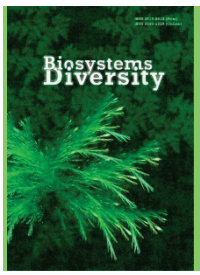

Biosystems Diversity

ISSN 2519-8513 (Print)
ISSN 2520-2529 (Online)
Biosyst. Divers.,
2024, 32(3), 324–333
doi: 10.15421/012435

Conflicts between large carnivores and farmers/beekeepers in the Ukrainian Carpathians: Structure, dynamics, spatial distribution and effective coexistence measures

R. M. Cherepanyn*, **, Y. I. Zelenchuk***, T. S. Yamelynets*, ****, B. I. Vykhor*, Y. M. Andreychuk****

**World Wide Fund for Nature Ukraine (WWF-Ukraine), Kyiv, Ukraine*
***Vasyl Stefanyk Precarpathian National University, Ivano-Frankivsk, Ukraine*
****Verkhovyna National Nature Park, Verkhnii Yaseniv, Ukraine*
*****Ivan Franko National University of Lviv, Lviv, Ukraine*

Article info
Received 28.06.2024
Received in revised form 30.07.2024
Accepted 14.08.2024

Public Union World Wide Fund for Nature Ukraine (WWF-Ukraine), Raisy Okipnoi st., 4/170, Kyiv, 02002, Ukraine. Tel.: +38-093-727-88-12. E-mail: bvykhor@wwf.ua

Vasyl Stefanyk Precarpathian National University, Taras Shevchenko st., 54, Ivano-Frankivsk, 76018, Ukraine. Tel.: +38-097-271-46-25. E-mail: roman.cherepanyn@pnu.edu.ua

Verkhovyna Narional Nature Park, Pechishche Hamlet, 3-a, Verkhnii Yaseniv, 78712, Ukraine. Tel.: +38-067-802-09-51. E-mail: ya.zelenchuk@gmail.com

Ivan Franko National University of Lviv, Universytetska st., 1, Lviv, 79000, Ukraine. Tel.: +38-063-344-55-55. E-mail: taras.yamelynets@lnu.edu.ua

Cherepanyn, R. M., Zelenchuk, Y. I., Yamelynets, T. S., Vykhor, B. I., & Andreychuk, Y. M. (2024). Conflicts between large carnivores and farmers/beekeepers in the Ukrainian Carpathians: Structure, dynamics, spatial distribution and effective coexistence measures. Biosystems Diversity, 32(3), 324–333. doi:10.15421/012435

Conflicts between large carnivores and humans have been common in mountainous regions, with the Carpathians being particularly affected. Recently, interest among researchers and wildlife managers in studying and managing these conflicts has grown significantly. Unfortunately, the coexistence between humans and wildlife and its implications for nature and society have been largely overlooked in Ukraine. This study analyzed conflicts between large carnivores (*Canis lupus*, *Ursus arctos* and *Lynx lynx*) and farmers/beekeepers within designated model territories in the Ukrainian Carpathians, focusing on the effectiveness of conflict prevention strategies implemented between 2018 and 2023. Among the stakeholders analyzed, 79.0% were farmers (livestock owners) and 21.0% were beekeepers. It was observed that 73.0% of farms and apiaries experienced conflicts with large carnivores during the study period; incidents included 64.8% with wolf attacks, 31.3% with bear attacks, and 24.2% with lynx attacks. Notably, conflicts involving livestock owners and large carnivores decreased nearly fivefold, from 54.9% in 2018 to 11.0% in 2023. Similarly, bear-related conflicts among beekeepers nearly halved, from 29.2% to 16.8%. The adoption of electric fences significantly increased among farms and apiaries from none to 33.9%, and the proportion of farmers using dogs for livestock protection without experiencing large carnivore conflicts rose from 3.3% to 20.9%. These pilot findings highlight the effectiveness of such measures in reducing conflicts and improving coexistence quality. The results provide valuable insights into the structure, dynamics, and spatial distribution of conflicts in the Ukrainian Carpathians, underscoring their importance for the conservation of rare species and the implementation of effective management strategies for wild animal populations, sustainable farming, and habitat conservation in regions inhabited by large carnivores. An integrated approach that considers the needs of both human communities and wildlife, involving collaboration among scientific bodies, public organizations, and government entities at various levels, is crucial for devising and executing effective conflict management strategies in diverse landscapes.

Keywords: grey wolf; brown bear; Eurasian lynx; human-wildlife interactions; wildlife conservation; wildlife management; conflict mitigation; livestock and apiaries.

Introduction

Research on conflicts between humans and wild nature, especially with large carnivores, has increasingly captured the interest of scholars, as evidenced by the growing number of scientific publications on this topic in recent years (Nyhus, 2016; Qamer et al., 2023). Over the last decade, publications in some regions have increased by 57.0% (Sharma et al., 2021). The need for effective landscape management, conservation of endangered wildlife populations, and sustainable development of communities in natural and modified environments drives this surge in interest. Therefore, it is crucial to develop and implement management strategies based on robust qualitative and quantitative data regarding large carnivore populations and human-wildlife conflict across various regions (König et al., 2021; Narayan & Rana, 2023).

Unfortunately, there is a significant lack of scholarly work addressing conflicts between large carnivores and humans within the territory of Ukraine (Vykhor et al., 2021). A number of recent studies have extensively analyzed the population structure, dynamics, and distribution of large carnivores in the Ukrainian Carpathians and Polissia (Dykyy & Shkvyria, 2015; Zagorodniuk & Rizun, 2022; Kudrenko et al., 2023; Palmero et al., 2023). Synchronizing the population counts of the grey wolf (*Canis lupus* Linnaeus, 1758), brown bear (*Ursus arctos* Linnaeus, 1758), and Eurasian lynx (*Lynx lynx* Linnaeus, 1758), hereafter referred to as wolf, bear, and lynx respectively, across regional, national, and international levels is crucial for the effective monitoring of these large carnivores (Vykhor et al., 2022; Cherepanyn et al., 2023). However, without a deep understanding of the interactions and conflicts between large carnivores – specifically wolves, bears, and lynxes – and humans, long-term programs aimed at managing landscapes and conserving populations of rare species in the region will likely be ineffective (Marchini et al., 2019, 2021).

According to the IUCN SSC (International Union for Conservation of Nature Species Survival Commission) guidelines on human-wildlife conflict and coexistence, human-wildlife conflict is defined as a "struggle that emerges when the presence or behavior of wildlife poses actual, perceived, direct and recurring threats to human interests or needs – leads to disagreements between groups of people and to negative impacts on people or wildlife". Conversely, human-wildlife coexistence is described as "choice is being made by humans at some level and in some form to share landscapes and natural resources with wildlife in sustainable ways through agreements and cooperations between different groups of people" (IUCN, 2023). In recent years, many European countries have witnessed the recolonization of their territories by large carnivores that had previously vani-

shed (Trouwborst et al., 2017; Plaschke et al., 2021). For instance, as wolf populations recover and expand across Europe, conflicts with livestock owners are becoming increasingly common (Fedyń et al., 2022; Singer et al., 2023). An increase in conflicts and losses of sheep and goats has been correlated with a rising density of wolf populations in many European countries, including Slovakia (Find'o et al., 2023). Unfortunately, Ukraine lacks a national system for collecting, preserving, and processing data on conflicts between large carnivores and humans, such as farmers and beekeepers, unlike many European countries where such incidents are systematically recorded annually (Berce et al., 2020). For instance, in Germany, wolf attacks on sheep escalated from 39 cases in 2010 to 706 in 2019, with injuries rising from 114 to 2559 sheep; similarly, in Austria, injuries from wolf attacks increased from 18 sheep in 2010 to 81 in 2019 (Berce et al., 2020). In 2021, the total number of livestock lost to wolf attacks reached 453 in Austria and 2538 in Germany, among other statistics (Marsden et al., 2023).

Nevertheless, the correlation between the number of wolves on the territory and the negative impacts of conflicts is diminishing over time, suggesting that livestock owners and authorities are increasingly adapting to the presence of these carnivores through enhanced conflict prevention measures (Singer et al., 2023). Consequently, many European countries are implementing state programs to prevent and mitigate conflicts with large carnivores and launch communication campaigns to shift societal attitudes toward these animals amidst rising conflicts and wolf populations. However, fostering sustainable coexistence between humans and large carnivores in natural and modified environments is a significant challenge, necessitating comprehensive strategies (Papp et al., 2022).

Ukraine is home to three types of large carnivores - wolf, bear and lynx. The wolf is a species allowed to be hunted in Ukraine (Salvatori et al., 2002). The bear and the lynx are listed in the Red Data Book of Ukraine (Akimov, 2009). All three species are also protected under the Berne Convention ratified in Ukraine (Convention, 1979). The country has also developed national action plans for the conservation of bears and lynxes in line with European standards (Order of the Ministry of Environmental Protection and Natural Resources of Ukraine No 595 of September 16, 2021, approving the Action Plan for the Conservation of the Eurasian Lynx; and Order No 679 of October 20, 2021, approving the Action Plan for the Conservation of the Brown Bear). Following the national and international Action Plans for large carnivores conservation (Breitenmoser et al., 2000) and recommendations from the Secretariat of the Carpathian Convention and the International Council for Game and Wildlife Conservation (Hackländer et al., 2021), key objectives include studying, understanding, and monitoring human-carnivore conflicts and developing effective prevention and mitigation strategies for such conflicts in targeted regions. Notably, the Carpathian Mountains, where these conflicts are most prevalent, have been the primary focus of our research.

Materials and methods

For our study on conflicts between large carnivores and farmers/ beekeepers in the Ukrainian Carpathians, the following districts were selected: Verkhovyna, Nadvirna, Kalush, and Kolomyia in Ivano-Frankivsk region; Rakhiv, Khust, and Tyachiv in Zakarpattia region; and Stryi in Lviv region (Fig. 1). These territories were chosen due to the presence of farms situated on highland mountain grazing meadows and apiaries within these districts, areas that overlap with the habitats of large carnivores and thus present a potential risk of conflicts.

The distribution of the analyzed farms across the Ukrainian Carpathians is influenced by the region's ethnocultural and natural characteristics. Specifically, traditional farming practices involving free grazing of livestock on highland meadows are predominant in the Rakhiv and Khust districts of the Zakarpattia region, as well as the Verkhovyna and Nadvirna districts of the Ivano-Frankivsk region. In other parts of the Carpathians, these traditional farming practices are less developed due to varying natural and ethnocultural conditions. Consequently, the primary focus areas for studying conflicts between farmers and large carnivores are in these specified districts of Zakarpattia and Ivano-Frankivsk regions (Fig. 1).

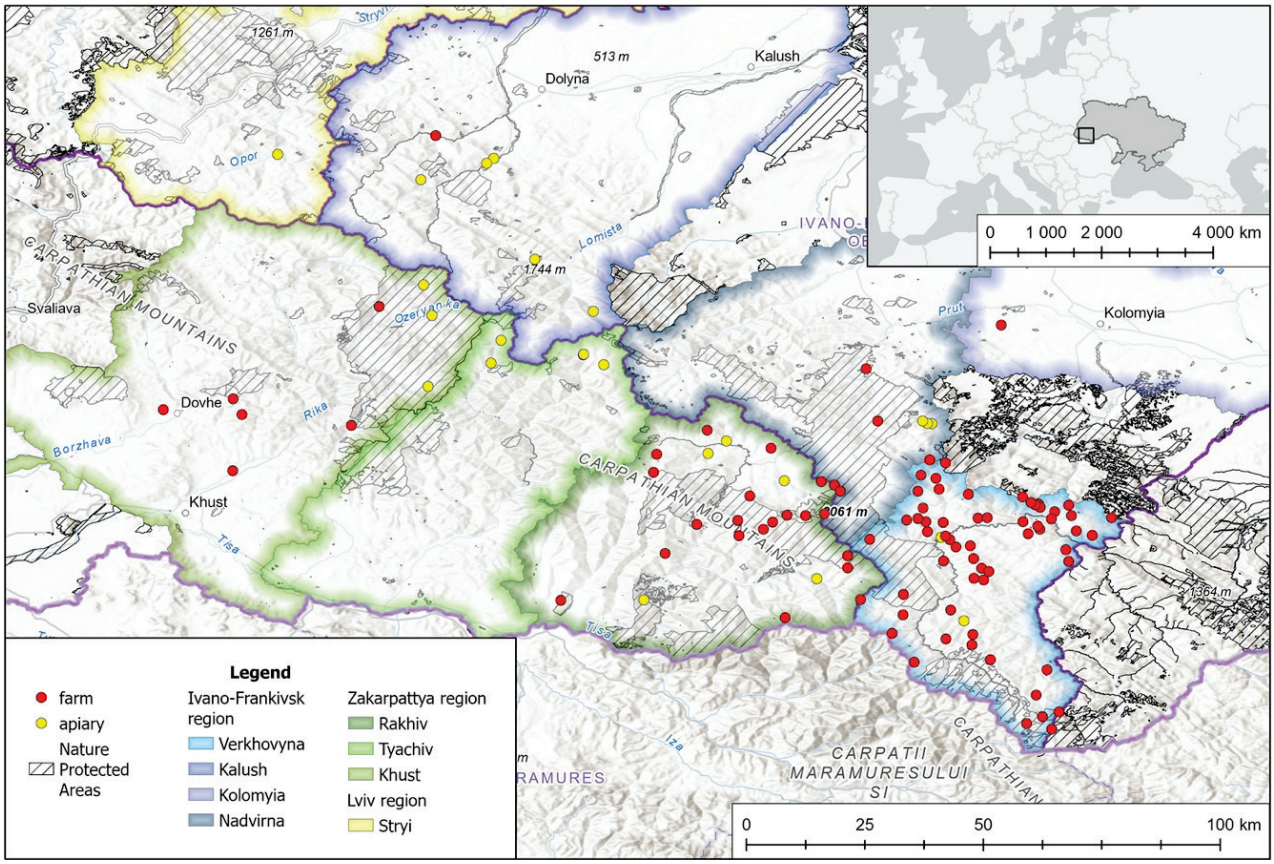

Fig. 1. Map of the research territory showing selected farm and apiary locations used to analyze the structure, dynamics, consequences, and spatial distribution of conflicts between large carnivores and farmers/beekeepers in the Ukrainian Carpathians from 2018 to 2023

The selection of study sites for investigating conflicts with bears was primarily based on the location of apiaries. These apiaries are situated in high-mountain, remote regions within bear habitats, where the potential risk of conflicts with bears is significant. 115 locations were chosen, comprising 91 farms and 24 apiaries. These sites are spread across diverse economic zones, including forestry areas, nature protection areas, and village council territories. Notably, 13 farms and 3 apiaries are within protected natural areas (Fig. 1). To analyze conflicts with large carnivores, an annual survey targeting farm and apiary owners was implemented, focusing on the occurrence and types of conflicts with wolves, bears, and lynxes, as well as the outcomes of these conflicts throughout each year. These surveys were conducted consistently from 2018 to 2023. Additionally, where feasible, incidents resulting from carnivore attacks – such as killed or injured livestock and destroyed beehives – were directly documented with photographic evidence.

The annual questionnaires conducted from 2018 to 2023 included a comprehensive set of questions for respondents, covering: the name and geographical details (district, region, coordinates) of the farms/apiaries; economic type (beekeeper, sheep, cattle, or aviary-type farm); presence or absence of conflicts within the year; species of large carnivores involved (wolf, bear, lynx); consequences of such conflicts (e.g., number of killed/injured livestock, destroyed/damaged beehives); protective measures in place, including the presence of guard dogs (specific breeds like Alabai, Carpathian shepherd, German shepherd, Great Pyrenees), electric fences (installation year and effectiveness post-installation); and additional context such as the operational status of the farm/apiary, the survival of contact persons, and whether the owner has been mobilized for military service.

Data collected from the respondents were processed using Microsoft Excel to analyze the structure and dynamics of conflicts involving large carnivores in designated model territories of the Ukrainian Carpathians from 2018 to 2023. Additionally, a suite of the Sensing Clues Platform online tools was utilized for further processing, data analysis, and reporting. To assess the spatial distribution of these conflicts, a geodatabase in GDB format was established within the ESRI ArcGIS Pro 3.2.2 licensed software environment. This enabled the creation of a relational database that can be dynamically updated with new information.

The geodatabase is structured into several key blocks. The 'Geolocation' block is designated for the spatial positioning of objects, featuring an index field with a unique value for each location to maintain data integrity and enable connections within the geodatabase. The 'Economy' block holds attributes related to the management types at farms/apiaries, while the 'Species' block documents the large carnivores involved in conflicts at these economic sites. The 'Consequence of Conflicts' block records preventative measures like electric fences and herding dogs. Each block includes a temporal component, facilitating spatio-temporal analysis of conflicts and outcomes. Additionally, the geodatabase incorporates vector datasets of Ukraine's administrative divisions and protected area boundaries to pinpoint regions most impacted by conflicts. Heat maps visualizing conflicts as dynamic surfaces of varying densities and hot spot maps, based on a standardized cartographic model, further analyze spatial conflict patterns (Andreichuk & Yamelynets, 2015; Elbakidze et al., 2017; Chaskovskyy et al., 2021).

Results

Structure and dynamics of conflicts. An analysis of respondent data categorized by their type of work activity revealed the following distribution among stakeholders: 78.0% – cattle and sheep owners, 1.0% aviary farm and 21.0% beekeepers. Notably, 7.0% of farm owners were mobilized into the army in 2023 to protect Ukraine from Russian armed aggression. The analysis of conflict dynamics with large carnivores from 2018 to 2023 indicates significant changes in the model territories of the Ukrainian Carpathians. Specifically, the proportion of livestock owners reporting conflicts decreased from 54.9% to 11.0%. Concurrently, the adoption of electric fences for farm protection against these predators rose from 0 to 23.1% (Fig. 2a). Additionally, the proportion of farmers who experienced conflicts while using herding dogs for protection also saw a notable decrease, mirroring the overall decline in conflicts, from 33.0% to 6.6%. The correlation coefficient between these two indicators is 0.9, suggesting a strong relationship. Notably, conflicts among farmers employing dogs for protection are 1.6 times lower than the general rate of conflicts with large carnivores.

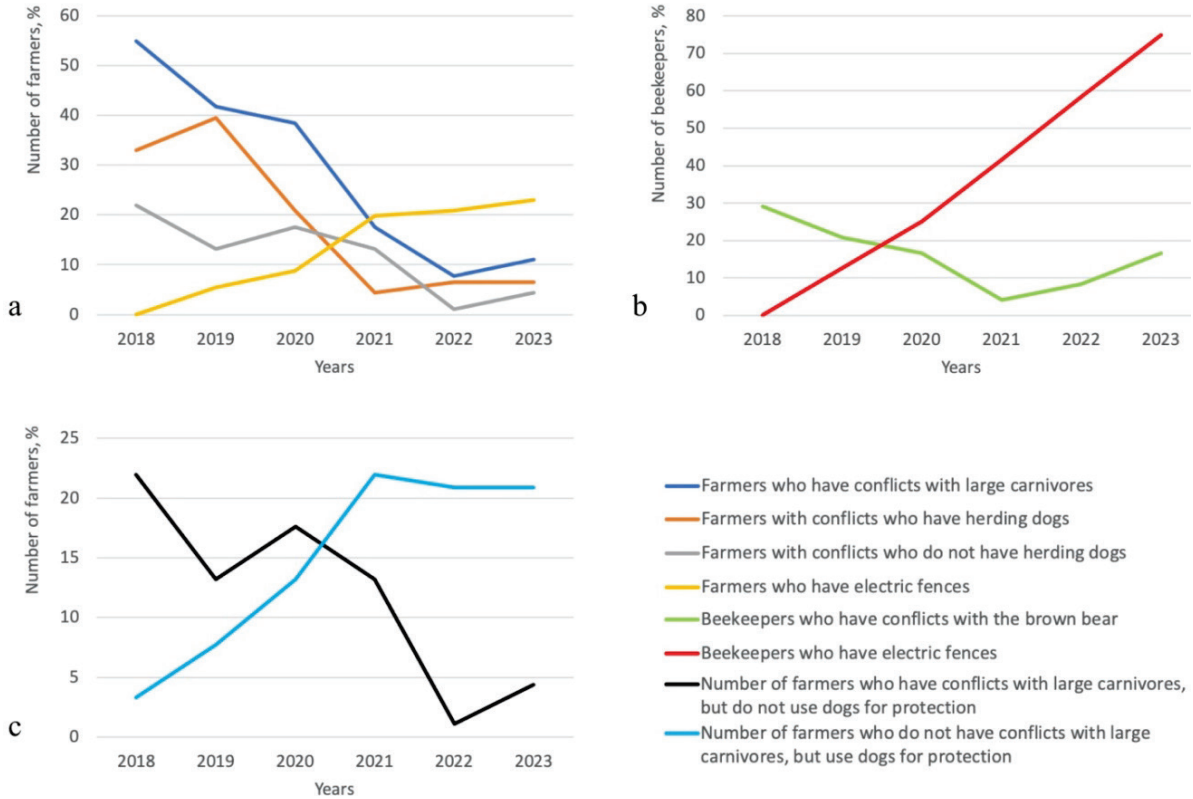

Fig. 2. Dynamics of conflicts between large carnivores and stakeholders and the corresponding protection measures (electric fences and herding dogs) in the Ukrainian Carpathians from 2018 to 2023: *a* – details conflicts between farmers and large carnivores (wolves, bears, lynxes); *b* – outlines conflicts between bears and beekeepers; *c* – tracks the adoption of herding dogs for livestock protection

The analysis of the dynamics of conflicts between bears and beekeepers from 2018 to 2023 reveals significant changes in the model territories of the Ukrainian Carpathians. The proportion of beekeepers experiencing conflicts with bears decreased from 29.2% to 16.7% by 2023. Concurrently, the use of electric fences by beekeepers to protect their apiaries from bear-related conflicts surged from 0% to 75.0% (Fig. 2b).

This shift reflects a broader trend where the share of farmers and beekeepers experiencing conflicts with large carnivores has diminished in correlation with the increased adoption of electric fences for farm protection, highlighting the effectiveness of this preventative measure. Further analysis shows a growing proportion of stakeholders without conflicts: from 2018 to 2023, the percentage of farmers reporting no conflicts with large carnivores almost doubled, rising from 45.1% to 89.1%. Additionally, there is an observable increase in the number of farmers who employ herding dogs or use electric fences, further supporting the trends in conflict mitigation.

The analysis of the effectiveness of the herding dogs used for livestock protection reveals a strong negative linear correlation between the number of farmers who have conflicts with large carnivores and do not use dogs for herd protection and those who do not have conflicts but use dogs. The correlation coefficient for these variables is –0.8. In 2018, 22.0% of livestock owners who did not have dogs reported conflicts, while only 3.3% of those using dogs for herd protection reported no conflicts (Fig. 2c). By contrast, in 2023, the share of livestock owners who had conflicts and did not use dogs decreased to 4.4%, while the proportion of farmers without conflicts who used dogs increased to 20.9% (Fig. 2c). This analysis specifically excluded farmers who use electric fences to isolate the impact of dogs as the sole protective measure. Despite a general reduction in human-large carnivore conflicts across the model territories in the Ukrainian Carpathians, these findings underscore the high effectiveness of employing herding dogs in conflict prevention. Farmers who use herding dogs exhibit significantly lower conflict rates with large carnivores. Further, an analysis of the breeds of dogs used by livestock owners in the Ukrainian Carpathians shows that the Carpathian Shepherd Dog is the most prevalent, accounting for 58.1% of the dogs used. The Alabai is the next most common breed, used by 27.9% of farmers. The German Shepherd and the Great Pyrenees Mountain Dog are less common, representing 7.5% and 6.5% of the dogs used, respectively. There were 93 dogs across all farms analyzed in the model territories.

The distribution of dogs used for livestock protection among farmers varies widely. While the number of dogs per farm ranges from 1 to 6, the breakdown is as follows: 29.4% of farmers keep 2 dogs, 20.6% have 3 dogs, 17.7% use 4 dogs, another 17.7% maintain just 1 dog, 8.8% employ 5 dogs, and the smallest group, 5.9%, manage 6 dogs.

Further analysis specifically focusing on farmers who do not use electric fences illustrates the effectiveness of shepherd dogs in preventing wildlife conflicts. For instance, in 2018, shepherd dogs helped 11.0% of livestock owners avoid conflicts with wolves, 4.4% avert conflicts with lynxes, and 1.1% fend off bear attacks.

The use of electric fences and herding dogs has proven to be substantially effective in protecting herds and preventing conflicts with large carnivores in the model territories of the Ukrainian Carpathians. These effective and reliable methods make them valuable for future farm protection strategies.

Conflict consequences. The impacts of conflicts following attacks by specific species of large carnivores – wolves, bears, and lynxes – have varied significantly across the model territories of the Ukrainian Carpathians from 2018 to 2023. Notably, the majority of conflicts involve wolf attacks. In 2018, 51.6% of farms reported wolf attacks on their livestock. By 2023, however, this figure had decreased sharply to 6.6%, indicating a significant reduction in wolf-related conflicts (Table 1). These percentages far exceed those of farms affected by lynxes and bears.

A breakdown of the affected farms by type of economic activity reveals that sheep owners experience the highest incidence of wolf attacks. Specifically, 26.4% of sheep farms were attacked in 2018, which decreased to 6.6% by 2023. Farms engaged in other economic activities reported much lower rates of wolf attacks (Table 1). This disparity is largely due to the vulnerability of sheep as prey and their prevalence in the highland areas of the model territories.

Table 1

Dynamics of conflicts between large carnivores and farmers/beekeepers on model territories of the Ukrainian Carpathians during 2018–2023

Proportion of farmers/beekeepers, %	Years					
	2018	2019	2020	2021	2022	2023
Conflicts with grey wolf						
Farmers in total	51.6	38.5	29.7	13.2	7.7	6.6
Cattle owners	13.2	7.7	9.9	1.1	0	0
Sheep owners	26.4	17.6	17.6	12.1	5.5	6.6
Horse owners	2.2	1.1	3.3	0	0	0
Goat owners	1.1	0	0	0	1.1	0
Pig owners	1.1	1.1	1.1	0	0	0
Dog owners	1.1	1.1	1.1	1.1	1.1	1.1
Conflicts with Eurasian lynx						
Farmers in total	16.5	15.4	7.7	3.3	0	2.2
Cattle owners	3.3	3.3	2.2	0	0	0
Sheep owners	7.7	7.7	5.5	3.3	0	2.2
Horse owners	0	0	0	0	0	0
Goat owners	0	0	0	1.1	0	0
Pig owners	0	0	0	0	0	0
Dog owners	1.1	0	0	0	0	0
Conflicts with brown bear						
Farmers in total	15.4	11.0	13.2	4.4	0	2.2
Cattle owners	7.7	2.2	5.5	2.2	0	1.1
Sheep owners	7.7	5.5	6.6	2.2	0	0
Horse owners	1.1	1.1	1.1	0	0	0
Goat owners	0	0	0	0	0	0
Pig owners	1.1	1.1	1.1	0	0	0
Dog owners	0	0	0	0	0	1.1
Beekeepers	29.2	20.8	16.7	4.2	8.3	16.8

The assessment of the consequences of conflicts resulting from wolf attacks on farms shows that sheep are the most commonly targeted domestic animals by wolves. In 2018, 194 sheep were killed or injured by wolves, which decreased to 14 in 2023 (Table 2). Cattle were also victims of wolf attacks, with incidents declining from 24 in 2018 to none in 2023. This sharp reduction in sheep and cattle casualties can be attributed to several factors. Firstly, the increased implementation of electric fences among farmers experiencing conflicts has likely played a significant role. Changes in wildlife populations, including wolves and ungulates, may have influenced these dynamics. Notably, the imposition of a hunting ban in Ukraine starting in 2022 during martial law could have altered the ungulate populations in the Ukrainian Carpathians, indirectly affecting wolf behavior. Together with protective measures like electric fences and herding dogs, these changes are believed to have contributed significantly to the decrease in the negative impacts of wolf conflicts on farms.

Among the various large carnivores, lynx attacks on farms are less frequent than those by wolves and bears. In 2018, 16.5% of farms reported conflicts resulting from lynx attacks. However, this rate has significantly declined, with only 2.2% of livestock owners reporting such incidents in 2023 (Table 1). This represents a notable decrease, indicating that conflicts involving lynxes are becoming increasingly rare. The incidence of lynx attacks is almost three times lower than that of wolf attacks.

The proportion of farms affected by the type of management was analyzed, revealing that sheep owners experienced the highest number of conflicts with lynxes. Specifically, 7.7% of sheep farms reported lynx attacks in 2018, which decreased to 2.2% by 2023. Other economic activities saw considerably fewer lynx attacks, as indicated in Table 1. This disparity is attributed to sheep being particularly vulnerable prey for lynxes and the prevalence of sheep farming in the highland areas of the model territories in the Ukrainian Carpathians.

The assessment of conflict consequences from lynx attacks on farms indicates that sheep are the most frequently targeted domestic animals by lynxes. In 2018, 19 reported incidents of sheep being killed or injured decreased to 4 by 2023 (Table 2). Cattle attacks also diminished, from 7 in 2018 to none in 2023. The impact of conflicts involving lynxes is significantly less severe than those with wolves, with the number of domestic animals killed or injured by lynxes being 4–9 times lower, varying by year. The notable reduction in the number of sheep and cattle affected since 2021 can be attributed to more widespread use of electric fences and potential changes in the populations of lynxes, ungulates, and other wildlife in the region.

The share of farms faced with bear attacks is uneven. In 2018, 15.4% of farmers reported bear attacks on their livestock. However, there has been a notable decline in such conflicts; by 2023, only 2.2% of livestock owners reported bear attacks (Table 1). The frequency of bear attacks on livestock is comparable to conflicts with lynxes. Moreover, bear-related conflicts are 3.0 to 3.5 times less frequent than conflicts involving wolves, depending on the year analyzed.

Table 2

Conflicts consequences with large carnivores among farmers/beekeepers on model territories in the Ukrainian Carpathians during 2018–2023

Number of killed/injured domestic animals/destroyed beehives, pcs.	Years					
	2018	2019	2020	2021	2022	2023
Attacks by grey wolf						
Cattles	24	12	12	1	0	0
Sheep	194	131	151	35	12	14
Horses	2	1	4	0	0	0
Goats	3	0	0	0	2	0
Pigs	1	1	1	0	0	0
Dogs	1	2	2	1	1	2
Attacks by Eurasian lynx						
Cattles	7	6	2	0	0	0
Sheep	19	14	16	5	0	4
Horses	0	0	0	0	0	0
Goats	0	0	0	1	0	0
Pigs	0	0	0	0	0	0
Dogs	1	0	0	0	0	0
Attacks by brown bear						
Cattles	15	2	8	2	0	1
Sheep	21	17	22	6	0	0
Horses	1	1	2	0	0	0
Goats	0	0	0	0	0	0
Pigs	1	1	1	0	0	0
Dogs	0	0	0	0	0	1
Beehives	107	33	16	4	26	13

The incidence of bear attacks on farms varies by the type of livestock management. In 2018, 7.7% of sheep and cattle-owned farms reported conflicts with bears, which decreased to 1.1% by 2023. Notably, cattle owners experience more conflicts with bears than with lynxes. This difference is attributed to the bear's larger size and biological traits, which make it more likely to target cattle. Conversely, the lynx, being smaller, more frequently preys on sheep, which are easier for it to hunt.

Bear attacks have notably impacted beekeepers as well. In 2018, 29.2% of apiaries reported conflicts with bears, a rate that decreased to 16.8% by 2023. Notably, bear attacks on apiaries are substantially higher than on livestock farms, as detailed in Table 1.

The impact of bear attacks on apiaries and farms has been assessed. Sheep have been identified as the most commonly targeted domestic animal by bears. In 2018, 21 sheep were reported killed or injured, but by 2023, no such incidents were recorded (Table 2). Bears also attacked cattle, with incidents declining from 15 in 2018 to just 1 in 2023. The consequences of bear attacks on farms are considerably less severe than wolf attacks – the number of domestic animals killed or injured by bears is 4–8 times lower than those by wolves, varying by year.

The impact of bear conflicts on beekeeping was assessed by tracking the number of destroyed or damaged beehives. In 2018, bear attacks resulted in 107 damaged or destroyed beehives, decreasing to 13 by 2023 (Table 2). This significant reduction in bear-related damage and conflicts since 2021 correlates with increased use of electric fences at the apiaries. Post-installation, bears approached 16.8% of the apiaries but were deterred by the electric shocks and left the area. In one instance, a bear attempted to dig under a fence but was similarly repelled by the electric shock. These incidents demonstrate that electric fences effectively prevent bear attacks and safeguard apiaries.

Spatial distribution of conflicts. From 2018 to 2023, 73.0% of the surveyed farms and apiaries experienced conflicts with large carnivores at least once. These incidents and their geographic patterns are detailed on a map (Fig. 3), which illustrates the distribution of conflicts across the Ukrainian Carpathians, marked by the type of economic activity (apiary, cattle ownership, etc.) and the presence or absence of electric fences. Additionally, the map highlights the outcomes of conflicts post-electric fence installation. Notably, of all the farms employing electric fences for protection, only one incident was recorded where a lynx successfully breached the fence and fatally attacked a goat.

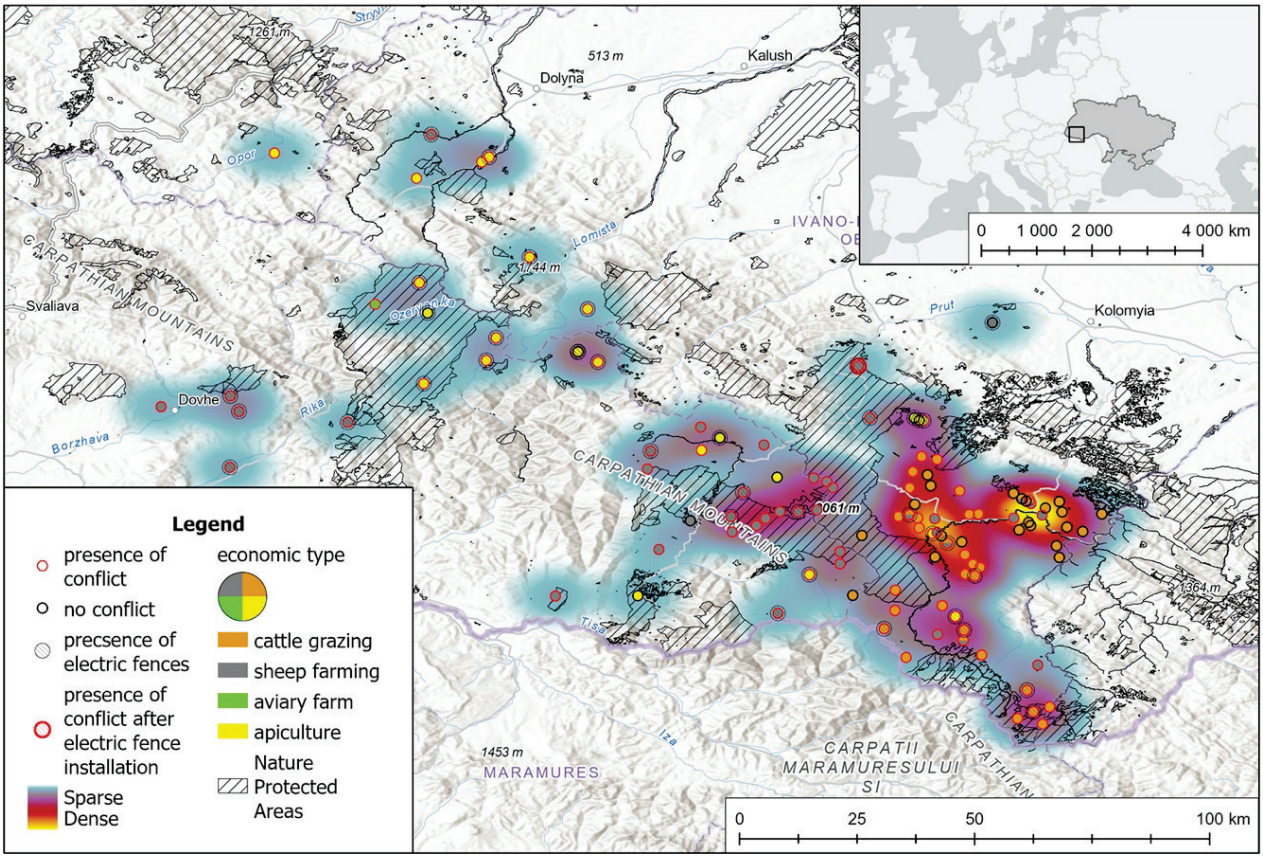

Fig. 3. Spatial distribution of conflicts between large carnivores and farmers/beekeepers in the Ukrainian Carpathians in the period from 2018 to 2023

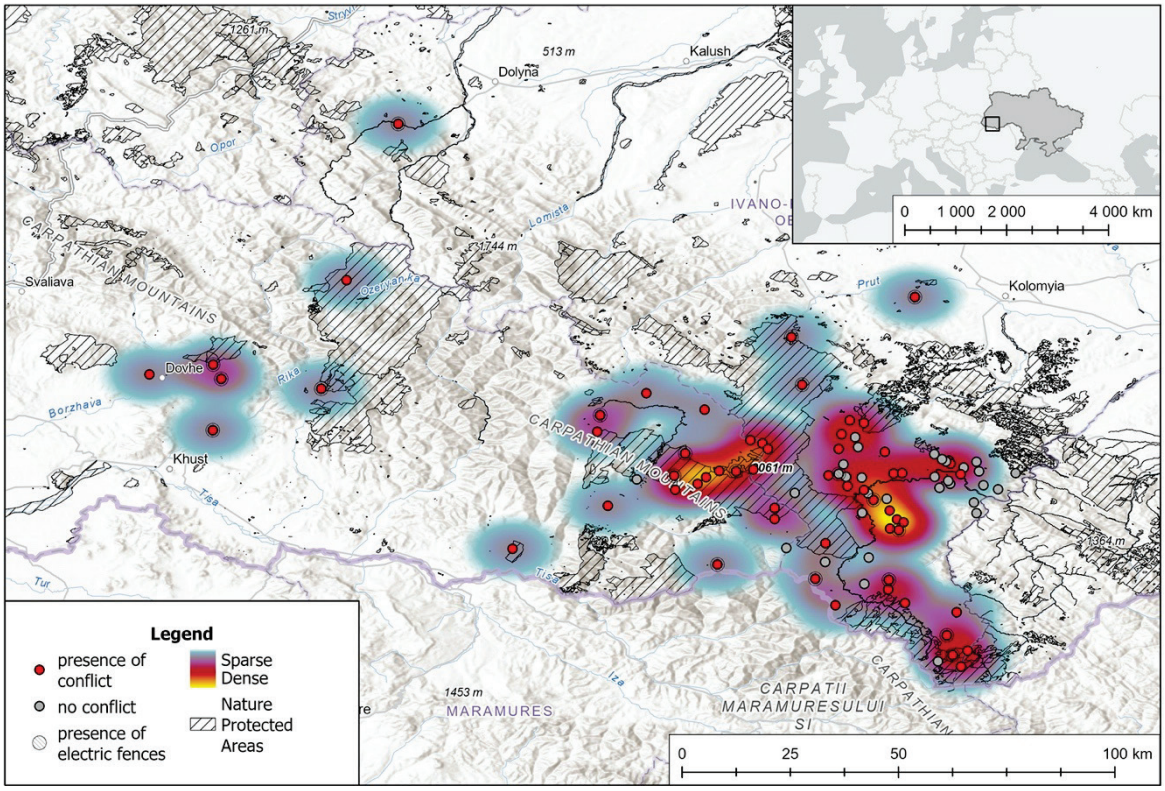

Fig. 4. Spatial distribution of conflicts between wolves and farmers in the Ukrainian Carpathians in the period from 2018 to 2023

Except for this solitary case, electric fences have proven highly effective in preventing wildlife conflicts, underscoring their utility as a reliable deterrent. 33.9% of analysed farms and apiaries use electric fences, with 31.3% of these installations facilitated by WWF-Ukraine.

The analysis revealed that 64.8% of farmers experienced at least one wolf attack from 2018 to 2023. These incidents and their spatial distribution and density are illustrated on the map (Fig. 4), covering specific Ukrainian Carpathian regions. This map also details the deployment of electric fences on farms as a protective measure against wolf attacks. Currently, electric fences are installed on 23.1% of the farms surveyed among livestock owners. Between 2018 and 2023, 31.3% of the analyzed farms experienced bear conflicts. Notably, 70.8% of beekeepers and 20.9% of livestock owners reported at least one bear attack during this period. Beekeepers face more than three times the risk of bear conflicts than livestock owners. Electric fences are used by 75.0% of analyzed beekeepers (the share of electric fences among farmers is 23.1%). The spatial distribution of conflicts with bears and their density in certain Ukrainian Carpathian regions are shown on the map (Fig. 5).

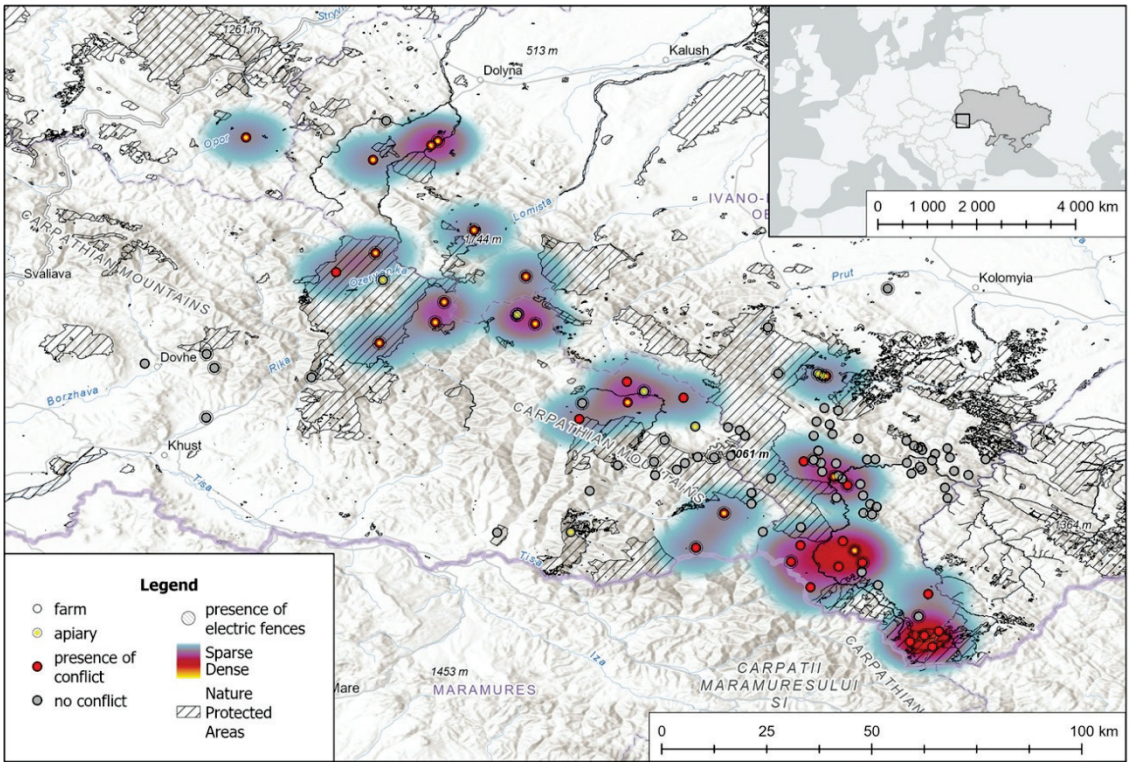

Fig. 5. Spatial distribution of conflicts between bears and farmers/beekeepers in the Ukrainian Carpathians in the period from 2018 to 2023

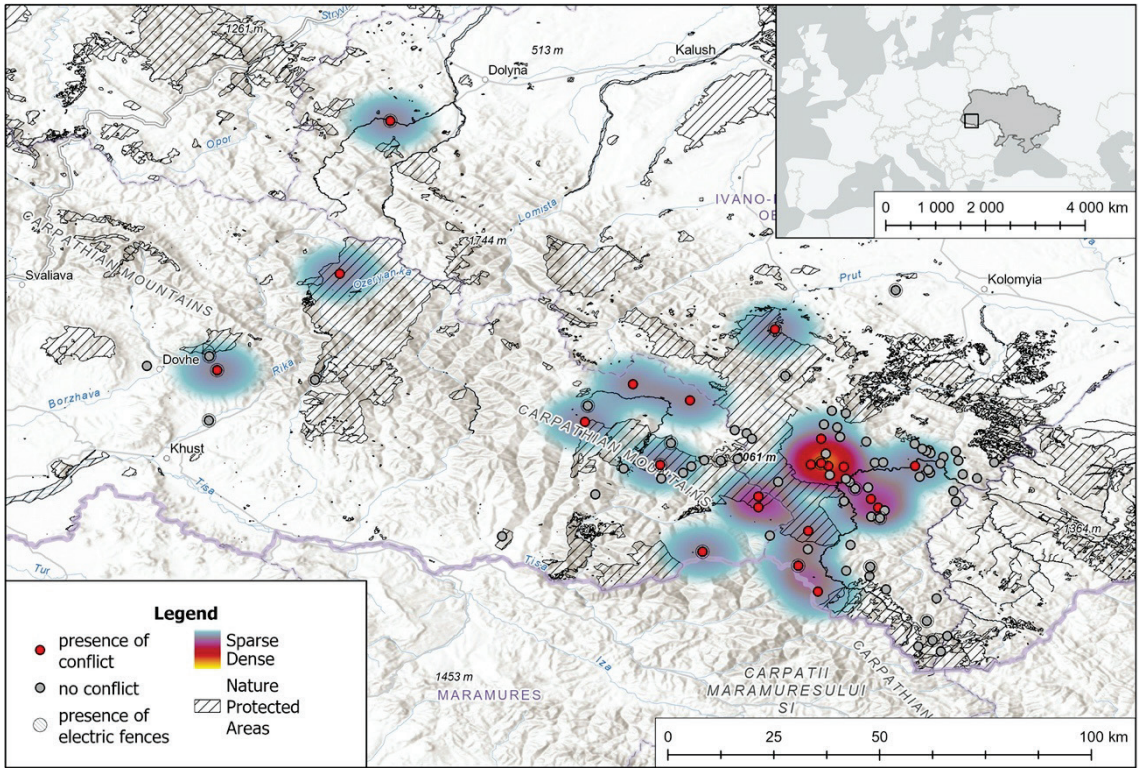

Fig. 6. Spatial distribution of conflicts between lynxes and farmers in the Ukrainian Carpathians in the period from 2018 to 2023

24.2% of farms faced lynx attacks at least once during 2018–2023. The spatial distribution of conflicts with lynxes and their density in certain regions of the Ukrainian Carpathians is shown on the map (Fig. 6). As can be seen from the results, conflicts with lynxes occur in a significantly smaller number of farms compared to conflicts with wolves and bears in the Ukrainian Carpathians. Instead, conflicts with the wolf are the most frequent.

Discussion

Our study's findings are aligned with other conflict studies across the Carpathians. For instance, in Slovakian model territories, wolves are reported to cause 4–6 times more damage than bears (Rigg et al., 2011), while in the Ukrainian Carpathians, this ratio ranges from 4–8 times. Additionally, livestock losses from lynx in Ukraine and Slovakia are comparatively minimal (Rigg et al., 2011).

When livestock losses from large carnivore attacks are compared to the total livestock population in the Ukrainian Carpathians, the impact appears minimal. In the Verkhovyna and Rakhiv regions, for instance, there are 17,000 sheep. The loss of sheep due to large carnivore attacks in these regions during the peak years of conflict was merely 1.0%. Similarly, with a total cattle population of 9,000 in the same regions, the loss of cattle during the highest conflict years was just 0.3%.

A comparison of research results on using electric fences to protect against bear attacks shows a damage reduction ranging from 79.2% to 100% (Khorozyan & Waltert, 2019, 2020). In our study, after the implementation of electric fences – which increased from 0.0% to 75.0% coverage – the frequency of conflicts in the analyzed apiaries nearly halved, and the incidents of bear-related damages to beehives decreased by eightfold from 2018 to 2023. In the Romanian Carpathians, research highlighted a correlation between the proximity of livestock to forests and the incidence of bear conflicts: closer distances significantly increase the likelihood of conflicts involving bears and livestock such as cows or sheep. Similar proximity to villages was also linked to heightened bear conflicts (Pop et al., 2022). However, this aspect has not been thoroughly researched in the Ukrainian Carpathians, pointing to a gap in the local studies that demands a more detailed investigation.

The effectiveness of species conservation and sustainable coexistence between humans and large carnivores depends on societal perceptions, attitudes toward these animals in various social contexts, and community behavior (Lescureux et al., 2010, 2011; Dorresteijn et al., 2014; Azevedo et al., 2024). There exists a noticeable reluctance among herders and hunters to alter their practices in ways that could lessen their impact on large carnivores (Hovardas, 2018; Glikman et al., 2023). Occasionally, hunters view carnivores as "pests" encroaching on "their" game (Linnell et al., 2008). Nevertheless, adopting adaptive management strategies is crucial for conserving large carnivores, especially wolves, tailored to their specific habitats (Mech, 2017). Furthermore, shifting public attitudes towards these predators is essential to recognize their ecological benefits and potential to boost tourism and enhance the region's international appeal (Kavčič et al., 2022).

Globally, electric fences are acknowledged as highly effective for promoting coexistence with large carnivores and protecting farms from attacks, with a success rate exceeding 75.0% (Oliveira et al., 2021). These systems remain operational from three months to three years (Khorozyan & Waltert, 2021). Similarly, herd guard dogs also demonstrate a substantial efficacy range of 26.0–75.0%. Conversely, lethal measures, such as culling wolves, show low efficiency as they do not cease the attacks (Khorozyan & Waltert, 2021; Oliveira et al., 2021). Studies have indicated that lethal predator control methods yield inconsistent outcomes, at times paradoxically leading to increased livestock losses. In contrast, non-lethal strategies have consistently benefitted wildlife populations, livestock safety, and human communities (Treves et al., 2024).

A recent study in Slovakia reveals no correlation between the number of wolves killed and decreased livestock losses (Kutal et al., 2023). Predominantly, wolves in Slovakia consume wild ungulates, accounting for 98.9% of their diet, with sheep and goats only comprising 0.5% (Kutal et al., 2020, 2023). Research on lynx attacks mirrors these findings, underscoring the effectiveness of electric fences and shepherd and guard dog oversight. However, selective culling and hunting have not significantly curtailed sheep losses, as new individuals typically replace those removed (Khorozyan & Waltert, 2021). Additionally, due to lynxes' minimal sheep predation, hunting proves to be an impractical solution (Khorozyan & Waltert, 2021). Similarly, in Latvia, wolves primarily target wild prey and conflicts with livestock owners are infrequent and localized, as verified through dietary biomass studies and analysis of wolves' stomach contents (Andersone & Ozoliņš, 2004). A study of the effectiveness of electric fences in Germany has demonstrated that electric fences significantly

reduce the risk of negative outcomes from wolf conflicts, with effectiveness ranging from 50.0% to 100.0%. Consequently, electric fences are recommended as a highly effective strategy for mitigating farmer-wolf conflicts (Bruns et al., 2020). The role of herding dogs in protecting livestock from large carnivore attacks also receives significant scholarly attention, including studies on their effectiveness against wolf attacks on dogs (Yilmaz et al., 2015; Khorozyan et al., 2017; Tikkunen, 2019). According to some studies, having between 3 to 9 herding dogs is optimal for defending livestock from large carnivores (Iliopoulos, 2009). However, in our research, most farmers (29.4%) used only 2 dogs for protection, 20.6% used 3 dogs, and a small fraction (5.9%) employed 6 dogs to guard their herds.

Conflicts between humans and large carnivores, especially bears, can increase due to natural factors, such as periods of shortage of natural food resources for the animal. Research in the Bieszczady region of the Polish Carpathians shows that human-bear conflicts during the hyperphagia period (September to December, when bears bulk up for hibernation) were significantly more frequent in years with poor beech nut yields compared to years with normal or abundant yields (Bautista et al., 2023). Climate change also rapidly alters environmental conditions in many high-altitude areas, exacerbating human-wildlife conflicts globally (Cherepanyn, 2019; Abrahms, 2023). Further studies indicate that changes in climate and precipitation patterns also contribute to the escalation of these conflicts by increasing disease incidence among farm animals and livestock (Khorozyan et al., 2015).

Conflicts with large carnivores are frequently exacerbated by human actions such as unmanaged landfills, improper waste disposal in natural habitats, and feeding wild animals. These practices increase wildlife presence in human-dominated landscapes and their habituation to human proximity (Kuszlewicz et al., 2023; Cimpoca et al., 2024). Additionally, poaching presents another significant cause of conflict. Illegal and unregulated hunting depletes wildlife populations, compelling large carnivores to venture beyond their traditional ranges in search of food, often targeting domestic livestock (Singh & Singh, 2023). Moreover, the recent prohibition of hunting in Ukraine, initiated with the onset of martial law, might complement the effectiveness of electric fences in mitigating conflicts in the Ukrainian Carpathians. This hunting ban could potentially lead to a rebound in the populations of ungulates and other natural prey, thereby reducing carnivores' reliance on domestic animals. However, this hypothesis warrants further investigation within Ukraine.

For instance, studies conducted in Poland have demonstrated that as populations of wild boar (*Sus scrofa* Linnaeus, 1758) and roe deer (*Capreolus capreolus* Linnaeus, 1758) increase, the incidence of wolf attacks on livestock decreases. Conversely, significantly reducing natural prey increases livestock predation (Klich et al., 2021). Additionally, a study on lynx predation in northern Norway, involving 17 individuals, indicated that lynx are more likely to prey on sheep in areas where reindeer are scarce and sheep populations are dense. Over a six-year summer period, the number of sheep killed (47) was substantially lower than the number of deer taken (274) (Mattisson et al., 2014). These findings underscore the importance of considering the availability and density of natural prey in managing livestock predation by large carnivores.

One of the important processes capable of changing human attitudes towards large carnivores and wildlife, in general, is the mitigation of the consequences of conflicts, for example, by compensating for the damage caused by large carnivores by the state (Bautista et al., 2019; Leslie, 2019). Ukraine lacks a governmental program for compensating individuals for losses incurred due to large carnivore activities. Developing and implementing such a compensation scheme would benefit from an in-depth study of practices employed in European countries and regions like the Carpathians and the Alps.

Addressing conflicts with large carnivores requires monitoring and understanding the issues and developing and implementing proactive conflict management strategies at the state level. This includes measures to mitigate the impacts of these conflicts on people (Boronyak et al., 2022). In Europe, there is a trend towards prioritizing compensatory mechanisms to address the aftermath of conflicts rather than focusing on conflict prevention or adapting management practices in areas inhabited by large carnivores (Bautista et al., 2019). However, compensation programs alone are often insufficient to foster tolerant attitudes towards large carnivores. Effective conflict resolution also demands proactive and preventive measures (Gross et al., 2021).

Conclusions

Monitoring conflicts between large carnivores and farmers/beekeepers on model territories in the Ukrainian Carpathians has started. The structure of conflicts, dynamics, spatial distribution and use of coexistence strategies employed by stakeholders from 2018 to 2023 have been analyzed.

The frequency and severity of conflicts between large carnivores and farmers are declining. The most frequent encounters involve wolves, with livestock owners reporting a significant decrease in attacks, from 225 domestic animals killed/injured in 2018 to 16 in 2023. Lynx-related incidents are fewer, with attacks dropping from 27 in 2018 to 4 in 2023. Bear attacks also decreased markedly from 38 domestic animals and 107 destroyed beehives in 2018 to 2 animals and 13 beehives in 2023.

The proportion of farms targeted by large carnivores has similarly decreased. Attacks by wolves dropped from 51.6% in 2018 to 6.6% in 2023; by lynxes, from 16.5% to 2.2%; and by bears, from 15.4% to 2.2%. For beekeepers, bear attacks reduced from 29.2% to 16.8%.

Concurrently, the adoption of electric fences among farmers has risen sharply from zero in 2018 to 23.1% in 2023 and among beekeepers from zero to 75.0%. The percentage of farmers using dogs for herd protection without experiencing conflicts increased from 3.3% in 2018 to 20.9% in 2023. These trends suggest that electric fences and guard dogs are highly effective at preventing attacks from large carnivores.

In the future, continued data collection and monitoring of large carnivore populations and conflict incidents in the Ukrainian Carpathians are essential. Establishing this monitoring systematically across the region will aid in implementing and promoting comprehensive conflict mitigation strategies. Decisions concerning the management and conservation of rare species and the use, protection, and restoration of both natural and modified landscapes should rely on robust data.

All work in the frame of conflicts with large carnivores research and coexistence support in Ukraine was funded and coordinated by WWF-Ukraine via Nature FIRST project co-funded by the European Commission, HORIZON Research and Innovation Actions (Grant agreement ID 101060954 "Nature FIRST"); Coexistence for Conservation project (Funded by WWF-Poland); EuroLargeCarnivores project funded by the European LIFE Programme (LIFE16 GIE/DE/000661). We extend our deepest gratitude to the Ukrainian defenders, whose bravery has enabled Ukrainian scientists to continue their work under the challenging conditions imposed by the ongoing Russian armed aggression against Ukraine.

The authors declare no conflict of interest.

References

Abrahms, B., Carter, N. H., Clark-Wolf, T. J., Gaynor, K. M., Johansson, E., McInturff, A., Nisi, A. C., Rafiq, K., & West, L. (2023). Climate change as a global amplifier of human – wildlife conflict. Nature Climate Change, 13, 224–234.

Akimov, I. A. (2009). Cherevona knyha Ukrayiny. Tvarynnyi svit [Red Data Book of Ukraine. Animal world]. Globalconsulting, Kyiv (in Ukrainian).

Andersone, Ž., & Ozoliņš, J. (2004). Food habits of wolves *Canis lupus* in Latvia. Acta Theriologica, 49(3), 357–367.

Andreichuk, Y. M., & Yamelynets, T. S. (2015). GIS v ekologichnykh doslidzhenniakh ta pryrodookhoronniy spravi [GIS in environmental research and nature conservation]. Prostir-M, Lviv (in Ukrainian).

Azevedo, J. C., López-Bao, J. V., Dias, R., Santos, J. P. V., Pinto S., Pereira, J., de Castro-Pardo, M. (2024). Perceptions and attitudes of stakeholders on the return of brown bears (*Ursus arctos*): Contributions from a workshop held in Northern Portugal. Conservation Science and Practice, 6, e13064.

Bautista, C., Oeser, J., Kuemmerle, T., & Selva, N. (2023). Resource pulses and human-wildlife conflicts: Linking satellite indicators and ground data on forest productivity to predict brown bear damages. Remote Sensing in Ecology and Conservation, 9(1), 90–103.

Bautista, C., Revilla, E., Naves, J., Albrecht, J., Fernández, N., Olszańska, A., Adamec, M., Berezowska-Cnota, T., Ciucci, P., Groff, C., Härkönen, S., Huber, D., Jerina, K., Jonozovič, M., Karamanlidis, A. A., Palazón, S., Quenette, P.-Y., Rigg, R., Seijas, J., Swenson, J. E., Talvi, T., & Selva, N. (2019). Large carnivo-

re damage in Europe: Analysis of compensation and prevention programs. Biological Conservation, 235, 308–316.
Berce, T., Černe, R., Bertolotto, S., Blaschka, A., Bragalanti, N., Braghiroli, S., Bruno, M., Calderola, S., Chioso, C., Cucè, L., Černe, R., Frick, C., Groff, C., Hilfiker, D., Horrix, I., Javornik, J., Knauer, F., Lüthi, R., Maceli, G., Marucco, F., Menzano, A., Mettler, D., Meyer, F., Nadalin, G., Nägele, O., Parzanese, E., Rasetto, P., Rauer, G., Rizo, S., Rossi, E., Simčič, G., Simon, N. R., Steyer, K., Truc, F., Walter, T., Wölfl, M., Zanghellini, P., & Zeni, M. (2020). Prevention of damages caused by large carnivores in the Alps. In: Large carnivores, wild ungulates and society working group (WISO) of the Alpine Convention. Life WolfAlps EU, Innsbruck.
Boronyak, L., Jacobs, B., Wallach, A., McManus, J., Stone, S., Stevenson, S., Smuts, B., & Zaranek, H. (2022). Pathways towards coexistence with large carnivores in production systems. Agriculture and Human Values, 39, 47–64.
Breitenmoser, U., Breitenmoser-Würsten, C., Okarma, H., Kaphegyi, T., Kaphegyi, U., & Wallmann, U. M. M. (2000). Action plan for the conservation of the Eurasian lynx (*Lynx lynx*) in Europe. Council of Europe, Strasbourg.
Bruns, A., Waltert, M., & Khorozyan, I. (2020). The effectiveness of livestock protection measures against wolves (*Canis lupus*) and implications for their coexistence with humans. Global Ecology and Conservation, 21, e00868.
Chaskovskyy, O., Andreichuk, Y., & Yamelynets, T. (2021). Zastosuvannia GIS u pryrodookhoronniy spravi na prykladi vidkrytoyi prohramy QGIS [The use of GIS in nature conservation on the example of the open program QGIS]. Prostir-M, Lviv (in Ukrainian).
Cherepanyn, R. M. (2019). Changes in population vitality of rare arctic-alpine plant species in high mountain part of the Ukrainian Carpathians under influence of climatic factors. Studia Biologica, 13(1), 117–128.
Cherepanyn, R. M., Vykhor, B. I., Biatov, A. P., Yamelynets, T. S., & Dykyy, I. V. (2023). Population dynamics and spatial distribution of large carnivores in the Ukrainian Carpathians and Polissya. Biosystems Diversity, 31(1), 10–19.
Cimpoca, A.-L., Voiculescu, M., Crețan, R., Voiculescu, S., & Ianăș, A.-N. (2024). Living with bears in Prahova Valley, Romania: An integrative analysis. Animals, 14(4), 587.
Convention on the Conservation of European Wildlife and Natural Habitats. Standing Committee (1997). Texts adopted by the Standing Committee of the Bern Convention on the Conservation of European Wildlife and Natural Habitats (19 September 1979): 1982-96. Council of Europe Publishing, Strasbourg.
Dorresteijn, I., Hanspach, J., Kecskés, A., Latková, H., Mezey, Z., Sugár, S., von Wehrden, H., & Fischer, J. (2014). Human-carnivore coexistence in a traditional rural landscape. Landscape Ecology, 29, 1145–1155.
Dykyy, I. V., & Shkvyria, M. G. (2015). Vedmid buryi (*Ursus arctos*): Problemy zbererhennia ta doslidrhennia populaciyi v Ukraini [Brown bear (*Ursus arctos*): Problems of conservation and studying of population in Ukraine]. LTD SIK Group Ukraine, Kyiv (in Ukrainian).
Elbakidze, M., Angelstam, P., Yamelynets, T., Dawson, L., Gebrehiwot, M., Stryamets, N., Johansson, K. E., Garrido, P., Naumov, V., & Manton, M. (2017). A bottom-up approach to map land covers as potential green infrastructure hubs for human well-being in rural settings: A case study from Sweden. Landscape and Urban Planning, 168, 72–83.
Fedyń, I., Bojarska, K., Gerber, N., & Okarma, H. (2022). Blood trail of expansion? Long-term patterns of livestock depredation by wolves in Poland. Ecological Research, 37(3), 370–380.
Finďo, S., Gallay, I., Mikušová, M., Skuban, M., & Bučko, J. (2023). The impact of large carnivore population density on sheep and goat losses in Slovakia. Research Square, Durham.
Glikman, J. A., Frank, B., D'Amico, D., Boitani, L., & Ciucci, P. (2023). Sharing land with bears: Insights toward effective coexistence. Journal for Nature Conservation, 74, 126421.
Gross, E., Jayasinghe, N., Brooks, A., Polet, G., Wadhwa, R. & Hilderink-Koopmans, F. (2021). A future for all: The need for human-wildlife coexistence. WWF, Gland.
Hackländer, K., Frair, J., & Ionescu, O. (2021). Large carnivore monitoring in the Carpathian mountains. University of Natural Resources and Life Sciences, Vienna.
Herfindal, I., Linnell, J. D. C., Moa, P. F., Odden, J., Austmo, L. B., & Andersen, R. (2005). Does recreational hunting of lynx reduce depredation losses of domestic sheep? Journal of Wildlife Management, 69, 1034–1042.
Hovardas, T. (Ed.). (2018). Large carnivore conservation and management: Human dimensions. Routledge, Abingdon.
Iliopoulos, Y., Sgardelis, S., Koutis, V., & Savaris, D. (2009). Wolf depredation on livestock in Central Greece. Acta Theriologica, 54(1), 11–22.
IUCN SSC guidelines on human-wildlife conflict and coexistence (2023). IUCN, Gland.
Kavčič, I., Álvares, F., Avanzinelli, E., Boitani, L., Borgna, I., Iliopoulos, Y., Krofel, M., Linnell, J., Nowak, S., Reinhardt, I., Rigg, R., Simon, R. N., Scillitani, L., Stronen, A. V., Trbojević, I., Walter, T., & Majić Skrbinšek, A. (2022). Non-consumptive use of wolves in tourism: Guidelines for responsible practices. Biotechnical Faculty, Ljubljana.
Khorozyan, I., & Waltert, M. (2019). A framework of most effective practices in protecting human assets from predators. Human Dimensions of Wildlife, 24(4), 380–394.
Khorozyan, I., & Waltert, M. (2019). How long do anti-predator interventions remain effective? Patterns, thresholds and uncertainty. Royal Society Open Science, 6, 190826.
Khorozyan, I., & Waltert, M. (2020). Variation and conservation implications of the effectiveness of anti-bear interventions. Scientific Reports, 10(1), 15341.
Khorozyan, I., & Waltert, M. (2021). A global view on evidence-based effectiveness of interventions used to protect livestock from wild cats. Conservation Science and Practice, 3, e317.
Khorozyan, I., Soofi, M., Ghoddousi, A., Hamidi, A. K., & Waltert, M. (2015). The relationship between climate, diseases of domestic animals and human-carnivore conflicts. Basic and Applied Ecology, 16(8), 703–713.
Khorozyan, I., Soofi, M., Soufi, M., Hamidi, A. K., Ghoddousi, A., & Waltert, M. (2017). Effects of shepherds and dogs on livestock depredation by leopards (*Panthera pardus*) in North-Eastern Iran. PeerJ, 5, e3049.
Klich, D., Sobczuk, M., Basak, S. M., Wierzbowska, I. A., Tallian, A., Hędrzak, M., Popczyk, B., & Żoch, K. (2021). Predation on livestock as an indicator of drastic prey decline? The indirect effects of an African swine fever epidemic on predator–prey relations in Poland. Ecological Indicators, 133, 108419.
König, H. J., Carter, N. H., Ceauşu, S., Lamb, C. T., Ford, A. T., & Kiffner, C. (2021). Human-wildlife coexistence in science and practice. Conservation Science and Practice, 3, e401.
Kudrenko, S., Fenchuk, V., Vollering, J., Zedrosser, A., Selva, N., Ostapowicz, K., Beasley James, C., & Heurich, M. (2023). Walking on the dark side: Anthropogenic factors limit suitable habitat for gray wolf (*Canis lupus*) in a large natural area covering Belarus and Ukraine. Global Ecology and Conservation, 46, e02586.
Kuszlewicz, K., Pirga, B., & Zwijacz-Kozica, T. (2023). Niedźwiedź 2030. Fundacja Dziedzictwo Przyrodnicze, Nowosiółki Dydyńskie.
Kutal, M., & Dula, M. (2020). Evidence-based hunting policy needed in Slovakia. Science, 370(6521), 1174.
Kutal, M., Dul'a, M., Selivanova, A. R., & López-Bao, J. V. (2023). Testing a conservation compromise: No evidence that public wolf hunting in Slovakia reduced livestock losses. Conservation Letters, 17, e12994.
Lescureux, N., & Linnell, J. D. C. (2010). Knowledge and perceptions of Macedonian hunters and herders: The influence of species specific ecology of bears, wolves, and lynx. Human Ecology, 38(3), 389–399.
Lescureux, N., Linnell, J. D. C., Mustafa, S., Melovski, D., Stojanov, A., Ivanov, G., Avukatov, V., Von Arx, M., & Breitenmoser, U. (2011). Fear of the unknown: Local knowledge and perceptions of the Eurasian lynx *Lynx lynx* in Western Macedonia. Oryx, 45(4), 600–607.
Leslie, S., Brooks, A., Jayasinghe, N., & Koopmans, F. (2019). Human wildlife conflict mitigation: Lessons learned from global compensation and insurance schemes. HWC SAFE Series, WWF Tigers Alive.
Linnell, J., Salvatori, V., & Boitani, L. (2008). Guidelines for population level management plans for large carnivores in Europe. A Large Carnivore Initiative for Europe, Rome.
Marchini, S, Ferraz, K. M. P. M. B., Foster, V., Reginato, T., Kotz, A., Barros, Y., Zimmermann, A., & Macdonald, D. W. (2021). Planning for human-wildlife coexistence: Conceptual framework, workshop process, and a model for transdisciplinary collaboration. Frontiers in Conservation Science, 2, 752953.
Marchini, S., Ferraz, K. M. P. M. B., Zimmermann, A., Guimarães-Luiz, T., Morato, R., Correa, P. L. P., & Macdonald, D. W. (2019). Planning for coexistence in a complex human-dominated world. In: Frank, B., Glikman, J. A., & Marchini, S. (Eds.). Human-wildlife interactions: Turning conflict into coexistence. Cambridge University Press, Cambridge. Pp. 414–438.
Marsden, K., Schwarz, L., Froese, I., Klusmann, C., Eul, J., Merzanis, Y., Psaroudas, S., & Hovardas, T. (2023). Livestock depredation and large carnivores in Europe: Overview for the EU Platform. Platform for the Coexistence of People and Large Carnivores, Berlin.
Mattisson, J., Odden, J., & Linnell, J. D. C. (2014). A catch-22 conflict: Access to semi-domestic reindeer modulates Eurasian lynx depredation on domestic sheep. Biological Conservation, 179, 116–122.
Mech, L. D. (2017). Where can wolves live, and how can we live with them? Biological Conservation, 210, 310–317.
Narayan, E., & Rana, N. (2023). Human-wildlife interaction: Past, present, and future. BMC Zoology, 8(1), 5.
Nyhus, P. J. (2016). Human-wildlife conflict and coexistence. Annual Review of Environment and Resources, 41, 143–171.
Oliveira, T., Treves, A., Vicente López-Bao, J., & Krofel, M. (2021). The contribution of the LIFE program to mitigating damages caused by large carnivores in Europe. Global Ecology and Conservation, 31, e01815.
Palmero, S., Smith, A. F., Kudrenko, S., Gahbauer, M., Dachs, D., Weingarth-Dachs, K., Kashpei, I., Shamovich, D., Vyshnevskiy, D., Borsuk, O., Korepanova, K., Bashta, A.-T., Zhuravchak, R., Fenchuk, V., & Heurich, M. (2023). Shining a

light on elusive lynx: Density estimation of three Eurasian lynx populations in Ukraine and Belarus. Ecology and Evolution, 13, e10688.
Papp, C.-R., Scheele, B. C., Rákosy, L., & Hartel, T. (2022). Transdisciplinary deficit in large carnivore conservation funding in Europe. Nature Conservation, 49, 31–52.
Plaschke, M., Bhardwaj, M., König, H. J., Wenz, E., Dobiáš, K., & Ford, A. T. (2021). Green bridges in a re-colonizing landscape: Wolves (*Canis lupus*) in Brandenburg, Germany. Conservation Science and Practice, 3(3), e364.
Pop, M. I., Dyck, M. A., Chiriac, S., Lajos, B., Szabó, S., Iojă, C. I., & Popescu, V. D. (2023). Predictors of brown bear predation events on livestock in the Romanian Carpathians. Conservation Science and Practice, 5, e12884.
Qamer, R., Zishan, A. W., Nahila, A., Jahangeer, A. B., Mohd, H., & Shreekar, P. (2023). Human-wildlife conflict: A bibliometric analysis during 1991–2023. Regional Sustainability, 4(3), 309–321.
Rigg, R., Find'o, S., Wechselberger, M., Gorman, M. L., Sillero-Zubiri, C., & Macdonald, D. W. (2011). Mitigating carnivore-livestock conflict in Europe: Lessons from Slovakia. Oryx, 45(2), 272–280.
Salvatori, V., Okarma, H., Ionescu, O., Dovhanych, Y., Find'o, S., & Boitani, L. (2002). Hunting legislation in the Carpathian Mountains: Implications for the conservation and management of large carnivores. Wildlife Biology, 8(1), 3–10.
Sharma, P., Chettri, N., & Wangchuk, K. (2021). Human-wildlife conflict in the roof of the world: Understanding multidimensional perspectives through a systematic review. Ecology and Evolution, 11(17), 11569–11586.
Singer, L., Wietlisbach, X., Hickisch, R., Schoell, E. M., Leuenberger, C., den Broek, A. V., Désalme, M., Driesen, K., Lyly, M., Marucco, F., Kutal, M., Pagon, N., Papp, C. R., Milioni, P., Uzdras, R., Zihmanis, I., Zimmermann, F., Marsden, K., Hackländer, K., López-Bao, J. V., Klenzendorf, S., & Wegmann, D. (2023). The spatial distribution and temporal trends of livestock damages caused by wolves in Europe. Biological Conservation, 282, 110039.
Singh, S., & Singh, S. (2023). Human-wildlife conflict and coexistence. Biophilia Insights, 1(2), e202312004.
Tikkunen, M., & Kojola, I. (2019). Hunting dogs are at biggest risk to get attacked by wolves near wolves' territory boundaries. Mammal Research, 64(4), 581–586.
Treves, A., Fergus, A. R., Hermanstorfer, S. J., Louchouarn, N. X., Ohrens, O., & Pineda-Guerrero, A. (2024). Gold-standard experiments to deter predators from attacking farm animals. Animal Frontiers, 14(1), 40–52.
Trouwborst, A., Boitani, L., & Linnell, J. D. C. (2017). Interpreting 'favourable conservation status' for large carnivores in Europe: How many are needed and how many are wanted? Biodiversity and Conservation, 26(1), 37–61.
Vykhor, B., Cherepanyn, R., Tymochko, S., & Zelenchuk, Y. (2021). Zakhyst khudoby ta pasik vid napadiv velykykh khyzhakiv [Protection of livestock and apiaries from attacks by large carnivores]. WWF-Ukraine, Kyiv (in Ukrainian).
Vykhor, B., Dykyy, I., Tymochko, S., Franchuk, M., Khojetskyy, P., Cherepanyn, R., & Yamelynets, T. (2022). Metodyky obliku rysi, vedmedia ta vovka [Lynx, bear and wolf monitoring methods]. WWF-Ukraine, Kyiv (in Ukrainian).
Yilmaz, O., Coskun, F., & Ertugrul, M. (2015). Livestock damage by carnivores and use of livestock guardian dogs for its prevention in Europe – a review. Journal of Livestock Science, 6, 23–35.
Zagorodniuk, I., & Rizun, E. (2022). Eurasian lynx (*Lynx lynx*) in the Ukrainian Polissia: A biogeographical analysis. Theriologia Ukrainica, 24, 104–119.