Dynamics of the number of hunting animals in the area of the alleged flooding of the Nizhneboguchanskaya HPP

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Abstract. The forecast of changes in the biodiversity of fauna in the zone of expected influence of regulated water bodies is based on the basis of monitoring of hunting resources. A list of the main game animals of the Boguchansky district of the Krasnoyarsk Territory has been compiled. Winter route surveys were carried out on the right and left banks of the Angara River in the zone of alleged flooding during the construction of the Nizhneboguchanskaya HPP. The number of commercial species and its dynamics for three years were revealed. Species-specific essays have been compiled that characterize the abundance of the animal in the study area with predictive changes in ranges and population density. Recommendations are given on measures to minimize the anthropogenic impact of the HPP construction.

1 Introduction

Fluctuations in abundance are characteristic of all animals, but they manifest themselves to varying degrees. In natural populations seasonal and annual changes in numbers are distinguished. Annual fluctuations are represented by two groups controlled by abiotic factors and biotic factors. Anthropogenic forest management leads to the loss and change of habitats [1]. There are practically no climax habitats of animals in the study area. The main factors of their change are deforestation, forest fires, and hydraulic structures [2]. Changes in the hydrological regime, microclimatic conditions and soil moisture in the coastal area of the reservoir affect the vegetation of both the reservoir itself and coastal areas. All terrestrial ecosystems that go under constant flooding of the Nizhneboguchanskaya HPP are doomed to death. The rise in the groundwater level, first of all, causes a decrease in the current growth of trees in diameter and height, and also leads to a gradual change in the vegetation and soil cover. The zone of negative influence is confined not only directly to the edge of the reservoir, where it occupies an area of several hundred meters, but also to the transition zone (the depth of groundwater varies from 0.5 to 2.5 m). And only in the strip where groundwater does not rise above 3 m from the surface, no significant transformations in the soil and

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vegetation cover occur [3]. Rapid landscape change associated with human activity is currently challenging the evolved dynamic stability of many predator-prey systems, forcing species to respond behaviorally to new environmental stimuli [4, 5, 6]. Understanding the interacting roles of climate and habitat in shaping wildlife population dynamics can help identify synergistic pathways that contribute to population persistence or decline in variable and changing conditions [7, 8, 9]. Knowledge of long-term dynamics allows making forecasts of the number of animals, which are necessary when planning measures for the rational use of hunting resources [10, 11]. One of the main methods for determining the number of animals is winter route accounting.

2 Materials and methods

The methodology for winter route accounting of hunting resources includes planning accounting routes, conducting field work on accounting routes, and calculating the number of hunting resources [12]. Field work is carried out on days with favorable weather conditions from January 23 to March 5 (hereinafter referred to as the field work period). Under unfavorable weather conditions: in a blizzard, in a snowfall, with a strong wind or with the formation of a dense crust, when the tracks are swept up or it is impossible to determine their species, field work on the registration routes is not carried out. The configuration of accounting routes is planned to be of arbitrary shape (rectilinear, broken, closed). The distance between parallel sections of the same accounting route should be at least 1 km (if a broken, closed form of the accounting route is planned), the distance between adjacent accounting routes should be at least 1 km. An accounting route scheme is a map-scheme and an electronic track of the actual configuration of the planned accounting route, recorded on a satellite navigator during its preliminary passage. The accounting route scheme is saved as an electronic file.

On the first day of field work on the survey route the tracks and paths of animals are covered with snow or the integrity of the track of animals is violated (with a branch, stick, ski, etc.) (hereinafter referred to as grout) in such a way that on the second day it was possible to determine the newly appeared on registration route traces of animals; on paper (in a notebook) the number of traces on the day of grouting is noted. On the second day of field work (hereinafter referred to as trace counting), the counting route is passed in the same direction as during the trowelling. The interval between grouting and taking into account the traces along the entire length of the accounting route should fit into the daily interval (24 hours). It is allowed to reduce the daily interval between grouting and taking into account traces on the accounting route up to 20 hours or its increase to 28 hours. When taking into account the traces on the counting route: the intersections of the tracks of animals of the considered species are counted and each intersection of the tracks is marked on paper. In the case of application for grouting and/or accounting for traces of vehicles, the speed along the accounting route should not exceed 40 km/h [12].

3 Results and discussion

The first survey route on the left bank of the Angara River was fulfilled on January 26, 2022. The air temperature was -33°C. It was clear. It snowed lightly at night. The route was repeated on January 27, 2022. The air temperature was -25°C. It was clear.

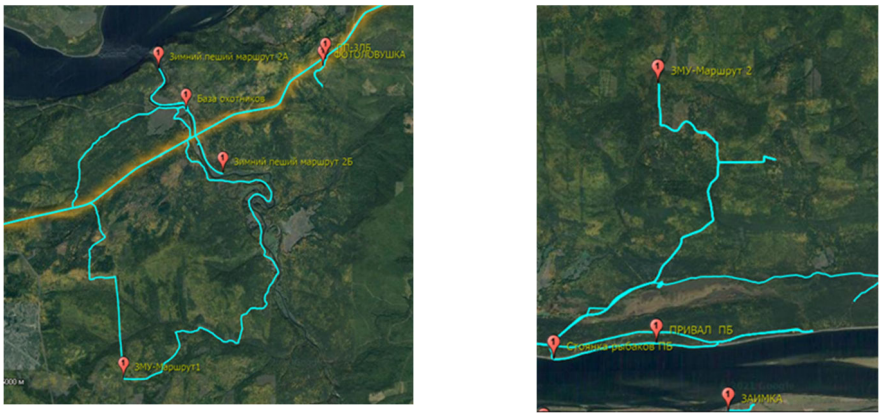
The second route was laid on the right bank of the Angara River. The traces were grouted on 01/30/2022. The air temperature was -17°C. Subsequent counts were carried out on 01/31/2022 and 02/02/2022.

The snowmobile "Buran", hunting skis, navigation devices GarmineTrex 20x were used. A brief description of winter route surveys is given in Table 1.

Table 1. Description of routes for winter route surveys 2022.

Route No	Length, km	The length of the survey route for each group			Short description
		Forest	Field	Swamp	
1	33.250	31.250	2	0	closed route, the first half of the route goes along the Mura River, the second is cross-country
2	13.750	12.750	1	0	linear cross-country route

Route maps taken from navigation devices are shown in Figure 1.



a b

Fig. 1. Winter route counts of 2022: a) route No. 1 in the area of the settlement of Nevonka; b) route No. 2 in the area of Shiversky settlement.

The accounting data for the number of hunting resources in 2022 are shown in Table 2.

Table 2. Results of winter route counts of commercial species.

Kind	Number of tracks per 107 km of the route	Number of tracks per 10 km of the route	Animal density per 1000 ha
Squirrel ordinary Sciurus vulgaris L., 1758	30	2.8	12.6
Wolf Canis lupus L., 1758	2	0.2	0.22
White hare Lepus timidus L., 1758	87	8.2	9.6
Siberian roe deer Capreolus pygargus P., 1771	15	1.4	0.8
Weasel Mustela nivalis L., 1766	14	1.3	0.7
Fox ordinary Vulpes vulpes L., 1758	3	0.3	0.1
Elk Alces alces L., 1758	8	0.8	0.5
American mink	50	4.7	2.4

Mustela vison S., 1777			
Sable *Martes zibellina L., 1758*	90	8.4	4.0
Grouse *Bonasa bonasia L., 1758*	6	0.6	6.1

Let us analyze the dynamics of the number of the main species of game animals in the Boguchansky district of the Krasnoyarsk Territory over the past three years (Table 3). Headcount indicators for 2020, 2021 taken from the data of the state monitoring of hunting resources and the state hunting of the economic register, posted at the link: http:www.mpr.krsktate.ru.

Table 3. Dynamics of the number of game animals.

Kind	**Animal density, spc per 1000 ha Density**		
	2020	**2021**	**2022**
Squirrel ordinary *Sciurus vulgaris L., 1758*	9.46	9.8	12.6
Wolf *Canis lupus L., 1758*	0.05	0.05	0.22
White hare *Lepus timidus L., 1758*	2.77	3.1	9.6
Siberian roe deer *Capreolus pygargus P., 1771*	0.11	0.15	0.8
Weasel *Mustela nivalis L., 1766*	0.25	0.3	0.1
Fox ordinary *Vulpes vulpes L., 1758*	1.08	1.1	0.5
Elk *Alces alces L., 1758*	0.24	0.13	2.4
American mink *Mustela vison S., 1777*	2.98	3.5	4.0
Sable *Martes zibellina L., 1758*	40.41	38.3	6.1

A graphical representation of the dynamics of the number of some species of game animals according to the data of winter route counts over the past three years is shown in Figure 2.

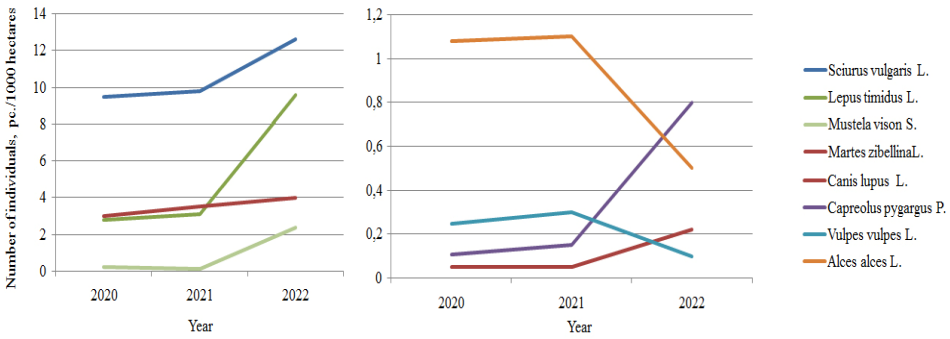


Fig. 2. Dynamics of the number of commercial species.

The species profiles characterizing the abundance and density of the animal in the study area are given below.

Squirrel ordinary (Sciurus vulgaris L., 1758)

Since the squirrel is characterized by an ephemeral type of dynamics (sharp fluctuations in numbers, usually with a cycle of 4-5 years), its abundance in recent years has been at a level much higher than the average. It can be assumed that in the next season we should expect a decrease in the number of the animal. The main factors affecting the number of squirrels are the availability of food, mainly pine and spruce seeds, as well as weather conditions and enemies, primarily sable, eagle owl, and goshawk. Changes in habitat conditions caused by the construction of a hydraulic structure will not have a significant impact on the natural course of the squirrel population dynamics and the stability of its population.

3.1 Wolf (Canis lupus L.,1758)

The main number of wolves lives in the Siberian Federal District. The number of wolves is increasing. The withdrawn number of animals is at best half of the available population and cannot ensure its noticeable decrease, since only the removal of 84% of the livestock of this predator subsequently leads to a sufficient depression of its population [13]. In the majority of regions, the withdrawn number of wolves is several times lower than the existing number. The wolf comes to the territory of the study area periodically, lingering for a year or two. Depends on the depth of the snow cover. In the future, when creating a regulated water body, an increase in the number of predators in the estuarine sections of large tributaries of the reservoir is expected.

3.2 White Hare (Lepus timidus L., 1758)

One of the widespread and popular hunting species of animals. Cyclical fluctuations in its abundance are common to vast areas with similar physical and geographical conditions. The main reserves of this species (51%) are concentrated in the territory of the Siberian Federal District. The number of white hare can be subject to sharp fluctuations. The main enemies are lynx, wolf, fox, owl. Often hares die from various epizootics, and young animals from bad weather conditions (prolonged cold rains, snow in the spring and summer). The white hare population can quickly recover. Under favorable weather conditions, the female can bring up to two litters (for spring-summer, early autumn). In the Boguchansky district, an increase in numbers is observed. In the zone of influence of the reservoir, as a result of changes in the regime of temperature and air humidity in wet years, the survival rate of rabbits will decrease. However, an increase in the area of meadow and shrub vegetation as a result of a change in the hydrological regime of the territory will have a positive impact on the food base of the white hare.

3.3 Siberian Roe Deer (Capreolus pygargus P., 1771)

The number of roe deer is affected by anthropogenic and biotic factors (poaching, withdrawal of productive land from use (flooding) and periodically occurring natural disasters (heavy snowfalls, sleet, floods). An increase in the number of roe deer is observed due to shallow snow and the absence of a wolf until February. The number of wolves in the estuarine areas of large tributaries of the reservoir will affect the density of roe deer in floodplain habitats.

3.4 Fox Ordinary (Vulpes vulpes, L. 1758)

In the Siberian Federal District the number of foxes, despite minor fluctuations, remains at a fairly high level. The decrease in livestock is due to the reduced survival rate of young animals. Recently, anomalous weather changes (floods, summer heat with fires) have been noted in Central Siberia, which worsened the living conditions of the fox and its potential prey. The fox has practically no enemies, hunters also get the minimum number of foxes. The limiting factor is the lack of places suitable for burrows. In the Boguchansky district, the fox keeps mainly near the river. Angara, in the floodplain and on the right-bank terraces. On the right bank it occurs in floodplains of small rivers, tributaries of the river. Angara. The average fox density is 0.1 individuals per 1000 ha. In the second half of the winter season, with an increase in snow density, the fox makes longer transitions, walks more widely in meadows and other open spaces. Over time, after the formation of meadow vegetation over large areas, as a result of a change in the hydrological regime of the territory, adaptation and an increase in the number of mouse-like rodents are expected, which will increase the food base of the fox.

3.5 Elk (Alces alces L., 1758)

The relatively low density of the moose population in the Boguchansky district is largely due to poaching. Traces of life are constantly found. In places of winter concentration (old overgrown clearings with regeneration of aspen and pine), 36 heaps of excrement were counted. Creases and gnaws of annual shoots were noted in the same places. According to the survey data, moose calving occurs in the floodplains of streams and low swampy floodplains of the river that have not been cut down. The predation of wolves, and in some regions of brown bears, is also noted as one of the main factors hindering the growth of the elk population.

3.6 American mink (Mustela vison S., 1777)

On the territory of the Siberian Federal District an increase in the number was noted. According to the survey data of the winter route accounting, the number is also increasing in the Boguchansky district. Winter fluctuations in the water level of the reservoir will negatively affect the state of the mink population. At the same time, more optimal conditions for its habitat will be formed in the downstream. Mink migrations are predicted up the tributaries of the reservoir and into the downstream zone.

3.7 Sable (Martes zibellina L.,1758)

Due to the organization of nature reserves and the state program for the reacclimatization of the species, sable resources were restored to a level corresponding to the capacity of the land by the beginning of the 21st century. At present, the sable is, in fact, the only fur hunting species, the production of which still allows the hunters of Siberia to exist. The length of the daily run of the sable depends on the influence of environmental factors (weather, nature of snow cover, abundance of food). Sable migration in the territory of Central Siberia is observed every fourth year. Sable migration occurs before dry years. After such years, the number of sables drops sharply [14]. The data obtained on the winter route accounting indicate a consistently high level of sable stocks in the main areas of its habitat. There is a gradual increase in the number of sable in the floodplain lands of the river. Angara. A temporary migration of sable from a narrow band of direct influence of the reservoir is expected.

3.8 Grouse (Bonasa bonasia L., 1758)

Compared to capercaillie and black grouse, hazel grouse populations are less sensitive to various forms of anthropogenic impact, but more susceptible to the influence of biotic and abiotic factors. The correlation coefficient between bird population density and average brood size, according to data for the Krasnoyarsk Territory over the past 12 years, showed a relationship between these indicators ($r=0.47$, $t=1.61$, $P>0.05$). Despite the decline in the number of birds in the area, the average seasonal catch increased: summer-autumn - up to 8.6 hazel grouse on average per hunter. In the winter season - decreased to 2.1 hazel grouse. The density of hazel grouse according to the winter route accounting of 2022 is 6.1 individuals per 1000 ha. As a result of the construction of the hydroelectric power station, hazel grouse may migrate up the tributaries. Flooding of shoals and pebbles will reduce the area where chicken gastroliths are consumed.

4 Conclusion

As a result of the research, it was established that the number of the main commercial species in the Boguchansky region is stable, in some species (Capreolus pygargus P., Alces alces L., Mustela vison S., Martes zibellina L., etc.) its growth is observed. The lands subject to flooding during the construction of a retaining hydroelectric power station are currently inhabited by dynamically stable populations of animals, including valuable ones. To preserve rare protected species, it is necessary to identify their habitats that do not fall under flooding and create protected areas in these areas. For migratory species, violations of migratory routes can be compensated by protecting the places of new animal crossings. Carrying out biotechnical measures (feeding, salt licks, flitches, pebbles, artificial nests) will help to preserve the number of animals. For animals (moose, roe deer, red deer, reindeer), biotechnical facilities should be located at least 5-10 km from the edge of the reservoir. It is necessary to regulate the number of wolves. In the estuarine areas of large tributaries of the reservoir in the preserved valleys, zoocomplexes are formed with an increased abundance and migratory activity of many animal species. They received the conditional name "living valleys" [15]. It is necessary to organize additional protection of all "living valleys". The Sosnovaya, Mostovaya, Talaya, Nevonka, Mura and Chadobets rivers need special protection.

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