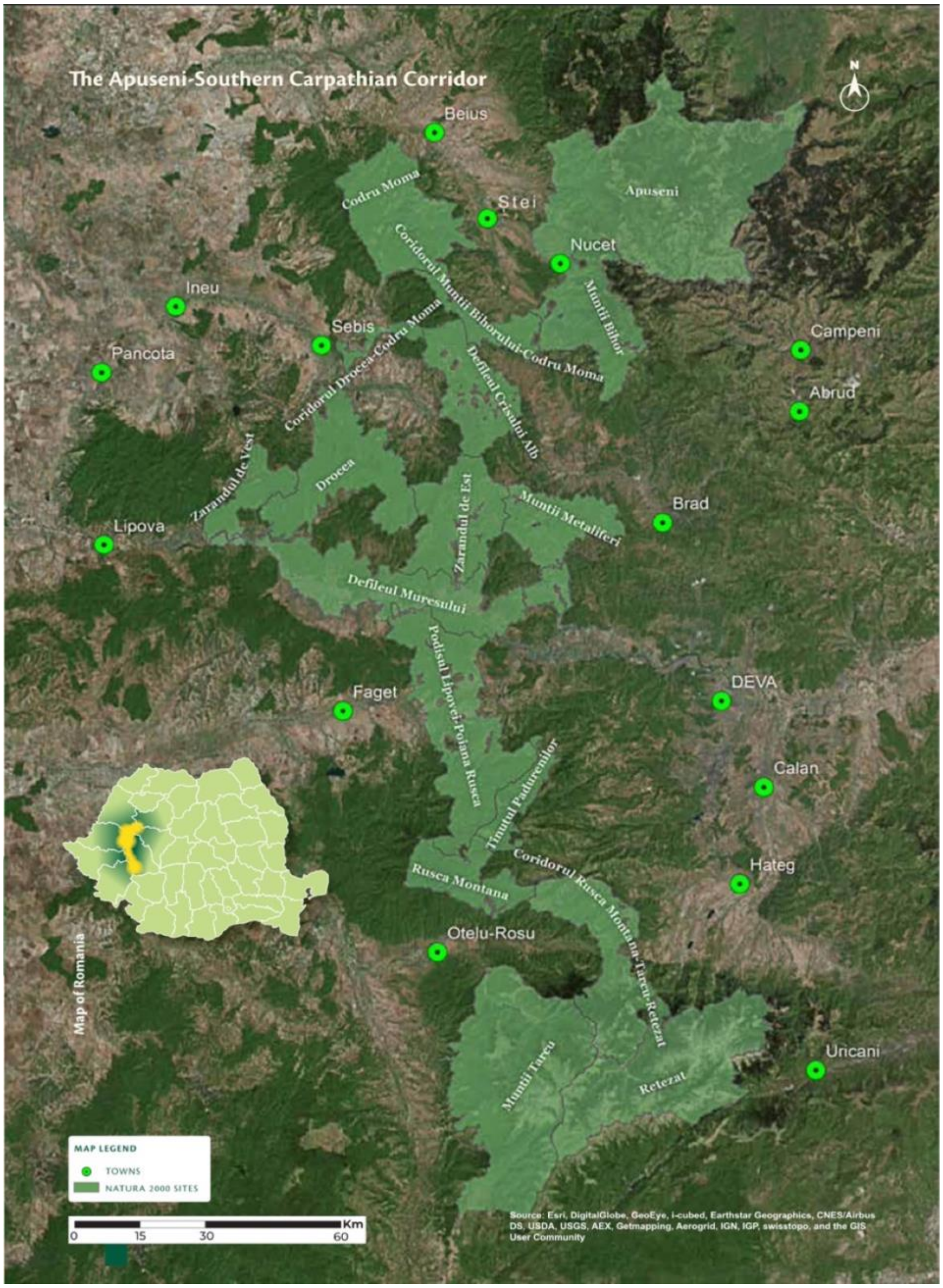

Figure 20. The Apuseni Link, an ecological corridor of Natura 2000 sites (LCC Report, no date).

Wolf populations living here (Figure 21) represent the most vulnerable populations in Romania due to the intersection of several geographical, political and economic factors, including (i) a relatively small population, (ii) spatial separation from the rest of the Carpathians and other wolf populations, and (ii) the proposed construction of two motorways, one in the south (interrupting connectivity with the Southern Carpathians) and one in the north-east (interrupting connectivity with the Eastern Carpathians).

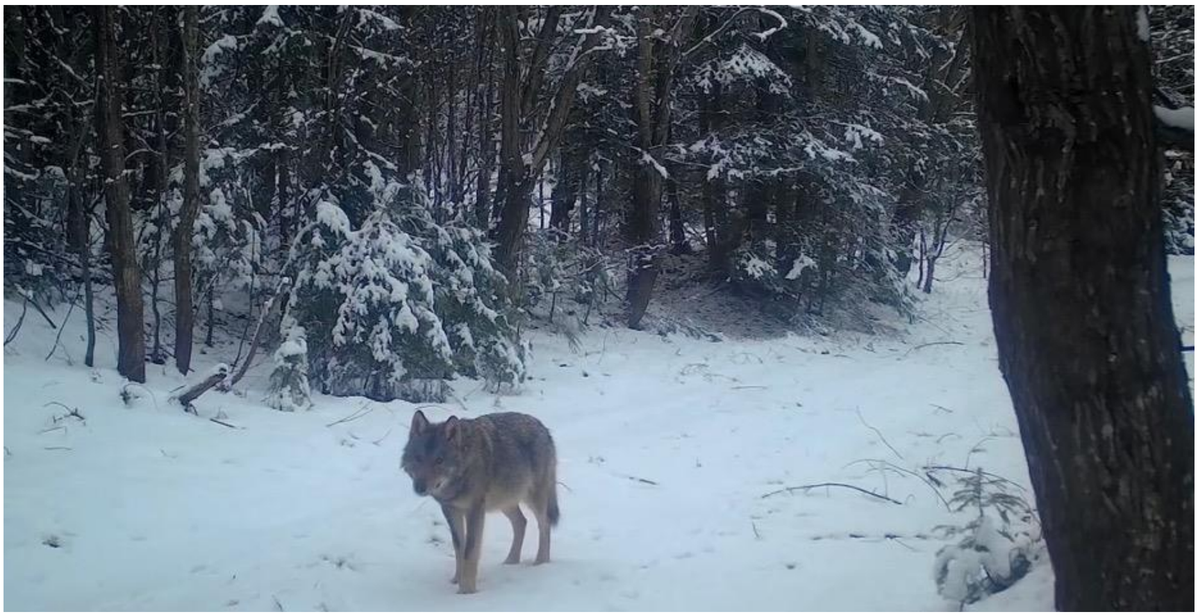

Figure 21. Grey Wolf in the Apuseni Natural Park (Source: APN).

With a medium altitude of 1000 m.a.s.l., the relatively low height of these mountains and the favorable landscapes have led to the development of a relatively dense network of human settlements (Figure 22) and, implicitly, complex infrastructure (Figure 23) that has caused habitat fragmentation and habitat loss.

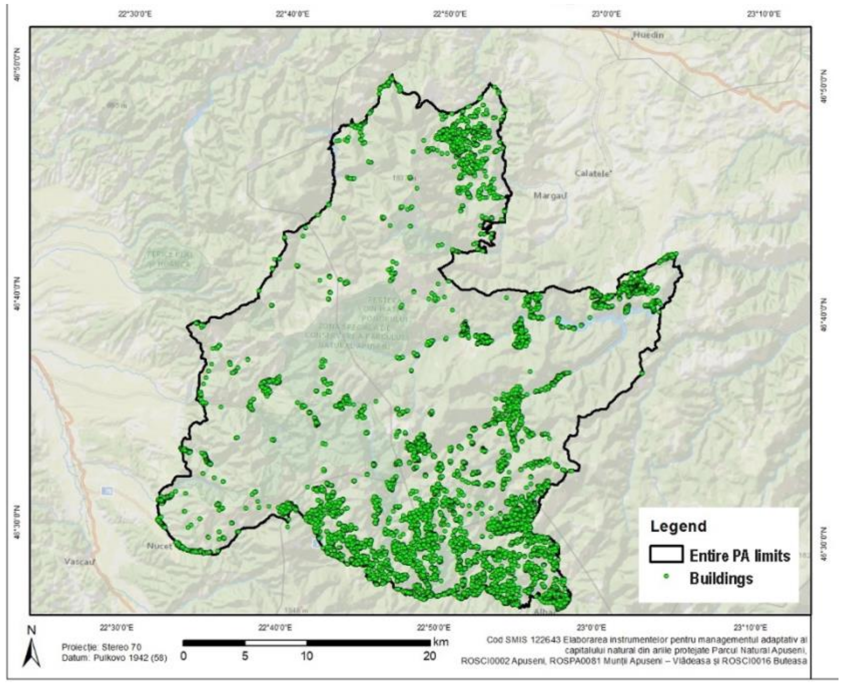

Figure 22. Distribution of settlements and buildings on the surface of Apuseni Natural Park and adjacent protected areas (ANPMP, 2023).

The overlapping of human settlements with large carnivore territories facilitates conflicts. The park's management plan shows that livestock (particularly sheep) predation by wolves is one of the most common causes of human wolf conflicts in this area.

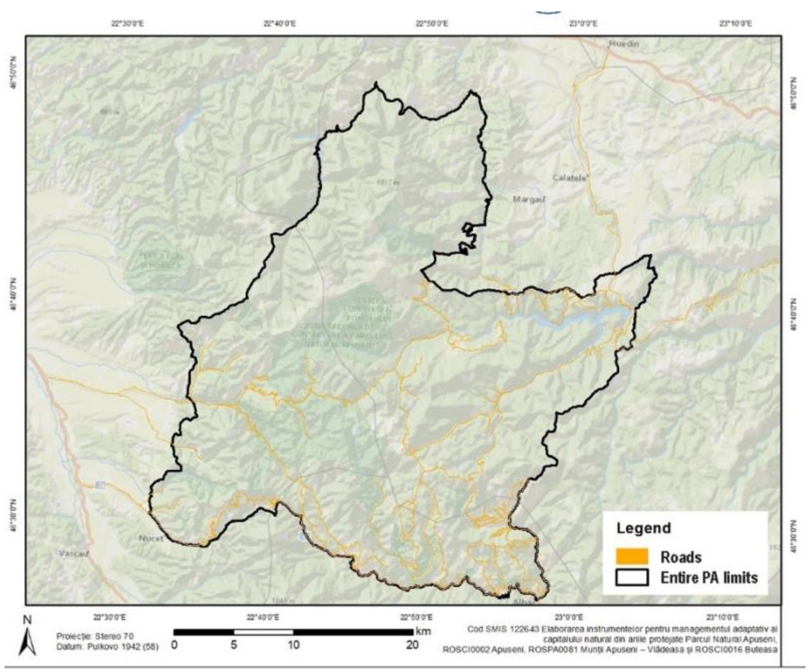

Figure 23. Distribution of road infrastructure on the surface of Apuseni Natural Park and adjacent protected areas (ANPMP, 2023)

4. Analytical framework

As the previous chapter has shown, human-wolf conflicts are the single most important threat to the long-term conservation of wolves in Europe and effective conflict resolution is of top priority for wolf management and conservation. Understanding the way HWC unfolds in the present case is therefore essential for finding solutions to lower the conflict, reduce negative attitudes and improve long-term human-wolf coexistence. In-depth research analyzing the conflict situation is essential to provide management with the tools and understanding it needs in this difficult endeavor.

There are several characteristics that such research should embody. First, it should be integrative and interdisciplinary in order to grasp all dimensions of the conflict (Mascia *et al.,* 2003; Manfredo and Dayer, 2004; Dickman, 2010). Second, it should be well-focused and purpose-driven in order to produce useful practical results in the short time given. Third, it should be able to adapt previous knowledge and expertise to the specific context and issue. Such research would therefore be based on a theoretical framework that comprises this complexity and interdisciplinarity, combining both ecological principles and social theoretical considerations.

4.1. Ecological principles underpinning the research

Conservation of wildlife requires an understanding of biology and ecology in order to find solutions that work with natural processes and not against them**.** In order to find effective solutions for large carnivore conservation, and in particular to the problems that arise from HWC manifested in the specific case of this research, there is a need to integrate ecological knowledge on both the species and its habitat in an interdisciplinary approach. Therefore, the design of the present approach is tailored to this specific case and is based on a strong analytical framework of essential ecological theories, concepts and underlying ecological principles that are useful in understanding wolf biology, its interactions with the environment, its behavioral patterns and, more specifically, in explaining wolf predation on livestock.

Ecology dictates that each individual organism acts to maximize its own survival and the perpetuation of its genes. At the same time, each individual is part of a larger population, community or ecosystem. The interaction between organisms and their physical environment is what creates this larger assembly, the ecosystem, which is normally in a state of dynamic equilibrium. Through alteration of normal physical processes and interactions, humans intensify disturbance and accelerate change, pushing ecosystems towards unanticipated directions (Orland, 2004; Vold and Buffett, 2008). The impacts human activities have on the environment have consequences also on wolf populations and can ultimately influence and aggravate conflicts. Examining more specific principles and phenomena can show how certain natural processes are influenced and disturbed by human activities, leading to increased predation (Mattson, 1990).

Theories concerning foraging behavior, such as the optimal foraging theory are especially useful in explaining predation. '*Optimal foraging theory'*, first formulated in 1966 by R. H. MacArthur and E. R. Pianka, attempts to predict an animal's behavior when searching for food (Pyke, 1984). Simply put, an animal will aim to gain the most benefit for the lowest cost (lowest energy consumption) during foraging, in order to maximize its fitness. Therefore, one should be able to predict the strategy that the animal will adopt. One of the advantages of using this model for this study is that it can help explain predation in the following way: wolves are specialized in hunting deer and other ungulates and therefore they will treat livestock as prey, a domesticated version of their natural prey (Treves and Karanth, 2003; Graham *et al.,* 2005). Wolves in Europe prefer medium sized wild ungulates (Newsome *et al.,* 2016), similar in size to the livestock usually present in wolf populated areas here (sheep and goat). Even though livestock may present attenuated or erratic predator avoidance strategies compared to wild prey (Laporte *et al.,* 2010; Muhly *et al.,* 2011), their domestication did not lead to the complete absence of such anti-predator behavior or physiological defense traits (such as horns, antlers, spikes and fangs). Under conditions of stress, they show similar behavioral responses to predators as wild prey: vigilance, flocking, flight, behavior inhibition under cover, changes in habitat selection and various changes in movement patterns (Dwyer, 2004; Laporte *et al.,* 2010) but these responses can be more weak or inconsistent. Wolves' preference seems to be a combination of prey size, prey defense strategies, and prey abundance (Janiero-Otero *et al.,* 2020).

Overall, wolves tend to select wild prey over livestock even when livestock is abundant (Newsome *et al.,* 2016; Janiero-Otero *et al.,* 2020). But when wolves' natural prey becomes scarce, the cost of hunting it will increase (more energy is spent locating prey). Because they are an opportunistic species, wolves will choose the prey that is most abundant, being capable of changing their diet according to food availability. The more abundant and easily accessible livestock (such as free ranging animals or unprotected pastures), similar or smaller in size to the wild, will require less costs, less energy spent (Janiero-Otero *et al.,* 2020), and therefore, in line with the assumptions of this theory, in these conditions wolves will choose livestock over wild prey to optimize their energy expense. Of course, there will also be some costs associated with preying on livestock (e.g. overcoming protective measures and the risks imposed by the presence of humans) but if, in the overall scheme, the cost of hunting livestock will be lower than in the case of the natural prey, in other words, if livestock will be more "profitable", wolves will seek to predate it. This is especially true in situations when livestock are left to graze freely in small numbers (Janiero-Otero *et al.,* 2020), a depletion of the natural prey (Merigi *et al.,* 2014) and of dispersing wolf individuals (i.e. lone wolves that do not benefit of the increased hunting power of the combined pack) (Imbert *et al.,* 2016).

The '*Marginal Value Theorem'* (Charnov, 1974; Krebs and Davies, 1989; Sinervo, 1997) is very useful in explaining particularly this last case. The Marginal Value Theorem is an optimality model that problematizes travel time and energy gain in an animal's quest of exploiting a certain patch of food, stating that there is a "giving up time" when an organism must decide when it is economically favorable to leave a patch that it is exploiting if it is no longer profitable. An animal's decisions in foraging will be influenced by the need to maximize the rate of energy gain which is a function of load size (amount of food intake) per unit of time spent traveling to the patch and foraging in the patch (Sinervo, 1997). In case of prey depletion, energy gain for hunting wild prey will be low, with wolves having to spend more time (and therefore energy) in searching for prey and the amount of intake will be low. In these cases, wolves can decide to "give up" the search for natural prey and choose livestock in order to maximize energy gain (especially lone and less experienced individuals who need to expend more energy in catching wild prey expressing anti-predator mechanisms, as opposed to hunting livestock which have lost or reduced this capacity).

In this way, these theoretical considerations are very useful for managers in understanding the importance of *preventative measures* to lower predation, but also the importance of *preserving healthy prey populations*, and the importance of *avoiding pack disruption* through hunting (Imbert *et al.,* 2016). Another advantage of this theory is that it helps identify the reasons why wolves tend to choose certain physical characteristics of the environment at the moment of attack, and it can shed light on identifying the most relevant factors influencing predation. This, in turn, can also provide essential information on the type of preventative measure(s) to take.

There has also been much criticism brought to the validity of the optimal foraging theory (Pyke, 1984; Gray, 1987; Pierce and Ollason, 1987) and several limitations have been identified. Criticisms show that some of the assumptions the theory makes might not be entirely correct in reality: the power of natural selection to produce perfect designs of foraging strategies and the fact that these strategies are shaped by natural selection with no other intervening factors. Other critical arguments are related to the fact that this theory lacks precision in practice because the concepts it entails are very difficult to measure and show that the theory can never be truly tested.

The most important disadvantage that is relevant in the context of this study is that this theory cannot entirely explain predation (Pyke, 1984), especially overkill situations (Mysterud, 1980), due to the vast array of intervening factors that shape actual situations. The theory cannot fully grasp the vast complexity of the real world where organisms are integrated systems constantly affected and influenced by external and internal factors (e.g. in case of wolves, the influence of past experience in finding/capturing prey, pack hierarchy behavior, pack disruption, and dispersing individuals). The exact effects of all active factors and their complex interaction are very difficult to test in the field, and thus to fully understand. The fashion in which various factors influence predation is not yet fully understood as their effect on predation can, in some cases, differ from situation to situation. A prime example is the case of the relationship between prey presence and predation. In many cases the absence/scarcity of native prey was shown to increase predation on livestock (prey scarcity hypothesis), whereas in other situations the presence/abundance of native prey was shown to also increase predation rates by attracting and increasing the number of predators (prey tracking hypothesis) (Suryawanshi *et al.,* 2013; Nelson *et al.,* 2016). This relationship becomes even more complex if we consider the difference between prey *availability* vs. prey *accessibility* and phenomena such as prey antipredator behavior and the effects that *coupled human-natural systems* (Carter *et al.,* 2014; Carter and Linell, 2016) and the *landscape of coexistence* (Oriol Cotterill *et al.,* 2015; Rio-Major *et al.,* 2019) have on predation.

The *Ecology of Fear* (Sih, 1980; Lima and Dill, 1990; Brown *et al.,* 1999; Laundré *et al.,* 2010) quantifies the non-lethal, fear and stress driven behavioral responses of prey animals to the risk of predation, such as increased vigilance (Lima and Bednekoff, 1999), flight, flocking, behavior inhibition under cover, changes in habitat selection and various changes in movement patterns (Laporte *et al.,* 2010, Dwyer, 2004). The concept of *Landscape of Fear* (Laundré *et al.,* 2001; Preisser *et al.,* 2007; Laundré *et al.,* 2010; Miller *et al.,* 2014; Atkins *et al.,* 2017; Allen *et al.,* 2019; Miller and Schmitz, 2019) is a spatial conceptualization of this theory, showing that all of these behavioral responses that prey exhibit to consistent predator risk responses, create "a tractable spatial distribution of predator–prey interactions" (Miller *et al.,* 2015), a new heterogenous "landscape" of safer but less optimal foraging choices for prey and of more abundant but also less optimal predation opportunities for carnivores. The threat of predation causes a redistribution of the areas where prey forage, even at the expense of foraging quality. Prey species will avoid areas characterized by high degrees of prey catchability, and will select habitats with low predator lethality, leading to a discrepancy between where prey is *available* versus *accessible* to carnivores (Laundré *et al.,* 2009; Trainor and Schmitz, 2014). Prey availability alone will not be enough to guarantee hunting success for carnivores, and thus, many carnivores will prioritize prey vulnerability as much, or even more, than prey abundance (Hopcraft *et al.,* 2005; Balme *et al.,* 2007; Fuller *et al.,* 2007; Laundre *et al.,* 2009; Davidson *et al.,* 2012). Large carnivores will, more often than not, choose to hunt in habitats characterized by certain spatiotemporal combinations of landscape features that render prey more vulnerable to predation (Hopcraft *et al.,* 2005; Laundré *et al.,* 2009; Smith *et al.,* 2020), a mix of land uses, vegetation structure, human activities, and prey densities (Gorini *et al.,* 2012). Carnivore predation on livestock can thus be better understood by identifying these spatial and temporal patterns of vulnerable areas (Miller and Schmitz, 2019).

When trying to understand predation, the influence of human presence and human activities cannot be ignored. Humans also shape how animals behave, interact and use the landscape through management and their presence, therefore theories based strictly on predator and prey biology and behavior are insufficient to explain predation. *Landscape of coexistence* is a concept that emerged as a subset of the *Landscape of Fear* and was first introduced by Oriol-Cotterill *et al.* (2015). This concept is now being advanced as a central consideration in wildlife management (Smith *et al.,* 2015; Rio-Major *et al.,* 2019, Miller and Schmitz, 2019; Kautz *et al.,* 2021) that specifically accounts for the effects that human presence and human-caused mortality risk have on large carnivores and their distribution and behavioral ecology.

Just like prey, predators react with fear to threats, such as fire, competing packs, other large carnivores and also the threat of humans (Smith *et al.,* 2015; Rio-Major *et al.,* 2019). Oriol-Cotterill *et al.* (2015) argue that large carnivores respond to human threat by spatiotemporally separating their activities in order to reduce contact with people and that this behavioral adaptation may be more important in shaping their distribution and behavioral ecology in human-dominated landscapes than the distribution of resources. Such human-induced shifts in predator distribution can change the risk landscape for prey species by providing refuge through spatial decoupling prey from predators (Muhly *et al.,* 2011) or, on the contrary, through concentrating danger by overlap of temporal activities (Shamoon *et al.,* 2018).

Therefore, the *Landscape of Coexistence* is a more adequate concept in explaining and predicting patterns of predation on livestock because it updates the theories and concepts described so far to a current reality: the increasingly prevalent presence of humans in most terrestrial large carnivore habitats and the consequential downgrading of carnivores from ultimate, to penultimate predators. The role of humans in predator prey interactions becomes more and more important. As shown above, if we rely on the optimal foraging theory alone, we will predict that carnivores in human-dominated areas should choose domestic livestock over wild prey based on their larger abundance and increased vulnerability. But this has been shown not to be true in many such landscapes (Newsome *et al.,* 2016; Janiero-Otero *et al.,* 2020). The *Landscape of Coexistence* helps us understand that, in these human-dominated landscapes, carnivores make complex foraging decisions that account for not only prey abundance and vulnerability but also for the human-caused risk of mortality (Rio-Major *et al.,* 2019), even at the cost of increasing energy expense for foraging. This makes carnivores choose livestock less than classic foraging theories would predict, opting for their wild prey instead (Oriol-Cotterill *et al.,* 2015; Janiero-Otero *et al.,* 2020). Sometimes, even when densities of wild prey become reduced, carnivores have been shown to shift their diets towards alternative wild prey species rather than livestock to maintain their energetic requirements (Woodroffe *et al.,* 2007). But when wild ungulates are very rare or even absent, carnivores adapt to highly human-dominated landscapes by feeding mostly on livestock and other food sources (Miller and Schmitz, 2019; Janiero-Otero *et al.,* 2020). In most cases, as soon as wild prey populations recover, carnivores turn back to choosing wild prey over livestock (Meriggi *et al.,* 2014; Imbert *et al.,* 2016). These findings reemphasize the importance of maintaining and restoring adequate wild prey densities and imposing preventative measures in order to lower predation and improve coexistence in highly human-populated areas where carnivore and human habitats overlap. The ideas put forward by these concepts also show that understanding the mechanisms and spatiotemporal patterns of livestock predation associated with different management interventions can provide insight into improving coexistence between predators and livestock (Miller and Schmitz, 2019; Rio-Major *et al.,* 2019; Kautz *et al.,* 2021; Gaynor *et al.,* 2022).

Integrated coupled human-natural systems (CHNS) (proposed by Carter *et al.,* 2014) is another approach used for understanding the interaction between people and wildlife, but this framework expands the perspective to a much more comprehensive and integrative view of the issue, analyzing the patterns, causes, and consequences of changes in wildlife populations and habitats, human populations and land uses, and their interactions. It emphasizes the importance of seeing the human and natural components of a system as coupled rather than separate, showing that there is continuous multi-dimensional feedback between these components. In emphasizing that humans are part of nature, and that social and ecological systems are linked through feedback mechanisms, socio-ecological systems (SES) are defined as a perpetually dynamic, complex system with continuous adaptation (Berkes *et al.,* 2003). As Redman *et al.* (2004) puts it, the social dimensions of ecological change and the ecological dimensions of social change need to be linked by integrating social sciences into ecological studies.

Thus, the much broader CHNS approach is even better suited for understanding human-carnivore dynamics in human-dominated landscapes, presenting three main advantages. First, CHANS uses a combined social and environmental perspective bringing together theoretical and analytical techniques from diverse disciplines to understand the nuances of these very complex systems. Second, it expands the focus from a unidirectional relationship (how people affect wildlife) to a much more complex approach that can identify key interdependent relationships and mutual feedback between people and wildlife and their habitats and the larger ecosystem.

Third, CHNS zooms out to a broader analysis of cross-scale (e.g., spatial, temporal, and organizational) interactions between people and wildlife.

Thus, the current research adopts such a comprehensive, integrative and multidisciplinary approach for understanding human-wolf conflicts in the complex and dynamic human-influenced landscape of the ANP.

The complex approach adopted by CHNS is very well suited to describe human-wolf interactions and wolf predation on livestock. As demonstrated above, predation is influenced by a wide array of factors, from wolf and prey (both wild prey and livestock) biology and behavior to *habitat and food characteristics and availability* (Gilbert and Lanner, 1995; Baruch-Mordo *et al.,* 2014) and human influence. Constraints in the availability of habitat and food lead wolves closer to human activities (Kaczensky *et al.,* 2012). Usually, areas where wolf and human activities overlap are also associated with high numbers of livestock, as grazing is a common livelihood of people living in these areas (Miller, 2015). Especially in cases of poorly protected free grazing animals and pastures with poor husbandry practices, livestock becomes increasingly vulnerable to wolf attacks. The situation is aggravated further by human induced decreases of available wild prey, *habitat fragmentation* and the subsequent increase of edge effects. '*Edge effects'* depicts a phenomenon generated by habitat fragmentation in which core areas are increasingly divided into smaller patches that are no longer connected and therefore suffer an increase in edge habitats (Sisk and Haddad, 2002). These edge habitats are shown to be greatly used by predators to attack prey, because they are both richer in prey species and provide good cover for predators (Gibbs *et al.,* 2008).

In adopting the CHANS approach, this research also recognizes the importance of engaging SES as Complex Adaptive Systems (CAS) emphasizing that "*SES related concepts such as resilience, adaptability, transformability, and stewardship are all informed by the underlying assumptions that inform our understanding of the characteristics and dynamics of CAS*" (Preiser *et al.,* 2018, p. 2). At the base of CAS's lay the fundamental theoretical premises of complexity thinking (Rogers *et al.,* 2013), complex systems theory (Cilliers, 1998; Cilliers *et al.,* 2013) and Complex Adaptive Systems theory (Levin, 1998; Gunderson and Holling, 2002). Understanding and modeling SES as CAS (Berkes *et al.,* 2003; Levin *et al.,* 2013) has emerged as a relatively recent, but well-established field of research for understanding the connections and feedbacks that shape the dynamics and attributes of SES (Carpenter *et al.,* 2012; Fischer *et al.,* 2015), necessary to identify and explain the complex nature and associated patterns of SES systems. Relying on a heuristic framework of these defining attributes of CAS (Preiser *et al.,* 2018) in operationalizing the CAS thinking is essential for identifying the best methods and approaches suited for this purpose (Biggs *et al.,* 2015) while also understanding the tradeoffs and the practical implications (Levin *et al.,* 2013) of integrating the central features of CAS into SES.

Focusing on the adaptive nature of CAS, through an overview of the most prominent work in the field, Preiser (*et al.* 2018) defines the 6 fundamental principles that characterize such systems – relational, adaptive, dynamic, open, contextual and causal – thus providing a heuristic framework for the operationalization of the CAS approach and assisting in-field researchers in shifting focus, adapting methods and practical approaches and dealing with normative challenges when engaging with complex SES. Through the present research, I further develop these principles and guidelines tailoring them to the specific case of HWC (section 10.1. of Chapter 10).

All the theories and concepts presented so far that help describe landscape scale effects of all these various factors on wolf distribution, abundance, predation patterns and predation on livestock, raise the importance of understanding the role of *space and spatial patterns* in wolf management. Scale and space play an important role in the present research, determining the choice of the study methods, the ways of thinking about and understanding the problem, and the approach taken to investigate the issue.

'Spatial ecology' "*centers on how landscape spatial configuration influences population and community dynamics of organisms*" (Collinge, 2001, p. 1). This framework was initially born from the confluence of two other important ecological approaches: landscape ecology, and population and community ecology. Tilman and Kareiva (1997) are amongst the first theoreticians to explicitly discuss spatial ecology and give a background overview of efforts that have led to its formation. The early theories in ecology considered ecosystems to be homogenous. Later came the realization that this is not in fact true, and that spatial variation is a key factor influencing populations. This realization stood at the base of spatial ecology and other related fields such as metapopulation theory and landscape ecology (Rockwood, 2006) and the subsequent concepts of ecological networks (Jogman and Pungetti, 2004) and polarized landscapes (Rodomann, 1974). This spatial variation gives rise to diversity and variety in the natural world (*Legendre and Fortin, 1989)* and provides clues about certain interactions that shape this distribution (Azaele *et al.,* 2015*).* This framework is crucial to the guidance of this research as, based on its assumptions, it will show that interactions between biophysical factors can shape the distribution of predation attacks.

A growing interest in studying spatial patterns was sustained by the rapid advancements in technology, remote sensing, satellite imagery and geographic information systems and also by the development of environmental sciences that were highlighting issues such as habitat fragmentation and habitat loss. Spatial visualization of these patterns in time gave rise to the notion that habitat fragmentation increases the vulnerability of species populations by reducing the area of habitat available to local populations. As we have seen already, this leads to human activities overlapping with wildlife habitats and therefore gives rise to conflicts.

Scientists have increasingly recognized that "space matters" and have tried to find answers to the question of how to practically integrate spatial information with biological conservation efforts (Collinge, 2001). One way is through '*spatial modeling*' of environmental conflicts, an innovative tool to identify conflict hotspots (Miller, 2015) and find the best preventative measures. Based on considerations of spatial ecology theory (and the concept of spatial modeling) and the other theories and concepts presented so far, this research can help show the role biophysical factors and certain human practices have in the distribution and occurrence of conflict in the study area.

The use of geographic information systems in this study will help to visually represent the distribution of the conflict in the territory, to predict and visualize the risk of predation (through risk maps and risk modelling) and to build a useful visual interactive tool for *inter alia* managers.

4.2. Institutional mapping and socio-political considerations underpinning the research

Socio-political considerations

While in certain cases an approach based on general, purely ecological principles might be enough for the conservation of some species (Simonic, 2003), this does not hold for the present case. Understanding and protecting large carnivores is a much more demanding process. The centuries-long interaction of large carnivores and humans, the strong emotions and values associated with them, and the complex issues surrounding their competition with humans for resources and space, make large carnivore conservation a real challenge (Linnell, 2013). Human interests have to be met, but this should be done without endangering the survival of the species (Simonic, 2003). Public attitudes towards wolves can be generally negative (Boitani, 1995), particularly if the problem is not properly addressed by management (Decker *et al.,* 2002; St. John *et al.,* 2012; Kahler *et al.,* 2013; Mariki *et al.,* 2015). Demands are usually for problem animals to be removed. But lethal control, especially in protected areas, is problematic and efforts to reduce wolf populations alone will not reduce conflicts (CPW, 2015), especially in areas that continue to disregard preventative measures. On the contrary, recent reports show that livestock predation by wolves could even increase due to social disruption of packs (Imbert *et al.,* 2016) as this creates more dispersing individuals.

In such situations managers are faced with the very difficult and complex task of finding bilateral solutions to assure both wolf conservation and human wellbeing. Choosing the best management strategies thus becomes a very difficult task that managers need to be prepared for by having a strong understanding of the way the human aspect of the conflict unfolds in the protected area. Efforts must be made to understand and influence human behavior and practices. People's discontent and their subsequent reactions and behavior is not only about wolves themselves, but it is also about the managers, authorities and institutions that are responsible for managing wolf populations (Decker *et al.,* 2002). Understanding the social framework and the current institutional arrangement around HWC is therefore crucial.

Institutional mapping

Institutional arrangements and the overarching governance systems play a very important role in the final outcome of the conflict. As the ecological and the social systems become interwoven in case of HWC, institutions become a ligament that ties together these two systems (Gatzweiler and Hagedorn, 2002). When the scales of ecological processes are well matched with the human institutions responsible for managing human-wildlife interactions, governance becomes more *coherent*, and more *effective* (Leslie *et al.,* 2015). Insight into the ways in which all these institutions interact is therefore crucial to understanding the governance of wildlife populations, and thus ultimately the potential of institutional arrangements to enhance or ameliorate conflicts over wildlife management (Woodroffe *et al.,* 2005).

As demonstrated above, the concept of '*governance'* encompasses institutions, and the two concepts are tightly interconnected (Paavola and Adger, 2005; McFadden *et al.,* 2010). Broadly defined, ***'institutions'*** are systems of rights, rules and decision-making procedures that give rise to social practices, assign roles to participants in these practices and govern interactions among players of these roles (Young, 2002). Simply put, institutions are rules that define what individuals may, may not, or must do (North, 1990; Ostrom *et al.,* 2002). The opportunities and constraints individuals face in any particular situation, the information they obtain, the benefits they obtain or are excluded from, and how they reason about the situation are all affected by the rules or absence of rules that structure the situation, in other words, by the respective institutional arrangements (Ostrom, 2005). In the HWC context this means that actors involved in conflict situations are affected in multiple ways by the institutional framework governing those situations.

When systems of rules are composed of written and codified sets of regulations and contracts (e.g. legislation), we refer to them as *formal institutions*. Underlying these institutions there is an entire set of *unwritten norms and values* (Clark *et al.,* 2005; McFadden *et al.,* 2010) including, for example, codes of conduct, customs, taboos, convention and other social norms (North, 1990; Young, 2002). The boundaries between formal and informal institutions are not always clearly defined, and their interplay can create tensions and conflicts, but also synergies (Hagedorn, 2008). Institutions as "crystallized values" are thus a crucial element of social life at all levels (Fisher *et al.,* 2012), creating the framework in which HWC are manifested. *Institutional analysis* in the field of HWC aims to examine the complexity of these formal and informal patterns of social relationships within wildlife management in order to reveal the societal mechanisms that drive and maintain conflicts with the final aim of improving coherence in wolf management.

This is especially important because, in crafting institutions and systems of rules, a poor understanding of how particular combinations of rules affect actions and outcomes in a specific social context, can lead to unexpected and even disastrous outcomes (Ostrom, 2005). Inadequate systems of management and mitigation strategies are unlikely to generate positive effects and can result in escalating human-human conflicts (Bowen, 2012). On the contrary, a favorable management regime can contribute to the persistence of certain vulnerable wildlife species even at high human densities (Linnell *et al.,* 2001). Thus, studying and understanding these systems of formal and informal rules – the institutional arrangements – around HWC through institutional analysis is very important in the process of conflict mitigation.

'Institutional analysis' is used in several academic disciplines, each using different meanings and connotations when defining institutions: from formal laws and rules to more informal norms, customs and power relations and even ways of thinking. Most commonly though, institutional analysis deals with how individuals and groups construct institutions, how institutions function in practice, and the effects of institutions on each other, on individuals, societies and the community at large (CIPEC, 2005). Institutional analysis can be used to assess the capacity and behavior of institutions in carrying out reforms, helping to identify constrains and opportunities, at different levels (in internal processes, relationships among organizations, or even system-wide), and therefore determining factors that may support or obstruct a given reform.

'Institutional mapping' is an approach to institutional analysis that can contribute to understanding the existing distribution of power and the way this influences the adoption and success of any particular policy or management strategy. Institutional mapping is an empirical and practical exercise, undertaken with a particular purpose (McFadden *et al.,* 2010). The purpose in case of HWC research is to contribute to understanding the local institutional arrangements and social factors that drive the conflicts, through analyzing functional relationships that are relevant to decision making regarding wildlife management and conflict resolution. The value of this exercise lies in its predictive power: it can tell managers what to expect in an impact-response chain of action and/or a decision-making process (Aligica, 2006).

Orienting towards problem identification within an exercise of '***mapping institutional processes'*** involved in HWC management is a very useful and practical way of gaining insights into how certain institutional processes can slow down conflict resolution and/or even aggravate conflicts; it can help identify where these process break down and what specific constraints they face; it can determine institutional roles and the effectiveness of policies and practices of managing HWC; and can help provide recommendations on how to foster an institutional process that allows for more efficient conflict mitigation (Anthony *et al.,* 2010; Richie *et al.,* 2012). This research undertakes this analytical framework in understanding the institutional arrangements and social context around wolf management in the Western Carpathians. It does so with the aim of gaining a simplified schematic understanding of the very complex institutional and social processes that promote or inhibit conflicts.

Ultimately, the main purpose of wildlife management and conflict mitigation strategies is to promote change towards reduced or at least an acceptable level of conflict, and towards improved coexistence between people and wildlife. Institutional mapping, and more specifically process mapping, is central to successfully achieving this goal (McFadden *et al.,* 2010). It is essential to consider not only the substance of the desired change (what physical outcomes are desired from a certain mitigation measure) but also the more difficult to define human factors and chains of action (the institutional processes) that *enable* change to happen. The key value of institutional mapping is that it greatly contributes to understanding opportunities and barriers toward identifying and enabling change (McFadden *et al.,* 2010).

5. Methodology

5.1. Structural approach

Considering the interdisciplinary nature of this research and the twofold structure of the mapping exercise it proposes, a combination of *qualitative* and *quantitative* procedures was necessary. The methods used are viewed as complementary, with each adding essential pieces to the puzzle of human-wolf conflicts. This combined approach can represent a powerful tool to inform and illuminate policy and practice (Ritchie and Ormston, 2014).

Due to the complexity of this combined multidisciplinary methodological approach, the methods, design considerations and results are presented separately for each of the three major methodological elements of this research: the analysis of spatial biophysical factors (Chapter 6) the analysis of non-spatial and husbandry factors (Chapter 7) and the analysis of institutional factors (Chapters 8 and 9). These three parts correspond to the three central research questions, RQ 1, a, b, and c.

Chapter 6 focuses on predator prey interactions in a purely spatial context analyzing the spatial bio-physical factors that are associated with the risk of wolf predation on livestock. It describes the Risk Mapping Analysis in a stepwise narration of the all the design and statistical procedures that were undertaken and, finally, the results of the modeling process. Chapter 7 moves the focus to the non-spatial factors and the husbandry and human management measures that also profoundly influence the outcome of predation events, introducing the role of humans and human-wildlife interactions in this spatial food web. Lastly, chapter 8 moves completely into the roam of human influence on risk, looking at the role of management and decision making at the institutional level. Chapter 9 zooms out to put all the afore-mentioned aspects into perspective.

The specific details of design considerations and methods applied in each part of the research are discussed extensively within each empirical chapter as there are substantial differences in how the methods were used. Also, each of these chapters reflects upon the limitations of the contextual application of the used method.

5.2. Overview / summary of methods

A first step in meeting the objectives of the research was to carry out a preliminary exploratory investigation of the study area in order to obtain background information on the conflict situation, assess the availability of relevant data, establish connections and develop a study design tailored to the reality in the field. This was done through an extensive pilot study further described in section 5.3.

Another important step in the initial stages of the dissertation was identifying and creating a database of all potential relevant influential factors affecting conflict in the area (see subsection "*Identifying relevant indicators*" in section 6.3. of Chapter 6). These were identified as biophysical, husbandry/management, and institutional factors. This is the point at which the study design branches into the three main methodological approaches.

One of the next objectives of the study was to assess the relationship between an array of biophysical and husbandry factors and the selection of certain sites by depredating wolves. In order to do this, in-person semi-structured interviews were taken with livestock producers in the study area (see subsection "*Interviews with livestock producers*" in section 7.2. of Chapter 7) with the purpose of creating a database of predation events and gathering data on non-spatial factors. The interviews were based on a previously carefully constructed questionnaire (see subsection "*Questionnaire structure and wording*" in section 7.2. of Chapter 7 and Appendix II for the complete questionnaire) but also included open-ended questions and open discussions probing into the attitudes, beliefs, feelings and struggles related to HWC of livestock producers, seen as one of the stakeholders affecting and affected by conflicts in the study area. Thus, part of the data collected through these interviews also served for the institutional analysis, as I included shepherding as an institution. Analyzing this data helps understand the bidirectional nature of human-wolf interaction. Data on spatial bio-physical indicators was derived through spatial software (see subsection "*Collecting the data*" in section 6.2. of Chapter 6) and merged with the data on predation events collected through these interviews. This formed the basis for building a predictive model for predation and risk maps within the Spatial Risk Analysis further described in Chapter 6.

The data on husbandry/management and non-spatial biophysical factors also collected through these interviews was correlated with the predation events and analysed quantitatively in order to assess the role of people and their preventative measures in conflict outcomes (Chapter 7). Participant observation was also used at this stage.

The next set of research objectives had the aim of analysing existing policies and practices concerning wolves and their management, identifying actors involved in this management and investigating and mapping institutional processes and their role in conflict. For this purpose, in-depth unstructured and semi-structured interviews were conducted with key institutional actors identified through purposive and snowball sampling procedures. Interviews were recorded, transcribed, translated and finally coded and analyzed (see subsection "*Data analysis*" in section 8.2. of Chapter 8). Document and record analysis, and personal observation were also used at this stage.

Ethical principles (see section 5.4.) were considered throughout the data collection process.

Issues related to reliability and validity and the various ways of minimizing potential bias that were adopted are described separately at the beginning of each of these chapters.

5.3. Pilot study

As part of a pilot study, during the course of approximately one year prior to the onset of the main body of the research, I undertook several exploratory visits to the study area (Apuseni Natural Park) and to Cluj-Napoca, a major city located relatively close to the park. The main aims of this pilot phase were to:

1. collect baseline data and information necessary in the initial stages of my research (related to human-wolf conflict manifestation, occurrence and intensity; wolf and livestock distribution; local context; key people to contact in the initial stages; etc.);
2. strengthen collaborations with key informants and experts who could assist me in key areas of my research;
3. establish collaboration with the Apuseni Natural Park administration and obtain park approval for performing the field work in the territory of the protected area;
4. inquire about the availability of official reports on wolf attacks;
5. obtain data on the localization of mountain pastures and other grazing areas necessary for the field work;

6. discuss and develop my approach for Spatial Risk Mapping.

During this time, I organized meetings with four professors from Babes-Bolyai University in Cluj-Napoca (pertaining to Psychology, Biology, Geography and Environmental Science and Engineering Faculties) who are experts in zoology, spatial modeling, statistics and spatial software. These meetings served the purpose of discussing and developing the approach I intended to use for the Spatial Risk Mapping exercise and to deepen my understanding of this method.

Also, during this time, I met and discussed with members of NGOs working in conservation projects related to large carnivores in Romania, with representatives of the hunting associations functioning on the territory of the park, and members of the Search and Rescue Service in the area. These discussions broadened my understanding of the local context in which conflict manifests in the area; the nature of the conflict and the main issues; wolf behavior and wolf populations; people's perceptions and behavior in response to wolf attacks; factors influencing wolf attacks; the institutions and organizations that have a role in wolf management; laws and regulations; and national controversial debates on the subject. These discussions also served the very important purpose of networking and tying connections that proved to be essential for future collaborations during the time of the research: obtaining housing in the Search and Rescue and Park Administration huts during field work in the park; assuring assistance during interviews with livestock producers on the surface of the park; identifying and contacting potential interviewees; and obtaining important documents and law summaries for document analysis.

Also very important were my visits to Apuseni Natural Park administration during which I established a formal collaboration with the park, to present my project proposal and obtain their valuable feedback and approval; and to obtain information and data. Most importantly, I obtained the approval of the Scientific Council of the park for performing the field work in the territory of the protected area.

5.4. Ethical considerations

This research was undertaken in accordance with recognized research ethical principles (Strauss and Corbin, 1990; Bryman, 2012; Webster *et al.,* 2014) and commonly agreed standards of good practice (Ritchie and Lewis 2003; Marvasti, 2004; Ritchie *et al.,* 2014). It adheres to the Central European University's Ethical Research Guidelines and Ethical Research Policy (Appendix I).

Therefore, first of all, the researcher respected principles of integrity and transparency and a commitment to intellectual honesty and personal responsibility in performing the research. This research also respected the following main ethical considerations: obtaining voluntary informed consent, ensuring anonymity and confidentiality, and protecting participants and researchers from harm.

Participation in this study was voluntary and informed consent was secured by informing participants about all aspects of the research project which might reasonably be expected to influence willingness to participate, and, additionally: the purpose of the research; who was undertaking and who was funding the study; how the respondent was selected; expected duration and procedures; participants' rights to decline to participate and to withdraw from the research once it has started; how the information will be used and what was required of the participant. The research upheld individuals' rights to confidentiality and anonymity and these rights were made clear to participants. The participation of respondents was free of any form of coercion or pressure and no payments or incentives were offered in advance, for participation.

Also, participants were informed of procedures for contacting the researcher with possible further questions or concerns related to this study. Participant's consent for recording the interview was obtained.

This research does not intend to uncover any sensitive information that could bring any harm to the participants. However, all potential ways in which harm could occur will be considered and if necessary aversive action was taken to ensure the privacy and psychological and physical well-being of the participants.

Potential sources of harm to the researcher were also considered. The following were identified: travel and hiking, collecting data from mountain pastures and other grazing areas (risk of attack by livestock guarding dogs); hiking and camping in large carnivore habitats. All measures were taken to avoid injury mainly by ensuring the company of a park ranger or other research assistant; through acquiring self-defense tools; maintaining a cautious attitude and using appropriate means of transport.

Finally, the researcher made sure to consult and follow relevant laws and the regulations imposed by the Apuseni Natural Park administrators to researchers doing research on the territory of the park. A research permit was obtained from the park administration prior to the onset of the fieldwork. The Park administration was informed before and after each field work session taking place within the limits of the park.

6. Identification and analysis of spatial biophysical factors

Answers RQ 1a: “What landscape attributes influence wolf predation of livestock?”

6.1. Introduction to Spatial Risk Mapping

Not all large carnivores with access to livestock will prey on them. As argued in section 4.1. of Chapter 4, carnivores tend to prefer wild prey, if this is available, even when livestock is abundant (Nowak *et al.,* 2005; Janiero-Otero *et al.,* 2020), therefore large carnivores, even in human-dominated landscapes, can coexist with people and domestic animals for long periods of time without considerable conflict (Tompa, 1983; Wydeven *et al.,* 2004; Woodroffe *et al.,* 2007; Newsome *et al.,* 2016). Yet, in some areas, carnivores cause extensive damage, significantly impacting human livelihoods and conflicting with human interests. Why are some areas prone to become conflict hotspots while others remain islands of peaceful coexistence? There is growing evidence that the distribution of human-carnivore conflicts is not random and that locations of conflict share common characteristics (Wydeven *et al.,* 2004; Treves *et al.,* 2011). These show up as common patterns around the world, pointing to the possibility that human-carnivore conflicts might be predictable.

Identifying the factors that are associated with attacks of wolves on livestock helps predict the localization, distribution, extent, and intensity of the risk of predation. This can prove useful for managers to help target their efforts and increase the efficiency of their actions.

Many studies have engaged in the difficult task of quantifying and mapping the risk of predation by looking at the cause-and-effect relationships among variables in the last two decades (Boyce *et al.,* 2002; Kaartinen *et al.,* 2009; Treves *et al.,* 2011; Gorini *et al.,* 2012; Abade *et al.,* 2014; Miller *et al.,* 2015, 2016; Pimenta *et al.,* 2018; Boronyak *et al.,* 2020; McInturff *et al.,* 2021; Davoli *et al.,* 2022). Such studies attempt to quantify the effect of spatial heterogeneity on predator–prey interactions in terrestrial mammalian systems, i.e. in freely moving species with high mobility, in non-experimental settings (Gorini *et al.,* 2011). ‘*Predation risk modeling’* (spatial statistical approach) (e.g. Treves *et al.,* 2004, 2011; Marucco and McIntire, 2010; Davie *et al.,* 2014; Miller *et al.,* 2015) is an established approach in identifying high priority conflict hotspots, mostly developed since the mid-2000s (Miller, 2015). The increasing availability of spatial data, GIS software and wildlife telemetry technology has facilitated advancements in this field (Morris *et al.,* 2016). Spatial risk modelling represents a more and more useful tool in understanding predation spatial patterns and in informing livestock management and carnivore conservation.

Spatial risk models use spatially explicit data on carnivore-prey encounters in order to quantify and map the associations between predator-prey dynamics and landscape attributes (Hebblewhite *et al.,* 2005). Hebblewhite *et al.,* (2005) show that predation risk is not necessarily equivalent to just where predators and prey are found but rather that landscape attributes can render prey more or less susceptible to predation. This idea is at the core of spatial risk modelling, based on principles of spatial ecology, predation risk and optimal foraging theory (see section 4.1. of Chapter 4). In short, these principles describe how predator-prey interactions are shaped by the interplay between predator hunting strategies, prey avoidance tactics and the physical environment, in both space and time. Humans also shape how animals interact and use the landscape through management and their presence, shaping the landscape of coexistence (see details in Section 4.1).

Although livestock may show attenuated or erratic predator avoidance tactics compared to wild prey (Laporte *et al.,* 2010; Muhly *et al.,* 2010), and their movement can be controlled or restricted by humans who partly shape the way they use the landscape, their behavior and spatial resource selection patterns are nonetheless still shaped by predator avoidance and optimal foraging tactics (Dwyer, 2004; Dwyer, 2010; Laporte *et al.,* 2010) and habitat features affect their vulnerability to predation. Therefore, the sites where livestock are present on a landscape and are most likely to be encountered (*prey availability*) may differ from locations where carnivores can make a successful kill (*prey accessibility*) (Hebblewhite *et al.,* 2005; Hopcraft *et al.,* 2005; Trainor and Schmitz, 2014). Thus, while hunting, carnivores will account for prey "catchability" as much as, or even more than prey abundance (Hopcraft *et al.,* 2005; Balme *et al.,* 2007; Fuller *et al.,* 2007; Laundré *et al.,* 2009). Conversely, the location of where livestock are more likely to be killed is a function of not only carnivore distribution, but also of landscape attributes that render livestock more or less vulnerable to predation once encountered (Hebblewhite *et al.,* 2005). These areas of vulnerability will vary across the landscape following the natural variability of environmental attributes. Therefore, in order to identify and predict the distribution of these key conflict "hotspot" locations, the predation risk modelling analysis requires two types of data: information on the location of carnivore-livestock interactions and information on the landscape where these interactions take place. This allows risk models to identify the specific habitat features that are associated with carnivore attacks.

To study these habitat associations, all models share a common approach, having a dataset consisting of a set of use and non-use sites for which a range of habitat variables have been recorded. This data is then subjected to analysis through a particular algorithm or classifier (e.g. discriminant analysis, logistic regression, decision trees and artificial neural networks) leading to the formulation of a "rule" capable of correctly classifying cases as use (positive) (where carnivore-livestock interactions are present) or non-use (random) (where interactions haven't been observed). The accuracy and usefulness of this process can be evaluated by assessing how many of the cases are predicted correctly.

Most studies adopting spatial risk modeling to predict the risk of carnivore predation on livestock (including the present research) use kill-sites to represent locations of carnivore-livestock interactions (Miller, 2015). Kill data can be obtained from databases on livestock mortality created based on livestock owners' reports of predation events for the purpose of obtaining financial compensation or insurance. Alternatively, when these reports do not exist, data can be obtained from interviews and surveys with livestock producers.

Other than kill site locations, a model also needs random points to represent the range of available conditions in the landscape. By comparing attributes at sites where livestock were killed to all areas available to predator and prey, it becomes possible to estimate the spatial overlap of various landscape variables and their effect on predation. Models can be built with presence-absence data (locations where events did and did not occur: observed vs. not observed) or presence-'availability' data (locations where events occurred and where they could have occurred: used vs. available) (Miller, 2015).

The second type of data models need is information on the landscape attributes at the location of predation events. There is a wide array of factors specific to a particular environment that can influence patterns of predation (see section 4.1 for a more detailed explanation of their role in explaining predation). These factors can be largely grouped into four main categories: species (predator and prey distribution and abundance), biophysical (characteristics of the physical environment), human presence (features representing human infrastructure such as villages, roads, etc.) and husbandry (human land use and management). Species and environment related factors are particularly important for representing both prey availability (species presence and abundance) and prey accessibility (vulnerability based on the surrounding environment) (Miller, 2015). Factors related to human influence can also substantially alter the likelihood of conflict (Dickman, 2010) either by decreasing or increasing risk. The threat of human-caused mortality can shape carnivore distribution and predatory behavior and thus, husbandry and management preventative measures can greatly reduce the risk of predation (Oriol-Cotterill *et al.,* 2015; Janiero-Otero *et al.,* 2020). The larger scale consequences that human population and land use have on driving changes in wildlife population and habitat (such as reducing prey population, encroaching, habitat fragmentation and so on) can also greatly shape predation patterns (Carter *et al.,* 2014). Carefully selecting biologically meaningful variables, relevant to the site-specific context, pertaining to all these four categories, ensures a proper a-priori design of the modeling exercise and strengthens the ability of risk models to identify variables specifically associated with carnivore attacks (Treves *et al.,* 2011).

The primary analytical approach most commonly used in studies (including the present research) for mapping carnivore risk to livestock is based on *resource selection functions* (RSFs). RSF is defined as any function that is proportional to the probability of use by an organism (Manly *et al.,* 1993). *Resource selection probability functions* are functions that estimate the probability of use of a resource unit (e.g., carnivore selecting livestock) and are easily adaptable to spatial data, being used to reveal associations between landscape characteristic and selection frequencies (Lele *et al.,* 2013). They are therefore often applied to generate spatially explicit predictions of predation risk (Boyce *et al.,* 2002; Manly *et al.,* 2002). The prevailing statistical method used for RSF is a binomial generalized linear model (GLM), usually logistic regression. RSFs can be modeled at a variety of spatial scales, depending on the species and the scientific question being studied (Johnson, 1980).

The modeling process is based on an "*Information-Theoretic*" or "*I-T*" approach, which intends to minimize the *information lost* when a certain model is used to approximate full reality (Burnham *et al.,* 2011). In other words, these models quantify the *distance* between a certain model and full reality with the intention to identify the one model in a set of models that minimizes information loss most and is hence closest to reality. The I-T approach is not just data analysis; it's a complete process that begins with careful design of strong science-based research questions and ends with "*quantitatively and also qualitatively assessing the evidence"* for the set models, dropping, refining and adding new hypothesis. (Burnham *et al.,* 2011). This comes in contrast with the more traditional methods that focus on "*testing*" null hypothesis based on test statistics and associated *p* values. The I-T approach is not a "test" but rather a complex methodology based on empirical science used to develop a well-though-out and relevant set of a-priori hypotheses – a set of models – that are then quantified, ranked and interpreted based on model selection and multi-model inference.

Therefore, after obtaining a set of biologically plausible candidate models, the next key step in the analysis is selecting the model/models that best fit the data. This is particularly important nowadays when geographic information systems can easily provide us with a large number of landscape variables for our biological models (Burham and Anderson, 2002). Information criteria such as the Akaike Information Criteria (AIC) or Bayesian Information Criteria (BIC) are some of the most commonly used tools for model selection. When more than one top model emerges, *Multi Model Inference* and *Model Averaging* may be employed (Burham and Anderson, 2002; Burnham *et al.,* 2011). *Testing the model fit* is done in order to determine whether the selected model accurately describes the data. It estimates the relative closeness of each fitted model to the conceptual truth with the goal of finding the best fitted model in the set (Anderson and Burham, 2002). There are various statistical approaches used for this purpose: e.g., AUC (Area under the ROC Curve), ROC (Receiver Operating Characteristic), Homser-Lemeshow.

Next, the model's strength and usefulness need to be tested. A very basic way to do this is determining whether the model deviates from a random null model. But most RSFs are assessed by measuring the model's predictive accuracy. External validation (using independent data for comparison against model prediction) is the most rigorous method for model validation and represents the ideal method to use (Miller, 2015). Internal validation (using the existing data set by partitioning and cross-checking data, i.e. K-folds cross validation) is used as an alternative when external methods are not possible.

Producing a meaningful map of the predicted risk based on the results on the modeling process is an important step following the analysis as mapping the RSF results can enhance study findings and make them more accessible to researchers and wildlife managers (Morris *et al.,* 2016). Maps communicate information through a visual language composed of colors and symbols and therefore have the ability to bridge communication challenges and engage communities (Rambaldi *et al.,* 2006). Mapping the predicted risk represents a highly effective tool in transposing the results of this highly specialized and technical analysis into an easy to understand, universal language accessible to various groups of stakeholders.

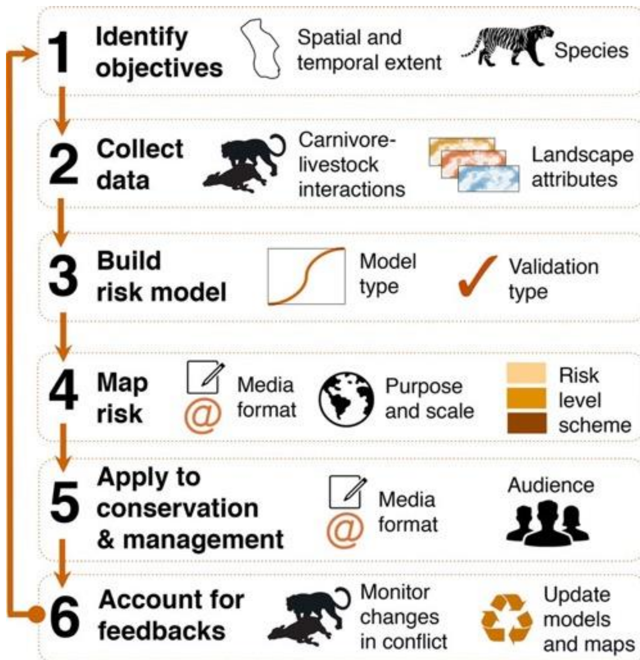

Figure 24. The six-step process of creating and applying predation risk maps to mitigating human–carnivore conflict (Miller, 2015).

Communicating results and recommendations to relevant institutions and stakeholders and accounting for the feedback effects that can arise for the use of risk models are steps of the analysis (see Figure 24 above) that are rarely taken by any study (Miller, 2015). Researchers focus on the highly technical statistical procedures and the mathematically measured “success” of their analysis, but they tend to forget that the reality in the field is a highly complex and dynamic system in which carnivores, livestock, the physical landscape and humans continuously interact and respond to each other, constantly changing in response, which is why the period of time during which these models offer valid, up-to-date predictions can be quite limited. To account for this feedback, models must regularly be updated and revised based on recent data from the field (Marucco and McIntire, 2010) in order to offer reliable, up-to-date guidance on predation patterns, especially when risk maps are incorporated into management, conservation and policy.

If Spatial Risk Mapping is integrated into decision making in a systematic way, this quickly expanding informative tool can be valuable to managers for identifying conflict hotspots and predicting the risk of predation, therefore helping managers and livestock owners understand where, when and how to act.

Still in its infancy, this tool has great potential to become widely used in mitigating human-large carnivore conflicts. There is an important, yet unexplored, value in the use of this tool in Romania. The value of this exercise resides in its innovative character, as spatial risk modelling of predation patterns has never been carried out in Romania or surrounding countries. The originality of this approach resides in the fact that the modelling process was tailored to the research area.

6.2. Limitations and issues of reliability and validity

The biggest limitation of this study was in obtaining the kill site data in the context of a lack of official reports and an official data base. I extensively discuss these aspects in section 7.1. of Chapter 7, where I describe my approach to data collection.

Another limitation of this research, as of most other studies engaged in spatial risk modeling to predict the risk of carnivore predation on livestock, is that it uses kill-sites only to represent locations of carnivore-livestock interactions. Thus, it only quantifies the *realized* predation risk (where livestock are killed) and does not take into account unsuccessful attacks and the non-consumptive or trait mediated effects of carnivores over livestock that make up the *fundamental* predation risk (Hebblewhite *et al.,* 2005). Nevertheless, since this research is not specifically interested in the non-consumptive effects on livestock, but rather focused on understanding and predicting livestock losses per se, successful kill sites are an adequate signal since, presumably, landscape features play a role in differentiating between successful and attempted kills. There is great value in this exercise considering the urgency and the serious immediate implications of carnivore predation on livestock for both human livelihoods and carnivore conservation.

Furthermore, trying to deconstruct the components of predation into the various stages of predation (i.e. search, encounter, kill) (Hebblewhite *et al.,* 2005); accounting or unsuccessful carnivore attacks; attempting to evaluate non-consumptive effects of predators [such as livestock antipredator responses (Laporte *et al.,* 2010), stress and fear (Brown *et al.,* 1999; Dwyer

2004) and vigilance (Lima and Bednekoff, 1999) as part of the “landscape of fear” (Laundre´ *et al.,* 2010), and it’s implication on overall productivity and financial outcomes; and trying to take into consideration the effects that coupled human-natural systems (Carter *et al.,* 2014) have on predation, accounting for perceived risk; integrating non-spatial and husbandry factors that shape the risk – can all be challenging, time-consuming and expensive, and sometimes even currently unrealizable, tasks. Yet, these are all aspects of predation that shape the landscape in important, but often invisible, ways. Not accounting for these aspects in quantifying risk and subsequent decisions can lead to selection bias (McInturff *et al.,* 2021) and inaccurate models. This major issue merits much more attention and research in the field and represents an important area of future research.

There is much to understand about the interplay of factors influencing predation. Nevertheless, identifying the most relevant factors influencing predation is of great value for finding the best possible preventative measures. There are various measures a researcher can take in order to reduce uncertainties related to the complexity of this issue. Designing this research as an interdisciplinary framework that combines spatial risk analysis of the biophysical factors influencing predation; integrating husbandry and management factors also influencing risk; yielding participatory maps of perceptions on predation risk; examining TEK and the perceived practical and context-specific effectiveness and social acceptability of non-lethal prevention tools among livestock producers – were all measures I took to address this potential bias. This socio-ecological approach has rarely been undertaken and thus, this analysis helps fill an important research gap (Dickman, 2010) while also laying the ground for improving the interoperability of different scientific approaches (McInturff *et al.,* 2021) that scientists and managers can undertake in the field to gather richer data on, and successfully mitigate, human-wolf conflicts.

In order to reduce uncertainty and bias concretely throughout the exercise of Spatial Risk Modeling, I decided to adopt the strategy described by Burnham and Anderson (2002), a strategy and philosophy of critical thinking based on biological and ecological principles and the judgement and experience of the researcher, centered on the underlying science of the issue and a good understanding of the specific context: studying published literature on carnivore predation models and on other issues closely related to it; having in-depth discussions about risk modelling with close peers and people directly involved in the research; predicting nonlinear and threshold effects; hypothesizing about what interactions might be important in the specific context of the Western Carpathians; combining or restructuring variables to create more meaningful ones; dropping irrelevant variables; identifying similar parameters among groups; and so on. Burnham and Anderson group these measures under the concept of *a priori modeling*. They recommend that an initial set of candidate models should be built before the analysis, predicated on science and biology, and careful consideration of the problem based on the scientist's training and experience in the field. Models should be formulated on inquiries into the way biological systems work, backed by critical thinking and early exploratory data. They suggest that proper a priori model building and careful subsequent model selection, parameter estimation and measurement of precision leads to avoiding data dragging, which can lead to overfitting models, in other words to obtaining spurious results and misinterpreting them.

The process of careful a priori design represented a large proportion of the time and effort I invested in this analysis. The initial pilot study and the extensive literature and theory review presented in the previous sections represented the basis for designing and tailoring the research to best represent the specific context of my study area. Thorough thinking and intense discussions with peers, experts and park managers helped shape hypothesis and identify context relevant variables and threshold effects. Various statistical and conceptual decisions (e.g. variable selection based on pass of significance; detecting autocorrelation and eliminating auto correlated factors from the model) were taken to obtain a set of biologically relevant variables to be used in the modeling process. Countless other design decisions were taken throughout the analysis. I describe the details of these decisions as they emerge in each of the steps in the modeling process further presented in the next section.

Model selection and model validation were also employed at the end of the modelling process as ways to minimize uncertainty by determining the model's usefulness and predictive power. This is an essential part of the research because these predictions are often used in decision making. In the case of human carnivore conflicts, inaccurate management recommendations based on these models can lead to more livestock losses, affecting both people's livelihoods and the carnivore populations (Treves *et al.,* 2011).

After taking all possible measures to reduce uncertainty and bias, we have to remember that no mathematical model can fully represent reality and there are no absolutely true models, but rather that models are a way to simplify reality in order to achieve an understanding of the dominant features and the main dynamics of the phenomenon we are studying (Burnham and Anderson 2002). Models are like maps, they can be useful at various scales but are never completely “true” (Burnham *et al.,* 2011). The main goal is to obtain a robust parsimonious model, one that is able to filter and separate information from noise, to give us the best simplified understanding of this reality.

6.3. Methodology

Although literature in the field helped shape the structure of the analysis by suggesting the main backbone of the process to build upon (Figure 25), the model itself was personally designed to best fit the particular context of the research area. The methodology used for the spatial risk modeling in this research was adapted from Miller *et al.,* (2015) and consisted of several steps (first proposed by Miller, 2015):

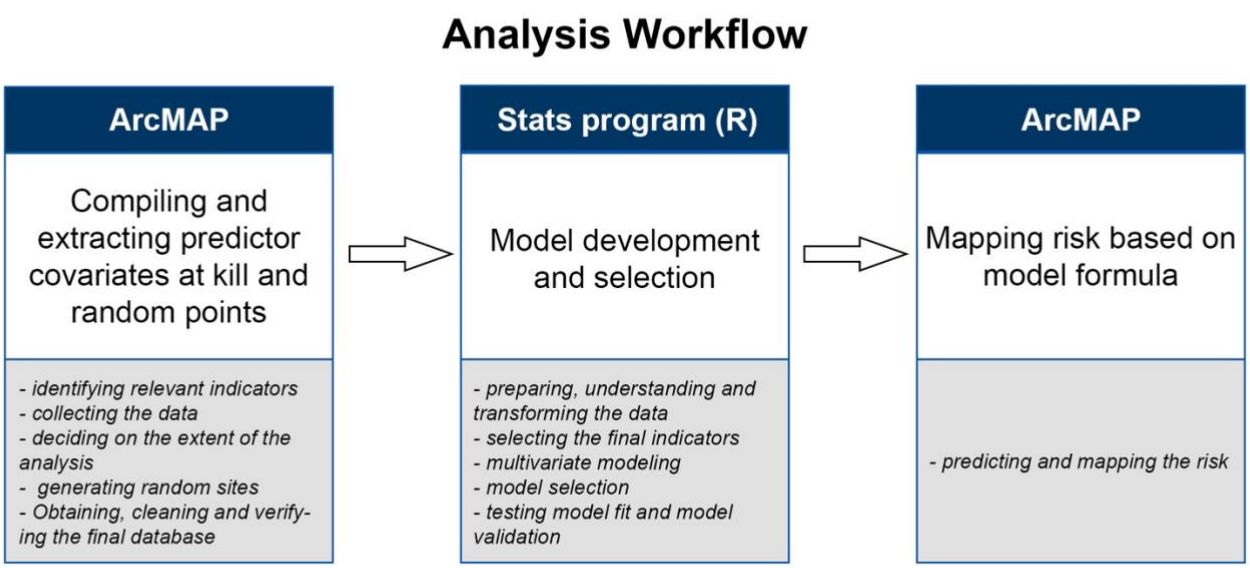

Figure 25. Workflow describing the main steps of spatial risk analysis and main software used.

Step 1. Identifying relevant indicators

Different factors may be important in explaining predation sites. As presented earlier, these factors can be largely grouped into four main categories: species (predator and prey distribution and abundance), biophysical (characteristics of the physical environment), human presence (features representing human infrastructure such as villages, roads, etc.) and husbandry (human land use and management).

The factors potentially associated with wolf predation on livestock in the study area (in other words, the "*Indicators*", "*Predictors*" or "*Variables*") have been identified based on the (i) most relevant factors found in literature, (ii) results of past investigatory trips to the study area (see section 5.3), and (iii) results of interviews conducted with livestock producers and other relevant actors. The indicators were selected based on a careful consideration of their role and relevance in the context of this study case. Throughout their work, Burnham and Anderson (Anderson and Burnham, 2002; Burnham and Anderson, 2002; Burnham *et al.,* 2011) stress the importance of starting off with "multiple working hypotheses", carefully identifying an a-priori set of hypotheses based on the reality in the field. In this step I describe the set of variables considered for this analysis and the working hypotheses that I based my initial variable selection on.

An initial set of predictors was considered before the fieldwork, and others were added as more insight was gained from the local context. Both biophysical and management/social factors were considered for the analysis (Table 1).

Characteristics of *vegetation* (forest cover, forest edge), *topography* (water source, slope, altitude, terrain ruggedness) and *land-use* (habitat type) were considered to reflect the wide array of **biophysical factors** that can influence predation in the study area. Considering the fact that wolves (and other predators) seem to benefit by cover provided by tall vegetation when hunting (Gibbs *et al.,* 2008; Davie *et al.,* 2014), I hypothesized that the risk of predation would be influenced by the density and *height of vegetation*. This is a hunting strategy that has been observed in various landscapes throughout the world. Davie *et al.,* (2014) found that tall vegetation provided an advantage to wolves in Mongolia, increasing the risk of predation, most likely due to the cover tall vegetation provided, minimizing the risk of detection by humans and making those areas appear "safer" but also decreasing shepherd vigilance and thus making livestock more vulnerable. Similar findings on the influence of vegetation cover on predation have emerged from North America (Robel *et al.,* 1981, Treves *et al.,* 2004; Zarco-González *et al.,* 2013), Italy (Mattiello *et al.,* 2012) and India (Miller *et al.,* 2015). The complexity of the landscape in my study area (see section 3.2. "*Apuseni Natural Park*" in Chapter 3) prompted the design of similarly complex variables specially designed to best capture the specific nuances of the influence of tall vegetation and the *edge effect* (see section 4.1. *"Ecological principles underpinning the research" in Chapter 4*). I hypothesized that the risk of wolf predation would increase with proximity to forest, peaking at the edge of the forest on a surface stretching for a few hundred meters on both sides of the forest edge, in and out of the forest and then gradually decrease. Promberger *et al.* (2000), within the Carpathian Large Carnivore Project, report that flocks kept away from the forest suffered less loses while most attacks occurred in and near the forest. I also expected that the amount of forest edge (calculated as total length per buffer of 500 m around each location) will be a strong indicator, with the risk of attack positively correlated with length of forest edge. Further, because wolves use forest cover as a strategy to attack and shepherds also use forest as protection against environmental conditions (hot midday sun; wind and rain) and to move their flocks from one grazing area to another, I expected the risk to be higher as the percentage of forest cover per surface area increases. However, because the presence of sheep inside the forest can only usually be recorded maximum of 1-2 km into the forest (as shown by the findings of both the pilot study and the interviews with shepherds, institutional actors, and experts), I expected that areas with deep forest will show a decreased risk of predation.

The type of habitat can influence predation in a similar way to vegetation, with the risk of predation possibly increasing in areas with more complex, mixed, mosaic habitats (Treves *et al.,* 2004; Kaartinen *et al.,* 2009) and also in areas with higher proportion of pastures (Treves *et al.,* 2011; Davie *et al.,* 2014).

The topography features (altitude, slope, terrain ruggedness, water sources) included in this analysis were selected based on findings showing that these features are used by wolves while hunting (Table 1).

Variables describing *human presence* (roads, built-up areas), *management* (park boundaries) and *habitat type* were selected to capture the effect that **management/social factors** have on wolf predation on livestock.

Table 1.Predictor variables proposed for study (both spatial and non-spatial), showing data source, hypothesis of their effect on risk of wolf predation and evidence supporting the hypothesis.

Category		Variable (unit)	Data source (citation)	Hypothesis or effect on response	Citations supporting hypothesis
Bio-physical factors	Vegetation	Habitat type & Land use	Corine Land Cover https://land.copernicus.eu/pan-european/corine-land-cover/clc-2012	Increased predation risk in areas with more complex, mixt, mosaic habitats. Positive correlation with high proportion of pasture and low proportion of croplands	Treves et al. 2004 Kaartinen et al. 2009 Treves et al. 2011 Davie et al. 2014
		Forest (or tall vegetation) cover (%)	Calculated from satellite imagery of canopy cover https://glad.umd.edu/gladmaps/globalmap.php	Increased predation risk in areas with higher percentage of tall vegetation	Robel et al. 1981 Treves et al. 2004 Davie et al. 2014 Kaczensky et al. 2008
		Dist. to forest (m)	Calculated in ArcMap* https://glad.umd.edu/gladmaps/globalmap.php	Proximity to forest will elevate the risk; open habitats farther from forests have highest risk	Treves et al. 2004 Treves et al. 2011
		Forest Edge Length	Calculated in ArcMap* https://glad.umd.edu/gladmaps/globalmap.php	Risk of depredation is positively correlated with the length of forest edge	Gibbs et al. 2008
	Topography	Dist. to nearest water source (m)	Calculated in ArcMap based on water source layer* UBB Faculty of Geography	Predation risk changes with distance from high to low Proximity to water will elevate the risk	Robel et al. 1981 Treves et al. 2004 Kaartinen et al. 2009
		Slope (%)	Calculated in ArcMap based on DEM* UBB Faculty of Geography	Positive correlation with the risk of predation	As these two indicators seem to be related to habitat complexity, the present research intends to test this hypothesis Suryawanshi et al. 2013 found a negative correlation of ruggedness with predation
		Terrain ruggedness (index – m)	Calculated in ArcMap based on DEM or standard deviation of slope* UBB Faculty of Geography		
		Altitude (m)	Calculated in ArcMap based on DEM* UBB Faculty of Geography	There might be a certain interval of altitude within which wolves are most likely to predate on livestock (this might be determined by wolf, prey and livestock presence)	The present research intends to test this hypothesis Suryawanshi et al. 2013 found a positive correlation with predation
	Temporary	Precipitation	Interviews	Low visibility due to increased precipitation and dim light (dusk and dawn) might increase the risk of depredation	The present research intends to test this hypothesis
		Time of the day	Interviews		The present research intends to test this hypothesis Packer et al. 2011 Palmer et al 2017 Smith et al. 2020
Husbandry practices (preventative measures)		Size of pasture (m^2)	Satellite imagery/ interviews	Positive correlation with risk of predation - proxy for livestock densities	Bradley and Pletscher 2005 Kaartinen et al. 2009
		No. of livestock	Interviews	Positive correlation with risk of predation	Mech et al. 2000 Treves et al. 2004 Bradley and Pletscher 2005 Kaartinen et al. 2009
		Calving (1, 0 or no. of calves)	Interviews	Presence of vulnerable livestock increases risk of depredation	Bradley and Pletscher 2005 Kaartinen et al. 2009
		No. of farmers	Interviews	Human presence decreases risk of depredation	The present research intends to test this hypothesis
		No. of guarding dogs	Interviews	Guarding dogs are commonly used to guard livestock in Romania. Literature has opposing opinions on this subject (wolves also attack dogs (Bangs et al. 1998) and dogs might attract wolves to livestock (Andelt 2004).	Coppinger et al. 1987, 1988 Bangs et al. 1998 Andelt 2004
		Presence of sick animals (1, 0 or no. of sick animals)	Interviews/ observation	Presence of vulnerable livestock increases risk of depredation	Bradley and Pletscher 2005 Kaartinen et al. 2009
		Carcass disposal practices (categories)	Interviews/ observation	Preventative measures can reduce risk of depredation	The present research intends to test this hypothesis
		Existence of fences or other preventative measures (grades)	Interviews/ observation		
Human presence		Distance to nearest road (or road density) (m)	Calculated in ArcMap based on road layer* UBB Faculty of Geography	Increased predation risk further away from roads or high road density	Robel et al. 1981 Treves et al. 2004
		Distance to nearest settlement (m)	Calculated in ArcMap based on built-up layer* UBB Faculty of Geography	Increased predation risk further away from areas of human activity	Robel et al. 1981 Treves et al. 2004 Bradley and Pletscher 2005 Davie et al. 2014
Management		Habitat type (land use)	Corine Land Cover https://land.copernicus.eu/pan-european/corine-land-cover/clc-2012	Human presence decreases risk of depredation	Oriol-Cotterill et al 2015 Janiero-Otero et al. 2020 Carter et al 2014
		Distance to park border	Ministry of Environment http://www.mmediu.ro/articol/date-gis/434	Risk of depredation increases with distance from park boundaries and peaks in core areas	The present research intends to test this hypothesis

**the value of these indicators was calculated from base layers in ArcMap. For more exact details please read this section.*

I predicted that the risk of predation will increase with distance to human dominated areas such as roads and settlements due to human avoidance tactics. Because wolves are protected on the territory of the park, but the range of hunting grounds extends and overlaps with the territory of the park, I also hypothesized that the risk of predation will be highest in the core areas of the park, increasing with distance from its boundaries. My assumption was therefore that wolf's avoidance of local people and hunters, and therefore lower predation rates, should coincide with the degree of human intervention in territory and the type of land-use. Natural habitats with low human presence and high degree of prey catchability should show the highest predation rates.

Both spatial and non-spatial management-related factors were identified, although only spatially explicit factors were included in the model. This is because predation risk models are built in a spatially explicit context and use site-specific data on past carnivore attacks on livestock in order to quantify, predict and map predation hotspots (Miller, 2015), based on associations between predator–prey encounters and landscape attributes (Hebblewhite *et al.,* 2005).

See Table 4 for more details related to the final factors included in the analysis and Table 1 for a complete list of spatial and non-spatial factors identified as potentially influencing risk of predation) in the study area.

When calculating some of the predictor variables influencing predation, such as percentage of forest cover, and forest edge length, I needed to establish the spatial grain that would be most relevant for this purpose. For choosing this spatial resolution, wolf hunting behavior, the structure of the landscape, shepherding management strategies and livestock defense strategies were considered. A 500m resolution buffer around each point was chosen based on the hypothesis that this likely represents the scale at which wolves or livestock use different micro habitat patches. This was initially suggested by Davie *et al.* (2014) who examined the influence of landscape factors on predation at multiple spatial scales (100m, 250m, 500m and 1000m) and found that the 500 m resolution had the best fit, suggesting that the overall habitat composition on a 500 m area around predation sites has a stronger influence on kill probability than does variation across a greater or a smaller area. This may represent the scale at which wolves or livestock perceive and use different micro habitat patches (Davie *et al.,* 2014). This was also true for my specific study area by analyzing the local knowledge on wolf attack behavior on livestock as described by various actors directly involved in these events: the rangers of the park, the institutional actors, the local people and the shepherds and livestock managers. The decision was also based on a close analysis of the topography and landscape of the study area. The entire surface of the park is a mosaic of forest and open landscapes in which alpine pastures and grasslands are very fragmented and relatively small in size. The average width of a pasture is approx. 1 km, and generally not greater than 2 km (Figure 26). Therefore, a flock of sheep (and a kill site) is never further away than a few hundred meters from the forest. A spatial resolution of 500 m is thus ideal to capture the dynamic between forest and open landscape.

Figure 26. Relatively small alpine pastures in the park, fragmented by patches of forest.

Step 2. Collecting the data

The first and most important step after identifying an initial set of indicators is collecting accurate and complete data on both the predation events and the indicators. This model was based on a binary response variable (logistic regression) and required acquiring data on two types of locations: locations where wolf predation events occurred and random locations representing where events could have occurred, “kills” and “non-kills”. Kills were represented by attack locations, whereas non-kills were represented by random points. In this section I describe how data was collected for kill locations. The process of generating random points is described in the following steps.

Due to the lack of official data disclosed during the pilot study (section 5.3. in Chapter 5), information on wolf attacks and pasture characteristics at the moment of the attack were obtained from semi-structured questionnaires administered to livestock producers during face-to-face interviews conducted from May to December 2017. See section 7.2. of Chapter 7 for a detailed description of this method and Appendix II and III for the complete survey. Potential bias related to this form of obtaining data and measures taken to minimize the bias are also described in this section.

'Successful' or "kill" events (where wolves killed or injured livestock) were distinguished from 'unsuccessful' events (wolves attempted an attack but were unsuccessful) based on survey responses indicating whether or not the livestock individuals involved in the event were injured or killed (for more details related to the interviews and concerns about reliability please see section 7.1. of Chapter 7). Only "successful" events were included as data for the models. All sheepfolds have also experienced unsuccessful events, most more frequently that successful ones. Most of these events happen during the night when the sheep are enclosed and guarded by the shepherd and the dogs. Wolves attempt attacks but are most often deterred by the dogs led by the shepherd. These types of events were not recorded for the analysis.

There were a few situations when "successful" events were not included in the study:

- when a livestock animal, usually a young lamb or an old sick sheep, was left behind by the moving flock and was subsequently found and killed by a wolf. Examples: a lamb gets its hoof stuck between the roots of the trees while the flock is passing through a patch of forest and is unintentionally left behind, the remains found the next day; an old or sick sheep that cannot keep up with the flock anymore is left behind and subsequently attacked by wolves;

- when the event happened more than 10 years ago. These events were not included in the analysis in order to reduce the possibility of obtaining inaccurate information, and also because landscape features can change over such a long period of time, thus possibly altering the result of the analysis;

- when the location of the event could not be determined with sufficient accuracy.

All other successful events (from now on referred to as "kill events") were considered for the analysis. Kill events happened both in and around the pastures but also in the grazing areas within the park, in forests and along the migration paths. These predation events were recorded, and their spatial coordinates were mapped based on data collected in the field with the help of a handheld GPS (Garmin eTrex 10, 2011, +/- 3m accuracy) or georeferenced on a map together with the respondent (Figure 27).

Figure 27. Recording the location of kills in the field.

I believe the accuracy of the georeferencing to be similar (around 3 meters) due to survey design and its application in the field. I personally worked with each respondent to georeference the location as precisely as possible, with the maximum amount of detail: exact distance from the forest edge or specific landmarks, triangulating responses, and by being always assisted in the field by an expert (Figure 28) in the topography of the area (a ranger, mountain rescue worker, forest guard). In the very few cases when this wasn't possible in the field, I recorded the conversation with the responded and subsequently checked the accuracy of the georeferencing with the experts in an office setting at a later time. Double checking the accuracy of each point was also done for all data points at the end of data collection.

Each kill site was given a unique code for future identification of each individual event. Cases where wolves killed more than one livestock individual during a single predation event at one location were treated as a single kill in order to distinguish individual kill sites and to treat the data as individual predation events. This was because the purpose of the research was to identify the hotspots of livestock predation – or where livestock were likely to be killed – rather than the risk of predation to livestock – or the likeliness of being attacked for individual livestock. Thus, I analyzed data at the unit of the kill site rather than the number of depredated livestock.

Spatial software (ArcGIS v.10.1; ESRI, Redlands, CA) was used to derive the rest of the necessary input spatial data (the predictor variables) from satellite imagery and also from land-use and land cover maps at the spatial extent of hunting grounds and county obtained from the park administration, Ministry of Agriculture and Rural Development, the National Forest Administration, Babes-Bolyai University in Cluj-Napoca and from online sources (Table 1). Most landscape variables were obtained as, or converted to, raster format and rescaled to the same resolution.

Figure 28. Part of the team of rangers that assisted me in my field work.

For some indicators, a series of preliminary calculations were needed in order to obtain the data:

- the forest layer was derived from a canopy cover raster obtained from a GLAD database;
- forest edge was obtained by transforming the forest raster into a polygon and then line feature;
- distance to forest edge, water sources, built-up areas, park border and roads were calculated using the NEAR function of the Analysis toolbox;
- forest cover and length of forest edge were calculated for a buffer of 500 m around each location using the INTERSECT tool of the Analysis toolbox and the CALCULATE GEOMETRY function;
- terrain ruggedness, slope and altitude were derived from the DEM (Digital Elevation Model);
- Habitat type was derived from a Corine Land Cover data set that was then merged and reclassified in order to be ecologically relevant (also see Cristescu *et al.,* 2019).

Step 3. Deciding on the extent of analysis

<u>Predator/prey species</u>

The biology of predator and prey distributions, predator hunting strategies and prey defense mechanisms, research questions, and management goals of the studied protected area were all considered when deciding which data to include in the analysis. Initially kill event data was collected for all three large carnivore species in order to get a general sense of the extent of the physical conflict between people and large carnivores in the study area, and of how wolf predation fits into the more general context of livestock losses to carnivores experienced by the local people. Subsequently, only wolf predation events were considered for the final analysis as this species is the focus of my dissertation. Although bears and lynx also killed livestock, the number of these events were lower and the specifics of the events significantly differed from wolf kills (type and size of killed livestock; location and time of kill events, number of livestock killed in one event, prevention strategies used by shepherds, and so on). Wolves have different hunting strategies than the other large carnivores and thus they must be analyzed separately (Miller *et al.,* 2014).

Predation events involving all livestock types (sheep, goat, cow, horse, dog) were recorded but only attacks on sheep and goat were retained for analysis. This is because most predation events occur in the high alpine pastures of the study area (80% of all sampled sites) where shepherds graze their flocks seasonally, during warm months. These flocks consist of sheep and goat and are guarded by livestock guarding dogs. Sheep and goat are also raised within the households of local people living in the lower altitude villages. Because the environmental and husbandry conditions representing these two cases vary considerably, I decided to exclude predation events occurring around villages in the lower altitude areas in the cold seasons. Most of these events were attacks on dogs. Horses and cattle are also grazed in high-altitude pastures, but these species have marginal importance in wolf diets and have a seasonal occurrence (Sin *et al.,* 2019). When preying on domestic species, wolves seem to show a lower selection of larger, heavy prey in comparison to smaller species that are more easily preyed upon (Janiero-Otero *et al.,* 2020). The sample size of events involving horses and cattle in my data set was too small to accurately model and thus this data was also discarded. Another consideration is that, because of the significantly larger sizes of these species, and thus most likely different hunting strategies of wolves, they represent a distinct case that must be analyzed separately. Guardian dogs defending livestock or households were also killed by wolves both in the high alpine pastures and in the villages, but these events were also excluded due to the small sample size and the fact that wolves might display different strategies when attacking guarding dogs rather than livestock (Wydeven *et al.,* 2004). It is worth mentioning here that wolf attacks on dogs seem to be specific to this region and are rarely mentioned in other areas of Europe (NAPW, 2018), thus they represent a special case of wolf predation that should be analyzed separately, but that represents an important ground for future research.

<u>Temporal and spatial scale</u>

Data was collected for all predation events described by livestock producers. A number of considerations were made which excluded some data from progressing further for the modeling exercise:

- as environmental characteristics vary temporally, only events occurring in the last decade previous to data collection (2007-2017) were included in the analysis;
- only events occurring in the warm season (May to early November) were kept, as this is the season when livestock are grazed in the alpine pastures (see section on *Transhumance* in section 3.1).

The spatial extent of kill locations was limited to the area of the park, plus a buffer area of 5.6 km from the park boundary. This buffer area was included considering the wide home range of wolf packs that are not aware of, or bound by, these human boundaries. A predation event happening close to the border of the park might have been caused by a wolf pack whose territory ranges across both the park and outside the limits of the park. Also, shepherds grazing their flocks in pastures near the park limit often crisscross in and out of park limits, as there is no physical boundary that divides pastures located on the borders of the park. Because the goal of this dissertation is to inform park managers, I decided to add this buffer area to make sure all these events are included in the analysis.

Step 4. Generating random sites

Selecting a comparison set of random non-kill points to represent the range of conditions available in the landscape is crucial to discriminate high risk from low-risk sites and therefore minimize framing bias (Alexander *et al.,* 2006; Treves *et al.,* 2011). Spatial risk correlation models can be built based on presence-absence or presence-availability data (Boyce *et al.,* 2002; Hebblewhite *et al.,* 2005). This analysis follows a use-availability design, therefore random sites needed to sample from the available landscape, showing where attacks could happen. Thus, in identifying these sites, wolf and livestock presence in the territory was considered. Because data on wolf and prey population occupancy and density is not available for the park area, wolf home range was used to define the spatial extent of random points. An inclusion area was created based on a buffer around kill locations with a radius of 5.6 km, representing the radius of the average European and national wolf range (100 square km) (Jędrzejewski *et al.,* 2007; APM Vrancea, 2010; Berde *et al.,* 2016). This buffer was also restricted by the size of the study area. All kill and random sites were sampled within this inclusion area.

The analysis was based on the informed assumption that livestock were present throughout this entire territory due to the following reasons:

- data on livestock distribution was unavailable, but livestock are generally distributed throughout the inclusion area (personal observation based on study results);
- livestock distribution changes over time as favorable grazing areas also change;
- livestock producers tend to move their flocks throughout the entire territory in search of better grazing areas, constantly varying these patterns of movement within the highly fragmented and very mixed landscape of the park; and
- livestock can therefore be present in a various array of micro-habitats and graze throughout all accessible vegetation.

A ratio of 3 times as many random points than attack points was chosen based on the sample size and based on a review of relevant literature in the field (Miller *et al.,* 2015; Black and Anthony, 2022). Also, in order to ensure that the same environmental conditions are not repetitively sampled, a minimum distance of 500 m between each random point was imposed. This resolution was chosen based on the same considerations mentioned in step 3 ("*Deciding on the extent of analysis*").

Step 5. Obtaining, cleaning, and verifying the final database

A spatial database was created by compiling all final kill sites with the absence data in ArcGIS. I then extracted the value of each predictor variable at each location. Eleven spatially explicit variables were initially included in the analysis: Habitat type, Forest cover, Distance to forest edge, Length of forest edge, Distance to road, Distance to settlement, Distance to water source, Distance to park border, Slope, Altitude, Terrain ruggedness (Table 4). Attack vs. available locations were coded as binary responses of 1 and 0, respectively. This coding was used to build logistic regression to determine which of the variables included in the analysis were most strongly associated with kills, in order to predict the risk of future livestock predation. The unique code name of each attack location was kept for association. The accuracy of conflict event locations was verified further by checking the point coordinates in GIS for each sample. The database was cleaned and prepared for input into R software for statistical analysis.

Step 6. Running the statistical analysis in R

a. <u>Preparing, understanding and transforming the data</u>

I started by preparing the data base and running preliminary exploratory statistics to better understand the data. Habitat type needed to be transformed in order to make it available for the modeling process. Looking at the cross table of this covariate I realized that I needed to reclassify it in order to make it relevant for the analysis and to keep the interpretation of the results simple for communication to management. Initially, the Corine Land Cover database representing the source layer of this variable consisted of 18 categories representing various anthropogenic environments (where strong human presence is a common factor), open landscapes and forested habitats. I decided to group the categories by these three criteria, based on prior evidence that wolves are influenced by vegetation height when hunting (Gibbs *et al.,* 2008; Miller *et al.,* 2015) and based on the hypothesis that human presence decreases the risk of predation (Carter *et al.,* 2014; Oriol-Cotterill *et al.,* 2015; Janiero-Otero *et al.,* 2020). Thus, I was able to gather these dispersed categories into groups relevant to wolf behavior and to the risk analysis. A similar approach was taken by Cristescu *et al.,* (2019) for understanding LC habitat choice and suitability in Romania.

All other variables have already been calculated and generated as described in step 2.

All covariates were also standardized to ensure the coefficients are compatible and to speed up computations. For this purpose, I used the "*scale ()*" function from the base package. This is a generic function that centers and scales the data values of each column of a numeric matrix by subtracting the mean of each column and dividing it by its standard deviation (Becker *et al.,* 1988):

$$(x - mean(x)) / sd(x)$$

where *x* is a column, that is, a variable; *mean(x)* is the average of the variable and *sd* is the standard deviation.

Both the scaled and non-scaled data were retained for later use.

b. Selecting the final indicators

As described in step 1, a total of 11 initial spatial variables were included in the analysis. The next step was to statistically filter the variables and select only the most relevant to be included in the model. In order to determine which individual variables are associated with wolf predation on livestock, univariate regression (single predictor variable) was first conducted for all predictor variables, by testing the association of each predictor variable (and their quadratic form where necessary) against the dependent variable (kill/absence data). GLM, logistic regression was used for this purpose. Only the relevant variables (those that showed significant correlation with predation) were selected based on the AIC (Akaike's Information Criterion, Akaike 1974)[3] scores. I compared the AIC score against the score of a null model that was created for each variable (Table 2). If the AIC of the variable didn't improve the AIC of the null model for that variable by a difference in AIC of $\Delta \geq 2$[4], then the variable was dropped from the global model. Distance to road was dropped at this point.

[3] The Akaike Information Criterion (AIC) is an estimator of the relative quality of a set of statistical models (Aho *et al.*, 2014). In estimating the amount of information lost by a model, AIC deals with both the risk of overfitting and underfitting. The best-fit model based on AIC is the one that explains the greatest amount of variation using the fewest possible independent variables. When comparing models in the same data set, AIC estimates the quality of each model, relative to each of the other models (the lower the AIC scores the better the fit) (Sakamoto *et al.*, 1986). Thus, AIC represents a form of model selection (Burnham and Anderson, 2002).

[4] A difference of $\Delta \geq 2$ is considered, as a rule of thumb, the threshold at which a model is considered to have substantial support or not and should or should not receive consideration in making inferences. Models having $\Delta \geq 4$-7 have considerably less support and models with $\Delta > 10$ have no support and can be omitted from all further consideration (Burnham and Anderson, 2002). However, Burnham *et al.* (2011) stress that models having between $\Delta \geq 2$-7 should not be easily dismissed and inference should be rather based on model likelihoods, probabilities, evidence ratios and derived from all models in the set.

As described in *Step 1*, I expected distances to built-up area, road and forest edge to yield a non-linear function in the univariate regression analysis, such that the risk of predation associated with these variables would peak at a threshold at a certain distance after which any additional distance would lead to a decrease in response. “Distance to settlement” and “Distance to forest edge” showed such a relationship (Table 2), thus I included their quadratic form in the multiple regression and saw that this lowered the AIC of the global models. This is a very important step because many times, in natural systems, relationships are not linear, and one should always consider asymptotes, thresholds and other nonlinearities when modeling biological systems (Anderson and Burnham, 2002).

Table 2. Performance of each variable (that passed the correlation test) in the univariate regression.

Variable	AIC linear	AIC quadratic	AIC of random/null model
Habitat type	546	546	651
Terrain ruggedness	606	607	651
Altitude	590	591	651
Dist. to water source	635	636	650
Dist. to road	651	653	650
Dist. to settlement	597	572	652
Dist. to park border	610	610	652
Dist. to forest edge	538	524	652

To further increase the accuracy of the model, I removed any highly correlated variables in order to avoid collinearity between the covariates in the model. By calculating Spearman’s correlation coefficient for pairs of variables, I identified and removed all closely correlated variables ($r \geq 6$ or above). I made the decision of which variable to keep based on the performance of the two correlated variables in the univariate regression analysis, thus keeping the one with the strongest predictive power.

“Slope” and “Ruggedness” strongly correlated with each other ($r = 0.997$, $N = 576$, $p < 0.001$, one-tailed). In the GLM analysis they performed very similarly, therefore “Slope” was removed, and “Ruggedness” retained as this variable is, in this particular case, better for predicting the risk of a predation event. Ruggedness (calculated as change in elevation) makes more sense, since it can affect animal running speed, grazing locations and ultimately hunting success.

“Forest cover”, “Forest edge length” and “Distance to forest edge” also showed strong correlations (Forest cover & Distance to forest edge, r = -0.888; Forest edge length & Forest cover, r= -0.739 and Forest edge length & Distance to forest edge, r- 0.688; N= 576, p < 0.001). Therefore “Forest cover” (AIC = 571) and “Forest edge length” (AIC = 621) was dropped and “Distance to forest edge” (AIC = 532) kept based on performance in the GLM analysis.

Next, the Variance Inflation Factor (VIF)[5], a metric for multicollinearity[6], was calculated and yielded values < 1.7 showing no collinearity within the data set.

After selecting variables based on the above-mentioned considerations, a total of 7 variables with 9 terms were included in the next step of the analysis. In order of their predictive strength in the univariate regressions, these were: “Distance to forest edge” (and its quadratic form), “Habitat type”, “Altitude”, “Distance to settlement” (and its quadratic form), “Ruggedness”, “Distance to park limit”, and “Distance to water source”.

c. Multivariate modeling

The next step was to analyze this data through multivariate modeling (logistic regression). “Habitat type” is a factor variable and was therefore transformed into dummy variables[7] in order to make it possible for it to be included in the multiple regression analysis. This was done automatically by the R software, after I assigned “Anthropogenic” as the reference level.

Like in the univariate regression analysis, I started with a null-model, a model with Gaussian Null distribution, based on an IID (Independent Identically Distributed)[8] sample. Variables were introduced into the model one by one (process done both manually and double-

[5]The variance inflation factor (VIF) detects and quantifies the severity of multicollinearity in a regression analysis. It provides a measure of how much the variance (the square of the estimate's standard deviation) of an estimated regression coefficient is increased because of collinearity. Small VIF values indicates low correlation among variables and should be, under ideal conditions, lower than 3. However, it is acceptable if it is less than 10. (Dodge, 2008; Everitt and Skrondal, 2010)

[6] Multicollinearity occurs when independent variables in a regression model are highly correlated to each other. This represents a problem because independent variables should be independent. *Multicollinearity* usually increases the standard errors of the coefficients, leading to a type two error (James *et al.,* 2003), undermining their statistical significance, and making it hard to distinguish between the individual effects of the independent variables on the dependent variable. A high degree of correlation between variables can lead to overfitting model and problems in interpreting the results (Burham and Anderson, 2002).

[7] Dummy coding is a means of translating the grouping information associated with a categorical variable into a new set of numeric (dichotomous) variables, which can be included as predictors in a regression model. Dummy variables usually have values of 0 and 1, with this coding facilitating greater interpretation of the intercept in regression models. The number of dummy variables is k-1, the number of categories minus 1, as one category will be the intercept, or the reference level.

[8] The null model is based on an IID sample of random variables that share the same probability distribution and are independent events (Gotelli and Ulrich, 2012). Two events are said to be independent if the occurrence of one does not give you any information as to whether the other event occurred or not. What this means in our particular case is that, within the null model, the probability of a kill is not affected in any way by the predictor variables. Naturally, this model would have the worst performance and the lowest predictive power, thus the highest AIC.

checked with the "dredge" function) and the strength of the model was tested after each new variable was included. All possible combinations were tested[9], and several top models emerged. The same combination of variables stood out within each of these top models. AIC was used to rank the models and choose the best and the most parsimonious model with the highest predictive power.

d. Testing model fit and model validation

Once the top model was identified, it was tested in order to demonstrate its predictive power by testing model fit and validating the model. This is a critically important step, as the results of the model may be used to inform management and can influence management decisions. However, many studies involving risk analysis don't carry out model validation (Miller, 2015). When placed in an ecological context the results of the model may be misleading if the model's accuracy and usefulness is not evaluated through error assessment (Chatfield, 1995). I used standard testing methods used for spatial risk models in biological and ecological sciences (Fielding and Bell, 1997; Boyce *et al.,* 2002; Bolker, 2008; Miller, 2015). There is a range of techniques for measuring error in presence/absence models used to study habitat associations (Table 3). The simplest, and most widely used, measure of prediction accuracy is the number of correctly classified cases (Fielding and Bell, 1997). *Receiver Operating Characteristic* (ROC) curves provide one of the most powerful tools for visualizing and comparing classification results (Bi and Bennett, 2003) and is commonly used in ecological studies employing risk modeling (Kaartinen *et al.,* 2009; Zarco-Gonzalez *et al.,* 2013; Abade *et al.,* 2014; Miller *et al.,* 2015; Smith *et al.,* 2015, 2020). I used the AUC - ROC Curve also known as AUROC (*Area Under the Receiver Operating Characteristics*)[10] to test model fit. *Testing the model fit* is used to make inferences about observed values in order to determine whether the selected model accurately describes the data. It estimates the relative closeness of each fitted model to the conceptual truth, how related actual values are to the predicted values in a model.

[9] Due to the small number of variables, this was programmed manually in the R software.

[10] AUROC is one of the most important evaluation metrics for model performance (Fielding and Bell, 1997; Bi and Bennett, 2003; James *et al.*, 2003), assessing the discrimination of a fitted logistic model based on sensitivity and specificity. ROC is a probability curve (Fawcett, 2006), a plot of the values of sensitivity versus one minus specificity. A model with high discrimination ability will have high sensitivity and specificity simultaneously, leading to a ROC curve which goes close to the top left corner of the plot. A model with no discrimination ability will have a ROC curve which is the 45-degree diagonal line. AUC (Area Under the Curve) represents the degree or measure of separability. It tells how much the model is capable of distinguishing between classes. The higher the AUC (with values ranging between 0 and 1), the better the model is at predicting 0s as 0s and 1s as 1s (Swets, 1988).

Ecological modelling has little merit if the predictions are not assessed for their accuracy using independent data (Verbyla and Litaitis, 1989). The process of comparing model output against independent data in order to measure the model's predictive accuracy is defined as *model validation*. For validation I used *K-folds cross validation*[11], an internal validation method commonly used to measure the accuracy of risk models predictions in ecological studies (Treves *et al.,* 2004; Kaartinen *et al.,* 2009; Edge *et al.,* 2011; Soh *et al.,* 2014; Behdarvant *et al.,* 2014). K-folds cross validation is a resampling procedure that both calibrates and tests the entire data set by partitioning and cross-checking the data multiple times (Boyce *et al.,* 2002) (Table 3).

Table 3. Some of the more common strategies used to obtain testing data for validating ecological models (adapted from Fielding and Bell 1997).

Method	*Notes*
Resubstitution	No partitioning is carried out, the same data are used for training and testing. This tends to provide optimistic measures of prediction success.
Bootstrapping	Bootstrap samples (sampling with replacement) are used to assess prediction success. Accuracy is usually reported as a mean and confidence limits.
Randomization	Random samples are obtained by sampling without replacement. Accuracy is usually reported as a mean and confidence limits.
Prospective sampling	A new sample of cases is obtained after the model has been developed. These could be from a different region or time.
k-fold partitioning	The data are split into k ($k > 2$) sets, only one of which is used for training. The remaining $k - 1$ sets are pooled for testing purposes. Also known as the hold-out or external method. Accuracy is usually reported as a mean and confidence limits.
Special cases of k-fold partitioning Leave-One-Out (L-O-O)	Also known as jackknife sampling, n samples of 1 case are tested sequentially, the remaining $n - 1$ cases forming the training set.
$K = 2$	Data are split into one training set and one testing set. A variety of strategies may be employed to determine the split.

Step 7. Predicting and mapping risk

After testing the model fit, the optimal regression model was transformed into a probability surface in ArcGIS by using predict function in raster calculator to predict and map

[11] K-folds Cross-validation is a resampling procedure used to evaluate the performance of models on a limited data sample. It estimates how the model is expected to perform in general when used to make predictions on data not used during the training of the model (James *et al.*, 2013).

model predictions (Miller *et al.,* 2015). The mathematical equation obtained in R was transposed as a spatial analysis equation by using the geo-information functions of the ArcGIS software. The final output is a spatial database that represents the territorial risk (vulnerability) symbolized in order to reflect the different risk areas, from areas of low risk to high risk.

This stage focuses on the visualization of the results. A series of maps and other representations of the conflicts and the risk of predation were created. Focusing on the visual approach, by choosing appropriate forms of representation, categorization, colors, gradients, scales, symbols, etc. the aim of this stage is to produce meaningful maps and representations of the risk as primary tools to communicate the result of the risk modeling. Miller (2015) highlights the importance of these visual tools as a way to bridge communication challenges and ease the interpretation of the risk of predation.

6.4. Results

From May to December 2017 most sheepfolds and livestock producers in the study area (the park and the surrounding buffer) were visited. A total of 353 GPS locations were obtained initially, representing wolf kill sites (N=222), sheepfold and household locations (N=80) and other relevant data (N=51) such as locations of events caused by other LC species, location of dens, failed wolf attacks, wild boar presence, etc. Each kill site was given a unique code for future identification of each individual event. Of these, a final number of 144 kill sites were retained for building spatial risk models. The discarded sites represented events older than 10 years prior to the moment of data collection, events that happened in the immediate area just outside the borders of the study area, events involving livestock other than sheep and goat (horses, cows, dogs) and events where the location was not precise enough, inaccurate or incorrect (see *Step 3. Deciding on the extent of analysis* in section 6.3). Therefore, the kill sites retained for the analysis represented events that happened between 2007 and 2017 occurring in the grazing season (May to early November).

For many of the recorded predation events, wolves killed or injured more than one livestock individual during a single predation event at one location (N=25 events representing 17% of the entire sample where 2 – 24 animals were killed or injured, an average of 3.76). These events were treated as a single kill. Two hundred thirteen livestock individuals were involved in these events, predominantly sheep and rarely goat. Most of these were healthy, white color, female individuals, with an average age of 2.5 years. A significant proportion (33%) of these livestock were lambs and in 65% of all predation events, the flock in which the kill happened contained juvenile individuals. The average size of the sheep flocks was 350 sheep.

Most predation events happened in the middle of the warm season, during the day, with a peak at noon, in freely grazing flocks on the move through the high-altitude pastures. All sheep were enclosed during the night and grazed freely during the day in the pastures around the sheepfold and were guarded by sheep guarding dogs and shepherds at all times. Most predation events happened during good weather conditions, while a large proportion of events were reported during "bad weather" (rain and overcast, drizzle, wind, fog, sleet, thunderstorm, downpour). For all these events, only one compensation claim was made, but was rejected because the shepherd was grazing the sheep in the forest at the moment of attack (grazing in the forest is forbidden) and due to lack of proper paperwork.

Chapter 7 presents these results and discusses the effects of these husbandry related factors in detail.

Model predictions of predation risk

One hundred forty-four kill locations and 432 random sites (a total of 576 points) with corresponding data from 11 spatial indicators represented the basis for the analysis.

As predicted "Distance to settlement" and "Distance to forest edge" showed a non-linear distribution and introducing their quadratic form significantly improved the performance of the global model. "Altitude", although initially had some effect in the univariate regression, did not perform well during the multivariate analysis, as it did not improve the AIC of the models in any combination. Therefore, this variable did not make it into the top models (Table 4).

Table 4. The variable selection process.

	Variables initially included in the study	Variables dropped during correlation tests	Variables dropped during univariate regression	Variables included in best model
1	Habitat type			Habitat type
2	Forest cover	Forest cover		
3	Dist. to forest edge			Dist. to forest edge (and quadratic form)
4	Length of forest edge	Length of forest edge		
5	Dist. to road		Dist. to road	
6	Dist. to settlement			Dist. to settlement (and quadratic form)
7	Dist. to water			
8	Dist. to park border			Dist. to park border
9	Slope	Slope		
10	Altitude			
11	Terrain Ruggedness			

Several top models emerged (Table 5). Of these, 3 models had the lowest AIC values and fell very close within the threshold Δ AIC values of 2 of each other (401 and 403.1). Four variables with 6 terms showed up recurrently in each of these 3 top models and proved to be essential in describing the risk of predation: “Distance to park limit”, “Distance to settlement” and its quadratic form, “Habitat type” and “Distance to forest edge” and its quadratic form. Because “Habitat type” is a categorical variable, it has been split into dummy variables during the analysis. The model containing only this set of four variables with 6 terms, model no.2, had an AIC of 403.147. The addition of “Terrain ruggedness” to this set of variables in model no.3, improved the AIC to 401.08 and, the extra addition of “Distance to water source” in model no.4 improved it even more, to 400.99. Terrain ruggedness showed a negative correlation with risk, pointing at the fact that areas with lower ruggedness could be more prone to predation. Distance to water source yielded a positive correlation, showing that the risk of predation could increase with distance from sources of water. Nevertheless, both “Terrain ruggedness” and “Distance to water source” had low relative importance values and adding these two extra variables only improved the AIC by a difference of Δ ≥ 2.1. Therefore, as all these three models performed similarly, and as they all contained the same recurrent set of 4 variables with 6 terms, after careful consideration I decided to use *Occam's razor* (Duignan, 2021) to shave off extra assumptions (Ball, 2016) and choose the model with less variables, model no2, based on the principle of parsimony (Burnham and Anderson, 2002) and researcher judgment of the specific context.

Excessive elaboration won't lead to a better model, on the contrary, according to William of Occam (the first proposer of the principle of parsimony) we should seek an economical description of the phenomena we are studying, searching for explanations constructed with the smallest possible set of elements (Duignan, 2021), devising simple, evocative models and avoiding overparameterization. As George Box famously said, "*All models are wrong, but some are useful*" (Box and Draper, 1987, p. 424).

Table 5. The top models that emerged from the analysis.

Model	No. of variables	Variables included in the model	AIC	Δ AIC	K	Log likelihood
Null model	650-652					
1	5	Habitat type Dist. to settlement Dist. to settlement squared Dist. to park border Dist. to forest edge	409.16	8.17	7	-197.58
2	6	Habitat type Dist. to settlement Dist. to settlement squared Dist. to park border Dist. to forest edge **+ Dist. to forest edge squared**	403.147	2.155	8	-193.57
3	7	Habitat type Dist. to settlement Dist. to settlement squared Dist. to park border Dist. to forest edge Dist. to forest edge squared **+Terrain Ruggedness**	401.083	0.091	9	-191.54
4	8	Habitat type Dist. to settlement Dist. to settlement squared Dist. to park border Dist. to forest edge Dist. to forest edge squared Terrain Ruggedness **+ Dist. to water source**	400.992	0	10	-190.50
5	5	Dist. to settlement Dist. to settlement squared Dist. to park border Dist. to forest edge Dist. to forest edge squared	417.12	16.128	6	-202.56
6	7	Dist. to settlement Dist. to settlement squared Dist. to park border Dist. to forest edge Dist. to forest edge squared Terrain Ruggedness Dist. to water source	409.82	8.828	8	-196.91

Δ AIC – difference between the AIC's of the respective model and the top model
K – number of estimated parameters (this includes the intercept and dummy variables)

Figure 29 shows the relationship between each predictor variable of the optimal model and the kill probability.

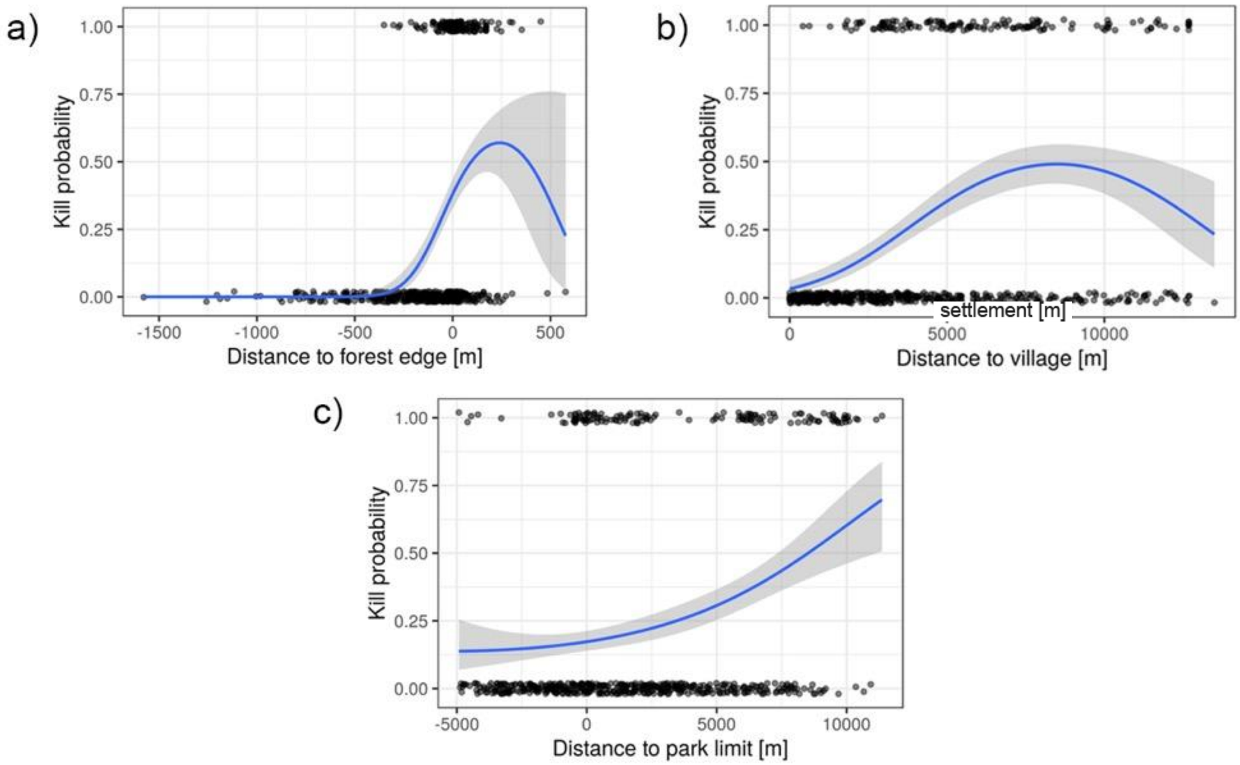

Figure 29. Relationship between each predictor variable and kill probability.

The blue line represents the modeled prediction of kill probability. The 95% confidence intervals are shown in gray. In Fig 24a, 0 represents forest edge, moving inside of forest are negative values and moving outside of forest are positive values. In Fig 24c, 0 represents park limit, moving inside of the park are positive values and moving outside of park limits are negative values.

The chosen optimal model significantly improved the AIC of 675 of the null model. Although the relative importance of "Habitat type" was the lowest, removing it from the top models did not improve the model, on the contrary, it significantly lowered AIC values (see models no. 5 and 6 in Table 5), showing that, in combination with the other indicators, this variable plays an essential role in describing the risk of predation, and should therefore be included in the top models.

The optimal model predicted the probability of wolves killing livestock in case of an encounter between both groups. Livestock were most accessible to wolves in open pasture areas close to the forest, closer to the core area of the park and away from villages. As predicted, the risk to livestock increased with closer proximity to the forest edge and the core area of the park and decreased in areas with higher human presence.

Kill probability showed a quadratic relationship to the distance to settlement, with livestock vulnerability increasing at farther distances up to a threshold and then decreasing. Kill probability also showed a quadratic relationship to the distance to forest edge, this time with the risk of predation decreasing with distance in and out of the forest. Livestock were most accessible to wolves around 8 km from inhabited areas and 200m away from the edge of the forest.

The contribution of each variable to the prediction of predation risk was measured by its relative importance in the model (Table 6). *Distance to park limit*, *Distance to settlement*^{2}, and *Distance to forest edge*^{2} all ranked ≥0.8 in relative importance and most strongly explained the location of kills.

The relative importance of these variables remained high across all top models.

Table 6. Predation risk model output showing the predictor variable relative importance, coefficient (b), and standard error (SE) in the final two models considered for the selection of the best model. Normalized relative importance values range from 0 to 1, indicating a strong contribution to the model*

	Model no.2				Model no.4			
Predictor variable	**Importance**	**Normalized importance**	**β**	**SE**	**Importance**	**Normalized importance**	**β**	**SE**
Intercept	NA	NA	-1.7E+01	6.09E+02	NA	NA	-1.7E+01	6.1E+02
Habitat type, dummy 1: tall vegetation	0.024	0.005	1.4E+01	6.09E+02	0.024	0.005	1.4E+01	6.1E+02
Habitat type, dummy 2: open fields	0.025	0.005	1.5E+01	6,09E+02	0.025	0.005	1.5E+01	6,1E+02
Dist. to settlement	4.713	1.000	7.2E-04	1.5E-04	4.712	1.000	7.3E-04	1.5E-04
Dist. to settlement squared	3.417	0.725	-4.1E-08	1.2E-08	3.433	0.728	-4.1E-08	1.2E-08
Dist. to park border	4.088	0.867	1.3E-04	3.2E-05	4.016	0.852	1.3E-04	3.2E-05
Dist. to forest edge	4.270	0.906	5.3E-03	1.2E-03	3.842	0.815	4.8E-03	1.2E-03
Dist. to forest edge squared	2.735	0.580	-1.2E-05	4.5E-06	2.712	0.575	-1.2E-05	4.5E-06
Dist. to water source					1.458	0.309	5.7E-04	3.9E-04
Ruggedness					1.898	0.402	-3.6E-02	1.9E-02

**Relative importance values were calculated with the varImp() method in the Caret package of R software and represent the absolute value of the Z score.*
Blank cells indicate that the variable was not included in the model.
'NA' indicates statistic is not applicable.

Habitat type (expressed as dummy variables *Open pastures* and *Tall vegetation*) showed a significantly lower importance in the top models, but it's exclusion from the analysis showed a strong decrease of the model's strength (see model no. 5 and no. 6 in Table 5), thus highlighting that *Habitat type*, in conjunction with the other top variables, still plays an essential role in explaining the risk of predation.

Model validation

I used AUROC to test model fit. The AUC value for this test was 0.87 which shows an excellent fit (Figure 30). AUC values of < 0.5 are usually taken to indicate low accuracy, values of 0.5–0.7 indicate useful applications and values above this threshold indicate high accuracy (Kaartinen *et al.,* 2009). What this means is that this model is best in the sense of trading-off bias versus variance of the fitted model parameters.

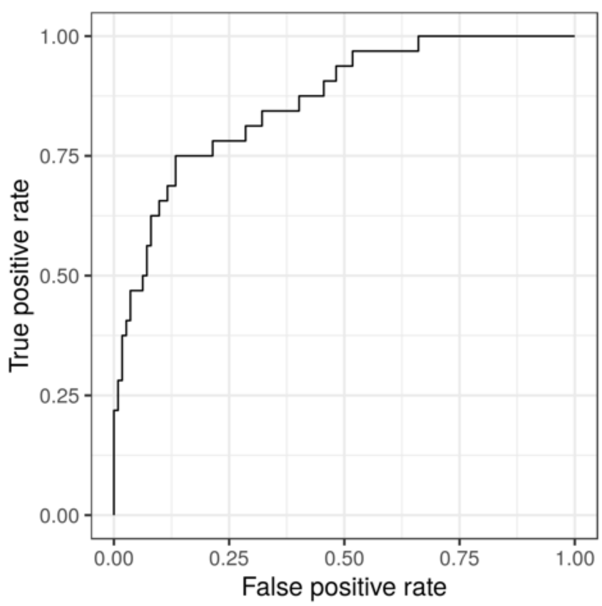

Figure 30. The ROC (Receiver Operating characteristics) curve for best model

For validation I used K-folds cross validation. The average K-folds score12 (k=4) for the model was 0.9. Thus, one can conclude that the model is approximately 90% accurate on average.

Post modeling experimentation

The hypothesis that "Forest cover" would show a non-linear pattern similar to "Distance to forest edge" when replaced in the global model was confirmed. The results showed that

[12] The Accuracy of the model is the average of the accuracy of each fold.

“Forest cover” had indeed a threshold relationship (the risk peaked at around 40-50% cover, which is the equivalent of the edge of the forest) (Figure 31) and that the strength of this variable significantly improved with the added quadratic form, both in the one-by-one GLM and also in the global model. Its performance was now similar to “Distance to forest edge”. One can thus replace “distance to forest edge” in the optimal model (AIC: 403.1, AUC: 0.86; and average K-folds score: 0.9) with “forest cover” without seeing almost any change in the performance of the model (AIC: 401.9, AUC: 0.87; and average K-folds score: 0.9). This is explained by the fact that the two variables reflect the same influencing factor: the cover provided by the tall vegetation in forested habitats that facilitates successful wolf hunting. By initially testing three different ways of expressing this factor, I was trying to find the best way to capture the complexity of its dynamics in relationship to the risk of predation and learn more about the intricate web of interactions at this level that make forest such a strong influencer of risk. Also, discovering that this variable can be used interchangeably with other variables showing the influence of forest on the risk of predation, may be helpful in case one of these variables is easier than the other for livestock producers, managers and other stakeholders to conceptualize and apply in the field.

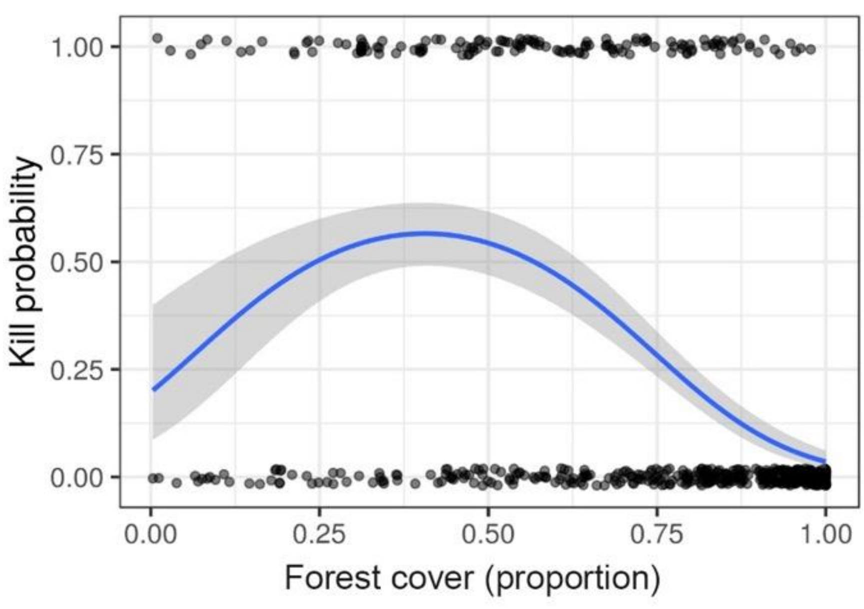

Figure 31. Relationship between Forest Cover and kill probability.

The 95% confidence intervals are shown in gray.

Spatial patterns of predicted risk

The risk maps obtained after projecting the risk offered visual insight into the spatial distribution of the predicted livestock predation patterns. The maps showed that the risk was greater in the higher altitudes of the park, the alpine areas characterized by a highly fragmented forested environment, a mosaic of patches of forests and alpine pastures. The model predicted that core, isolated areas, farthest away from the inhabited settlements of the local communities fell into the highest risk category. See Figures 32 and 33 for more details.

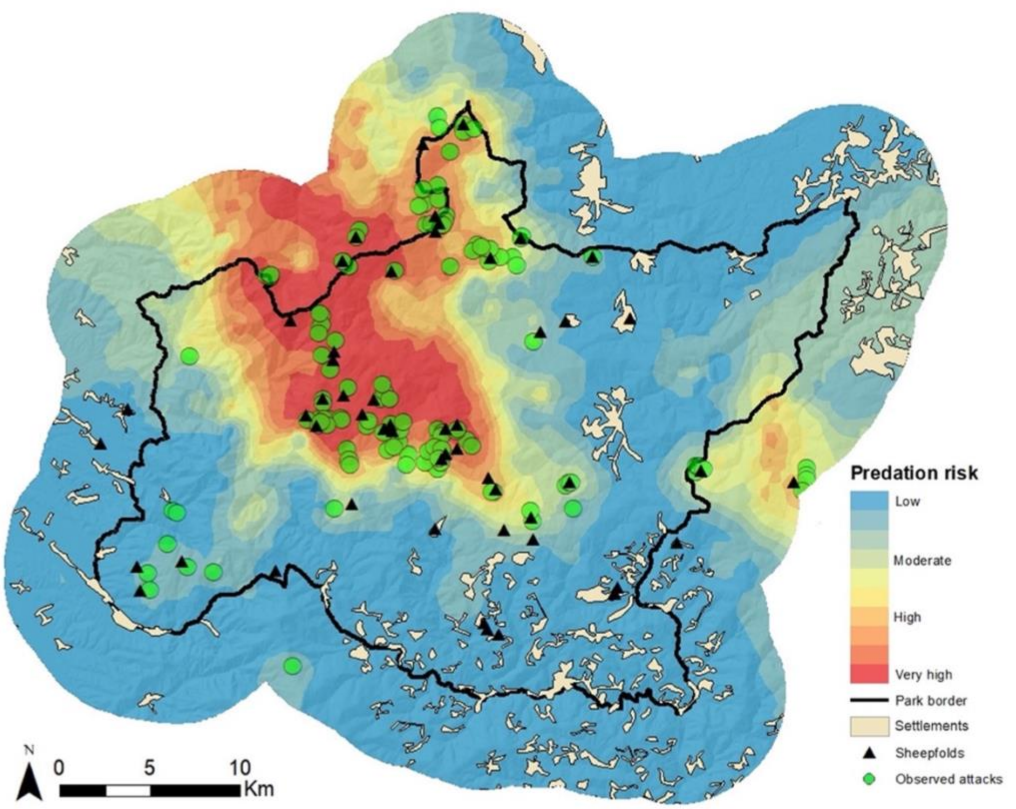

Figure 32. Predicted risk of wolf predation on livestock on the surface of ANP

Maps illustrated a region of high risk extending into the center of the park, overlapping with core areas for wolves, and the heightened chance of attacks on livestock grazing within this core zone.

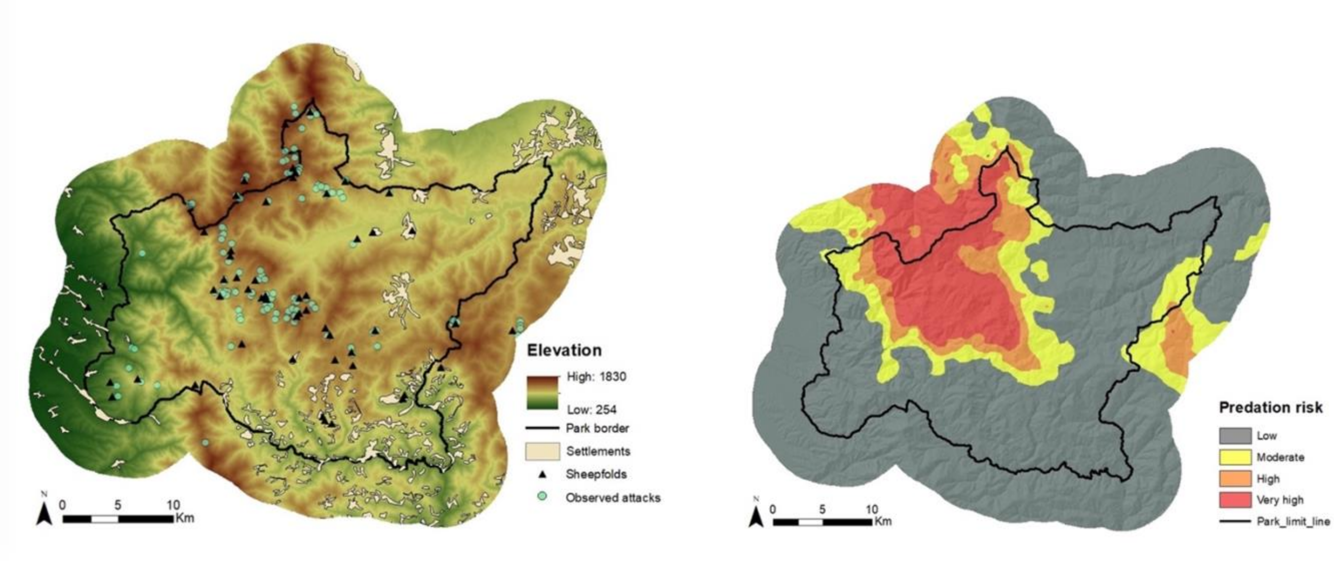

Figure 33. Hot spots of wolf predation risk compared to landscape features and elevation.

The analysis of data gathered on people's subjective perception of risk (presented in section 7.2. of Chapter 7), allowed for projecting this perceived risk on the same scale as the calculated risk (Figure 34), thus allowing for the comparison between the two (see section 7.4.4) and opening the ground for an extensive discussion on the factors that influence people's perceptions of risk. These aspects are detailed in the following chapters.

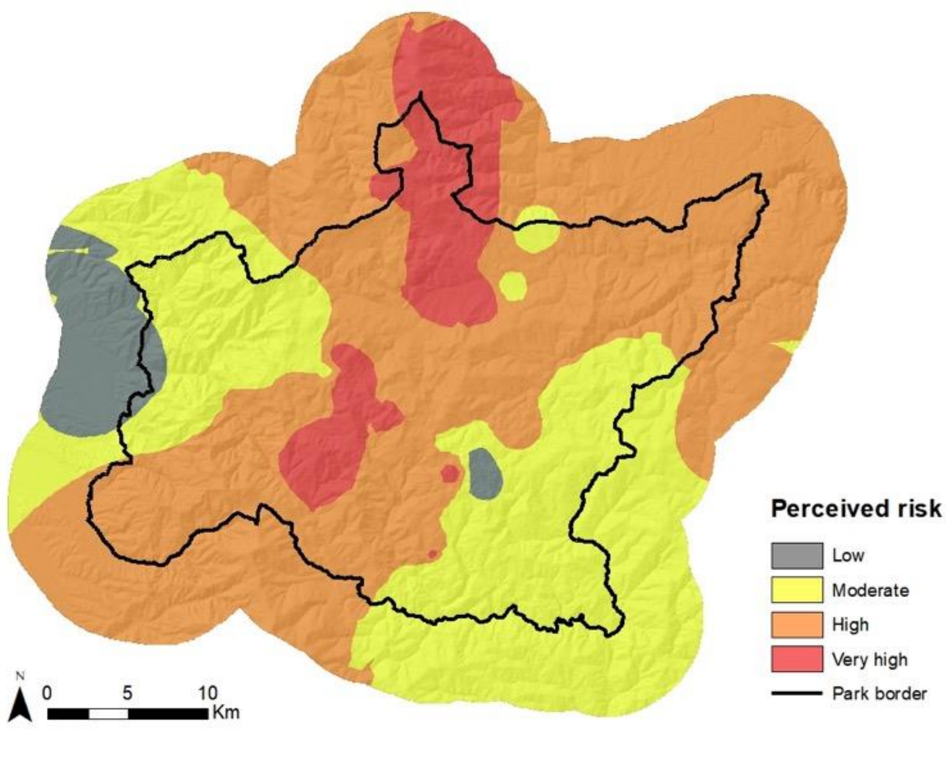

Figure 34. Projection of perceived risk of wolf predation on livestock on the surface of Apuseni

6.5. Discussion

The analysis revealed that biophysical, land-use, human-presence and management spatial attributes, when built into a carefully designed model, can be used to predict spatial patterns of livestock predation by wolves, offering key insights needed to explain the relationship between landscape features, wolf hunting strategies and livestock vulnerability to predation in a certain landscape.

Generated at a fine spatial grain (500m resolution) the model was able to pinpoint prey vulnerability in respect to certain environmental features and specific predatory decisions and adaptations made by wolves during attacks on livestock, as opposed to models built at more coarse resolutions (1-25 km) that may capture only more general aspects of predator prey encounters resulting from wolves' search for prey across broad spatial grains (Gorini *et al.,* 2012).

6.5.1. Influence of tall vegetation and adaptive wolf hunting strategies

The optimal model showed risk of predation to be higher in areas with tall vegetation, near dense tall patches of forest with tall transitional shrubs and poor visibility. Before building the model, it was hypothesized that **distance to forest** would influence the risk of predation in a non-linear pattern, with the risk peaking at a certain threshold. As predicted, the risk was low in deep forests and increased with closer proximity to forest edge and open pasture, peaking at around 240 m away from the forest edge (see Figure 29 in the results section). After this point, the risk starts to decrease. It would be interesting to see how much the risk decreases in the open pastures, but the model cannot show us what happens after 600 m away from the forest. This is mostly due to the fact that the landscape on the surface of the park is highly fragmented and mixed. Forest is predominant but it is fragmented by patches of grasslands and alpine meadows that are on average not wider than approximately 1-2 km and are surrounded by forest. But even these open pastures are sprinkled with small patches of woodland (Figure 35). This makes it very unlikely for a kill or random site to exist further than 500-600 meters away from the forest as there is no pasture wide enough for this to occur. Nevertheless, what the model does shows is that there is a decreasing trend of the probability of risk after 240 m into the open pastures. The choice of a fine grain of 500 meters thus proved essential in capturing the effect of tall vegetation.

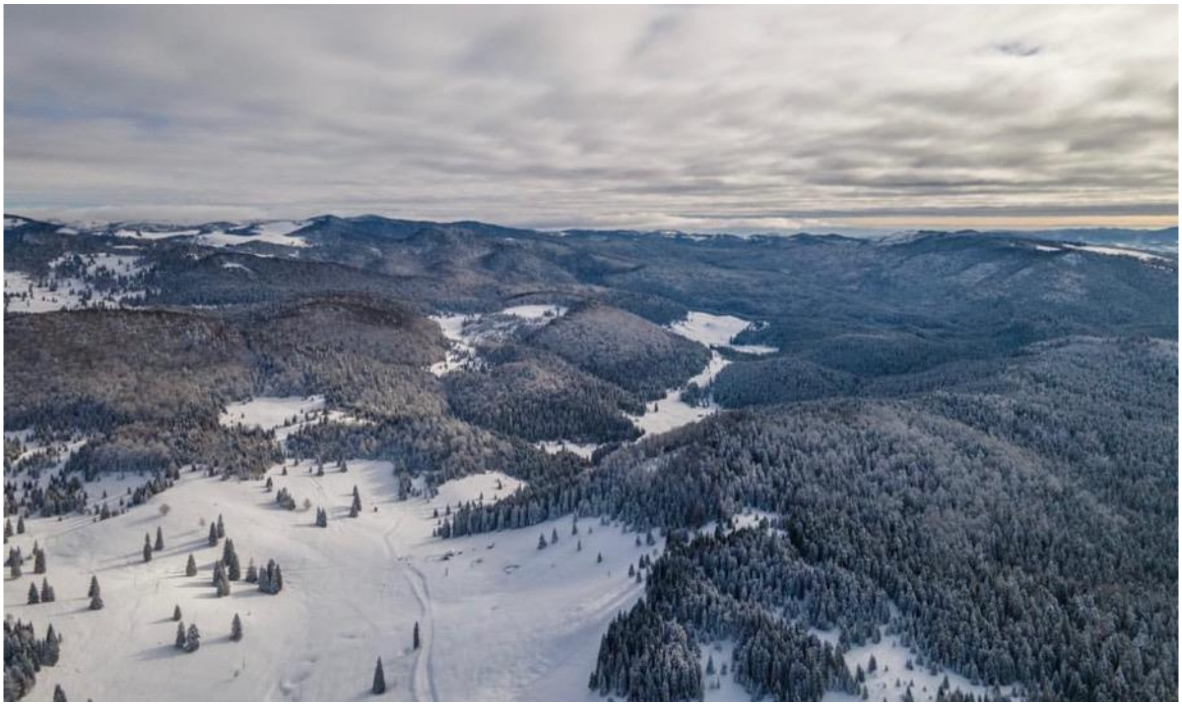

Figure 35. The fragmented landscape of the alpine area in APN (Souce: APN).

This finding is very similar to results emerging from the Romanian Eastern Carpathians, reported in the National Action Plan for Wolves (NAPW, 2018) that show the highest frequency of kills occur when the livestock enclosure or other sheepfold dwellings are situated between 0 and 250 m away for the forest edge. In their case, the risk continues to decrease steadily with distance from the forest after this point, just as I would predict for my data. They also show that grazing inside of the forest or any other tall vegetation greatly increases the risk of predation. Similarly, results yielded by the Carpathian Large Carnivore Project (Promberger *et al.,* 2000) show that flocks kept away from the forest suffered less losses while most wolf attacks occurred on flocks in and near the forest.

It is very important that the results obtained here are correctly interpreted. Although the model shows the risk to be lowest in the middle of forested areas, this is in fact only a function of a relative absence of livestock there. Although presence of sheep flocks in the forest is generally prohibited, shepherds still use the edge of the forest for rest, shade and protection against harsh weather conditions (hot midday sun; heavy rain and wind) and to move their flocks to water sources or from one grazing area to another. Shepherds only guide their flocks into deep forested areas when they need to cross the forest as part of their seasonal migration between pastures or between the high-altitude alpine pastures and the lower altitude villages. Thus, sheep presence can generally be recorded only to a maximum of 1-2 km into the forest. This leads to a relative absence of attacks in the deep forest and a shortage of kill sites (1's) here. Random sites (0's) thus overwhelm kill sites in these areas and this pushes the model to show a low risk. Figure 36 illustrates this idea.

This result should not be interpreted by managers and livestock producers as an invitation to lead and graze livestock in the forest. In the scenario where sheep would be constantly present in the forest, I hypothesize (both based on these results and on those of Robel *et al.,* 1981 ; Bangs and Shivik, 2001 ; Treves *et al.,* 2004 ; Nowak *et al.,* 2005 ; Kaczenski *et al.,* 2008 ; and Davie *et al.,* 2014), that the risk would actually be very high here due to the advantages wolves have over livestock/natural prey in this environment: sound and visual cover, increased terrain ruggedness and complexity, the root system, presence of streams, higher depth and longer persistence of snow, etc.

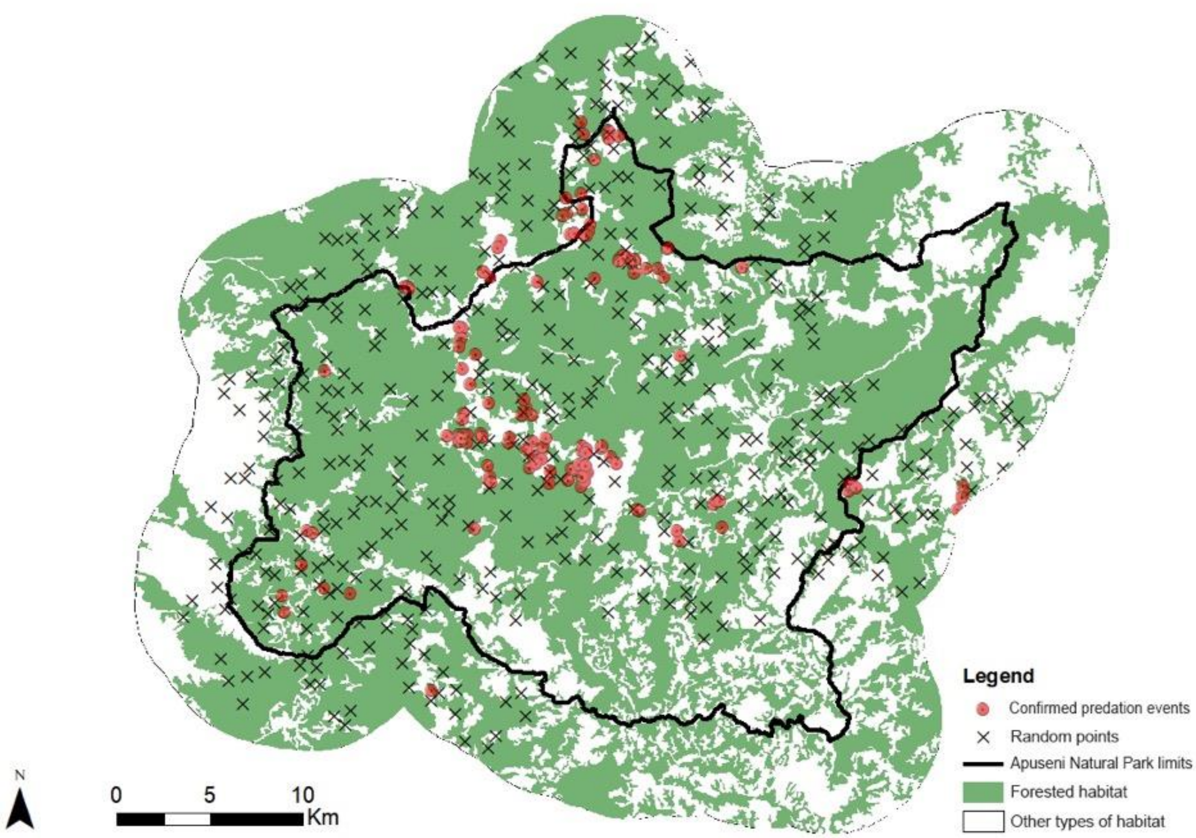

Figure 36. The location of confirmed predation events and random points compared to forested habitats

The model showed the risk of being highest very close to the edge of the forest. This confirms the edge effect hypothesis (see section 6.2., Step 1) that predicts predation levels to be higher in edge habitats. This effect was also described by most shepherds (and park rangers) within the unstructured interviews (see section 7.3. of Chapter 7). Wolves supposedly use the cover of the forest to approach the flocks unseen and attack livestock in this area where prey and livestock are most vulnerable. There are a few possible explanations for this phenomenon. To outrun a predator, vigilance and speed are crucial (Mech, 1966). Because shepherds and their flocks use the edge of the forest for rest during mid-day, it is likely that the level of vigilance decreases during this time. Shepherds are most likely laying down resting or even asleep and the livestock would be motionless, also resting or grazing in the shade. The guarding dogs usually take up strategic positions, evenly distributing themselves along the edge of the forest in order to be able to detect predators approaching from the forest. But the tall and dense vegetation limits the ability of both dogs, livestock and shepherds to detect wolves due to limited field of view relative to a more open habitat, thus rendering livestock more vulnerable to wolves. The decreased vigilance and lowered visibility brough about by this situation would then be coupled with slower response speed, due to the high midday heat. Another situation is when shepherds bring the herd into the forest in search of protection from harsh weather conditions. The heavy rain would lower visibility even more while a strong wind blowing through the tall vegetation would hinder the ability to aurally detect an approaching predator even more. The results of the non-spatial factors influencing predation show that almost 40% percent of kills occurred during bad weather conditions: drizzle and overcast, rain, wind, fog, sleet, thunderstorm, downpour.

The risk at the edge of the forest peaked at about 240 meters away from the forest. This particular distance can be explained by several factors. An average size sheep flock (350 individuals) would likely be spread out on a similar distance along the edge of the forest and livestock individuals would be encountered and attacked by wolves somewhere along this distance. It is also likely that wolves would initiate the attack as they exit the forest and are detected but the chase and kill would happen over a span of a few hundred meters. But an even more likely explanation is connected to the fact that the edge of the forest in these high-altitude areas presents a transitional woodland/shrub habitat that extends a few hundred meters from the edge of the forest into the open grassland. This transitional habitat is characterized by tall bushy vegetation with occasional scattered trees, an ideal habitat for wolves to use as visual cover and concealment while attacking livestock. This transitional habitat would thus extend the edge effect to approximately this distance. Terrain ruggedness and vegetation complexity would still be high in this transitional strip, contributing to livestock vulnerability through poor visibility and detection of approaching predators, slower reaction time and lowered mobility and speed in escaping an attacking predator (especially true in case of sheep, who tend to get their hoofs caught up easily in roots and dense vegetation). Shrubland has been shown previously in literature to increase the risk of wolf predation on livestock in similar landscapes (Davie *et al.,* 2014).

The general topography and particular composition of the landscape specific to these high-altitude areas of the park could contribute to the edge effects themselves. The entire surface of the park is a mosaic of forest and open landscapes in which alpine pastures and grasslands are very fragmented and relatively small in size. Areas with small habitat fragments exhibit especially pronounced edge effects.

All these factors could decrease visibility, and thus predator detection, reaction speed and mobility (of not only livestock, but also people and dogs guarding them) along the edge of the forest and therefore render livestock more vulnerable to wolf attacks (Figure 37). Once in the open field, the risk would decrease with distance from the forest due to the decreased opportunity for cover, and the simplification of the terrain.

Figure 37. Sheep enclosures situated near the forest edge (Source: APN).

What particularly stands out from this analysis is just how important the element of “cover” is for wolves in attacking livestock. This result is somewhat surprising in the light of the fact that wolves are considered to be wide-ranging active coursing predators, known to hunt in open areas (Wells and Bekoff, 1982) where they can chase down prey over large distances (Middleton *et al.,* 2013). Typically, wolves hunt mammals cooperatively in packs (Mech, 1970; Mech *et al.,* 2015) by surrounding, outrunning, outlasting, and exhausting their prey (Kruuk and Turner, 1967; Kleiman and Eisenberg, 1973; Peterson *et al.,* 2003). However, while preying on livestock throughout the very fragmented landscape of the Apuseni Natural Park, wolves most often attack flocks alone or in very small groups of maximum 2 to 3 individuals (as reported by 70% of shepherds, but also rangers and hunters - see section 7.3. of Chapter 7) and seem to show flexible hunting strategies when preying on livestock. In this landscape, wolves seem to have evolved stalking-hiding or ambush-like hunting tactics specifically tailored for catching and killing livestock, using forest as cover to avoid the sensorial detection by livestock, guarding dogs and people (Figure 38).

Figure 38. Location of an ambush attack situated a few hundreds of meters above the sheepfold. As the flock was grazing, early in the morning, a wolf jumped out of the trees on the left and killed one of the livestock.

This result is unexpected since using vegetation type and structure is typical for stalking hunting behavior characteristic for felids (Murray *et al.,* 1995). Wolves typically rely on endurance pursuit instead (Poole and Erickson, 2011) drawing advantage over prey in terrain roughness (Suryawanshi *et al.* 2013), snow depth (Wikenros *et al.,* 2009) and open landscapes.

According to their predominant hunting mode, predators are traditionally divided into three main categories (Miller *et al.,* 2014): (i) sit-and-wait or ambush predators (e.g. egrets, horned lizards, praying mantis), (ii) sit-and-pursue predators (e.g. owls, tigers, wolf spiders), and (iii) active hunting or cursorial predators (e.g. kites, wolves, dragonfly adults). Wolves fall in this last category of predators that constantly move through their environment to find, follow and chase down prey. They have been shown to approach prey slowly, minimizing the distance between them and prey, until prey bounces and the chase begins. Usually, wolves spend many hours and ample travel distances before achieving hunting success (Mech *et al.,* 2015). Average chases of ungulates last one to two km (Mech, 1966; Peterson, 1977).

Contrary to such previous findings on wolf hunting tactics, my analysis suggests that wolves use the forest edge and the adjacent dense shrub habitat to escape detection, and stalk and surprise livestock by launching sudden and quick attacks over small distances. The element of surprise, provided by tall vegetation cover (and any other concealing elements), appears to be a very important factor affecting predation success of wolves in my study. Hunters in this study confirm that, while preying on their natural prey, wolves display the well-known, classic pursuit hunting technique, but that this is not always the case while predating on livestock. This phenomenon is also supported by findings of the next chapter showing that forest edge, bad weather, nighttime, and any form of sensorial concealment (visual, auditive, and general secludedness), all variables known that provide sensorial cover, are considered by shepherds to highly increase the risk of predation.

This altered hunting strategy of wolves is also described in reports coming from the shepherds, stating that wolves seem to “sneak up” to the flock and “grab” a certain individual that is within their immediate reach. Several shepherds describe even seeing wolves crawl on their bellies in the tall grass right up to the sheep and then launch a sudden surprise ambush attack on the unaware animal. They also describe wolves patiently waiting in the dense bushes around certain trees in very specific sheep resting spots (Figure 39) that the flocks visit every day. Knowing their routine wolves anticipate the sheep coming and wait there for extended periods of time until the sheep flock arrives, and the sheep lay down to rest in the shade provided by the tree, unaware of the motionless wolf hiding in the dense vegetation. Only then do they launch the attack from a practically laying down position onto the sheep that have settled down very near them. Shepherds also report that wolves target the most vulnerable body part of the livestock, usually grabbing the neck area, tearing the main vein thus quickly making the kill. Even in cases when they don't succeed at killing the livestock on the spot, they are described to strongly hold on to their prey and carry it away using their entire body, including their tail, to tightly latch on to their prey. Again, this behavior is much more typical to stalkers and ambushers like felids that stop their prey on place as soon as they surprise it and start the killing process "well fastened" to their prey (Mech et al., 2015, p. 2).

Figure 39. Left: Sheep settled in their resting spots in the shade of the forest while dogs are guarding. Right: Carcass from a wolf depredation event that occurred in the forest

This ambush-like behavior is not unique to wolves in this study. One other study, published by Gable *et al.* (2018; 2021; 2023), shows that wolves use ambush tactics to hunt beavers in Greater Voyageurs Ecosystem of International Falls, Minnesota. Their study is the first systematic analysis of wolves ambushing behavior and it clearly shows that wolves choose ambushing locations to counter and capitalize on the sensory abilities of their prey. Gable *et al.*

demonstrate that wolves can anticipate the predictable movements and behavior of their prey due to a fundamental understanding of their prey's sensory abilities. This could easily translate in my research into wolves' ability to predict the behavior of sheep flocks using specific areas of the forest edge for rest and capitalize on the sensorial cover provided by this tall edge habitat to ambush livestock.

This has been observed elsewhere and probably represents an effective hunting strategy. Dense vegetative cover has been shown to increase probability of livestock predation due to increased cover for predators and decreased prey sight lines (Robel *et al.,* 1981; Treves *et al.,* 2004; Mattiello *et al.,* 2012; Zarco-González *et al.,* 2013). Davie *et al.* (2014) believe that tall vegetation limits the ability of pastoralists to detect wolves and decreases vigilance thus rendering livestock more vulnerable to wolves. Kunkel and Pletscher (2001) also found that wolves seem to have little trouble detecting prey even in heavy cover (probably due to wolves relying more on scent than vision to detect prey) and that cover may be important in helping wolves conceal their approach.

What the current research adds to these findings is the discovery of the stalking and ambush like hunting strategies that wolves employ while preying on livestock in such concealed circumstances. Only one other source of literature (Heptner, 1998) mentions this behavior in the eastern part of Europe, describing wolves as displaying variable hunting modes, from pursuing prey as a pack in the winter to hunting individually in the summer, when they rely on concealment and ambush.

It is possible that these hunting strategies are successfully applied by wolves in the previously mentioned studies too, thus leading to increased rates of predation in concealed environments, but their data collection methods (use of official reports) did not allow for identifying this behavior. As the current study was based on face-to-face interviews to collect the data on the predation events, this allowed for long open-ended discussions with the shepherds directly involved in the attacks who consistently reported this hunting behavior.

These findings, although in need for more thorough investigation, challenge the classic concept that wolves are primarily cursorial predators (i.e., predators that kill their prey by outrunning and outlasting them) (Mech, 1966; Peterson, 1977; Peterson *et al*, 2003; Poole and Erickson, 2011; Miller *et al*., 2014; Mech et al., 2015). Instead, wolf-hunting strategies appear to be highly flexible, wolves being able to alternate hunting modes (cursorial and ambush hunting) depending on their prey and the specific environmental make-up. Although not fully backed up by data in this study, this hypothesis can represent a very important path for new research of wolf hunting tactics. If confirmed by future research, this finding can contribute to overturning the traditional notion that wolves rely primarily on hunting strategies that involve pursuing, testing, and running down prey and bring unprecedented insights into adaptive hunting tactics wolves use in attacking livestock. A search for clear causal explanations must wait for more detailed behavioral studies, but in the meantime, I believe these findings have value for managers and stakeholders.

6.5.2. Influence of human presence

Kill probability also showed a quadratic relationship to **built-up areas (settlements and other inhabited areas)** with the risk of predation increasing with distance up to a certain threshold (approx. 8000m) then decreasing (see Figure 29 in the results section). Wolves are generally believed to avoid heavily populated regions, mostly retreating to more natural areas away from human settlements (Kaartinen, 2005; Jędrzejewski, 2008). This seems to be true in my study area as well, and here, this is probably a function of two of the most important factors

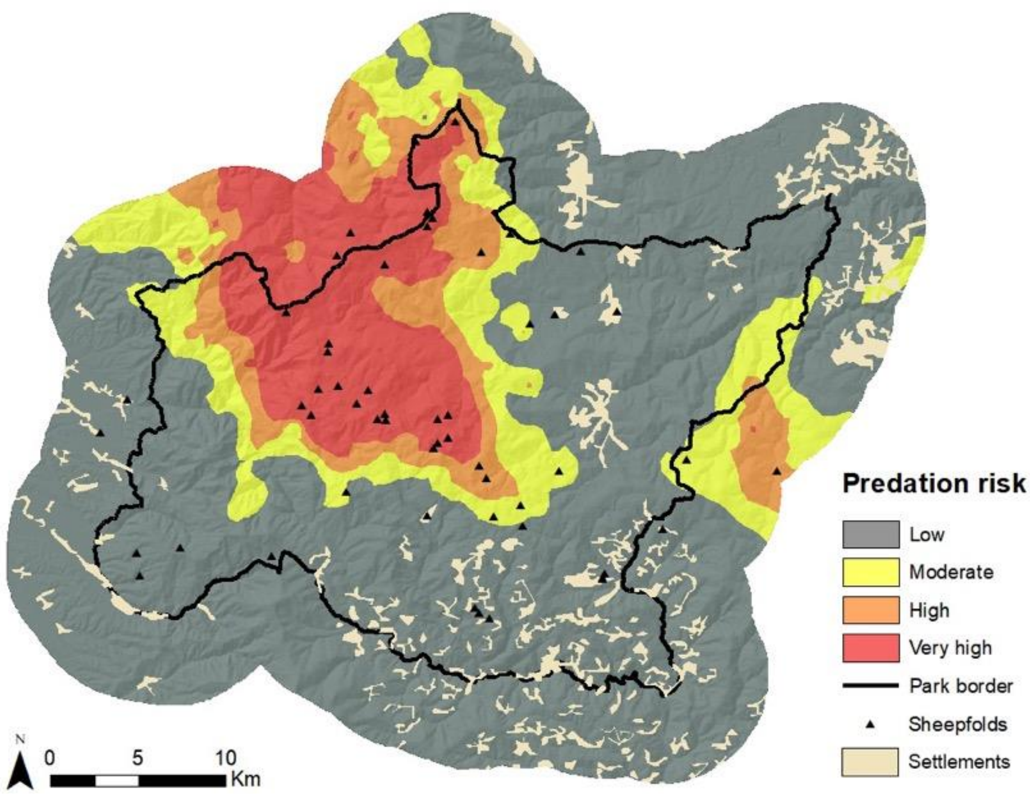

Figure 40. Hotspots of predicted risk of wolf predation on livestock compared to settlements on the surface of APN.

influencing predation events: availability of prey and presence and distribution of the predator (wolves) which is in turn affected by the presence of people. Most kill events occurred in the high alpine pastures where sheep and goat temporarily graze during the warm months of the year. These pastures are located several kilometers away from inhabited areas of the park found at the lower altitudes (Figure 40) and away from human infrastructure such as roads and railway.

The flocks are brought back down to these villages during cold months and are grazed in the grasslands and agricultural lands around the villages. Although the flocks are still available to wolves here, there are very few predation events on sheep and goat occurring in these areas (N = 3, 1.3 % of all predation events). This is probably due to the proximity of people.

Human presence and threat of human-caused mortality could be causing wolves to avoid these areas, spatially and temporally separating their activities in order to reduce contact with people, thus choosing livestock less in these areas and opting for their wild prey instead (Carter *et al.,* 2014; Oriol-Cotterill *et al.,* 2015; Janiero-Otero *et al.,* 2020). This has been shown to be true in many other such human-dominated landscapes (Nowak *et al.,* 2005; Behdarvand 2014; Newsome *et al.,* 2016; Janiero-Otero *et al.,* 2020). The constantly low kill probability response for settlements compared to other landscape attributes demonstrates wolf aversion to human presence and the lower likelihood of an attack on livestock within built-up areas. These results reinforce the findings of similar studies (Oriol-Cotterill *et al.,* 2015; Janiero-Otero *et al.,* 2020) and show that there is an increased risk of predation for livestock producers grazing their flocks in remote areas, away from human presence.

In a recent (2020) global-level review of available literature regarding gray wolf diet and prey densities, Janiero-Otero *et al.* found that areas where livestock were left to graze freely in small numbers (<20 individuals/km^2) and high densities of livestock enclosed overnight were more vulnerable to gray wolf attacks. They also show that the style of husbandry affects livestock losses with predation greatly increasing in herds without any protection. Both findings are confirmed by my research (see section 7.3. in Chapter 7). Thus, the results of this analysis present a management opportunity to increase the use of preventative measures (vigilance, livestock guarding dogs, presence of shepherds, night enclosures, improved carcass disposal methods, use of deterrents, etc.) when they graze their flocks in these temporary alpine pastures in the high altitudes of the park, compared to the lower altitude pastures around villages.

These results also reinforce the knowledge that in human dominated landscapes wolves prefer their natural prey over livestock if their natural prey is abundant, even if livestock are more easily accessible to them in these landscapes. Sheep flocks grazing freely near inhabited areas of the park are much less well guarded (with fewer shepherds and livestock guarding dogs present) than the ones up in the high alpine pastures. Even so, attacks on livestock in these areas have a much lower frequency, representing only 20% of all recorded events (including attacks on other types of livestock such as dogs, horse and cattle) and only 1.3% of sheep kills. This result is in line with the most recent findings in the in the field showing that in many landscapes, wolf diet consists predominantly of their wild prey, even when livestock are abundant, easily accessible (Nowak *et al.,* 2015) and even when livestock have a substantially higher density than wild prey (Janiero-Otero *et al.,* 2020).

6.5.3. Management factors associated with increased risk

The risk was also dependent on the **distance to park borders**, with the probability of a kill peaking in the core area of the park and decreasing linearly towards the park boundaries and with distance away outside the park limits (see Figure 29 in the results section). This area of high risk extends to, through and beyond the park's NW border, overlapping with the territory of two other Natura 2000 sites, ROSCI0016 Buteasa and ROSPA0081 Munții Apuseni Vlădeasa, that were integrated under the APN adiminstration in 2014. The fact that this area represents a contiguous habitat, devoid of human settlements and under a similar protection regime, is the reason why this strip of high risk here extends beyond park borders.

Figures 32 and 33 in the results section illustrate this region of high risk inside of the park, demonstrating the heightened chance of attacks on livestock grazing in these core areas, where small open pastures surrounded by patches of forest located somewhat away from roads and villages provide ideal hunting grounds for wolves (see Figure 41). This confirmed the initial hypothesis that predation risk would increase with distance from park borders into the core area of the park. I based this hypothesis on management policies. During the time spam of this research, hunting of large carnivores was forbidden on the surface of the park but not outside the boundaries. Also, hunting of game species on the surface of the park was limited, while these limitations did not apply outside the boundaries.

Yet, hunting grounds are distributed in and around the park, in a mosaic fashion, completely covering the surface of the park and its vicinities. Some hunting grounds partly overlap with the surface of the park. This creates situations in which one hunting ground covers both areas within and outside the park, the park border dividing the hunting ground into two (Figure 42).

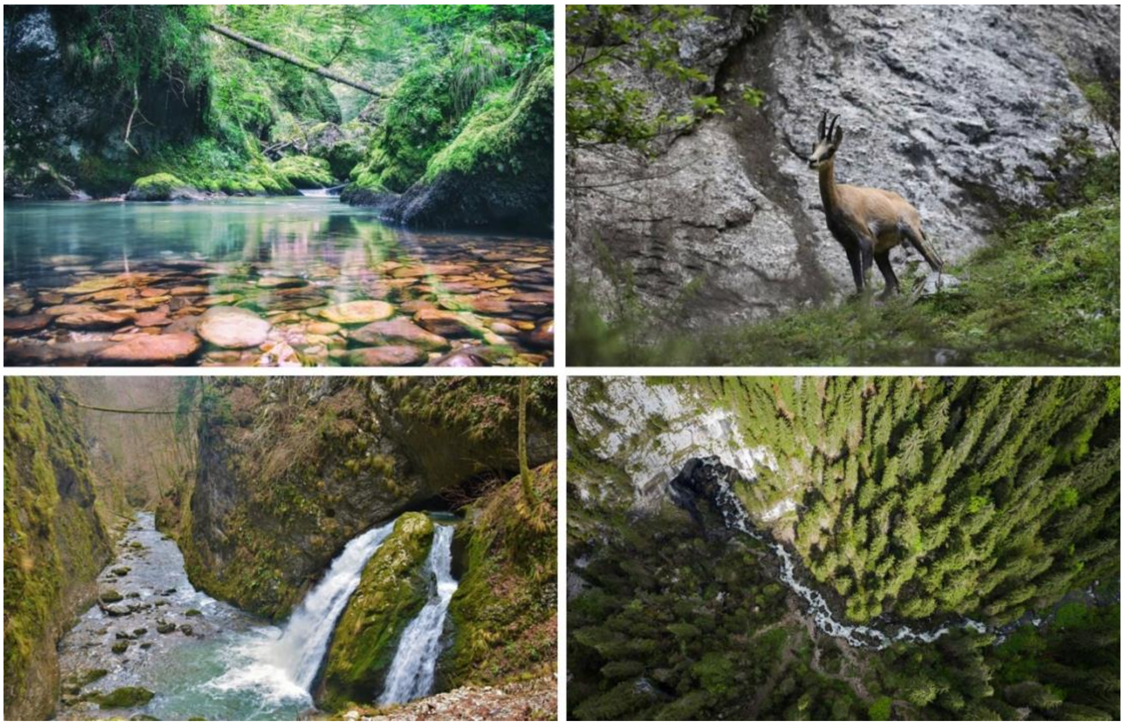

Figure 41. Core areas of the park represent ideal wolf habitat.

Therefore, wolf hunting quotas were still attributed to that particular hunting ground which strived to realize the quota by hunting wolves from the part of their territory that is outside the park.

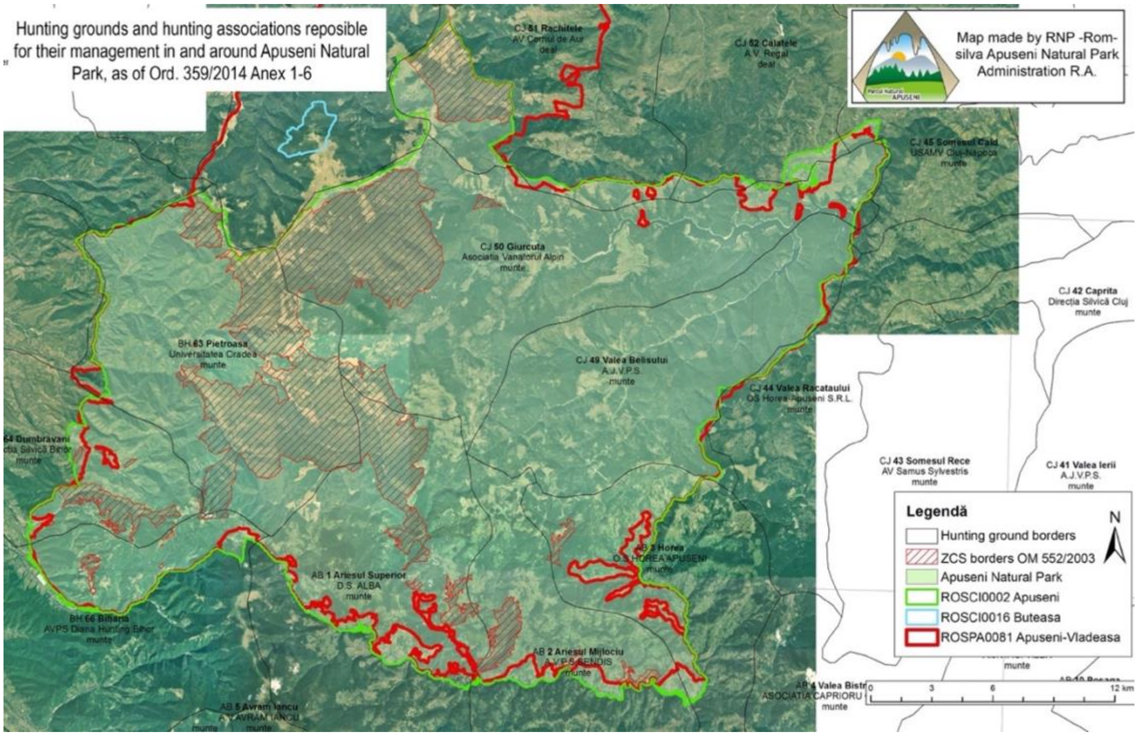

Figure 42. Distribution of hunting grounds in and around Apuseni Natural Park (ANPMP, 2023).

Naturally, wolves cannot easily perceive these human imposed boundaries and will move freely throughout their entire territory, but, under the threat of hunting, it seems reasonable that they would tend to concentrate away from the hunting areas at the outer edges of the park towards the "safer" core areas in the middle. The same would be true for game species that would also find the core areas of the park a refuge (Figure 43) from the increased hunting activities happening immediately outside park borders, concentrating in safer core areas of the park and thus, further attracting wolves to these areas.

While the most recent and only wolf distribution map (Figure 18 in section 3.2. of Chapter 3) put forward by the Park Administration (ANPMP, 2023) shows suitable wolf habitat evenly distributed across most of the surface of the park, this map also highlights that wolf distribution spatially separates from areas of human inhabitance in the south of the park (see also Figure 44 below). Also, while this distribution map shows wolves evenly present on most of this remaining area, we need to keep into account that this does not indicate specific areas used by wolves for hunting, and most importantly we need to keep in mind that this map was issued in 2023, for the first time in the history of the park. No sound scientific distribution data was available until this point and during the time of the data collection for this dissertation. Interviews with park rangers show that there has been a perceived increase in wolf numbers and pack size since the complete ban on large carnivore hunting of 2016 until today. This increase could have led to a significant change in wolf distribution.

Figure 43. Red deer grazing undisturbed in the core area of the park (Source: ANP).

Regarding livestock distribution, the situation is similar: there is no official distribution map available for livestock, nor is there a precise official number of sheep grazing on the surface of the park. The only information available coming from the park administration, is a document entitled "*Study on the socio-economic environment and the situation of lands in the protected natural areas of Apuseni Natural Park and the protected natural areas it administers*" (Nitu, 2022) that was issued as part of the project for updating the park's management plan, document that shows an estimate of sheep and goat numbers in the settlements surrounding the park. As mentioned in this document, due to the lack of data, this estimate is based on numbers issued by the National Institute of Statistics (NIS). Such estimates are issued by the NIS only once every 10 years, when an agricultural census takes place. This data shows an estimate of 23.842 sheep and 2680 goat individuals in the settlements neighboring the park in 2010 and 27584 sheep and 3607 goats in 2020. Without available data on livestock distribution in the park, the distribution of alpine pastures represents the only indicative of where livestock are grazing in the park. I thus use this map to illustrate potential livestock distribution for comparison purposes (Figure 44).

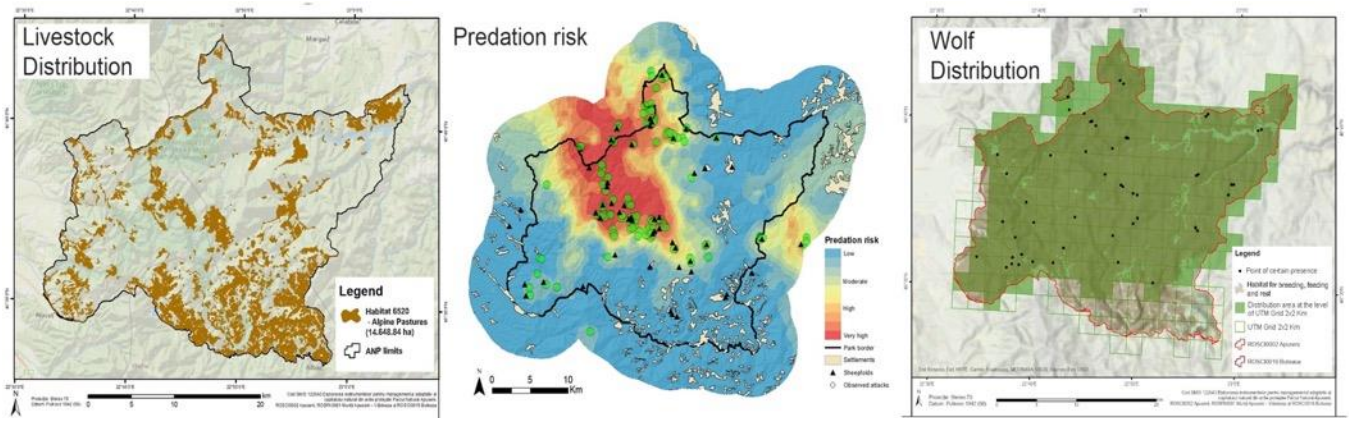

Figure 44. Comparison of predation risk map (middle) with wolf (left) and livestock (right) distribution maps (ANPMP, 2023).

Despite the lack of exact distribution data, by highlighting behaviors such as distancing from human settlements and anthropogenic land use types (see Figure 33 in previous section), choosing habitats marked by low human impact, and concentrating in core protected areas (Figure 44), the results of this analysis point out wolves' tendency to avoid areas of human activities and increased hunting by retreating to core areas of the park at the time of this study. Figure 45 represents a comparison of the risk of depredation with areas of highest human activity, here represented by human settlements and building and road infrastructure.

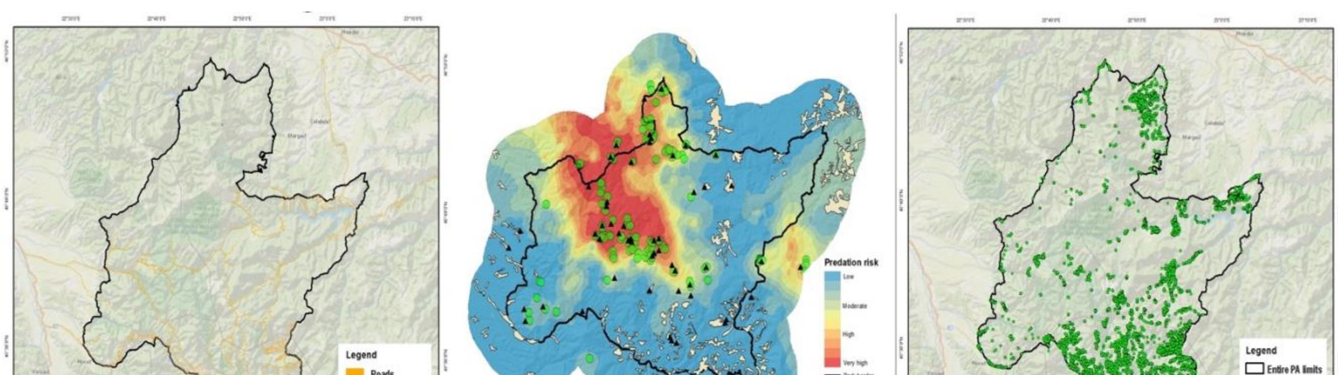

Figure 45. Comparison of predation risk map (middle) with road infrastructure (left) and settlements and buildings (right) distribution maps (ANPMP, 2023). The two side maps include two Natura 2000 sites that are under the same administration as APN, hence the borders in these two maps extend more to the north than those of APN.

This effect may be increased by the fact that these core areas are characterized by a general low human presence where wolves can minimize the risk of encountering people and where certain prey species have a higher protection status. The zoning of the park (see Figure 19 in section 3.2. of Chapter 3) facilitates this context by completely forbidding the practice of flushing as a hunting method in the core areas of the park where large carnivores den, as a means of reducing disturbance. In order to further reduce disturbance, park management also limits human activity in all protected core forested habitats by forbidding changes in land use, campfires and motorized vehicles and limiting the use of forest resources in these habitats in the Core Protection Zones. All of these measures greatly reduce human disturbance and provide rich and healthy core habitats, thus, according to our hypothesis, presumably attracting large carnivores and prey to these areas.

In a national-scale study, Cristescu *et al.* (2019) also show year-round use of these high-altitude pastures by wolves and their avoidance of artificial areas. In highlighting wolves' preference for high levels of ruggedness and higher proportion of forest cover, their results support my hypothesis that these wild core areas are an important home range component for wolf persistence, "*possibly because it provides refuge from persecution*" (Cristescu *et al.* 2019, p. 16). Studies in Mongolia similarly suggest that wolves avoid humans by using areas that are less accessible, especially to hunters that use vehicles (Kaczensky *et al.,* 2008).

The remote alpine pastures and grasslands surrounded by vast areas of forest in these core areas appear to be attracting wolves as well as livestock producers and their flocks during the seasonal summer and early fall grazing. Grazing livestock within the core area of the park is limited by park regulations to certain pastures and prohibited in the forested areas. Nevertheless, shepherds graze their flocks freely throughout the entire territory except the deep forests, and often use the forest edge for rest and cover from the elements (Figure 46).

Figure 46. Flocks resting at the forest edge.

Thus, a possible vicious cycle is created: wolves that retreat to these core areas in order to find shelter from hunting and other human activities encounter livestock flocks and can cause damage by predating on this readily available prey that they have been well adapted to hunt for centuries in the humanized environment of Southern and Eastern Europe (Iliopoulos, 2009). This hypothesis still needs to be further tested by future research, but it's value lays in the fact that it highlights the importance of combining carnivore occurrence from confirmed distribution records with habitat suitability analyses as this could help identify management needs for different management zoning areas of the park, thereby improving protection effectiveness. I thus applaud the latest initiative of the Park Administration to launch a larger scale study of these issues as part of their most recent Management Plan.

6.5.4. Effect of land-use

The type of habitat also proved to be strongly associated with the risk of predation. The risk peaked in natural grassland habitats, followed by natural wooded areas and was lowest in human modified landscapes such as highly managed agricultural lands, mines, dumps, and urban areas. This suggests that the sheepfolds at highest risk of wolf predation are those located away for human activity in remote mixed, complex landscapes showing a mosaic of forests and grasslands, in areas where detection by humans and livestock is low. This pattern is consistently confirmed throughout the results of this analysis, being also captured by the other variables part of the optimal model: the contrast between natural vs. anthropogenic; wolves' preference for unmodified natural environments and their tendency to avoid heavily anthropogenic environments; and wolves' choice of secluded and remote cover-providing areas, all seem to be reoccurring themes within the findings of this analysis. The analysis of the influence of vegetation, previously described above, similarly showed that the risk peaked very close to the forest edge, and that this relationship showed a non-linear trend, with the risk decreasing after a few hundred meters into the open landscape. Interpreting the effect of human presence indicators suggests that this effect is maximized in remote areas, away from human settlements. Lastly, looking at how management factors influence the risk of predation also showed that natural, wild and secluded core areas are preferred by wolves in this study area as they seem to avoid heavily populated areas characterized by a large degree of human activity.

These finding are similar to those reported by Kaartinen *et al.,* (2009) who show that in Finland, wolf attacks on sheep farms are most likely to occur in the mosaic of forest, small wetlands, clear cuts and plantations, away from areas with a large proportion of agricultural and built-up landscapes. Behdarvand *et al.,* (2014) also found that variables related to land use/cover types affected by anthropogenic influences on the landscape, such as irrigated farms and human settlements, were the most important in predicting wolf attack risk levels. The type of land use was found by Davie *et al.,* (2014) to play an essential role in predicting areas of high conflict areas, reflecting patterns of space use by wolves. In a very recent study, Mayer *et al.,* (2022) show similar land use/cover associations with established wolf pack presence and predation in Central Europe, highlighting the importance of protective measures in reducing predation success.

The heavily fragmented mosaic landscape of forest interspersed with small open pastures in the core area of the park closely surrounded by a mixture of anthropogenic elements of landscape (Figure 47), might be the strongest factor driving predation of livestock to this area.

Figure 47. From the eyes of the wolf: outlook over remote, often-predated sheepfolds in the alpine pastures of the park, view from an intensely used wolf path.

But considering landscape is a very dynamic system, human generated changes in land use should be expected to lead to a redistribution of hunting locations and habitat potentiality, thus a redistribution of predation hotspots. Various studies of spatial patterns of canid attacks on livestock have shown that human presence and human alteration of natural landscapes, such as changes in land-use and habitat fragmentation, greatly increase the chance of predatory attacks in the proximity of human populated areas (Jhala, 2003, Timm *et al.,* 2004). Mayer *et al.,* (2022) best capture this phenomenon, demonstrating that the highly cultivated landscapes of today's Central Europe show increased levels of predation risk attributed to non-resident wolves being dispersers into agricultural areas with low availability of wild ungulate prey and high livestock densities.

So far, the results of this study indicate that wolves seem to avoid preying on livestock in populated regions, mostly targeting flocks in the more remote core areas of the park. Despite this result, I urge that the spatial trend of predation must be closely and cautiously observed in the future. As shown by literature in the field, certain conditions - decrease in natural prey availability (Meriggi and Lovari, 1996; Sidorovich *et al.,* 2003), disruptions in population size (Thruber and Peterson, 1993) and pack dispersion (Imbert *et al.,* 2016) – and an aggregation of suitable resources in human-modified landscapes is enough to attracts wolves to these areas (Wilson *et al.,* 2006).

6.5.5. Summary

The analysis revealed that biophysical, land-use, human-presence management spatial attributes, when built into a carefully designed model, can be used to predict spatial patterns of livestock predation by wolves, offering key insights needed to explain the relationship between landscape features, wolf hunting strategies and livestock vulnerability to predation in a certain landscape.

Generated at a fine spatial grain (500 m resolution) the model was able to pinpoint prey vulnerability with respect to certain environmental features and specific predatory decisions and adaptations made by wolves during attacks on livestock. In summary, results of this model suggest to managers and livestock producers that livestock flocks in the study area are at a higher risk of predation by wolves in the remote natural high alpine pastures (situated in the core area of the park) where they graze during the warm months of their seasonal migration. While grazing in these areas, livestock are most vulnerable in the open grasslands and pastures near the edge of the forest, where dense and tall vegetation minimizes sensorial detection.

7. Identification and analysis of husbandry/non-spatial biophysical factors

Answers RQ 1b: "What non-spatial biophysical and husbandry factors influence wolf predation of livestock?"

The spatial risk analysis presented in the previous chapter has demonstrated that the risk of predation is dependent not only on pure biophysical and species related factors, but also on human presence and threat of human-caused mortality that is shaped by the spatial configuration of human activities and, in turn, by management decisions. Humans shape predator-prey interactions and how these species use the landscape and thus, husbandry and management preventative measures can greatly reduce the risk of predation (Oriol-Cotterill *et al.,* 2015; Janiero-Otero *et al.,* 2020). Wolves, livestock, shepherds and their livestock guarding dogs constantly interact, responding to each other's strategies in the form of a never-ending process of co-adaptation. Capturing these interactions, and the influence of non-spatial factors in the risk of predation, is the purpose of this chapter. Here, I will compile the methodology and results of the analysis of the semi-structured interviews conducted with livestock producers that were conducted with the added purpose of gathering additional data on the husbandry practices and non-spatial data on the attacks. The focus is also on people's local and professional know-how in dealing with wolves, their knowledge of the species, their attitudes and their perceptions both towards wolves and their management. This allows for the quantifying of perceived risk and its comparison with physical risk, adding a final, important dimension to the complexity of these conflicts and bridging the multiple dimensions of the research, contributing to the knowledge on the complex web of processes and interactions that lead to conflict, but also to co-adaptation and coexistence. This novel socioecological framework (Carter and Linnell, 2016) for operationalizing coexistence (Lute and Carter, 2020) in an increasingly human-dominated world has rarely been undertaken (McInturff *et al.,* 2021) and thus, this analysis helps fill an important research gap (Dickman, 2010) while also laying the ground for improving the interoperability of different scientific approaches that managers can undertake in the field to gather richer data on, and successfully mitigate, predation risk.

7.1. Limitations and issues of reliability and validity

Because there are no official recorded data on the exact location and conditions at the moments of attack (no systematic records have been kept after the change of the communist regime and attacks are rarely reported), interviews with persons directly involved in the conflicts represented the best available way to obtain this data and therefore represented a crucial step of this research. An advantage of using this method, even when records are available, is that it allows for much richer data to be collected than from official reports (McInturff *et al.,* 2021). Much information, especially on husbandry practices, knowledge of the species, attitudes and perceived risk, cannot be obtained from records; the only way is for the researcher to visit the locations of attacks and collect targeted data in the field. This is also highly important because, through direct observation, it is possible to identify new key predictive factors that are specific for this area. Also, by directly discussing with the person suffering the attack, I was able to obtain more complex data, not only for the spatial risk mapping exercise, but also about non-spatial factors and husbandry practices influencing kills. Through these interviews it was also possible to elicit a sense of people's perceptions on the conflict and information that can pinpoint issues in the institutional and management processes being analyzed, data that was essential for the last section of this research: the identification and analysis of social and institutional factors that influence and maintain conflicts.

One of the most important limitations of this method is that it assumes that the respondent's answers are correct and that they can accurately geolocate the attack. However, as there is no other way to obtain this data, I acknowledged this potential bias and assumed that information provided by the interviewees is correct. Nevertheless, this method can and has been used with success, as shown by similar peer-reviewed studies also looking at landscape factors influencing predation by wolves (Behdarvand *et al.,* 2014; Davie *et al.,* 2014) and other large carnivores (McInturff *et al.,* 2021). By taking all possible measures to reduce bias brought about by this assumption, I consider that the data base I obtained is sound and reliable.

A potential issue that could arise from this form of data collection is the *self-serving bias* (Miller and Ross, 1975) of the respondents, with producers possibly engaging in self-protective attributions that could affect the accuracy of the data they provided. Yet, this bias has been shown to be relevant mostly only when respondents expect some form of personal success or positive outcomes from this behaviour. Financial compensation would be the only positive outcome producers would gain from exaggerating wolf attacks. But as there are no links between this research and expectations of compensation, especially in the context of the non-functioning national compensation scheme, *subjective assessment* (Burgman, 2001) and overestimations of attack events for this reason are very unlikely.

To determine whether the information shepherds give on wolf kills would be reliable, I first had to determine whether shepherds could correctly identify a wolf and distinguish it from similar species potentially preying on livestock. Considering the low rates of wolf-dog hybridization in the Romanian Carpathians (Jarausch *et al.,* 2023), feral dogs are the only other animal in this area similar enough to wolves (Linnell *et al.,* 2002) which they could be mistaken for. For this purpose, I included a short test at the beginning of the questionnaire (see Appendix II) that asked shepherds to distinguish between 4 images (two of wolves and two of feral dogs), having to name the species in each case. The vast majority (97.7%) of the respondents successfully passed this test[13] by correctly identifying wolves.

Also, in order to assess the level of the presence of feral dogs in the area, I asked respondents about their knowledge of the presence of feral dogs in the area and about their ability to attack livestock and wild prey. I asked these questions before the species recognition test, in order to reduce bias in their responses. Only a small number of respondents (N=6) have seen feral dogs in the area and approximately half of the respondents believed that feral dogs would not be able to attack livestock or wild prey. These initial results suggest that the presence of feral dogs is low. I was able to reinforce this finding by discovering that there is a policy according to which hunters are officially instructed to shoot any dog running free that is not wearing a yoke (a wooden crosspiece hanging on a chain that is fastened around the neck). The presence of this yoke indicates that the dog belongs to a shepherd and is intended to stop the dog chasing after wild animals by restricting dogs engaging in chasing behaviour. I also triangulated this by asking shepherds about their use of yokes. Most of them were aware of this policy and about 60 percent of them used yokes. Also, scientific literature shows that, contrary

[13] This first step was a necessarily methodological step that would validate the next methodological steps – delving into the specifics of wolf attacks on livestock. While the interpretation of the answers given by the shepherds in relationship to how they identify wolves from feral dogs is a form of results, these results are only relevant to the methodology, and therefore they are presented here prior to the "Results" section.

to popular belief, few dog populations are truly feral when it comes to food acquisition (Vanak *et al.,* 2009) as they typically forage human-derived food sources to a large extent (Daniels and Bekoff, 1989; Butler and du Toit, 2002). The conclusion I arrived to, based on all this information, is that the presence of feral dogs in the area is low, and shepherds are experienced enough to correctly distinguish them from wolves. While some of the kills could still be caused by feral dogs, this evidence suggests that the number of these events would not be large enough to affect the model or the general trends of predation.

Potential bias can also arise in situations where the respondent wasn't present at the moment of attack and therefore would have needed to identify the species responsible for the kill based on the signs on the carcass. However, since in 99.3% percent of the events (there was only one event when flock was not guarded), the shepherd was present at the moment of the attack, this potential bias was insignificant for this study. Shepherds constantly guard their flocks, most often in numbers of 1 or 2 (and up to 4), even during the night, thus they can spot the predator responsible for the attack, and, as shown, they are unlikely to mistake it for another species.

To maximize the accuracy of the mapped kill locations, I worked with each respondent to georeference the location as exactly as possible, with the maximum amount of detail: exact distance from the forest edge or specific landmarks, triangulating responses, and by being assisted in the field by an expert in the topography of the area (a ranger, mountain rescue, forest guard). In the very few cases when this wasn't possible in the field, I recorded the conversation with the respondent and subsequently checked the accuracy of the georeferencing with the experts in an office setting at a later time. Double checking the accuracy of each point was also done for all data points at the end of data collection. Using a very similar method, McInturff *et al.,* (2021) ground-truthed locations provided by shepherds in their study, showing that these locations were within the same level of error (10 meters) as a GPS device, therefore validating the accuracy of these locations and the soundness of this method.

Another possible source of bias is poor memory of the respondent (Papworth *et al.,* 2009). I collected data for all the events shepherds could remember, but in order to reduce personal amnesia bias, I only kept events that happened withing a time frame of 10 years prior to data collection. This threshold may seem large, but I based this decision on analysing the data after the field work was completed, based on the level of detail provided by the respondent and the average timespan that most respondents could confidently recall. Limiting data collection for this timeframe was also necessary in order to minimize bias brought by changes in the physical landscape. An analysis of all 100 interviews with shepherds revealed an almost astonishing accuracy and level of details of their memory of these events. They remembered very clearly and were able to recount with an impressive amount of detail exactly when and where the attack took place, the circumstances, the number of wolves involved and so on. This may be since successful attacks happen only about 2-4 times per grazing season for the sheepfolds most visited by wolves and 1-2 times every few years for the less frequented ones, and therefore, these events represent the highlights of a shepherd's yearly activity and a measure of their skilfulness (see McInturff *et al.,* 2021). My discussions with them and my observations showed that shepherds take great pride in their job, which they rather describe as a profession, or a calling. For a shepherd a wolf kill always shows one of two possibilities: it is either a failure of the shepherds or their livestock guarding dogs to defend the herd due to a mistake or lack of ability, or it reflects the exquisite mastery of the wolves in succeeding to overcome the solid line of defence put up by the shepherds and their dogs. Thus, a shepherd never forgets these events and proudly recounts them to fellow shepherds with accuracy and detail. It was, in fact, a common occurrence that interviewed shepherds recounted predation events happening to other shepherds in nearby sheepfolds. I used this data to confirm the accuracy of the information I already had about events by triangulating details from sometimes even 3 or 4 other shepherds. This also gave me greater confidence that my interviewees were not intimidated by my presence and were not trying to give false information. When responding to my questions about predation events, their responses almost always took the shape of a story told with much passion and pride. Therefore, I acknowledge the potential bias resulting from memory failure or intentional inaccurate responses but confidently consider shepherds reliable, knowledgeable stewards of nature who are familiar with the landscapes that they spend so much time in and who would have no incentive not to provide reliable data.

7.2. Methodology

Interviews with livestock producers and local communities

As stated in section 6.3. of Chapter 6, the data on kill events necessary for the spatial risk analysis was collected through face-to face interviews with livestock producers/herders in Apuseni Natural Park based on a previously designed questionnaire (Appendix II and III). Additionally, these interviews inquired about opinions, perceptions and knowledge on the topic of wolves and wolf management. These interviews mainly targeted shepherds and other livestock producers, but several other relevant groups were approached in order to complement but also verify and triangulate the information provided by producers. Groups and particular representatives of these groups were selected through a *criterion-based* approach (Ritchie and Lewis, 2003; Bryman 2012; Ritchie *et al.,* 2014) based on an initial sample unit that was expanded through *snowball sampling*. The main criterion behind their selection was their likelihood to have experience, knowledge and/or expertise related to predation events. Some of the interviewees represented official institutional workers interviewed as part of the unstructured and semi-structured interviews with social/institutional actors. This is largely discussed in the Methodology section of Chapter 8. Thus, interviews included members of the local communities, rangers, mountain rescue members, mountain hut owners, local officials, hunters and foresters.

<u>Administering the interview</u>

All known temporary pastures in the high altitudes of the study area and other grazing areas in the park were visited. The entire population (N=80; shepherds living in these temporary pastures and other attack witnesses) was therefore sampled. In finding these sheepfolds I used both existing data on the location of sheepfolds provided by the park administration and other institutions involved in wolf management, but also applied a snowball sampling method to ensure that I was sampling the entire population. Only a small number (approximately N=3) of these shepherds were missed because they were either not present at the sheepfold when I arrived, or the sheepfold had moved to a location I wasn't able to locate. Semi-structured interviews were conducted in order to allow for open ended questions and more comprehensive responses. I did not administer the survey in an official PAPI (paper and pencil) fashion because I did not want to intimidate the interviewees. Instead, I compressed the original 11-page long questionnaire (Appendix II) into 2 pages (Appendix III) that I used only as personal guidelines for me to conduct the interview. This allowed the interviewees to feel more comfortable. This also represented a more feasible technique considering the situation in the field: many of the interviews occurred in a pasture where the shepherd was grazing the flock. This entailed conducting the interview while walking along with shepherds moving their flocks along the alpine pastures, when milking sheep, or under harsh weather conditions (Figure 48).

Figure 48. Interviews with shepherds in the high-altitude pastures of the ANP.

Each interview lasted an average of 40 minutes with the longest ones up to 2 hours. The discussion was sometimes followed by a short exploratory visit to the place of previous attacks in order to obtain the exact GPS location and other relevant data. I also spent time at each site observing the sheepfolds, the customs of the shepherds and their day-to-day activities, specifically management and preventative practices that influence the success of predation events (Figure 49).

In performing these interviews, I was assisted by maps and images obtained from the Apuseni Natural Park administration, the Connect Carpathians project and the Faculty of Geography of Babes-Bolyai University of Cluj Napoca.

For all interviews, ethical considerations were followed as detailed in section 5.4. in Chapter 5.

Figure 49. Interviewing shepherds during their day-to-day activities: grazing and milking sheep.

Rationale in the choice of interviews

The most important factor determining the choice of face-to-face interviews as the main data collection technique was ***the characteristics of the study area***: relatively isolated rural communities within the boundaries of Apuseni Natural Park, Romania. As my target respondents were shepherds grazing livestock in the high and remote alpine pastures and people owning livestock living in relatively isolated rural communities in the park, face-to face interviews were the best method (if not even the only possible method) to use (see McInturff *et al.,* 2021). People's access to the internet, postal services and even telephone, especially in the case of shepherds living in improvised, temporary sheepfolds in high alpine pastures (Figure 50), is very limited and most of the time impossible.

A second factor that determined my choice was the ***effects on questionnaire design***: my presence in the field, directly communicating with the people I interview allowed for a larger number of more complex questions, with a longer time of administration, and thus, for a more in-depth view on the analyzed issues (Hunter and Brehm, 2003). Also, my presence in the field allowed me to give explanations and instructions and thus I was able to ask richer and more open-ended questions, filter questions, use visual aids, reduce item non-response, control the sequence of question order and identify and clarify difficulties encountered.

Figure 50. Improvised sheepfold in the high altitudes of the park, where the shepherd lives from May to October.

Face-to-face administration of the questionnaire increased the ***response rates*** (Yu and Cooper, 1983) especially as people living in these isolated areas are usually farmers, most are middle aged or elderly, unfamiliar with technology, and with relatively low levels of formal education, who might struggle with written questionnaires (Figure 51). Also, these people are renowned as very friendly hosts and story tellers and therefore more open to interviews and conversation than to more formal, rigid forms of survey administration. I obtained an almost 100 % response rate (only one out of all the shepherds I visited refused to answer the survey, stating that he does not guard the sheep while they graze and therefore, he blames himself and not wolves for his losses).

Increased response rates also increased the ***representativeness of the sample*** by reducing non-respondent’s bias. Face-to-face interviews also increased sample representativeness by raising the possibility of obtaining a good sampling frame (allowing for snowball sampling) and by controlling who answered the questionnaire (it was important that the person directly involved in predation events - the shepherd - would be the one answering the questions instead of helpers and relatives of the shepherd or even the owner of the flock).

Figure 51. One of the interviewed sheepfolds, located on the peaks of the Apuseni Mountains.

Lastly, a very important reason for choosing in-person interviews was the need to collect additional data directly from the field: observing and measuring biophysical and anthropogenic factors at the location of attacks (Figure 52).

Figure 52. Personal observation of sheepfolds, as a way of better understanding the reality in the field.

Questionnaire structure and wording

The questionnaire at the base of the interviews was structured in 6 sections exploring different aspects of the conflict. These sections include questions that cover all five types of question content identified by De Vaus (2014): *behavior, beliefs, knowledge, attitudes* and *attributes*. The six sections of the survey elicited:

1. Demographic data

Surveys assessed general demography of the respondents including age of the respondent, level of education, way they earn their livelihood, experience in herding, level of income and gender. This section also included two questions about hunting, trapping or poisoning of wolves or other animals, with the intent of revealing cases of retaliation and assessing people's reactions.

2. Knowledge of the species

The next section was directed towards people's knowledge of large carnivores present in their area, particularly wolves (number of wolves and wolf packs and fluctuations in time, wolf dens), their level of interaction with large carnivores, their knowledge and opinions about wolf management, and their ability to distinguish wolves from feral dogs. In certain cases, local people have the most accurate estimate of the number of wolf packs in their area and the localization of dens and the spatial distribution of the packs. Even though this knowledge is not scientifically proven, I believe it shouldn't be ignored. Traditional ecological knowledge has long been advocated as having the ability to improve scientific research through more and sometimes more accurate information (Inglis, 1993; Freeman and Carbyn, 1988; Johnson, 1998), and the potential to be used to understand and predict environmental events upon which the livelihood or even survival of the individual depends (Huntington, 2000).

3. Predation variables

Through a series of filter questions, this section elicited information about people's personal experiences with wolf attacks, reporting, compensation, and livestock loss due to other causes. The level of people's perceived risk was also assessed on a scale from low to high ("no risk", "low risk", "medium risk", "high risk"). This question was repeated in a different form at the end of the questionnaire in order to check the accuracy of people's responses in relation to how they perceive the risk. A key part of this section were questions meant to capture local people's *know-how* in dealing with wolf attacks e.g., season, time of day and other circumstances that favour wolf attacks. At the end of this section the respondents were also asked an open-ended question meant to elicit other information on what influences wolf attacks, by giving the respondent a chance to freely discuss about this subject, accessing their know-how in interacting with wolves.

4. Predation events

This survey section provides the data necessary for the risk analysis by inquiring about specific predation events (frequency and timing, location, number and type of livestock killed or injured), characteristics at the moment of attack (whether the flock was free-grazing or enclosed, guarded or not, number of livestock guarding dogs and people present at the moment of attack), information on the livestock individuals involved in the attack (sex, age, colour, state of health), weather conditions at the moment of the attack (temperature, wind, cloud cover, meteorological phenomena), general pasture characteristics (size of the pasture, overall number and type of livestock and guard dogs, number of shepherds), and husbandry practices (carcass disposal method, calving, preventative measures).

5. Preventative measures

This section focused on people's general behaviour and practices in relation to taking preventative measures and how these measures can influence attacks. Respondents were asked about what preventative measures they generally take, who is responsible with guarding the livestock and whether they use yokes for livestock guarding dogs and why they need to use them. Then a series of preventative measures appropriate for the local context (livestock guarding dogs, fenced enclosures, grazing method, proper carcass disposal, herder's presence, avoiding forested environments) were enumerated and the respondent was asked to rate the effectiveness of these measures on a scale from low to high ("not effective", "low", "medium" and "high"). The same was done for a list of institutional management measures aimed at reducing predation (compensation schemes, population control, killing problem animals, relocating problem animals, preventative measures instated by the Park Administration). The questions in this section were aimed at assessing how people's behaviour and their acceptance of official management measures is influenced by their perceptions of how effective these measures are.

6. Perception of risk

The last section intended to capture the general perception of people about the conflict: are people positive, negative or neutral about the presence of wolves in their area? Would they want the number of wolves to decrease, stay the same or increase? Are they worried for their personal safety and that of their livestock? Do they fear wolves? One other question that elicited essential information for the research was included here: respondents were asked to quantify the risk of predation in their area on a scale from 0 to 3, 0 meaning no risk, 1 - low risk, 2 – medium level risk, and 3 – high risk. This question quantified people's perception of risk and was repeated in a different form earlier in the survey (see subsection 4. 'Predation events' above) in order to test the accuracy of the response. Obtaining this data was essential for comparing the calculated risk of predation (assessed though the Spatial Risk Mapping exercise) with the perceived risk. Both these were mapped, and the visual results helped interpret the difference in how people perceive the risk. The last question of the survey probed into people's attitude towards living with wolves. Respondents were asked to name their preference in what should happen with the wolf population in their area (should the number of wolves increase, stay the same or decrease).

7. Open-ended discussion

The survey was followed by an open-ended discussion at the end of the interview meant to probe more into people's concerns, opinions and perception of the conflict, the way to manage the conflict (both at a personal and institutional level) and the risk of predation.

Data analysis

Part of the data obtained through these interviews was analysed as part of the spatial risk mapping analysis (see section 6.3. of Chapter 6).

Additional data were also analysed quantitatively looking at relationships between several variables, in order to understand how conflict is associated with, not only purely spatial biophysical factors, but also with a series of management and preventative measures. I looked at how conditions at the moment of the attacks (e.g. time of day, weather conditions, number of livestock guarding dogs and shepherds, size and composition of flock) are related to the outcome of the event, as this can show when the risk of losses due to wolves is higher and therefore when there is a need to focus more on preventative measures. I also put these conditions together in multivariate statistical models evaluating their joint effect, in order to see how these non-spatial conditions can also play a role in the likelihood of an attack and to show how certain preventative husbandry measure can reduce losses even in high-risk areas. I also looked at the sex, age, state of health and colour of livestock individuals involved in these events as this might reveal more vulnerable individuals in the flock. I explored the interviewees' demographics, knowledge of the species, preventative measures they take and their perceptions and attitudes to see how they correlate and how they associate with the level of predation they experience.

Quantitative data were transcribed and coded and represented a total of 78 variables. The database was then cleaned and prepared for analysis and exploratory statistics were run to understand data and distribution. Due to the large sample size (>50), the Kolmogorov-Smirnov test of normality was used, confirming, where needed, that assumptions of normality are met. Two other variables – calculated spatial risk per depredation event and calculated spatial risk per sheepfold – were added later to the database by extracting the correspondent risk values for each location from the map of predicted risk created in the previous chapter.

The quantitative analysis of this data was done using univariate methods to describe the data (descriptive statistics, central tendency, and dispersion); bivariate methods for identifying significant relationships between variables; and multivariate techniques for exploring independent variables and their association with dependent variables. The particular statistical operation used depended on the distribution and level of measurement obtained for that specific data. Where possible, questions were formulated to allow for interval data to be obtained because this provides the most flexibility in data analysis. Charts and tabular representations were used to better illustrate relationships, but summary statistics were mostly used to describe the variables in the text. I used correlation tests to measure the direction and strength of relationships between various non-spatial physical characteristics, husbandry and management related indicators, the number of kills and the calculated risk for each event, in order to paint a more complete picture of what factors are associated with wolf predation in the study area and to describe what factors people's opinions, behaviour and their perceived risk are associated with. I used crosstabulation, Spearman's correlation (r^2) and Chi Square (X^2) for ranked categorical data (ordinal data), Pearson's correlation (r) for normally distributed scale (ratio) data, Spearman's correlation (r_s) and Eta Coefficient (η) test for pairs of interval and ordinal data and point biserial correlation coefficient, part of Pearson's test for pairs of continuous and dichotomous categorical data (coded as 0,1 or 1,2). As a test of statistical significance, I used one-way ANOVA (F) for continuous dependent variables and ordinal dependent variables. For multivariate analysis, I used Ordinal Logistic Regression for ordered categorical dependent variables and Multiple Linear Regression for continuous dependent variables. All underlying assumptions were checked as a first step in the multivariate analysis. Multicollinearity was assessed through the Variance Inflation Factor (VIF) and based on the Correlation Coefficients, through a correlation matrix (the threshold used was $r_s = 0.80$). The standard alpha levels of $p < 0.01$, and $p < 0.05$ were designated as the threshold of significance. I discuss the results of all these analysis in the following section.

Lastly, qualitative data obtained from the open-ended questions and discussions was used to complement and integrate the results of this chapter, describing the TEK of shepherds and other local people. Aspects related to people's fears and concerns, opinions and beliefs, their perception of the conflict and of the way conflict should be managed (both at a personal and institutional level) acted as a complementary part to the analysis of the institutional factors influencing conflicts, as described in Chapter 8.

7.3. Results

From May to December 2017, 80 sheepfolds and households were reached and approximately 100 interviews were conducted. Several situations accounted for multiple interviews for the same sheepfold or household:

1. Two different shepherds, same sheepfold

In certain situations, the same sheepfold hosts two sets of shepherds that alternate in staying at the sheepfold and guarding the sheep: two shepherds are there for two weeks, then leave and two others take their place for the next two weeks. To make sure I would capture all predation events happening within the respective sheepfold, I interviewed both sets of shepherds. This resulted in two interviews for the same sheepfold.

2. <u>Old shepherd, new shepherd</u>

In a few cases, the shepherds I was interviewing, currently tending the sheep, have been on the job for only the last year or two. To make sure I captured all the predation events for the last 10 years, in these cases, I sought out and interviewed the previous shepherd.

3. <u>Shepherd plus livestock owner</u>

In situations when the interviewee was only the person tending the sheep, but not the owner or the flock, I obtained the contact details of the owner and interviewed them as well.

4. <u>Shepherd plus shepherd assistant</u>

Certain sheepfolds were tended by a main shepherd and an assistant or second shepherd. If possible, I interviewed both, in order to get as much information as possible and to triangulate[14], making sure the information provided was more accurate.

5. <u>Independent respondents reporting on the same event</u>

For the purpose of triangulation, I recorded the same event related by several individuals. For example, a certain attack was remembered and recounted by several independent respondents such as a villager, a shepherd from a different sheepfold, a ranger, a mountain rescue worker, a mountain hut owner, a local official, a hunter or forester (see Methodology section). Because these were independent respondents, I was able to use the data provided by them to validate information and reduce bias inherent to this data collection method (see section "Reliability and Validity"). I purposely approached as many relevant interviewees as possible during my fieldwork and questioned them about wolf attacks in order to get this triangulation.

6. <u>Snowballing</u>

Some interviews had the sole purpose of snowballing, gathering more information about possible attacks, and sheepfolds that might have been missed.

[14] Triangulation involves using multiple sources of data to examine the same phenomenon.

7. Subsequent attacks

At the end of the fieldwork, I attempted to revisit or call most of my interviewees to ask about any subsequent attack that might have happened during the one year of fieldwork. If there was additional data, I recorded it through a follow-up interview.

Each sheepfold/household was given a unique code for further identification in data analysis. The location, name, local ID, and phone number of the respondents were recorded for contact purposes, but this data was kept confidential and was not used further for any other purpose in the research.

Demographics

The majority of the respondents were male (82%), aged 20 to 80, with an average age of 50 (SD= 12.7). Tending for livestock was the primary livelihood for most of them (84%), while a small percentage were also employed (9%) or retired receiving a pension (7%). The level of experience in shepherding and tending for livestock among the respondents reached a maximum of 70 years, with an average of 31 (SD= 17.5). The level of education ranged from primary to higher education, all respondents having completed at least primary school and 63.5% finishing high school. Twenty three percent completed an additional vocational education and 6% completed higher education.

Knowledge of the species

The high level of experience in shepherding was also reflected in the respondents' knowledge about and experience with large carnivores (Figure 53). In a vast majority (97.7%), respondents were able to correctly identify wolves and differentiate them from similar looking species (feral dogs). Ninety percent of respondents reported having seen or heard wolves throughout their lives and 60% have even directly interacted with wolves as part of their job to guard livestock and fend off predators. Respondents report seeing an average of 2-3 wolves and even single individuals roaming around flocks. The level of interaction with other species of large carnivores present in the area (bears and lynx) was lower, with almost 30% of the respondents reporting having never seen a bear in the wild and as high as 70% never seeing a lynx.

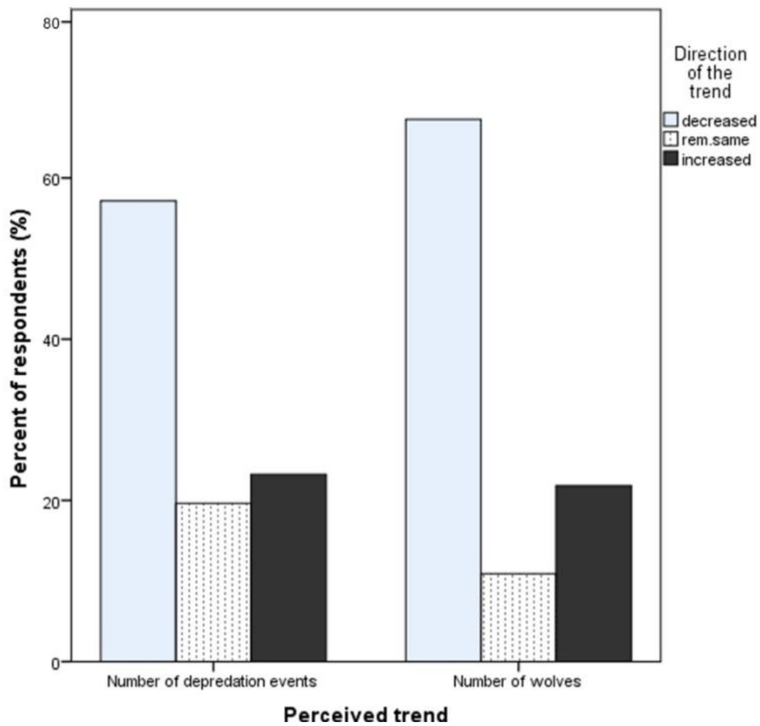

Figure 53. Respondents' direct experience with large carnivore (N=80).

Approximately 30% of respondents have interacted with bears while guarding their flocks and only 9% have interacted with lynx. People's level of interacting with wolves positively correlated with the frequency of wolf visits (all occasions when wolves have been observed in the proximity of the flocks) they reported (r_s (145)= 0.437, $p< 0.01$) and the number of livestock killed (r_s (145)= 0.290, $p< 0.05$) or injured (r_s (145)= 0.413, $p< 0.01$).

Respondents also claimed to be aware of the size and trend of the wolf population and packs around them. A number of 0 to a maximum of 6 wolves was reported by each respondent, with an average of 3 (SD= 1.57). The majority of respondents (55%) believed these wolves were not organized in packs but rather acted alone or in very small groups of 2 to 3 individuals. Respondents with larger flocks reported seeing fewer wolves (r_s (164)= -0.399, $p< 0.01$), and believed they were less likely to be organized in packs (r_{pb}(164)= 0.366, $p< 0.01$; η=0.815). The number of wolves reported also positively correlated with the number of years of experience of the shepherd (r_s(164)= 0.399 $p< 0.01$).

Most people (67%) perceived a decrease of wolf presence in their area in recent years, while 11% believed the number of wolves has remained constant and 22% perceived an increasing trend. The trend of wolf predation events was very similar, showing a correlation between the two phenomena and consistency in people's reporting (Figure 54).

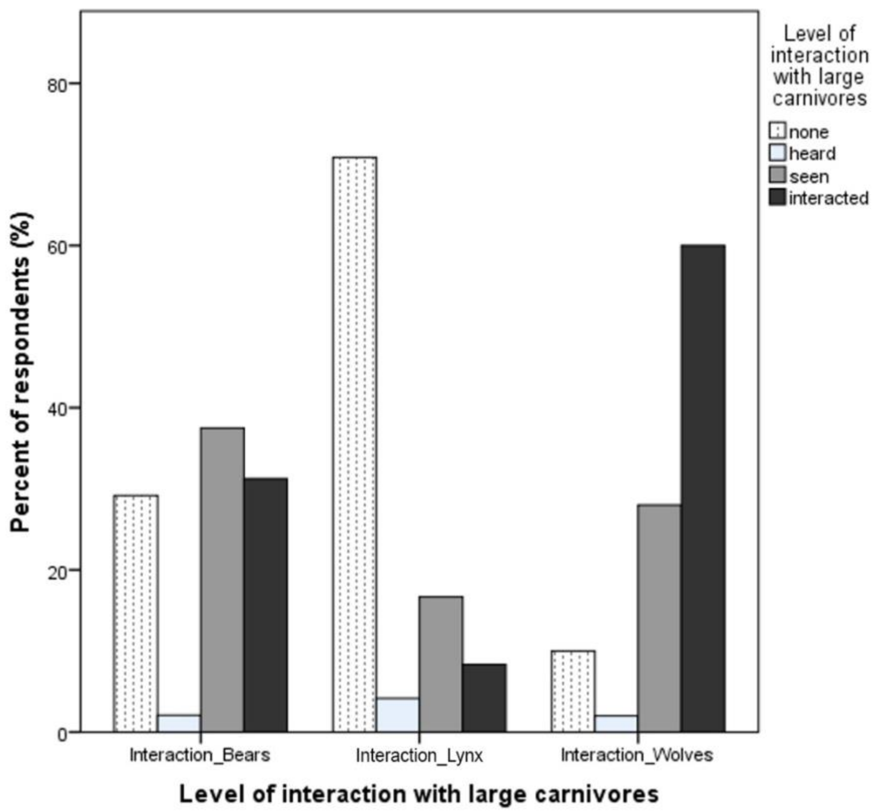

Figure 54. Perceived trend of the number of wolves in recent years (N=80).

The perceived trend negatively correlated with both age and experience of the respondent and positively with the rate of wolf visits they experienced, and the size of the flock (Table 7). At the same time, people who perceived an increase in wolf numbers were more inclined to rate the effectiveness of traditional preventative measures higher and perceived a higher risk of predation in their area.

An ordinal logistic regression analysis ($X^2(2)= 18.77$, $p< 0.001$) of the cumulated effect that these independent factors have on the perceived trend of wolf numbers, showed only the frequency of wolf visits [$B= 1.22$ (95% CI, 0.46 to 1.97), $Wald_X{}^2= 10.03$, $p< 0.01$] having the strongest influence on the perceived trend, closely followed by the level of experience [$B= -0.54$ (95% CI, -0.98 to -0.10), $Wald_X{}^2= 5.90$, $p< 0.05$]. The other factors did not yield statistically significant effects in the regression analysis.

Table 7. Results of bivariate correlations for the trend of wolf numbers and predation events (significant correlations only).

			Age	experience shepherding	Rate of wolf visits	Size of the herd
Spearman's rho	Trend wolf numbers	Correlation Coefficient	-.246	-.345**	.466**	.322*
		Sig. (2-tailed)	.070	.010	.000	.017
		N	55	55	55	55
	Trend predation events	Correlation Coefficient	-.305*	-.431**	.567**	.401**
		Sig. (2-tailed)	.024	.001	.000	.002
		N	55	55	55	55

Contrary to their knowledge related to the species, people's responses related to institutional wolf management were quite vague. Asked to name the institution primarily responsible for addressing problems involving wolves in their area, 57% of the respondents stated they don't know and only 16% correctly identified the responsible institution as being the local councils. A long list of other responses was given: "No one", "Own loss", "God", "Hunters", "Foresters", "APIA", "FFI", "the veterinarian" (Figure 55). When asked which institution they think *should* be responsible, their responses were just as diverse: 28% did not know, 33% responded "Hunters" and again, a long list of various answers was given ("God", "Hunters", "Foresters", "APIA", "AJVPS", "the park", "the state").

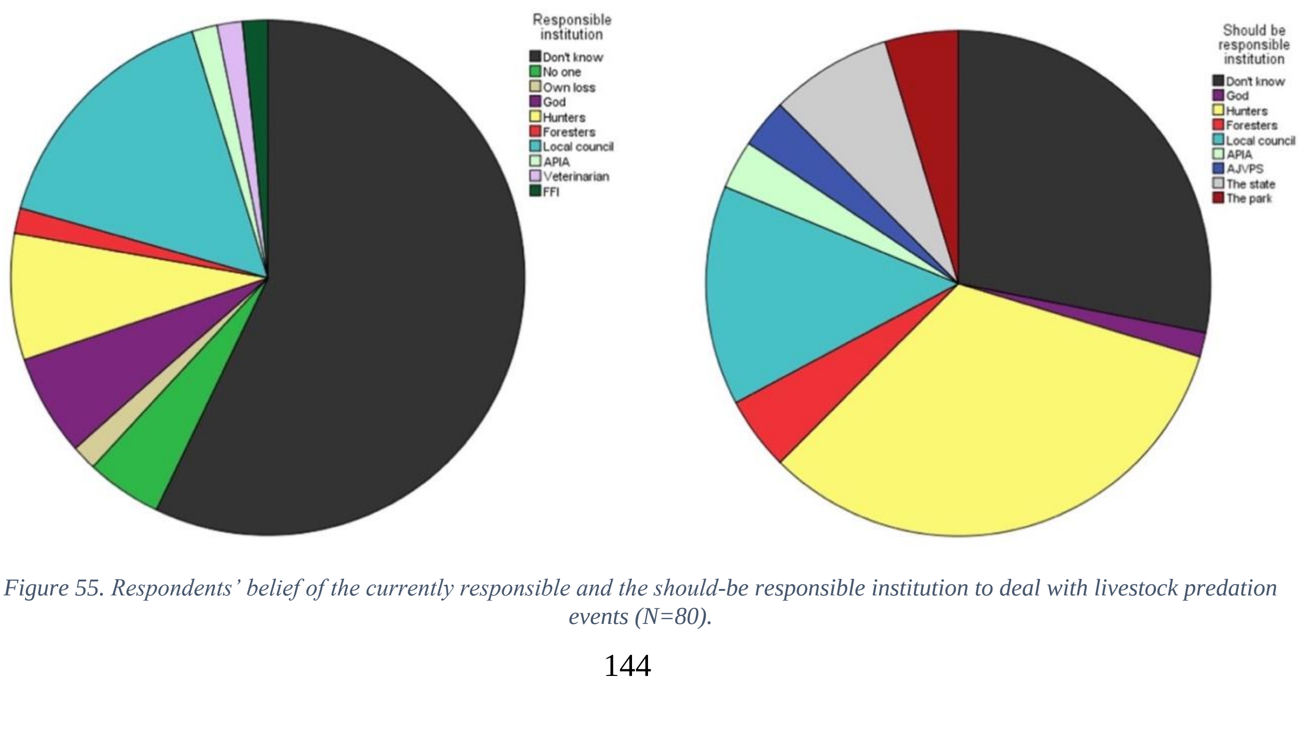

Figure 55. Respondents' belief of the currently responsible and the should-be responsible institution to deal with livestock predation events (N=80).

Predation variables

In this section I report on people's know-how in relation to wolf predation and dealing with wolf attacks. Respondents were asked about their knowledge and opinion on the temporal variation of wolf predation and an open-ended discussion elicited information about any other circumstances favoring wolf attacks on livestock. When asked about the specific time of the day most prone to wolf attacks, respondents reported nighttime as having the highest risk (36%), followed by daytime (19%), and dawn (12%) and dusk (12%) (Figure 56a). Twenty percent of respondents believed the specific moment of the day did not influence the risk of predation. When asked which season was most prone to wolf attacks, most respondents believed it was autumn (47%), followed by winter (13%), summer (8%) and spring (7%) (Figure 56b). Twenty five percent of respondents believed seasons did not influence the risk of predation.

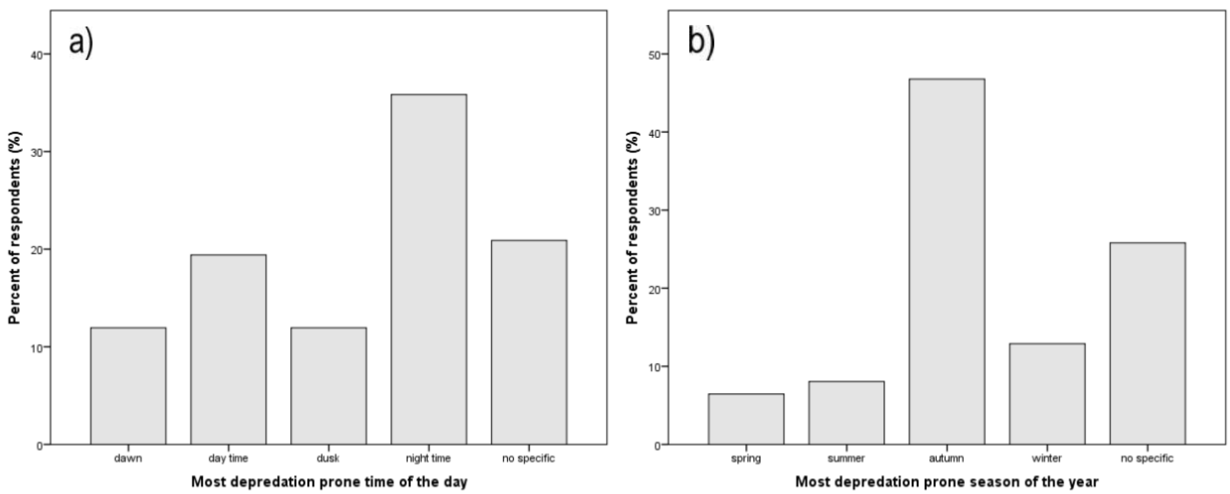

Figure 56. Shepherds' know-how related to the temporal variation of predation events during (a) the time of the day and (b) the months of the year (N=80).

Other conditions influencing wolf attacks, identified by the respondent were: bad weather (fog, rain, downpour, overcast, storm, low temperatures, harsh winters, frost, snow, frozen snow, deep snow), forest and forest edge, open fields, terrain ruggedness, level of isolation, level of visibility, level of sound, number of wolves, wolf hunger (reduction of wild prey), abundance and availability of prey, wolf habituation, wolf travel corridors, size of the herd, level of herd coagulation, presence of juveniles in the herd, livestock guarding dog experience, level of vigilance, guarding the flock, presence of electricity/civilization/people.

Of these, weather conditions were by far the most often mentioned (86% of respondents), with rain followed by fog at the top of the list of meteorological phenomena influencing wolf predation. Forest edge was close behind, mentioned by 70% of respondents.

Predation events

All results of spatial data collected for each specific event are reported in Chapter 6, as part of the Risk Mapping Analysis. Here I integrate all data collected on predation events, and report on the non-spatial and husbandry factors related to attacks. The results presented here only reflect this particular sample and can be interpreted only to suggest certain trends or associations and suggest dependency that could help extrapolate to other events.

Between 2007 and 2017, out of an approximate total of 165,000 livestock (see more detailed discussion in background section 3.2. Apuseni Natural Park) grazing in the study area (calculated based on an average of 16,500 livestock per year), wolves killed or injured 213 individuals within 144 predation events, representing 0.13% of all livestock. Most of these individuals were sheep (96%) and rarely goat. Of these, 97% were females aged 1 month to 7 years old with an average age of 2.5 years (SD= 1.6). A significant proportion (33%) of the livestock attacked by wolves were represented by very young individuals (aged between 1 month and 1 year old). Also, in 65% of all predation events, the flock in which the kill happened contained juvenile individuals. Livestock individuals attacked by wolves were predominantly white (98%) with only a few individuals of mixed black, white and brown color. Almost all were reported to be in a good state of health (99.4%). The average size of the sheep flocks that suffered predation was 350 sheep (SD= 143.3), with a range between 8 and 700. Respondents reported losing between 0 and 97 sheep annually (with an average of 6) due to other natural causes (disease and age).

Most predation events happened during the day (82%), with a peak at noon and a second peak in the early afternoon. This was reflected in the fact that most kills happened in freely grazing flocks on the move through the high-altitude pastures (84%) and only a small number of events happened while livestock were enclosed for the night. During the night, most events occurred between 00:30 and 02:30, representing 14% of all attacks, or 79% of all nighttime events. During the day, most events occurred between 10:00 and 13:00 (late morning and noon), representing 43.6% of all events or 53% of daytime events (Figure 57a). All sheep were enclosed during the night and grazed freely during the day in the pastures around the sheepfold and were guarded by sheep guarding dogs (up to 10, with a mean of 4) and shepherds (most often 1 or 2 and a maximum of 4) at all times. Most predation events happened during good weather conditions (63%), while a large proportion of events were reported during “bad weather”: rain and overcast, drizzle, wind, fog, sleet, thunderstorm, downpour. Rain and fog (26%) accounted for most events happening during bad weather conditions. The predation rate peaked in the middle of the warm season with an increased rate still persisting in the fall (Figure 57b).

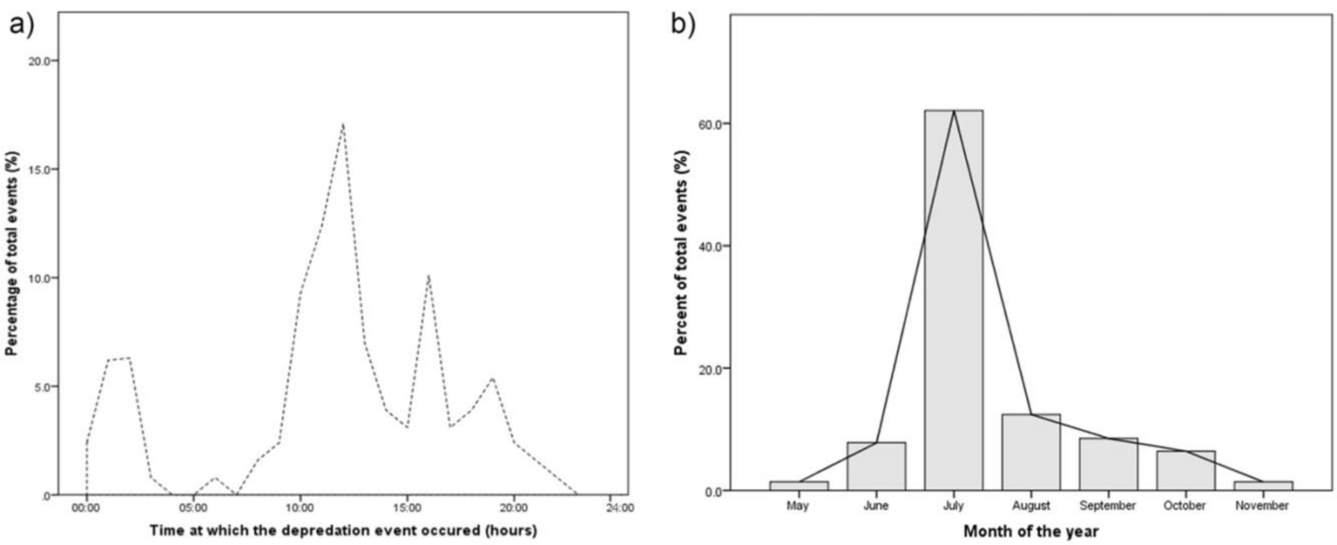

Figure 57. Temporal distribution of predation events during the time of the day (a) and months of the year (b) (N=80).

For all events, only one compensation claim was made, but was rejected because the shepherd was grazing the sheep in the forest at the moment of attack (grazing in the forest in forbidden) and due to lack of proper paperwork.

The data for the total number of livestock involved in each event was collected per three groups: number of livestock killed and left (N=90), number of livestock killed and taken/eaten (N=81) and number of livestock injured (N=42). There was a significant negative correlation between whether or not the attack was interrupted by guard dogs and the number of livestock taken/consumed (r_s (100)= 0.714, p< 0.01; η=0.621) and a significant positive correlation with the number of livestock killed and left (r_s(100)= -0.258, p< 0.01) suggesting that due to this interruption wolves were not able to complete the attack and drag away and consume the animal.

The statistical significance of this association was tested using an analysis of variance, the results showing that there was indeed a significant difference between the two groups, and the effect of whether or not the attack was interrupted on the number of livestock taken/consumed ($F(1,99)= 62.05$, $p< 0.01$) was significant. This association showed up again in the relationship between the number of livestock that were only injured during the event and the flow of the attack ($r_s(100)= -0.548$, $p< 0.01$; $\eta=0.525$) with all injured individuals showing up in interrupted attacks in the crosstabulation, suggesting again that wolves were deterred by the guard dogs before completing the kill.

Looking at the crosstabulation of these three groups, we can see that in both overkill cases recorded, the livestock was killed and left (24 killed and left in 2014; 11 killed and left and 4 taken in 2017) even though the attack was not interrupted by dogs.

A multiple linear regression analysis of the variables found relevant in the bivariate analysis, shows that interrupting the attacks by LGD has the strongest effect on the number of livestock killed and taken, followed by the number of people guarding at the moment of attack. (Table 8).

Table 8. Results of the regression analysis for the number of livestock killed and consumed by wolves during a predation event.

Coefficients[a]

Model[b]		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	-.597	.200		-2.987	.004		
	No. of animals in the herd	.001	.000	.158	1.754	.083	.732	1.365
	No. of people guarding	-.208	.084	-.220	-2.489	.015	.763	1.310
	Was the attack interrupted	.782	.095	.652	8.243	.000	.948	1.055

a. Dependent Variable: Number of livestock killed and taken/eaten in that predation event

b. Top model $R= 0.651$; $F(3,97)= 23.8$, $p< 0.01$

In the bivariate correlation tests we also saw a moderate association between the number of livestock taken/eaten and weather conditions (η=0.358), the time of the year when the predation event happened (η=343) and the presence of juveniles in the herd ($r_s(130)= 0.194$, $p< 0.05$), but these associations did not prove to have predictive power in the multivariate model.

The total amount of wolf damage per event was associated with the time of the day when the predation event happened (η=0.537). There was a low association between the time of the day when the attack happened and the presence of juveniles in the herd ($r_s(124)= -0.269$, $p< 0.01$), the trend suggesting that attacks on herds containing lambs were more frequent later in the day. There was also a moderate association between the size of the herd and whether the attack happened on free grazing or enclosed herds ($r_s(134)= -0.254$, $p< 0.01$; η=0.641) with enclosed flocks attacked more when in larger numbers and free grazing flocks attacked more when in smaller numbers. An analysis of the variance between the two variables showed that the size of the flock attacked by wolves did vary according to whether livestock were free or enclosed ($F(1,133)= 3.656$, $p< 0.05$).

The results of the bivariate analysis also suggest that there were more dogs ($r_s(134)= -0.296$, $p< 0.01$; η=0.251) and more people ($r_s(134)= -0.212$, $p< 0.05$; η=0.228) guarding the livestock when enclosed, during nighttime (dogs: η=0.583; people: η=0.552) than during the day. This finding was confirmed verbally by the respondents and also by looking at the crosstabulation of the data. Larger flocks were also guarded by more dogs ($r(135)= 0.360$, $p< 0.01$) and more people ($r(135)= 0.411$, $p< 0.01$) than smaller flocks.

A correlation matrix was also created to analyze the effect that sheepfold-husbandry-related variables had on the overall risk. This risk was calculated for each sheepfold by averaging the calculated spatial risk for each predation event suffered by the respective sheepfold. For the sheepfolds that did not suffer from attacks, the value of the risk variable was calculated by extracting the risk value of point corresponding with the coordinates of the sheepfold from the predicted risk map. A total number of six of these variables showed statistically significant associations with risk. See Table 9 for more details.

Table 9. Results of bivariate correlations for the risk of predation compared to sheepfold-husbandry-related variables (significant correlations only).

Correlations

		Rate of wolf visits	Carcass disposal method	Effectiveness compensation	Effective-ness relocation	Effective-ness electric fences	Experience shepherding
Spearman's rho Risk per sheepfold	Correlation Coefficient	.471**	.356*	.380**	.326*	.312*	-.308*
	Sig. (2-tailed)	.000	.013	.005	.017	.022	.024
	N	55	48	54	53	54	54

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Preventative measures

All respondents reported taking preventative measures to reduce the risk of wolf kills. The most commonly used measures were livestock guarding dogs, shepherd's presence and fenced enclosures during nighttime. In all sheepfolds livestock were enclosed during the night, grazed freely during the day and were guarded by livestock guarding dogs (up to 10, with a mean of 4, SD=2.2) and shepherds (most often 1 or 2 and a maximum of 4) at all times. Sheep guarding dogs were by far considered the most effective preventative measure (reported by 81% of the respondents) and the combination of dogs guarding together with people was thought to be even better.

Respondents were asked to rate the effectiveness of these and several other *personal and husbandry* preventative measures on a scale from low to high. The presence of people, guarding dogs and nighttime fenced enclosures was rated as highly effective by the large majority of the respondents. People who rated the presence of people as highly effective, also showed a higher number of shepherds guarding the flocks in practice. Most respondents found keeping away from forest and carcass disposal methods to be of high or medium effectiveness in preventing predation. All respondents reported disposing of the carcasses and the most used method was feeding them to the dogs (74%). Burying (24%) and burning (2%) were also reported practices. The choice of grazing areas and routes was the least seen as highly effective (by only 44% of respondents) with a substantial fraction of respondents considering this measure to be ineffective (26%). The perceived effectiveness of avoiding forests as a preventative measure positively correlated with the perceived trend in wolf numbers ($r_s(161)= 0.302$, $p< 0.05$) and negatively with the number of livestock lost due to wolf predation ($r_s(164)= -388$, $p< 0.01$; $\eta=0.555$). The effectiveness of carcass disposal methods was negatively correlated with the age ($r_s(149)= -357$, $p< 0.05$; $\eta= 0.781$) and experience ($r_s(146)= -363$, $p< 0.05$; $\eta= 0.764$) of the respondent. The rated level of effectiveness of avoiding forests, selecting safe grazing routes and proper carcass disposal also positively correlated with each other (Table 10).

Table 10. Results of bivariate correlation test for the effectiveness of traditional preventative measure: choosing grazing routes, avoiding forest and carcass disposal methods.

Correlations

			Effectiveness grazing routes	Effectiveness avoiding forest	Effectiveness carcass disposal methods
Spearman's rho	Effectiveness grazing routes	Correlation Coefficient	1.000	.794**	.291*
		Sig. (2-tailed)	.	.000	.041
		N	55	55	50
	Effectiveness avoiding forest	Correlation Coefficient	.794**	1.000	.355*
		Sig. (2-tailed)	.000	.	.012
		N	55	55	50
	Effectiveness carcass disposal methods	Correlation Coefficient	.291*	.355*	1.000
		Sig. (2-tailed)	.041	.012	.
		N	50	50	50

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

When asked to rate the effectiveness of *official* management measures aimed at reducing livestock loss, respondents believed wolf population control to be the most effective (83%), followed by removing problem animals (77%). Relocation of problem animals was considered ineffective by the majority of respondents (61%). Compensation schemes, *if properly implemented*, were thought to be effective by 76% of respondents. The perceived effectiveness of compensation schemes was positively correlated with the rate of wolf visits the respondent experienced ($r_s(164)= 0.315$, $p< 0.05$). Most respondents were not open to the idea of receiving electric fences or guard dogs provided by management officials and did not believe in the effectiveness of being provided with these by officials. Respondents who did wish to have electric fences and saw them more effective, were those who had larger flocks ($r_s(164)= 0.346$, $p< 0.01$) and those who perceived an increase in the number of wolves ($r_s(161)= 0.301$, $p< 0.05$) and wolf predation ($r_s(161)= 0.328$, $p< 0.05$) in recent years.

Perception of risk

People's perception of the risk of their own livestock being attacked by wolves was measured on a low to high risk scale. Of the respondents (N=60), 42% chose low, 27% opted for medium and 31% quantified the risk as high. People were also asked to quantify their level of worry and concern (also framed as "fear") for the safety of their livestock and their own due to wolf attacks. Most respondents were not worried about their personal safety (77%), 14% were a little worried and only 9% were very worried. Respondents were more worried for the safety of their livestock, most of them being very worried (52%), 21% a little worried and 27% not worried at all. Lastly, people were asked about their preference in what should happen to the wolf population in their area. People inclined toward a decrease of wolf population (37%), while 26% believed the number of wolves should stay the same and only 9% thought it should increase. Although this question was initially designed on a three-layer scale, respondents decisively added a fourth one: "zero". Twenty nine percent of the respondents, without being prompted, chose this fourth alternative, stating that they would prefer there to be no wolves in their area.

The level of perceived risk, the level of concern and the preference for the future trend of wolf populations all positively correlated with each other. In order to test what variables have an effect on the level of perceived risk, Ordinal Logistic Regression was employed on a data set of 14 variables hypothesized (based on significant bivariate correlations and researcher's experience) to influence how people perceive the risk: rate of wolf visits, number of wolves, trend of depredation events, size of the herd, number of people protecting the herds, level of experience, education and interaction with wolves of the livestock producers, amount of loss due to depredation (killed and injured), the tendency to favor culling as a management measure and people's concern related to their livestock's and their own safety. After eliminating variables that did not improve or contribute to the optimal model, five variables showed to have statistically significant influence on the perception of risk (Table 11). Two variables – concern for livestock's safety and trend in number of wolves – did not meet the level of statistical significance but were kept as they overall improved the performance of the top model, showing that their contribution in the model was important.

Table 11. Results of the regression model for perception of risk.

Coefficients[a]

Model[b]		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[Perceived risk = 1]	8.939	2.523	12.556	1	.000	3.995	13.884
	[Perceived risk = 2]	11.932	2.991	15.911	1	.000	6.069	17.795
Location	Experience shepherding	.101	.033	9.460	1	.002	.037	.166
	Risk per sheepfold	-2.960	1.413	4.385	1	.036	-5.730	-.190
	Rate of wolf visits	2.088	.648	10.372	1	.001	.817	3.358
	Responsible for protecting	2.357	.768	9.409	1	.002	.851	3.863
	No. of wolves	-1.203	.405	8.845	1	.003	-1.996	-.410
	No. wolves trend	.954	.566	2.840	1	.092	-.156	2.064
	Worried lv safety	.567	.534	1.124	1	.289	-.481	1.614

a. Dependent variable: Perception of Risk

b. Top model $X^2(7)= 41.35$, $p< 0.001$

The reported perceived rate of wolf visits positively corelated with the amount of wolf damage experienced by the respective sheepfold ($r_s(167)= 0.727$, $p< 0.01$). Shepherds experiencing higher level of interaction with wolves ($r_s(145)= 0.369$, $p< 0.01$) and higher rates of wolf visits ($r_s(167)= 0.315$, $p<0.05$), were more worried about the safety of their livestock. People more worried for their personal safety wanted less wolves in their area ($r_s(161)= 0.321$, $p< 0.05$), while there was no such correlation with people who were worried for their livestock's safety. At the same time, people more worried about their own safety believed less in the efficiency of population control as an official management measure ($r_s(161)= -0.249$, $p< 0.01$).

In this case too, an ordinal logistic regression analysis was conducted with the scope of understanding what variables drive respondents to desire less or no wolves. An initial set of 15 variables was included in the analysis, selected on the basis of their result in one to one correlations with the dependent variable and based on the researcher's hypothesis: number of wolves and the trend over time, rate of wolf visits, the trend of predation events over time, level of damage experienced by the respondent, shepherd's age, experience and level of education, their level of perceived risk and of concern, both regarding themselves and their livestock, size of the herd and of the pasture, and the perception regarding the efficiency of culling as a management measure. Four of these variables showed statistically significant influence on wanting less or no wolves, with p-values less than 0.05 (Table 12). The concern for personal safety, the level of education and the perception on the trend of depredation events, although not passing the test of significance in the model, contributed to improving the overall performance of the top model and thus, were kept in the analysis.

Interestingly, wishing for fewer or no wolves also negatively correlated with how effective the respondents saw wolf population control ($r_s(154)= -0.383$, $p< 0.01$; $X^2= 18.68$, $p< 0.01$) and problem animal removal ($r_s(152)= -0.396$, $p< 0.01$; $X^2= 19.21$, $p< 0.01$) as official management measures. Wishing for fewer wolves also correlated with lower levels of education ($r_s(152)= -0.319$, $p< 0.05$) and with higher experience in livestock raising ($r_s(158)= 0.307$, $p< 0.05$).

Table 12. Results of regression analysis regarding the opinion on future trend of wolf numbers.

Coefficients[a]

Model[b]		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[Opinion_wolf_trend = 1]	-4.341	2.177	3.975	1	.046	-8.608	-.074
	[Opinion_wolf_trend = 2]	-.967	2.004	.233	1	.629	-4.895	2.961
	[Opinion_wolf_trend = 3]	1.738	2.009	.749	1	.387	-2.199	5.676
Location	Experience shepherding	.047	.022	4.407	1	.036	.003	.090
	Worried pers. safety	.684	.562	1.482	1	.223	-.417	1.786
	Perceived risk	1.392	.503	7.650	1	.006	.406	2.379
	Worried lv. safety	-.921	.443	4.324	1	.038	-1.789	-.053
	Manag. measure.culling	-1.119	.492	5.163	1	.023	-2.084	-.154
	Level of education	-.424	.256	2.730	1	.098	-.926	.079
	No. of wolves trend	.512	.498	1.057	1	.304	-.464	1.488

a. Dependent variable: Opinion on future wolf trend

b. Top model $X^2(7)= 28.14$, $p< 0.001$

7.4. Discussion

Past investigations on the factors associated with wolf and other large carnivore predation have mostly focused only on spatially explicit data, examining the cause-and-effect relationships between the risk of predation and several spatial variables that can be computed from a map. But for every predation event, there is also a large amount of additional, non-spatial information (temporal factors, weather conditions, preventative measures, livestock individual and flock characteristics, livestock husbandry related factors, behavior at the moment of attack, experience and vigilance of those guarding the livestock) that can be analyzed to discover certain trends and associations in the data that might be just as relevant for the outcome of the predation event as the analysis of spatial factors. Examining these non-spatial data, as done in this chapter, offered complementary insights needed to explain the factors that are associated with wolf success in hunting livestock and to create a more comprehensive image of the risk, one that is more grounded in the complex reality in the field.

Through this analysis I was able to, at least in part, capture and reflect on the intricate web of interactions that occur between people, guard dogs, sheep and wolves during a predation event. Reflecting on these interactions led to the birth of a new concept, first developed and described here, in this dissertation: the framing of the *Integrated Antipredator Response (IAR)* of the *human-dog-sheep system*, acting in sync as one complex system – one organisms – when interacting with wolves, under the framework of a complex and adaptive process of coadaptation here defined as *the Integrated Adaptive Response System* (IARS). This concept is described in more detail below.

Additionally, the analysis of respondents' knowledge and perception data, allowed for describing this knowledge in terms of TEK and the comparison of the physical risk with the perceived one, and the visual representation of the two. This helped understand how people's personal history, their experiences, their opinions and concerns, all shape the way they perceive wolf predation and wolf management.

7.4.1. Non-spatial factors influencing wolf predation

Livestock and herd characteristics

Livestock individuals attacked by wolves were predominantly white female sheep. This is probably a function of husbandry, as there were overall very few individuals of other colors in the herds, and these were most often goats that usually represent a very small fraction of the flocks (Figure 58). While there is no data on the gender composition of the flocks, it is most likely that females predominate, since they are used for milk production and breeding.

Figure 58. Male goat.

The age of the individuals seemed to play a role in wolf livestock selection. A considerable proportion of the livestock involved in the attacks were young individuals – lambs under one year old (Figure 59) – and their presence in the flock seemed to attract more kills. This might be due to the fact that lambs represent vulnerable individuals (Bradley and Pletscher, 2005), targeted by wolves as a means of lowering energy consumption while predating on livestock. In natural habitats, wolves have been shown to prefer prey that requires the lowest energy consumption in the chase-capture-consumption process in relation to the energy gain following consumption (Stephens and Krebs, 1986). Wolf prey selection patterns seem to be determined by prey vulnerability, which is connected to prey age and body size (Mattioli *et al.,* 2011), wolves selecting juveniles over adults as optimal prey.

Figure 59. Lamb nursing in the high-altitude pastures of the Apuseni Mountains.

The results suggest that the size of the flock played a role in the outcome of the events, with enclosed flocks attacked more when in larger numbers and free grazing flocks attacked more when in smaller numbers. This could also be a function of the level of density within the flock (Figure 60) and livestock vulnerability. Large herds of livestock may serve as greater attraction to wolves (Kaartinen *et al.,* 2009) or have a higher probability that the herd contains highly vulnerable individuals (Bradley and Pletscher, 2005).

While the exact causal explanation for this phenomenon cannot be given based on these results, this does seem to be a recurrent finding in the literature. Larger herds in other parts of the Romanian Carpathians seem to also suffer more predation (Rigg, 2001). Iliopoulos *et al.* (2009) also found that the total losses per farm were positively correlated with the size of livestock unit and Nowak *et al.* (2005) found more damage per attack in bigger flocks. Also, in a very recent (2020) global-level review of available literature regarding gray wolf diet and prey densities, Janiero-Otero *et al.* found that areas where livestock were left to graze freely in small numbers (<20 individuals/km^2) and high densities of livestock enclosed overnight were more vulnerable to gray wolf attacks.

Figure 60. Large flock early in the morning, just about to be released to graze in the alpine meadows.

Weather conditions

As previously shown, weather conditions were most frequently identified by shepherds as factors that increase the risk of predation. Although most recorded predation events happened during good weather conditions, over one third occurred in "bad weather" represented mostly by fog and rain, but also overcast, storm, wind, and sleet. Literature in this field rarely mentions the association of wolf attacks with these weather conditions, highlighting an important area for future research. Snow seems to be the only weather-related factor discussed in literature that wolves draw advantage on during predation (Mech, 1970; Peterson and Allen, 1974; Peterson, 1977; Huggard, 1993). Snow is also mentioned by shepherds as an influential variable but does not show up in the current data because of the temporal distribution of recorded events. Fog, rain and the other conditions identified in this data set can be attributed to wolf use of sensorial cover as part of their adaptive strategy to attack livestock as described in the results section of the previous chapter. The fact that more attacks happened during good rather than bad weather conditions might just be a function of increased vigilance and preventive behavior in circumstances with poor meteorological conditions.

Temporal variation: Circadian rhythm and seasonality

Results show a circadian variation in predation rates as most events happened during the day, with a peak in the late morning and early noon (10:00 and 13:00) (Figure 57a), a second and a third peak in the afternoon, and a fourth peak after midnight (00:30 and 02:30). This was correlated with the fact that most kills happened in free grazing flocks on the move through the high-altitude pastures and only a small number of events happened while livestock were enclosed for the night. Although shepherds have predicted nighttime to have the highest risk of predation (Figure 56a), the reported kills showed only a smaller peak during this time. This can be explained by the fact that shepherds, aware of the increased risk at nighttime, double down on preventative measures and increase the protection of their flocks to the maximum during the night. In fact, the data backs this up, showing that more dogs and more people guard the livestock when enclosed during nighttime compared to daytime. Shepherds confirm this by reporting that all the dogs they own are on the job during the night, and that they themselves are present in maximum numbers during the night, in close proximity to the enclosures, or even sleeping in dedicated wood refuges right by the livestock enclosure, ready to jump into action when prompted by dogs (Figure 61).

Shepherds also mention that there is an increased rate of wolf visits during nighttime compared to daytime. Despite this increase in wolf attacks during the night, the success rate is much lower, suggesting that preventative behavior (particularly guarding the flocks and using enclosures) is an essential tool for lowering predation. *"Wolves know where the herd's vulnerable point is, at noon, when they get closer to the woods, that's when they snatch the sheep. Not in the evening, not in the morning, at noon*." explains the leader of a hunting association majorly overlapping with the territory of the park. There was a similar marked seasonal pattern reported from other parts of the Romanian Carpathians (NAPW, 2008) and other parts of the European wolf range (Italy: Meriggi *et al.,* 1991; Fritts *et al.,* 1992; Ciucci and Boitani, 1998; Gazzola *et al.,* 2008; Bulgaria: Genov, 1992; Slovakia: Voskár, 1994; Poland: Nowak *et al.,* 2005; Greece: Iliopoulos *et al.,* 2009).

Figure 61. Temporary shed next to the livestock enclosure where the shepherd sleeps at night in order to be able to react swiftly in case of a wolf attack during the night.

Attacks peaked in summer and early autumn, when livestock numbers and availability in pastures were relatively stable (Figure 57b). As part of the transhumance phenomenon, shepherds and sheep flocks usually leave the mountain in middle to late autumn, when grass is no longer suitable for grazing and harsh weather conditions force shepherds to retreat to lower altitudes. The drop of the warm season peak of predation coincides with the time when most shepherds descend from the alpine pastures. Although the risk of predation has been identified by shepherds as highest in autumn and winter (Figure 56b), this is not reflected in the trend of reported predation events because, most often, sheep flocks are already absent from the landscape by this time and therefore, there are no events to report. During the cold season, near settlements, wolves mainly attack and kill dogs and there are very few cases of livestock losses to wolves. This may explain the difference between the perceived and observed risk in terms of seasonal variation. The second smaller autumn peak can be explained by an increase in predation events on the few flocks that stay behind longer into the higher risk season. These flocks, being the only ones left behind in a now more remote and harsh environment, experience higher rates of wolf visits by a higher number of individual wolves (possibly grouping into more considerable size packs during the colder seasons as reported by park rangers who monitor wolf packs in the field) concentrating on these fewer remaining livestock. Thus, these flocks have a harder time keeping up an impenetrable line of defense. The worsening weather conditions can also decrease the vigilance of shepherds and dogs (Nowak *et al.,* 2005). This phenomenon is only further exacerbated by the post-weaning (August-October) increase in food demand and mobility of growing wolf pups (Smietana, 2000; Jêdrzejewski *et al.,* 2001), also given their higher growth rate at this age (Iliopoulos *et al.,* 2009) (Figure 62).

Figure 62. Wolf pack feeding on a deer kill. In the far back we can see the mother of the 6 cubs, supervising their feeding. (Source: APN).

Protection of livestock

All identified sheep flocks were protected by a number of 0 to 10 dogs with an average of 4 (M= 4.02, Mdn= 4, SD=2.2) and a number of 0 to 4 people with an average of 2 (M=1.45, Mdn= 1, SD=0.78) at all times, with very few exceptions. According to Iliopoulos *et al.* (2009), 3 to 9 dogs is optimal depending to the size of the sheep flock in a similar landscape (Greece). They show that after this optimal threshold is passed, the protective role of dogs gradually decreases, possibly due to fact that a large number of guarding dogs may result in poor nutrition, lack of appropriate training and development of unsuitable behavioral traits, like killing of livestock. Training, amongst several other factors, affects the guarding dogs' performance (Coppinger *et al.,* 1983; Hansen and Smith, 1999).

Guarding the flocks is considered by shepherds in the study area to be a basic and essential preventative measure (see subsection "Shepherd know-how" below) and this husbandry practice was proven efficient by the analysis of the collected data. A regression analysis shows (see Table 8 in the Results section) that when this dog defense line is also backed up by people, the number of livestock losses is greatly reduced. The efficiency of this measure is also confirmed from other parts of the Romanian wolf range (Rigg, 2001; NAPW, 2008; Ivascu and Biro, 2020). Shepherds and dogs can interrupt wolf attacks in the approach, attack, kill and eating phase (Linnell *et al.,* 1996) and may disrupt depredatory sequences by wolves, enforcing indirect or direct aggression (Coppinger and Coppinger, 1987). In my study area, when attacks were interrupted by the intervention of dogs and people, wolves were most often unable to complete the kill, leaving behind injured livestock individuals or unconsumed carcasses. This finding is backed up by the fact that all injured individuals resulted exclusively from interrupted attacks. Also, in uninterrupted attacks, the proportion of consumed kills was higher while the proportion of animals killed and left was much smaller. The only exception to this phenomenon in my study area were overkill situations. In both overkill cases recorded, livestock was killed and left even though the attack was not interrupted by dogs. But this is a typical behavior exhibited by predators during surplus killing (Kruuk, 1972; Miller *et al.,* 1985; DelGiudice, 1998), when they kill more prey than they can immediately eat and then they either cache or abandon the remainder.

This guarding behavior of LGD is important because it can lead to a significant reduction of losses (Andelt, 1992; 2000). Wolves are deterred before they manage to make more kills, and, without any protection by dogs, the potential losses could be much higher than they currently are. Also, injured livestock recovered from wolves are immediately treated by the shepherds with much skill and most often survive, reducing the losses even more.

Similar findings were reported in a similar landscape (Western Carpathians of Poland). Nowak *et al.,* (2005) found that the lack of proper guarding of livestock flocks was more conducive to wolf attacks, showing that the lower rate of protection in the Bieszczady Mountains of Poland results in larger damage by wolves compared to Romania where flocks are better protected and use livestock guarding dogs. Livestock comprise only marginal importance in wolves' diet in the Romanian Carpathians (Salvatory *et al.,* 2002; Nowak *et al.,* 2005; Sin *et al.,* 2015; Corradini, 2016; Rastrelli, 2016), despite the large number of livestock present in wolf habitats. This could very well, at least in part, be a function of the high degree of flock protection practiced in these areas. Janiero-Otero *et al.,* (2020) show that the style of husbandry affects livestock losses by predation greatly increasing in herds without any protection. Iliopoulos *et al.,* (2009) found that sheepdog use reduces losses per attack and wolf attacks on livestock kept inside enclosures that were non-predator proof were on average four times more destructive than those when livestock was guarded by a shepherd. Espuno *et al.* (2004) found that the presence of dogs (especially when coupled with confining livestock) was predicted to prevent a large majority of kills that would have occurred in the absence of dogs.

Other than loses, the use of LGD has been associated with a higher level of long-term tolerance for wolves and other LC (Ivascu and Biro, 2020) and is ethnically believed to be essential in maintaining the balance between predators and humans (Teacă, 2016). Ivascu and Biro (2020) hypothesize that the centuries-long uninterrupted use of endemic LGD breeds by Romanian pastoralists might be one of the main factors behind the historic survival and conservation of LC in the Romanian Carpathians.

7.4.2. Shepherds' know-how: Tradition Ecological Knowledge

Knowledge of the species

There is a centuries long tradition in raising and herding livestock in the Romanian Carpathians. This tradition led to the birth of distinct shepherding communities and has modeled the relationship between people, animals, and the mountainous ecosystems in the area (Săgeată *et al.,* 2023). Over time, shepherding became a profession, a cultural identity, a way of living and pastoralism in the Romanian cultural legacy and is a defining feature of Romanian identity (Triboi, 2017). The customs, practices, knowledge, and know-how in livestock raising have been passed on from generation to generation, and thus, people practicing this profession nowadays are continuing an ancestral tradition (Figure 63).

Figure 63. Shepherd and his flock just descended from the alpine pastures, as part of the early transhumance.

Their profession assumes a very distinctive form of extensive spatial and conceptual knowledge of the landscape (Bassett and Turner, 2007; Houessou *et al.,* 2020; Durá-Alemañ et al., 2024). Shepherds can exhibit well-thought-out and precise decision making on herd movement (Savini *et al.,* 2014) based on awareness of livestock nutritional requirements and feeding behavior (Turner and Schlecht, 2019); botanical knowledge of pasture composition, biomass and spatial-temporal distribution (Bailey, 2005); and an awareness of predator and prey species. Many shepherds also show great skill in training guard dogs and raising and handling their livestock, they demonstrate perseverance, stamina, ability to cope with partial social isolation (Moritz *et al.,* 2011), a large capacity of endurance and adaptability in a harsh environment, a skilled ability to read and interpret meteorological conditions and an overall strong innate feel for their surroundings (Schlecht *et al.,* 2020).

This large set of skills, which are both learned and acquired from experience, is what I identify as the shepherd's "know-how". This analysis captures and describes this know-how, particularly focusing on aspects of wolves and wolf predation the study area.

As expected, the analysis of the respondents' demographics showed that shepherds in the study area have a very high level of experience in livestock raising, with an average of 31 years of experience and a maximum as high as 70 years of practice. Tending for livestock is the primary livelihood for most of them. These results reinforce the concept of shepherding seen as a profession and a way of living rather than a simple job. According to the shepherds, the apprenticeship in livestock raising and herding often begins in childhood, and is integrated in a unique division of work, within which certain activities such as milking or tending to sheep are entrusted to the young apprentices who combine effort with play and juggle shepherding with school. Therefore, the shepherds' knowledge, skills and experience – passed down from seniors and acquired through many years of practice – are complemented by formal education, as confirmed by the results showing that shepherds have relatively high levels of education, all of them finishing primary school and over 60% of them graduating high school.

The shepherds' high level of experience in livestock raising is also reflected in their direct experience with large carnivores, and with wolves in particular (Figure 64).

As part of their daily commute through large carnivore habitat while grazing livestock in high altitude pastures and grasslands of the park, and as part of their everyday struggle to protect the livestock from predators, shepherds come into close proximity to wolves, bears and sometimes even jackals and lynx. Often, they are even engaged in direct interaction with these predator species, especially with wolves.

The results show that this seems to be directly related to the rate of wolf attacks and the amount of wolf-caused damage that shepherds experience. During a wolf attack on their herd, shepherds not only coordinate and guide their dogs to fight and chase away wolves, but themselves engage directly in the task, coming into very close contact with wolves. The more attacks shepherds experience and the more intense these confrontations are, the more exposure and experience in dealing with wolves they gain.

Figure 64. Having many decades of experience and interaction with LC behind him, this respondent recounts, with a smile on his face and a gentle tone, how he fought a bear with his bare hands and survived.

This constant and close contact they have with wolves on a day-to-day basis gives shepherds a good understanding of local wolf packs, as shown by the results of this analysis. Not only are they familiar with wolf appearance and demeanor (being able to easily and correctly distinguish wolves from similar looking species such as feral dogs) but they can also distinguish particular wolf individuals and claim to be aware of the local wolf numbers and distribution, reproduction, behavior and hunting strategies, and population trends. The results of a regression analysis confirm that the level of experience a shepherd has – and thus also the frequency of wolf visits they experience – directly influences their perception and knowledge of the local wolf population, showing that less experienced individuals are more likely to perceive an increased trend of wolf number and predation events in areas of frequent wolf activity. This is easily explained through the fact that, when apprentice shepherds begin their work at the sheepfolds, they start entering into contact with wolves that visit the sheepfolds regularly. As time goes by, they experience more and more wolf visits and predation events, thus they perceive this as an increase in the trend of wolf numbers and predation. But more experienced shepherds will naturally have had more time to assess, and this will allow them to compare trends over a more significant amount of time, giving them a better sense of the real numbers. With an average of 31 years of experience, and a maximum of 70, we can confidently say that overall, shepherds have a good sense of the actual situation.

According to the shepherds, wolves visiting livestock flocks are most often seen roaming alone or in very small groups of 2 to 3 individuals, rather than large compact packs. This finding was backed up by rangers and hunters in interviews. This could be a function of many factors, including wolf population size and density (Zimen, 1976; Thurber and Peterson, 1993), but abundance and availability of prey population (Zimen, 1976) could also play an important role. Thurber and Peterson (1993) describe a very similar wolf distribution in Isle Royale and found that the proportion of lone wolves was higher when the population was at low levels, whereas average size of packs declined with density of wolves. I engage in this comparison due to the relative similarity of the specific context of the two cases: relatively isolated populations susceptible to loss of genetic diversity due to separation from the larger wolf population. Similarly to Isle Royale – an island on Lake Superior – the Apuseni Mountains are a branch of the Carpathian Mountains that is geographically separated from the rest of the Carpathian Arch. Not being directly connected to the rest of the Carpathian chain, "*the Apuseni have the appearance of an island. This makes them more memorable but, at the same time, perhaps more vulnerable*." (Moş and Brînzan, 2024, p. 16)

As the Isle Royale case suggests, two hypotheses may explain high numbers of solitary wolves and small groups approaching livestock in the Apuseni Mountains. One is that the density of wolves is high compared to available resources, therefore more individuals may disperse due to inter-pack conflict and to find new food resources. Another hypothesis is that, just like on Isle Royale, wolves might be attempting to maximize food intake and reproductive possibilities in the context of low wolf densities. None of these hypotheses can be confirmed or tested until consistent and solid studies are made to determine the exact wolf population size and distribution, movement patterns and diet composition in the park. At the moment this study was realized, the park estimated a maximum number of 26 wolves in the ANP. This would indicate an average density of 3.4 wolves/100km^2, considerably higher than national estimates of 1.8 – 2.5 wolves/100km^2 (NAPW 2018). Yet, this information might not be fully reliable, especially as this data was based on studies carried out before 2008 and corroborated with field observations, most of which come from yearly evaluations performed by the hunting associations with the park, studies that have been repeatedly shown to use flawed methodology (see section *Evaluation of wolf population and Quota awarding* in section 8.3.3). Although the gray wolf is one of the species for which Apuseni Natural Park was designated, the park's management plan at the time of this study (2016) only contained one short paragraph related to wolves. In this paragraph it was stated that the 26 wolves that live on the surface of the park represent the optimal number for this territory, but this statement was not backed up in any way. It is only very recently (2023) that the park administration finished an extensive study on the territory of the park, including research on protected fauna populations. Even though the results of these studies are not available for the public, the latest management plan (ANPMP, 2023 - under approval), that is based on these results, reports 25 to 38 wolves living on the territory of the park, forming a "permanent", "stable" wolf population with "favorable" conservation status, "widely spread" over a surface of 66,800 ha representing 88% of the park's total surface (see distribution map, Figure 18 in chapter 3). More detailed information on wolf pack composition, movement, trends and hunting strategies, wolf diet composition, reproduction and ethology are still missing in the management plan.

Almost 70 percent of the respondents involved in this study (particularly the more experienced), and some park rangers and hunters, report a decrease in wolf numbers in the years preceding this study and they associate this with a decrease in wolf predation as well (see also Figure 54 in the Results section). While this could indicate a decline in the wolf population on the territory of the park (opposed to what we see in the latest management plan), it could just as well be a consequence of the change in wolf pack structure, the dispersion of large packs into smaller groups of wolves and lone individuals giving people the perception of a decrease in the number of wolves. Almost half of the respondents also reported an increased presence and damage of wild boar, also confirmed by park administration and the hunting associations. This can be a function of certain management strategies of hunting grounds aiming at increasing game populations. But on the other hand, it can also be a symptom of wolf population reduction due to poaching and derogation hunting (see more details in section 8.3.3. of Chapter 8) because, as shown previously, wild boar is one of wolves' main prey in this part of Europe. Boar is predominantly selected by wolves in the Romanian Eastern Carpathians and a large proportion of the wolf's diet is also represented by wild boar in Southern Europe (Italy, Spain: Llaneza *et al.,* 1996; Ciucci *et al.,* 2004; Mattioli *et al.,* 2011; Milanesi *et al.,* 2012), and elsewhere in Central and Eastern Europe (Estonia, Belarus, Hungary, Bulgaria: Valdmann *et al.,* 1998; Genov *et al.,* 2010, Lanszki *et al.,* 2012).

One hypothesis that has a strong support based on the data available for this research is that wolves in the park tend to organize in small groups or even act alone (Figure 65 b) when approaching and hunting livestock in the study area, as a possible adaptation of their hunting strategies when preying on domestic prey. As discussed in the previous chapter, wolves in this landscape tend to show very flexible hunting strategies when attacking livestock. The stalking-hiding or ambush-like hunting tactics that wolves tailored for catching and killing livestock as previously described would require less, or even no pack cooperation, hence the sighting and reporting of solitary individuals by shepherds. Also, wolves might need to use less effort while preying on domestic animals because livestock are smaller in size and show more attenuated antipredator behavioral responses than wild prey (Laporte *et al.,* 2010; Muhly *et al.,* 2010), and because livestock's movements can be controlled or restricted by humans who partly shape the way they use the landscape. Therefore, wolves might not require the coordinated effort of a large pack and instead appeal to adaptive alternative hunting strategies and techniques. Wydeven *et al.,* (2004) found similar wolf pack dynamics in Wisconsin, showing that smaller packs with smaller home ranges were more often involved in livestock predation. Thus, the reported reduced pack structure and the dispersal of individuals in Apuseni Natural Park might be a consequence and a characteristic of wolf predation on livestock.

Figure 65. Left: Gestating female wolf. Right: Lone wolf. (Images captured by the APN surveillance cameras).

Another hypothesis based on interview findings is that the lone individuals spotted by shepherds are females or other pack members in search for lower effort prey while tending for their new pups born in late spring. Literature shows that raising pups acts as a social bonding mechanism for wolf packs and triggers a major behavioral change while tending for pups during the summer months: the pack forgoes its nomadic hunting behavior and focuses its activities at fixed homesites (Holleman and Haber, 2013) reducing movement and temporarily becoming stationary around den and rendezvous sites. The female during this time is under great pressure to acquire food for her pups and in need of fast nourishment herself given the increased energetic demand while nursing her pups. Needing to hunt on smaller distances while also energetically depleted, female wolves might choose to lurk around livestock flock awaiting an opportunity. Several shepherds report female individuals accompanied by a young pup prowling around the flocks.

The small groups of 2-3 wolves reported to visit flocks could also be the female or a pack member teaching young pups how to prowl and hunt. Another possible hypothesis is that post-weaning growing young wolf individuals have an increase in food demand and mobility (Smietana, 2000; Jêdrzejewski *et al.,* 2001) given their higher growth rate at this age (Iliopoulos *et al.,* 2009) and therefore choose easier prey during their apprenticeship in learning to hunt.

This is also the period when young adults are predisposed to disperse, therefore the lone individuals visiting sheepfolds could be unexperienced dispersers in search for an easy kill.

Previous research (Thruber and Peterson, 1993; Wydeven *et al.,* 2004) has shown that predation on livestock can be aggravated when packs are disrupted due to poaching and hunting, which can result in lone individuals in search of easy prey. Can the solitary wolf individuals attacking the livestock in Apuseni Mountains have resulted from disrupted packs due to hunting and poaching? These are all questions for future research. A thorough study based on telemetry and camera trap data covering pack movement and dispersal, denning and pack composition, genetic analysis showing wolf diet composition and how this is associated with dispersing individuals, would be essential to shed more light on this phenomenon. Such studies would also prove crucial to the long-term successful management of these relative isolated wolf populations in the Western Carpathians.

This is an area I identify as very much in need of future research, especially as this situation expands to a national level, characterized by the same shortage of reliable data based on up-to-date nation-wide solid scientific research (Popescu *et al.,* 2016). Despite these data deficiencies, estimates of abundance and trend are central in justifying national policies (Darimont *et al.,* 2018) such as hunting, lethal control, and strict protections (read more in the following chapter).

Variables influencing predation

Shepherds' knowledge and know-how in relation to wolf predation and variables influencing predation proved again to be vast and comprehensive. When prompted to name factors that could possibly influence the risk of wolf predation on livestock, they identified over 40 such factors pertaining to various categories of spatial and non-spatial indicators: biophysical (species related, vegetation, topography); weather conditions; temporal (circadian and seasonal); sensorial cover (visual, auditive, general); husbandry and human presence. Thus, shepherds covered most factors associated with wolf predation identified by the scientific literature and more, on the basis of their experience rather than formal learning (Table 13).

This was a surprising and unique finding of this research, backing up the idea that TEK has the utility to complement and improve scientific research through more and sometimes more valid information (Freeman and Carbyn, 1988; Johnson, 1992; Inglis, 1993). The list of factors identified by shepherds can be used by future research to understand and predict predation events.

Of all the factors identified by shepherds, weather conditions were mentioned most, especially fog and rain. Harsh winter conditions, with frost and deep or frozen snow were also considered to be a major factor. The second most often mentioned variable was forest and forest edge.

Table 13. Variables identified by shepherds as having the potential to influence wolf predation on livestock and the scientific literature that also identified these factors.

Category	Subcategory	Variables identified by shepherds	Equivalent in scientific literature
Biophysical	Species	Number of wolves Wolf hunger (reduction of wild prey) Prey abundance and availability Wolf habituation Wolf travel corridors	Wydeven, 2004 Harper *et al.,* 2005 Davie *et al.,* 2014 Hovens and Tungalaktuja, 2005
	Vegetation	Forest Forest edge Open fields	Robel *et al.,* 1981 Treves *et al.,* 2004; 2011 Davie *et al.,* 2014 Kaczensky *et al.,* 2008 Mech *et al.,* 2000 Bangs and Shivik 2001 Stahl *et al.,* 2001
	Topography	Terrain ruggedness	Suryawanshi *et al.,* 2013
Weather conditions		Bad weather Fog Rain Downpour Overcast Storm Low temperatures Harsh winters Frost Snow Frozen snow Deep snow	Mech 1970 Peterson and Allen 1974 Peterson 1977 Huggard 1993 Ciucci and Boitani 1998 Mussiani *et al.,* 2005 Nowak *et al.,* 2005
Temporal	Circadian	Nighttime	Ciucci and Boitani 1998 Mussiani *et al.,* 2005 Iliopoulos *et al.,* 2009
	Seasonal	Cold seasons (autumn and winter)	
Sensorial cover	Visual	Level of visibility Human altering of pasture habitats	Mech *et al.,* 2000 Bangs and Shivik 2001 Stahl *et al.,* 2001 Gable *et al.,* in 2001 Kunkel et Pletscher 2001 Robel *et al.,* 1981
	Auditive	Level of sound Silence	
	General	Level of isolation Secludedness Wild areas	
Husbandry	Herd characteristics	Size of the herd Level of flock aggregation Presence of juveniles in the herd	Iliopoulos *et al.,* 2009 Ciucci and Boitani 1998 Mech *et al.,* 2000 Treves *et al.,* 2004 Bradley and Pletscher 2005 Kaartinen *et al.,* 2009
	Level of protection	Presence of people guarding the livestock Presence of dogs guarding the livestock Experience of livestock guarding dogs and people Level of vigilance	
Human presence		Electricity Civilization Level of population	Behdarvand *et al.,* 2014 Treves *et al.,* 2004 Bradley and Pletscher 2005 Davie *et al.,* 2014 Jędrzejewski, 2008 Kaartinen, 2005

7.4.3. Prevention measures

Traditional prevention measures: Husbandry and protecting livestock

Relatively few studies examine the perceived practical and context-specific effectiveness and social acceptability of non-lethal prevention tools among livestock producers (Volski *et al.,* 2021). This study is an attempt to determine the "social effectives" (Volski *et al.,* 2021) of both official (imposed by management authorities) and husbandry related preventative tools and strategies used in the ANP to reduce predation and mitigate livestock losses.

Livestock guarding dogs

Protecting livestock is seen by shepherds as the most important measure in lowering wolf caused damage. The presence of shepherds and dogs guarding the flock is considered essential in deterring approaching wolves. LGD are the shepherd's most important ally in this task. The use of dogs has been a common non-lethal method for reducing predator impacts on livestock for centuries in Europe (Allen *et al.,* 2016). The low levels of losses to wolves (an average of 4.6 individuals, SD= 7.745, per sheepfold for the 10-year period) recorded at the sheepfolds in the study area seem to indicate that LGD are successful at protecting livestock flocks even in high-risk areas (see subsection "*Protection of the livestock*" in the foregoing). A similar conclusion was also reached from other parts of the Romanian Carpathians (Mertens and Promberger, 2000).

LGD are raised and trained from puppyhood to protect livestock from predators, as part of a tradition as old as shepherding (Figure 66). Specialized endemic Romanian breeds of LGD have evolved over time, some as old as the Celtic tribes. These dogs are intensely treasured by their owners and these breeds are the subject of national pride. Four breeds of LGD have evolved in the Romanian landscape: the Bucovina Shepherd (also called the "Southeastern European Shepherd"), the Raven Shepherd (also called "crow"), the Mioritic Shepherd and the Carpathian Shepherd. Of these, the last two have been officially registered and the Mioritic has even been recognized by the FCI (International Canine Federation). These dogs are bred and raised among the sheep, socialized with the herd of livestock they are guarding (Landry, 1999), being taught to view the flock as their own property that they defend against competitors, property that they share with their leader that is the shepherd.

Figure 66. Livestock guarding dog puppy at a high-altitude sheepfold.

Livestock guarding dogs' instinctive prey drive has been bred against for thousands of years (Ivascu *et al.,* 2020; Macon and Whitesell, 2021), they have never been taught to attack or hunt, and the instinct that they pass down from generation to generation is that of defense and protection (Teacă, 2016). It has been shown that these dogs protect the livestock by guarding, i.e., by remaining near them and actively defending against predators when necessary (McGrew and Blakesley, 1982; Coppinger *et al.,* 1983; Allen *et al.,* 2016). They do not defend by establishing territories and excluding predators (Allen *et al.,* 2016). Their shepherding behavior, intense vocalization, high aggressiveness towards an attacking predator, great attentiveness to livestock, high trustworthiness, great activity level, intelligence and fast mobility are all attributes that combined with the flocking behavior of sheep, help circumvent attacks but does not prevent or discourage predators to exist in the proximity (Coppinger *et al.,* 1983; Andelt, 1999; Allen *et al.,* 2016; Mosley, 2020).

Guard dogs bond very strongly with their owner and their flock (Coppinger *et al.,* 1983; Hansen and Smith, 1999; Ivascu *et al.,* 2020) and will do everything they can to protect them from any harm. They will go all the way to defend and recover livestock prey from predators, and they do this under close supervision and guidance of the shepherd. Training through experience is essential for their performance (Coppinger *et al.,* 1983; Hansen and Smith 1999). In the Romanian Carpathians dogs are not individually trained by the shepherds, but rather they learn by experience from the older dogs, by being put in the flock as soon as they are old enough (Mertens and Promberger, 2000). Good LGD walk among and around the flock as it grazes, evenly spaced apart, and attentively follow basic instructions from the shepherds, such as returning to their posts after rushing for a false alarm. Well socialized LGD stay with the flock at all times, lying near the edges of the flock and in prominent positions around the enclosures even during the nighttime.

Participant observation has shown that, during an attack, shepherds and dogs cooperate with each other in a synchronized manner, skillfully coordinating their movements and tactics under the lead of the dominant figure, the shepherd. Vigilance and skill are two main features identified by shepherds as key for their success. Once the intruder is deterred, and the danger is gone, dogs retreat back to their assigned guarding posts near the flock and retake their role in supervising the livestock and their surroundings.

By deterring wolves, LDG help reduce livestock loses, especially when the use of dogs is coupled with human attendance (Ciucci and Boitani, 1998) and nighttime confining (Espuno *et al.,* 2004). The optimal use of guarding dogs is also essential (Macon and Whitesell, 2021). This entails good training and a strong degree of bonding with the livestock (Coppinger *et al.,* 1983, Hansen and Smith, 1999; Macon and Whitesell, 2022). Dogs thus become part of an integrated system: livestock, dogs and people function, act and respond together during an interaction with wolves. This well synchronized and coordinated antipredator response based on a very tight interaction between the three, is what I define as the *integrated antipredator response (IAR)* of the *coupled human-dog-livestock system.* Even before an attack occurs, dogs strategically distribute themselves in guarding posts spread out alongside an invisible circle around the flock, or on the side of the flock that is most vulnerable, such as along the edge of the forest. They alternate this behavior with patrolling the area in order to detect when wolves are in close proximity (Linhart *et al.,* 1979; Green and Woodruff, 1983; Hansen and Smith, 1999) and may even use scent marking as part of this patrolling behavior as an added form of defensive olfactory communication (Bidder *et al.,* 2020). Extensive open-ended conversations with shepherds during interviews and participant observation have led to the idea that dogs perform this array of guarding behaviors not only from a protective shepherding instinct, but also in response to a command from the shepherd. Long and hard training coupled with their innate fidelity and devotion (Figure 67) makes these dogs extremely sensitive to even the slightest cue from their owner (Teacă, 2016; Ivascu and Biro, 2020).

Figure 67. Shepherd and his puppy guard dog form a life-long bond.

The livestock also recognize their role and stay within the invisible protective circle. When a predator approaches, dogs immediately alert the sheep and the shepherd with their intense vocalization. The sheep react by immediately flocking together with the dogs and the shepherd. This kind of spatial bonding between livestock and dogs has also been described elsewhere (McGrew and Blakesley, 1982; Zingaro *et al.,* 2018, Mosley, 2020). The shepherd reacts by quickly taking up the position of leader and coordinator of the defense line. Through a series of subtle cues and commands, he orchestrates the antipredator response, intervening in the dogs' response only when necessary. Dogs coordinate not only with the sheep and the shepherd but also between themselves, working together, as a pack, distributing tasks and spatial positioning, with one or more dogs remaining close to the sheep while others move to challenge and deter the intruder (McGrew and Blakesley, 1982; Van Bommel and Johnson, 2015; Allen *et al.,* 2016).

The discovery of this very intricate and integrated response as it emerged from the data led to the development of the IAR concept that I put forward here. Although certain aspects of this interaction between people, dogs and livestock have been previously described in literature as shown above, these have never been put together to describe an *adaptive integrated human-dog-livestock antipredator response system*. In expanding the hypothesis of Ivascu and Biro (2020), I believe that it is this *Integrated Antipredator Response (IAR)* that has maintained the relatively low levels of predation and the strong human-wolf coexistence in the Carpathian Mountains for centuries, despite the presence of a well-established, continuous and viable wolf population sharing the same space with a large number of livestock being raised in these habitats as part of the grazing tradition. In fact, I believe it is this century long coexistence of wolves and people with their dogs and livestock that has led to the birth of this integrated response by fine-tuning and refining this ancestral relationship over time. It is a product of adaptation and coadaptation.

It is not only people, dogs and livestock that respond to each other. I here raise the hypothesis that wolves also have learned to adapt to the antipredator responses of this coupled system. As shown previously, one discovery of this research (yet to be fully supported by tailored research) is the adaptive response of wolves to preying on livestock in this landscape: their observed capacity to switch between hunting modes (described in Section 6.5.1. of Chapter 6), from cursorial to ambush stalking, using sensorial cover in order to evade the vigilance of shepherds, dogs and livestock. Another example of a wolf adaptation response, is the "*baiting behavior*" described by shepherds during open-ended discussions: when the line of defense put up by dogs seems impenetrable (particularly when livestock are enclosed during the night and *all* dogs are present around the enclosure), a female wolf of the pack approaches the flock prudently (while the rest of the pack maintains distance to remain undetected) and exhibits mating behavior to attract dogs away from the flock. A variation of this same strategy is a male wolf individual exhibiting submissive behavior or acting as if wounded and/or weak (yelping and yipping; low posture; holding their tails down and often lower their bodies; pawing). While dogs pursue the female or the "weak" wolf, and move away from their guarding posts, the rest of the pack approaches the livestock launching a swift attack, most often taking only one livestock individual and dragging it away before the dogs return. This baiting behavior is also reported from other parts of the Romanian Carpathians (Rigg, 2001).

Shepherds, dogs and livestock respond to these behaviors again, by taking strategic preventative measures and increasing vigilance in areas and conditions characterized by increased vulnerability. It is thus a constant process of action and reaction to each other, an integrated system in which the constituent components adapt to each other, *a system of coexistence* that has naturally evolved over time. Thus, the pioneer concept here defined as the *Integrated Adaptive Response System (IARS)* is a real-life example of the classic CAS conceptual framework (Preiser *et al.*, 2018) widely described in SES theory and research (Berkes *et al.,* 2000; Berkes *et al.,* 2003; Glaser *et al.,* 2008). CAS focuses on studying the dynamics and interactions in SES, and thus "*extends the definition of traditional systems theory by recognizing that CAS contain adaptive components and capacities*" (Preiser *et al.*, 2018, p. 2). The adaptive interaction between the components of the pastoral system and wolves allows the IARS to change and evolve over time in response to feedback and changes in the specific context. This means that the IARS has an internal memory and a capacity to learn from previous responses and interactions between its components (people, dogs, livestock and wolves), and this influences and shapes current and future system trajectories, thus perpetuating coadaptation and coexistence.

This classic case of a CAS, especially when studied under the CASES framework (see section 10.1. in Chapter 10) can provide many valuable lessons to assist future human-wildlife conflict studies in understanding the relations and feedback that shape the dynamics and features of socioecological systems under study. I believe there is great value in further developing the IARS concept through future research by investigating the interactions between the components of the system and its role in suppressing predation. As non-lethal control methods are becoming more and more popular (Mosley, 2020) and more socially acceptable than lethal methods for predator control (Bruskotter *et al.,* 2009; Slagle *et al.,* 2017), it is key to investigate and learn from what can be considered the oldest form of non-lethal intervention and a naturally evolved tool for lowering predation.

Fencing and human presence

Second in ranking on the list of preventative measures rated most efficient by shepherds are fenced enclosures. These are 1 or 2 m tall wood fences creating an enclosure that harbors the flock during the night with the purpose of defending them from predators (Figure 68).

Figure 68. Fenced enclosures and the nighttime refuge where the shepherds sleep while guarding the sheep from wolves.

This main enclosure, which is also the largest, is called “târla”. This is where the livestock spend the night and where they can find the salt they need at the beginning of the grazing season, under the form of a “rock salt” lump placed in this main enclosure. A secondary and a third enclosure, adjacent to the first one, act as dividers for the flock while milking the sheep. At the end of the day, when the flock returns from the open alpine pastures where they graze freely, the sheep and goats are herded into the second largest enclosure called “Strunga mare”. From here, the animals are directed through a narrow pass into the smallest enclosure – “Strunga mica” where the lactating females are milked and then released into the main enclosure (Figure 69). Also, these enclosures are in certain cases used to separate the flock into two groups –

lactating females and their young, and non-lactating individuals – usually until August when the lambs are weaned, and the females are ready to mate.

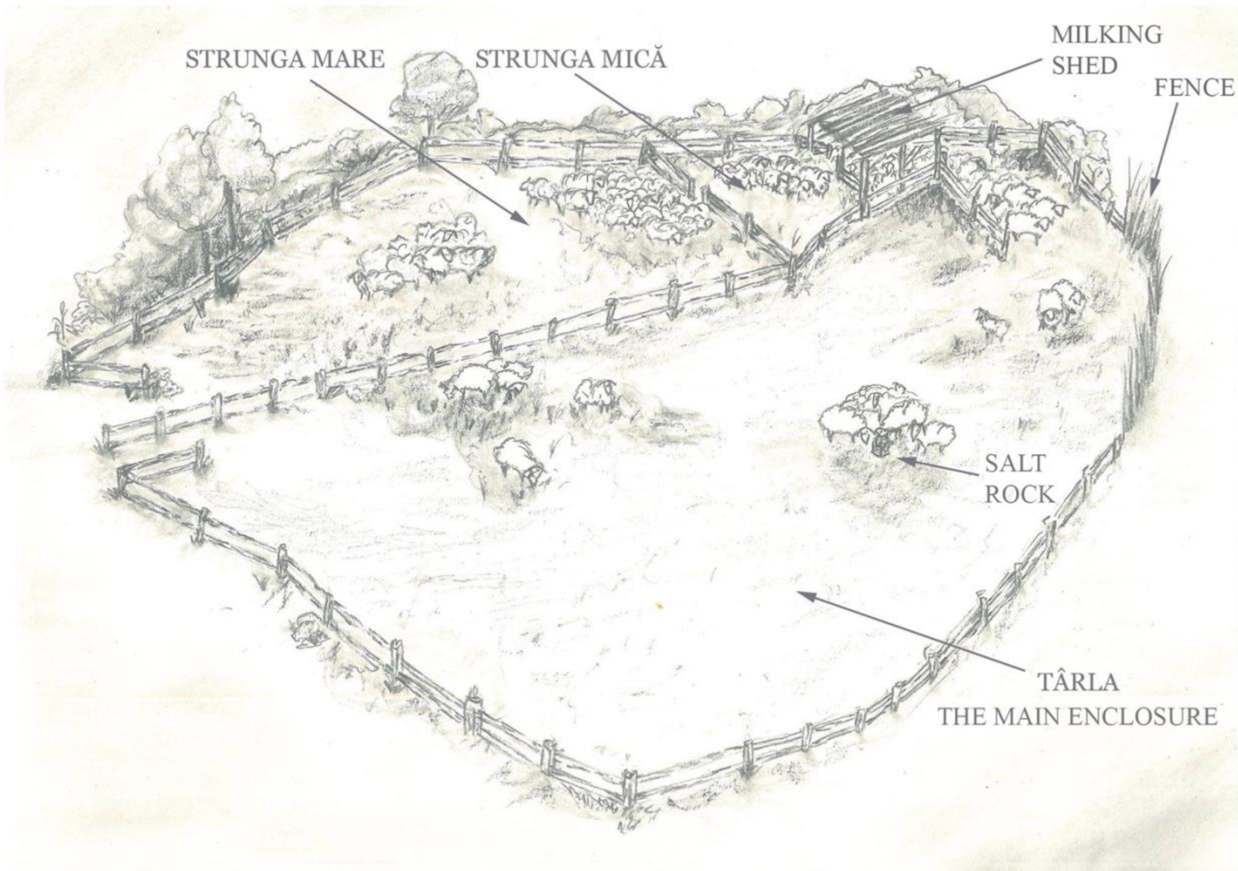

Figure 69. The structure of the fenced enclosure (drawing made by Claudiu Calin adapted from LPJ project, 2015).

Although shepherds consider these enclosures important for protecting livestock during the night, they see their efficiency as high only when coupled with the presence of guarding people and dogs. An interesting result was that shepherds with larger flocks perceived a higher risk of predation and thus tended to increase protection by guarding in larger numbers. This may back up the idea that larger flocks are more attractive to wolves (Kaartinen *et al.,* 2009). This shows up in the predation data too, in which larger flocks experience more predation when confined in the night enclosures (see section "*Non-spatial factors influencing wolf predation in the study area*" above). While the opposite is true of free grazing livestock, with smaller flocks attacked more while out grazing, this may be only a function of the higher vulnerability of these small flocks on the move in high-risk landscapes.

All the dogs of the sheepfold guard the livestock by night, by strategically positioning themselves in guard posts distributed around the enclosures. At least one shepherd is also present, all night long, sleeping in a temporary wood shelter placed by the enclosures. If alerted by dogs at any point during the night, they quickly emerge from the shelter and take on the role of lead of defense. All other shepherds, assistants and family are in the temporary sheepfold hut, also situated in close vicinity of the enclosures and thus they are also alerted in case of a confrontation.

A similar finding is described by Espuno *et al.,* (2004) showing that confining or simply gathering sheep at night in the presence of livestock-guarding dogs was predicted to prevent most kills (94%) that would have occurred in similar conditions in free ranging flocks.

Carcass disposal methods

The next husbandry measure rated on the scale of efficiency in prevention were proper carcass disposal methods. Properly disposing of carcasses is important because they can attract predators (Linnell *et al.,* 2012). Most shepherds reported feeding the carcasses to the dogs as a way to dispose of them. While this raises a flag of concern related to the habituation of dogs to hunting sheep, shepherds deny this possibility, arguing that it has never been observed within their sheepfold. They state that livestock losses are relatively rare (only a few individuals per year), therefore feeding carcasses to the dogs is a rare occurrence and that they cook the meat before giving it to the dogs (this changes the taste of the meat). They also report that these dogs have never been taught to hunt, being always fed by the shepherd since puppyhood. But most importantly they believe that livestock guarding dogs will not hunt livestock because these breeds do not have the hunting instinct, this being replaced by the defense instinct, genetically selected generation after generation. Scientific literature backs these statements. The three basic characteristics considered critical for a good livestock guarding dogs are trustworthy, attentive and protective (Coppinger and Coppinger, 1987). The absence of predatory behavior lies at the basis of these three behaviors and at the basis of LGD selection, thus, dogs must display investigatory and submissive behaviors that do not threaten sheep or other livestock as these desirable behaviors are signs that the right instincts are working (Lorenz and Coppinger, 1986). If the dogs display stalking-type behavior, they are replaced.

The results of correlation tests also show that shepherds who engage in more risky disposal methods such as burying or abandoning carcasses, tend to be the less experienced shepherds experiencing higher rates of wolf visits in higher risk areas. Feeding carcasses to dogs was associated with lower rates of wolf visits compared to other carcass disposal methods, confirming that this can be an effective traditional preventative measure.

Flock movement

Although shepherds rate the effectiveness of keeping away from forest edge as high and identified forest and forest edge as a high-risk factor influencing predation, they still use forest edge regularly while grazing sheep as a travel corridor, as a refuge for rest and as cover from harsh weather conditions, relying on their skills and on increased vigilance to protect the herd in these situations. The higher risk of forested environments for wolf predation is confirmed and widely discussed in section 6.5.1. Influence of tall vegetation in Chapter 6. Despite being clearly aware of this risk, shepherds state that this is a risk they have to take, especially under harsh weather condition (such as very hot summer days or intense thunderstorms and hale) in the absence of alternative solutions.

Social effectiveness of official prevention management measures

Most shepherds believed in the effectiveness of official management measures aimed at reducing livestock losses but were skeptical about their proper implementation in practice. Wolf population control and removing problem animals were believed to be highly effective by most shepherds and relocation of problem animals was mostly seen as ineffective. Most respondents were not open to the idea of receiving electric fences from authorities and did not believe in the effectiveness of this preventative measure. Respondents who were open to the idea were shepherds managing larger flocks in higher risk areas and shepherds who perceived an increase in wolf numbers and wolf predation in recent years. This is probably due to the fact that a larger flock is more difficult to manage and defend, especially during the nighttime when livestock are enclosed and especially if attacks are frequent. While shepherds are ambivalent about electric fences, hunters declare that these fences are inefficient for protection against wolf attacks because wolves will jump over them.

Shepherds in higher risk areas, suffering more losses due to wolf predation, seemed to be more open to the idea of compensation. Shepherds generally believed in the efficiency of compensation schemes in relieving losses in theory but find them nonexistent in practice. Only one predation event was reported to authorities for compensation, and no compensation was awarded for all events recorded for this study, stretching over the span of more than a decade. This is most likely due to a lack of information, the difficulty of the process and a general mistrust in authorities (see an extensive discussion on this topic in Chapter 8). Most shepherds were not even aware of the responsible institution they should appeal to and only a small percentage identified the correct institution as being the local councils (Figure 55).

A regression analysis looking at the relationship between the calculated spatial risk at each sheepfold and people's attitudes related to husbandry and official management measures shows that shepherds in higher risk areas are more likely to consider official management measure are more effective.

7.4.4. Perception of risk

Understanding people's perceptions of the risk of predation in particular, and of various more detailed aspects of coexisting with wolves in general, is important (Treves *et al.,* 2006; Dickman, 2010; Marchini and Macdonald, 2012; Suryawanshi *et al.,* 2013; Kansky and Knight, 2014; Treves and Bruskotter, 2014). Their perception of how good or bad the outcomes of living with wolves are ultimately influences their attitudes (Beedell and Rehman, 2000) and directs their responses (Eagly and Chaiken, 1983) both towards wolf populations, but also towards management authorities and conservation, shaping the manifestation of conflicts (McInturff *et al.,* 2021).

The way shepherds, in my study, perceived the risk of predation directly reflected in their level of concern about their own and their livestock's safety and in their attitude towards coexisting with wolf populations. While there was a relatively even distribution of answers related to the level of perceived risk on the range from low to high, there wasn't a perfect spatial overlap of the perceived and measured risk (Figure 70).

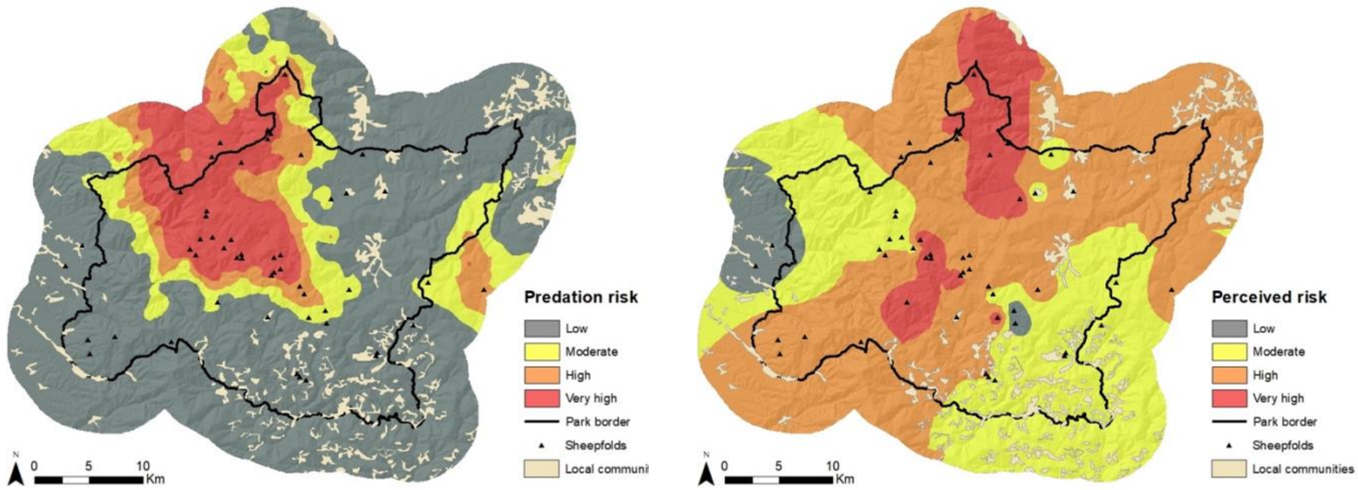

Figure 70. Comparison of predicted risk to perceived risk.

This may be because, as the survey responses and the open-ended discussions with the interviewees have suggested, people's perception of risk can be influenced by a wide array of factors, such as each person's personal history and demographics; their personal direct experience with predation events; their knowledge of the species; their natural surroundings; their perception of local management and even their own unique political, philosophical, spiritual and world views and beliefs, as well as their social context, traditions and culture. People's perception of the consequences of living with wolves as being positive or negative can vary widely among individuals and social groups based on such factors (Røskaft *et al.,* 2007), and while these perceptions do not always agree with the actual situation, they still form the basis of their attitudes. Although this study does not fully tackle the entire complexity of this subject, I believe there is still great value in delving into these aspects that have been given almost no attention in the world of human-wolf conflict in the study area. Quantifying and describing the perceived risk in relation to the factual measured risk acts as a complementary part of the research, adding knowledge on the web of processes and interactions that lead to conflict, but also to co-adaptation and coexistence.

The results of a regression analysis (see Table 11 In the Results section) show the perception of risk being shaped by the convergence of seven main factors, hereby presented in the order of their importance in the model: the rate of wolf visits, the level of experience in shepherding, the number of people involved in protecting the livestock, the perceived number of wolves living in the vicinity of the sheepfold, the calculated risk of predation, the perceived trend of wolf numbers over time and the level of concern for the safety of livestock. In the following I interpret these results on the basis of not only this regression analysis, but also the one-by-one associations between the variables in the data on the basis of contextual knowledge acquired throughout the research and findings of peer scientific literature.

My first conclusion is that people's perception of risk (and consequently the level of concern for the livestock's safety) is directly influenced by the frequency of wolf visits, the level of damage and the level of direct interaction with wolves experienced by each person. This seems to be self-explanatory: the more a person comes in contact with wolves and suffers more losses due to wolves, the more they will tend to worry about their own safety and the safety of their livestock. Naturally, this increases the level of risk that they perceive and the level of protection they engage in. In turn, this can increase their negative attitudes towards wolves (Barmoen *et al.,* 2024). Other studies have found that, on the contrary, there might be evidence that more exposure actually reduces perception of risk and increases acceptance (Carter *et al.,* 2012), while risk perception still influences wildlife acceptance even without any actual direct experience with the species (Riley and Decker, 2000). Here I attempt to give a more nuanced explanation to this phenomenon, as I put forward the hypothesis that the level of experience in shepherding each person has, plays a crucial role in how they understand and interpret risk.

As discussed earlier in the "*Knowledge of the species*" section, we see that less experienced, novice shepherds tend to perceive a higher intensity of conflict with wolves as they first start to experience wolf predation at the beginning of their career. With only a few years of living and working in this landscape, the novice shepherds will have a different baseline of comparison over time than that of the shepherds with many years of practice under their belt. When wolves and people cohabit in the vicinity of a sheepfold over time, the chances of encounters increase, as does the likelihood of being involved in a confrontation. Regularly seeing and interacting with wolves as part of their (relatively) new job might, and progressively entering into contact with more and more wolves, increases their conscious or subconscious predisposition to automatically register the risk of a potential confrontation (Røskaft *et al.,* 2007), without having the long-term context for assessing the magnitude and intensity of this risk. Also, as shown previously, experienced shepherds take pride in storytelling of the conflictual situations they were involved in with wolves, and, as these stories get to the ears of the less experienced shepherds by word of mouth, this vicarious conflict exposure might further increase the perception of risk of the less experienced. This is confirmed by other studies that have shown that vicarious wildlife conflict can inflate the perception of risk (Nesbitt *et al.,* 2023).

As a consequence, the novice shepherd will interpret and perceive a higher level of conflict despite reporting less wolves, likely resulting in increased concerns and lower acceptance for wolves. Even though they perceive an increased number of wolves and predation events, novice shepherds actually report fewer wolves around them in the present compared to more experienced shepherds. The explanation is the smaller window of time. The more experience shepherd has been on the job long enough to have a better sense of the real size of the wolf pack they cohabit with, and thus, they report a higher number of wolves in their vicinity, closer to official numbers. At the same time, because they have a much wider range of experiences that allows them to put facts into perspective and make comparisons over time, although they have knowledge of more wolves in their area in the present, they nevertheless associate this with a decrease of wolves and wolf predation over time. Even if they do still experience predation and damage in the present, they are more aware of the level intensity of the conflict compared to the past (Røskaft *et al.,* 2007). Unlike the novice, the more experienced shepherd seems to estimate risk, not on the basis of wolf numbers at a certain moment, but rather based on the rate of wolf visits in convergence with the level of damage they suffer in a larger temporal context. This explanation is supported by the fact that in one-by-one regression analysis, there was no significant relationship between the level of experience and the level of perceived risk, but in the multivariate model, the convergence of level of experience with rate of wolf visits and number of loses are positively associated with an increase in reported risk.

As they gather experience with exposure, shepherds also acquire skill and know-how in mitigating the risk and reducing losses. This does not only greatly reduce damage caused by wolves, but is also likely to increase people's confidence, reduce their concern for the safety of their livestock and improve their acceptance. Through the time-tested husbandry preventative measures and active defense strategies they take, more experienced shepherds are very likely to lower the calculated risk and also perceive it lower. Meanwhile the opposite is hypothesized for the notice shepherds. This creates a squeed image of risk, leading to lower risk areas being perceived as higher risk and vice versa. This situation is very well reflected in the distribution of the two types of risk on the map, but also, clearly emerges from the regression model by looking at the negative dependency relationship between the calculated and perceived risk (Table 11).

These results shows that skillful implementation of simple traditional preventative measures can reduce the risk of predation and, over time, reduce concerns around losses, empower livestock producers and thus, raise acceptance levels and enhance cohabiting in the same landscape. Despite the fact that the findings show a general preference of livestock producers to decrease the number of wolves in their area in the future, we can see that the shepherds who were most worried about the safety of their livestock – and thus those who experienced higher rates of predation – were *not* more inclined to have a negative attitude towards coexisting with wolves. Despite perceiving the increased risk, they did not wish for a decrease in wolf numbers.

This is contrary to other studies, which show that people living near wolf populations tend to express more negative attitudes (Llewellyn, 1978; Kellert, 1985; Tucker and Pletscher, 1989; Røskaft *et al.,* 2007; Barmoen *et al.,* 2024). I hypothesize that this could be a function of fear rather than distance. My own findings show that people who did wish for smaller wolf populations, or even no wolves, were those who were most concerned about their personal safety. This is not unique to this research, other studies have also found that the most important variables explaining negative attitudes towards wolves (and all large carnivore species) regarded the concern of the respondents for their own and their family's safety (Røskaft *et al.,* 2007; Barmoen *et al.,* 2024). This finding speaks about the role of fear in influencing people's perceptions and their attitudes towards wolves, and ultimately the coexistence with large carnivores. Fear, and the factors that drive fear, are important to acknowledge when engaging in human-wolf studies. Although this research does not tackle the subject of fear in its full complexity, the results bring to light several important factors that influence fear-related negative attitudes. Similarly to other peer reviewed studies (Bjerke, 2001), the data suggests that age, level of education and the immediate environment of the respondent seem to directly influence these attitudes.

Firstly, we see that people wishing for less or no wolves were those with lower levels of education, suggesting that education also can play a role in reducing fear of wolves, and in better understanding and accepting the presence of wolves in the landscape or the causality of wolf predation on livestock. Scientifically, and from a management point of view, the presence of wolves, and other large carnivores in the Apuseni Mountains and the ANP in particular, is a possible indicator of a relatively healthy environment. It has been shown that higher levels of education can be associated with more knowledge about the importance of protecting and maintaining a healthy environment (Kellert and Berry, 1987). Higher education positively influenced attitudes towards wolves in other studies too (Røskaft *et al.,* 2007) and has been found that poorly educated people have "*higher dominionistic, negativistic and utilitarian views*", while highly educated people show the opposite (Bjerke *et al.,* 1998). Shepherds in particular, and farmers in general, might have a quite different view of what constitutes a "healthy" environment (Kaltenborn and Bjerke, 2002) and this could also be influenced by education.

Surprisingly, results show that people with more years of experience in herding livestock were also more inclined to say that they wish for a lower presence of wolves. Although I did not find a direct correlation between this preference and the age of the respondent, I hypothesize that this might be also a function of age (Bjerke *et al.,* 1998) as age and experience are closely correlated. At the same time, more experienced shepherds had lower levels of formal education. Røskaft *et al.,* (2007) found that people with higher levels of education tended to be more positive, and that people became more negative with age. People from older age groups with more experience in farming may anticipate future encounters and confrontation and a continuous predation of livestock, consequently expecting more damage, hence their wish to have decreased wolf populations in the future (Vittersø *et al.,* 1999). Also, older people may be influenced by already formed attitudes from their earlier experiences that may not fully overlap with current discourses. As shown previously in this discussion, more experienced shepherds predominantly reported a decrease in wolf numbers and wolf predation in recent years which means that the increased wolf interactions they experienced in the past, over the course of many years, could influence their current attitude.

Lastly, results show that respondents who did not trust in the efficiency of official management measures, such as population control and problem animal removal, were more inclined to have a negative position towards coexisting with wolves, meaning they were more inclined to want less or no wolves in their area in the future. This could result from a feeling of frustration or helplessness in relation to official management. Mistrust in the authorities and the management of wolves and generally shepherding related issues emerges from the open-ended discussions with shepherds. More experienced shepherds, with years of frustration behind them, would have less trust in authorities and thus be more negative. These aspects are more widely discussed in the next chapter.

While all these are possible explanations, I hypothesize that one of the most likely reasons behind this surprising finding is of a very different nature, and stems from the process of elicitation itself. I base my argument on behavioral decision research showing that people's preferences are often constructed in the process of elicitation (Slovic, 1995). The way the question is posed, can, in certain situation, even result in "preference reversal" and normatively equivalent methods of elicitation can produce systematically different responses. In closer analyzing the question eliciting these responses – "*would you rather have the number of wolves in your area increase, stay the same or decrease?*" – we see how elicitation bias could influence the response, especially considering that this was the last question of an emotionally-laden one to two hour-long discussion on the topic of conflict with wolves. When a shepherd who has been fighting off wolves for virtually his entire life, and has faced frustration with the management process for an extended period of time, is asked if he would prefer to have more or less wolves around, the answer could very well be strongly influenced by a range of emotions accumulated over the course of the interview and over the course of a lifetime of interaction with wolves. Scientific research shows us that a range of emotional signals – somatic markers – lead normal decision makers to have a reasonable fear of risks (Lerner *et al.,* 2015). Whether they operate at a conscious or subconscious level, emotions powerfully influence decision making (Loewenstein and Lerner, 2003). When faced on a day-to-day basis with recurrent wolf attacks and livestock losses in high-risk areas, the shepherd's natural reaction would be to lower the risk. The science of emotions shows that decision making is a conduit that in normal individuals is aimed at (consciously or subconsciously) avoiding negative feelings (e.g., fear, guilt, regret) and increasing positive ones (e.g., security, pride, happiness) (Keltner and Lerner, 2010). Emotion based decision theory thus leads us to believe that shepherds, when asked if they would prefer a decrease of wolf populations in their vicinity (that undoubtedly brings along a decrease in predation and more security and alleviation to the shepherds), should naturally choose the option that reduces the risk.

Regardless of the true reason shepherd's responses, it becomes clear that there is still much to learn about their attitudes and perceptions. I identify this as an important research gap in the study area and I suggest that an in-depth study of these aspects could start with some of the speculations put forward in the current discussion.

7.4.5. Summary

The results of this analysis show that shepherds' position towards the presence of wolves in the landscape is clearly related to a reaction towards large carnivores and their management. People with a positive position are inclined to accept coexisting with wolves in the same landscape and to let wolves live in their area, even though they might experience some costs, like the loss of livestock and dogs. People perceiving increased conflict on the other hand, are more inclined to prefer to have wolves gone. By having wolves in their close vicinity, shepherds face the experience of predation firsthand and fear for their future or for increasing losses. This is then coupled with people's distrust in the capacity of management authorities to assist in protecting against predators and mitigating losses due to predation, despite people viewing these official preventative and mitigating measures as potentially effective. These negative expectations contribute to negative attitudes towards coexisting with wolves. While this knowledge cannot be used to predict livestock producers' specific actions in specific situations (and maybe not even their attitudes or views towards wolves), the results of this study suggest that we can use this knowledge of people's perceptions to predict how they expect management authorities to act. We can also confidently state that management authorities must consider producers' perspectives, input and TEK (defined here as "know-how") (Durá-Alemañ *et al.,* 2024) alongside with data-based tests of ecological effectiveness of management tools and strategies. At the same time, they must base management decisions not only on spatial risk models, but they should compare risk maps with the perceived risk mapped in collaboration with those directly involved in predation events. Iteratively working with livestock producers can have the added effect of building trust in the authorities, in the management process and in the scientifically proven efficiency of management measures (Volski *et al.,* 2021).

Improving management can thus contribute to better attitudes towards living with wolves and thus can help maintain the fragile coexistence characteristic to this area. At the same time, we must not disregard the broader social and economic context that shapes attitudes towards large carnivores (Skogen *et al.,* 2019) and the wide array of factors that can influence them. Literature has shown that people's views and beliefs on large carnivores they share their space with, are marked by ambivalence, internal dilemmas and ambiguity rather than stable valuations (Skogen *et al.,* 2017) and that human conflicts over large carnivores are rooted in deeper societal tensions, possibly even very little related to the predator species per se (Skogen, 2001, Sjölander-Lindqvist, 2008, Skogen *et al.,* 2008, 2017). The scope of the next chapter is to probe into this broader context and identify the social and institutional factors that further maintain and drive conflict.

8. Identification and analysis of social and institutional factors

Answers RQ 1c. How do social and institutional factors influence conflicts on a local and national level?

The purpose of empirical research examining the *human aspects* of wildlife conflicts is to provide a better understanding of the multitude of socio-political aspects that drive, maintain and/or reduce conflicts. This knowledge is essential for the process of designing and implementing sound mitigation strategies. Successful performance of institutions is a function of *institutional coherence* (Kenworthy, 2006). Working under the *institutional mapping analytical framework*, this research proposes to understand this complexity of human conflict by schematically mapping all the key factors comprising the conflict framework (Aligica, 2006): the key *actors*, the institutional and legislative *arena* in which the conflicts unfold, the manifestation of these conflicts (the *action*) and above all, it intends to identify and map the institutional *processes* for wolf management (e.g. compensation system, population estimation, derogation awarding, overseeing institutions) and the issues that hinder the proper implementation of these processes (see Figure 1 in section 1.5. of Chapter 1).

The nature of this research problem (human-human conflicts: Knight, 2000; Madden, 2004; Dickman, 2010; White and Ward, 2010; Cooney *et al.,* 2015), requires the use of qualitative methods to explore these aspects: interviews, document analysis and personal observation were utilized. This qualitative, interpretive analysis draws from the data in order to gain a synthetic understanding of the situation by offering insight into the institutional processes and the issues that emerge, with the final aim of providing a meaningful guide to action.

8.1. Limitation and issues of reliability and validity

The purpose of this chapter is to complement the knowledge on the multitude of factors that influence conflicts, moving the focus from the biophysical completely into the realm of human interactions that drive, maintain or reduce/amplify conflicts. Because the aim of this chapter focuses on investigating and mapping institutional processes and their role in conflict, the methodology is consequently narrowed to capture these aspects. This research does not employ a full institutional analysis per say, but rather a *process analysis* that employs an in-depth investigation of issues hindering conflict resolution. This research also does not implement an attitude analysis but rather it tries to understand all the different perspectives of the actors involved and their perception of the conflicts.

Interviews were unstructured and semi-structured in nature, limited to the point of saturation and only included a core set of carefully selected interviewees, essential for the research, as discussed below.

This open-ended style of interviewing is criticized to possibly bring more bias and unreliability through reducing uniformity and generalizability (Weller, 1998), but because the aim of this exercise was not to generalize results, but rather to identify key issues that break down the successful flow of conflict management processes and to gain an in-depth understanding of the very complex subject of human conflicts in wolf management, the advantages of using this method outweighed this limitation. The flexibility of the open-ended nature of interviews allows the free flow of ideas, gives the interviewee a chance to shape the discussion and thus allows for revealing ideas that the interviewer might not have thought of.

The unstructured or semi-structured interviewing method can also have the disadvantage of making it difficult to interpret responses or to elicit information without biasing or influencing responses. In order to reduce this possible bias, the central topics and areas of focus were carefully defined within a well-thought-out framework of questions, prior to the interviewing. Research goals and objectives were closely considered while conceptualizing the guiding framework. This clear and concise guide was used during all the interviews to keep focused. Yet, the design of the interviews remained flexible and emerged during the fieldwork, with sample profile and interview focus being altered if information emerged to indicate a change was needed.

As with other non-probability sampling techniques, criterion-based sampling, as employed in this research, can be prone to researcher bias due to the fact that the selection of the sample units depends on the researcher's subjective judgment, the researcher making subjective or generalized assumptions when choosing participants. But because the goal of this analysis is not to make *statistical* conclusions or generalizations, this bias is not of relevant concern here. The criterion-based selection of a core set of interviewees is a purposeful type of sampling that differs from probability sampling of quantitative research in that purposeful samples are generally small in size, and their utility and credibility are questioned on the basis of their logic and purpose (Shaheen and Pradhan, 2019). Criterion-based sampling was ideal for my purposes as it promotes an in-depth analysis of information rich samples while it eases the discovery of major system weaknesses for improvement.

And in-depth, line by line, fully inductive analysis was performed only at the beginning of data analysis, with coding subsequently specializing on identifying actors and issues that occur in processes.

8.2. Methodology

Interviews

Unstructured and semi-structured interviews were conducted with selected members of local communities, representatives of institutions, opinion leaders and stakeholders involved in large carnivore conservation and management (protected area staff, environmental agencies, hunting associations, etc.). A *nonprobability sample* approach (Cornesse *et al.,* 2020) was adopted. The sampling procedure in this case was *criterion-based* or *purposive* (Ritchie and Lewis, 2003; Bryman, 2012; Ritchie *et al.,* 2014) also labelled as *judgement sampling*. This means that the respondents (sample unit) were selected with a specific *purpose*, based on certain *criteria*, such as their involvement in wildlife conflict mitigation, wildlife policymaking, research, and/or wolf management and conservation. A preliminary list of the key actors to be included in the study was initially identified through the literature review and pilot study and subsequently broadened during field work especially through *snowball procedures*. The complete list of actors and their respective roles in wolf management is presented in Table 14 in the next section. A total of 30 interviews were conducted and the interviewing stopped when the *point of saturation* was reached (the point where increasing sample size no longer brings new data) (Ritchie *et al.,* 2014).

A pre-constructed set of topics guided the interviews. The content mainly focused on institutional processes for wolf and human-wolf conflict management; the role of respective actors/organizations in these processes: when, how and with what consequences they are acting;

how they interact with other actors; the issues that emerge in the processes; how and where these issues play into or affect the conflict framework; and general information of the conflict framework: how and with what intensity are the conflicts manifested at the social level and what is the perceived level of conflict?

With the respondents' agreement, the interviews were recorded, then transcribed, translated and finally coded and analyzed (see subsection "*Data analysis"*).

Document and record analysis

A series of official and unofficial documents were used to supplement interviews and field observations and to cross-check the data. These included public conversation threads, legal and policy documents, management plans, relevant reports issued by key institutions (reports on population estimates, habitat support capacity, large carnivore conservation status, etc.), propositions for hunting derogations, action plans and strategies, internal regulations and documents stating roles and responsibilities and official related website and media output. Documents were examined through thematic and content analysis (Joffe and Yardley, 2004) based on the underlying research questions, by focusing on extracting information on actors involved in wolf management; the organizations, their structure and how they function; and the structure and coherence of the institutional processes. The purpose of using this method was to deepen the understanding of institutional policies and practices and to assist in schematically mapping institutional processes and identifying issues. The analyses of these documents can stimulate thinking about the data that is emerging from the interviews. In other words, the aim is to discover additional information to complement the data gathered through other methods and then organize this data into an explanatory scheme.

Participant Observation

Using participant observation can be a method to collect additional data, complementing other methods (formal interviewing and document analysis), by actively observing during informal interviews and other conversations, and taking detailed field notes. This type of observation (Figure 71) can be seen as a method of providing a "written photograph" of the situation under study (Erlandson *et al.,* 1993).

Figure 71. In field observation is especially valuable in these remote alpine landscapes.

An in-depth understanding of the local context is essential for this research, especially for examining the social and institutional environment in which conflicts unfold. During my fieldwork I was immersed in the local context for an extended period (approx. 10 months) and was therefore able to gain valuable knowledge (Figure 72).

Figure 72. Field work in Apuseni Natural Park.

During this time, I kept records of any communication and/or behavior that pertained to the scope of the research questions put forward by this study.

Beginning with early spring and through the end of summer of 2017 I relocated to remote areas of the natural park where I visited pastures and local communities in order to obtain data for the spatial risk mapping (Figure 73). During this time, as part of the face-to-face interviews but also during less formal conversations, I obtained a sense of local people's attitudes and perceptions related to HWC in the area and their concerns and complaints related to the way these conflicts are managed. During the rest of my fieldwork, I was exposed to a different set of perceptions and concerns: those pertaining to officials and institutional actors with roles in the manifestation of conflicts.

Figure 73. Moments from my relocation to the Apuseni Mountains.

The prolonged immersion in the local context and in many informal situations can foster free and open communication with research participants and thus can (i) provide additional information that interviewees would not provide in a formal context, (ii) help gain a better understanding of the local context, perceptions, and ways of seeing and thus, (iii) bring a more in-depth and rich understanding of the phenomenon under study (Cohen and Crabtree, 2006).

Especially in the light of the recent controversial changes related to wolf management happening in the Romanian political context, this form of observation proved to bring very valuable information to this research.

Data analysis

Data collection and analysis were iterative throughout the research. Analysis of the data was performed continuously throughout the enquiry, beginning after the very first interview. This constant iteration provided continuous feedback that helped keep me informed and ensured that I collected meaningful data. This is particularly important considering the complexity of the subject being investigated and the uncertainties it implies. A reflexive stance was maintained throughout the inquiry in order to ensure impartial and accurate interpretation of the findings. This was done through comparative thinking, keeping pace with relevant literature, gathering multiple viewpoints, employing different methods to gather the data (interviews, document analysis and personal observation), interviewing multiple representatives of institutions, being conscious of personal assumptions and maintaining an attitude of healthy skepticism (Strauss and Corbin, 1998).

For the first few interviews, micro-analysis was employed to analyze relevant paragraphs and segments, as this type of very focused, line-by-line analysis is especially important at the inception of the research in order to improve the data collecting process from the beginning, to understand the richness of data that the initial interviewing strategies and questions can bring, to raise analytical sensitivity, to identify the researcher's and respondent's assumptions and the implications of these assumptions. Next the data was manipulated through conceptualizing, defining categories and subcategories, analyzing properties and dimensions, relating categories--in other words, coding (Strauss and Corbin, 1998). Diagrams played an important role in this process, representing a first step towards schematically representing the complex reality of conflicts.

Processes were brought in as an essential part of the analysis. Thus, the analysis looked at action, interaction among actors and contingencies (context) that form the institutional processes around wolf management. The interplay between context (the structure) and action/interaction also represented a main focus, as the two are closely linked, with the context determining a change in the action. The discrepancies in this interplay (when the action of the organizations is not aligned with the present context – the current conflict manifestation) constitute what this research defines as “issues” in the institutional processes. Therefore, coding for discrepancies as per each stage/phase of the processes was an essential part of the analysis.

This allowed me to identify the routine of the action of these institutions that usually leads to their lack of response to change and to discover the conditions which combine to sustain the issues that emerge in the chain of action that constitutes institutional processes. This was done by examining the data in the coding process and looking for: what is the sequence of events in the respective process; in what stage/phase of the process do the sequence of events break down creating issues; who are the actors involved in the action/interaction; what form the issues take; what problems/issues are being answered through action/interaction; is the action/interaction staying the same or changing in response to contingencies; are actions/interactions aligned and coherent; how do the consequences of one action/interaction play into the next sequence of actions/interactions (Strauss and Corbin, 1998). Both micro and macro analysis were used for process analysis of the data.

Examining data for processes has as a secondary beneficial effect, the fact that it brings all the data together, connecting categories, concepts, phenomena and actors (Strauss and Corbin, 1998). An emphasis was put also on further identifying relevant actors in order to complete the map of actors involved in wolf management and also to sustain the snowball sampling procedure by identifying future respondents.

8.3. Results and discussion

In characterizing the human-wolf conflict in Romania, the concept of 'threatened coexistence' is essential to understand. Naturally, there is a difference between how conflicts are manifested in areas where wolves have been extinct for decades and areas where they have continued to coexist with people. In the former, conflicts can be more straightforward and intense, whereas in the latter, conflicts can be much more subtle and very complex. This is the case in Romania, where the visible manifestation of the conflict is only the tip of the iceberg. Underneath lies a very complex web of interactions that has formed over centuries of people and wolves sharing the same landscapes and resources, and yet has seen a number of recent shifts. Many times, it is the symptoms of these conflicts that are more obvious. They emerge on the surface as visible, sometimes intense, manifestations that initially appear to be independent events. The relatively recent complete ban of large carnivore hunting in Romania; street protests to stop exaggerated quota hunting; the increase of wild boar damage perceived by local communities in the Apuseni Natural Park; wolf packs dispersing and adopting new hunting strategies; mass media presenting inflated reports of predation events; outdated hunting-oriented institutions struggling to maintain status-quo; new NGO's and organizations accessing EU funds, lobbying and pushing change to encourage conservation; and top authorities torn between taking contradictory stances - are all good examples in this sense (read more about these subjects in the following sections). These examples, coupled with the observed active changes in wolf management and the very animated and widespread debates around this subject that include the participation of actors from a wide variety of fields (scientists, universities, state institutions, national and international authorities, PA managers, NGO activists, hunting and forestry representatives, livestock producers, local communities and a large number of citizens), show why understanding the overall conflict framework and the various drivers, manifestations and tradeoffs is important but also difficult to fully understand. Grasping the complexity of this issue is the main purpose of this chapter.

Working under the framework of *Institutional Process Mapping* (read more in Chapter 4), the aim of this chapter is to describe the manifestation – and identify the main drivers – of the human-human conflict around wolf management, by identifying tradeoffs and examining and mapping actors and policies, laws and regulations, processes and issues involved in wolf management. This undertaking is particularly timely, as indirect interhuman conflicts seem to gain increasingly larger dimensions than the direct human-animal conflicts, with more significant impacts and consequences on the future of wolf populations and human-wolf coexistence.

In an attempt to simplify this complex reality of human-human conflicts in a form that is easier to grasp, the design of this chapter follows the schematical structure presented in Chapter 1 (Figure 1) based on the concept of mapping, central to this research. The "mapping" process, in this case, aims to set the stage by describing the main *actors* involved in the conflicts (the institutions and stakeholders and their roles in wolf management), the *arena* in which they manifest (the complex set of rules, laws, regulation and international agreements around wolf management and wolf status) and the complex set of *interactions* and *chains of action* that finally shape the conflicts (the current various forms of conflict manifestation and the main conflict drivers). Once the context is portrayed, the chapter then intends to systematically present this information in the form of *process mapping*, a schematic representation of wolf-management-related institutional processes broken down as main steps, issues that emerge and solutions to these issues. Finally, the chapter zooms out to focus on the larger picture, putting these conflicts between people and wolves into a different light by adding a temporal dimension to the analysis. This new perspective brings forth new ideas and unexpected conclusions.

8.3.1. The actors: institutions and stakeholders with role in wolf management

Management of wolves in Romania is approved by the central public authority in the Ministry of Environment, Water and Forests through regional and national Environmental Protection Agencies. The main institutions and agencies directly involved in wolf management in Romania are: protected area managers and hunting grounds administrators; The Ministry of Environment, Water and Forests; local and national Environmental Agencies, the Forest Guard, the National Agency for Protected Areas (formed and dissolved several times in recent years), and local municipalities.

The primary stakeholders in wolf conservation include landowners, livestock owners and farmers, local communities, hunters, scientists, tourists, environmental NGOs, and governmental agencies. For a more comprehensive list of actors directly and indirectly involved in wolf management or HWC, and their function, see Table 14.

Table 14. Actors affecting and affected by conflicts and their functions related to wolf management or HWC.

ACTORS	FUNCTION RELATED TO WOLF MANAGEMENT OR HWC
Ministry of Environment, Water and Forests (ME)	Coordinates and gives decisions on a national level: - approves derogations for hunting wolves - requests studies for population estimates from NEPA (National Environmental Protection Agency) - coordinates and empowers NEPA and its local agencies in giving compensation for attacks
Local Environmental Protection Agencies (EPA's) and the National Environmental Protection Agency (NEPA)	- executes and implements ME decisions; - oversees protected species management; - evaluates projects that might impact on protected areas (PA) and protected species;

	- administrates PAs that don't have custodians (they give custodies) and assure the well-functioning of all others; - has one representative in the committee for assessment of predation (CAD) caused by wolves.
Local public authorities (LPA): local municipalities	- has one representative in the committee for assessment of predation (CAD) caused by wolves - Represent local communities (including livestock managers)
Local hunting ground administrators (usually Hunting Associations) which respond to the National Hunting Council	- are in charge with game species management: decide and approve harvest quotas for game species (these then must be approved by NEPA); establish measures for maintaining ecological stability and for damage prevention; estimate game population status and size; control poaching; etc. - has one representative in the committee for assessment of predation (CAD) caused by wolves
The National Forest Guard	- regulates both hunting and forestry - ensures that hunting is performed according to the law - verifies local hunting ground administrators - sets up feeders, bathers and salt pans - carries out the evaluation, inventory and selection of game - ensures optimal conditions for reproduction and growth - fight poaching by all means
The General Association of Sport Hunters and Anglers of Romania (AGVPS)	- sport hunting - influence prey population abundance and distribution
Local Associations of Sport Hunters and Anglers (AJVPS)	- represent AGVPS locally
National Agency for Payments and Interventions in Agriculture (APIA)	- hold data on livestock effectives - give incentives for grazing livestock (from EU)
Protected Area Administration	- implements measures related to wolf management included in PA management - has one representative in the committee for assessment of predation (CAD) caused by wolves on the territory of the PA
National Agency for Protected Areas (formed and dissolved several times in recent years) (ANAP)	- takes on management of National Parks

Environmental NGOs: - WWF (World Wildlife Fund) Romania - ACDB (Association for the Conservation of Biological Diversity) - Milvus Group - FFI (Flora and Fauna International) - Agent Green - FCC (Foundation Conservation Carpathia) Federation Coalition Nature 2000 (comprised of 22 Romanian environmental NGO's	- informally monitor and influence decisions in wolf management through lobbying and advocacy - perform research and studies - elaborate action plans in collaboration with the ME - can become custodians of PA
Research Institutes/universities - Marin Drăcea National Forestry Research-Development Institute - Forestry Research Institute (ICAS) - Forestry Department of Transylvania University of Brasov (UTB)	- Are subcontracted by the ME to perform annual LC population evaluation studies and establishing hunting quotas; - Cooperate with ME to elaborate plans of measures for LC hunting, as a solution to reduce damage - members of these institutions act as Ministry advisors
The Search and Rescue Service (Salvamont)	- has agents that patrol study area and therefore has a strong knowledge of the local area and local manifestation of conflicts
Local forest units	- have priority in winning custody of PAs if forests cover >50% of PA surface - Can win management of a hunting ground
The Natural Monuments Association of the Romanian Academy	- Reviews the yearly data on large carnivore populations and the quota propositions yielded by the Hunting Associations and decides on the size of the quota that they then forward to the ME for approval
The National Veterinary Sanitary and Food Safety Authority through the sanitary-veterinary and food safety departments;	- has one representative in the committee for assessment of predation (CAD) caused by wolves - implements Ministry decisions on damage causing LC individuals
Local communities, livestock managers (represented by local townships), tourists, scientists	- varied roles in conflicts

8.3.2. The arena: wolf protection status, management and policy

In this section I briefly outline the most relevant laws regulating wolf populations in Romania, as each of these can be easily accessed on-line in their complete form:

- Emergency Government Ordinance OUG 57/2007 on the regime of protected natural areas, conservation of natural habitats and wild flora and fauna;
- Law no. 149/2015 for amending Law 407/2006 on hunting and the protection of the game fund;

- Decision no. 743/2015 on the organization and functioning of the Forest Guard;
- Law no. 5 of the Forestry Code (2008).
- Order of Ministry no. 724/2019 for the approval of the level of intervention in the case of bear and wolf species, in the interest of the health and safety of the population and in order to prevent significant damage.

Also relevant, legislation regarding husbandry practices and livestock protection is represented by law no. 72/2002 and Government Decision HG 748/2002.

Romania is also signatory to several international agreements that have relevance to the conservation of large carnivores:

- Treaty of Accension to the EU:
    - "Habitats Directive" (EU Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora 1992)
    - Nature Restauration Law;
- Bern Convention (Convention on the Conservation of European Wildlife and Natural Habitats, 1979, Bern);
- Carpathian Convention (Convention on the Protection and Sustainable Development of the Carpathians);
- Convention on Biological Diversity (UNCED-Convention, 1992, Rio de Janeiro);
- CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora, 1973, Washington);
- CMS (Convention on the Conservation of Migratory Species of Wild Animals).

Other relevant initiatives and documents include:

- Large Carnivore Initiative for Europe (received official status of a Specialist Group within the Species Survival Commission (SSC) of the International Union for the Conservation of Nature (IUCN) in 2010);
- Action Plan for the Conservation of Wolves (*Canis lupus*) in Europe (Boitani 2000);

- Initiative for Large Carnivore Conservation and Sustainable Management launched by The Directorate-General for Environment is the European Commission (DG – ENV) in 2012;
- The EU Platform on Coexistence between People and Large Carnivores (2014);
- WOLFLIFE, LIFE project in the Eastern Carpathians (2014-2019);
- Key actions for Large Carnivore populations in Europe (2015);
- The LIFE EuroLargeCarnivores project *"Improving coexistence with large carnivores in Europe"* (2017-2022)
- National Group for Large Carnivore Conservation;
- The most recent (yet under approval) Management Plan of ANP (MP 2023) scientifically backed by data obtained through the "Development of tools for the adaptive management of the natural capital in the protected areas Apuseni Natural Park, ROSCI0002 Apuseni, ROSPA0081 Apuseni Mountains - Vlădeasa and ROSCI0016 Buteasa" project, carried out by ROMSILVA.

Subsequent law related to bear hunting, relevant for this research:

- Emergency Decree 81/2021 approved through Law 197/2022 regarding the approval of immediate intervention methods to prevent and combat attacks by brown bears on people and their property, within the urban areas, as well as on the amendment and completion of some normative acts regarding the approval of immediate intervention methods to prevent and combat attacks by brown bears on people and their assets, within the urban areas, as well as for the modification and completion of some normative acts.
- Order of Ministry no. 723/2022 for the approval of the level of intervention in the case of bear species, in the interest of the health and safety of the population and in order to prevent significant damage.
- LAW no. 242 of July 23, 2024 to complete art. 1 of the Hunting and Hunting Fund Protection Law no. 407/2006, as well as for the amendment and completion of the Government Emergency Ordinance no. 81/2021 regarding the approval of immediate intervention methods to prevent and combat attacks by brown bear specimens on people

and their property, as well as for the modification and completion of some normative acts.

Wolf status in Romania has oscillated widely in the last 50 years and is under active change, even today. In conformity with European legislation, wolves in Romania are currently listed in the national legislation as a protected species, meaning that hunting is forbidden (exception only when state authorities issue special derogations). The legal status of wolves in all European Union countries is directly specified in the Habitats Directive (92/43/EEC) as a priority species and most countries have integrated this directive into their own national legislation. This is also the case of Romania. By default, wolf populations are listed under Annex II – which requires the establishment of Natura 2000 sites for protecting the habitat of the species – and Annex IV which requires strict protection, prohibiting any destruction or damage to wolf populations (but with derogations still possible under Article 16) (Kaczensky *et al.,* 2012). All special derogations issued for hunting wolves must be based on sound baseline data obtained through a coherent methodology.

8.3.3. The process: issues that hinder institutional processes

In this section, I attempt to compile the outcomes of this study in a systematic way and, under the concept of "mapping", schematically represent my findings in a form that allows for the understanding of how and where the institutional processes break down, what issues were identified and how these issues become drivers of conflict. At the same time, I also show solutions (identified both through the interviews, but also through personal analysis) that could help improve each process by addressing issues as they emerge in each step of the processes. These solutions could be seen by managers as management recommendations that, if used synergistically, could help mitigate conflicts. Managers should keep in mind that these recommendations should be constantly adapted to the specific context of each particular case and constantly updated in response to any changes that come up. This is particularly true in the Romanian current context of rapid and constant change in the management of large carnivores. For this exercise I use the model put forward by Anthony *et al.,* (2010), where the authors similarly use a schematic representation to compile detailed data on institutional roles and the effectiveness of policies and practices of controlling damage-causing animals at Kruger National Park and Limpopo Province (South Africa) while also offering recommendations on alleviating conflicts in the respective context. I propose a similar schematic representation of the main processes in wolf management (Population evaluation; Quota awarding; Management of Livestock grazing and Subsidies; Prevention, Compensation, Mitigating poaching; Managing Environmental Disturbance and Managing Protected Areas) broken down in a step-by-step analysis of procedures, issues that become drivers of conflict and solutions based on good practice in carnivore management.

Evaluation of wolf population and Quota awarding

Despite all the legal requirements for wolf management in the last decades, wolves in Romania, until 2017, were still hunted in significant numbers through an annual derogation quota approved by the Ministry of Environment through a Ministry Order. The procedure took into account data (collected through monitoring performed by the hunting units) regarding annual population estimates, environmental carrying capacity and annual level of damage. Thus, every year, special hunting permits were issued for each hunting unit, allowing the culling of several hundred individuals of wolves, bears, lynx and wild cats (Maanen *et al.,* 2006). This was done using a loophole in the law, as derogations are allowed by the Habitat Directive that approves eliminating special case damage causing animals (Dale-Harris, 2016). This worked as an exception to the national law and the EU Habitat Directive, officially intended to keep wolf and other large carnivore populations at an optimum size. But the processes of evaluating the optimum size of populations and their estimation, have been found to show several methodological flaws, lacking scientific oversight and rendering biologically unrealistic and unreliable data (Popescu *et al.,* 2019). This led to national debates and a reform of the law in 2016, forbidding LC hunting until a new methodology would be devised and implemented. Nevertheless, exceptions to the law were soon approved once more and, as a consequence, special derogations are again issued on an annual basis using the same outdated methodology.

Double counting and intentional overestimation are two of the main issues raised about this estimation methodology. At the same time, the methods used and the results of these estimations are not always transparent (Salvatori *et al.,* 2002; Duncan 2011; Popescu *et al.,* 2016) and the estimation process is carried out by the same institution that manages hunting (Cazacu *et al.,* 2014), hinting at a conflict of interests. In accordance with Art. 2 of the Hunting Law no. 407/2006, game is a renewable natural resource, a public good of national and international interest, and administered by the central public authority responsible for hunting. The management of wild game is ensured on the territory of hunting units by licensed legal entities, at their own risk and responsibility, based on the management contracts concluded with the specialized territorial structures of the central public authority responsible for hunting. Simply put, the state game managers forward management of game to the hunting grounds, run by an administrator, usually a Hunting Association that won the bid to manage the respective territory. This management comes in the form of monitoring game populations, assessing population size, proposing hunting quotas, and allowing a certain number of hunters each season to cull game within the limits and the conditions approved withing the quotas. As a consequence, the hunting associations are the direct beneficiary of the revenues that come from the hunting activity (Popescu *et al.,* 2016), thus constituting a prima facie case of conflict of interest. Wildlife expert at NGO 1 warns of the illegal practices that can arise from this flaw in the methodology that allows pursuing personal interests: "*In practice, they shoot twice as much as they have quota, who checks them?! The hunting guard is part of it too!". "These derogations, in my opinion are masked hunting*", agrees a university professor, NGO activist and member of the Romanian Academy. Hunters themselves agree with the dysfunctionality of this system: "the evaluations are fictitious, they have nothing to do with reality". They admit to this conflict of interest in their declarations: "*we make some [money] from the quotas they give us."*

Hunting in Romania has been operated for decades as a significant revenue-producing activity for both the public and for private businesses (Sparks, 2005; Popescu *et al.,* 2016) and sport hunting from foreign hunters may represent a significant source of income for game managers (Salvatori *et al.,* 2021). Over the last decades, this has grown into a "multimillion-euro industry" with hunters from all over the world paying considerably large amounts of money to hunting associations in order to claim a trophy from the Carpathian Mountains of Transylvania (Dale-Harris, 2016). "G*ermans. They pay 3000 euros per [deer] trophy. […] For a bear it would be up to 10.000 euros*" confirms the member of one of the hunting associations. The income from this trophy hunting goes directly to the Hunting Ground managers (Salvatory *et al.,* 2021). This fact is again confirmed by hunting association members themselves: "*No, they pay <u>us</u>. We need* *to make some savings too*." The state authorities also gain from this as part of the cost for the trophy hunting go to them too.

The official population estimation reports that hunting institutions issue and send to the government for approval of hunting derogations greatly differ from parallel specialist estimations which find that wolf populations are approximately 25-30% lower than the official numbers[15]. For example, the annual report issued by the hunting administration for 2015 shows an estimated number of 5772 wolves living in Romania[16], while literature in the field and individual reports[17] show approximately half that Figure, with an average of 2750-3000 wolves (Linnell *et al.,* 2003; Maanen *et al.,* 2006; Kaczensky *et al.,* 2012; Blanco and Sundseth, 2023). The same annual report proposed, based on this estimation, 919 wolves to be approved in 2015 for hunting through derogations for population control purposes. The governmental agencies that then evaluate these reports decided on a number of 600 wolves to be hunted through the government-issued hunting quotas (Figure 74).

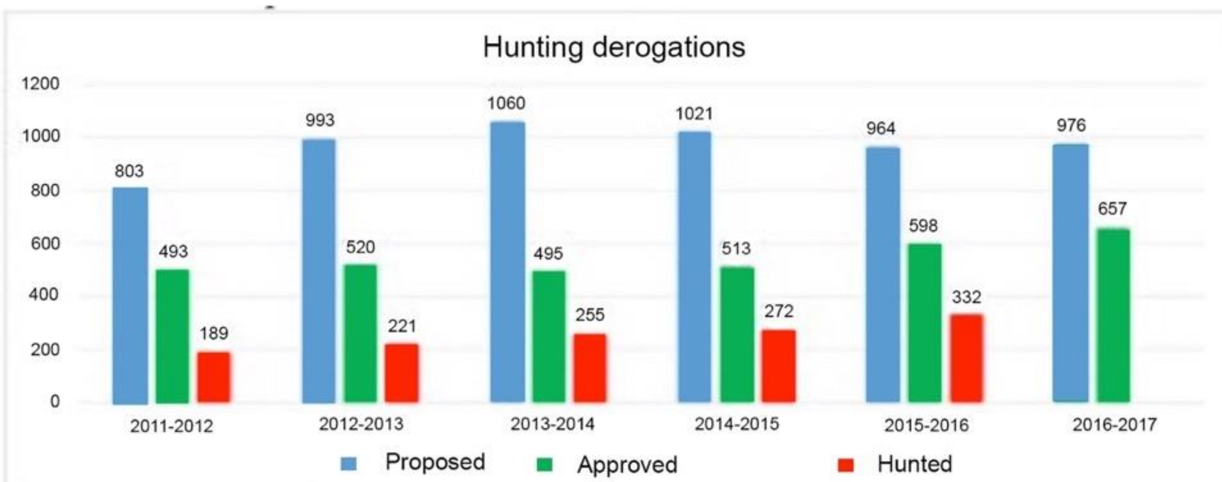

Figure 74. Derogations issued for wolf hunting between 2011-2016 (NAPW, 2018).

15 *The status of wolves and bears in Romania* in *improving the conditions for Large Carnivore Conservation* at http://www.lifextra.it/index.php?option=com_content&view=article&id=62&Itemid=69&lang=en

16 8) Official report for estimations of large carnivore and wild cat populations: *Centralizatorul efectivelor de ras, urs, lup si pisisca salbatica evaluate în 2015, comparative cu cele evaluate în 2014, al realizărilor cotelor de recoltă aprobate pentru sezonul de vânătoare 2014/2015 şi al propunerilor de cote de recoltă pentru sezonul de vânătoare 2015/2016, pe fondurile de vânătoare*. [in Romanian]

17 Individual report for estimations of large carnivore and wild cat populations for 2015-2016 issued by Transilvania University, Brasov: *Studiul privind estimarea populaţiilor de carnivore mari şi pisică sălbatică din România (Ursus arctos, Canis lupus, Lynx lynx şi Felis silvestris) în vederea menţinerii într-o stare favorabilă de conservare şi pentru stabilirea numărului de exemplare din speciile strict protejate care se pot recolta în cadrul sezonului de vânătoare 2015-2016*. Brasov, Romania. [in Romanian]

Between 2010 and 2016, a minimum of 160 and a maximum of 332 wolves per year were hunted legally in Romania, amounting to a total of 1429 wolves (representing approximately half of the total population at the time) for this entire time frame (NAPW 2018). Based on the recommendations of studies requested by the public authority, on average only approximately 20% of the numbers proposed by hunting grounds were approved for culling each year through special derogations. But even so, from 2010 to the end of 2016 there has been an increasing trend of the number of wolves approved and hunted each year (Table 15), reaching as high as 20.9% of the estimated national wolf population approved for culling in one year and as high as 11.6% of the wolf population culled on this basis in one year (NAPW, 2018). After the ban of 2016, wolf hunting is forbidden, yet a significant number of wolves continue to be hunted each year (97) as "exceptions" under special derogations for DCA.

Table 15. Approval of quotas and culling of wolves during 2011-2016 (NAPW - National Action Plan for Wolves, 2018).

Hunting season	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016
Approved - % of estimated population*	19.6	19.2	17.2	18.3	20.9
Culled - % of estimated population	7.4	8.1	9.0	9.7	11.6
Culled - % of the maximum number approved by the central authority	37.9	42.5	51.5	53.0	55.5

**estimated size of the wolf population reported annually by the Ministry of Environment*

Whether they are the product of a methodological flaw or the consequence of personal interest at an individual or institutional level, the population estimates fuel nationwide debates and act as important institutional drivers of the interhuman conflict. Studying and understanding these issues becomes essential because they lay at the core of the human conflicts around wolves. In this case, for example, the hunters enter into competition with wolves for game populations and this competition is one of the main drivers of this conflict, especially when considering that the public and private game managers are beneficiaries of revenue from hunting activities. The presence of wolves in a certain area contributes to decreasing the hunting quotas for game species in that area. Therefore, hunters can have more negative attitudes and believe that wolves are directly reducing the hunting quotas, while they are also over-predating the game fauna.

To act as an independent objective institution, the Romanian Academy, through a Special Commission, is charged with analyzing all the relevant data and making an objective decision on the size of the quotas to be approved each year. In making an objective decision, the Academy should take into consideration independent studies of wolf population and environmental carrying capacity and level of damage and compare them to the data yielded by the hunting units. But in the context of a general lack of any independent and objective nationwide data, and in the context of a lack of will to do so, it becomes obvious that there is a need for reform.

Figure 75 summarizes the main issues that emerge in this estimation and derogation approval process. An overall look at this list reveals that the main issue is the lack of sound, country-wide data on wolf population parameters. Despite the fact that Romania, as an EU Member State, is obliged to monitor the status of the species listed in the Habitats Directive, wolf population status is assessed mostly on the basis of estimates made by hunting associations without reliable monitoring and knowledge of basic population parameters (Sin et al., 2019), pointing at the fact that these methods may lack the power to detect population trends, impacts of hunting and other sources of mortality (Treves and Karanth, 2003), thus risking to result in over-mortality and affect long-term population viability (McLoughlin, 2003). These facts suggest a lack of capacity for science-based population management (Popescu *et al.,* 2016).

Every hunting ground evaluates carnivore populations based on snow tracks on one single day a year, "*and we believe them, as if it's so easy to evaluate wildlife populations*" says a university professor, NGO activist and member of the Romanian Academy of Science. "*We <u>have to</u> believe their word, because there is no way to verify the validity of these facts*" adds the Commissioner of the National Environmental Guard. "*I don't find the evaluation to be very scientific, they see the same tracks multiple times*" continues the interviewee explaining that, because each hunting ground chooses different dates to do the evaluation, the same individuals are counted over and over again leading to exaggerated population estimates and thus, to improper, and even dangerous management: "*Five hunting grounds report the same five wolves, 5x5, 25 wolves, can you imagine?! So, let's see, how many should we approve [for culling]? Well, let's approve a fifth: 5… so you end up shooting all of them!*". Whereas this interviewee considers it "*a methodological flaw*", other voices warn of an intentional tweaking of numbers: "*The administrator of the hunting ground has an interest in increasing numbers. […] Their interest is to perform the evaluations in such a way that they receive their quota"* declares the biologist at a regional EPA. “*They count the same individuals twice, three times, four times. […] Their interest is also to overestimate in order to ask for a higher quota. That's why this happens*.” agrees the wildlife expert at NGO 1. Hunters themselves admit that the evaluation process is flawed and that the numbers are overestimated: “*[the methodology] is not ok*” says a hunting guard, “*we know wolves wander a lot. If in my terrain we find five wolf tracks and in my neighboring unit we find also five, that doesn’t mean we have ten wolves, we have five*”.

The general lack of official consensus on population parameters continues today, as the numbers put forward in various official documents vary considerably. There is an impending need for *“more studies and [focus on] the reality on the ground, not what we do on paper… [we need] to be able to monitor and see that reality in the hunting ground, not with what they force us to see...”* (Private Hunter 1).

Yet, despite the lack of robust data, the official discourse informing the general population, promoted by top authority figures is that the number of wolves and bears, is “too high” and overweighs the environmental carrying capacity leading to increasing attacks on livestock and people and the habituation of bears to people and their settlements. Identifying LC as “threats”, authorities promote population control through hunting as the only viable solution. Such practices are misleading, as one would need to have a clear image of all biological population data to make such claims. Even more, EU level studies have found that lethal management has no or little positive effect and even counter-intuitive effects on wolf and bear livestock predation (Blanco and Sundseth, 2023). Lethal control in the case of wolves, can lead to de-structuring packs, thus even leading to increased predation rates (Peebles *et al.,* 2013; Lorand *et al.,* 2022; Elbroch and Treves, 2023).

All these issues point at the fact that “*wolf management [in Romania] has been based more on perceptions rather than real data*” (NAPW, 2018). The misguided management strategies we see today highlight this gap in data and the need to infuse scientific research into large carnivore management (Popescu *et al.,* 2019). When monitoring is inadequate, data on animal abundance is poor, decisions are sometimes made without adequate scientific rigor (Artelle *et al.,* 2014), and management agencies benefit from hunting revenue, hunting may promote unsustainable mortality levels (Treves, 2009) with dire consequences to the long-term sustainability and viability of large carnivore populations (McLoughlin, 2003; Popescu *et al.,* 2016).

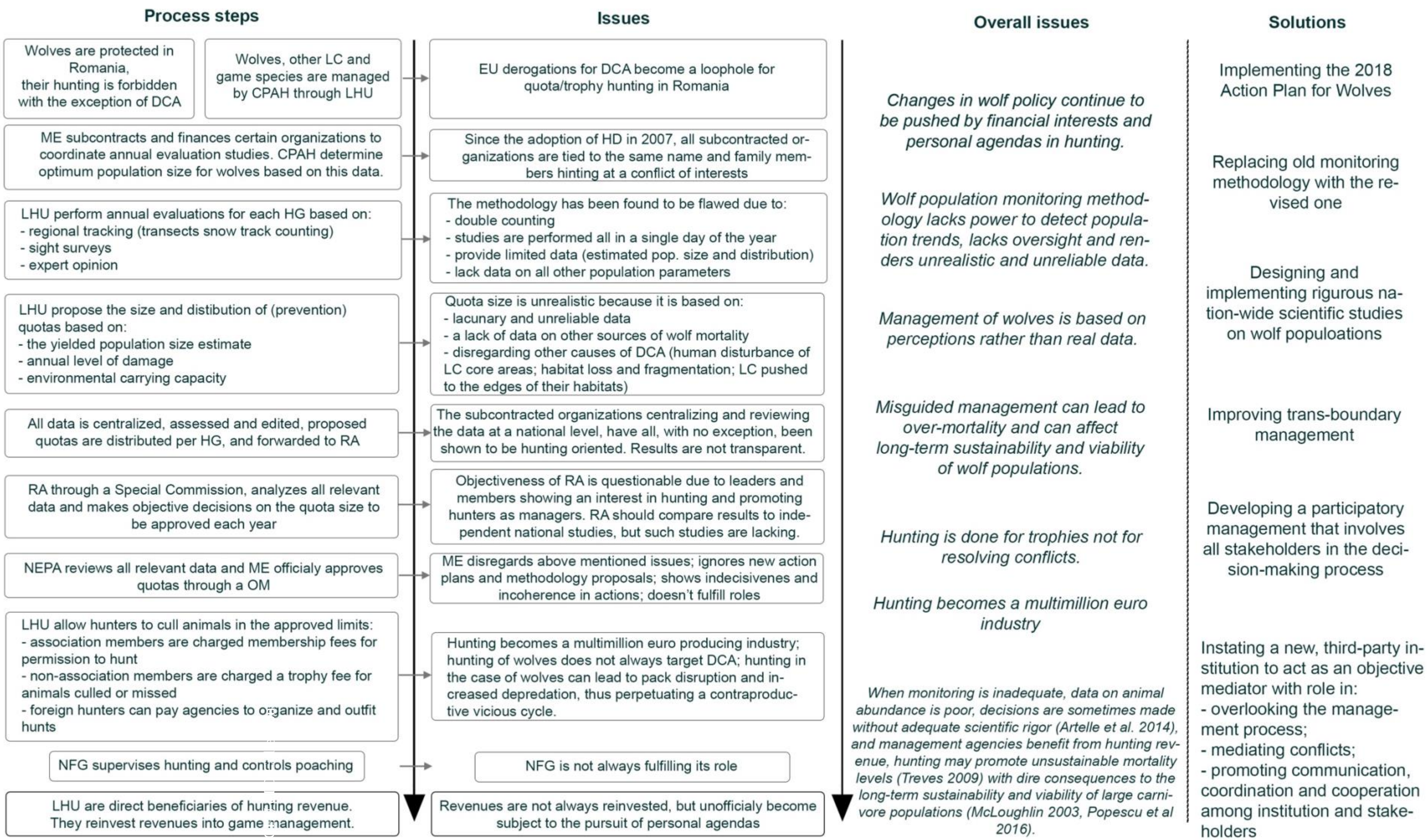

Figure 75. Steps of the Population Evaluation and Quota Awarding processes, issues that arise in each step, an overlook of the main issues and proposed solutions. Abbreviations: DCA (Damage Causing Animal); LC (Large Carnivores); CPAH (Central Public Authority for Hunting); LHU (Local Hunting Units); HG (Hunting Ground); RA (Romanian Academy of Science); NEPA (National Environmental Protection Agencies); ME (Ministry of Environment); OM (Order of Ministry); NFG (National Forest Guard)

Management of Livestock grazing and Subsidies

Policies regarding livestock rearing and grazing play an important role in the manifestation of conflicts. Agricultural subsidies paid to livestock producers encourage the increase of livestock numbers.

Data issued by the National Agency for Payments and Interventions in Agriculture (APIA) show that the number of livestock in Romania has significantly increased in recent years, with the number of sheep and sheep owners doubling during 2007-2013. This increase can be correlated with the similar increasing trend of the subsidies offered per capita for sheep during 2007-2012. The number of livestock has continued to increase over the past decade, reaching a total of approx. 12 million sheep and goats individuals in 2023 according to the National Institute of Statistics (NIS, 2024). According to Eurostat (2024), this puts Romania on the second place in the EU for both the number of sheep and goats (second after Spain) but also for the density of these livestock per 100 ha (second after Greece). Even more, livestock owners also receive subventions for pastures owned or leased in alpine areas. All these incentives, coupled with the monetary benefits livestock producers in alpine areas gain from livestock rearing (sheep and goat milk is 6 times more expensive than cow milk according to the park management) and the traditional practice of transhumance, greatly increase the number of livestock grazing in or close to wolf habitat.

Subsidies are offered only to individual enterprises and family farms, authorized physical persons who keep a producer certificate for animal breeders and juridical persons dealing with animal farming (Popescu *et al.,* 2023). Subsidies are offered as direct payments in conformity with article 37 of EU regulation no. 1307/2013 by APIA which is a Romanian agency functioning under the Ministry of Environment that manages the European funds for implementing support measures financed through the European Agricultural Fund for Rural Development (EAFRD). EAFRD is a European funding mechanism which was set up for the financing of Rural Development Program actions by the European Union Council Regulation (EC) No. 1290/2005 of 21 June 2005 on the financing of the Common Agricultural Policy. The objective of the EAFRD is to contribute to the competitiveness of agriculture, the sustainable management of natural resources and climate action, as well as to the balanced territorial development of rural areas.

This situation reflects an antagonism between two different stated government and EU policy objectives: on one hand EU Directives aim to conserve large carnivore populations and their habitat while on the other hand EU subsidies for agricultural development in rural areas encourage livestock grazing in the proximity of wolf habitat (Figure 76).

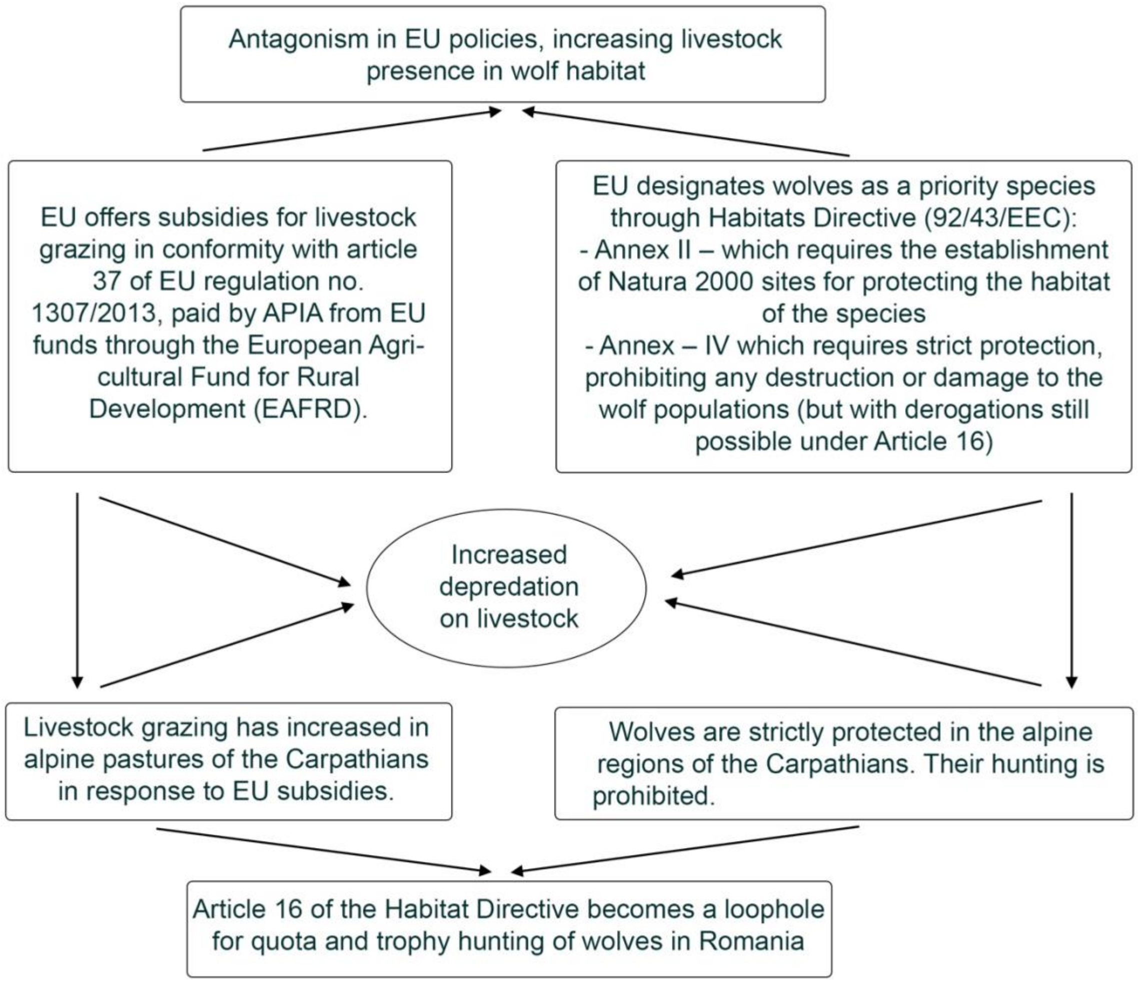

Figure 76. Incoherence in EU policies leads to increased predation and conflict.

In other words, "*the EU puts sheep into the wolf's mouth*" says a member of the Romanian Academy of Science. "*This is not a theory but a reality*!" confirms the national wildlife and protected area expert of NGO1.

To compensate for increased predation, the European Commission has elaborated *Guidelines for State aid in the agriculture sector*, requiring member state authorities to implement national compensation schemes to partially - and more recently (2018), fully - cover both direct and indirect costs brought to livestock owners due to damage caused by LC and for protection measures to prevent future damage. But the funding for these payments is required to be supported by Member States from the budget of national and regional government, with the exception of funding for costs of prevention measures, that can be co-financed by EAFRD. Yet, lack of funding is a major source of institutional incoherence in Romania (and not only there), and a main driver of interhuman conflict at both government, institutional, organizational, and personal level. As a consequence, payments are often delayed for long periods of time and the applications procedures are perceived as overly complicated by the locals. These aids are sometimes not enough to help the livestock producers. Producers don't have enough financial support to sustain investments for modernization of the livestock sheds and improve technical endowment.

In parallel with these issues, the compensation process in Romania only exists in theory, but is not functional in reality (see following subsection "Compensation"). In a snowball effect, this leads to a dysfunctional, chaotic and incoherent implementation process of compensation schemes, conflict among institutions, and a perception of injustice, mistrust in authorities and increased negative attitudes on the part of local communities, livestock producers and even hunters, both towards wolves and management authorities, further possibly leading to retaliatory responses.

"It wouldn't bother me, believe me, I wouldn't do any more hunting, but then protect the wolf – God bless the wolf – why don't you keep it as special conservation area? Why do you let the livestock graze there? So, you don't let me hunt, because it's forbidden in that area – the deer breed there and everything is protected – but then why do you let them graze? [...] But it's easy to do on paper. [...] And then they say they protect. What the hell are they protecting? They are not protecting anything, they are only protecting some papers that they make. They have 5 employees and one secretary who have to do something, right?" declares in frustration the manager of a hunting ground overlapping a large area of the park. *"[We need] managers to be in sync with the reality in the field"*, continues the hunter.

Compensation schemes today, counterproductively, become drivers of conflict, as does the subsidy system. The difficulty in meeting requirements, the overly complicated application process and delayed payments add to people's frustration and mistrust in management authorities. "*We keep raising sheep, but we don't know why*" says the member of the Romanian Academy. "*Other than cheese, nothing is used, so why do we raise them?*" comes the question. And the answer follows: "*So that some private owners can get their subventions*".

Thus, through an antagonism in these regulations, the EU creates a situation that acts as a driver of human-wolf conflicts in Romania and presumably, also in other Member states characterized by low financial capacity. Also, this situation shows how institutional decisions and policies can influence conflict and highlights the importance of identifying and anticipating the various tradeoffs in order to fully understand and mitigate conflicts.

Prevention

The main legislative document regulating management of damage caused by wolves and other LC in Romania is Government Decision no. 1679/2008 brough to Hunting Law nr. 407/2006, that establishes the conditions for granting compensation. Prevention is mentioned as a prerequisite for receiving compensation. Prevention is required both on the part of livestock producers, but also on the part of the hunting administrators responsible for game management on the territory of the hunting grounds where wolves are present (see requirements in Figure 77).

In terms of prevention measures for wolf depredation, the law requires:

Livestock owners to:

- ensure the protection of livestock during grazing or during other livestock rearing activities;

- use only permitted areas for livestock grazing, according to the law;

- shelter livestock at night only in designated guarded enclosures;

- move livestock through the forest to the grazing and watering places only on the routes established for this purpose, by mutual agreement, with the respective game management authorities.

Game managers to:

- develop management plans for maintaining optimal level of wolves;

- fully harvest the quota for DCA wolf individuals, as approved by the CPA;

- remove DCA individuals in areas with high risk of depredation or upon notification of the livestock owner, with a minimum 24 hours prior notice to CPA;

- request, in line with the law, the necessary approvals for granting, redistributing or supplementing harvest quotas for DCA for hunting outside the legal periods;

- to cull DCA that cause damage or that may cause damage, in affected areas.

Figure 77. Prevention measures for wolf predation required through law.

This is where any official mention of prevention stops. In fact, the “prevention” measures required from the official authorities are not truly prevention per se. On the contrary, all of these official measures refer to culling wolves as a means of avoiding loss, the very opposite of what true prevention should mean: deterrence. In fact, through these legal requirements, central public authorities for hunting and for environmental protection seem to disregard the importance of the latest developments in the field of good practice in management of wolf and other LC populations. The most recent study elaborated by the European Commission on LC management clearly shows that there is a general lack of evidence that lethal management has a significant effect in minimizing wolf predation on livestock. Even more, lethal control has been shown to have counter-intuitive effects, especially in the case of wolves, as it can lead to de-structuring packs, thus leading to increased predation rates (Blanco and Sundseth, 2023).

The legal requirements fail to mention any of the essential, state of the art preventative measures existing today to protect sheep stock from predation by wolves (Table 16): net wire fences and electric fences, fladry and electrified fladry, flashing lights and siren devices and other alarm or scare devices, Rad boxes, shock collars and other deterrents (Bruns *et al.,* 2020).

Table 16. Non-lethal management and prevention tools identified so far (Shivik, 2004; Bangs et al., 2006; Gehring et al., 2006; Bruns et al., 2020).

CATEGORY	TOOLS
Livestock guarding dogs	Specialized livestock guarding breeds trained by livestock manager
Human presence	Increasing human presence; all-night presence in high-risk periods such as calving
Husbandry/livestock management practices	Reducing attractants; Calving control; switching or changing pasture us; night feeding; changing herd structure; etc.
Hazing or physically scaring wolves	direct harassment of wolves with the intent of frightening by means such loud noises (e.g., air horns), firing shots in the air, spotlights or other confrontation with wolves.
Barriers and exclusion	Fencing (nighttime enclosures, electric fences, electrified fladry)
Alarm or scare devices	RAG (radio-activate guard) boxes; Alarm and flashing lights devices; Fox lights; radios; music players, etc.
Experimental practices	Shock collars; bio-fencing
Translocation	Relocating DCA

For the time being, most of these methods are not available in the mountainous landscape of the Romanian Carpathians. In part, this is due to lack of financial capacity, both on the part of livestock managers, and on the part of managing institutions and authorities. Yet, in an effort to compensate DCA losses in the context of wolf recovery and return to Europe, the EU offers the possibility of co-financing the implementation of prevention schemes for Member States under the EAFRD funding mechanism. The lack of attempts to access these funding sources on the part of central public authorities points, once more, at a lack of interest in non-lethal preventative management practices and seems to stems from a weak capacity to implement EU regulated conservation measures and a general poor institutional capacity of national institutions to implement proper wildlife management measures.

Despite this weakness at an institutional level, NGO and private conservation activist groups lobby for the introduction of such prevention measures, in the scope of pushing wolf and other LC management towards more sustainable goals based on non-lethal tools rather than control through hunting. Electric fences are the main such non-lethal prevention tool in the course of being introduced to livestock producers in the Romanian Carpathians. In the scientific literature, electric fences have been found to be the most promising prevention measure, especially in combination with fladry and electrified fladry (Bruns *et al.,* 2020). Regulating the use of electrical fences, raising awareness on the efficiency of these measures and offering financial support and compensation for livestock managers in installing and using fences are the main points activists are lobbying for. NGO's who are making efforts in this sense, argue that electric fences could greatly reduce losses brought by wolf predation, particularly if installed around the nighttime enclosures, thus representing a major improvement to the personal preventative measures taken by shepherds.

In my research (Chapter 7) I have found that electric fences are desired by just a handful of shepherds in theory but considered not implementable in practice, mainly due to a perceived lack of capacity or will of authorities. Within the same analysis I have found that the preventative measures and the TEK of the shepherds helps prevent most kills, despite a large number of unsuccessful wolf attacks. The most efficient preventative measure, according to the perception of shepherds directly involved in wolf conflicts, are livestock guarding dogs and the presence of humans. The results of my own data analysis, point to the same thing: the Integrated Antipredator Response of the Human-Dog-Livestock System was shown to be the most important and efficient prevention measure, while also being one of the oldest prevention practices, naturally evolved and tested over centuries of interaction between people and wolves.

The presence of people, dogs and fenced nighttime enclosures are the top choices of respondents in my study. Flock management, removing attractants and avoiding high-risk areas were next on the list. Although official prevention management measures were generally considered effective, there was a general disbelief in their proper implementation in practice, most likely stemming from the same lack of trust in authorities.

Even though prevention measures are only marginally mentioned in official regulatory documents, and official management authorities fail to implement or compensate for such measures, traditional preventative behavior leads to significantly lower levels of predation in Romania compared to other similar landscapes where these are not practiced.

Clearly, this system can be improved with adjustments such as taller fences for the nighttime enclosures, exclusively using authentic flock herding and guarding dog breeds, maintaining an optimum number of dogs, and ensuring permanent presence of people in high-risk situations and locations. But regardless, the system has proved its efficiency over centuries. Shepherds feel very strongly about these prevention measures and consider them the best line of defense against wolf depredation. Based on their know-how and TEK in shepherding, and dealing with wolves, they also identified a truly wide array of factors influencing predation (see Table 13 in the Results section of Chapter 7). Further researching these factors and including some of them into preventative strategies has great value.

Compensation

The main institutions involved in LC damage management in Romania are local public authorities (LPA's), sanitary-veterinary authorities, managers of hunting units, the Agency for Environmental Protection, the Forest Guard, the Ministry of the Environment and managers of PA's (when predation occurs in a PA). Compensation in Romania is awarded only to proven cases of predation through a national compensation scheme coordinated by the hunting administration and regulated through Hunting Law nr. 407/2006. The methods of ascertaining damage and granting compensation are currently established by Government Decision no. 1679/2008. The financial costs of compensations for the damages caused by LC are supported by the central public authority for environmental protection (The Ministry of Environment) from a budget approved for this purpose, unless the manager of the hunting unit in question, did not fulfill his obligations for the prevention of damages.

The same law stipulates that livestock owners can only benefit from this compensation if they fulfill their obligations for ensuring prevention and protection. Thus, livestock owners need to: (1) prove the ownership of livestock; (2) ensure the protection of livestock during grazing or during other livestock rearing activities; (3) use only permitted areas for livestock grazing, according to the law; (4) shelter livestock at night only in designated guarded enclosures; (5) move livestock through the forest to the grazing and watering places only on the routes established for this purpose, by mutual agreement, with the respective game management authorities. If the flock is located on the territory of the park, in addition to these obligations, the livestock owner must also obtain authorization for grazing on park land from the park management and inform the park of the location of the sheepfold.

These stipulations of the law were established as a means to translate EU imposed regulations related to the compensation system. The EU requires Member States to provide the funding source necessary to cover both direct and indirect costs of compensation, apart from prevention that can be co-financed by the European Commission through EAFRD (Figure 78).

But, in an effort to comply with the EU standards, this system most often becomes inefficient due to misinformation, lack of funding, weak institutional capacity to implement the process and the complicated nature of the procedure for reporting and confirming predation events (DE) (Figure 79).

The national population evaluation reports show that out of 839 cases of LC predation events reported during a period of one year (2015-2016), only 218 (~26%) were accepted as complying with EU standards and compensated[18]. Also, the compensated amount reaches the owner only after a long period of time, sometimes as much as 3-5 years (Wildlife expert, NGO1). In this situation, many people might refuse to report an attack, and thus the actual number of conflicts might be much higher than official reports show (Madhusudan, 2003; Choudhury, 2004; Anthony *et al.,* 2010; Karanth *et al.,* 2013). Even more, there are also cases when people do not

[18] Individual report for estimations of large carnivore and wild cat populations for 2015-2016 issued by Transilvania University, Brasov: *Studiul privind estimarea populaţiilor de carnivore mari şi pisică sălbatică din România (Ursus arctos, Canis lupus, Lynx lynx şi Felis silvestris) în vederea menţinerii într-o stare favorabilă de conservare şi pentru stabilirea numărului de exemplare din speciile strict protejate care se pot recolta în cadrul sezonului de vânătoare 2015-2016*. Brasov, Romania. [in Romanian]

report attacks because they are illegally grazing livestock in restricted areas, or because they are lacking paperwork or authorizations, thus not fulfilling their obligations stipulated by law.

	Compensation for direct costs
Compensation covers	Damage for animals killed, plants destroyed. Material damage to: farm equipment, machinery and farm buildings and stocks.
Funding source	Member State financing only (national / regional government) under de minimis or through a State aid notification.
Permitted % support until 2018 amendment	100% of market value of animals or plants. Repair cost or economic value of the affected asset before the event that caused the damage.
Permitted % support after 2018 amendment	No change.
	Compensation for indirect costs
Compensation covers	Veterinary costs from the treatment of wounded animals. Labour costs related to the search for missing animals.
Funding source	Member State financing only (national / regional government).
Permitted % support until 2018 amendment	80% of total costs.
Permitted % support after 2018 amendment	100% of total costs.
	Prevention measures
Compensation covers	Costs associated with prevention measures such as fencing, livestock guarding dogs or shepherding.
Funding source	EAFRD co-financed with national / regional budgets. Or Member state financing only (national / regional government).
Permitted % support until 2018 amendment	100% if under non-productive investment measure or agri-environment-climate measures within Rural Development Programmes (co-funded by EAFRD). 100% if under de minimis. 80% if notified under State aid – 100% for collective investments.
Permitted % support after 2018 amendment	100% if under non-productive investment measure or agri-environment-climate measures within RDPs (co-funded by EAFRD). 100% if under de minimis. 100% if notified under State aid.

Figure 78. Prevention measures for wolf predation required through law.

Most often, the true reason behind not reporting predation events is a lack of information, the difficulty of the process and a general mistrust in authorities.

This mistrust in the authorities, and the negative attitudes that come along with it, stem from the perceived inefficiency of the compensation system; from the overly complicated subsidy awarding system that leads to frustration due to bureaucracy, strict regulations and late payments; from lack of information from the authorities; and from the lack of involvement of livestock producers and local communities in a participatory decision-making process and from a general mistrust and frustration of people with the local authorities.

> *"We [the Commission) issue a report and a file that is sent forward to the Ministry of Environment but… mostly no compensation (is awarded) (laughing). Mostly nothing. They [the livestock producers] don't even have protection (measures), many times it happens by night, there are a lot of things that are not ok…you shouldn't leave (the herd) during the night, or in the forest. Usually, people call me. And after that I tell them to call the local municipality, but fast! They have to call within 24 hours, or else it's too late."* (Hunting Association Leader)

Thus, some of the most important issues standing in the way of proper implementation of this process are:

- People don't report attacks because they don't know who to address, because they lack documents and authorizations, because they haven't fulfilled their obligations to protect the livestock according to the law, because of the lack of means to travel from
- the mountain pasture down to the local town halls within 24 hours to report the attacks in person, due to bad past experience with the compensation process;
- If a report is made at the local council, many times this report doesn't go further due to the lack of capacity of the local authorities;
- If the report is furthered to the EPA, sometimes the commission formed of all the above-mentioned institutions that need to gather to evaluate the case doesn't manage to do so within the allowed timeframe of 48 hours;
- The commission doesn't have enough allocated resources, for example, they don't have a vehicle to travel with off-road to the affected pasture;
- If the ID tag of the taken livestock is missing, the veterinarian who is also part of the commission, needs to take all remaining livestock in the flock and crosscheck each ID with those in the records to identify the missing one. This becomes a very tedious and time-consuming process when the flock is composed of hundreds of individuals;
- If the commission manages to reach the site and evaluate the case, many times the report that they issue is forgotten in official institutional offices due to lack of capacity, funding or malingering;

- If the file does receive approval for compensation, most times, due to insufficient funding, the compensated amount reaches the victim only after prolonged periods of time, of even years, or doesn't ever reach the beneficiary.

Shepherds involved in my study (particularly those suffering more losses) generally believed in the efficiency of compensation schemes in relieving losses in theory but found them nonexistent in practice. For all events recorded for this study, stretching over the span of more than a decade, only one predation event was reported to authorities for compensation, and no compensation was awarded. Most shepherds don't know what the course of action for receiving compensation is and only a small percentage know who they should appeal to (Figure 55 in the Results section of Chapter 7). Because the territory of the park is divided into many territorial units, shepherds often times don't know to which local town hall they pertain. Oftentimes, local town halls themselves do not know the procedure, or they do not inform local communities. When prompted to say who they think should be responsible, shepherds' answers ranged widely, but the most interesting responses were "no one", "own loss" and "God". These responses can be interpreted as learned helplessness but also as a deep acceptance of the way things are, of losses to predators being part of nature and part of coexisting with large carnivores.

Most people interviewed through this study (including the 80 livestock producers) find the compensation scheme to be dysfunctional, and most agree that the main reason is the overly complicated damage evaluation procedure and the lack of funding due to the fact that "*the money is not planned for in the budget*" (local EPA employee 1).

> "*Who would give them [compensation]? They don't. The laws says they should, but the law says a lot of things. If the wolf killed two or three of their sheep, they won't declare it. They rather miss out on that money than go through the process and waiting so long to get the money, IF they get it*." (Hunting guard)

Figure 79 presents the main issues that emerge in the compensation process in a step-by-step narrative. Apart from not relieving the financial burden of damage caused by LC to local communities, the non-functionality of this system reflects the incapacity of responsible institutions to effectively respond to and mitigate conflicts. Even more, the existence of a non-functioning compensation system nevertheless communicates a sense of entitlement and injustice to people directly in contact with carnivores, thus people feel as "victims" of the "damage" caused by these animals that otherwise are mostly seen as an integral part of nature, just as bees, mosquitoes, hawks and foxes, storms and floods, all natural elements we come in direct contact with: "*nobody compensates you if you got stung by a bee*". "*Normally, when one owns sheep, one implicitly assumes possible losses*" mentions a member of the Romanian Academy in supporting the idea that tolerable levels of damage produced by wolves would normally be seen as natural occurrences.

> "*If the person is sent to the local town hall, they have to descend from the mountain. They travel over 100 km to submit the request for the case. One needs to intervene three days after this request is submitted. So the person says: ~why should I go?~ They prefer not to. […] They have 500, thousands of sheep up there, they won't leave them [unsupervised]. […] Also, if [the wolf] takes one or two sheep, they need to travel over 1 km to find something [as proof], so they don't have anything to show [as proof]. They see the wolf grabbing the sheep and taking it away into the forest. Now go and find it*!" (Hunter)

People's interpretation of the malfunctioning of the compensation systems also leads to increased negative attitudes towards both wolves and the authorities responsible for their management. In not receiving compensation, despite "*having a right to*", people become "victims" once more and feel discontentment towards those responsible to provide it, leading to a lack of trust in authorities but also, to frustration and possible retaliatory behavior towards predators, stemming from a feeling of injustice. Thus, as an ill-functioning institutional process, compensation, instead of relieving damage and mitigating conflicts, becomes a significant driver of both direct and interhuman conflict. Hunters, local people, livestock producers, park managers and authorities enter in conflict.

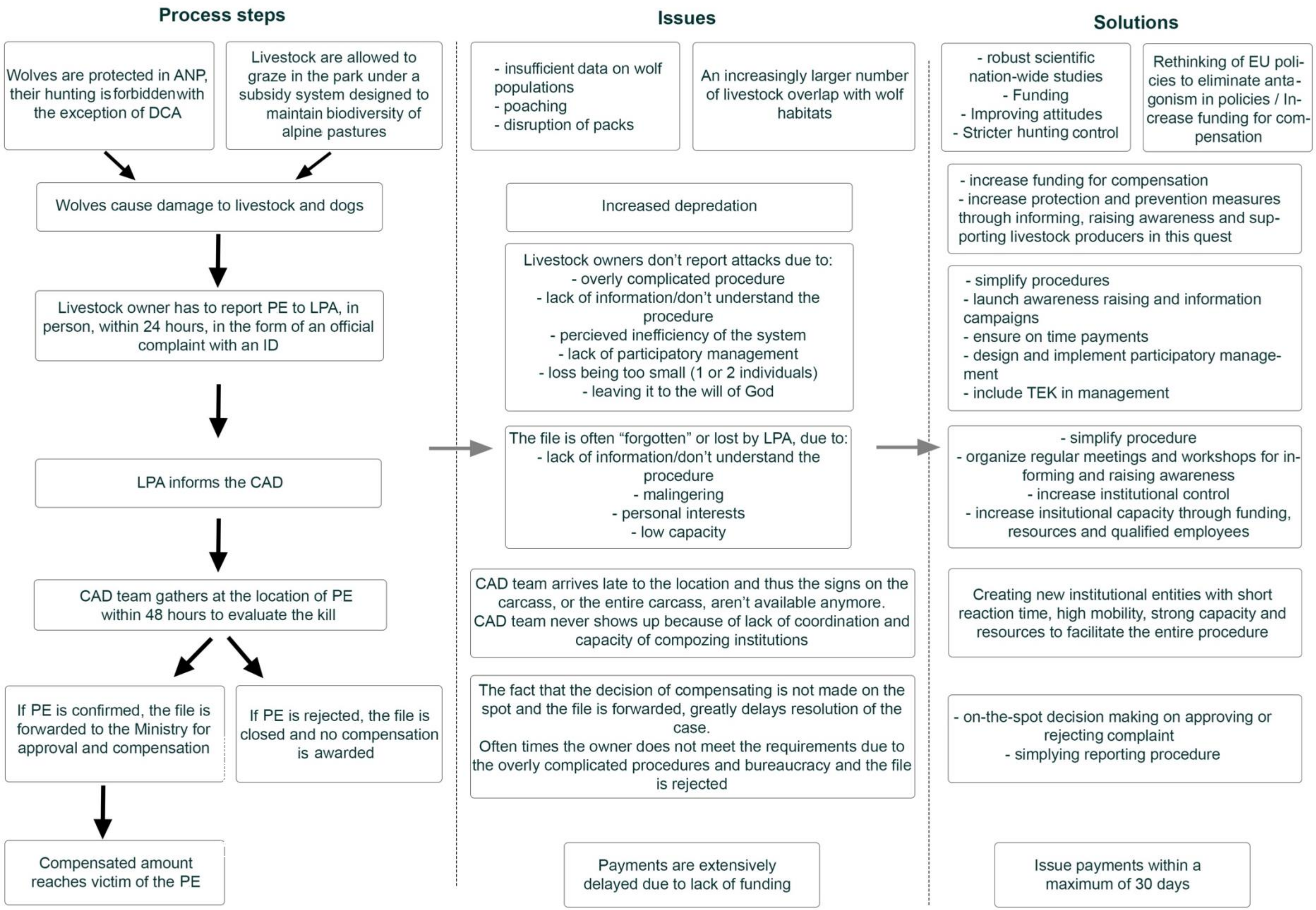

Figure 79. Steps of the compensation procedure for damage caused by wolves, issues that arise in each step and proposed solutions. Abbreviations: PE (predation event); LPA (local public authorities; CAD (Commission for assessing damage); TEK (traditional ecological knowledge).

"I found [wolves] dead, I made about 2-3 reports. Because I made a report, I am asked to await a commission, that comes from the Ministry, to assess the situation. The Environmental Guard needs approval from the Ministry to come see the wolf that has been dead there for 3 days.

Or, if I have damage, if wolves ate one of the shepherd's sheep, they say the commission needs to come. But I'm in Cluj county, they have to come from the Rachitele town hall, they have to come from ITRSV, they have to come… The mayor can't tomorrow because he has a meeting at the County Council, he'll come the day after tomorrow. The Forest Guard has a meeting tomorrow, they will come the next day. The Environmental Guard cannot come. And there are 4 institutions. And wait, if it's in a park or some site, we have to announce them too. Until 7 crazy people gather to come see a piglet or a deer... all that is left is the hair. […] By the time [the commission] is there in 4 days, is there anything left of that carcass? Nothing. If I'm filming, forget the carcass, I'll show tracks, excrement, everything that indicates the presence of wolves there, I've put cameras [they don't take it into consideration].

Last year the wolves killed about eight of my bucks. The ministry told me they are gathering the commission, and they would come and do the evaluation. I gave them the camera footage, I gave it to them because I have no interest, but they [only] give me harvest quotas to shoot the female deer. But, if in the evaluation sheets I have presence of wolves, large carnivores, how can I also shoot the female deer? If wolves make the natural selection, how can I make another artificial selection as well? Everything starts from the level of those above who do not understand and do not want to see what is happening in the field." (Private Hunting Association leader).

Various stakeholders believe that the solution is simplifying the procedures for awarding compensation by dissolving the Commission that evaluates cases and allowing local hunting representatives, the local forest guard, or the rangers – all of whom are already in the field – to acknowledge and evaluate the loss instead. These local representatives could bring their own expertise and photographic evidence to back their findings and allow the responsible institution to approve the case and offer the compensation. Thus, the livestock owner suffering the attack wouldn't have to leave his livestock unattended in order to travel to the local townhall and would have a greater incentive to report the attacks due to their swift resolution.

Another important problem with the procedure of ascertaining the predation event is that the commission only shows up approximately 3 or 4 days after the event occurred. In hot summer days, livestock owners cannot leave the carcass out for such a long amount of time due to the risk of infection and because this can attract predators to return. Therefore, they prefer to burn the carcass as soon as possible and avoid getting the rest of the herd sick. If local representatives would be the ones evaluating the case, they would show up at the scene much more quickly, as they are located in, and regularly patrol, the region. Even more, these local representatives know the locals and are constantly in contact with them, thus they would be better able to judge the validity of the facts reported by the victim. These representatives could be trained to increase their skills and awareness in investigating predation events (Acorn and Dorrance, 1990). This is especially true in cases where wolves attacked the flock in open landscape but dragged the livestock into the forest to consume it. As the shepherd would have no proof that the attack happened in authorized grazing territory, the decision to award compensation would be mostly up to those evaluating the case. In the current situation, shepherds are concerned about reporting cases close to or in the forest because, apart from having the case rejected, they could raise the attention of the Forest Guard or the Environmental Guard and that could bring them accusations related to illegal grazing in forested habitat, or of having the sheepfold placed too close to the forest. "*The forest is their plate. Of course they will try to eat it if you put it in their plate!*" says the biologist at a regional EPA. But because of the landscape layout, in the Apuseni Mountains, it can become challenging to avoid the forest.

> *"Compensations are good, unfortunately they don't work"* (National wildlife and protected area expert NGO1).

Institutions at the local level are struggling to cope with the compensation demands, partly due to low awareness of the procedure, low capacity and resources, and a lack of funding for preventive, proactive approaches, but also due to malingering. "*They prefer not to complicate it for themselves*" believes the national wildlife and protected area expert at NGO1.

> "*Compensation?! Did you ever see the state to give out money? They ask for it, not give it. Let's be serious! They all do this. They don't want to create a precedent. Cause then the other ones will demand too. This way, (they say) no, no, no, and they stand by this. [Why doesn't the State want to give money?] Just watch the TV,*

what do they do with the money?! Complicated and intertwined are the ways of God! [Romanian expression]" (Hunting Association leader)

One of the issues in instating local representatives as damage evaluators is the lack of means to prove objectivity and lack of conflicts of interest. When an attack occurs in a hunting ground where the managers haven't fulfilled their prevention quota, it is the managers who have to cover the financial value of the loss.

These deficiencies of the institutional system suggest the need for creating new institutional entities with short reaction time, high mobility, and good capacity and resources to facilitate the entire procedure. These units, which I propose to name LC Caused Damage Prevention and Management Units, could fill the gaps in the current system, coordinate and supervise action, simplify procedures and lead to an overall improvement of the system. These units should have expertise and power of decision to approve or reject, on-the-spot, a compensation demand and issue the payment that should reach the victim within 30 days. Such units should also be responsible with mapping and monitoring of high-risk areas, identifying factors contributing to wolf caused damage, implementing novel technical damage prevention measures and offer advice and support to livestock producers and local communities to implement such tools. Another solution would be to renounce altogether of the compensation system.

But in the lack of any such solutions, as we have already seen, the poor implementation of compensation schemes, can lead to strong opposing attitudes towards the conservation authorities and a decline of support for wolf conservation (Madden, 2004). At the same time, the inefficiency of the compensation system leads to a lack of sound data on the actual amount of damage caused by wolves, the location of these attacks, their frequency, the context of the attack, all essential information for managers in their quest to mitigate conflicts and lower illegal hunting and increase tolerance.

Mitigating poaching

> *"Wolves are a protected species at a national level, but, anyway, even if they are not hunted [officially], I've heard of cases of there being poaching...intensive poaching... especially the wolf."* (National wildlife expert, NGO1)

Another major problem in wolf management is illegal killing mostly caused by conflicts between wolves and the interests of hunters and shepherds. In forested habitats, wolves enter into competition with hunters for game species and in the alpine meadows they enter into conflict with shepherds due to livestock predation. Poaching can represent a high source of mortality in this case (Geacu, 2009; Liberg *et al.,* 2012; Popescu *et al.,* 2016). As found by this study, poaching and poisoning is customary in the park. Interviewees mention shooting, poisoning and trapping as the most often practiced illegal killing and are most outraged of poisoning because – as they go on to explain - poisoning affects not only wolves, but all other large carnivores, crows and hawks and vultures and eventually, the entire food chain. Livestock producers and local people are accused by hunters of putting caustic soda, strychnine and other poisons into carcasses and into cavities in trees together with honey: *"This is what's happening. I tell you, caustic soda is the best case scenario, but when strychnine is used, [the wolves] they're finished" (Hunting Association Leader)*. Hunters are accused of shooting wolves during flush out hunts. Individual private hunters are accused of illegally killing and taking the shot animals for trophy in order to avoid paying the fees or "*just for the thrill*". Hunters are also accused of trapping carnivores using stalking methods, attractants, foot traps, and even placing broken glass in sheep carcasses in order to kill carnivores by destroying their intestines.

> "*When a wolf appears in the range of their gun, they shoot. They don't take the restriction into consideration. Anyway, who checks them after all?*" (Wildlife and protected area expert NGO1)

There are several issues that come up in the process of controlling illegal hunting. One of the problems is that poaching is allegedly done even by authorized hunters, at night, or while theoretically out doing their job: "*They can be association members too, who usually poach and then go legally to the association as if nothing happened*" (Ranger 2). This greatly affects wildlife populations as "*they say that the quota wasn't reached, but in fact [the individuals] were harvested 2 or 3 times*". Since only carnivores and a few other species are protected but otherwise hunting is allowed, "*there is no way to supervise every hunter every single day, otherwise there would have to be a ranger for every hunter, to follow him around 24/7*" (Ranger 2). Even more, cases have been reported where the hunting guard – the person in charge of supervising every official hunt party to ensure that the law is followed – is, himself, also a poacher. Rangers, who see them in the field, point at this issue: "*they say that they are patrolling, we have cases like this where they mask it. It happens very often. The ones who should protect and supervise the poaching activities, are the ones who do it themselves and then they say there are only out on the job*".

As rangers they don't carry guns, they are even threatened by poachers: "*my colleagues receive threats such as*: ~*I had you in the range of the gun, if you keep following me… I thought of your kids and…* ~ *[…] They broke our cars, some of us were hit*", and so, they need to always be accompanied by a member of the police or the mountain gendarmery, especially at night and in very isolated areas. What makes the situation of illegal hunting even more severe, is the fact that it is a large-scale under the rug activity endorsed by the system and pushed by hunters' frustration with the ban on hunting wolves: *"I have colleagues who told me: ~If they don't give me harvest quota this year either, I'm going to shoot them all, [Swearing] poison them there, let them die~."*

Wolves, in this context, are seen as a factor that reduces valuable game populations, especially during winter when overkill is more common. "*It's a pity*", "*it's a shame*", "*it's a waste*" believe the hunters. Therefore, they want to have the right to shoot wolves when they see them as too many: "*It would be good if they gave us quotas for shooting bears and wolves. They should give the quota back*." This wouldn't only provide a feeling of control but also financial benefits from foreign trophy hunting as seen in the previous chapter. Controlling both carnivore and game populations is what hunters believe would bring balance to the ecosystem, and the reason behind this is that their view is skewed towards the idea of man's ownership over nature, towards their own ownership over game: "*they should give us authorization for one or two wolves a year if they exaggerate with the deer, because it is a waste if they kill ten deer in a year. Better shoot two wolves, right? Isn't it a waste*?" Their frustration with official policies around hunting can push some individuals to take matters into their own hands.

> "*Here we don't really have hunters, here we have authorized poachers, because the hunters put their gun over their shoulder and go whenever they want.*" (Ranger 2)

In the light of these issues, hunters themselves, reflect on the ethical aspects around illegal hunting: "*everything is based on personal interests... I'm not saying, [hunting] it's a passion, it's a hobby, but until a certain point.*" The "passion" for hunting, or the personal interest, unfortunately is believed to spread into all realms of society and manifests through corruption in the enforcing institutions and this affects supervision and control: "*The police are either their friends, or they already know about it, or it's even them who teach how to do these things, how to proceed, like when one is caught, they teach them how to react. We even had cases where the police were teaching them what to do when we catch them and how to drive away with the cars so that we don't catch them. The moment we caught them, they give them indications about loopholes in the law, they give them information, even though they should not*." (Ranger 2)

> "*Those who are passionate hunters, they go and take, but no one knows about it. […] when you have to pay for a deer or a boar a few thousands, why not go by night and get it for free?*" (Ranger2)

Managing habitat disturbance

Despite the fact that habitat disturbance seems to be only a marginal factor in conflict management, based on findings of this study I suggest that managing habitat disturbance would greatly decrease both conflict and damage caused by predators. One of the main habitat disturbing factors is wild berry and mushroom harvesting. Every year, when the season is open – between May/June to September – hundreds of people make their way to forested habitats of the park in order to harvest medicinal and aromatic plants, seeds, resin, snails, truffles, wild mushrooms and berries, particularly blueberries (Figure 80).

Figure 80. Non-timber forest resources.

Although non-timber resource harvesting is regulated by the authorities, this activity "*represents a big problem*" and "*clearly affects large carnivores*". This is due to the fact that the process is ill-functioning and breaks down leading to multiple issues along the way (Figure 81). The habitat's capacity support needs to be evaluated in order to approve a certain quantity of wild goods to be collected each year. Commercial agents can apply for a permit to harvest berries that are awarded through bids. If they receive the permit, they gather at the site in large numbers and form a team that covers preestablished routes through the core of the forested habitat, distributed evenly on the land as transects in a study, that rakes the entire territory in search for berries. Apart from the obvious disturbance that these teams of people bring to the wildlife in the forest, this activity particularly affects carnivores.

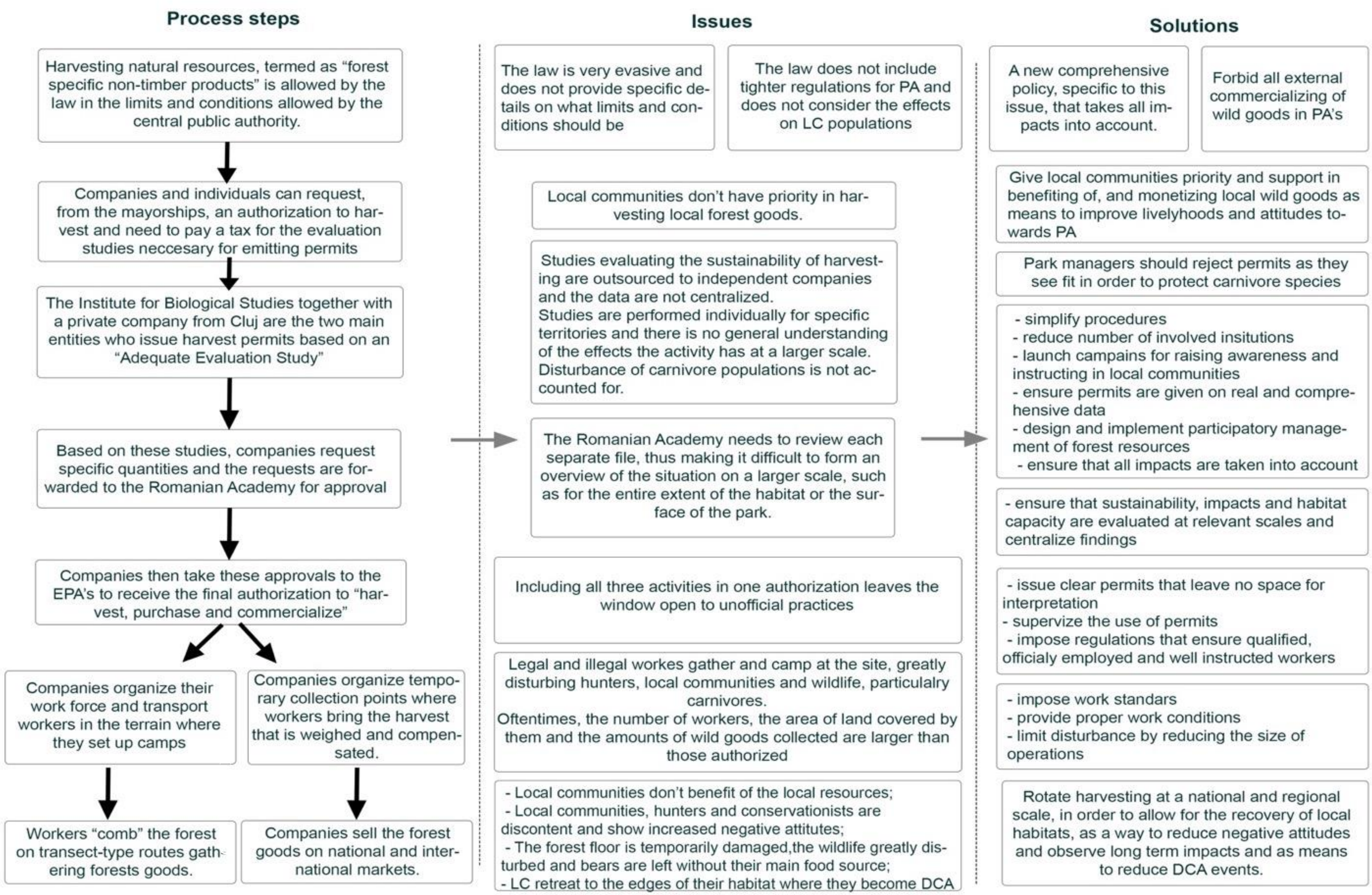

Figure 81. Steps of the process of management of natural non-timber resources, issues that arise in each step and proposed solutions. Abbreviations: EPA (Environmental Protection Agency); PA (Protected Area); DCA (Damage Causing Animal); LC (Large Carnivores).

Most often gatherers come in much larger numbers that are allowed through permits and composed of mostly poor Roma people who are paid, by the day, little amounts of money to do this job, and thus they malinger, make a lot of noise and disturbance, build fires and camp in the forest and leave large amounts of refuse behind while also significantly damaging the forest floor. Approximately 40 companies come to the area, and each company has about 30 employees, bringing the official total up to roughly 1200 workers living in the park for the summer, travelling dozens of km each day, combing the habitat in order to extract wild produce. Unofficially, the number increases considerably.

> "*They leave refuse. I am actually surprise that the bears don't… I think the Apusenies will end up like Brasov… [luckily] the bear population here, being isolated from the rest of the Carpathians, I think they haven't yet found out from their neighbors that they can live out of garbage*." (Commissioner at the National Environmental Guard)

Several institutional actors interviewed through this study raise a concern related to this activity, mentioning that it can seriously disturb and impact fauna, especially large carnivores that need truly isolated and wild areas to retreat to. In fact, institutional actors give specific examples of areas where carnivores used to inhabit but disappeared after berry and mushroom harvesters came in.

> "*Disruption clearly happens […] First of all, the presence of humans determines the carnivores to move to another area and second, the food resource for bears decreases. And then the bears, when they don't have the best food source, the forest berries, they are forced to find [their food] from another place. And that's why the attacks are also increasingly more frequent.*" (National wildlife and protected area expert at NGO1).

Wild berries, such as cranberries, blackberries, raspberries and blueberries mostly grow in coniferous forests, thus the territory upon which the harvesting activity is organized in fully overlaps with the core large carnivore habitat. Wild mushrooms also prefer forested habitats. If these core areas are disturbed during the harvest, large carnivores are quick to retreat to the edges of the habitat where they encounter pastures and local settlements. In being pushed away from their core habitats into human dominated territory, large carnivores (and not only) can cause damage, thus increasing conflict with local communities. Apart from disturbing carnivores due to the noise and the presence of people, this activity scares wild prey out of the habitat and thus, wolves must follow.

At the same time, this activity also depletes the forest of one of the main nourishments for bears, thus increasing the likelihood of them causing damage to human property.

Wild berries, such as cranberries, blackberries, raspberries and blueberries mostly grow in coniferous forests, thus the territory upon which the harvesting activity is organized in fully overlaps with the core large carnivore habitat. Wild mushrooms also prefer forested habitats. If these core areas are disturbed during the harvest, large carnivores are quick to retreat to the edges of the habitat where they encounter pastures and local settlements. In being pushed away from their core habitats into human dominated territory, large carnivores (and not only) can cause damage, thus increasing conflict with local communities. Apart from disturbing carnivores due to the noise and the presence of people, this activity scares wild prey out of the habitat and thus, wolves must follow. At the same time, this activity also depletes the forest of one of the main nourishments for bears, thus increasing the likelihood of them causing damage to human property.

> "*The Academy tried last year, sent a paper to the Ministry of the Environment proposing that the Ministry of the Environment prohibit the collection of these resources from national parks, natural parks and Natura 2000 sites, which have been declared for protecting the bear. This was intended specifically to preserve this food resource. The ministry did not want it*." (University professor, NGO activist and member of the Romanian Academy)

Romania is one of the main exporters of wild berries in Europe. Hundreds of tons of berries are collected each year and there are over 300 companies having wild berry harvesting as their main registered activity. The Institute for Biological Studies together with a private institute from Cluj are the two main authorities who evaluate the resources based on an "Adequate Evaluation Study" that they perform in exchange of a tax paid by the interested companies. Within this study they only take into account the flora and the production of wild resources, making prognosis based on levels of precipitation and the quality of soils, but don't consider impacts on wildlife populations. Based on this study they determine what is the quantity of each specific wild natural resource that can be harvested annually from a specific territory. For blueberries for example, they approve approximately 3 tons per hectare for harvesting. Companies then request harvest rates through bids and receive a quota. These quotas then must be assessed and approved by the Romanian Academy of Science. The companies then take the approval to the local EPA's who issue the final authorization to "harvest, purchase and commercialize" the wild goods. One of the issues is that the Romanian Academy and the EPA can't realistically question the studies that come from the evaluator institutes. Thus, they just approve permits. Even more, the reliability of these studies is questioned: "*my opinion is that these studies are done from behind the desk*" (Councilor for the Bureau of Quality of Environmental Factors at EPA). This is because these studies only specify the amount to be extracted over a certain overall territory and don't distribute this amount in such a way to ensure a balanced exploitation of resources. When performing habitat capacity studies, these research institutes should take into account carnivore population size, it's distribution and feeding patters in order to determine where, when and how much to harvest, but "*considering the fact that we don't know what size of population we have, just an estimation based on what the hunters say, is not [enough]...you cannot take a decision based on that*" adds the national wildlife and protected area expert at NGO 1.

Another complication is that when the land is administered by a hunting association, that is not the same as the landowner, then the respective association also has to give its approval.

Most importantly, none of these institutions take into account the impact on carnivore populations. The only institution that accounts for these impacts and has power to reject permits is the park administration who "*should issue recommendations, including related to the studies*" and give permits "*in a differentiated manner, especially in areas where they know that there aren't as many carnivores, then they could give permits for those areas and where there are carnivores and conflicts, they should avoid giving them*" (National wildlife and protected area expert, NGO1). Unfortunately, the park administration does not oppose permits except for the special conservation areas, so as to align with their designation as a *natural park*. But this permissive attitude should be directed towards local communities, whereas the permits are given almost exclusively to outside companies. This issue can be tracked down to the local town halls, where companies first apply with a request to harvest. If the mayors – who represent local people in this process – don't desire to harvest locally, they accept the request forwarded by the companies and negotiate a price per kg of collected wild goods. Each mayor has the freedom to negotiate the price they receive from the companies and "*It is not easy to constantly verify what are the quantities they actually collect*" (biologist at regional EPA). Interviewees accuse mayors of following personal interests when approving requests: "*Mayorships! Of course! They take the money…everyone gets their share*" (Commissioner at the National Environmental Guard). In the very few cases when the mayor rejects requests and allows local communities to benefit from local resources, the harvesting business continues but becomes illegal.

Another issue is that "harvest, purchase and commercialize" is a wide definition that allows for a wide range of unofficial practices. One of such practices is allowing any person coming with a batch of berries to sell them at the "acquisition points" – specially designated point at the entrance to the forests where large trucks collect and pay for the forest goods brought by each harvester (Figure 82).

Figure 82. Temporary acquisition point for wild berries and mushrooms in the park.

Thus, even people who aren't officially employed can collect and sell the berries at these points. This is made legal through the fact that the law regulates the need for permits only for batches of over 3 kg. Anything under that amount is considered collecting for self-use and is freely allowed. Thus, if harvesters use small containers to collect and bring them to the collection point before they reach the weight of 3 kg, they cannot be verified or stopped. Companies have permits to "purchase" making the transaction legal. Thus, hundreds of workers harvest the berries for these companies without being employed by them. This is beneficial for both the workers and the companies because of avoiding taxes. This creates a situation where dozens of cars and vans gather at the edge of the forest and unload hundreds of gatherers who set up temporary camps. Workers live in tents in these forest camps throughout the harvesting period. Local communities and law enforcement complain that these people, mostly Roma, build fires inside the forest, are violent and sometimes drive unregistered cars without licenses (Figure 83).

Figure 83. Harvesters at the gathering site in the park.

"*It's the same permit [for all three activities]. It's not a separate permit to harvest and a separate one to… so they do all kinds of mishmash. […] Roma people gather at the acquisition points and they don't keep size into account, they don't keep anything into account. […] all they want is to get their money. […] So practically there is no control.*" (University professor, NGO activist and member of the Romanian Academy)

This can lead to the presence of a large number of illegal gatherers with no conservation ethic in the core forested habitats of that park and with no legal means to verify or deny their right to be there. Hunters are discontent because this activity greatly disturbs game, also hunting parties cannot be carried out due to the risk of injuring the workers. Even more, hunters say that these workers take and appropriate wildlife surveillance cameras. All conservationists also oppose the activity due to the way in which it affects carnivore populations. In addition to having to support the consequences of disturbed wildlife causing damage, local communities are also upset because they feel that their own local resources are "exported" to these outside companies who then sell the harvest to urban national and international markets as bio products, yielding great profits on the wild berries collected by them using the cheapest work force. Also, because most of this work force is represented by Roma people from counties outside of the park, brought to the site in busses by the respective companies, local people feel betrayed and invaded. They feel that the resources the land they live on offers, are stolen from them (Figure 84).

As a consequence, this activity only increases conflicts and people's negative attitudes towards authorities and park managers. Harvesting in the forest – alongside logging, fragmentation, infrastructure development, increased presence of people in the forest, intense artificial feeding – only exacerbates the frustration of local communities by pushing wildlife out of forested core areas and into conflict with people. Thus, the process of harvesting natural resources, as an ill-regulated activity, becomes a main disturber for carnivore populations and an important aggravator of conflict with local communities.

Figure 84. Harvesting point on the surface of the park.

"*The wolf and the bear retreated due to the chaotic activities, the timber logging, these activities that are spread out everywhere made the wild animals retreat*." (Ranger 2)

Managing protected areas

At a first glance, it might seem hard to see the connection between people's attitudes towards wolves and their conflict with authorities, but at a deeper investigation we see how people's dissatisfaction, frustration and lack of trust in the authorities – be the park manager, central public authorities or even the Ministry – can directly affect their tolerance for protected carnivore species. In the previous section we have seen how not involving local people in local resource harvesting can cause a lot of conflict with the communities. If local communities would be the main beneficiaries of these resources and if they would be assisted in monetizing these resources as local organic goods under funded projects, their attitudes towards conservation could increase alongside their livelihoods (Wild and Mutebi, 1996; Dovie *et al.,* 2000; Kellert *et al.,* 2000; Singleton, 2000; Thakadu, 2005; Cuyler *et al.,* 2020).

> "*Normally, in a Park, local communities should be the ones to exclusively use local resources, including the timber*." Ranger 1

In striking contrast, the reality in the field shows people greatly struggling to survive in poor rural communities, with no support from the authorities other than that of local rangers and the EU subsidies. In fact, people are refused their rights over their own lands and instead of being a priority, are pushed away in favor of external commercial agents and specific personal interests. Generally, local communities are tolerant both towards the park and towards large carnivores. "*They understand and accept park restrictions if they are explained to them*" say the rangers. "*As a nation we are at peace with this [coexisting with wolves]. Of course, there are the occasional upsets of the shepherds […] but I wouldn't raise them to the rank of conflicts, [as they are not] impregnated in the society, in the mind of the society*" explains the biologists of an EPA. But "*when rights are not respected, compensation and subsidies are not awarded, and there is no firewood*", local people start to move away, young people leave the country or go to the cities to find work and make a living, and so, "*the villages are being emptied*". "*In the evening, it's all desolate. Except workers and employees of state-owned institutions such as the mayors, the police, the hunters, us and the mountain gendarmery, there is no one*" recounts a local ranger.

First of all, local people are greatly dissatisfied due to the restrictions they have on cutting timber from the surface of the park for firewood, especially in the context of large – legal, or illegal – state-owned timber cutting operations. People owning forested land in special protection areas are not allowed to use the trees for firewood but are also not compensated for this due to the lack of funds. Furthermore, after lobbying and corruption led to a change in policies, people were also refused the right to cut small amounts of wood for personal needs in special designated areas, in favor of large economic agents who have greatly increased the price of wood. "*This is national discrimination*" say the park rangers who find themselves helpless in changing the situation: "*We would forbid the logging because the economic agents cause a much greater impact on habitats as they go through with tractors and trucks. Local people used to come with the horse and carriage, and they would only take their minimum survival needs, they would* *process the wood for personal needs and so, the impact was very small.*" (Ranger 2). Romsilva (the national forest management entity) and the Ministry are the ones who imposed these new regulations and "*nobody wants to block the economic agents because they are big, and one cannot stop them as the interests are very big to take for themselves*" explain the rangers. All rangers can do is look away when they find local people taking wood to heat their homes, after all "*local people don't take without personal agreement*" with the foresters, but the economic agents "*take at a large scale while local people look at the truck with wood… and the poor man is desperate because he has to leave to earn his living elsewhere while the others pass by him with the wood from his own home, from next to his property*."

Another major source of conflict was the EU INSPIRE project that has put many of people's lands (already in the park), including agricultural land, grass meadows and pastures, under the regime of scientific reservations, completely limiting people's rights on the land while also reducing subsidies for that land. Even some of people's houses were included in these reservations. "*What should we do? Should the man leave his key and go away?*" asks a ranger in indignation. This project was initiated by the Ministry from European funds, but "*the limits were traced in the office*" accuse the rangers. "*And the people are desperate now*". Local people have formed little coalitions to sue the authorities, and they have high chances of winning because there is no legal basis yet, "*but someone made a decision, and now they are all washing their hands, and look another way.*"

Owning land in the park also comes with complex bureaucratic and financial burden. Apart from having to obtain tedious documentation and permits for grazing livestock in the pastures of the park and a highly bureaucratic subsidy system, livestock producers are also regularly confronted with predator attacks, while compensation is only promised but almost never delivered. Most of these people also own crops that are often damaged by wild boars or deer, whose populations have greatly increased after the policy change that privatized hunting grounds.

"*You know how it is, the smallest ones are the ones to receive the fists, sort of to say, and for anything that happens, this idea has been suggested to people that the park protects. The local town halls, the police, everyone says that the park protects. […] But this idea was suggested because all the institutions, probably, want to get away…~the park won't let you~. And that's how* *this very intense reluctance towards the park was created*" says Ranger 2 in explaining how the blame for all of these issues falls on the park, despite the fact that the Park cannot overrule the law and commands that come from the higher authorities. "*We have to respect the rules that come from above*" explains the ranger.

8.3.4. Summary

The main aim of this chapter was to identify and map the issues that arise in institutional processes around wolf management that become drivers of conflict. By identifying these issues, I was able to suggest solutions that could help improve the efficiency of these processes to fulfil the aim they were designed to fulfil. The discussion revealed that the lack of data is the main issue hindering the process of yearly wolf population evaluation and quota awarding and suggests that there is a need to formulate and implement a new methodology that would yield sound scientific data on the entire range of relevant parameters at a national level. In order to make the compensation process functional, there would be a need to simplify procedures and increase funding. Prevention should come before compensation, and I recommend that TEK of local people be taken into account when conceiving management measures by involving locals into a participatory and adaptive management. The focus should also be on introducing more non-lethal preventative tools, in close collaboration with livestock producers. Cautious and well-though-out measures should be taken for reducing poaching, not just by increasing control, but also by working on mitigating the root causes that lead to poaching. One of the most important aspects here is attitudes, both towards wolves, but also towards authorities. Reducing frustration and improving attitudes would significantly reduce illegal killing of wolves and would increase the efficiency of all official measures and processes in wolf management. Reducing people's frustration with the compensation and subsidy systems, empowering locals in improving their livelihoods by generating incomes from park resources, creating an environment suitable for discussion among stakeholders – are all examples in this sense. Creating an objective independent intermediary entity to coordinate efforts for reaching agreement, propose compromise, mediate debates and control the proper implementation of jointly agreed management strategies would, in my view, be the most critical step in reaching a wolf management process that turns conflicts into opportunities, one that benefits both people and wolves. The next chapter focuses on this topic, delving deep into the web of interactions that drive debate and conflict at a societal level, and drives the discussion towards an unexpected conclusion: that conflicts can also be viewed in a positive light, as important drivers of change and key mechanisms of coexistence.

9. From conflict to coexistence

9.1. Drivers of conflict – in a nutshell

This chapter attempts to summarize the findings related to how direct and indirect conflicts are manifested in - and derive from - the human and institutional realms. I will shortly outline the most important drivers of human-wolf conflict, as identified throughout this analysis. These main topics summarized here emerged from an extensive analysis (condensed here due to length considerations) of the social and political tensions dominating the field of wolf and other large carnivores in recent years. This analysis was based on the open-ended interviews with stakeholders (presented in section 8.2. of the previous chapter) but also on an in-depth investigation of the public statements of stakeholders.

A long list of concerns emerged from this analysis: livestock producers not fully understanding their responsibilities; shepherds not knowing who to ask compensation from; the local mayor feeling overwhelmed in the simple task of requesting compensation from the overarching authorities; local people not knowing how to monetize on the presence of carnivores in their area; the members of the hunting association not knowing who approves the quotas they request or that Nature 2000 is not an NGO that opposes hunting; the average hunter not being aware of wolf population status in the area; various institutions passing blame and responsibility from one to another; the top authority approving trophy hunting despite a recognized lack of sound scientific data on populations. What comes across these facts is that at an individual level – whether talking about a hunter, a shepherd, an institutional worker or a local person – there is very little awareness of many facts happening at a larger scale than that of individual's daily activity. It appears that the average person involved in one way or another in wolf conflict doesn't have interest in or access to wider information but rather knows very well their own small "slice" (the job they are directly put in charge of). They do their job, their everyday activities and chores, but they might not be aware of the purpose of that activity, how it integrates in the larger scheme of things. This portrays a lack of communication or transparency, or maybe a lack of motivation and interest, even within institutions not only between institutions.

Therefore, first on the list of human-wolf (and other LC) conflict divers in Romania is the **weak institutional capacity**. Ambiguity concerning species; failure to integrate results of biological, ecological and also social scientific studies into management and action plans; poor reporting; **low level of transparency** and public involvement; **lack of a participatory management**; inadequate response times, overlapping responsibilities; corruption and bureaucracy; controlled and biased media; weak communication, coordination and cooperation between state institutions and different regions of the country, lack of real dialog and the **lack of a mediator in the form of an objective entity**, the **absence of sound monitoring systems** for the wolf populations - are all issues stemming from the weak institutional framework in Romania. In disregarding the reasons behind the complete ban on LC hunting of 2016, the national authorities reinstate trophy hunting without a sound scientific base. In disregarding the National Action Plan for Wolves put forward by WOLFLIFE under the wing of the Ministry of Environment in 2018, objectives regarding the management of the species are not clearly identified, and the authorities act according to reports based on subjective information collected from hunters. Also, in disregarding the 2017 stakeholder workshop organized by WWF and AGVPS through the National Group for Carnivore Conservation on improving management, stakeholders continue to be left out of the planning and implementation of coherent wolf population management actions. This promotes confusion, malingering and passing on of responsibilities and accusations. When an attack happens, local people, those directly affected by the event, turn to the managers of the hunting grounds expecting them to assume responsibility. Hunters pass the guilt on to the park administration, EPA's and the Forest Guard who didn't award the quotas. These institutions, in turn, pass the guilt to the central authority, the Ministry. The Ministry then increases quotas as means of reducing damage that their budget cannot cover for, or as means to quiet the conflicts or even as part of financial interests. The **lack of a coordinated nation-wide action plan for wolves** leads to the implementation of a predominantly reactive management and the total **lack of preventive management**. The **lack of substantiated information** (Popescu *et al.,* 2016; Cristescu *et al.,* 2019; Sin *et al.,* 2019) on the size and dynamics of the wolf population, collected in a unified and standardized manner, affects the decisions of the responsible authorities. As a direct effect, certain parts of the Romanian wolf population are under significant pressure.

Habitat loss and fragmentation is another major driver of conflict. The construction of major motorways interrupting connectivity between the three major groups of the Carpathian

Mountains, major railway and several road modernizations in areas of wolf habitat; deforestation (that both decreases habitat and increases human accessibility into wolf habitat), decrease of habitat connectivity, all affect wolf populations (Berde *et al.,* 2016). Maintaining connectivity between the different wolf population in Romania is essential for the conservation of the species, especially considering the high degree of fragmentation in wolf population distributions in the rest of Europe and the threat of a future fragmentation of the national wolf population, resulting from uncoordinated anthropogenic development, poor forest management and the general incoherence in wolf management mentioned in the foregoing.

Hunting, logging, uncontrolled motorized tourism, foreign trophy hunting, poaching, berry picking and other forms of forest resource harvesting, are all forms of **habitat disturbances** that are perturbing game and carnivore species, pushing wolves and bears to the edges of their habitat into contact with humans, human activities and livestock, leading to increased predation and acerbated direct and indirect conflict.

Illegal killing is customary in the park (see Section 8.3.3. in Chapter 8). As we have seen, incoherent wolf management could exacerbate poaching, as policy and the poor implementation of certain management measures (compensation, subsidy awarding, prevention) can lead to strong opposing attitudes towards the conservation authorities (due to feelings of frustration, injustice and mistrust), a decline of support for conservation (Madden, 2004) and even retaliatory responses.

The **reduction of prey populations** (wild boar *Sus scrofa*, red deer *Cervus elaphus*, roe deer *Capreolus capreolus*, and chamois *Rupicapra rupicapra*) due to feral dogs, abandoned dogs and jackals, natural causes, poaching and hunting is another major threat to wolves in Romania. The way hunting quotas for game species are awarded (through a general scheme without considering regional differences in habitat, size and structure of game populations) contributes to losing game species viability (Berde *et al.,* 2016), especially in certain areas. A reduction in prey abundance would pull along a reduction in wolf populations, as it is well established in the scientific world that prey availability primarily limits large carnivore populations (Maanen *et al.,* 2006). Hunters in this study also support this claim. A reduction in prey abundance, would also push wolves to prey on livestock, thus leading to increased predation and more conflict.

Modernization and development of rural areas alongside the pollution, habitat fragmentation and disturbance they bring, greatly affect carnivore populations.

”Nowadays there is a strong conflict around wolves, and indeed, it's more between people and people...unfortunately, conflicts are also generated [they don't just naturally arise]. Practically, this entire conflict situation is a result of the large carnivore management and the management of the natural resources in the last few years. Intense artificial feeding [supplementary feeding], the presence of people in the forests, the various activities, including, the berry gathering, the logging in the forest, the fragmentation, construction, roads, touristic infrastructure....all of these are pushing bears and wolves to new areas, leading to a perceived high number of bears and wolves. In areas where before there were no bears and wolves, now there are. This is true. But just as true it's the fact that in areas where before there were bears and wolves, now there aren't any anymore.” (wildlife expert NGO1)

The discourses around wolves in Romania are marked by a strong **conflict of values** that becomes yet another driver of conflict. The discrepancy between utilitarian/hunting-oriented views and mutualistic/conservation-oriented ones, leads to a wide array of broader political and social tensions, nation-wide disputes, and **a politization of wolf management** based mainly on the pursuit of personal agendas related to hunting interests. Hunters strive to maintain their decades-old status-quo of dominance over wolf and game management policies, mainly felt as from a **resistance to socio-legal changes**. In an effort to survive in the changing culture, hunters themselves recognize the need for reform.

This divergence of values is also reflected in European law, manifested through the existent antagonisms in objectives and the recent changes in wolf policy that downgraded wolf protection status.

The next section delves deeper into this subject, showing how this divergence of values and attitudes sits at the root of the human-human conflict around wolves.

9.2. From villain to hero: Attitudes as drivers of conflict

At the very core of inter-human conflict around wolves, as we will see in this section, lays the clash between interests related to hunting.

Even though wolves in Romania today don't make the headlines as often as bears do as part of the debate around the reinstated hunting quotas, the opinions expressed related to wolves are just as mixed, even within the same groups. Despite the now well-established knowledge that wolves, via a suite of direct and indirect effects on ecosystem structuring and stability, play an essential and integral role in maintaining the health and biodiversity of wildlife and ecosystems (Ritchie and Johnson, 2009; Ritchie *et al.,* 2012; Ripple *et al., 2013,* 2014), and indirectly, livestock and public health, attitudes of the Romanian public towards wolves still vary largely from sympathy to aversion.

Hunters and, to some degree, shepherds are prone to have more negative attitudes (Szabo and Anthony, 2012). Shepherds and local people may perceive wolves as a threat to livestock (Treves, 2009; Bruskotter and Wilson, 2014; Hogberg *et al.,* 2016; Schroeder *et al.,* 2018) and, to some individuals, the presence of wolves may reflect loss of social power, property rights, and a utilitarian landscape for some individuals (Skogen and Krange, 2003; Skogen *et al.,* 2008). Even though EU level studies clearly assert that wolves do not represent a threat to human lives (Blanco and Sundseth, 2023), fear also remains a factor influencing people's attitudes.

Damage caused by livestock predation of wolves in Romania is insignificant compared to other causes of livestock loss (NAPW, 2018), and yet this issue is perceived as overly important. Hunting ground managers in particular, believe that actual levels of damage are much higher but that livestock loss in many cases cannot be proven by shepherds, or is simply not reported. This is in part due to the overly complicated and ill-functioning compensations system (see more in section 8.3.3). Unsuccessful wolf attacks and regular wolf visits to livestock flocks further increase the perceived magnitude of wolf predation (Chapter 7). Negative attitudes towards wolves can also be inflated by two other controversial issues: surplus killing (Bjärvall and Nilsson, 1976; DelGiudice, 1998) and killing of dogs by wolves (Lescureux and Linnell, 2014).

Despite these negative attitudes, through centuries of coexistence, the wolf is accepted to a relatively high degree by people living in the countryside, as long as livestock predation does not exceed reasonable limits (Boitani, 1995; Maanen *et al.,* 2006).

More than the actual level of damage caused by wolves, it's people's mistrust in authorities stemming from incoherent implementation of financial support, extreme bureaucracy and lack of involvement in the decision-making processes, that becomes a main driver of negative attitudes towards large carnivores, especially in protected areas.

Based on my own findings, hunters tend to have the most negative attitudes towards wolves. As a general rule, game management deliberately allow significant numbers of large predators in the hunting areas, in line with the national conservation goals, in theory due to their role in improving the health and trophy quality of other game species (Sparks, 2005). The role of wolves in keeping away disease in game species has even recently been strongly reinforced by the swine fever epidemic that has affected over 49 countries in Europe since 2021, including Romania. Several studies (Szewczyk *et al.,* 2021; Blanco and Sundseth, 2023) now clearly show that wolves help eliminate or control swine fever by consuming infected wild boar individuals and carrion before they have a chance to infect other animals. Despite the fact that this knowledge should be mainstream especially among hunting-oriented groups, many hunters still feel in competition with wolves over game species. They believe that wolves are over-predating on wild ungulates and livestock despite the general consensus in the scientific world that prey availability primarily limits large carnivore populations (Maanen *et al.,* 2006). This may be partly due to the fact that some hunters believe[19] that the only way to keep hunting associations financially viable in the current situation is to attract foreign trophy hunting through "high quality" game, thus they desire abundance of game species, abundance that they might consider threatened by predators taking their share.

Mass media also inflates wolf related conflicts, contributing to a more negative image of the wolf. Using headlines such as "*Dozens of sheep, torn apart by a pack of wolves*" [20]; "*A village terrorized by wild animals*"[21]; "*Wolf packs have frightened villagers who are afraid to go outside their home*"[22]; "*Wolves and bears do havoc in a village*"[23], events are usually exaggerated and fill

[19] This is based on an analysis of my personal interviews with representatives of hunting associations but also through a review of hunters' public opinion expressed in an on-line conversation thread about "*The survival of the hunting associations"* between members of hunting associations from all around the country. See entire conversation thread at: https://www.vinatorul.ro/public/forum/viewtopic.php?f=55&t=19734 [in Romanian], accessed 29.12.2023

[20] see news articles at: http://stirileprotv.ro/stiri/actualitate/zeci-de-oi-din-alba-sfasiate-de-o-haita-de-lupi-la-cat-se-ridica-paguba-ciobanilor.html; http://ziarharghita.ro/hu/13-oi-sfasiate-de-o-haita-de-lupi-in-harghita.

[21] see news articles at: http://www.informatiata.ro/stire/Un-sat-intreg-terorizat-de-o-haita-de-lupi-VIDEO/6379; http://protv.md/stiri/social/o-haita-de-lupi-terorizeaza-un-sat-intreg-din-causeni-zeci-de---204321.html.

[22] see news article at: https://point.md/ro/noutati/obschestvo/o-haita-de-lupi-ataca-doua-sate-din-rezina-oamenii-se-tem-sa-iasa-in-cimp-la-lucru.

[23] see news articles at: http://www.gandul.info/stiri/lupii-si-ursii-fac-prapad-intr-un-sat-din-cluj-mananca-oi-capre-vaci-15595525; http://stiri.tvr.ro/lupii-fac-ravagii-in-vatra-dornei--ataca-in-haite-stanele-sau-gospodariile_80419.html.

the media with dramatic words and inflated descriptions of predation events. For example, the headlines of a news about a multiple kill in a village say "*wolves have decimated the sheep flock of a villager*"[24] when the text of the news then states that actually only 15 out of 150 sheep that the sheep flock contained were killed. Some news appeal even to folk terror legends describing a "*cursed place where a creature (a wolf) frightens all the villagers*" and "*the victims who have survived the encounter describe a big black wolf that had supernatural characteristics*"[25] (Figure 85). This kind of dramatic and inflated journalism, the general negative light in which the news is presented and the fact that the focus is mostly only on conflict and issues, can influence people's attitudes.

> "*Conflicts have always existed, but now they are much more advertised and some of them are also provoked. Especially now, since they forbid hunting, this has been the purpose: to highlight as many such problems and interactions with communities as possible so that they have all the arguments for showing that hunting is ultimately the only solution. I actually heard of accounts of people on purpose leaving animal carcasses in the communities to attract predators*." (Large Carnivore Expert)

Figure 85. Pack of wolves appearing black in the dim light of dusk. Source: APN.

[24] see news video at: https://www.youtube.com/watch?v=RIDjMx1Yk1k.

[25] see news article at: http://a1.ro/news/inedit/tot-satul-a-vazut-strigoiul-in-romania-exista-un-loc-blestemat-unde-o-creatura-ii-sperie-pe-toti-dispare-doar-daca-iti-faci-cruce-id382880.html.

Yet, since the scandalous ban of hunting in 2016, media has started to show the other side of the coin too and portrays the controversy around the conflicts of interests in hunting, revealing cases of corruption and the role of personal agendas in policy making.

The complete ban of large carnivore hunting at the end of 2016, the subsequent reinstatement of quotas and the entire debate around this subject seems to be bringing along a further aggravation of conflicts over LC management, but at the same time, it is also bringing a rethinking of large carnivore management, even while actual change is still facing resistance.

In reviewing an extensive amount of data coming from the very inner core of the hunting-oriented groups[26], a new idea starts to emerge: that hunters themselves are starting to become aware of the institutional incoherence we so far identified within the game management institutions and that hunters themselves, despite the inertia at an institutional level, recognize the need for change, the need to "*reform the entire system, from its roots*". As a recurring topic of the conversation, hunters seem to agree that corruption, lack of transparency, conflict of interests and the pursuit of personal interests often define the leadership and sometimes even the existence of the hunting associations. This shows how deep the roots of "the old ways" go, how strong the financial incentive behind hunting is, and how fiercely the hunting-oriented institutions are defending their position of power and authority.

This "*crisis*", as hunters refer to this situation, brings to surface a series of issues, that have been silently disrupting the functionality of the system for many decades, threatening to impair the long-term survival of hunting associations. In response, hunters propose an entire set of solutions to stop "the demise" of the hunting "business": diversifying the hunting services by setting up new small hunting themed enterprises such as stores and meat selling; ensuring wages of employees while reducing/changing membership fees; respecting members in order to maintain their loyalty; centralizing management; better management vision and strategies; hiring competent directors and lawyers to represent the associations, or on the contrary, transforming the associations into NGO's in order to avoid money-thirsty leaders; organizing team-buildings and activities that involve hunters' family members in order to change the stigma around hunters

[26] As part of an analysis of my personal interviews with representatives of hunting associations but also through a review of hunters' public opinion expressed in an on-line conversation thread about "*The survival of the hunting associations"* between members of hunting associations from all around the country. See entire conversation thread at: https://www.vinatorul.ro/public/forum/viewtopic.php?f=55&t=19734 [in Romanian], accessed 29.12.2023

seen as "*butchers*"; educate and expose the new generation to hunting in order to create a more positive image of hunters through events, fairs, stands; encourage lay people to "*learn the taste of the gun out in the wilderness*" and charge for them to fire the guns; ensuring more "*high-quality*" game to attract more hunters; improving infrastructure (such as vehicles for traveling in the field, dogs, weapons (not rifles), cabins, good food and so on); and investing more in foreign trophy hunting.

The decades old status-quo of game management is thus being challenged not only from the outside, by conservation-oriented institutions, groups and scientists, but even from within, while the nation-wide debate around large carnivore management is shaking up the stagnant "old-ways", not only of hunting and game management, but of the entire institutional framework around carnivore management, and not only.

The intense debate around wolf management is an illustration of how difficult it is to reconcile opinions and to reach a consensus in carnivore management, even when steps are taken in the right direction. Hunters accuse conservationists to be biased towards protecting only carnivores and thus destabilizing the natural equilibrium. Conservationists accuse hunters of not understanding how natural ecosystems function and of wanting to substitute the apex predator by eliminating carnivores. Just a short glance at these so varied stances gives us clearer insights into the magnitude of the current human-human conflict around large carnivores in Romania and the complexity of the issues.

To get a better view of where we stand in the complexity of these issues, the next section zooms out in time in order to put the magnitude of today's conflicts into perspective, and thus, to better understand the direction in which wolf management in heading.

9.3. Conflicts as drivers of change – adding a temporal dimension to the analysis.

Beginning with the Middle Ages, extermination campaigns slowly eradicated wolves from most Central and Western European countries. Wolves completely disappeared from England around the 1500s, from Scotland in 1743, Ireland in 1770 and Switzerland in 1872 (Geacu, 2009). The 19th century brought the complete eradication of wolves from Germany, The Netherlands, Belgium, Denmark, the Czech Republic, and Hungary (Almăşan and Ionescu, 1993). While wolves were never completely eradicated in Romania, consistently maintaining healthy and viable populations as a result of favorable living conditions, they were still subject to extensive persecution campaigns that have drastically reduced their population size.

The management of wolves in Romania has in time proved a controversial issue. Before the First World War, despite control and eradication campaigns already being instated in all Romanian provinces, wolf populations were not put at risk (Geacu, 2009). At the time, the complete unified state of Romania as we know it today was not yet formed, as it was only after the First World War that all the Romanian provinces united under one country. The period between the two world wars brough an increase of wolf populations, despite wolves continuing to be hunted on and off during this time and despite the severe reduction in prey population due to poaching (Geacu, 2009). Hunting control acts continued to be issued, but considering the social, economic and political context of the war years, the results of the control campaigns were modest. With wild prey populations at a low point, predation on livestock increased dramatically during this time. Therefore, from 1949-1979, a drastic eradication campaign sustained by financial incentives was launched with the aim of reducing the wolf population by any means (shooting, poisoning, trapping, capturing cubs). Nearly 20,000 wolves were killed in just one decade (Almasan and Ionescu, 1993). Wolf numbers reached a minimum of 1560 individuals at the end of the 1960's (Kecskes, 2008). After this, a ban on weapons issued by the leading authority of the state favored the recovery of wolf populations. The interest in wolf hunting decreased and, in the following decade, the hunting administration reevaluated the role of wolves in the ecosystem. The first steps towards wolf conservation were represented by the complete ban on the use of poison in 1991 and signing the Bern Convention in 1993. As of 1996 wolves were declared a protected species and as of 2005, they were included in the Red Book of Vertebrates in Romania. With the new protection status, and with wild boar and deer populations increasing, wolf numbers started timidly recovering. Today, wolf populations in Romania reach approximately 2750-3000 individuals, placing Romania as the country with the largest wolf population in Europe (except Russia). Despite periods of large fluctuation in the size of wolf populations associated with the intense extermination campaigns, the number of wolves in Romania never dropped below 1500 individuals, Romania being one of the very few countries in

Europe (and worldwide) to maintain continuous and viable wolf populations that survived the ferocious eradication campaigns.

Wolf populations in Europe are now considered to be on the rise (Chapron *et al.,* 2014). Research in the field (Chapron *et al.,* 2014; Boitani and Linnell, 2015) suggests that the recovery of wolves in Europe has been facilitated by a combination of socio-economic and biological factors such as a shift in hunting philosophy and practices, the birth of the EU legislation for conservation (The Bern Convention and the Habitat Directive), changes in public attitudes towards large carnivore conservation and the political transitions to democracy in socialist countries. It is also suggested that the socio-economic changes characteristic to this period such as large scale rural-urban migration and land abandonment have contributed to a decreased pressure on carnivores. Improvements to habitat quality (for example through reforestation), increasing prey populations as a consequence of updates in the management of hunting, as well as an increase in preventative practices have also been identified as factors contributing to the recovery of wolf and other carnivore populations in Europe.

Niedziałkowski and Putkowska-Smoter (2020) suggest that in addition to the structural mechanisms that have been thought to influence wolf comeback in Europe, there is also an array of underlying socio-political factors that have pushed new discourses and policy transformation through the values, beliefs and actions of concrete social actors with interest in wolf management. Based on a model of policy change, the authors argue the socio-political changes of the 1990s in Poland created a window of opportunity for environmental activists and wildlife biologists to instigate critical policy changes that moved wolf governance from the domain of hunting to that of nature conservation.

In an even more recent study looking at the institutionalization of wolf management in Germany, Niedziałkowski (2023) distinguishes between the way modern-day conservation-oriented wolf management was instated in the absence of wolves in Western European countries, and post-soviet Eastern European countries with continuous and stable wolf populations throughout the 20th century. The author identifies three models of change in these later countries where wolf management fell within hunting policy dominated by hunters and game specialists and needed to transition to a more conservation-oriented discourse. These different models involved a range from mild to intense role of Europeanization in this process: (1) countries characterized by a high degree of "inertia" (Radaelli, 2003) with minor changes in policy (non-EU countries); (2) countries that “accommodated” EU regulations during accession to EU while retaining a policy path of lethal control used management interventions stipulated in the Annex V; and lastly (3) Poland, where wolf policy transformed internally before the accession to the EU, thus involving only minor adjustments brought by Europeanization.

According to these criteria, Romania would fall into the second category of countries where Europeanization through the accession to the EU played a significant role in policy change. The fall of the communist regime and the accession of Romania as an EU member state can be identified as a window of opportunity that opened up the possibility for a transformation of wolf related policy under a new ecological paradigm, while hunting oriented institutions continued to maintain their dominance in wolf management based on a certain degree of lethal control maintained through derogations under the label of “exceptions” allowed for maintaining low damage levels and population safety. Based on my own interpretation, I argue that Romania stands at a middle ground between this second model and Poland, and rather represents a self-standing model on its own. While in Romania synonymous changes have not taken such a vertiginous and direct route as in Poland, we can however, see sprouts of change in mentality, independent of the influence of the EU. I argue that this transformation happened in the background of a new discourse already emerging in the general consciousness (based on a deep and ancient valuation of wolves, dug deep into people’s psyche), a discourse that diverged from the historical path dominated by hunters and the image of wolves as game or pests. The first steps towards creating specific environmental protection laws in Romania were taken in the 1970’s, during the administration of the communist regime, when the need for modern legislation capable of addressing a variety of environmental issues was first identified in the region. However, despite several environmental laws and policy measures being promoted for the first time, implementation in practice proved ineffective (Dorondel, 2019), largely due to the regime’s aggressive policies of industrialization and intensive agriculture, prioritizing production at any cost. Yet, in Romania, wolves benefited from restrictions imposed on hunting by the communist authorities that lead to the increase in wild prey and wolf populations alike (Kecskes, 2008). It is widely assumed that the complete protection awarded to bears during this time by the primary state authority, Nicolae Ceausescu, followed his personal interests in bear hunting (exclusive access to trophies) in the late 1970s’ (Crişan, 1994). In a prideful quest for status, of him becoming the top hunter in the country, Ceausescu shot as many as 400 bears during his despotic reign, including 24 in a single day (Quammen, 2003), but banned all other hunters from culling bears. This personal agenda had an umbrella effect leading to a rigorous conservation of large carnivores and wildlife protection within special designated hunting areas, leading to a significant increase in large carnivore populations.

The fall of the communist regime brought a profound transformation of the Romanian society involving democratization, decentralization, transition to market economy and economic growth, new political parties in power, elaboration of new rules and standards, an unprecedented access to information, a new flow of international support that facilitated the birth of new actors playing increasingly important roles and gaining increasing agency in wolf management: environmental NGO's. This profound transformation represented the fertile soil that helped sprout the seeds of environmental protection in Romania. Successively, the desire of Romanian society to "catch-up" with the West and the focus on achieving the earliest possible ascension to the EU, represented a very powerful incentive to further grow this seed and was probably the main driver in the development of environmental protection policies (including wolf management related policies) at the time. New regulations for - and related to - the protection of the environment were born in a struggle to harmonize Romanian legislation with the EU environmental policies. Thus, Europeanisation, particularly the adoption of European biodiversity conservation rules, proved fundamental for establishing conservation-oriented wolf policy in Romania.

Some voices advocate that accession to the EU represented *the only* driver of change that came in a pure top-down fashion with no alteration in discourse or mentality at a societal level. I propose several arguments that oppose this idea, using the Polish model for institutional change presented above as a base to argue that the changes in wolf governance in Romania over the past 50 years represented a multidirectional process of transformation that involved all domains of society.

On one hand, as shown above, the first environmental ideas and laws were born already during the communist regime. Even a few books and articles touching environmental subjects were written in this time. This is surprising in the context of the very rigid political regime that strictly controlled information inflow and restricted almost any links with the West, especially after 1971 when most environmental movements were starting to flourish in western countries.

These movements had no echo in Romania at that time as even fundamental writings with a major role in the evolution of global environmental movements such as Rachel Carson's "Silent Spring" (1962) failed to penetrate the bubble that the regime kept the society in, remaining unknown to Romanian public (Dorondel, 2019). Then, the post-socialist period brought first and foremost, freedom. Freedom of speech, freedom to travel, access to information and an opening to the world. Despite the economic harshness that marked this period, there was a strong and predominant desire to reconnect with the West, to "catch-up" in various domains and topics that had, for a long time, been forbidden by the socialist regime.

With the path opened by the socio-political changes that came after the Revolution and backed by the new environmental movements, national, but also external NGO's, biologists and researchers, but also members of the general community, contributed to creating a new image of wolves and started to lobby for policy change. Faced with a much stronger resistance of old institutions to maintain status quo, these changes were (and still are) happening at a much slower pace than in the Polish model and are still underway today. Following this model of institutional change, we could interpret the historical shift in wolf governance in Romania after the Second World War as an institutional phenomenon in which changes in policy are influenced in various degrees both by the relations between institutions with interest in wolf management and by the broader socio-political, economic and environmental factors (Niedziałkowski and Putkowska-Smoter, 2020). In line with this theoretical paradigm, we can conceptualize wolf governance in Romania as a public policy informed by a certain dominant way of interpreting wolves. As the general public view of wolves in Romania started changing from a utilitarian interpretation based on a hunting approach to wolf management to an increasingly more mutualistic approach, there was (and still is) a shift in wolf related policies dominated by a new ecological discourse oriented towards protection and conservation of the species. In closely observing the situation in Romania, I would go one step even further than Niedziałkowski and Putkowska-Smoter (2020) in their idea that changes in wolf policy can be initiated not only top down, but also bottom up by the carefully orchestrated action of certain groups and institutions, and suggest that these changes can be initiated even from a social level, when the shift in the society's environmental consciousness and awareness reaches a tipping point, becoming an unstoppable and yet subtle force that pushes the transformation forwards in all domains, including that of public policy. To support this claim, I use the model of the drastic changes in environmental governance pushed by the "First Earth Day" social movement in the USA in the 1970s. This environmental movement was born from the very fabric of the American society, when the awareness of the general public on the need to act for a better environment reached a critical threshold and pushed society to demand cleaner water, air and land for the sake of environmental protection and public health. The movement, led by millions of people, resulted in the creation of the Environmental Protection Agency as well as numerous essential environmental laws such as the Clean Water and Endangered Species Act and has won its place in history as the largest social and environmental movement in the U.S.

In a similar fashion, in the context of a freeing of thought, the ideas and values related to wolves, deeply rooted in the Romanian consciousness and tradition, constituted the seeds of change. We can hypothesize that the newly gained access to information and the new flow of ideas in the Romanian society after the fall of the communist regime, played a crucial role in creating the pathway for the new environmental paradigm and the new image of the wolf.

Whether seen in a positive or negative light, wolves have always played a special role in the life, culture and identity of people in Romania. The ancestors of Romanian people, the Dacians, showed veneration and fascination with wolves (Ruck, 2016) and even got their name from the wolf ("daoi" means "wolf"). Dacians believed that they were born from wolves, considered the wolf to be protector and identified with it in battle. When defending their territories they wore wolf masks, had steel wolf flags and made wolflike sounds to impose terror to the enemy and to show their strength and determination. The ritual of their metamorphosis into wolves is the renowned *lycanthropy* (Ruck ,2016). Later on, Dacians were conquered by the Romans, who, themselves too, believed to have wolves at the very foundation of the Roman empire, based on the famous legend of Romulus and Remus being raised by wolves. As the conquering of the Dacian territories by the Romans lead to the formation of the Romanian people, wolves clearly play a major role in the ancestry and psyche of Romanians.

Immediately after the Revolution, with the hardships brought by the two world wars and the following decades of oppression under the communist regime finally over, Romanians were ready to start anew, to reevaluate their sense of freedom and identity and to rethink the past looking at the future. Having wolves at the core of their identity and at the other side of their doorstep uninterruptedly for centuries on, Romanians had already reserved an important spot for wolves in their common consciousness. Finding national pride in the image of wolves, and in the wealth of the country's natural resources seen as one of the only treasures remaining among the ruins left behind by communism and with the wind of environmental change flowing in from the West, people from various backgrounds showed a readiness to rethink their position in wolf-related matters and gather together to push for change. When hunting quotas proved to be an undercover operation to continue to hunt wolves despite their new protection status, people united in the streets to sign petitions and protest against these outdated policies, no longer feeling constrained by an oppressive regime in expressing their opinions. While these protests happened in the larger cities and might not have represented the view of rural communities, local population or certain groups and institutions, they nevertheless show that a seed of change was growing in public consciousness and a new image of the wolf was forming at a societal level. Countless on-line and street protests of thousands of citizens speak for themselves. Just a few examples are: *stop the "Timber mafia", "Save Romania's Forests", "Stop logging in Romanian national parks"*, and "*Cut the greed, keep the forests*"[27].

Whereas the transformation of wolf governance under a new paradigm of conservation in the Polish model undertook a very direct and expedited path, in Romania these changes are very gradual, slow and continue to encounter resistance from still-standing communist era institutions maintaining hunting-oriented utilitarian views of wolves as damage causing animals, competition for game species or even pests. These institutions defend the status-quo that maintains their historic role as the main drivers of wolf management decisions. These institutional agreements are difficult to challenge as they have over time become more and more reinforced and "path-dependent" (Pierson, 2000). Thus, through a loophole in the EU legislation, wolves continue to be hunted despite their protected status.

Activists continue to push policy change and advocate especially for more transparency, better methodologies in annual estimating wolf numbers and independent, reliable scientific data to back up management decisions. Despite this, forestry and hunting institutions remain authoritative in wolf governance, and their influence and agency in the ministry continues to

[27] See video at: https://www.youtube.com/watch?v=sLgPkHX13to

affect policy. Thus, wolves become proxies for tensions among proponents of using resources (such as hunters, foresters, etc.) and adepts of preservation and conservation.

The constant back and forth interactions result in the tumultuous societal level changes in wolf (and large carnivore) related policy that we see today (formerly described in this chapter) representing a dance of power and agency between the two sides. Literature shows how these social conflicts, born among actors and groups with different values, beliefs and interests towards wolves, then influence wolf governance. The interaction among actors and institutions are constantly constructed and reconstructed through conflict (Meadowcroft, 2002) leading to the birth of public policies. Both through cooperation and conflict, trade-offs between competing objectives are identified, common social and political goals are discussed, and resource allocation is debated, leading to a process of decision making (Meadowcroft, 2009). Thus, human conflicts over wolves, mediated through culture, economy and politics, become a social phenomenon that leads to policy building and, at the same time, reshapes the social context. I therefore argue that the human-wolf conflicts as we see them today in the study area, and in Romania in general, are part of a larger process of change that is pushing not only policy but also attitudes and discourses around wolves.

This idea of conflicts viewed as drivers of change comes in support of my argument, showing that, in Romania, the transformation in wolf governance was pushed not *only* by impersonal mechanisms of adopting external legislation, neither was it induced exclusively by the lobby and action of a handful of self-standing actors and activists, but rather it was woven from the very fabric of the society, through a web of countless interactions amongst various formal and informal actors, from the relentless dance of power and agency between institutions with interest in wolf governance in the specific external context of the time. This transformation is inherently complex, and its complexity is intrinsic to a society that has been sharing the same space and resources within an uninterrupted coexistence with wolves.

It is in the context of this complex socio-political transformation that we must view human wolf conflict and all the associated issues that we identified so far. Many times, the connotation of the concept of "conflict" is inherently seen as negative but in looking at this concept in the larger context presented here, we can see conflicts as opportunities, as triggers and drivers of change. In a reduced conflict scenario, as is the polish example, there is no longer a driving force to further push policy change. But as anybody involved in the environmental field very well knows, this a very complex and dynamic system in constant change as a response to relentless interactions. This is particularly true in the present study case in which carnivores, livestock, the physical environment, and people continuously interact and respond to each other, constantly changing in response. Such a dynamic system requires similarly flexible and adaptive management strategies, responsive institutional arrangement and up to date policy. Conflicts, when effectively resolved, inherently create change, constantly fine-tuning decisions, management strategies and policies, inevitably pushing towards a win-win situation among conflicting parties, a win-win that brings better outcomes for both carnivores and people alike. Therefore, I believe it is essential that we always maintain an open stance when dealing with human-large carnivore conflicts, constantly stiving to keep focus on the larger context, consider all parts involved, identify issues and search for solutions, as this is the way to maintain conflicts on the path to resolution and policy change. Introducing conflict resolution into decision-making in a systematic way can be an essential tool for managers and policy makers to better understand when, where and how to act and what measures to take. Under the umbrella of a mediating entity, this feedback loop based on conflict resolution, could in fact encourage cooperation among conflicting parts, bring coherence to institutional arrangements and contribute to building coexistence in the long run.

9.4. Summary

An overall conclusion we can draw from this analysis of conflict manifestation and drivers, is that wolf policy in Romania, and beyond, is being shaped by two contradictory but interconnected processes of institutionalized management leading to both maintenance and disruption of conservation goals. On the one hand, conservation of wolves has been institutionalized through a series of legal acts, procedures and guidelines for management, establishing management administration entities, policy instruments (such as compensation and prevention measures), institutionalized projects and studies. On the other hand, wolf conservation, and the coherent institutionalization of wolf conservation is being challenged by its politization and lobby work oriented at maintaining the status-quo of hunting and forestry institutions as official managers, at changing existing regulations and laws, transforming their interpretation according to personal and political agendas, and directing the institutionalization of wolf management towards solutions that protect the position, interests and agendas of dominant actors in the agricultural and hunting sector.

Within an official statement opposing the most recent policy change related to hunting quotas, three of the most active environmental NGOs in Romania (WWF, ACDB and Milvus Groups), capture this state of affairs:

> *"Bears, wolves, lynx and wild cats are protected by law, not only at the national level, but at the European level, by the Habitats Directive. Although this law clearly states that the approval of derogation quotas can only be done if alternative solutions are presented, studies present hunting as the only solution to reduce damage. In order to continue hunting large carnivores, even after our accession to the European Union, the damage caused by these animals was always invoked. Although hunting does not solve this problem, the level of damage reported by hunters also increases from year to year to justify the increasingly aggressive decimation of large carnivores.*
>
> *In this way, the authorities only treat the symptoms, but ignore the real causes of the problems, such as deforestation, the lack of an effective compensation system in the case of damage caused by these species, the lack of security for local communities or the absence of a strategy for large carnivores in Romania's forests"* (Ivanov, 2016).

Despite these challenges, wolf policy in Romania in recent years has consistently centered more on protecting wolves and decreasing the number of wolves culled through institutional management policies. But what lies underneath, the number of wolves killed through poaching, road accidents and other sources of mortality, the effects that human stressors have on wolf habitats and the real status of the wolf population in Romania, are all still unknown. Until a robust nationwide study on the wolf population is done, one can only make assumptions based on insufficient reliable knowledge.

At the same time, these intense debates may also represent the first signs of an eventual transformation of not only carnivore management per se, but also of related institutions at their core. The traditional institutions that are struggling to survive in the midst of changing social values and legal frameworks are composed of networks of resources managers and users whose power is now threatened and are seen by environment-friendly elements of society as representing undesirable values and behaviors. A reform of these stagnant old institutions that maintain dysfunctionality in the world of game, carnivore and habitat management may be on the horizon as more of the Romanian population has changed its ways of thinking about nature, wildlife and carnivores, opening the path to a more stakeholder-inclusive management, transparency, accuracy in management and a more satisfactory meeting of the goal of coexistence.

10. How can we secure coexistence?

Answers RQ 2. "Based on the biophysical, social and institutional factors identified, what management practices and/or institutional arrangements are most likely to mitigate human-wolf conflicts in the ANP and beyond?"

10.1. What makes coexistence possible? The CASES framework.

"Wolves and people were not natural enemies. The humans' relationship with other animals established their rivalry with wolves."

(Jon. T. Coleman, Vicious: Wolves and Men in America, 2004)

This research analyzes the wide array of biophysical, husbandry, management, and institutional factors that influence and drive direct and indirect conflicts between people and wolves and identifies solutions that would aid mitigating conflict. In order to grasp the full complexity of this subject, unlike earlier work, this research takes on **a novel holistic and interdisciplinary approach** that sees the human and natural components of the complex and dynamic human-influenced landscape of the Western Carpathians of Transylvania as coupled rather than separate. By adapting and further advancing the *Integrated Coupled Human-Natural Systems* (CHANS) framework proposed by Carter *et al.,* (2014), this research develops **a comprehensive, integrative and multi-science framework** to capture the intricate web of interactions and mutual feedback between the various components of this system (wolves and their natural environment; livestock, livestock guarding dogs and shepherds; local communities; stakeholders and managing institutions at local, national and international levels).

This socio-ecological approach has rarely been applied in human-wildlife conflict research and thus, this analysis helps fill an important research gap (Dickman, 2010) while also laying the ground for improving the interoperability of different scientific approaches (McInturff *et al.,* 2021) that scientists and managers can undertake in the field to gather richer data on, and successfully mitigate, human-wolf conflicts.

The results reveal that unpacking conflicts is not a simple matter and no simple solutions exist. When analyzed holistically, through an integrated suite of interdisciplinary methods, conflicts prove to be shaped by a multitude of drivers, some of them clearly visible, but many of them subtle, intricate and deeply sown into the fabric of societal interactions. The main steps to start with are identifying the discrete elements of this issue, documenting their complex interactions, mapping the manifestation of conflict and understanding conflict drivers. Only then can one move on to analyze and structure the yielded data and systematically present findings in a form that can help better understand the entire conflict framework, identify weak spots and envision solutions that would lead to a better coexistence.

It is important to understand that although conflict, and its manifestations, might sometimes be much more subtle at first glance, investigating deeper through a very detailed micro analysis can reveal their true magnitude. Just like an iceberg, underneath the visible manifestation of conflicts, can lay much more complex issues, that, if undetected and undealt with, can lead to irreparable damage to conservation efforts. The importance of these conflicts and tradeoffs must not be disregarded, especially considering that the fragile balance of coexistence between people and wolves in the Romanian Carpathians, and beyond, can easily erode under the weight of inadequately managed escalating conflicts and their effects.

To keep the boat of coexistence floating, we must, first of all, patch up the holes in our vessel by finding immediate solutions to the straight-forward problems we identified as rendering the process of wolf management incoherent. But then, we must reunite our efforts and work together to rebuild our ship of coexistence, based on a common effort of communication, collaboration and cooperation within *participatory co-management* and adaptive *governance* on the basis of an *integrative, adaptive and functional framework*.

In the context of the very intricate and dynamic interplay of all the biophysical, spatial and non-spatial husbandry management and socio-political factors engaged by this research – a complexity that is intrinsic to a society that has been sharing the same space and resources with wolves and other large carnivores uninterruptedly for millennia – I identify the need for a new framework that can organize and appropriately approach this complexity. An extensive review of scientific literature revealed a relative scarcity of studies that design and practically implement integrated multi-science conceptual frameworks for HWI research (Pooley *et al.,* 2017; Thapa *et al.,* 2024). Despite a general consensus that it is no longer tenable to study ecological and social systems in isolation from one another (Redman, 2004), and despite an increasing number of studies approaching SES as integrated systems and engaging in extensive qualitative descriptions of HWI as complex, multi-faceted phenomena (Dickman, 2010; Nyhus, 2016), empirical studies of HWI so far have nonetheless rarely developed and applied context-tailored integrated frameworks as part of their approach. Most of this research emerged in the last decade and develops conceptual models of evaluating human interaction with natural systems and more specifically HWI (to a lesser degree), that primarily remain theoretical (Balasubramaniam, 2021; Hill, 2021) rather than implemented in context-specific situations to generate empirical or quantitative observations. There is still disproportionately less scientific work that focuses on human related aspects of HWIs and a dearth of studies that evaluate their effects as an integrative whole (Balasubramaniam, 2021).

My immersion into the practical and theoretical aspects of the endlessly complex world of human-wildlife interactions in human-dominated landscapes within SES and CAS systems, has led to an understanding of these issues and to a development of my thinking about these systems. This resulted in several theoretical and practical considerations that I believe could enrich and advance the field of HWC and specifically the practical implementation of CHNS based approaches: an extensive, holistic review of conflict drivers; a reinterpretation of the concepts of *Coexistence* and *Human-Wildlife Conflicts*; an *integrative* approach to *Adaptive Governance tailored to HWC;* and the birth of a tailored complex adaptive socio-ecological systems framework for HWC and HWI studies, that I here define as *Complex Adaptive Socio-Ecological Systems (CASES)* for HWI studies. All of these concepts are detailed below as I describe the evolution of my thinking process and presents the steps of conceptual design that have led to the birth of this framework.

Complex Adaptive Socio-Ecological Systems *for Human-Wildlife Interaction research*, hereafter '**CASES'** (Figure 86), is based upon, and combines, the classic SES and CAS models, but it also expands and further develops and adapts these approaches to better fit research in the specific field of human-wildlife conflicts. I based the design of this framework around the key concept of *Conflicts* reinterpreted as *key intrinsic regulating mechanisms that drive change* within the processes of co-adaptation and co-governance, embedding a potential to breed long-term functional structures of coexistence in complex socio-ecological systems. I built my approach on the fundamental state-of-the-art theoretical premises of complexity thinking (Rogers *et al.,* 2013), complex systems theory (Cilliers, 1998; Cilliers *et al.,* 2013) and Complex Adaptive Systems theory (Levin, 1998; Gunderson and Holling, 2002) in understanding and modeling SES (Berkes *et al.,* 2000) as CAS (Berkes *et al.,* 2003; Levin *et al.,* 2013) and in identifying the best methods and approaches suited for this purpose (Biggs *et al.,* 2015) while also understanding the tradeoffs and the implications (Levin *et al.,* 2013) of the integration of the central defining features of CAS (Preiser *et al.,* 2018) into SES (see theoretical framework in Chapter 4).

I complement and build upon this theoretical foundation based on my own findings and understanding as I tailor CASES to the specific field of human-wildlife studies and human-LC studies in particular.

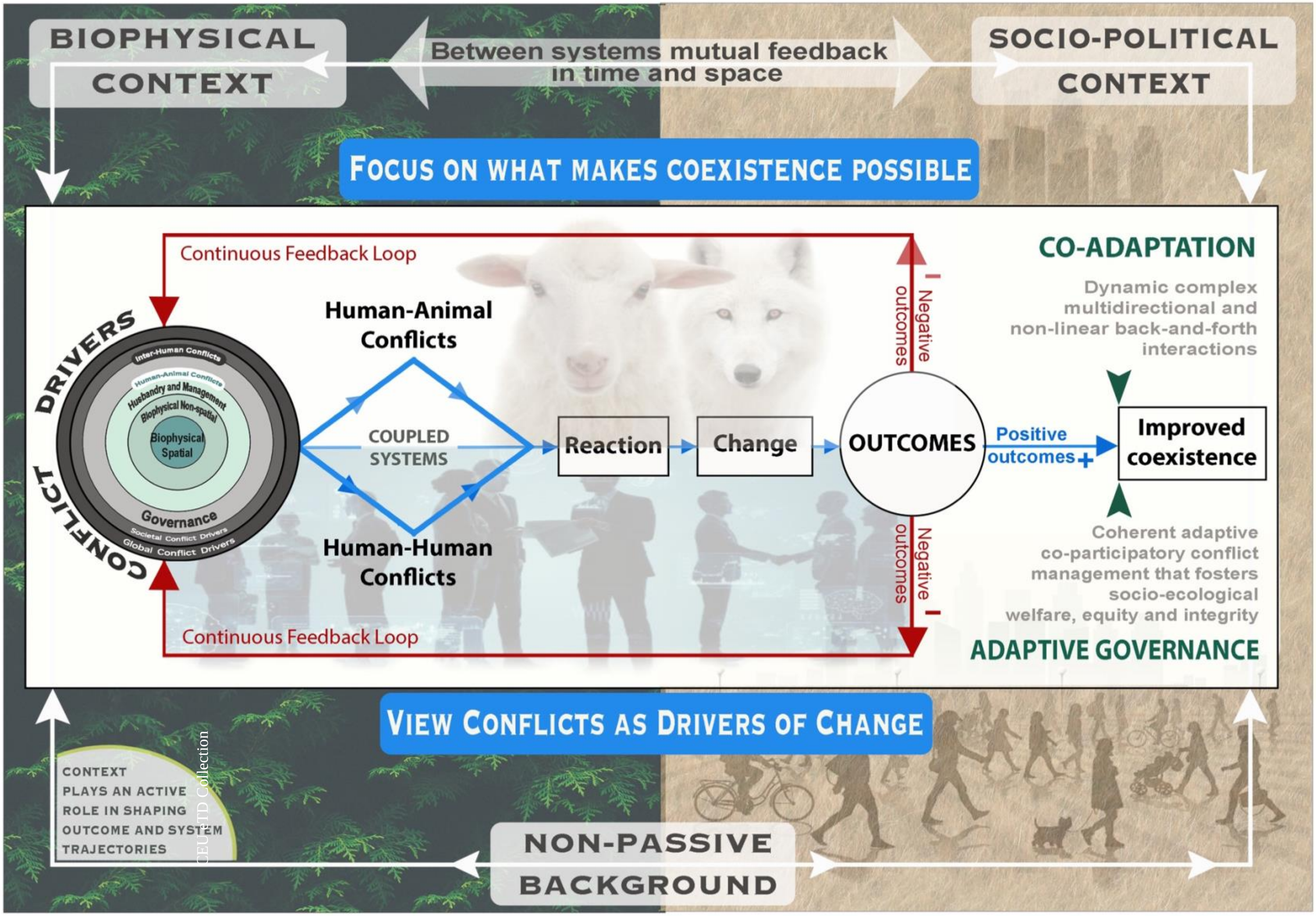

Figure 86. CASES: Complex Adaptive Socio-Ecological Systems – a new framework for Human Wildlife Conflict studies.

Central to CASES are *conflicts seen as drivers of change*. This idea represented the embryo for the conception of this framework. Similar work was done by Hill (2021) and Pooley (*et al.,* 2021) who, in parallel, reach the same basic conclusion: the need to reconceptualize coexistence as a fluid continuum and conflict as an agent of change that can facilitate cohabitation – a valuable component of coexistence rather than solely a negative occurrence. Extended reflection and analysis of the nature of conflicts and the factors that drive them both in time and in space, yielded the conclusion that conflicts are not intrinsically negative (Pooley *et al.,* 2021), as are most often portrayed in literature on HWC, and that the assignment of "negative" or "positive" can only succeed a subjective interpretation of their outcomes. Whether positive or negative, *conflict outcomes shape the landscape of coexistence*.

Laying at the core of my research, I have found that the issue of conflicts also lies at the core of our relationship with wildlife and at the same time, also at the core of our own interactions with each other when faced with issues of wildlife governance. This extended reflective process led to the realization that conflicts also stand at the very core of our coexistence with wildlife (Hill, 2021), whether it is a functional coexistence or a compromised one. It started to become clear that conflicts are imbedded with a powerful force, an ability to push outcomes in either direction, but, nevertheless, a force that has immense potential.

To further develop this idea, I sought to construct a comprehensive overview of the complex nature of conflicts by aggregating the various types of drivers of conflict, both those identified within my own methodological process and practical research and those that emerged from the analysis of local Traditional Ecological Knowledge (see Tables 1 (Chapter 6) and 14 (Chapter7) and section 9.1 of Chapter 9), all of which I then support and complement based on thorough literature review on the topic (for reference also see Mech and Boitani, 2003; Woodrofe *et al.,* 2005; Agrawal and Ostrom, 2006; West *et al.,* 2006; Holmes, 2007; Dickman, 2010; Barua *et al.,* 2013; Chapron *et al.*, 2014; Kansky and Knight, 2014; Linnel *et al.,* 2015; Redpath *et al.,* 2015; Treves *et al.,* 2015; Carter and Linnel, 2016; Pooley *et al.,* 2017; May, 2022).

The result is a schematic representation (Figure 87) that attempts to assemble a conceptual typology of conflict drivers, a typology that clusters different types of influential factors based on their nature, in a systemized classification format.

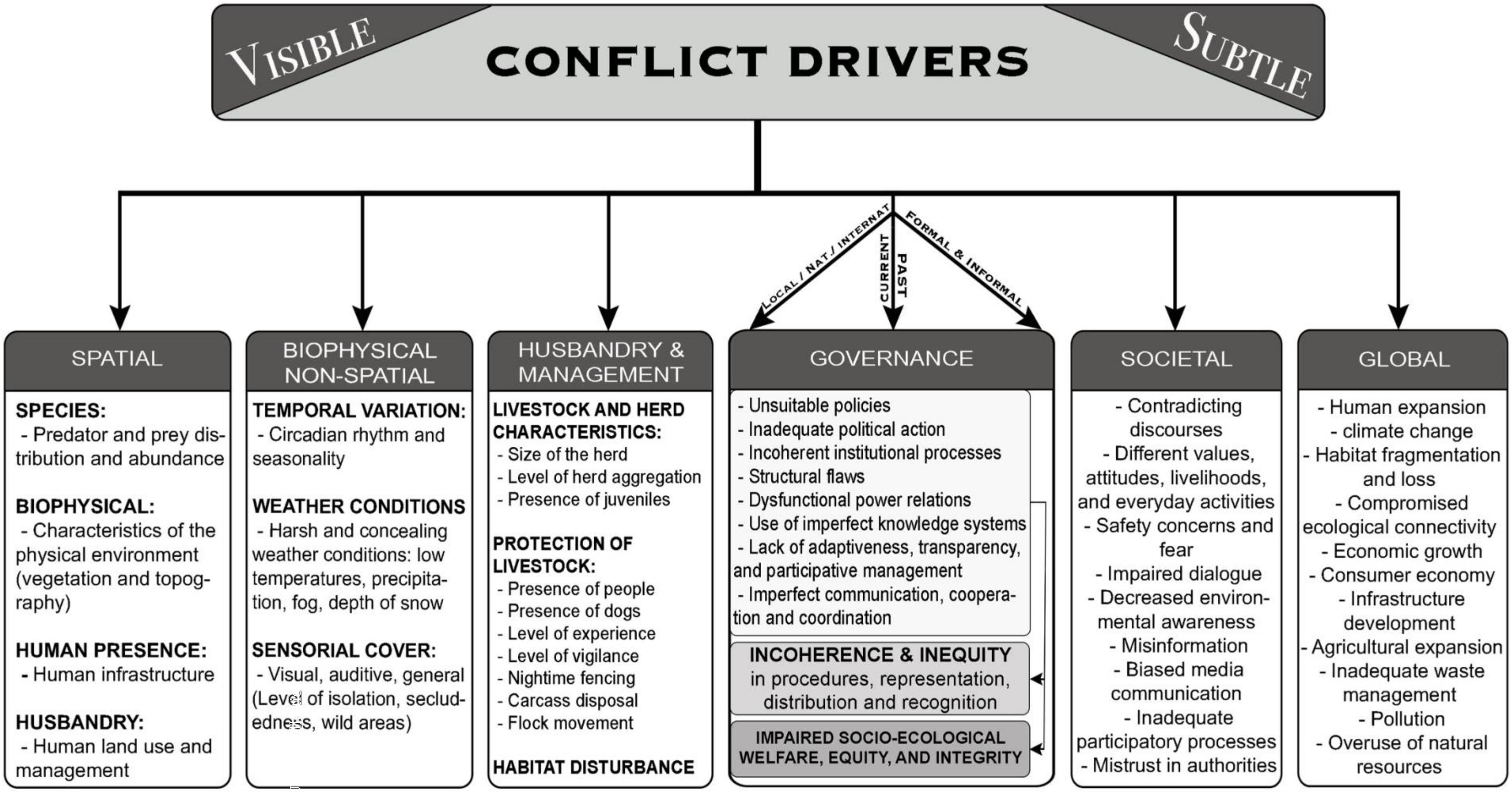

Figure 87. Systemized representation of HWC conflict drivers.

To provide an interdimensional understanding of the nature of conflicts, I reorganized this classification into a concentrical representation that aids the visualization of the magnitude at which these types of conflict drivers act and how they interact with each other (see the representation of “Conflict Drivers” in Figure 86).

Analyzing the complexity of drivers reminds us of how intricate the web of interactions that leads to conflict can be, and how important it is to capture the many direct and subtle interactions that can lead to conflict. The multidimensional nature of conflict drivers also reminds us that the human and the natural systems are inextricably interlinked and, thus, neither of them should be – or even *can* be – studied or addressed as independent systems but rather they need to be seen as one integrated socio-ecological system (Carter *et al.,* 2014).

By recognizing that humans are part of nature (as more thoroughly described in Chapter 4), socioecological (SES) systems represent a well-established scientific approach for studying HWI in human-dominated landscapes. SES describe dynamic complex systems with continuous adaptation (Berkes *et al.,* 2003) and emphasize that the social and the ecological are linked together through feedback mechanisms, thus both these dimensions need to be considered by integrating social science into ecological studies (Redman *et al.,* 2004) and vice versa. The CHANS approach (Carter *et al.,* 2014) suggests such a combined socio-environmental perspective by bringing together diverse disciplines to understand the nuances of these complex systems and pledging for the need of broader analysis of multilevel and cross-scale interactions between people and wildlife. I adopt these ideas in designing my own interpretation of a coupled socio-ecological system, viewed through a multi-dimensional and cross-scale lens (Figure 88). I then, over the course of my research, continue to build on and add to these previous efforts, thus further developing the conceptual postulations of CASES.

As such, CASES adopts the base principles of the CHANS approach and integrates them into the larger CAS theory (Preiser *et al.,* 2018) for SES studies (read more about CAS in Chapter 4), thereby emphasizing that *Context*, *Multilevel interaction*, *Constant change*, *Open exchange*, *Nonlinearity*, and *Adaptiveness* are all essential features of complex SES and need to be integrated into the SES theory, just as I have found true within my own research of the specific case of HWC in the Western Carpathians. As mentioned before, the conceptual framing of SES as CAS is not a new idea, but an established approach that has emerged as a significant field of research for understanding the interactions and feedback systems that shape the dynamics and features of SES (Fischer *et al.,* 2015). Scientific literature has substantially supported the recognition that social and ecological systems are inextricably linked (Berkes *et al.,* 2003; Díaz *et al.,* 2006; Summers *et al.*, 2012; Wu, 2013) and thus they are inseparable ontological entities, intricate assemblages (DeLanda, 2006) of interactions or intertwined, complex, and adaptive SES (Folke *et al.,* 2016).

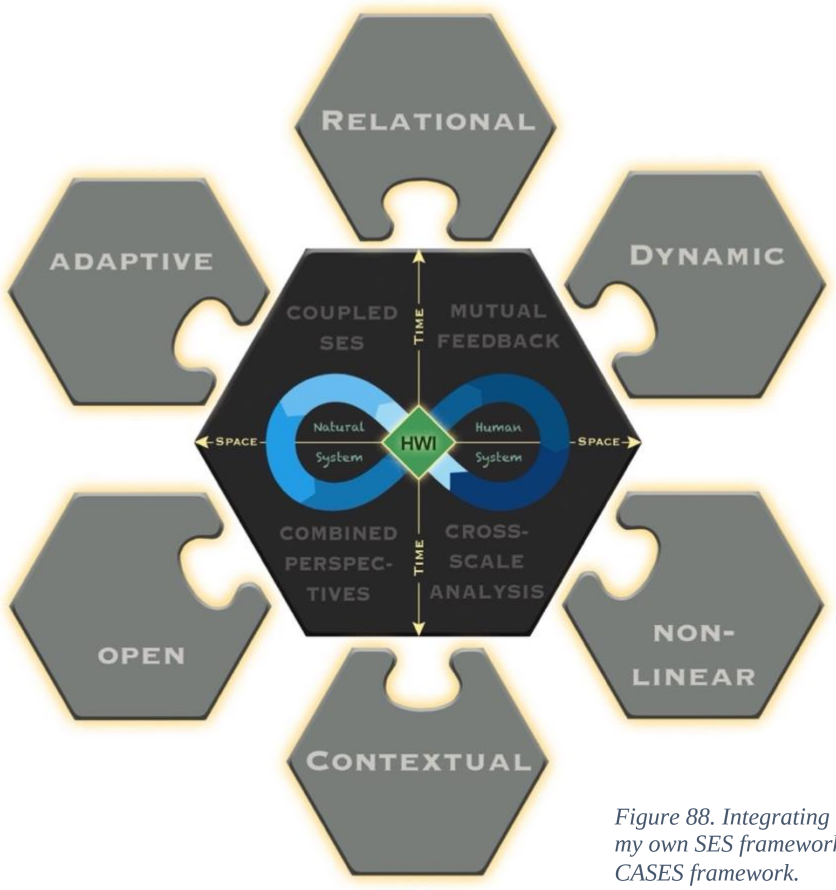

Figure 88. Integrating the CAS fundamental principles into my own SES framework as a base for the newly proposed CASES framework.

However, there has been a limited practical application of this theory – currently increasingly used in place-based studies (de Vos *et al.,* 2019) such as studies from China (Li *et al.,* 2024), Tanzania, and Madagascar (Tan Tengö, 2004) – and therefore a limited understanding for identifying suitable methods and practical approaches to studying SES as CAS (Preiser *et al.,* 2018; Balasubramaniam, 2021). There is thus a need to operationalize this conceptual framework to facilitate the understanding of practical applications of this approach. By adopting a complex, integrative and multidisciplinary theoretical and methodological approach for understanding human wolf conflicts in the dynamic human influenced landscape of the Apuseni Mountains, this research unearths a classic case of CAS and provides an example of a practical application of the SES as CAS, while also providing the context to further advance and operationalize this approach by integrating it into the HWI-tailored CASES framework.

Figure 88 illustrates the integration of the CAS fundamental principles into my own SES framework as a step forward in envisioning an integrative conceptual frame. Biophysical

Further on, I demonstrate how I adopted and practically implemented CAS's six foundational principles (Preiser *et al.,* 2018) into my own research (Figure 89). At the same time, I highlight the theoretical and methodological advancements and variations to the conventional approach proposed by my research.

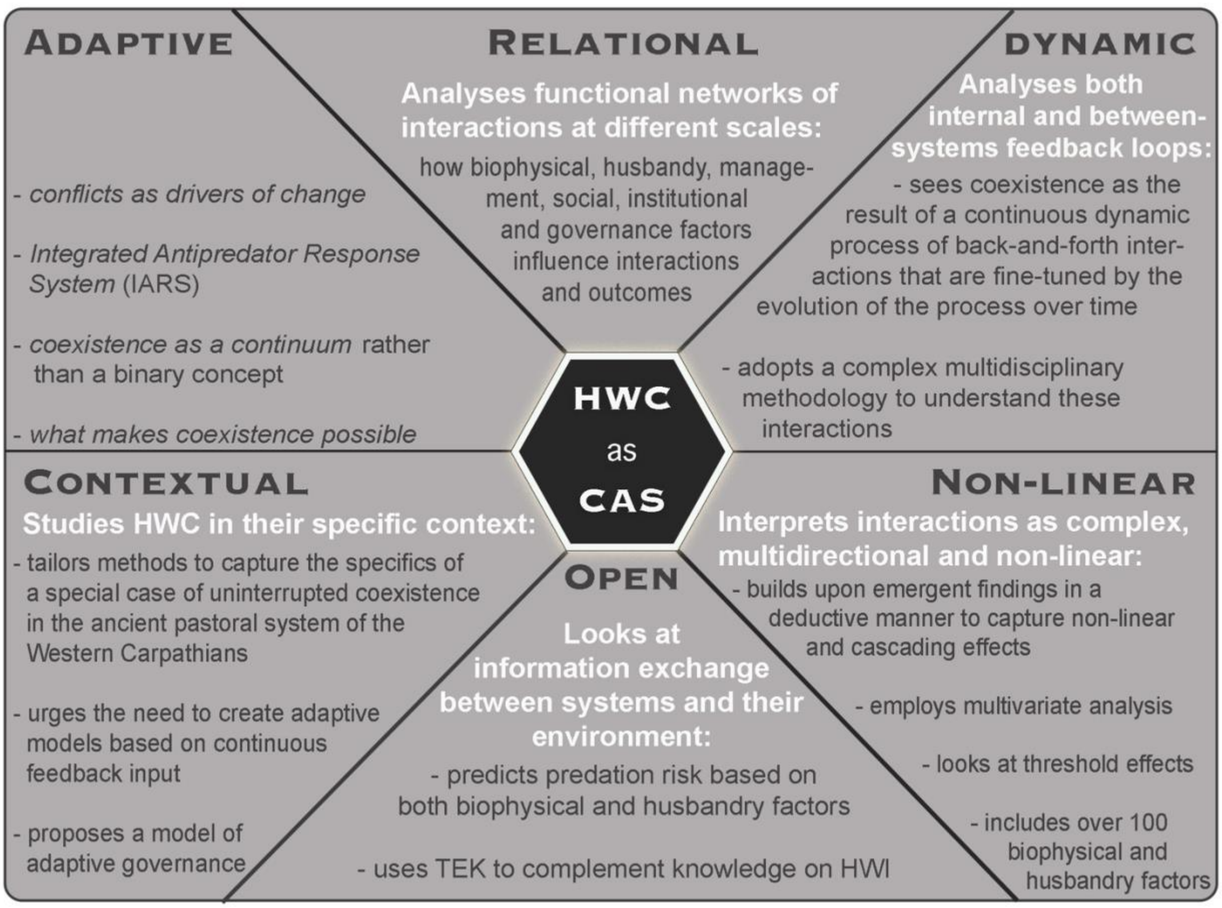

Figure 89. Adoption of CAS principle in the current research and main methodological and theoretical advancement.

This integrated approach lays at the foundation of CASES. The CASES framework explicitly and openly advocates for adopting the base principles of CHANS, SES and CAS to any human-wildlife interaction study and assists in integrating these baseline principles into a contextual adaptive framework, tailored to the specific socio-ecological context of the issue under study.

Furthermore, CASES adds to these principles in an effort to complete the list of fundamental predicaments that become indispensable when we approach HWC as internal regulating mechanisms of coupled SES systems under the umbrella of CAS. As such was born the dodecagram of the twelve fundamental principles of CASES, that I build in the following pages.

Under the CASES perspective, any project – be it scientific research or a wildlife governance process – attempting to understand and/or manage HWI, must take into account the Adaptive, Integrative, Cross-scale, Open, Dynamic, Complex, Multi-dimensional, Non-linear, Functional, Interdisciplinary, Multi-scale and Context-dependent nature of HWI when designing their approach. By integrating these principles, I attempt to bring a unified understanding of the subtle and intricate mechanisms that enable the process of progression from isolated human wildlife interactions to a full functional coexistence.

As an essential step in this direction, I construct the CASES framework around the fundamental question of *"What makes coexistence possible?"*, and propose to move the focus from the conventional research path that engages only factors that *hinder coexistence in the moment,* to a more holistic approach that would entail a broader investigation into what subtle and intrinsic mechanisms *support functional coexistence on the long term*. In line with parallel state-of-the-art research in the field (Frank, 2015; Pooley *et al.,* 2017; Frank and Glikman, 2019; Hill, 2021; Pooley *et al.,* 2022), I propose a *reinterpretation and a new understanding of the theory of coexistence*.

Most traditional views talk about coexistence in dichotomous terms, and very often in such discourses, coexistence is presented as either present or absent. I consider this view limiting because, as long as people and wildlife live in the same space, there is always some degree of coexistence that can range from co-occurrence (Harihar *et al.,* 2013) to functional and sustainable long-term coexistence achieved through co-adaptation between humans and wildlife (Carter and Linnell, 2016). This range takes the form of various degrees of coexistence on a (malleable) scale from low to high. Whether stronger or weaker, threatened or stable, extended or more limited, *coexistence is nevertheless, continuous, and not dichotomous* (Figure 90).

When we see ***Coexistence as a Continuum*** (Frank, 2015; Frank and Glikman, 2019; Hill, 2021; Pooley *et al.,* 2022; Thapa *et al.,* 2024) rather than a binary concept, we can re-envision our approach for HWC studies in SES and adopt a much wider array of theoretical, conceptual and methodological approaches to study understand and manage our relationship with wildlife.

In the process of reframing coexistence as a continuum, we need to acknowledge the fact that this continuum has no ultimate endpoint, as a permanent state of perfect coexistence marked by the absence of conflict is impossible to achieve (Hill, 2021). Coexistence does not imply the absence of conflict (Pooley *et al.,* 2020), but it is rather a homeostatic state of peaceful cohabitation (Frank, 2016), mutually agreed upon to the extent possible (Pooley and Redpath, 2018), characterized by compromise, acceptance of tradeoffs and tolerable levels of risk (Pooley *et al.,* 2022; Thapa *et al.,* 2024) and costs (Carter and Linnell, 2016) for all parties, a state that can be achieved through reaching a win-win situation.

At the same time, we must understand the multiple-dimensional interplay of biological, ecological, cultural and societal factors take make a dichotomous perspective of HWI impossible and require a framing of coexistence that reflects the multi-faceted, nuanced, intricate and inherently complex nature of HWI. Rather than a static condition, HWI emerge under specific conditions at particular times and places through varying, uneven interactions between humans and wildlife (Frank and Anthony, 2021; Malley and Gorenflo, 2023).

This is where the reinterpretation of conflict as an inherent mechanism of coexistence enters into play to become an essential gear in shifting the perspective of HWI under the CASES framework, as complex socio-ecological adaptive systems that require equally complex research approaches. A specific conflict outcome can be both positive for certain groups and individuals and negative for others at the same time. The malleable nature of coexistence allows for a wide range of outcomes that are simultaneously interpreted and experienced in different ways by the various components of the system. This is why conflict outcomes should not be seen only as positive or negative, but rather liminal in nature with capacity to lead to win-win, win-lose, or lose-lose interactions. Consequently, the various degrees of coexistence, in this context, are not fixed points along the continuum scale (Hill, 2021) but rather variable in time and space according to the specific, and yet ever-changing context.

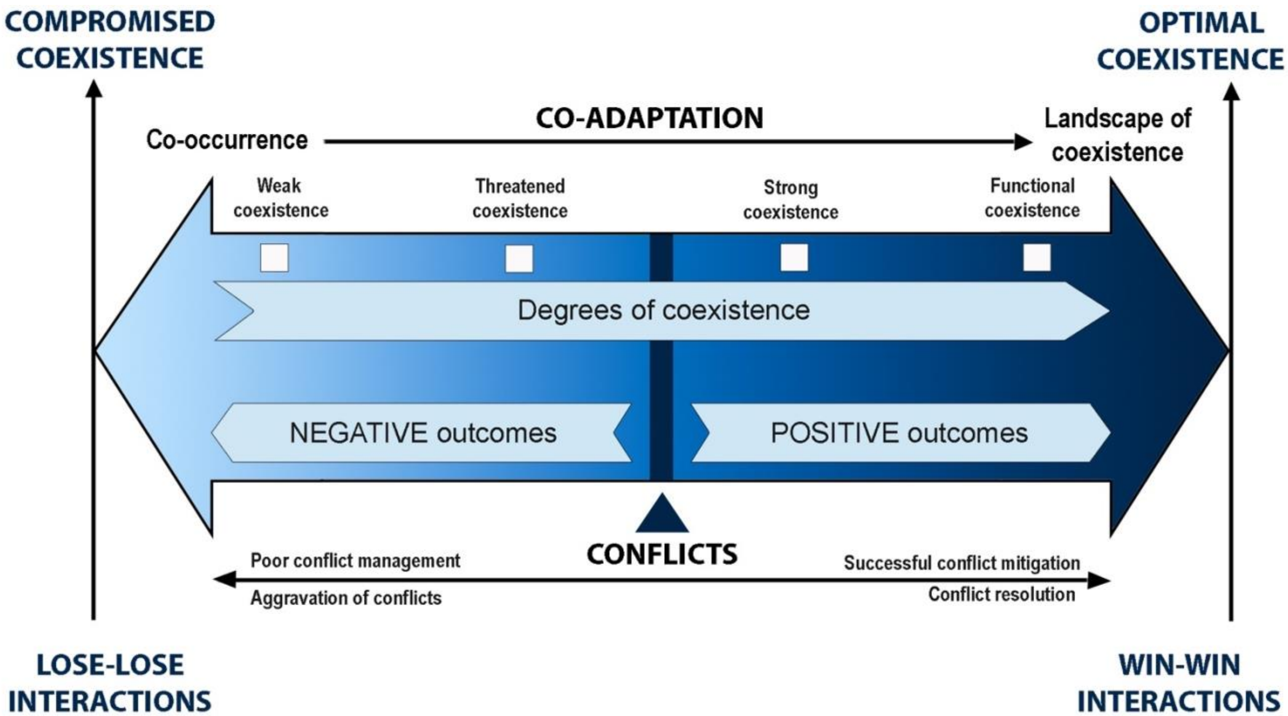

Figure 90. What makes coexistence possible? Reinterpretation of the nature of coexistence as a continuous rather than a dichotomous concept.

The reinterpretation of human-wildlife conflicts proposed here shifts the classic interpretation of conflicts as negative forces that lead to a degradation of coexistence, to a vision of *conflicts as intrinsic mechanism of coexistence* with capacity to generate win-win scenarios and to improve our relationship over time. I propose a reframing of ***Conflicts as Drivers of Change*** (Figure 91).

On the basis of this reconceptualization, I, thus, define HWC conflicts as "*liminal*[28] *phenomena representing internal self-regulating mechanisms of human-wildlife coexistence due to their intrinsic potential to drive change and transformation of the constellations of fundamental interdependent phenomena and causal networks of connections within complex socio-ecological systems, based on continuous feedback loops that fine-tune human-wildlife interactions over time and space*."

[28] Liminality (from Latin *limen*, "a threshold") is the quality of uncertainty in transition occurring at the middle of a transformation process fated to precipitate new outcomes that are not yet known; transition across a threshold situated at the border separating one configuration from another (Larson, 2014).

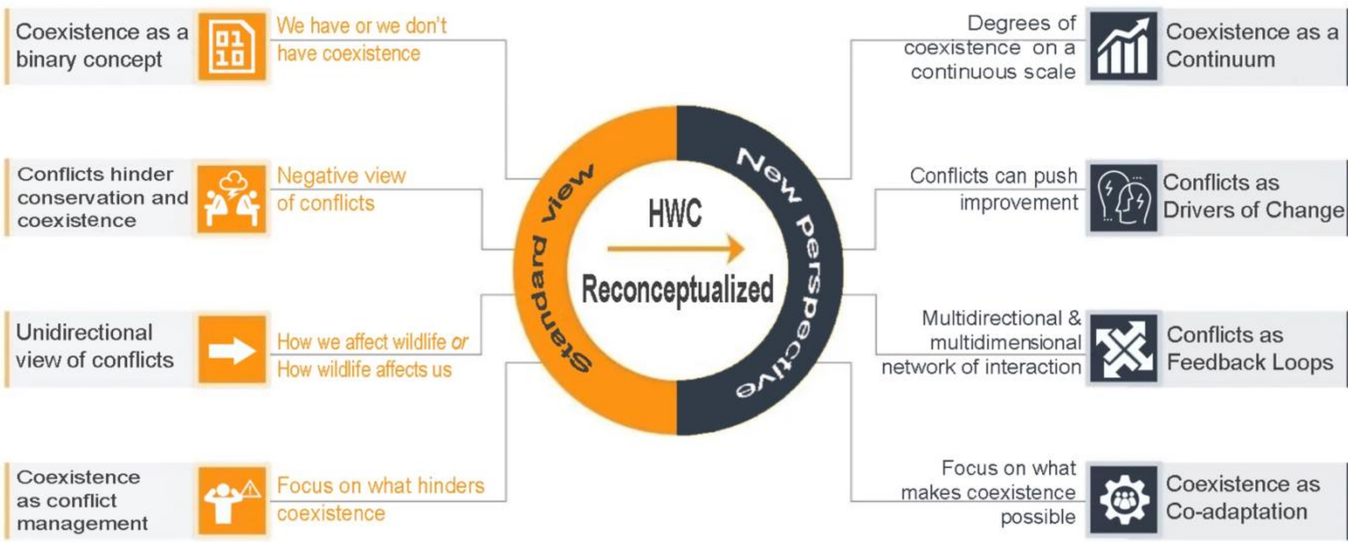

Figure 91. The novel perspective on interpreting HWC proposed by this research.

My arguments for reconceptualizing HWC mirror earlier debates promoting a rethinking of the label "human-wildlife conflict" (Peterson *et al.,* 2010) in a move to adopt a more coexistence-focused approach to HWI (Frank and Glikman, 2019) that switched the emphasis away from the victim-predator framework (Hill, 2021) and recognizes the significant value wildlife has, its agency and rights, and the tolerance often shown by people to sharing space with wildlife in specific traditional ways (Pooley *et al.,* 2022).

In order to better understand the potential of conflicts as internal driving forces of change that can support a self-propelling process of co-evolution and co-adaptation resulting in coexistence, we can compare coexistence to an embryo: just as an embryo has an inborn capacity to develop into a full grown organism and contains, embedded, from the very start of the process, all the information it needs to grow into its mature from, so do human-wildlife interactions have the potential and capacity to evolve from co-occurrence to coexistence. And similar to an embryo's development into a full-grown organism, so does coexistence exhibit a growth process through internal regulating mechanisms incorporating continuous feedback loops that provide all the necessary information for the system to progress through the various stages and degrees that lead to a functional fully developed coexistence. Through the scheme presented at the center of the CASES framework (Figure 92), I suggest that at the core of this intrinsic mechanism lay conflicts. Since conflicts are nowadays mostly seen as negative occurrences one might ask: *how can conflict lead to improved coexistence?* To answer this question, we must be open to reframe our view of conflict as *opportunities*. Just as within a living organism there are neurological signals that are triggered by certain external factors, and promote reaction, conflicts can also be seen as signals of inadequate system functioning that then cause a chain of reactions to rebalance the system within *an internal self-regulating mechanism of coexistence.*

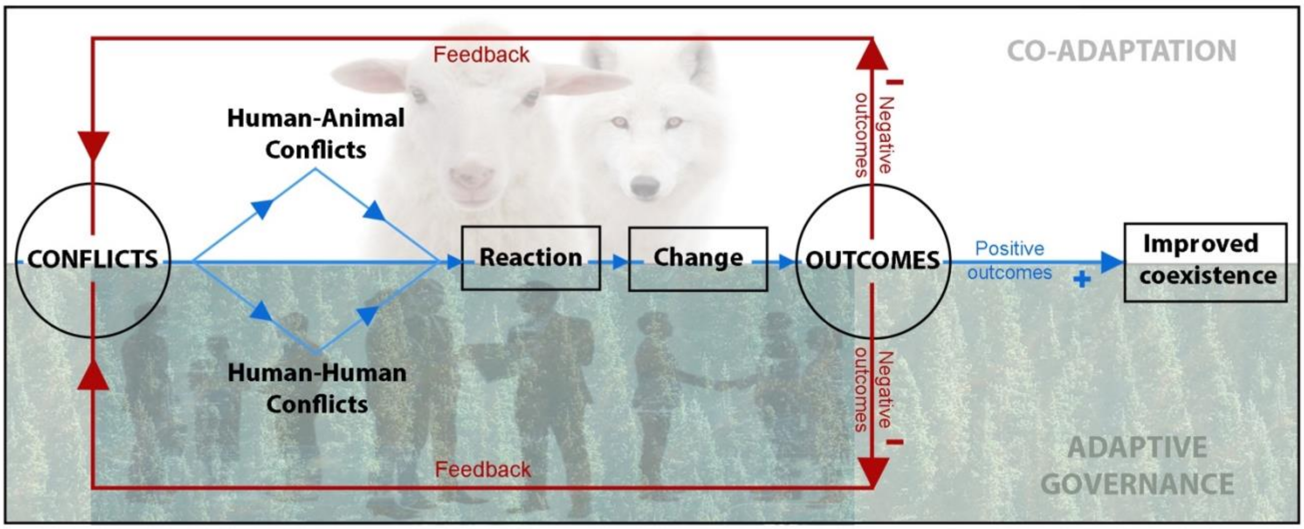

Figure 92. Conflicts as Drivers of Change.

To better illustrate this, in the forthcoming paragraphs I will apply this theoretical predicament to the specific case presented in this dissertation.

As highlighted throughout this research, people in the Western Carpathians have shared the same landscape for millennia and constant back-and-forth interactions have fine-tuned their relationship over time. The concept of a *Integrative Adaptive Response System* defined in section 7.4.3. of Chapter 7 describes how people, guarding dogs, livestock and wolves, adapt to each other by constantly reacting to the other's actions. This continuous action and reaction, that in the moment emerges to the surface as conflicts, overtime, leads to co-adaptation and, as such, is the base for functional and sustainable, long-term coexistence.

If we zoom out to include the inter-human conflicts around wolf-related issues into this argument, we encounter the same need for adaptiveness. Because HWI are so relentlessly dynamic, we conclude that managing conflicts should entail accounting for the constant changes in the system and using a feedback-loop-type of framework where governance policy and decisions are always updated according to current needs triggered by changes in the system. Here, once more, we can see conflicts at the core of this feedback mechanism. Once a certain conflict driver generates inter-human conflict, the involved actors will react in response through action that triggers changes in the system and generates either positive or negative outcomes for those involved. If there is a win-win situation and the outcomes are positive for both parties, we can agree that this conflict resolution led to an improvement of human-wolf relationship and to a more functional way of sharing the landscape. If, on the contrary, conflict leads to negative outcomes for either side, these outcomes will eventually become once more sources of conflict drivers – signals of a need for reform – thus completing the feedback loop. This feedback cycle that is relentlessly perpetuated, shows conflicts as a powerful engine that constantly refines interactions overtime.

If, on the other hand, conflicts again and again lead to negative outcomes, coexistence becomes threatened. The difference between the two scenarios - a thriving and a threatened coexistence - stands in the way conflicts are managed. In complex coupled SES systems like the one presented in this research, the web of interactions is very intricate and dynamic, forms unexpected nonlinear patterns, and expands over multiple dimensions, levels, scales and extents in both space and time. These interactions occur in the background of similarly complex natural biophysical systems and dynamic social and political contexts. As seen in Figure 87, the large majority of conflict drivers are of human nature because the way we react to wildlife directly, and to each-other when dealing with wildlife issues (through husbandry, management, governance) is, in-fact, the core determinant of the outcome of our interaction with wildlife. Through constant feedback input, the past and present political, administrative, economic and social factors (at local, national and international levels), influence institutions and organizations involved in wildlife management (Figure 93), shaping the degree of socio-ecological welfare, equity and integrity (May, 2022).

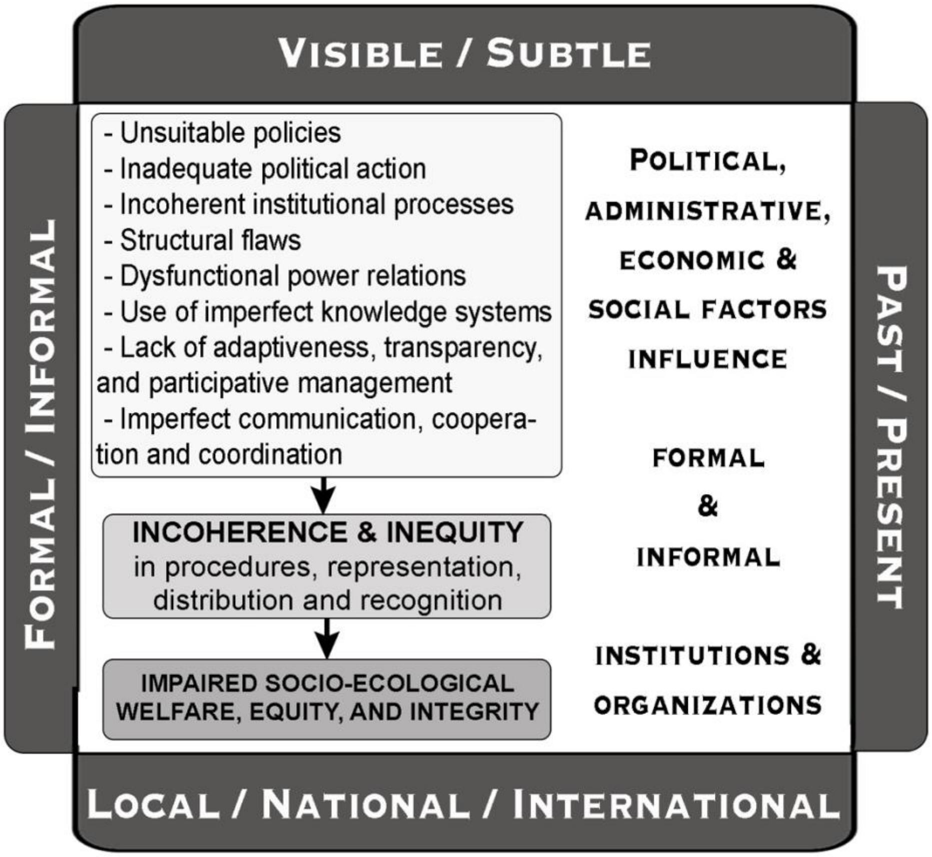

Figure 93. Nature and effect of governance related conflict drivers.

An *Adaptive Governance* framework that takes these feedback loops into account and constantly reviews management strategies based on the latest informational input can constantly improve management and ensure win-win outcomes in the long run (Figure 94). Even when outcomes are negative, an adaptive management approach built on flexibility can quickly identify issues and immediately readjust strategies and policies to account for this negative feedback and address negative outcomes resulting from previous management actions. I believe a relative state of peaceful coexistence can be achieved if win-win situations are facilitated by an adaptive management that focuses on not only preventing negative interactions, but also on effectively managing inevitable negative interactions in socially legitimate ways (Carter and Linnell, 2016), and collaboratively and adaptively intervening to enable positive interactions at a landscape scale (Marchini *et al.,* 2019).

This kind of adaptive governance of wildlife should, at the same time, be based on thorough planning (Marchini *et al.,* 2019; 2021) and a common effort made possible by ***the Triple***

C of participatory co-management: **C**ommunication, **C**ooperation and **C**oordination among *all* involved actors, including livestock producers and local communities and even representatives of the public.

In view of the framework that I propose, this kind of adaptive and participatory management should be supervised under the guidance of an *independent, impartial, but well-informed third-party mediator* who would play the role of ensuring that the needs of all parties are met. I thus consider this concept of ***Adaptive Participatory Governance*** **(APG)** of HWC as a key element of successful conflict management that leads to sustainable coexistence.

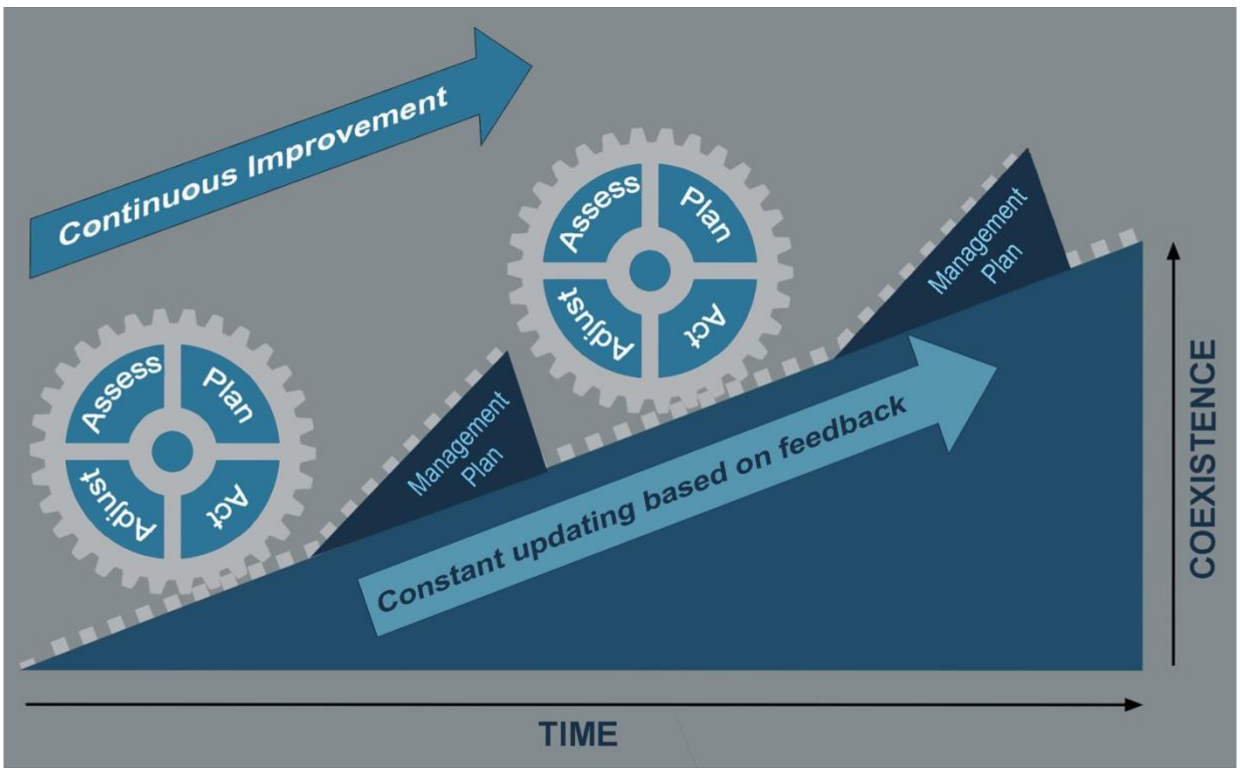

Figure 94. Integrative approach to Adaptive Management.

When conflicts are effectively mitigated, they inherently generate positive change, constantly fine-tuning decisions, management strategies, and policies, constantly pushing towards win-win scenarios in which both conflicting parties can benefit from better outcomes. Just as IARS is a key mechanism of coadaptation, *Adaptive Participatory Management* (APM) of HWC can, over time, also lead to improved coexistence. Incorporating the Adaptive Participatory Management concept into the larger CASES framework, represents a final step in completing the process of conceptualizing the CASES framework, as a heuristic framework for approaching HWC related issues.

Despite the fact that CASES was built based on an inductive learning process throughout the course of this research, this approach is nomothetic in nature and generalizable, thus can be widely adopted into HWC study and freely adapted by researchers in the field, serving as a baseline, starting-point study framework to guide the choice of theoretical and methodological approaches for specific research contexts. It can thus act as a *provisional framework* that can be reworked and tailored to best fit study case. CASES thus fits context-dependent *cases of HWI*, and context is at the core of this approach.

Because context actively shapes trajectories and outcomes of HWC situations, it can become difficult or even impossible to strictly follow or faithfully reproduce conventional general methodological approaches and preconceived frameworks in concrete HWC situations. This is why CASES was built upon the aforementioned twelve essential attributes, a set of fundamental principles that assemble the state-of-the-art understanding of HWC matters in SES and CAS systems into one comprehensive, multi-dimensional and broadly applicable framework that represents merely a guide for researchers and practitioners to construct their own context-adapted frameworks.

Figure 95 represents a pragmatic conceptual schematization of these foundational principles that make up the CASES framework, within an easy-to-follow visual schematization to guide the CASES-based approaches in the study of SES. By using this dodecagram of the twelve fundamental principles of CASES as a guide, each researcher or practitioner can benefit from assistance in carefully selecting the most appropriate methods that would ensure the best possible exploration or intervention (Cilliers, 2002) into real-world problem situations in a comprehensive and integrative manner (Preiser *et al.* 2017).

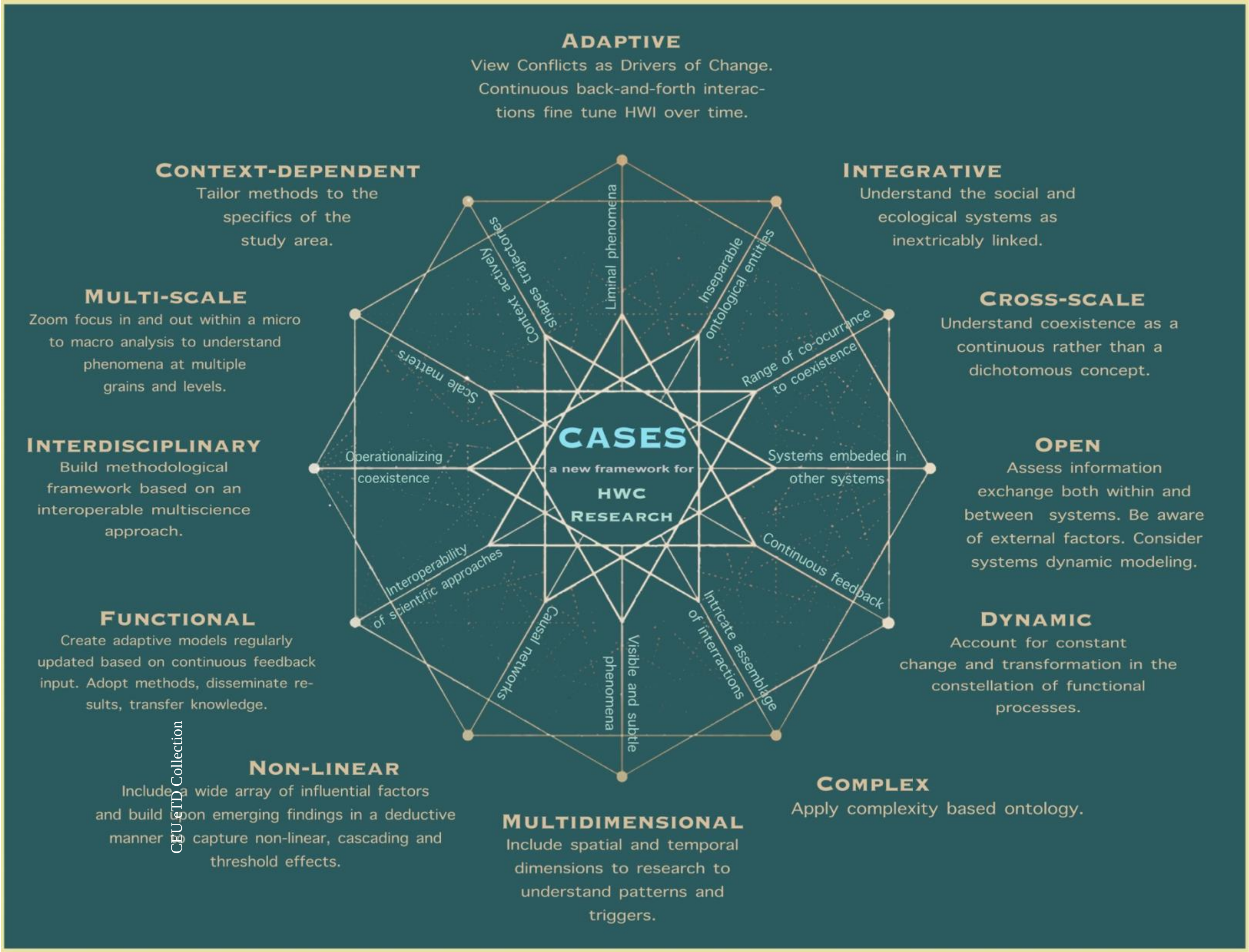

Figure 95. Dodecagram of the twelve foundational principles and main attributes of the CASES framework.

In the forthcoming concluding paragraphs, I detail the most important aspects to take into consideration when studying and engaging in research under the CASES framework. In summarizing the twelve fundamental principles of CASES, I identify three very important implications to be aware of when adopting the CASES framework.

First, working under this framework implies a shift in the way we think about conflicts and coexistence, understanding coexistence as a continuum and conflicts as Drivers of Change. This allows us to discern between various degrees of coexistence on a continuous scale and helps us better understand the internal dynamics that confer conflicts with an inborn capacity to push a relentless reconfiguration of the arrangement of interactions and thus helps us recognize and utilize the potential of conflicts to act as internal regulating mechanisms of coexistence.

Second, adopting CASES implies recognizing that the human and social systems are inseparably linked and consequently shape the choice of methods and practical approaches to study human-wildlife interactions.

Third, engaging HWI under CASES poses conceptual and methodological challenges for researchers and practitioners dealing with real-world situations, due to the inherent infinite complexity of these situations.

Working under the CASES framework enables identifying and tackling subtle and invisible drivers of conflict, inherent tradeoffs, cascading effects and hidden causal networks in HWI that, many times, impact both human and ecological systems in complex, and sometimes even paradoxical ways. The synthesized and unified understanding sheltered under the umbrella of the CASES framework has potential to be a useful instrument in the toolkit used to approach HWC research.

Redman *et al.* (2004) present a similar attempt to create a general framework for Long Term Ecological Research (LTER) in SES systems. In supporting Redman's ingenious, innovative and vastly comprehensive framework that emphasizes the need for integrating "*the social dimension of ecological change and the ecological dimension of social change*" within long term ecological studies, I strongly advocate that researchers in the field should not disregard the broader socio-ecological context that shapes HWI through both within-system, between-system and external factors.

At the same time, I suggest tailoring these general frameworks – such as Redman's framework or the CASES framework – to the specific context of the study area and not hesitating to build upon emerging findings in a deductive manner as this can facilitate capturing subtle, nonlinear and cascading effects, essential for fully understanding the dynamics of issues under study.

Most importantly, researchers and practitioners must never forget to regularly step back, reassess progress, reassess goals and look at the larger picture through a macro analysis of the situation, to understand the wider implications of the situation at hand. This **"micro to macro" approach**, as I define it here, if incorporated into a continuous-feedback-loop type of framework such as the CASES framework, is an essential tool that I strongly recommend being integrated into any analysis of human-wildlife conflict situations.

Finally, I also strongly suggest using the core conceptual typology of the main defining attributes of the CASES approach, as an assembly of characteristics, attributes and properties guiding the operationalization of the CASES framework, a way to facilitate its practical application and to equip scholars and practitioners with a better assessment and selection of suitable methods for understanding and managing HWI under this framework.

I strongly believe that wildlife governance based on all these aforementioned principles can foster long term socio ecological welfare equity and integrity.

10.2. Summary of findings, solutions and recommendations

"A wolf eats sheep but now and then; Ten thousand are devoured by men.
An open foe may prove a curse, but a pretend friend is worse."
[Poor Richard, 1740]

Bio-physical drivers of conflict

The risk analysis performed through this research revealed that biophysical, land-use, human-presence and management spatial attributes, when built into a carefully designed model, can be used to predict spatial patterns of livestock predation by wolves, offering key insights needed to explain the relationship between landscape features, wolf hunting strategies and livestock vulnerability to predation in a certain landscape.

In summary, the results of this model suggest to managers and livestock producers that livestock flocks in the study area are at a higher risk of predation by wolves in the remote natural high alpine pastures (situated in the core area of the park) where they graze during the warm months of their seasonal migration. While grazing in these areas, livestock are most vulnerable in the open grasslands and pastures near the edge of the forest, where dense and tall vegetation minimizes sensorial detection.

This study expands the focus from how prey use vegetation during antipredator responses to how wolves themselves also incorporate vegetation type and structure into their hunting strategies. A surprising and relatively unprecedented finding of this study is that wolves select certain vegetation features (and other landscape features) that provide them with cover when predating on livestock in order to increase hunting success. The element of surprise, provided by tall and dense vegetation at the edge of the forest, appears to be a very important factor affecting predation success on livestock for wolves in the study, suggesting that wolves in this landscape demonstrate stalking-hiding and ambush-like behavior as part of their hunting tactics. This finding challenges the classic notion that wolves are primarily cursorial predators that capitalize on their endurance to chase and outrun prey in open habitats (Mech, 1966; Peterson, 1977; Peterson *et al*, 2003; Poole and Erickson, 2011; Miller *et al*., 2014; Mech *et al.,* 2015). Instead, ***wolves here combine cursorial and ambush-like strategies*** **showing high**

flexibility while hunting, a possible adaptation to the fragmented landscape and as a possible response to the line of defense put up by sheep, guarding dogs and people acting as an integrated system.

This study suggests that livestock owners aiming to reduce livestock losses should be aware of these hunting strategies and prioritize grazing in open pastures and grasslands and open vegetation areas near roads and villages, outside of dense forests and away from the forest edge. It also urges them to increase vigilance and preventative behavior when finding themselves and their flocks in higher risk areas and situations. The risk of wolves (and other large carnivores) killing livestock is just one of many factors influencing their decisions about where to graze livestock (Miller *et al.,* 2015), thus, this study can provide the very much needed guidance to assist managers and livestock producers in this complex process. The predation risk maps resulting from the analysis (Figures 32 and 33) serve as a simple, easy-to-understand tool in this undertaking, representing a visual inventory of the high risks areas for wolf predation events, the distribution of conflict "hot-spots" within the surface of the park. Focusing conflict mitigation efforts to these areas identified as high risk for conflict can be a very important practical approach to greatly increase the success of mitigation efforts, considering that modifying human behavior across large areas is difficult (Treves *et al.,* 2004).

At the same time, the findings of this research reemphasize the urgency of well-thought-out management policies that take into account the importance of maintaining and restoring adequate wild prey densities, and the need for ecological corridors that connect core areas for wolf (and other LC) conservation, as well as the value of preventative measures in key conflict hot-spots for lowering predation and improving coexistence in highly human-populated areas where carnivore and human habitats overlap. Maintaining connectivity between the different wolf populations in Romania is essential for the conservation of the species, especially considering the high degree of fragmentation in wolf population distributions in the rest of Europe. Functional ecological corridors can contribute to the viability of the species because they ensure the introgression of new genetic material and the exchange of individuals between different populations. For these reasons, the chances of long-term survival of vulnerable patches of wolf sub-populations, significantly increase if there is an interconnection network that ensures the exchange of individuals between core populations and between packs.

These findings also indicate the urgent need for more scientific studies to evaluate the size and the distribution of wolf and prey populations in and around the park, but most importantly, at a nationwide level, and the need to incorporate these into the decision-making process. Defining optimal population levels, issuing hunting quotas and removing problem animals, should all be decision processes essentially informed by such studies. All of these above-mentioned management actions can have a profound effect on the scale and the distribution of conflict areas.

The spatial risk analysis undertaken by this research has demonstrated that the risk of predation is dependent not only on strictly biophysical and species-related factors, but also on human presence and threat of human-caused mortality that is shaped by the spatial configuration of human activities and, in turn, by management decisions. Humans shape predator-prey interactions and how these species use the landscape and thus, husbandry and management preventative measures can greatly reduce the risk of predation (Oriol-Cotterill *et al.,* 2015; Janiero-Otero *et al.,* 2020).

Non-spatial/husbandry and management mitigators of conflict

The analysis of non-spatial factors influencing predation (temporal factors, weather conditions, preventative measures, livestock individual and flock characteristics, livestock husbandry related factors, behavior at the moment of attack, experience and vigilance of those guarding the livestock) led to the discovery of trends and associations just as relevant for the outcome of the predation event as spatial factors. The results suggest that the vulnerability of livestock to wolf attacks depends on flock size, density and composition, with enclosed flocks attacked more when in larger numbers and free grazing flocks attacked more when in smaller numbers, while juvenile individuals seem to be at highest risk of predation. The risk of predation also varied with weather conditions, circadian rhythm and seasonality, peaking in the middle of day, in good weather conditions, during late-summer, early-autumn. Taking a closer look at these findings and comparing them to similar peer-reviewed studies, reveals that this latter pattern seems to be skewed, primarily as a function of increased protection, part of the prevention and protection strategies of shepherds. The increased vigilance and prevention strategies in perceived high-risk situations - such as the middle of the night, in the cold seasons, during harsh weather conditions - greatly reduce losses despite peak rates of wolf attacks in these conditions.

When interacting with wolves during an attack, shepherds, their guarding dogs and livestock act in sync as one organism, in the form of a synchronized and coordinated antipredator response that I conceptualize as "*the integrated antipredator response" (IAR)* of the "*human-dog-livestock system" (HDLS*). Wolves, livestock, shepherds and their livestock guarding dogs in the Carpathian alpine landscape constantly interact, responding to each other's strategies in the form of a never-ending process of co-adaptation. The description of this very intricate and integrated response, as it emerged from the data – here defined as the "*Integrated Adaptive Response System"* (IARS) of human wolf coexistence – represents a contribution of this research to the scientific world. In line with similar findings from other parts of the Romanian Carpathians (Ivascu and Biro, 2024), I conclude that it is this IARS that has maintained the relatively low levels of predation and the strong human-wolf coexistence in the Western Carpathians of Romania for centuries, despite the presence of a well-established, continuous and viable wolf population sharing the same space with an increasingly large number of livestock being raised in these habitats as part of a centenary grazing tradition. In fact, I suggest that it is this century-long coexistence of wolves and people with their dogs and livestock that has led to the birth of the integrated antipredator response by fine-tuning and refining (Durá-Alemañ *et al.,* 2024) this ancestral relationship over time. It is not only the HDLS integrated system that responds to wolves, but it is also wolves that respond to this system, in a process of continuous co-adaptation to the antipredator responses through finding new hunting strategies to circumvent the seemingly impenetrable HDLS line of defense: splitting into small groups or even acting alone; switching, as previously shown, between hunting modes, from cursorial to stalking and ambush; using visual and auditive cover of the bio-physical environment as means to evade vigilance of HDLS. IARS is thus a constant process of action and reaction, of adaptation and co-adaptation, a holistic and functional system of coexistence that has naturally evolved over time. I believe there is great value in further developing this concept through future research by investigating the interactions between the components of the system and its role in suppressing predation. As non-lethal control methods are becoming more and more popular (Mosley, 2020) and more socially acceptable than lethal methods for predator control (Bruskotter *et al.,* 2009; Slagle *et al.,* 2017), it is key to investigate and learn from what can be considered the oldest form of non-lethal intervention and a naturally evolved tool for lowering predation.

I argue that the set of traditional preventative strategies used by shepherds from generation to generation (particularly guarding the flocks by people and dogs and using nighttime enclosures), has, at least in part, led to the lower levels of damage caused by wolves in the Romanian Carpathians compared to other similar landscapes (Nowak *et al.,* 2005; Durá-Alemañ *et al.,* 2024), and might, at least in part, have contributed to the fact that livestock represent only marginal importance in wolves' diet in Romania (Nowak *et al.,* 2005; Sin *et al.,* 2015; Corradini, 2016; Rastrelli, 2016). As such, this research supports the recent presumptions in the field showing that preventative behaviors and non-lethal strategies are essential tools for lowering predation and are more effective than lethal control. Whereas a wide array of high-end, state-of-the-art non-lethal tools have been lately capturing the attention of managers and of the scientific world (electric fences and electrified fladry, RAG boxes, light and sound devices, shock collars and so on), this research reminds us that such tools are at the same time impractical, inaccessible or even impossible to implement in certain landscapes, such as the remote and wild alpine pastures of the Carpathian mountains, untouched by any form of human infrastructure necessary for such tools, such as electricity, internet or even access roads. The very simple, natural and easy-to-implement traditional prevention strategies, used by shepherds in Romania are at least just as effective as high-end tools, and are more versatile and practical. These measures are almost entirely behavior based, representing everyday husbandry and livestock management practices, active guarding behavior and use of TEK regarding factors increasing the risk of predation. Such prevention strategies could be successfully applied by managers and livestock producers in similar contexts elsewhere.

Shepherds' TEK in relation to wolf predation and variables influencing predation proved to be vast and comprehensive. With an average of 31 years of experience, shepherds interviewed in my research were able to identify and name - on the basis of their experience rather than theoretical learning - most factors associated with wolf predation identified by scientific literature so far (Table 14 in chapter 7). This suggests that **shepherd's traditional ecological knowledge matches or may even exceed classic scientific knowledge**. Through this surprising and unique finding, this research backs up the idea that TEK has the ability to complement and improve scientific research through sometimes richer and more accurate information (Freeman and Carbyn, 1988; Johnson, 1992; Inglis, 1993; Durá-Alemañ *et al.,* 2024). Shepherding as an ancestral tradition, a profession, and a way of living, arms shepherds with an impressive set of skills that I identify as a “shepherds’ know-how” in cohabiting with wolves, a know-how that is both learned (passed down by seniors and through formal education) and acquired from years of experience and close contact and interaction with wolves. This know-how reflects through shepherds’ good understanding of wolf packs (from being able to distinguish single specific individuals to being aware of local wolf numbers and distribution, reproduction, behavior and hunting strategies, and population trends), factors influencing the risk of predation, and prevention methods and strategies (training and raising livestock guarding dogs, proper carcass disposal methods, enclosing livestock, avoiding high-risk areas and situations, deterring wolves). In addition, shepherds’ extensive spatial and conceptual knowledge of the landscape, large capacity of endurance and adaptability in a harsh environment, skilled ability to read and interpret meteorological conditions and an overall strong innate feel for their surroundings, make them excellent candidates for working side-by-side with scientists to improve standard western scientific approaches. This finding represents one of the most valuable contributions of this research to the field of wolf conservation by highlighting the need to integrate TEK (aka the know-how of shepherds) in wolf management and the value of future research in this field.

Despite TEK of shepherds in the Romanian Carpathians playing an important role in maintaining the biodiversity of the alpine pasture landscape, in keeping predation levels low and, most importantly, in maintaining coexistence with wolves, the traditions and know-how of shepherds are being threatened by changing cultural mores, modernization, monetizing of livestock rearing, relentless political changes, Europeanization and subsequent rigorous regulating of shepherding. Issues in reporting predation events, receiving compensation, mistrust in authorities, retaliatory responses and poaching continue to become more and more complex as conflicts move up the societal and institutional scale, unfolding into intricate issues in both local and national wolf management leading to incoherent flow of institutional processes and compromised implementation of policies.

Through these findings, this research urges using the environmental expertise of shepherds and local people in managing natural resources, in this case by incorporating TEK into wolf management through participatory management. Including local communities and their knowledge in planning and decision-making in the fields of sustainable development, forestry and hunting, agriculture and farming, and LC management, would contribute to more positive attitudes of local communities towards management authorities and may help in achieving LC conservation goals in a more comprehensive and efficient, sustainable, and eco-friendly manner. At the same time, I urge the need to safeguard the century-old shepherding tradition in Romania, and I identify a research opportunity to further develop and describe TEK around shepherding, and its wide applicability in wolf and livestock management.

Social and institutional factors

The results show that predation on livestock (mainly sheep and goat) in the study area, although low, is customary and represents the main manifestation of the direct conflict between local communities and wolves. However, only a small amount of predation events are officially reported to authorities and, in many cases, rather than expecting the authorities to address the problem, people take the matter into their own hands in the form of retaliatory responses or surrender into lack of action and mistrust in the authorities. This is mainly due to: (1) the ill functioning compensation system based on overly complicated procedures, bureaucracy, and lack of funding; (2) people's poor awareness of their rights and responsibilities stemming from the lack of informing strategies on the part of authorities; (3) negative attitudes stemming from the lack of involvement of local communities and livestock producers in management decisions in the absence of participatory management, and (4) a difficult-to-access and incoherent agricultural subsidy system at the national and EU level that, through an internal antagonism of EC objectives, leads to increased predation and conflicts. Low reporting contributes to an already misguided management based on imprecise and lacunary data.

The impact that wolves have on game species and their competition with hunters is another major source of direct conflict. Wolves' tendency to attack dogs is, to a lesser degree, also a driver of conflict. All of these accounts are sources of direct damage caused by wolves to human interests. Although the actual degree of damage can be seen as low, the perception of those directly involved and affected by wolf predation can greatly influence the way the level of predation is seen and therefore can act as a driver of conflict. The analysis of people's knowledge and perception data, allowed for the comparison of the physical risk with the perceived one, and the visual representation of the two. This helped understand how people's personal history, their experiences, their opinions and concerns, all shape the way they perceive wolf predation and wolf management, and their overall coexistence with wolves. I conclude that the true measure of "conflict" is in between the factual and the perceived, and management needs to quantify and integrate the perceived level of risk and damage into conflict mitigation strategies.

In addition to these direct, in field manifestations of conflict between wolves and the people directly involved, wolves also become proxies for a wide array of broader political and social tensions as an indirect effect of the dispute between humans over wolves. These tensions and disputes influence wolf governance at a local but also national and even international level, leading to a situation where wolf management decision making becomes as much, or even more, a socio-political issue as a biological one. This politization of wolf management based mainly on the pursuit of personal agendas, results in less-than-ideal management strategies and their poor implementation at both local and national levels and leads to a situation where human interests and conservation goals are compromised. At the core of these issues lies a strong conflict between various interests of the many stakeholders involved in wolf management.

These unspoken interests foster an incoherent institutional environment that is expressed to the detriment of both wolf populations and local communities living in direct contact with wolves. There are various issues that hinder the proper implementation of management strategies and the coherent flow of institutional processes for wolf management. Concerning how the institutional and management process functions, Romania is characterized by what Lynch (2000) calls the "deception gap" between what is supposed to happen in theory on paper and what actually happens in practice. There is a clear distinction between theory and practice, as there is often a discrepancy between what is officially supposed to happen, or officially reported, and what is happening at a local level. Communication and cooperation among institutions is weakened by lack of dialog, opinion divergence, mistrust and conflicts of interest. Institutions are not always fulfilling their responsibilities and the reports they issue are not transparent and they do not comply with the results of parallel independent studies. Coherent implementation of institutional processes is hindered by corruption, malingering, overly complicated procedures and lack of funding.

There is a general lack of data on wolf populations, both at the level of the study area in the Apuseni Mountains, but also at a national level (Cristescu *et al.,* 2019): data on wolf population size, distribution and density is also outdated, skewed towards the classic hunting view of wolves as a "damage causing species" and intensely debated; genetic structure, pack size, dispersal distances and wolf diet, are all areas in need for more research and there is almost no data available on these aspects at a nation-wide level (Sin *et al.,* 2019). Projects and studies yielding local data on wolf populations are largely disregarded by management authorities. Results of recent national studies coordinated by the central authority are not transparent, possibly inaccurate and warn of being the product of a conflict of interest. Through highlighting this gap in data, this research highlights inadequate monitoring and misguided management strategies designed without adequate scientific rigor and emphasizes the need to infuse scientific research into large carnivore management in order to avoid compromising the long-term sustainability and viability of large carnivore populations in the Romanian Carpathians.

The official stance pushed forward for the general public today is that the number of large carnivores in Romania is "too high", outweighs the environmental carrying capacity and thus represents a threat to human lives, property and activities. But the public numbers for large carnivore population size put forward by the authorities have been accused of being incorrect, the result of faulty population size evaluation methods, double counting and false estimation (McLoughlin, 2003; Treves and Karanth, 2003; Popescu *et al.,* 2016; Popescu *et al.,* 2019) resulting in misguided management strategies (Popescu *et al.,* 2019) that support the effort of hunting institutions to maintain their decades-long status-quo as the institution having the largest influence on wolf and bear related policy outcomes. Propaganda, corruption, conflicts of interests and the pursuit of personal agendas still dominate wolf management. Despite relentless efforts of conservation activists to push forward new data, common-ground solutions and updated, scientifically-sound evaluation methods, and despite evidence that culling is an ineffective unsustainable and possibly counter-productive solution to large carnivore-related livestock conflicts, top authorities continue to push a LC management policy based on lethal control through annual hunting quotas and special derogations for damage causing animals. In the context of a general lack of data on the status wolf and other large carnivore populations in Romania (Cristescu *et al.,* 2019; Sin *et al.*, 2019), this practice threatens to break down LC populations, change their behavior and push them to closer and closer to human communities, thus increasing conflict. Wolves are still seen by hunters as competition for game and poaching wolves during these organized hunting expeditions is not uncommon. This threatens to further de-structure packs, leading to increased predation rates (Blanco and Sundseth, 2023) and thus to further exacerbate conflicts.

Can the solitary wolf individuals attacking the livestock in Apuseni Mountains have resulted from disrupted packs due to hunting and poaching? This is a question for very valuable future research.

The status quo of hunters as wildlife managers is hard to change, proving how deep the roots and how strong the influence of hunting institutions and individuals are. Behind this desire to control policy related to LC management, lie strong financial interests resulting from masked trophy hunting, a practice that has been going on for decades. These findings shows how lack of transparency, lack of an objective independent mediator and mistrust amongst and within institutions and stakeholders with interest in carnivore management, increases conflicts, hinders progress towards finding sound strategies for management of large carnivores, thus increasing uncertainty, debate and political chaos, all in detriment of the interests of those directly affected (both large carnivore populations and local communities, but also livestock managers and shepherds, individual hunters and conservation activists).

Solutions?

10.3. Solutions

"The important thing is that there be will...because solutions can be found."

(National Expert in Large Carnivore and Protected Area Management, NGO1)

This is not a simple matter. But to put it simply, I believe that in order to reach a sustainable, functional and coherent institutional management of wolves that ensures acceptable levels of conflict mitigation and long-term coexistence, we need reform and change. Reforming policies and institutions, changing attitudes.

We can start by tackling each issue as it emerges, slowly reforming institutions and policy incrementally as windows of opportunity open. At the same time, I believe we must also keep an eye on the larger picture in order to be prepared when the possibility for major reforms presents itself, and at that point decisive action will be called for. For instance, the current system whereby hunting organizations essentially control the scientific input related to carnivore populations sizes that goes into decision making must be abolished, but the opportunity to do so has not arisen yet. In order to be prepared, environmental specialists can work now to develop in theory a new system of independent science advice that could be implemented in the future. I advise managers and future researchers to use the CASES framework and the ideas of the Adaptive Governance described by this research.

To summarize, here are the main concrete solutions and recommendations proposed throughout this research, to tackle the issues that arise in the institutional realm:

- Improve institutional capacity: increase funding and resources; hire qualified personal; organize regular meetings and workshops; improve communication, cooperation and coordination (the triple C) among institutions and stakeholders; re-assign roles; reduce malingering and increase motivation; assume responsibilities; simplify procedures; shorten reaction times; increase mobility; provide training; redistribute tasks; modernize systems.
- Reduce institutional incoherence: increase institutional control and supervision; reduce bureaucracy; eliminate conflicts of interests; re-assign decision-making; redistribute roles; create new institutional entities to take over roles and tasks from those overburdened or unable to implement them.
- Improve attitudes: develop trust among stakeholders and institutions; ensure transparency; develop a participatory management that involves all stakeholders in the decision-making process; include TEK in the management process; create a platform to ease the implementation of new protection measures by both livestock owners and managers and offer financial and technical support in this quest; improve livelihoods by assisting local communities to access funds, tools and projects, to benefit of local natural resources, to create businesses; organize campaigns to inform and raise awareness on rights and responsibilities, procedures and opportunities; simplify bureaucratic procedures; raise awareness on the biology and ecology of LC and their role in maintaining healthy ecosystems that benefit both the environment and people alike.

- Centralize data, improve access to information and ensure transparency.
- Instate a new, third-party institution to act as an objective mediator with role in: overlooking the management process; mediating conflicts; promoting communication, coordination and cooperation among institution and stakeholders; finding common-ground solutions and supervising the implementation of management actions.
- Create a nation-wide database of sound scientific data on all wolf (and other LC)-related parameters, including those related to their habitats - obtained through rigorous, well-funded, transparent studies performed by independent researchers.
- Promote research on developing holistic, multidisciplinary approaches to mitigating conflicts
- Develop/implement up-to-date management plans, national action plans, projects and a new methodology for evaluating LC populations.
- Reassess and align laws and policies to reflect sustainable goals for wolf management that would benefit both people and wolves.
- Ensure that the law is followed.
- Fix the issues that were identified to hinder the main institutional processes around wolf management, in order to increase their implementability and functionality.
- Improve trans-boundary management and ensure large core areas in a steppingstone-type system.
- Develop the concept of adaptive management and update management strategies to include an integrated analysis conflicts drivers at a local level, that quantifies and integrates both the actual and the perceived level of risk and damage into conflict mitigation strategies.
- Assess and frame "conflict" as *a point between the factual and the perceived risk*.
- Understand conflicts as *drivers of chance* that constantly push the fine-tuning of decisions, management strategies and policies. Strive to maintain conflicts on the path to resolution and policy change.

I here also formulate recommendations specifically for the Apuseni Natural Park administration:

- Informing communities and raising awareness

- Improving communication
- Do participatory management
- Access project-based funding to study large carnivore populations
- Perform more accurate and detailed studies to support management plans and coordinate studies to see overall picture
- Limit resource exploitation and prioritize and support local communities to benefit of these local wild resources
- Carefully evaluate hunting authorizations and only allow the culling of DCA and problem animals
- Actively participate in control and supervision, particularly in activities such as hunting, logging and berry harvesting

The first three recommendations – "*Informing communities and raising awareness*"; "*Improving communications*" and "*Do participatory management*" – could be achieved together by organizing regular stakeholder meetings that include local communities. These workshops can be organized locally at one of the ranger stations in the park as this would encourage and facilitate access for locals while also providing a joint opportunity for leisure in the mountainous landscape for representatives of the stakeholders coming from the urban areas. During these workshops park management could present past results, current measures and future plans and vision in a language accessible to all, thus increasing transparency while raising awareness and informing. Park managers and representatives of authorities could present and explain rights and responsibilities to locals and assist them in the challenges they face in this sense. Institutional representatives could discuss existing policy and newly adopted laws and procedures in order to clarify responsibilities and ease the flow of the institutional processes leading to a better implementation of policies, but also improving communication, cooperation and coordination among institutions and stakeholders. Going through this process in the presence of local communities would raise the levels of trust in the authorities and in the management process. This would also be an opportunity to involve local communities when making decisions, both at the park level, but also beyond. In person joint open discussions can be highly beneficial as they appeal to our human nature through face-to-face contact and thus facilitate conflict resolution through identifying solutions that led to win-win situations. Joint discussion would also alleviate the burden of the park seen as the "bad guy", as locals would better understand that the park is not the only entity responsible for the rules and regulations people need to comply with, and that the park is not the direct source of various newly imposed laws or projects that greatly affect communities such as logging, berry gathering or the INSPIRE discussed in this dissertation.

The next two recommendations on the list – "*Access project-based funding to study large carnivore populations*" and "*Perform more accurate and detailed studies to support management plans and coordinate studies to see overall picture*" – can be achieved by assembling a team of park representatives, the park biologist, volunteers and collaborators from local universities and even master students and PhD candidates, a team that, together with an external consultant, can identify and access funding (especially EU funding) for research based on well written projects that could fulfill both needs: the need for data and the need for resources. Park administration could also tie collaborations with renowned universitates in the area to recruit volunteers for smaller research projects and attract students that would be interested in choosing the park as the study area for their research. This type of collaboration can also be extended towards other national and international science-oriented institutions.

The last three recommendations – "*Limit resource exploitation and prioritize and support local communities to benefit of these local wild resources*"; "*Carefully evaluate hunting authorizations and only allow the culling of DCA and problem animals*" and "*Actively participate in control and supervision, particularly in activities such as hunting, logging and berry harvesting*" – go hand in hand and require active involvement of the park's administration which has power of decision in reinforcing national and park policies that clearly require the administration to control resource exploitation by limiting extraction activities in key areas based on a well-documented zoning. By obtaining more in-depth scientific data yielded through the previously mentioned funded projects, the park administration could lay out clear regulation related to where, when, how and how much resources can be extracted and they can reject, based on their legal right to so, any requests or quotas that exceed these preestablished thresholds. Despite having limited resources and personal and despite rangers being unarmed – factors that have been shown to hinder proper control of illegal activities on the surface of the protected area – park representatives should, nevertheless, actively strive to increase their participation in control and supervision. This could be achieved by lobbying higher authorities for the right of rangers to carry guns, for resources needed in instructing and increasing personal, and for increased assistance from local police and gendarmerie. Private security companies and volunteers could also be engaged in these supervision activities as witnesses, observers and as a means to increase the representation of the park interests in these activities and the security of the rangers.

And now I want to let the voices of the people involved in these issues speak about the conflict and the solutions themselves. Nobody can say it better than them:

"We will end up like the European countries that have 1 or 3 wolves, the wolf populations will disappear. Why do they disappear? First of all, rural development, these activities that endanger the species, including poaching, illegal logging, logging vehicles, ATVs that are everywhere and disturb wildlife, the modification of habitats… they either have to move to another place or disappear altogether. Like now, wolves are moving, it's not really that bad, they are going up to the mountains, retiring because of economic and human activities.

My opinion is that everything should be set up and carefully thought about, analyzed, studied and then decisions should be made. Not like it is done in our country that decisions are made first and then studies are carried out. Like the saying goes that you put the cart before the ox, this is exactly how it is done here. We make decisions and then you see if they are good or not, the first time you make the decision and then you see what the consequences are and the consequences can be good, but most of the time they are drastic.

We have to see where the problem is. If the evaluations would be done for real and if they would done at a high [scientific] level, we would be able to see this year, or at least in a decade or at least in a few years, we would see what is disappearing, what is overpopulated and that's where there should be an intervention, if you really want to control the balance yourselves, then at least do it based on concrete data, instead of making up numbers out of the blue like now, that there are 10 boars and that there are 5 wolves.

If you give the power to only one institution… the hunting ground managers do as they wish because they each want to fire their own pots. But I believe that if the institutions cooperated, the one who has interests in manipulating the evaluations would not afford to do it anymore, I don't think he could allow himself to corrupt everyone, to make decisions on behalf of all institutions in order to get his way. We are talking about problems, but the problems stem from up there. The fish rots from the head." (Ranger 2)

These people, who face these problems day to day, believe that the main issues around wolf management stem from the lack of proper communication between or within institutions, a shortage of resources and capacities, unspecialized staff, weak control and supervision, in other words a dysfunctional system. Why is the system dysfunctional? Because "*someone has to gain from this*", because "t*he politicians have to get their money and support from somewhere*" answer the interviewees. When the institutional process that implements policy in the fields of carnivore management and timber exploitation is chaotic and there isn't a strict control "*it's easier to do…unofficial things*". Personal interests are more easily followed in a chaotic system. Hunting interests dominate wolf policy. Conservation of wolf populations should be a priority in a country that holds one of Europe's largest wolf populations and represent one of Europe's last islands of wilderness. "*But politicians look at things differently*" and this is "*because the easiest way of making money is from the exploitation of resources and development*." Consequently, the field of wolf management lacks capacity, information, communication, specialized staff, cars, budgets for field work and so on. Many times, staff is hired based on relationships and is not specialized because […] "*after all...it's easier to lead people who are...in a way...limited [have limited horizons], than people who are indeed good, specialists and who have a much better and wider vision on things*."

This is why any attempt to remediate the situation should start with data "a*s real as possible, as scientifically plausible as possible*" and "*monitoring as much as possible, to see the trend, including the population dynamic, the threats..*.". Any management decision should be based on the best possible data. And then, there is a need for dialog, "*dialog, collaboration, common projects involving everyone*" in order to identify "*those interests that suit most*" and establish a "*common ground*" way forward that focuses on "*improving the large carnivore management system*". After all, "*interinstitutional relations are in fact relations between people. If people can sit down and discuss in a civilized manner, then we can reach a common ground*". Of course, we cannot disregard the fact that "*hunters compete with all the carnivore and raptor species*" but if we start talking about "*hunting ethics*" and about "*respecting game*", then "*it's possible to reach an acceptable situation*" for hunters and wolves alike. "*The important thing is that there be will...because solutions can be found.*"

To draw a final conclusion, I believe that first and foremost, we must rethink our interpretation of conflicts, changing our perspective of conflict seen as inherently negative and destructive to see them as opportunities, as triggers, as drivers of change. In the spirit of this argument, our coexistence with large carnivores can be metaphorically compared to a house. It takes a lot of work, coordination and resources to build it, and it can only be built little by little, brick by brick. Coexistence can only be built interaction by interaction, solving conflict by conflict. We need to tear down the old walls of outdated and incoherent institutional agreements and narratives and build new ones, up-to-date and in line with the current context. Once our walls are standing, we need to add functional elements such as window and doors, plumbing and electricity. This translates into creating functional and coherent laws and policies. Finally, we add the finishing touches, fitting the house according to our personal needs, in our case, fine-tuning policies to fit the specific current context. Once we start living in our new house, we will have to constantly adjust it to our needs and do maintenance work. In order to live in coexistence with wolves we need to constantly adapt and fine-tune policies in response to conflicts so that the state of equilibrium is maintained. Just like any house, our coexistence with wolves will be fragile if we don't build it on a stable terrain of a deep understanding of the local context and on a solid foundation of extensive scientific data. But if we build our house of coexistence well it will become one of our most valuable assets, it will shape our lives, and we can sustainably live in it for decades or even centuries to come.

10.4. Contributions

Contribution to science

Going beyond local contributions, the lessons that this specific case (HWC in the Western Carpathians) can provide are relevant outside this geographic area, as they can inform the overall scientific community engaged in studying HWC and also the field of wolf conservation and HWC management worldwide. Because human-wildlife conflicts generally present similar patterns and have similar drivers in different parts of the world (Macdonald and Sillero-Zubiri 2004), they can often benefit by similar types of interventions (Macdonald *et al.,* 2012), and solutions can be transferable from one place to another and even from one species to another. Further, once implemented they can benefit multiple wildlife species in a way similar to the umbrella-species concept (Can *et al.,* 2014). From this point of view this research is relevant in three ways: first, it improves the transfer of knowledge from active empirical research on mitigation from other parts of the world (Kaczensky *et al.,* 2012; Can *et al.,* 2014) and from different scientific communities to this specific case in an interdisciplinary way; second, it adopts the best available methodologies and most adequate approaches to the specific context of this research and thus performs an in-depth, cross-disciplinary, focused and purpose-driven analysis of the conflicts; and third, by appropriately communicating results it further stresses the need and utility of transferring knowledge across different areas and scientific communities as the best way to understand and grasp the full ecological and social complexity of human-wildlife conflicts.

Based on conclusions drawn from this work, I urge that research looking at human-wolf and human-wildlife conflicts should approach study cases as integrated and dynamic socioecological systems and, just as any other studies of CAS systems, should "*have no a priori assumptions about key variables, emphasize nonlinear causal effects between and within systems, and view system equilibrium as multiple, temporary, and moving*" (Duit and Galaz, 2008, p. 312). I also emphasize the "*need for multiscale investigatory frameworks crucial for implementing integrated research*" (Redman, 2004, p. 161) in human-wildlife conflict studies.

The fact that wolves have never been extirpated from the Romanian Carpathians fostered a century long coexistence between people and wolves sharing the same landscape, leading to the birth of a wide array of coadaptation strategies that can provide many important lessons for wolf management in other systems, especially in areas where wolves are just returning. These circumstances have allowed local communities, and especially shepherds, to acquire a rich base of knowledge and know-how in living and dealing with wolves and wolf predation, as captured by this research. Using this traditional ecological knowledge can further complement and improve scientific research (Freeman and Carbyn 1988; Johnson, 1992; Inglis, 1993).

Methodological advancements

A corollary significance (and also an element of novelty) of this study resides in the fact that it utilizes a new perspective to examine conflicts, a perspective that many researchers, especially in this area, have not explored: adopting an interdisciplinary approach to analyze the overall scope of the conflict. Two essential pillars for understanding conflicts stand at the base of this research, the ecological and the social, and the two are bridged into a holistic approach. Thus, this research builds on the growing idea in the wildlife conservation scientific community that we must use analytical frameworks and conceptual tools appropriate for understanding and addressing policy problems rather than relying solely on biological and ecological science (Primm and Clark, 1996). This research thus supports the effort that scientists are currently making towards bringing together diverse concepts and theoretical frameworks stemming from many fields of study in order to tackle the complexity entailed in human-wildlife conflicts (Messmer, 2000; Graham *et al.,* 2005; Dickman, 2010; White and Ward, 2010). In adopting this interdisciplinary approach and bringing together varied qualitative and quantitative methods to analyze the conflict, this research contributes to the development of a common analytical framework for human wildlife conflicts. Such a general cross-disciplinary analytical framework with wide applicability to all social-ecological relations implied by human-wildlife conflicts, is meant to stimulate integrative discourses and use a common scientific language for researchers involved in studying such conflicts.

Opening future research opportunities

Even though this research does not address all gaps and solve all problems, its value and originality stand in the fact that it identifies and highlights existing issues and formulates relevant management recommendations, representing a leap forward to improved coexistence of people and wolves and an incentive for future studies. This research carves the way to interested parties (e.g. protected area managers), toward relevant future studies that could further improve wolf management, such as: further developing and improving spatial risk mapping as a useful management tool to identify conflict hot spots and as a quantitative and visual guide for targeting conflict mitigation interventions (Miller, 2015); identifying and building a common analytical framework; building a scientifically grounded nation-wide database on wolf populations; using state-of-the-art methods for assessing carnivore density and abundance (e.g. genetic capture-recapture methods, collaring, telemetry, calling) to improve the traditional monitoring system; continuing research on the efficiency of using livestock guarding dogs and other preventative and non-lethal methods; continuing research on the flexibility of wolf hunting strategies; assessing the effect of hunting on pack disruption; studying TEK as a way to complement scientific research;

using case-studies and work-groups for developing participatory management; developing an adaptive management based on interdisciplinary research grounding a holistic approach; more complex institutional and stakeholder analysis and mapping; etc.

From a scientific point of view, this research puts forward ideas and concepts that stand in line with parallel state-of-the-art approaches in the field and makes discoveries that can contribute to revolutionize classic knowledge if further developed through future research:

- designs a holistic and interdisciplinary approach to studying human-LC conflicts using a comprehensive, integrative and multi-science framework to capture the intricate web of interactions and back-and-forth feedback between the various actors;
- further develops and adapts the *Integrated Coupled Human-Natural Systems* (CHANS) framework proposed by Carter *et al.* (2014) to capture the intricate web of interactions and back-and-forth feedback between actors involved in human-wolf conflict through a novel socio-ecological approach;
- expands the focus from how prey uses vegetation during antipredator responses to how wolves themselves also incorporate vegetation type and structure (in the form of sensorial cover) into their hunting strategies;
- challenges the classic notion that wolves are primarily cursorial predators (Mech, 1966; Peterson, 1977; Peterson *et al*, 2003; Poole and Erickson, 2011; Miller *et al*., 2014; Mech et al., 2015), and, supporting the notion that wolves are highly adaptable, argues that wolves show flexibility while hunting, being able to demonstrate stalking-hiding and ambush-like behavior as part of their hunting tactics as a possible adaptation to preying on livestock in a fragmented habitat;
- discovers that shepherd's traditional ecological knowledge matches or even exceed classic scientific findings and defines it as *"shepherds' know-how";*
- puts forward the idea that the shifts in the discourse around wolves in Romania, that is transitioning utilitarian/hunting-oriented views into more mutualistic/conservation-oriented attitudes, is not just a product of Europeanization through top-down policies but is in fact a symptom of a profound global shift in human environmental consciousness and awareness. Thus, changes in wolf policy can be initiated not only top-down but also

bottom-up, from a societal level becoming an unstoppable and yet subtle force that pushes the transformation forwards in all domains, including that of public policy.

- develops the concept of "*Integrated Antipredator Response"* (IAR) of the "*human-dog-livestock system" (HDLS);*
- tailors the concept of participatory co-management to HWI management;
- develops the concept of *"micro to macro"* analysis in human-wildlife conflict studies.

Contribution to in-field conservation

Because wolf and human territories overlap, it is apparent that there is a need to ensure their coexistence, therefore this should be the final goal of any management measure. Contributing to improved human-wolf coexistence is the supreme contribution that this research hopes to bring. We should not forget that "*a well-written research article in a management journal is unlikely to reach many managers*" (Gigliotti *et al.,* 2000, p. 81). The last and maybe the most important point in the rationale of this study is that we, as scientists and researchers, have an unwritten moral and ethical obligation to disseminate our findings to the parties involved in our research and other interested parties in order to assist in those specific issues. Thus, this study's findings will be appositely disseminated to all parties affected by or affecting the conflicts and will ensure that its contribution is not only to enrich the scientific community but also to improve wolf management.

10.5. Conclusions

What is the way forward?

"You can't have five wolves and one sheep voting on what to have for supper."

[Larry Flynt]

In analyzing the intricate and chaotic stream of changes in wolf and bear management in the years of my studies, I have come to realize that the strongest driver behind policy changes in carnivore management is indeed, as mentioned various times throughout this work, the clash between conservation and hunting. Personal interests and the entire spectrum of motivations behind them (financial, status, management, competition for prey, retaliation, control, fear, pride and ego, pleasure, self-esteem, tradition, personal beliefs and perceptions around carnivores - and at the same time, people's role in nature) influence people's actions, even when they should be objective. These personal agendas, that can extend to groups of people acting as one entity (an institution), unofficially determine policy in this field.

Within this research I attempted to systematically identify issues that hinder improved institutional processes in wolf management and recommend solutions to these problems, but at the end of this analysis, I am made to realize that the dysfunctionality at the management level is actually much more deeply rooted in this clash between the utilitarian (particularly hunting) oriented view and the mutualistic/conservationist approach to large carnivores. Thus, after identifying "the surface" issues and fixes that would address them, I feel obligated to dig a little deeper. Underneath the dysfunctional management and chaotic, relentless policy changes, we see both sides striving to gain status and influence in policy making, not only for the "official" agenda of LC management, but also, in the case of some individuals, for pursuit of personal agendas. It's a struggle for power in influencing policy at an institutional level, and it is, in some cases, a struggle for financial benefits at a personal level.

As we have seen throughout this work, there is a strong and decades old status-quo of hunters and utilitarian views dominating LC management in Romania. We see this in both the everyday sports hunter or in the veteran association member hunting for trophies, in the hunting ground manager seeking to get a piece of the "cheese" and all the way to the top in personas leading the most prominent hunting profile groups, institutions and projects at a national level who are seeking to maintain their position as policy makers. This status quo that hunters so fiercely, avidly and sometimes even desperately strive to maintain is now being exposed and shaken, more and more through national debates that have dominated the attention of Romanian society at all its levels. Conservation oriented NGO's, research institutes and scientists are now pushing policy change more and more through lobbying and accessing EU funding for more rigorous science-based studies and data. At the same time, they are accessing these EU funds as the only way to obtain the income that would ensure their survival in the harsh institutional environment of wolf management in Romania. At the top sit the national authorities, inconsistent and chaotic in policy making, weak in maintaining an objective stance and weakened by incoherence stemming from clashing personal agendas.

What could we propose as a fix when the situation is so complex? This becomes a much more challenging task. How to line up the national legislation regarding LC management to a coherent, functional and effective policy strategy that would benefit both animals and people and be compatible with both European level law and relevant international conventions? And how to do this in the context of the EU itself showing greater incoherence and weakness in policy making and in implementing their long-term objectives in the conservation field? This is further complicated by the global context of climate change, continuing if slowed population growth, expansion of human settlements, intense industrialization of agriculture, aggressive habitat reduction and loss, increasing human conflicts and record rise in physical and mental health issues? We might be inclined to say, this is a hopeless task. But then again, when in the middle of a seemingly hopeless situation, one should always take a step back and look at the bigger picture.

Let's take a step back

"Fear makes the wolf bigger than he is."

[German proverb]

I began this research early in 2015 and life circumstances lead to me being involved in this research for almost a decade now. This extended period of time of closely following and observing the evolution of wolf related issues in my study area have allowed me to reach a critical realization essential for my research, one that I might have missed had I followed the typical expedited course of PhD completion. During my extended immersion in the subject, I struggled constantly to keep up with the relentless social, political, institutional and scientific updates in wolf-related matters, only to find myself repeatedly overtaken by the latest development in the field. In looking back now, close to the completion of my dissertation, trying to gather up my thoughts to put all the pieces of my work together, I realize that more important than almost any other discoveries that I have made during my analysis, is the fact that time itself, and the historical context, is one of the most important factors to take into consideration when trying to understand human-wolf conflicts. Introducing a temporal dimension into the equation of any wolf related conflict and looking at the historical evolution of the facts that lead to the respective situation, puts facts into context and results into perspective, making it possible to gain a much deeper understanding of a never-straight-forward matter: conflicts between people and people and wolves.

Wolf governance has undergone dramatic changes during its history and so have beliefs, values and discourses related to wolves. Over the last centuries wolves have gone from being venerated as mystical creatures to being viewed as pests, villains and people's "enemy no. 1" only to then be recognized as an essential species holding together the integrity of our natural environment. Governance of wolves has also varied greatly from management as a game species, to persecution, bounty hunting and even extirpation programs only to then shift to protection, conservation and reintroduction. The general public's views and attitudes have also transformed greatly from a spiritual interpretation of wolves drastically shifting to a utilitarian orientation that is nowadays becoming more and more mutualistic. This shift in perspective is still underway today and manifests itself through the very animated discourses around wolves and bears, public debates and street protests, recurrent media coverage, frequent policy changes, divergence of opinion among actors, increasing interest of researchers, bottom-up relentless efforts of activists and biologists to push change, and the top-down incentives to prioritize environmental protection in the last few years. I interpret all of these changes as being symptoms of a profound shift in human environmental consciousness and awareness, the birth of a new discourse related to large carnivores, a crossroads in our interpretation of wolves and of our coexistence with wolves. I consider this shift to be part of the large-scale environmental movement that began towards the end of the 20th century, facilitated locally, in Eastern Europe by the socio-political changes that came with the fall of the communist regimes. The transition to a democratic government has allowed for a new flow of ideas, information and action that in turn led to an unstiffening of the status quo utilitarian and hunting oriented perspective and the beginning of a new paradigm around the role of wolves in our coexistence with them. Europeanization, through the adoption of EU policies in the national legislation, represented a window of opportunity for a dramatic shift in wolf governance. But the shift in discourse around wolves was just as much a product of a societal level transformation, part of a global shift in human environmental consciousness and awareness. Thus, the changes in policy came not only top-down, but also bottom-up, pushed forwards from the very fabric of society.

Another crucial discovery I made was that conflicts cannot be understood or studied separately as independent occurrences and out of their larger context. Not one particular conflict stands on its own, independent, uninfluenced by other conflicts of the same or of a different nature, and no conflict can be fully understood if its context is disregarded. All the findings of this study - the factors influencing wolf predation, the drivers of interhuman conflict, the issues related to institutional processes that we've touched upon leading up to this discussion - would mean very little if all of these separate pieces wouldn't be put together to shape the larger picture. This is what I define as "micro to macro" analysis of human-wildlife conflict. Bridging the three major pillars of this dissertation together (chapters 6 - 8) is, in fact, the most important undertaking of this dissertation as it enhances the value of each separate section and builds up the acquired knowledge to a holistic view. This approach has led me to rethink the classic texts about conflicts and coexistence and to propose a more up-to-date and down-to-earth approach for socioecological studies venturing in this field, a new framework for HWC research based on four essential attributes: "interdisciplinary", "integrated", "multidimensional" and "adaptive". I, along with others, challenge the classic view of conflicts as negative forces hindering coexistence and reinterpret conflicts as drivers of change that represent inherent mechanisms of a coexistence based on coadaptation.

From a historical point of view, the direct conflict between people and wolves today could be seen as mild compared to the era of their persecution, when damage to livestock was much higher, when authorities declared war on wolves and rallied up almost all of the citizens of the country in the quest to eradicate wolves, when over 26,000 wolves were killed in less than a decade. Put in this light, one would question the need for such a study today, especially that wolves are now protected by law, livestock damage is (in theory) compensated and wolf populations are closely controlled. This is where it is important to broaden one's perspective and look at the big picture: the shifts in wolf governance towards protection of the species brought by the end of the 20^{th} century have also brough a shift in the nature of the indirect interhuman conflicts. Direct conflicts are not negligible in the Carpathians, but they are far less intense than the interhuman conflicts. These more indirect human-human conflicts do not immediately stand out and we are more likely to see only the symptoms randomly emerging on the surface, as the tip of an iceberg, but their implications are of crucial importance for human-wolf coexistence in the long run.

The intense debate and controversy around wolf management has greatly intensified tensions and debate between various parts of society on the subject of wolf governance creating even more conflict, but also more change. We see people from all classes and professions walking out into the streets and signing petitions to make their opinions on wolf governance heard; we see activists emphatically pushing new changes in wolf related policy through lobbying campaigns; we see conservative communist-era hunting-oriented institutions fiercely pushing to maintain a long outdated status-quo; we see mass media heatedly reporting on the latest developments on the subject (whether in line with reality or intentionally inflating stories and misleading public); we see NGO's, scientists and biologists, even academics advocating for the need for more scientific data; we see various nature protection oriented organizations constantly striving to access EU funds for wolf related projects in which they even collaborate with the national authorities in a struggle to push forward new policies, national action plans, management plans, national and international work groups specifically focused on large carnivore conservation and human-wildlife coexistence. We see the top national authority torn between maintaining the old hunting-orientated state of affairs and allowing change and thus playing a very complex, sometimes contradictory, but also crucial role in the dynamic of wolf related conflicts; we see the President of the country himself actively promoting environmental education, we see the laws and policies around wolf management rapidly changing and evolving at a pace never seen before. In looking at this larger picture we start to truly see the immensity of the iceberg under the water, or rather even better said, a volcano that is bubbling with the heated discourses, tumultuous developments and rapid changes in what are human-human conflicts over wolves and bears today. We start to see and understand the implications of the shift in perspective that has started to happen in the last decades in wolf governance in particular and in environmentalism in general.

Looking back at the statement at the beginning of this argument, that human-wolf conflicts nowadays seem mild compared to the past dominated by wolf persecution, we see that this is not in the least bit true. Conflicts are different in nature, but surely not inferior in intensity and far more complex.

Understanding where Romania stands today in its historical path of wolf governance helps put human-wolf conflicts in Romania and in the study area into perspective. Never before have debates between people over wolves in Romania been so heated than in this last half a century, never before have opinions on wolves been so diverse, never before have wolves had less space and never before has “the wolf war” been so intense… but at the same time, never before has there been a more tumultuous flow of ideas, debates, information, and policy changes around the matter of wolves, and never before has there been a more powerful push towards acknowledging and acting on the importance and the conservation of the species and its coexistence with humans. To what shores will this bring us to in our coexistence with wolves it’s hard to know. While wolves are returning to their former territories in European countries, the EU is incoherent and inconsistent in its policies. Romania is still in the midst of a transformation process, transitioning to new perspectives, new discourses, and new policies. We can only speculate where these changes will lead wolf management in Romania. But we are rethinking our relationship, we are pondering on our clashes and our choices in the past and we are more than ever open to finding ways of continuing to live together.

A concluding thought piece.

“*If you live among wolves you have to act like a wolf*.”

[Nikita Khrushchev]

In this closing section of my dissertation, I try to address a very important question posed by Luigi Boitani, one of the most renowned wolf experts in Europe, ‘*Why, in our contemporary culture, is the wolf considered "bad" to a much greater extent that its behavior and ecological role would justify?*’ (Boitani, 1995). Before looking for an answer, I propose even yet another question, How does this belief influence the way we act, what does this say about who we are, about our way of thinking and how can we change this view?

Many of the answers to these questions can be found in looking at society, the way it has evolved over time and at the role individuals play in the complex construct of society. There are very deeply held values and passionate arguments in the way people relate to wolves, and there are strong cultural, ethical and moral dimensions that underpin these values and arguments (Redpath *et al.,* 2015). Therefore, social theories depicting society and psychology seem to be the best place to look for answers to these issues.

In this succinct philosophical piece, I appeal to the work of social theoreticians and philosophers such as Ophuls, and Beck to sustaining my argument that the solution to the problems emerged from the human wolf conflicts and even to most of all the other environmental problems we face today comes from a change in attitudes. After all, as Foucault argues, being modern is an attitude!

As part of "Plato's revenge" a provocative philosophical essay calling for new ecological politics, Ophuls (2011) pleads for a return to the wisdom of the old. He claims that ecological exploitation and political oppression, two of society's great ills, cannot be solved by appealing to yet other ills as modernity tried to do. Therefore, he proposes a new kind of Enlightenment, one that expands human consciousness and awareness because "*no problem can be solved from the same level of consciousness that created it*" (Einstein quoted by Ophuls). The solution to the current state of society he provides us with is a new way of thinking, a new ethos. He appeals to wisdom and virtue in the service of both ourselves and our society.

He finds a need for a radical rethinking of our civilization, by adopting "a way of life that is materially and institutionally simple but culturally and spiritually rich". He proposes a society grounded on ecological, physical, and psychological reality, in which individuals live in communion with nature, following the "natural law". For this we need to "live more simply and naturally in face-to-face communities rooted in the land" and devise a steady state political economy for a long-term balance with nature.

In the constant striving for "more" of the present consumerist society, in the building of the anti-ecological Titanic described by Ophuls, people have invaded, fragmented and destroyed a considerable part of the wolf's habitat and, as a result conflicts with wolves are a problem that we have brought upon ourselves. Therefore, in order to find solutions to this problem, we should look inwards first, at our own society and our own actions that have led to conflict. By invading wolf territory, disturbing, decreasing and destabilizing wolf habitat and hunting its prey, people have put themselves at risk of their livestock being depredated. This is what Beck would call a self-inflicted risk (Beck, 1992). Instead of realizing that predation and conflict with wolves is a consequence of our own expansion into wildlife territory, people still tend to blame the wolf, seeing him as “the bad guy”, “the big bad wolf”. Due to the low acceptance and tolerance of wolves, conflicts are the main reason for wolf control (Boitani, 2000) and one of the major threats to its survival.

This negative view of wolves derives from fear, the desire for dominance over nature, mankind’s abandonment of its veneration of nature in favor of imposed doctrines, the expansion of the human population and human activities such as agriculture and farming, the dominance of rationality, the loss of tradition and the spiritual void characteristic to our modern times.

Wolves haven’t always been seen in this negative light. From the oldest times, wolves have been part of the human universe, being present in many of the oldest stories and myths. It has been a strong symbol of wilderness, strength and freedom. There has always been a very strong relationship between humans and wolves and the complexity of this relationship is reflected in the multitude of forms in which this animal is present in human mythology: it has been depicted as a funeral divinity, a totemic animal, keeper and guide of inaccessible worlds (a Psychopomp animal), protector of initiation, hunter of excellence, symbol of the warrior. The symbolism of the wolf is very diverse: it was a symbol of the uncontrollable forces of nature, of light, of ancient ancestors and heroic warriors, a symbol of guidance and initiation, an initiator and enemy of demonic forces, a nurturing maternal figure and a giver of life. Regardless of the symbol it took, the wolf was in a position of reverence and respect, it had a seat of honor in human culture (Boitani, 1995).

Just as the Native Americans and other traditional communities, including the Dacian people, the ancestors of the Romanians, also had a very close relationship with wolves and even got their names from the wolf. They based their way of life and battle on what they learned from wolves and nature: family structure, hunting strategies of hide and track, sharpness of senses, and skills in the way they fought and hunted. The legendary environmental wisdom and spirituality of these communities is a wisdom we can learn from, just as we can learn from the wisdom of wolves. Ophuls himself encourages us to appeal to the wisdom of the ancients and to live in accordance with nature’s design.

As a species, wolves have one of the most sophisticated social structures in the entire animal kingdom (Boitani, 1995). There is much to be said about the social lives of wolves. Wolves live in closed family groups and display a wide variety of complex social interactions and expressive means of communication (Kubinyi *et al.,* 2007).The set of social skills that wolves possess is probably one of the main factors that contributed to the success of this species (Kubinyi *et al.,* 2007).

There are many things we can learn from wolves. Wolves prefer a psychological war instead of the physical battle. They set boundaries as a way of cohabiting. They understand their place in the pack, they follow the rules and are loyal to their pack. They respect the leader. They excel at communication and cooperation. They work together to achieve a common goal that benefits the entire pack. They chose peaceful resolution of conflict to the extent possible. Their hierarchy is established based on ability and responsibility, rather than on size and power. In a pack, the dominant female leads in the same measure as the male does. The entire pack slows down when the female has pups, and they care for her and the pups. They protect the weak, the females and their young, the future of their species, even if it requires sacrificing themselves. The leading individuals assume responsibility for the entire pack and work towards the common interest of the group and not the self. Even more, they act as an example for the pack to follow. Wolves know when to rest. Wolves hunt as a means of survival, for nourishment and not for leisure. They benefit prey populations by selecting out the weak and the sick. They act as an umbrella species, maintaining biodiversity and healthy ecosystems through careful prey selection, thus acting as true biodiversity conservationists. Wolves are adaptable. Wolves can live and thrive even in very tough environments by making the most of the resources they have available (Figure 96). The complex social structure of the wolf creates a unified pack that transmits these genes of strength and resilience to the generations to come.

I believe that we need to use similar attitudes, personality, values and morals, if we want to maintain our claim as the dominant species. We need a leader attitude imbued with respect and humbleness in order to fulfill our self-assumed role as protectors and managers of wildlife and our environment. We need to rethink our relationship with nature. Until now people have understood growth as the development of reason, science, wealth and power, but I believe it's time to turn to our deeper selves, moving beyond our self-promoting egos and focus on inner growth, develop our wisdom, and realize that we can be a constructive part of nature if we so choose.

Figure 96. Wolves making their way through the frozen snow (Source: APN).

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Appendix I - Checklist on Ethical Issues in Research

This checklist is intended as a guide for CEU students/researchers in planning, designing and carrying out research, and for applying approval to the Ethical Research Committee. The numbers in brackets indicate the relevant section of the Guidelines on Ethical Research. In case applying for approval from the Ethical Research Committee, provide explanatory answers that enable the Committee to assess whether the Guidelines were followed.

A. General information

1. Project name/Title of thesis/dissertation:
Human-wolf conflict and management solutions in the Western Carpathians: Case study of Apuseni Natural Park, Romania
2. Name(s) of Applicant(s):
Gagyi Palffy Andrea
3. Contact information of applicants:
Address: Gadalin, nr. 189, com. Jucu, Cluj County, Romania Phone number: Hu: + 36 70 525 2624 Ro: + 40 766 366 456 E-mail: palffy_andrea@phd.ceu.edu
4. Department/Research Center:
Department of Environmental Sciences & Policy
5. Research Supervisor (if applicable):
Supervisor: Dr. Brandon P. Anthony (CEU) Committee members: Dr. Michael LaBelle (CEU); Dr. Alex McInturff (University of Washington)* *replacing Dr. Jennifer Miller (Panthera)
6. Supervisor's contact information:
Address: Nador u. 13, Room 105. | 1051 Budapest, Hungary Phone number: + 36.1.327.3000 ext. 2007 / F: + 36.1.327.3031 E-mail: anthonyb@ceu.edu
7. Date by which a decision on this application is required in order that the project can proceed as planned, if approval is required:

January 01, 2017
8. Expected date of completion:
September 2018
9. Abstract of the project/thesis/dissertation:
This study aims to examine the complex nature of human-wolf conflicts (HWC) in the specific context of the Western Carpathians, Romania, which harbours one of the last remains in the world of ancestral coexistence between people and wolves. This special case of threatened coexistence can provide many important lessons to wolf conservation and human-wolf conflict management worldwide. In order to grasp the full complexity of this subject, this research takes on a complex and novel interdisciplinary approach, combining insight from both natural and social sciences to analyse both dimensions of the conflict: the *human-animal conflict* (the biophysical environment that influences predation) and the *human-human conflict* (the social environment and the institutional framework), thus allowing an enhanced understanding of the overall scope of the conflict. It proposes to do this through a complex, twofold "mapping" exercise of both the biophysical and social factors shaping the conflict, with the aim to simplify and create a schematic understanding of a very complex matter: human-wolf conflicts. Supplying management with improved tools, information and recommendations can help prevent and reduce wolf-human conflicts and thereby maintain and/or enhance human tolerance of wolves, necessary to support viable populations in the Carpathians.

B. Funding

10. Sources, researchers' and their organisation's financial interests and ethical issues in case of external funding:
N/A

C. Participants
[If the research does not involve human subjects, go to section D.]

11. Does the study involve human subjects, and how? [Who will participate in the research? How will the subject/respondent group be chosen, what sampling techniques will be deployed? In which ways will the participants be involved? (2.1)

As part of the methodology proposed by this study, face-to-face, in-depth interviews will be conducted with:

1. Livestock producers/herders and other witnesses of wolf attacks on livestock in Apuseni Natural Park (as part of the data collection step for a Spatial Risk Modelling exercise) and

2. Selected members of local communities, representatives of institutions, opinion leaders and stakeholders involved in large carnivore conservation and management.

1. The entire population (the livestock producers/herders living in temporary pastures on the territory of the Apuseni Natural Park, and other witnesses of the attacks) will be sampled. Semi-structured interviews, about 1-1 ½ hours in length will be conducted and, in some cases, these will be followed by a short exploratory visit to the exact location of the wolf predation evets.
2. The sampling procedure in this case will be *criterion-based* or *purposive*. This means that the respondents (sample unit) will be selected with a specific *purpose*, based on certain *criteria*, such as their involvement in wildlife conflict mitigation, wildlife policy-making, research, and/or wolf management and conservation. A set of 30-50 unstructured and semi-structured interviews will be conducted.

12. Are there potential benefits and hazards for the participants?

[Are there risks to the subject entailed by involvement in the research? Have procedures been established for the care and protection of subjects? Will the participants be informed of possible risks and hazards?] (2.2 – 3.4)

No potential risks or hazards for the participants have been identified. All participants in this study could benefit from an improved conflict management, in case the recommendations formulated as an outcome of this study will be taken into consideration by the competent authorities.

13. Does the research involve any risks or pose danger to the researcher(s)?

[If yes, what procedures will be adopted to minimize the risks? Have the health and safety guidelines relevant to the area and character of the research been consulted and implemented?] (4)

Potential sources of harm to the researcher identified until now are: travel and hiking, collecting data from mountain pastures and other grazing areas (risk of attack by guarding dogs); hiking and camping in large carnivore habitats. All measures will be taken to avoid injury mainly by ensuring the company of a research assistant; through acquiring self-defence tools; maintaining a cautious attitude and using appropriate means of transport. Additionally, the park administration will be informed before and after each field work session taking place within the limits of the park.

14. Will all procedures ensuring that consent is informed be followed? [Including the possibility for withdrawing consent] (5.1)
Participation in this study will be voluntary and informed consent will be secured by informing participants about all aspects of the research project which might reasonably be expected to influence willingness to participate, and, additionally: the purpose of the research; who is undertaking and who is funding the study; how the respondent was selected; expected duration and procedures; participants' rights to decline to participate and to withdraw from the research once it has started; how the information will be used and what is required of the participant.
15. Are the recruitment procedures well planned, and risks of coercion considered? [Is there any sense in which subjects might be "obliged" to participate – or are volunteers being recruited? Does the participation of research involve financial or other remuneration?] (5.2)
The participation of respondents will be free of any form of coercion or pressure and no payments or incentives will be offered in advance, for participation. Also, participants will be informed of procedures for contacting the researcher with possible further questions or concerns related to this study. The participants' consent for recording the interview will be obtained.
16. Does the research involve incompetent adults, children or contexts where obtaining consent is impossible (i.e. public context, groups)? [Which "consent"-procedures will be applied instead?] (5.3 – 5.5)
No
17. Does the research involve deception? [This will not be applicable to many studies. In case deception of participants is involved: how is the impossibility to employ alternative non-deceiving method of research justified? How is the deception integral to the viability of research? Will debriefing be employed and how will the participant's reactions influence the use of the data obtained?] (5.6 – 6)
Not applicable
18. Will confidentiality and anonymity be secured? (8)
Yes. The research will uphold individuals' rights to confidentiality and anonymity and these rights will be made clear to participants.
19. Will data protection and storage requirements be followed? (8)

Confidentiality of the participants and of their data will be ensured throughout the processes of data collection, storage and use. Details that would allow individuals to be identified will not be published or made available to anybody not involved in the research.

20. Are there any plans for future use of the data beyond those already described?

Potentially as publications. In this case, all data will be classified/aggregated to eliminate identifying research respondents.

D. Other Aspects:

21. Dissemination of findings:
[What is the anticipated use of the data, forms of publication and dissemination of findings etc? In areas where information is jointly owned by participants as co-researchers' attention should be paid to how they want to use the data.]

This research adheres to the moral and ethical obligation to disseminate research findings to the parties involved in our research and other interested parties in order to assist in those specific issues. Thus, this study's findings will be published in scientific journal, but also disseminated to all parties affected by or affecting the conflicts and will ensure that its contribution is not only to enrich the scientific community but also to improve wolf management.

22. Have you considered how to ensure that ethics considerations are reviewed as the project proceeds?
[This is particularly relevant for projects that go on over a longer time period.]

Yes. A review of CEU Ethics Policy will be conducted at the onset of each stage of data collection.

23. Is there any other information, which you think would be relevant to the reviewers', or your own, consideration of the ethical issues raised in this documentation?

No.

DECLARATION

The information supplied above is to the best of my knowledge and belief accurate.

Gagyi A.

Signature of Applicant:_____ ___________

Date:_______28.11.2016__________

Appendix II – Livestock producers survey

ID:	**Attack location no.:**	**Recording ID:**
Administration area:	**Closest village:**	**Name:**
Date:	**Time:**	**Geographic coordinates:**

Apuseni Natural Park livestock producers survey

Introduction

My name is Gagyi Palffy Andrea, and I am a student at the Environmental Science and Policy Department of Central European University. I am conducting a study on human-wolf interactions in the Apuseni Natural Park, and I am now trying to understand wolf attack events and people's relationship with wolves.

Participating in this survey is entirely voluntary. You do not have to answer this questionnaire, but I would really appreciate it if you did, as it would help my research and contribute to broader understanding. All livestock producers grazing livestock in the ANP are asked to participate in this survey to share ideas, knowledge and experience on grazing livestock and living close to wolves. Everything you say will be completely confidential and treated anonymously.

Filling out this questionnaire will take about an hour. If there is any question you do not want to answer, that is fine. Also, you can stop the interview at any point. If there is any question you do not understand, please let me know.

If you are ok with this, I will record the conversation just to make sure I do not forget anything. But if you do not agree, I will just take notes.

1. Please indicate your primary livelihood:

   ☐ Farming

   ☐ Working as laborer

   ☐ Employed

   ☐ In care of caretakers

   ☐ Still in school

   ☐ Pensioner

   ☐ Other, please specify

   ____

_

2. Please indicate your age: ___________

3. How many years have you been a shepherd? ___________

4. What is the size of your flock? ___________

Section 1 – knowledge of species

5. a) How many wolves do you think there are in the vicinity of your sheepfold?

   ____

   b) How many wolf packs do you think there are in the vicinity of your sheepfold?

   ____

   How do you know this? Please explain:

____

____

____

6. Are you aware of the presence of any wolf dens in this area?

   ☐ Yes

   ☐ No

   If yes, can you show me where they are (either in the field or on a map)?

GPS coordinates: ____

7. In your opinion, has the number of wolves in your area increased or decreased in recent years?

☐ Increased

☐ Has remained the same

☐ Decreased

☐ Don't know

8. In your opinion, have predation events caused by wolves in your area increased or decreased in recent years?

☐ Increased

☐ Has remained the same

☐ Decreased

☐ Don't know

9. Do you recognize these animals? (showing pictures with wolf and feral dogs)

	wolf	feral dog
Picture 1	☐	☐
Picture 2	☐	☐
Picture 3	☐	☐
Picture 4	☐	☐

10. Do you think feral dogs can also attack livestock?

☐ Yes

☐ No

☐ Don’t know

11. In your opinion, who is primarily responsible for addressing problems involving wolves in your area?

☐ Apuseni Natural Park administrators

☐ Local authorities

☐ Local hunting associations

☐ Other (please specify)____

☐ Don’t know

Why do you say so? Why do you believe it is so?
____
____
__

12. In your opinion, who should be primarily responsible for addressing problems involving wolves in your area?

☐ Apuseni Natural Park administrators

☐ Local authorities

☐ Local hunting associations

☐ Other (please specify)____

☐ Don’t know

Why do you say so?
____
____
____
___

13. Have you ever seen or heard from a distance or closely interacted with one of these animals in the wild?

Bear	Wolf	Lynx
☐ Seen	☐ Seen	☐ Seen
☐ Heard	☐ Heard	☐ Heard
☐ Interacted with	☐ Interacted with	☐ Interacted with

Section 2 – predation variables

14. In your opinion, what is the risk of your livestock (in this location) being attacked by wolves?

☐ No risk

☐ Low

☐ Medium

☐ High

15. Have you ever lost livestock to wolves?

☐ Yes

☐ No (if no, please go to question no. 16)

a. Please fill in the following information about the event/events:

Date	Livestock type	Number Killed and taken/eaten	Number Killed and left	Number Injured	Total number

For each individual of livestock you lost, please fill in:

	GPS location	Age	State of health	Color	Other details
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					

b. As much as you remember, please fill in the following characteristics at the moment of the attack:
(complete for each attack and start with the most recent)

Date: ____
____
____

Location: ____
____
____

Time of the day: ____
____
____

Weather: ____
____
____

Enclosed or grazing: ____
____
____

No. of adult livestock in the herd: ______________________________
____
____

No. of juvenile livestock in the herd: ______________________________
____
____

No. of sick animals in the herd: ______________________________
____
____

No. of dogs guarding: ____
____
____

No. of people guarding: ____
____
____

Size of the pasture:____
If enclosed
- Carcass disposal method: ______________________________
____

____

- Presence of fences and other preventative measures:_____

____

____

c. Did you receive any compensation for the damage in any of the cases (if more)?

☐ Yes

☐ No

d. Did you report any of the attacks?

☐ Yes

☐ No (if no, please specify why)

____

____

(I don't trust local authorities; corruption; because of the reporting process itself; I have applied before with no results; personal reasons; Etc.)

→ If yes, please specify for each of the attacks:

- To whom did you report?

____

____

- What was the result of your report?

____

____

Go to Question 16

16. In your opinion, what is the most predation prone season of the year for wolf attacks?

☐ Spring

☐ Winter

☐ Autumn

☐ Summer

☐ No specific time of the year

17. In your opinion, what is the most predation prone period of the day for wolf attacks?

☐ Day

☐ Night

☐ Dusk

☐ Dawn

☐ No specific time of the day

18. Have you observed or do you have any knowledge of any other conditions or circumstances that seem to favor wolf attacks on livestock?

☐ Yes

☐ No (go to question no. 19)

Please specify and describe:____

____

Go to Question 19

19. If an attack takes place, what should someone do?

____

20. How many livestock do you lose each year due to diseases and natural death?

____

Section 3 – preventative measures

21. Have you taken any preventative measures to lower the risk of your livestock being attacked by wolves?

☐ Yes

☐ No (if no, please specify why)

Please specify and describe the preventative measures you have taken:

____
____
____
____
____
____

Go to Question 22

22. Who is responsible for the protection of your livestock when they are grazing?

____
____

23. Do you use yokes for your dogs? Why?

____
____

24. Please rate the effectiveness of these traditional guarding and preventative measures:

	Not effective	Low	Medium	High	Don't know
Guarding dogs………………………………………………	☐	☐	☐	☐	☐
Fenced enclosure…………………………………………	☐	☐	☐	☐	☐
Free grazing……………………………………………….	☐	☐	☐	☐	☐
Proper disposal of sheep carcasses…………………	☐	☐	☐	☐	☐
Herder's presence……………………………………….	☐	☐	☐	☐	☐
Keeping flocks away from forest edges………..…	☐	☐	☐	☐	☐
Others, please specify ………………………………………………………………….	☐	☐	☐	☐	☐

25. Please rate the effectiveness of these wolf management measures/processes in reducing wolf attacks:

	Not effective	Low	Medium	High	Don't know

Compensation schemes………………………………….	☐	☐	☐	☐	☐
Wolf population control through allocation of annual hunting quotas……………..	☐	☐	☐	☐	☐
Preventative measures (implemented by the park, eg. electric fences)…………………………….	☐	☐	☐	☐	☐
Killing of problem animals………………………………	☐	☐	☐	☐	☐
Relocating problem animals…………………………..	☐	☐	☐	☐	☐
Others, please specify ………………………………………………………………….	☐	☐	☐	☐	☐

Section 4 – Perception of risk

26. On this map of the region where your pasture is located, please mark the other sheepfolds you know of.

27. On this map of the region where your pasture is located, please draw areas of risk marking them in the following way: *no risk – low – medium – high* or *0 – 1 – 2 – 3*.

28. How do you manage differently according to the level of risk in your area?
____
____
____
___

29. How worried are you about your own personal safety because of wolves?

☐ Not afraid at all

☐ A little afraid

☐ Very much afraid

30. How worried are you about your livestock's safety because of wolves?

☐ Not afraid at all

☐ A little afraid

☐ Very much afraid

31. In your opinion, the number of wolves in your area should:

☐ Increase

☐ Decrease

☐ Stay the same

Why do you say so? Please explain:

____
____
____

Section 5 – demographic data

32. Gender (to be completed by the interviewer, do not ask)

    ☐ Male

    ☐ Female

32. What is the highest level of education you have completed?

    ☐ No school completed

    ☐ Primary school

    ☐ Secondary school

    ☐ High school

    ☐ Higher education

33. What is the total monthly income of your household?

    ☐ Below 500 lei

    ☐ 501 - 1000 lei

    ☐ 1001 - 1500 lei

    ☐ 1501 - 2000 lei

    ☐ Above 2000 lei

34. Does your household obtain meat from wild animals from areas around your village?

☐ Yes

☐ No

If yes, how often: -

35. If yes, what wild animals do you obtain/hunt?
    -

36. Have you heard of your neighbors poisoning, trapping or hunting wolves in retaliation?

Thank you for taking the time to complete this survey. Your input is valuable. If you have any further questions regarding this survey, please contact Palffy_Andrea@phd.ceu.edu or call +40 766 366 456.

Appendix III – Compressed form of the Livestock Producers Survey

ID:	**Attack location no.:**	**Recording ID:**
Administration area:	**Closest village:**	**Name:**
Date:	**Time:**	**Geographic coordinates:**

Apuseni Natural Park livestock producers survey

Introduction	**Knowledge of species**
Primary livelihood:	No. of wolves:
Age:	No. of packs:
Years as shepherd:	How do you know?
Size of flock:	Wolf dens (show me)
	Trend no. of wolves:
	Trend no. of attacks:
	Recognized animals:
	Feral dogs:
	Who *is* resp. for addr. prob.: Why?
	Who *should be* resp.: Why?
	Ever interacted with:

Predation variables	
Risk of lv being attacked:	Most depred. prone season:
Ever lost lv? (if yes fill page 2 and next box)	Most depred. prone mom. of day:
c. Did you receive compensation? d. Did you report attacks? If no, why? If yes: - to whom:________________________________ - what result:________________________________	Other circumstances that favor wolf attacks:
Lv. Loss due to diseases or natural:	In case of attack, what should one do?

Preventative measures		
Have you taken any?	Describe:	
Responsible with prot. lv.:		Use yoke?
Rate effectiveness:		
Personal Preventative measures -Guarding dogs: -Fenced enclosure: -Free grazing: -Proper disposal of carcasses: -Herder's presence: -Keep away from forest: -Other:		Management measures reducing attacks -Compensation schemes: -Population control: -Preventative measures by park: -Killing problem animals: -Relocating problem animals: -Other:

Perception of risk	**Demographic data**
On map: mark sheepfolds, mark and draw areas of risk	Gender:
How do you manage differently?	Education level:
Worried for pers. safety:	Income:
Worried for lv. safety:	Hunt? What species?
No. wolves should?	Heard of neighbor's retaliation?

ID:

Predation variables

Predation events:

Date	Livestock type	Number Killed &taken	Number Killed & left	Number Injured	Total number

Per each livestock individual:

	GPS location	**Sex** (M or F)	**Age** (years or: adult or juv.)	**Color**	**State of health**	**Other details**
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						

Per each predation event:

Date	**Location**	**Time of day**	**Weather**	**Enclosed/ grazing**	**No. adlt/ herd**	**No. juv./ herd**	**No. sick/ herd**	**No. dogs**	**No. people**	**Size of pasture**	**Carcass disp. methods**	**Presence of fences/ prev. measures**
	Long: ______ N Lat: E											
	Observations:											
	Long: ______ N Lat: E											
	Observations:											
	Long: ______ N Lat: E											
	Observations:											
	Long: ______ N Lat: E											
	Observations:											