

Grazing capacity of reindeer pastures in the boreal zone of the West Siberian Plain

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Abstract. Field studies were carried the grazing capacity of the reindeer in the boreal zone. The study is based on the study phytomass forage plants of the reindeer grazing. Soil, geobotanical descriptions were made grazing capacity on the methodology for determining productivity and calculating the fodder capacity of reindeer pastures. The identification of potentially suitable places for the reindeer was carried out on the basis of the decryption of satellite images and the digitization of thematic maps. Grazing capacity was with the allocation on the geobotanical map of the areas of distribution of pine-lichen white-moss and pine lichen-cowberry forests, and on the soil map - the areas of finding illuvial-ferruginous podzols. The study revealed that best the landscape-ecological conditions for the growth of lichens of the species *Cladonia alpestris* (L.) are the pinery on the podzols in Siberian ridges (Siberian Uvals). Based on the results of field studies, the fodder capacity of reindeer pastures for the studied areas was calculated, and the estimated number of deer was determined. The conducted studies make it possible to judge the state of individual areas suitable for reindeer habitats, and thus make it possible to assess the degree of prospects for reindeer breeding.

1 Introduction

The systemic nature of the developed territories of traditional nature management of the indigenous peoples of the North, belonging to the taiga natural zone of the West Siberian Plain [1], is determined by landscape and environmental conditions. Features of the geological events of the Arctic and Siberian regions determined landscape-forming processes that allow people to settle, live, take root and, in the present, use the resources of the territory. The growth of lichens of the species *Cladonia alpestris* (L.) Rabenh. is the main indicator that determines the possibility of reindeer husbandry in the territories of traditional nature management of the indigenous peoples of the North.

Reindeer breeding, for the indigenous peoples of the North: Khanty, Mansi, Nenets, permanently residing in the Khanty-Mansiysk Autonomous Okrug–Yugra, is a priority in their economic activity [2]. Reindeer husbandry in Russia is one of the most important areas of the indigenous self-employed population, especially in remote Arctic and Siberian regions. It is the basis of the culture of many indigenous peoples of the North, who have different traditions and extensive experience in reindeer herding in a variety of landscapes. In recent decades, the number of domestic deer in the boreal zone has sharply decreased

[3]. Changing landscape and ecological conditions associated with climate change and intensive land use of the Okrug territory affect the reduction of fodder lands. The study of the spatial distribution of natural reindeer forage lands in the boreal zone of the West Siberian Plain and the assessment of the landscape and ecological conditions of forage lands is the basis for substantiating traditional nature management in the Khanty-Mansiysk Autonomous Okrug –Yugra.

The conducted field studies make it possible to judge the state of individual areas of suitable habitats for reindeer at the present time (anthropogenic load, the presence of fodder plants, etc.) and thus make it possible to assess the degree of prospects for reindeer breeding.

2 Materials and methods

Reindeer pastures in the Khanty-Mansiysk Autonomous Okrug–Yugra make up 11.4 % of the entire territory, which is 6086.7 hectares [4]. Basically, they belong to the territories of traditional nature management of the indigenous peoples of the North, however, as the spatial analysis of landscape and ecological conditions shows, the territorial potential of reindeer pastures is much higher. In the course of the study, field surveys of the reindeer forage lands were carried out: in the eastern part of the landscape province of Surgut forested lowland (the ancestral lands of S.A. Aipin), located in the western part of the Nizhnevartovsk region; in the southeastern part of the Siberian ridges (Grishavin's family lands); eastern part of the Vakhsk forested lowland (Kolmakov's family lands). The territory belongs to the boreal zone of the West Siberian Plain and is located between 61°N. and 63° N. The studied key areas with fodder lands are confined to pinery: pine-lichen forests, pine-lichen-cowberry forests. They are common on mineral "islands" stretched along the small rivers of the Trom-Yogan and Agan basins, occupying small areas among marshy interfluvial spaces. Larger areas of fodder lands, with similar types of terrain, are common in the valley areas of the rivers Sabun and Vakh, Siberian ridges and Vakhsk forested lowland rivers, composed of sands, where *Pinus sylvestris* (L.) grows under conditions of good drainage and species of lichens of the species *Cladonia alpestris* (L.) Rabenh. [5].

During the survey of key sites, a soil, geobotanical description was made with the selection of lichen food available for reindeer on a plot of 1 m² (figure 1). The selection of lichen fodder is due to the method of determining the productivity of pastures and calculating the grazing capacity of deer pastures [6].

The study is based on the provisions of the landscape analysis methodology developed for the Khanty-Mansiysk Autonomous Okrug–Yugra [7]. The use of the landscape indication method and the use of semi-automatic interpretation made it possible to identify forage lands of reindeer pastures on Landsat satellite images with a resolution of 30 m in 2005, 2012 using the Semi-Automatic Classification Plugin of the QGIS software. Cartographic material was built using MapInfo Pro 15.0 software.

3 Results

Reindeer pastures are confined to lichen pine forests on illuvial-ferruginous podzols. The formation of pastures is determined by a number of factors, primarily lithological and climatic. The studied key areas belong to the transition zone from the middle taiga subzone to the northern taiga subzone and represent possible reindeer pastures with lichen growth. The boundary of distribution of lichens of the species *Cladonia alpestris* (L.) Rabenh. corresponds to the boundary of distribution of frozen rocks (Figure 2). Within these

boundaries, extensive complexes of oligotrophic swamps with forested sandy lowlands of the Pleistocene time were formed. Lichens of the genus *Cladonia* species mainly grow in elevated, well-drained areas, under the canopy of pine forests. Generalized geobotanical descriptions made on the studied sites testify to the same species composition of growing plants: *Pinus sylvestris* (L.), *Vaccinium myrtillus* (L.), *Ledum palustre* (L.), *Vaccinium uliginosum* (L.), *Empetrum nigrum* (L.), from lichens: *Cladonia alpestris* (L.) Rabenh., *Cladonia rangiformis* (Hoffm.), *Cetraria islandica* (L.) Ach..

The chemical composition of illuvial-ferruginous podzols shows low indicators of soil fertility: the reaction of the environment is pH water - 6.25 – 7.19; exchangeable forms of phosphorus 22 - 27.8 mg/kg, ammonium - 9 mg/kg; the amount of organic matter - 0.24 %, the amount of manganese 5.49 - 5.97 mg/kg. Low indicators of soil fertility create special ecological conditions for the growth of lichens.

The projective cover of the lichen of the species *Cladonia alpestris* is 92 %, with the inclusion of cranberries and wild rosemary, the height of the thallus of a well-formed species *Cladonia alpestris* is from 6 cm to 10 cm. reindeer pastures within the Siberian ridges 9.08 kg/m². In the dry state, the lichen biomass is 2.13 kg/m² and 2.65 kg/m², respectively (Figure 1).

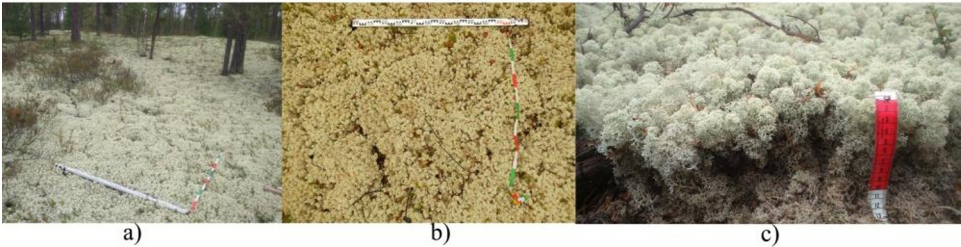


Fig. 1. Forage vegetation of the key sites for the study of reindeer pastures: a) Surgut forested lowland; b) Vakhsk forested lowland; c) Siberian ridges.

Based on the results of studying the phytomass of terrestrial parts of plants by weighing the lichen phytomass available for reindeer on key sites with an area of 1 m², the feeding capacity of reindeer pastures for the studied landscape provinces was calculated (Table 1).

Table 1. Reindeer forage capacity of pastures in the boreal zone of the West Siberian Plain

landscape provinces	Area of fodder lands within the landscape province, ha	Weight of raw food, c	Gross harvest of reindeer moss, c/ha	Estimated number of deer, units
Vakhsk forested lowland	4320	57	244944	8165
Surgut forested lowland	5635	74	415863	13862
Siberian ridges	8245	91	748646	24955
Total:	18200	221	1409453	46982

The data of the estimated number of deer based on landscape-ecological conditions and the reindeer feeding capacity are presented in Table 1. The calculation of the feeding capacity was carried out in a generalized way, by recalculating the gross harvest per square meter of lichen to the area of lichen distribution within the boundaries of landscape-ecological conditions. In the calculation according to formula (1), the daily allowance of food for deer in summer and winter was taken into account.

$$Fr = Tw \times Mw + Ts \times Ms$$

(1)

Where Fr is the amount of feed per 1 deer, kg; Tw is the number of snowy days; Mw is the mass of food in winter, kg; Ts is the number of snowless days; Ms is the mass of feed in summer, kg.

In summer, the mass of food in the summer period is 11–22 kg of green mass, in winter it is 8–14 kg of raw food [1]. The number of winter days in the study area suggests the number of days with snow cover (212 days), respectively, the number of summer days is 152. Thus, about 30 centers / year is needed per 1 reindeer. The derived data made it possible to calculate the required feed for one reindeer per year.

The results of the calculated forage capacity for the landscape provinces of the Vakhsk forested lowland, Surgut forested lowland, and Siberian ridges with the boundaries of potential reindeer pastures are shown spatially on a digital map for the administrative boundaries of the Nizhnevartovsk region (figure 2).

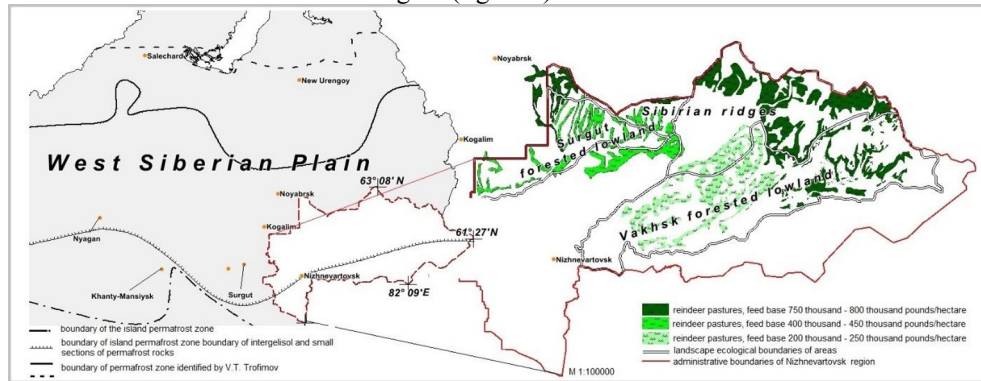


Fig. 2. The map is a diagram of the grazing capacity of the landscape provinces of the boreal zone of the West Siberian Plain, indicating the boundaries of frozen rocks identified by V.T. Trofimov [8].

The purpose of the map is to show the natural food resources of reindeer pastures and the number of domestic reindeer that can be reared and kept on pastures in a given pasture season each year.

4 Discussion

The data obtained in Table 1 are ideal for mathematical modeling, but it must be understood that they are also intermediate data. When calculating the food base, one should take into account the external impact on the oppression and subsequent restoration of lichens. Despite the fact that the restoration of lichens of the species *Cladonia alpestris*, et al. occurs the next year, the thallus is restored in 25 years. In the first years, recovery occurs in the form of separate spots with a diameter of 15–20 cm and a thallus height of 1 cm. Therefore, in order for food reserves to be not undermined, it is necessary that the deer eat no more than 4 % per 1 ha of reindeer moss. Thus, 11,000 heads of reindeer can be kept on 18,200 hectares of reindeer pastures. At the same time, taking into account the landscape and ecological conditions, the number of reindeer individuals will depend on the productivity of the food base: in the territory of Vakhsk forested lowland – 2041, Surgut forested lowland – 3465, Siberian ridges – 6239.

The above calculations of the possible number of reindeer are also conditional. Recently, natural hazards such as fires have become more frequent due to changing climatic conditions. This certainly affects the functioning of reindeer pastures. The average annual air temperature in the boreal zone of the West Siberian Plain in the last decade is 3.45 °C. Compared with the average annual air temperature in the period from 1998 to 2004, which was -2.3 °C. Temperature changes have taken place in the direction of warming. The sum

of positive temperatures averages 1358.1 °C, the sum of negative temperatures is -267.0 °C. Temperature changes lead to pyrogenic hazards when the sum of active temperatures above 1800°C occurs [9]. Pine lichen forests are the most fire hazardous type of plant fuel [10]. Lichens of the species *Cladonia alpestris*, et al. form a continuous layer of living ground cover and do not regulate their moisture content, so their burning can spread as early as the second day after precipitation. The post-fire restoration of the lichen of the species *Cladonia alpestris*, et al. occurs as early as the next year. It takes about 20-25 years to fully restore the lichen forage of reindeer pastures with a projective cover of 90 %.

5 Conclusion

The study revealed:

- Landscape-ecological conditions for the growth of lichens of the species *Cladonia alpestris*, et al. species are white moss pine forests and pine lichen-cowberry forests on illuvial-ferruginous podzols.

- Reindeer pastures are confined to certain natural conditions and types of terrain, the border of lichen distribution corresponds to the border of the island permafrost zone.

Potentially suitable places for reindeer have been identified. Geoinformation analysis was carried out on the basis of interpretation of satellite images and digitization of thematic maps of the Khanty-Mansiysk Autonomous Okrug–Yugra with the allocation of geobotanical areas of distribution of pine-lichen white moss and pine lichen-lingonberry forests, on the soil map - areas of finding illuvial-ferruginous podzols.

Reindeer capacity was taken as a criterion for assessing the quality of pastures, since it is the main property of the natural-territorial complex suitable for use as pastures for domestic reindeer, and provides an opportunity to ensure the annual (or seasonal) biological cycle of a certain number of deer without violating regional zootechnical norms for feeding, keeping and deer breeding.

The taxonomic unit in assessing the quality of reindeer pastures is the landscape-geobotanical difference.

The ecological and economic value of reindeer pasture types was determined by the following basic parameters:

- Coverage by fodder plants, which characterizes the features of the spatial distribution of fodder plants on the pasture, %.

- Economic supply of fodder plants, characterizing the fodder availability of pastures.

- Reindeer capacity of pastures, which determines the number of deer that can be kept, taking into account all pasture conditions.

- Seasonality of pastures, which determines the best season for the use of a certain type of reindeer pastures (seasonal features of the use of reindeer pastures).

As a final material illustrating the assessment of the quality of reindeer pastures, a thematic map for assessing the grazing capacity of reindeer pastures, M 1:100000, was constructed.

The higher forage capacity of Siberian ridges is explained both by the wider areal distribution of pine-lichens and by favorable landscape and ecological conditions for the growth of lichen of the genus *Cladonia* species (deposits of sandy composition, good drainage conditions).

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