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PERSPECTIVE

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

Bridging the gap between science, policy and stakeholders: Towards sustainable wolf–livestock coexistence in human-dominated landscapes

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Abstract

1. While the return of wolves (*Canis lupus*) to many European countries is a conservation milestone, the negative impacts are unevenly distributed across society, placing high pressure on livestock grazing systems.
2. For this perspective, scientists from diverse disciplines and geographical backgrounds reflect on the state of livestock–wolf interactions in Europe and formulate recommendations for enabling wolf–livestock coexistence.
3. We argue that co-designing, co-implementing and co-disseminating research with key stakeholders, such as livestock farmers, is a productive approach to developing and implementing locally appropriate coexistence strategies.
4. Decision-making should be informed by scientific evidence. We recommend that ecological data on wolves and livestock are collected and shared across borders. Evidence from the social sciences is important for understanding the human dimension of wolf–livestock interactions.
5. We suggest bridging the gaps within multidisciplinary wolf–livestock research to strengthen interdisciplinary insights, comprehensively evaluate management approaches and guide governance and policy decisions that properly account for inherent complexities.

6. *Policy implications*: As wolf populations and their impacts continue to grow in Europe, policymakers at all levels must make decisions that adequately safeguard wolf populations while simultaneously protecting livestock and livelihoods. This requires access to reliable scientific evidence.

KEYWORDS
adaptive management, *Canis lupus*, co-implementation, grazing systems, human–wildlife coexistence, interdisciplinary research, science communication, stakeholder engagement

1 | INTRODUCTION

The recovery of the wolf (*Canis lupus*)—an iconic carnivore that is strongly connected to human history and cultures—in many European countries is a conservation milestone. However, recovering wildlife populations bring sociocultural challenges, with costs and benefits unevenly distributed among members of society (Ceausu et al., 2018). The primary costs of living alongside wolves are incurred by livestock farmers who frequently struggle to adapt to their presence. Conversely, many people in the wider society hold positive sentiment towards wolves, appreciating both their intrinsic value and potential effects on ecosystems (Boyce, 2018; Kuijper et al., 2013) and local economies (Kavčič et al., 2022).

2 | THE WOLF IN A WIDER AGRICULTURAL CONTEXT

Wolves can threaten livestock grazing systems, a portrayal often emphasised in the media (Zscheischler & Friedrich, 2022). Contemporary livestock grazing systems face a number of challenges, including changing demographics, complex European Union (EU) and national subsidies and regulations, international trade agreements, economic constraints, effects of climate change and diverse issues of land abandonment or overgrazing (Gill et al., 2021; Mink et al., 2023; Török et al., 2016). Current policy mixes in many European countries, which aim to conserve large carnivore populations while supporting livestock production, have failed to adequately address this complexity. Siloed policy development has led to policies that lack coherence, consistency and comprehensiveness (de Boon et al., 2020). More holistic approaches are necessary, reframing the relationship from 'wolves versus livestock' to 'livestock with wolves'.

In this article, we—academics from diverse disciplines and members of governmental agricultural and non-governmental conservation organisations—combine our interdisciplinary perspectives and discuss five aspects that we consider especially important for supporting sustainable coexistence between humans and wolves in Europe, focusing on the role of science. Table 1 provides a summary of these five recommendations, their key aspects and challenges.

3 | UNDERSTANDING THE LOCAL CONTEXT AND ADDRESSING STAKEHOLDER NEEDS

Providing evidence-based, locally appropriate measures for adaptation and conflict mitigation can be challenging in areas where wolves have been absent for decades or centuries. A comprehensive, context-specific understanding of the needs of affected stakeholders is crucial when tailoring conflict management strategies. For example, for livestock farmers to support or implement livestock protection measures, interventions must be suitable for their husbandry practices (Eklund, Johansson, et al., 2020).

One important dimension of context is the status and history of wolf populations across Europe. Countries like Belgium and the Netherlands are just beginning to experience wolf presence. In Switzerland and Germany, wolf populations have rapidly increased over the past 20 years. Others, such as Slovakia along with most eastern European countries, have had a continuous wolf presence (Boitani et al., 2022). While policies should meet overall management objectives at the European scale, they must also account for disparate local ecological and social conditions.

Another crucial dimension of context is landscape configuration, which influences the effectiveness of protection measures and can hold sociocultural value for local communities (Eklund, Flykt, et al., 2020; Pettersson et al., 2021). Livestock production systems, tailored to particular landscapes, have evolved alongside a variety of livestock types and breeds (Török et al., 2016). In Europe, there is increasing tension between those who want to preserve these traditional cultural landscapes and practices, and the growing rewilding movement, which sees conservation opportunities in land abandonment (Tokarski & Gammon, 2017).

Additionally, legal and economic realities, which constrain the use of mitigation methods, differ among countries and regions (König et al., 2020; Pettersson et al., 2021). For example, the country-specific protection status of the wolf influences the use of lethal control (Figure 1). Regulations on the extent of government financial support also restrict livestock protection or compensation measures.

4 | EVIDENCE-BASED MANAGEMENT

Science can help tease apart complexities of wolf–livestock conflict, which includes both direct and indirect impacts of and on wolves,

TABLE 1 How can science contribute to wolf–livestock coexistence? Recommendations, key aspects and challenges.

Recommendations	Key aspects	Challenges
Improve understanding of local context and stakeholders' needs	• Livestock and husbandry practices. • Wolf ecology and behaviour. • Landscape configurations. • Legal status. • Economic support from national, regional and local authorities.	• Diverse husbandry systems and practices. • Uneven distribution of wolf populations in Europe. • High heterogeneity in landscape structures. • Protection status and actual implementation are country specific.
Provide data to enable evidence-based management	• Collecting and sharing robust ecological data on both wolves and livestock. • Collaborative assessment of management approaches. • Addressing human dimensions of wildlife and livestock management.	• In most countries, difficult to attain husbandry practice information on a relevant granulate (local) scale. • High intelligence and adaptability of wolves is challenging for the effectiveness of protection measures • Very little is known about the effects of lethal control (both positive and negative) in the European context, due to the species' protected status, but also ethical and technical challenges in study design. • The acceptance by stakeholders of conflict mitigation measures is crucial for their success. However, acceptance can be affected by many factors such as beliefs, competing goals or value systems, trust in institutions, ethical considerations, subjective norms, etc.
Co-design, co-implementation and co-dissemination	• Adaptive management and cyclical process of planning, decision-making, evaluation and feedback. • Constructive stakeholder–science–policy interface.	• Developing and maintaining collaboration and cooperation is resource intensive, therefore support from policymakers needed.
Mainstreaming and upscaling	• Need for a transdisciplinary and holistic approach, which brings diverse expertise/knowledge systems to the table. • Transitioning to large-scale and long-term projects is important for more comprehensive evaluation.	• Transdisciplinary research is challenging, as gaps between different knowledge systems, as well as diverse views, have to be bridged. • The scientific community is also a stakeholder, not a neutral party, with disciplinary biased views. • Recognition form policymakers on the local, regional, national and EU level needed for establishing and maintaining large-scale and long-term projects.
Communication	• Importance of effective science communication to the wider public. • Transparent and inclusive process of knowledge transfer. • Highlight where data are lacking.	• Media portrayal of wolves is biased, sensationalised and polarised. • Opportunistic selection, framing and dissemination of scientific results.

and conflicts between different groups of people over wolves (Eklund et al., 2023). In this section, we highlight three key roles science can play.

4.1 | Collecting and sharing ecological data

Decision-making on human–wildlife conflicts has typically drawn on evidence from biological sciences (Redpath et al., 2017), but crucial data are lacking. More behavioural data are needed to better understand wolf interactions with people and livestock given the capacity for wolves to learn overcome livestock protection measures or lose fear of humans (Meuret et al., 2020; Lescureux et al., 2018). Data on livestock production, including specific husbandry practices, types of livestock, locations and overall causes of mortality, are lacking at relevant spatial scales (Gervasi et al., 2021; Gill et al., 2021). Except for some countries, such as France, data are often only available at the national scale. Monitoring data on ungulate populations differs widely across Europe, making it difficult to understand patterns of habitat selection and livestock predation patterns (Janeiro-Otero et al., 2020). More standardised data are needed.

The distribution of wolves is generally well known, partly due to the obligation on EU member states to monitor protected species. Some countries, such as Switzerland and Germany, have established monitoring systems, relying on regional authorities and specific organisations to collect and supplement regional data for analysis at the national level (KORAFoundation, 2020; Reinhardt et al., 2020). Since wolf populations cross administrative boundaries, these efforts need to extend beyond individual countries. Frameworks for transboundary data sharing and exchange can ensure more comprehensive monitoring and management of transboundary wolf populations. Examples include CEwolf, a consortium of scientific institutes working on genetic monitoring of wolves (Jansman et al., 2021) and the Large Carnivore Initiative for Europe, an IUCN (International Union for Conservation of Nature) specialist group that produces summaries of European wolf population status (Boitani et al., 2022).

Collecting, maintaining and sharing ecological data on wolves, livestock and wild prey species are very resource intensive.

FIGURE 1 Current legal status and arrangements for lethal control of wolves, along with estimated wolf numbers and the number of wolves lethally controlled in seven European countries. In Norway and Switzerland, wolves are strictly protected under the Bern Convention. In EU member states, wolves are listed in HD Annex IV (strictly protected) except for Slovakia, where they are listed in HD Annex V (protected). Since 2021, wolves in Slovakia are strictly protected under national legislation. Reactive lethal control decisions respond to specific instances of wolf damage such as livestock predation. Proactive lethal control includes measures to actively manage wolf populations, for example, by setting hunting quotas, conducting licensed hunts or organising culls by special teams. Wolf population estimates are for the 2022–2023 wolf monitoring year (starting in spring) except for Switzerland (February 2023 to January 2024). The number of lethally controlled wolves refer to the 2023 calendar year, except for Norway (April 2022 to March 2023), Sweden (May 2022 to April 2023) and Switzerland (February 2023 to January 2024).

Collaboration between scientists in different disciplines, management authorities, land managers, foresters, livestock farmers and other stakeholders is crucial for maintaining a sufficient database. Despite increasing recognition of the value of involving agricultural scientists in wolf–livestock interaction research, it is still often overlooked. Networks formed by agricultural scientists in cooperation with practitioners, such as the COADAPHT (https://coadapht.fr/en) in France, have proven effective at addressing both the direct and indirect impacts of and on wolves as well as conflicts between people.

4.2 | Collaborative assessment of management approaches

The primary strategies for managing wolf–livestock conflicts are: (i) protecting livestock, (ii) compensating for livestock losses, (iii) reactive lethal control and (iv) proactive lethal control. Many livestock protection measures applied in central Europe, such as electric fencing and livestock guarding dogs, have been derived from the experience-based knowledge of people living in areas with continuous wolf presence (Bruns et al., 2020). When adopting these measures in areas recently occupied by wolves, it is difficult to evaluate their effectiveness in the field using rigorous experimental approaches due to confounding variables and other challenges (Louchouarn et al., 2020; Rigg, 2019). However, it can be done (Ohrens et al., 2019). Evaluating effectiveness of protection measures in new contexts, as well as assessing whether these measures have been correctly implemented, requires both experiential knowledge and an interdisciplinary perspective (Stone et al., 2017).

Compensation for livestock loss is a common tool for supporting livestock farmers, while insurance schemes offer a complementary model for possible livestock losses apart from governmental compensations (Marino et al., 2016). Although successful in reducing retaliatory killing, these methods have limited success in increasing tolerance towards wolves (Naughton-Treves et al., 2003). Often, the process of claiming and obtaining compensation is time- and labour-intensive due to complex bureaucracy and the need for external damage assessments. Indirect costs are rarely considered

(Widman et al., 2019), and many countries do not provide full compensation if protection standards are not met (de Boon et al., 2020). An alternative to compensation is payment for carnivore presence, which involves distributing the estimated costs associated with carnivores to stakeholders in areas with documented carnivore populations (Dickman et al., 2011; Macon, 2020). To our knowledge, this approach is currently only in use in semi-domestic reindeer husbandry areas in Sweden and Finland (Suvantola, 2013; Zabel et al., 2013) and its potential effectiveness in other European contexts is unknown. However, implementation in other parts of the world indicates challenges of determining the appropriate amount of monetary support because insufficient support will not increase tolerance, and excessive support may create perverse incentives (Macon, 2020). Additionally, it is necessary to secure stable funding and identify targeted outcomes based on the benefits of carnivore presence (Dickman et al., 2011).

In a press release on 20 December 2023, the European Commission proposed changing the status of wolves from 'strictly protected' to 'protected', (2023. https://ec.europa.eu/commission/presscorner/detail/en/ip_23_6752) in response to increasing wolf populations and their impacts. This change would ease restrictions on the use of lethal control, which is currently limited in many countries to the removal of 'problem' individuals or packs when other measures have failed (de Boon et al., 2020; Reinhardt et al., 2020). Due to the ethical and technical challenges of designing robust experimental studies, there is little empirical knowledge about the effectiveness of lethal control of wolves (Treves et al., 2019). While reducing wolf populations may decrease predation events, it could also have no effect or even increase future attacks on livestock by disrupting the social structure of wolf packs or allowing wolves to fill vacant territories (Eklund et al., 2017). In one of the few studies testing both hypotheses in France, results showed no conclusive effect (Grente, 2021). One argument for lethal control is that it could decrease motivation for retaliatory killing or poaching of wolves. While some studies suggest that it can reduce poaching temporarily, other studies indicate that it would not have the desired effect. In some cases, legalising wolf hunting has even led to increased poaching (Treves et al., 2019).

Should this EU proposal be accepted by member states, rigorous monitoring and co-designed research approaches are needed to evaluate the efficacy, social acceptance and sustainability of lethal control to balance the objectives of protecting both livestock and wolves.

4.3 | Addressing the human dimension of wolf–livestock interactions

Failing to adequately consider stakeholders' diverse needs, interests and concerns, evidence-based coexistence efforts may be met by resistance, especially from those impacted by wolves. Social sciences can illuminate sociocultural dimensions of conflicts by engaging with stakeholders and bridging the gap between science and practical implementation (Wilson, 2016).

Adoption of mitigation measures requires both efficacy and acceptance by stakeholders who apply the measures on the ground (Denninger Snyder & Rentsch, 2020; Volski et al., 2021). However, wolf–livestock interactions may be perceived differently by different people, or even by the same people in different situations and at a different point in time (Barmoen et al., 2024). Perceived risks of an attack and perceived effectiveness of mitigations measures might differ from actual risk or effectiveness (Bouwer & Fritz, 2023). The perceived feasibility of the intervention by the livestock farmers, as well as its alignment with their personal goals and ethics, may influence its acceptability (Eklund, Flykt, et al., 2020).

Human dimension research can help explain how factors such as perceptions, beliefs, value systems, emotional appraisals, trust in institutions and subjective norms (Barmoen et al., 2024; Echeverri et al., 2018; IUCN, 2023), situated within broader social contexts that include in-group and out-group dynamics, power structures and cultural backgrounds, shape human–wolf interactions. For example, specific stakeholder groups such as hunters, dog owners, reindeer herders, sheep owners and transhumance farmers show differences in acceptance and perceived effectiveness of protection measures (Eklund, Johansson, et al., 2020).

5 | COLLABORATION AND COOPERATION

The context-dependent nature of wolf–livestock interactions requires adaptive management and a cyclical process of planning, decision-making, evaluation and feedback (Williams & Brown, 2014). Assessing wildlife damage mitigation measures involves evaluating technical effectiveness, implementation by stakeholders and resource sustainability (Denninger Snyder & Rentsch, 2020; Louchouarn et al., 2020; Rigg, 2019; Stone et al., 2017). Frameworks for stakeholder participation that promote mutual knowledge exchange and trust building can guide effective integration of stakeholders and enable solution-oriented cooperation (König et al., 2021). Co-management approaches, including co-designing, implementing and disseminating mitigation measures, have been shown to increase conflict tolerance, improve the relevance of research questions and enhance knowledge production (English et al., 2018; Treves et al., 2019).

A constructive stakeholder–science–policy interface is crucial for evaluating the effectiveness of policy implementation. Legal and regulatory measures, along with economic and financial policy instruments, are essential for both conserving wolves and safeguarding the livelihoods of livestock farmers. Collaborating with affected stakeholders is crucial and complements scientific evaluation to ensure a balanced approach that incorporates scientific and local ecological knowledge. Such a comprehensive assessment is vital for understanding the real-world impacts of policy decisions and adapting them effectively, benefitting both wildlife conservation and agriculture (IUCN, 2023; Lute et al., 2020; Stone et al., 2017). While science can initiate these cooperations, it is

necessary that policymakers acknowledge their importance, actively participate and assist in developing and maintaining these platforms. However, such processes require a willingness on the part of researchers, managers and stakeholders to engage in mutually respectful dialogue. A stakeholder platform (https://environment.ec.europa.eu/topics/nature-and-biodiversity/habitats-directive/large-carnivores/eu-large-carnivore-platform_en) created by the European Commission to promote dialogue has struggled to engage with European level agricultural interest groups which left the platform soon after its creation.

6 | MAINSTREAMING AND UPSCALING

To effectively navigate the complexities of wolf–livestock interactions, expertise from a range of fields is essential (Redpath et al., 2017). We echo previous authors who stressed the importance of a transdisciplinary and holistic approach (de Boon et al., 2020; König et al., 2021). However, we also acknowledge that transdisciplinary collaboration is challenging, as there is a need to effectively bridge the gap between different knowledge systems, as well as diverse—and in our case, often polarised—views (Martin, 2021). It is also important to acknowledge that scientists are not neutral parties, but are stakeholders themselves, influenced by the perspective of their particular disciplines, their individual views and the various cognitive biases to which all people may be susceptible (https://www.verywellmind.com/what-is-a-cognitive-bias-2794963). To address this, we encourage the use of integrated frameworks, which can facilitate constructive dialogue between different interest groups and sectors (König et al., 2021). This includes practitioners with local and transformative knowledge, policymakers with target knowledge and scientists with systems knowledge (Pohl & Hadorn, 2008).

Transitioning to larger scale and long-term projects is beneficial for a more comprehensive evaluation of the effectiveness of management approaches, allowing for a deeper understanding beyond the scope of local and time-limited approaches (Stone et al., 2017; Treves et al., 2019). Scientific evaluation of these broader scaled and sustainable practices allows comparing differences, and identifying common trends applicable to broader governance and policy-making (Oliveira et al., 2021). As wolf–livestock conflicts often span multiple jurisdictions and timescales, it is essential to acknowledge the importance of scientific evaluation and to have support from policymakers at local, regional, national and EU levels.

7 | COMMUNICATION

Effective science communication to stakeholders and the public is important, especially in today's digital age where misinformation and conspiracy theories can spread rapidly. Media portrayal of wolves is often biased, with a tendency to cast them as suspects in attacks, leading to articles containing inaccurate or false information (Arbieu et al., 2021). Opportunistic selection, framing and dissemination of scientific results occur not only in the media but also among individuals and groups with strong pro- or anti-wolf positions (Blossey & Hare, 2022; Kuijper et al., 2019; Zscheischler & Friedrich, 2022). Under these circumstances, it is increasingly important to improve the transparency and inclusivity of the process for transferring fact-based scientific knowledge to the public (Hodgson et al., 2019). Scientists have the important role of providing factual and transparent information as well as highlighting where data are lacking in order to scientifically assess conflict mitigation measures and provide recommendations for future management.

8 | CONCLUSION

To foster sustainable coexistence between wolves and livestock grazing systems, societies must transition from viewing them as inherently incompatible to seeking approaches that promote the persistence of both. We believe that science can support this transition. Addressing the needs of both farming and conservation, ideally through adaptive, co-designed and evidence-based management, is vital for tackling the complexity of wolf–livestock interactions. This approach requires input from diverse fields and full integration of stakeholders in the preparation, implementation and assessment of research projects, management measures and policy instruments.

AUTHOR CONTRIBUTIONS

All authors have contributed to the acquisition and interpretation of data, critically reviewed and edited the proposal as well as the full manuscript and have approved the final version to be published. Emu-Felicitas Ostermann-Miyashita, Hannah Kirkland and Hannes J. König have conceptualised the initial idea. Emu-Felicitas Ostermann-Miyashita and Hannah Kirkland have worked on the design and drafting of the proposal as well as the full article. All authors have agreed to be named on the publication.

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CONFLICT OF INTEREST STATEMENT

Emu-Felicitas Ostermann-Miyashita and Darragh Hare receive research funding from WWF Germany to study public perceptions of large carnivores, including wolves, in Germany, although that

funding did not support the work presented here. Darragh Hare is a consultant for WWF Germany on the topic of human–wildlife conflict. Hannah Kirkland consults for Mossy Earth on conservation projects, though none are related to carnivores. Darragh Hare is an Associate Editor for People and Nature but was not involved in the peer review and decision-making process.

DATA AVAILABILITY STATEMENT

There has been no new data generated through this study. The publicly available data sources for Figure 1 are listed in the references.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Supplement material

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