



Population dynamics and spatial distribution of large carnivores in the Ukrainian Carpathians and Polissya

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Large carnivores play an important role as indicators of the state of the natural ecosystems. The analysis of the number and distribution of large carnivores (brown bear – *Ursus arctos*, Eurasian lynx – *Lynx lynx* and grey wolf – *Canis lupus*) was established in the Ukrainian Carpathians and Ukrainian Polissya. Annual data on the number of large carnivores on the territories of hunting units and nature conservation areas from 2009 to 2019 was summarized. To analyze the number and distribution of large carnivores in the Ukrainian Carpathians, data from 4 regions were taken into account, namely Lviv, Zakarpattia, Ivano-Frankivsk and Chernivtsi regions. To analyze the number and distribution of large carnivores in Ukrainian Polissya, data from 6 regions were taken into account – Volyn, Rivne, Zhytomyr, Kyiv, Chemihiv and Sumy regions. According to official data obtained from hunting units and nature conservation areas in 2019, there were 375 bears, 435 lynxes and 563 wolves in the Ukrainian Carpathians; and 4 bears, 128 lynxes and 609 wolves in Ukrainian Polissya. Based on the collected data, the maps of the distribution of large carnivores in the Ukrainian Carpathians and Ukrainian Polissya were created in the format of a grid of squares of 10 by 10 km (cell size 100 km²), namely – density maps of populations of large carnivores, as well as maps of forest habitats of large carnivores. The obtained results provided a better understanding of the dynamics of large carnivores over the last decade in terms of regions, as well as the density of populations of large carnivores in certain areas and their distribution areas in the Ukrainian Carpathians and Ukrainian Polissya. However, the summary results of the number of individuals obtained based on official reports of hunting units and nature conservation areas are overestimated due to the problem of "double" accounting of animals by users of adjacent lands (hunting units, nature conservation areas). Therefore, it is important to establish synchronization of accounting between users of adjacent lands (nature protection areas, forestries, etc.), to use unified research methods, and to exchange monitoring data and information between institutions of different state subordination. Such scientifically based data are the basis for the development and implementation of measures for the conservation and management of large carnivore populations at the regional, national and international levels.

Keywords: brown bear; Eurasian lynx; gray wolf; population size; nature conservation areas; forestry; hunting units.

Introduction

Large carnivores are large mammals that prey on other animals and are at the top of the food chain. Carnivores (predators) play an important role in maintaining the balance of ecosystems in the wild – they control the populations of other animals and carry out a selection of individuals at the population level.

There are 3 main large carnivores in Ukraine – brown bear (*Ursus arctos* Linnaeus, 1758), Eurasian lynx (*Lynx lynx* Linnaeus, 1758) and grey wolf (*Canis lupus* Linnaeus, 1758) (hereinafter: bear, lynx, wolf). Bear and lynx are protected species – both listed in the Red Data Book of Ukraine – lynx since 1994, and bear since 2003 (Akimov, 2009). The wolf is a common species that is allowed to be hunted – the wolf hunting season lasts from October to February due to Law of Ukraine about hunting management and hunting (February 22, 2000, No. 1478-III (edition of 10.03.2017) Bulletin of the Verkhovna Rada of Ukraine, No. 18). The wolf, the bear and the lynx are under the international protection of the Berne Convention – the Convention on the Conservation of European Wildlife and Natural Habitats (1979, E.T.S. 104 (IEL-MT 979) 70). The agreement has also been ratified in Ukraine, but in the case of the wolf, Ukraine reserves the right to regulate the number of wolves. At the European level, all three large carnivores are additionally protected

by the Habitat Directive – the Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (Official Journal of the European Communities, 22.07.1992; 206:7–50).

There are a large number of research works on the biology and ecology of large carnivores in Ukraine. In particular, K. A. Tatarynov and A. A. Slobodian attached great importance to the ecology and protection of large carnivores in western Ukraine (Tatarynov, 1974; Slobodian, 1991). I. V. Delegan, Y. O. Dovhanych, I. V. Dykyy and M. G. Shkvyria were engaged in studies of population structure, methods of monitoring and conservation of the brown bear in the Carpathians (Delegan, 2011; Dovhanych, 2013; Dykyy & Shkvyria, 2015). O. I. Kyseliuk studied the peculiarities of the large carnivore population management in protected areas (Kyseliuk, 2000). M. G. Shkvyria and S. M. Zhyla researched the lynx and wolf in the territory of Ukrainian Polissia (Shkvyria, 2008; Zhyla, 2009, 2021). P. B. Khojetskyy deals with the peculiarities of accounting for hunting fauna and rare large carnivores in Ukraine (Khojetskyy, 2002, 2007). Despite the large number of publications on large carnivores in Ukraine, they often remain unknown in the European context to foreign scientists (Kaczynsky et al., 2013; Kubala et al., 2021). Weak representation of Ukrainian scientific achievements in the international context is caused by the low rate of publication of materials in rated scientific journals and editions, which are known among relevant specia-

lists (Okarma et al., 2000; Von Arx et al., 2004; Shkvyrya & Vishnevskiy, 2012). Also, the level of international cooperation, exchange of information on the current state of wolf, bear and lynx populations in Ukraine and their environmental characteristics remains low (Hočevar et al., 2020). In particular, today there is a lack of consolidated data (obtained on common methodological approaches) on the number and distribution of large carnivores in the Ukrainian Carpathians and Ukrainian Polissya in the context of the last decade (Stergar & Slijepčević, 2017; Vykhor et al., 2022). Therefore, given the fragmentary nature of the materials on the total number of large carnivores in recent years and the lack of detailed maps on the current range of species, there is a need to compile available official information on this topic in Ukraine.

In autumn 2021, the Ministry of Environmental Protection and Natural Resources of Ukraine approved the National Action Plans for the Conservation of Bears and Lynx in Ukraine (Order of the Ministry of Environmental Protection and Natural Resources of Ukraine No 595 of 16 September 2021, on approval of the Action Plan for the Conservation of the Eurasian lynx (*Lynx lynx* L.) in Ukraine; Order of the Ministry of Environmental Protection and Natural Resources of Ukraine No 679 of October 20, 2021, on approval of the Action Plan for the Conservation of Brown Bear (*Ursus arctos* L.) in Ukraine). National Action Plans are official strategic documents that determine the more effective implementation of measures for monitoring, conservation and management of key rare species at the state level. Among the most important tasks of the National Action Plans for the Conservation of Bears and Lynx are the following:

- definition and approval of schemes of unified methods of species monitoring;
- establishment of systematic and regular monitoring of species, creation and definition of a system of standard monitoring sites in different administrative regions of Ukraine;
- detailed mapping of species habitats and distribution area in Ukraine.

Following the objectives of international and national Action Plans for species conservation (Breitenmoser, 2000) and recommendations on the specifics of monitoring large carnivores (Hackländer et al., 2021) issued by the Secretariat of the Carpathian Convention and International Council for Secretariat of the Game and Wildlife Conservation, we tried to find out the number, dynamics, current range and distribution of bear, lynx and wolf populations in the Ukrainian Carpathians and Ukrainian Polissya.

Materials and methods

During the implementation of this study, no methods were used that would violate the principles, provisions or articles of the European Convention for the Protection of Vertebrate Animals used for Experimental and Other Scientific Purposes (Council of European, European Treaty Series No. 123). Data on the number and distribution of large carnivores were collected without the use of any experiments on animals.

The analysis area was selected in accordance with the available general information on the distribution area of rare large carnivores (lynx and bear) in Ukraine. The main areas of bear and lynx distribution in Ukraine are the Carpathians and Polissya. Accordingly, 4 administrative regions (provinces) of the Ukrainian Carpathians (Lviv, Zakarpattia, Ivano-Frankivsk and Chernivtsi) and 6 administrative regions of Ukrainian Polissya (Volyn, Rivne, Zhytomyr, Kyiv, Chernihiv and Sumy) were selected for data analysis. Wolf in Ukraine is distributed not only in the Carpathians and Polissya, it is also a common species in the forest-steppe and steppe physical and geographical zones. However, in this study, we did not take into account these areas of the species distribution.

The following categories of data were used to compile information on the number, dynamics and distribution of bear, lynx and wolf populations in Ukraine.

1. Annual data of hunting animals by hunting units. Every year in Ukraine, users of hunting units submit to the regional departments of forestry and hunting “Report on accounting, capturing and breeding of hunting animals” – an annual form of state statistical observation – No. 2-TP, hunting (Order of the State Statistics Service of Ukraine No. 166 of

June 25, 2021). Territorial bodies of the State Forestry Agency organize data collection in accordance with the 2-TP form from hunting units within administrative-territorial units, and the State Forestry Agency summarizes data on the number of hunting animals by administrative regions and sends compiled data to the State Statistics Service of Ukraine.

The annual form of state statistical observation – No. 2-TP (hunting) – has not been updated for a long time, as there are a number of species listed in the Red Data Book of Ukraine among hunting animals, including bears and lynxes. On the one hand, it is unclear why the species listed in the Red Data Book of Ukraine, has not been yet excluded from the list of hunting species of the 2-TP form (hunting). On the other hand – the presence of these species in the official mandatory Report, obliges users of hunting grounds to account not only hunting animals, but also other species, in particular from the Red Data Book of Ukraine, which are present in hunting units. Mandatory registration of bears and lynx by users of hunting units allows us to obtain annual data on the number of these species outside the nature protection areas in Ukraine. Given this, it is advisable to change the title of the document “Report on accounting, capturing and breeding of hunting animals” in accordance with its content.

2. Data of nature conservation area institutions – nature reserves, national nature parks, regional landscape parks, etc. We used annual summary data on the number of large carnivores on the territories of the nature conservations institutions, as well as data contained in the annual official reports of nature conservations area institutions.

To analyze information on the number and distribution of large carnivores in hunting units and nature protection areas, we used data from 2009 to 2019. Data for 2020–2022 had not yet been compiled by all relevant institutions.

Population distribution maps were created using the desktop geographic information systems QGIS 3.26 (2022) (Andreichuk & Yamelynets 2015; Chaskovskyy et al., 2021). We used data on the number and distribution of large carnivores in 2018–2019 in protected areas and areas of hunting units to create maps.

In fact, the vector polygonal layer with the boundaries of the territories of hunting units and nature protected areas was created based on paper maps of hunting units, which were obtained from the regional departments of Forestry and Hunting. In total, the boundaries of 581 entities were digitized. In the attributes of the created layer was added information from the annual form of state statistical observation – No. 2-TP for the 2018–2019 year.

The vector polygonal forest layer was created on the basis of the Global Forest Change 2000–2019 database (Hansen et al., 2013) in the Google Earth Engine software environment (Gorelick, 2017). The “tree-cover2000” layer was used to create the forest layer. Because the study was conducted within the country and did not require too much detail, the resolution of the original forest cover rasters was reduced from 30 to 300 m/pixel. The obtained raster of forest cover was vectorized.

Maps of forest habitats of large carnivores were obtained as a result of the intersection of the forest layer and the layer of hunting units and nature protection areas with attributive information about the presence of large carnivores. The result was a layer with geometry of forest boundaries and attributive information on the number of carnivores in the context of each user. Forest plots belonging to hunting or nature conservation entities were merged into separate multi-landfills. An attribute was added to each landfill that reflected the territories belonging to the Carpathians or Polissya.

As the basis for further analysis, we use the indicator of population density – the conversion of the number of individuals per unit area (1 km²). Therefore, we first calculated the area of forest habitats for each hunting or nature conservation entity. The next step was to divide the number of individuals living on the territory of the entity by the area of the forest habitat within its territory. The obtained value was saved in the attribute field “density”.

A 10*10 km grid of the European Environment Agency reference grid was used to analyze the density of large carnivores individuals (wolf, bear or lynx). Grid coordinate system: ETRS89-extended/LAEA Europe (EPSG:3035). Each grid cell has its own unique identifier (CELLCODE). An intersection operation was performed between the grid layer and the forest habitat layer. The landfills of forest habitats are divided into contours

of hunting or nature conservation entities, additionally divided also by the boundaries of the grid cells.

Attributes from both source layers are present in each polygon. From the layer of forest habitats the attribute density was used – ie the number of individuals per 1 km². From the grid layer 10*10 km, a unique cell identifier was taken (attribute field Cellcode). The resulting layer conditionally called “intersected”.

The next step was calculating the potential capacity of forest habitats within each grid cell. To do this, the area of each landfill (km²) was multiplied by the population density (number of individuals per 1 km²). The result was saved in the “capacity” field.

The next step was to calculate the capacity for each grid cell. To do this, the compatible capacity of all polygons from the layer “intersected” within each cell of the grid layer was calculated. To do this, the attributes from the “intersected” layer were analyzed with the “Statistics by categories” tool. The sum of the values of the “capacity” field by category from the Cellcode field was calculated. From the results of the calculations, the amount obtained within each group was used. Thus, we obtained a table with 2 fields: Cellcode and capacity_sum (total capacity

of forest habitats within a specific grid cell). Similarly, a table was obtained with the area of forest habitats within each cell (area_sum).

The next step was to add the obtained total values of capacity and area of forest habitats to the vector layer of the grid. To do this, we used the tool “Join attributes by field value”.

The final step was visualization the obtained results on the maps – the density of individuals of the species (number of individuals per 100 km²) within the grid cells was denoted by the colour of different intensities depending on the value of the density index.

Results

The number of large carnivores in the Ukrainian Carpathians. As a result of summarizing information obtained from official sources (nature conservation areas and regional departments of forestry and hunting) on the numbers of lynx, bear and wolf in the hunting units and nature protection areas of 4 administrative regions in 2009–2019 years (Lviv, Ivano-Frankivsk, Zakarpattia and Chernivtsi regions), the number and dynamics of large carnivores in the Ukrainian Carpathians were found (Table 1).

Table 1

The number of populations of large carnivores (grey wolf, brown bear and Eurasian lynx) in the Ukrainian Carpathians (by regions) from 2009 to 2019 according to the data of hunting units and nature conservation areas

Region (province)	Species	Years										
		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Ivano-Frankivsk	grey wolf	104	90	98	82	84	79	87	86	95	94	90
	Eurasian lynx	85	98	112	80	93	83	99	97	101	91	108
	brown bear	153	162	176	124	129	112	135	137	128	114	115
Chernivtsi	grey wolf	28	25	29	29	25	24	39	49	50	64	49
	Eurasian lynx	70	73	69	76	80	75	44	40	48	50	48
	brown bear	27	27	27	24	27	32	32	24	25	29	29
Lviv	grey wolf	135	148	175	189	185	177	180	170	180	150	184
	Eurasian lynx	65	92	91	94	95	100	105	106	87	84	113
	brown bear	57	90	90	94	95	96	97	100	75	71	99
Zakarpattia	grey wolf	257	320	254	168	200	187	164	186	162	239	240
	Eurasian lynx	174	177	136	142	142	127	139	147	148	199	166
	brown bear	171	209	184	140	149	152	132	106	120	118	132
Together in all regions (provinces)	grey wolf	524	583	556	468	494	467	470	491	487	547	563
	Eurasian lynx	394	440	408	392	410	385	387	390	384	424	435
	brown bear	408	488	477	382	400	392	396	367	348	332	375

As a result, in 2019, in the Ukrainian Carpathians, according to the summary data from nature protection areas and regional departments of forestry and hunting there were 375 bears, 435 lynxes and 563 wolves (Table 1). Ivano-Frankivsk region has the highest number of bears and the lowest number of wolves. Until 2014, the largest number of lynx was observed in Chernivtsi region, but after 2014 the number of wolves began to increase and lynx decreased. The lowest number of bears is in Chernivtsi region. In Lviv and Zakarpattia regions wolves are the most numerous of the large carnivores and bears the least numerous (Table 1). In general, the dynamics of animal populations in the Ukrainian Carpathians from 2009 to 2019 remain stable without significant fluctuations (Fig. 1).

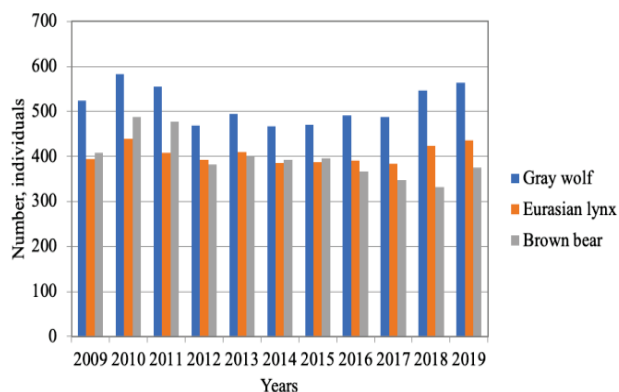


Fig. 1. Dynamics of the number of large carnivores (grey wolf, brown bear and Eurasian lynx) in the Ukrainian Carpathians (together in 4 administrative regions) during 2009–2019 years according to the data of hunting units and nature conservation areas

The total population of wolves in Ukraine is more than 2000 individuals, and up to 1000 are hunted annually, due to the official state data. In the Carpathians, the number of wolves (according to the official state data) is estimated at almost 560 individuals. The dynamics of lynx in the Ukrainian Carpathians have been stable in recent years – its number ranges from about 400 to 430 individuals.

It is also interesting to compare the data obtained on the number of large carnivores by region. The largest number of bears is in Transcarpathian (Zakarpattia) region. Then Ivano-Frankivsk and Lviv regions are followed by Chernivtsi region with the lowest number of bears. Since 2010 in the 4 regions there has been a tendency towards reduction in the number of bears (Fig. 2).

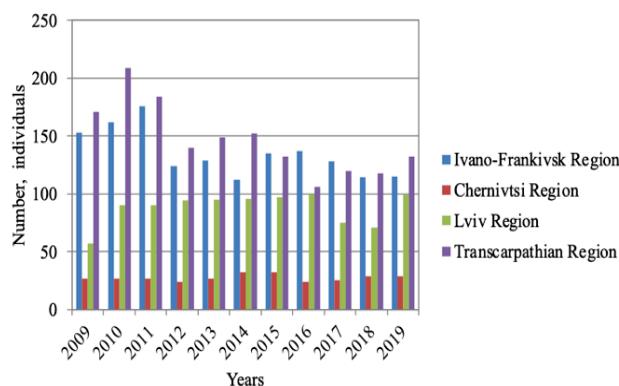


Fig. 2. The number of brown bears in the regions within the Ukrainian Carpathians during 2009–2019 years according to the data of hunting units and nature conservation areas

In the case of lynx, the largest number of individuals is also observed in Zakarpattia region – in recent years there have been more than 150 individuals. Fewer animals are in Ivano-Frankivsk and Lviv regions. The lowest number of lynx is in Chernivtsi region, where a decline in numbers after the year 2014 has been observed – from 75 to no more than 50 individuals. The reasons for such a dynamic need to be clarified (Fig. 3).

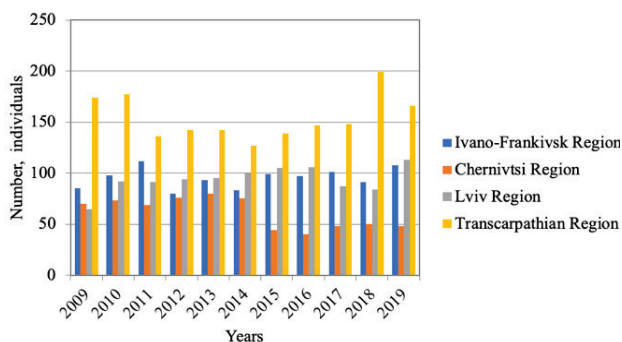


Fig. 3. The number of Eurasian lynx in the regions within the Ukrainian Carpathians during 2009–2019 years according to the data of hunting units and nature conservation areas

The largest number of wolves was observed in Zakarpattia region – more than 200 individuals in recent years (Fig. 4). There were slightly fewer animals in Lviv region – more than 150 individuals. No more than 100 individuals have been observed in Ivano-Frankivsk region over the last decade. It is interesting that the number of wolves almost doubled

(from 25 to 50 individuals) in Chernivtsi region after the year 2014. At the same time, the number of lynx on the contrary has decreased. The question of whether the decrease in the number of lynx correlates with the increase in the number of wolves in the region needs further study.

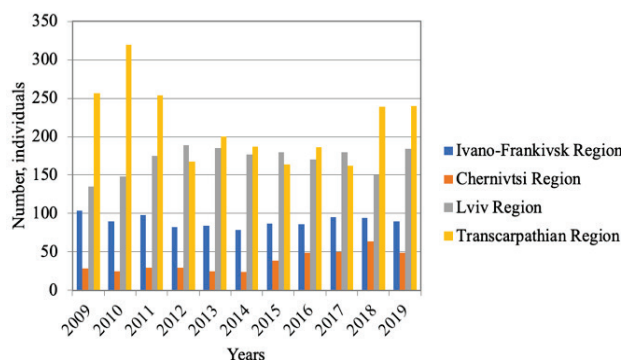


Fig. 4. The number of grey wolves in the regions within the Ukrainian Carpathians during 2009–2019 years according to the data of hunting units and nature conservation areas

The number of large carnivores in Ukrainian Polissya. As a result of summarizing information obtained from official sources (nature conservation areas, regional departments of forestry and hunting) on the number of lynx, bear and wolf in hunting units and nature protection areas of 6 administrative regions in 2009–2019 years (Volyn, Rivne, Zhytomyr, Kyiv, Chernihiv and Sumy), the number and dynamics of large carnivores in Ukrainian Polissya was found (Table 2).

Table 2

The number of populations of large carnivores (grey wolf, brown bear and Eurasian lynx) in the Ukrainian Polissya (by regions) from 2009 to 2019 according to the data of hunting units and nature conservation areas

Region (province)	Species	Years											
		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	
Volyn	grey wolf	27	14	16	10	14	6	14	28	41	51	47	
	Eurasian lynx	2	2	1	0	1	0	0	2	3	4	2	
	brown bear	0	0	0	0	0	0	0	0	0	0	0	
Rivne	grey wolf	64	75	74	60	60	77	91	134	139	124	119	
	Eurasian lynx	9	26	22	27	45	46	37	31	27	24	25	
	brown bear	0	0	0	0	0	0	0	0	0	0	0	
Zhytomyr	grey wolf	93	140	134	155	174	169	110	175	158	189	158	
	Eurasian lynx	31	26	26	33	46	52	39	47	47	43	53	
	brown bear	0	0	0	0	0	0	0	0	0	0	0	
Kyiv	grey wolf	98	109	107	82	80	91	89	85	84	91	99	
	Eurasian lynx	34	36	26	24	28	26	25	25	22	24	24	
	brown bear	1	0	0	0	0	2	1	3	2	3	3	
Chernihiv	grey wolf	199	166	137	156	131	123	138	164	182	186	152	
	Eurasian lynx	13	8	12	12	5	13	13	18	23	20	23	
	brown bear	0	0	0	0	0	0	0	0	0	0	0	
Sumy	grey wolf	84	75	79	92	84	64	63	56	46	51	34	
	Eurasian lynx	0	0	0	0	0	0	0	1	1	1	1	
	brown bear	0	1	1	1	1	1	1	1	1	1	1	
Together in all regions (provinces)	grey wolf	565	579	547	555	543	530	505	642	650	692	609	
	Eurasian lynx	89	98	87	96	125	137	114	124	123	116	128	
	brown bear	1	1	1	1	1	3	2	4	3	4	4	

Table 2 shows that, for example, in 2019 in the territory of Ukrainian Polissya, according to summary data from protected areas and regional departments of forestry and hunting, there were 4 bears, 128 lynxes and 609 wolves. In all 6 regions the number of wolves was the largest, followed by lynx and the number of bears was the lowest – the last two species do not occur in every region (Table 1). In general, the dynamics of populations of large carnivores in Ukrainian Polissya during 2009–2019 remains stable without significant fluctuations (Fig. 5).

Bears have been recorded on the territory of Ukrainian Polissya since 2009. Individuals occur in Kyiv (Chornobyl Radiation and Ecological Biosphere Reserve) and Sumy regions (Desniansko-Starogutsky National Nature Park). There are about 4 individuals (Fig. 6). In 2021, for the first time in more than 100 years, the footprints of a bear were recorded in Rivne region on the territory of the Rivne Nature Reserve (the information is indicated in the Annals of the Nature of the Rivne Nature Reserve).

Lynx is widespread on the territory of Ukrainian Polissya – there are up to 130 individuals in all 6 oblasts (administrative regions) (Table 2). There are two lynx populations in Ukraine – the Carpathian and the Baltic (in Polissya), but there is no information about their connection. Most likely, the link between the Carpathian and Baltic lynx populations was lost due to habitat fragmentation, infrastructure development and poaching.

Most lynx were found in Zhytomyr and Rivne regions. Fewer in Kyiv and Chernihiv regions. The lowest number of lynxes was in Volyn region and Sumy region – by 2019 up to 5 individuals in each region. In Zhytomyr region the dynamics of the lynx population increases from 30 to 50 individuals from 2009 to 2019, and in Rivne region, the dynamics of the lynx population decreases from 45 to 25 individuals since 2014. The dynamic of the lynx population is stable in Kyiv and Chernihiv regions (Fig. 7).

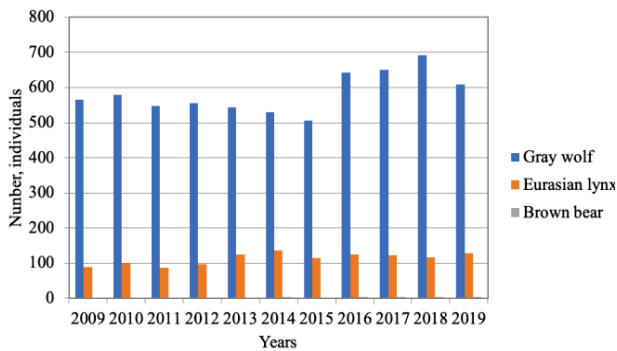


Fig. 5. Dynamics of the number of large carnivores (grey wolf, brown bear and Eurasian lynx) in Ukrainian Polissya (together in 6 administrative regions) during 2009–2019 years according to the data of hunting units and nature conservation areas

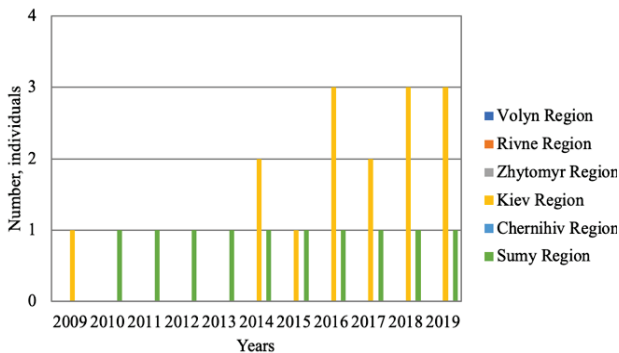


Fig. 6. The number of brown bears in the regions within Ukrainian Polissya during 2009–2019 years according to the data of hunting units and nature conservation areas

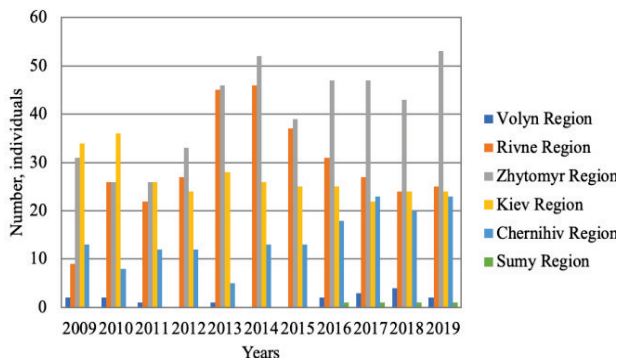


Fig. 7. The number of Eurasian lynx in the regions within the Ukrainian Polissya during 2009–2019 years according to the data of hunting units and nature conservation areas

Approximately 600 wolves inhabit the territory of Ukrainian Polissya according to official summary data from hunting units and nature conservation areas (Table 2). The largest number of wolves is in Chernihiv and Zhytomyr regions. In Rivne region, the dynamics of the number of the species increased from 2014 to 2019 by two times – from 60 to 120 individuals (and the number of lynx, on the contrary, decreased by almost two times in the same period – from 45 to 25 individuals). The correlation between these changes needs to be studied in more detail. In Volyn region, there was also an increase in the number of individuals – from 20 to 50 wolves. In Sumy region, the number of the species has been declining since 2013 – from 80 to 30 individuals. In Kyiv region, the dynamics of the wolf remain stable over the years (Fig. 8).

Distribution of large carnivores in the Ukrainian Carpathians and Ukrainian Polissya. The highest number of wolves in the Ukrainian Carpathians as of 2018–2019 years was observed in the Carpathian Biosphere Reserve (44 individuals), Uzhansky National Nature Park (34 individuals), National Natural Park “Skolivsky Beskydy” (21 individuals),

National Natural Park “Verkhovynskyi” (19 individuals) and Chermosky National Natural Park (21 individuals). In hunting units, a high number of wolves is observed in the hunting and fishing society “Hoverla” in Transcarpathia (23 individuals) and in the territory of the Turkiv hunting and fishing society.

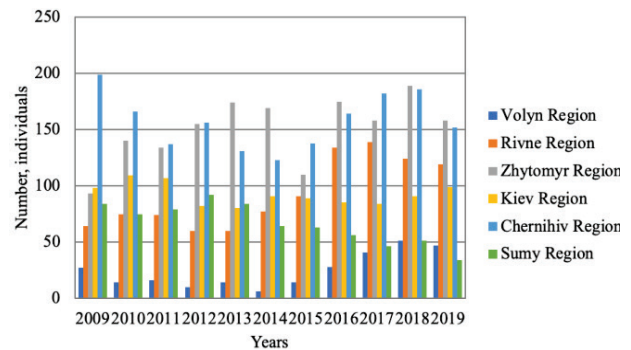


Fig. 8. The number of grey wolves in the regions within Ukrainian Polissya during 2009–2019 years according to the data of hunting units and nature conservation areas

On the territory of Ukrainian Polissya the highest number (over 15 individuals) of wolves as of 2018–2019 years was within the hunting and fishing enterprise “Koropske” (17 individuals) in Chernihiv region, in the Chomobyl Radiation and Ecological Biosphere Reserve (60 individuals) in Kyiv region, in Drevlyansky Nature Reserve in Zhytomyr region (35 individuals), Rivne Nature Reserve (21 individuals) and collective enterprise “Myslyvets” in Rivne Region.

Lynx is also widely represented in the Ukrainian Carpathians and Ukrainian Polissya. Thus, the highest number of lynx in the Ukrainian Carpathians as of 2018–2019 years was in the Chernivtsi region on the territory of National Nature Park “Chermosky” (12 individuals) and in Beregomets Forestry (14 individuals); in Ivano-Frankivsk region on the territory of National Nature Park “Syniohora” (13 individuals), as well as within the State Enterprises “Bolekhiv Forestry” and “Vyhodske Forestry” – 14 and 21 individuals, respectively, respectively; in Lviv region, lynxes are most common in the Skolivski Beskydy National Nature Park (24 individuals) and on the territory of the Turkiv Society of Hunters and Fishermen (14 individuals); in Zakarpattia region on the territory of the Carpathian Biosphere Reserve (11 individuals), Uzhansky National Nature Park (13 individuals), and also on the territory of the following hunting grounds: State Enterprises “Velykobyckivske Forestry” (21 individuals), “Yasynyanske Forestry” (15 individuals), “Mokryanske Forestry” (14 individuals), Society of Hunters and Fishermen “Hoverla” (14 individuals).

In Ukrainian Polissya the highest number of lynx as of 2018–2019 was in the Chomobyl Radiation and Ecological Biosphere Reserve (20 individuals) in the Kyiv region, and in the Nature Reserve “Drevlyansky” (15 individuals), hunting society “Prestige-O” (18 individuals), State Enterprise “Narodnytske Forestry” (10 individuals) in the Zhytomyr region.

The main area of bear distribution in Ukraine is the Carpathian mountains. As of 2018–2019, the largest number of bears was found in the Zakarpattia region on the territory of the following hunting grounds: State Enterprises “Velykobyckivske Forestry” (23 individuals), “Mokryanske Forestry” (28 individuals), “Brusturyanske Forestry” (10 individuals), societies of hunters and fishermen “Hrinivud” (8 individuals) and “Hoverla” (11 individuals). Among the protected areas of Zakarpattia region – the largest number of bears was in the Carpathian Biosphere Reserve (11 individuals) and in the Uzhansky National Nature Park (8 individuals). In Ivano-Frankivsk region there are 11 individuals on the territory of National Nature Park “Syniohora”, in State Enterprises “Bolekhivske Forestry” – 12 individuals, “Hrynyavske Forestry” – 14 individuals, “Vygodske Forestry” – 24 individuals. In Chernivtsi region on the territory of Chermosky National Nature Park and Berehometske Forestry 9 and 8 individuals were found respectively. The largest number of bears was in the National Nature Park “Skolivski Beskydy” in Lviv region – 27 individuals as of 2018–2019.

In the territory of Ukrainian Polissya, the bear is found only within the Chomobyl Biosphere Reserve and Desnyansko-Starogutsky NNP – 3 and 1 individuals respectively as of 2018–2019 years.

The density maps of populations of large carnivores were created in the format of a grid of squares of 10 by 10 km (cell size 100 km²), based on the collected data obtained from hunting units and nature conservation areas of the Ukrainian Carpathians and Ukrainian Polissya. The density of individuals of the species within the grid cells (number of individuals per 100 km²) is marked on the maps with a colour of different intensity de-

pending on the value of the density index, to visualize the obtained results (Fig. 9). Maps of large carnivores' forest habitats were also created by superimposing a map of forests of Ukraine on the map of large carnivores on the territories of hunting units and nature protected areas within the Carpathians and Polissya (Fig. 9). Forests play an important role for large carnivores as reproductive, transit and hunting habitats. Therefore, understanding their location, in the context of population distribution and density of large carnivores, is important for further species conservation and their sustainable management.

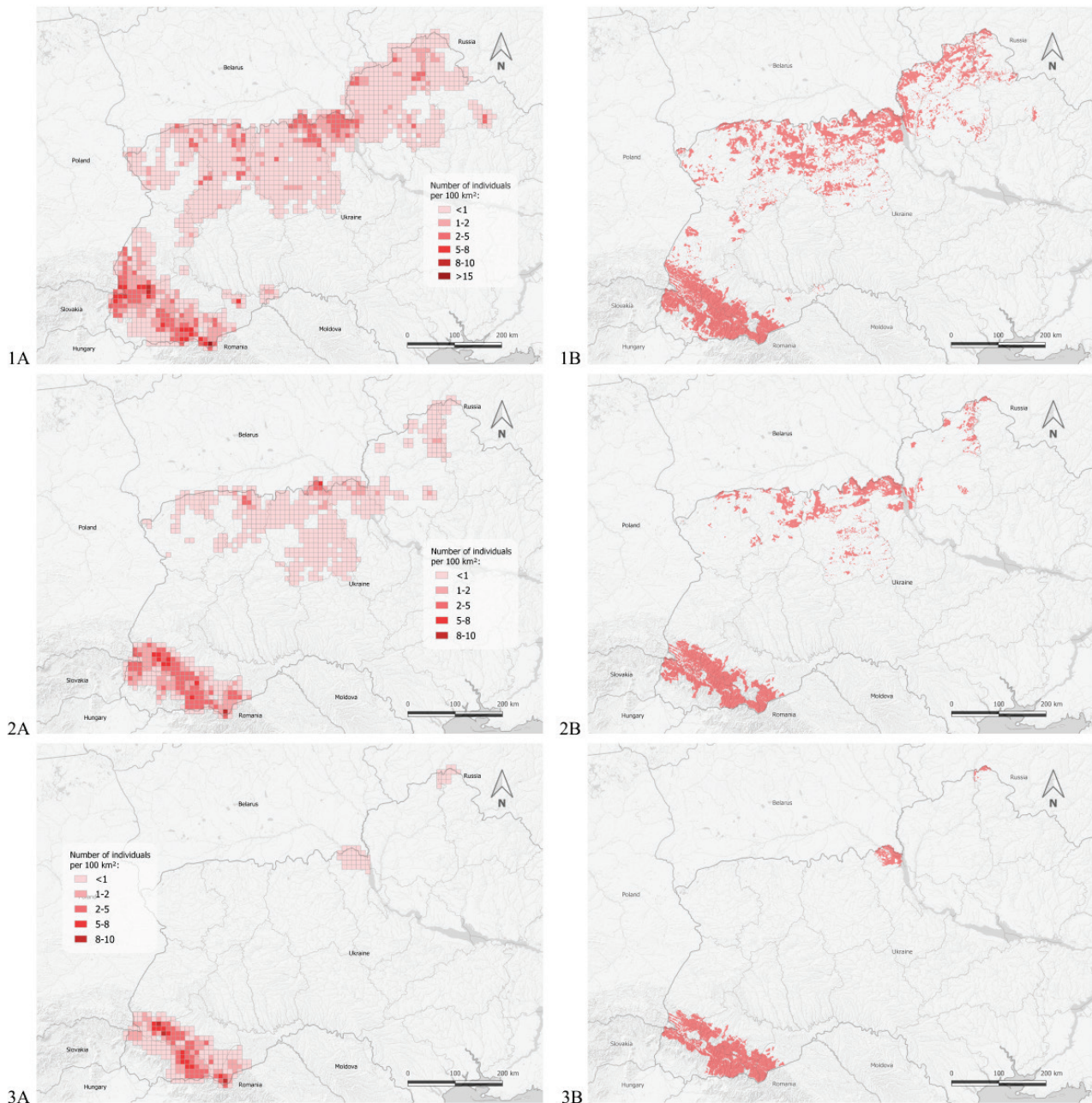


Fig. 9. Maps of the density (A) and forest habitats (B) of large carnivore populations in the Ukrainian Carpathians and Polissya according to the data of hunting units and nature conservation areas in 2018–2019 years: 1A, 1B – grey wolf; 2A, 2B – Eurasian lynx; 3A, 3B – brown bear

Discussion

According to official summary data of hunting units and nature conservation areas in the Ukraine, there are higher numbers of individuals of large carnivores than noted, for example, in the Red Data Book of Ukraine (Akimov, 2009) – where the number of bears was estimated at nearly 300 individuals and lynx no more than 500 individuals (nearly 400 in the Ukrainian Carpathians and nearly 100 in Ukrainian Polissya). This significant difference in the number of individuals in various sources is due to

different methodological approaches to counting animals, as well as overestimation of the final results due to double counting of large carnivores (double-counting of animals is a phenomenon when all rangers of nature protected areas, forestries or hunting units, count and report about the same individual, which crosses the boundaries of many hunting units, forestries or nature protection areas) (Zhyly, 2012). In modern conditions, monitoring of large carnivores in Ukraine is sporadic, it consists in carrying out winter monitoring by footprints and tracks on snow and does not always cover the entire range of a particular species. The main problem is

that there is no unified monitoring system, and insufficient coordination between land users of different subordination (state forestry enterprises, hunting farms, nature conservation areas). Winter counts of wild animals on the territory of each management unit usually are not synchronized with neighbouring territories. This leads to double registration of large carnivores and obtaining unreliable data on their number. Nevertheless, the obtained official summary data makes it possible to determine the general trend in the number of carnivores by years, general dynamics and distribution of the population on the national scale.

Large carnivores are characterized by large individual territories and the length of daily movement (tens of kilometres), which depend on the presence of suitable habitats, the availability of food resources, and the presence of human influence, and not on artificially created boundaries of forest land users, administrative districts, regions, or state borders (Kaczensky et al., 2006; Selva et al., 2017; Pop et al., 2018). As an example, we can cite the result of telemetry studies of a young male bear “Iwo” (Bartoń et al., 2019). In June 2015, a bear fitted with a telemetry collar by Polish scientists made a long transit from the Polish Beskids through the territory of Slovakia to Ukraine. Then his path for a month lay through the Skolivski Beskydy to the Central Gorgan. The bear was within three regions (Lviv, Zakarpattia, Ivano-Frankivsk) and five administrative districts (Turkivskiyi, Skolivskiyi, Mizhhirskiyi, Dolynskiyu, Rozhnyativskiyi) in the Ukrainian Carpathians. As a result, the “Polish” bear wintered in a den on the territory of the Ukrainian Carpathians (Bartoń et al., 2019; Vykhor et al., 2022).

It is clear from this example: if do not synchronize accounts of the animals on the territories of users of different management units, then both at the district and interregional levels, we will receive an over-counting or under-counting of the animal individuals. One animal can be counted at least twice in each of the five administrative districts, and from one bear in the reporting, we will receive 10 individuals.

Accurate population estimates are important information for the sustainable management of large carnivores. However, population management of large carnivores usually relies on density estimates that often lack statistical control and ignore inaccuracies that may arise from animal route surveys (Popescu et al., 2017). Overestimation of numbers of large carnivores may also occur when neighbouring users conduct winter counts of the animal individuals on different days. If there is no communication and cooperation between neighbouring land users and different management units, for example, a wolf pack that travels tens of kilometres in one day can be counted several times (Kusak et al., 2005; Vykhor et al., 2022).

Problems with overstating official data on large carnivores are also present in other European countries, particularly in Slovakia (Kubala et al., 2017). Thus, according to official statistical hunting reports, as of 2014, 1668 Eurasian lynx individuals were recorded in Slovakia (Poľovnická statistická ročenka SR 2014. Národné lesnícke centrum, Zvolen, Slovakia, 2015). And according to official data from the State Nature Conservancy, there are 300–400 lynx individuals in Slovakia (Dul’fa et al., 2021). But according to a statistically reliable assessment of the number and density of the lynx using the method of multi-season, systematic monitoring with the help of camera traps, it was established that the real number of the lynx population in Slovakia ranges from 197 to 337 individuals (Dul’fa et al., 2021). Thus, the lowest number was established during the analysis in 2015 (Kubala et al., 2017). Analysis of the lynx population number with the same methodology in 2017, 2019 and 2020 showed that there were 337, 303 and 280 individuals, respectively (Kubala et al., 2020; Dul’fa et al., 2021; Kubala et al., 2021).

The problem with official reporting in Slovakia is that hunters and forest guards report the number of individuals of large predators to the authorities at the national level using sporadic data based on observations of animal tracks, individual animals or the remains of their prey during the year, etc. (Kubala et al., 2017). This information is summarized at the national level, but its statistical reliability is doubtful. There is also the problem of a lack of synchronization of animal counts between land users, which leads to an overestimation of results already at the data collection stage (Kubala et al., 2017). In addition to communication between adjacent management units and data exchange at the local, national and international levels, it is also necessary to synchronize the methods of accounting, monitoring and data collection. There are many common methods of

monitoring large carnivores. These include a collection of data on representatives of the species throughout the year (visual observations, finds of victims, tracks, skins, wool, etc.) and registration of data to the Darwin Core Standard database; questionnaire method; winter route method of accounting by traces; detection of dens, mapping of tracks, etc (Vykhor et al., 2022). These methods are most often used, and they do not require special equipment or specialists. Less often, the analysis of the howling of a wolf and its vocalizations is used to obtain information about population spatial distribution, the reproductive success of the species, and the social behaviour of the animals (Russo et al., 2020).

It is also necessary to expand the use of modern monitoring methods in Ukraine to supplement the available information, such as: genetic analysis of the population, accounting of individuals with the help of camera traps, and also telemetry studies. This creates the possibility for permanent observation at monitoring sites and finding out details of the age and spatial structure of the population of large carnivores. It is important to note that the complex use of field observations and laboratory and technological means of analysis can show more reliable data on the state of large carnivore populations. In studies of spatial organization, home ranges and movement ecology; in research of prey ecology and food habitats; in the analysis of recolonization and reintroduction of large carnivore populations, a significant role is played by telemetric monitoring methods (Schadt et al., 2002; Ćirović et al., 2015; Mysłajek et al., 2018; Mysłajek et al., 2022). These methods are widely used in European countries, unfortunately, due to their cost, they are still rarely used in Ukraine (Vykhor et al., 2022).

Monitoring with the help of photo traps is actively used in Europe and Ukraine to analyze the number, density, distribution, structure and dynamics of populations of large carnivores (Tang et al., 2019; Dul’fa et al., 2021; Vyshnevskiy, 2021). Camera traps are especially actively used to monitor the lynx and recognize individuals of the species by spots on the fur (Weingarh, 2012; Stergar & Slijepčević, 2017; Gashchak et al., 2022). When it is impossible to recognize individuals in lynx populations with the help of photo traps due to the lack of clear markings on the body, the method of non-invasive genetic studies is included (Skrbinšek, 2017; Tang et al., 2019). In recent years, the assessment of information on the density, distribution, and genetic structure of populations of large carnivores through non-invasive sampling DNA, molecular analysis of biological material and animal life activity products (excrement, fur) has become especially widespread (Pérez et al., 2009; López-Bao et al., 2018; Mueller et al., 2022).

Many European countries, in recent decades, have observed the recolonization of territories by large carnivores where they once existed (Trouwborst, 2010; Chapron et al., 2014; Trouwborst et al., 2017). In Ukraine, we are also observing similar processes in the territory of Ukrainian Polissia, where during the last decade, the appearance of a brown bear has been recorded in the territory of Kyiv, Sumy and Rivne regions. The appearance of the brown bear in the territory of Ukrainian Polissia is explained by the migration of individuals from the territory of Russia or Belarus (Gashchak et al., 2016).

Despite the general trends of the increase of large carnivores in the neighbouring Carpathian countries, in the Ukrainian Carpathians in general, according to official data of users of hunting units and nature conservation areas, we observe a slight decrease in the number of brown bears from 2009 to 2019. Over the past 50 years, the bear population in the Ukrainian Carpathians has decreased almost fivefold, from 1200–1300 individuals in the 1970s to almost 300 individuals in 2009 (Tatarynov, 1973; Slobodian, 1991; Akimov, 2009). The state of the bear population has been stable over the last decade (from 2009 to 2019) in Ukraine, also due to the natural migration of bears from neighbouring countries (Romania and Poland) (Matosiuk et al., 2019). The high level of poaching keeps the bear population at the same level and prevents it from growing (Hackländer et al., 2021).

The dynamics of lynx in the Ukrainian Carpathians and Polissya according to official summary data was stable without significant fluctuations during 2009–2019. The Eurasian lynx is a species sensitive to globalization, its number and distribution are negatively affected by disturbance, loss of habitats and food base (Palmero et al., 2021). Poaching also remains the main reason for the decline in the number of Eurasian lynx all

over Europe (Červený et al., 2019). In particular, according to a survey conducted in the Czech Republic, most hunters believe that the lynx negatively affects other wildlife, and 27% said that they do not want to coexist with the lynx. Hunters also often consider the lynx as a competitor, because the lynx hunts ungulates, so hunters try to get rid of the lynx from hunting units. Both hunters and foresters knew about the illegal hunting of lynx firsthand, and the share of hunters who admitted to killing lynx themselves was 10% (Červený et al., 2019). Modelling shows that at least 25% of the Czech population might be poached annually – this limits population growth and further lynx distribution (Červený et al., 2019).

According to compiled official data, the wolf population in the Carpathians and Polissya remains stable. However, wolves remain a major source of conflict between humans and wildlife, leading to wolf persecution, increased poaching, reduced genetic diversity and gene flow between populations at a pan-European level (Rigg et al., 2011, Liberg et al., 2012, Hindrikson et al., 2017). In general, the conflicts of large carnivores with people (attacks of bears on apiaries, wolves, lynxes and bears on livestock) worsen the attitude of the local communities towards the presence of carnivores in the region and their conservation (Rigg et al., 2011; Mattisson et al., 2014; Dai et al., 2019). Therefore, in addition to monitoring the state of large carnivore populations, it is also important to monitor the frequency of conflicts (attacks of bears on apiaries, large carnivores on livestock and farms, etc.) to develop measures for large carnivore management and conflict prevention (Rondinini & Boitani, 2007; Recio et al., 2021). Such measures are planned to be implemented in Ukraine following the National Action Plans approved in 2021 for the conservation of the lynx and the bear.

Conclusions

The official data of users of hunting units and institutions of nature conservation areas on the number of large carnivores in the Ukrainian Carpathians and Ukrainian Polissya from 2009 to 2019 were compiled. The numbers of bears, lynxes and wolves in the above areas have been determined according to official information. Trends in the dynamics of the number of large carnivores within administrative regions were analyzed. Therefore, in 2019, there were 375 bears, 435 lynxes and 563 wolves in the Ukrainian Carpathians; and 4 bears, 128 lynxes and 609 wolves in Ukrainian Polissya. However, data on the number of large carnivores obtained based on official reports are overestimated due to the double-counting of animals by users of adjacent management units.

The information on the territories of distribution of large carnivores within the Ukrainian Carpathians and Polissya has been clarified – maps of forest habitats, distribution and density of species on the territory in the format of a 10 by 10 km grid (100 km²) have been created. The areas with the highest densities of bears, lynxes and wolves in the Ukrainian Carpathians and Ukrainian Polissya were identified – more than 15 individuals/100 km² for wolves, 8–10 individuals/100 km² for lynx and 8–10 individuals/100 km² for bears. The areas from the smallest to the largest number of animals were visualized on maps.

It is concluded that to improve the monitoring of large carnivores and obtain reliable data on their number and distribution, it is necessary to establish synchronization accounting between users of adjacent lands, nature conservation areas, forestries and hunting units; to carry out detailed systematic accounting of large carnivores and monitoring of their habitats using unified research methods at permanent monitoring model sites; to initiate genetic and telemetric studies of large carnivores, which will provide more detailed information on the structure of species populations. It is also necessary to establish scientific-based management of large carnivores and their habitats, to establish monitoring and prevention of carnivore-human conflicts, and to provide raising of awareness among forestry workers, hunting experts, and staff of nature protection areas about modern methods of lynx, bear and wolf monitoring.

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