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GOOSE BULLETIN appears as required, but at least once a year in electronic form. The bulletin aims to improve communication and exchange information amongst goose researchers throughout the world. It publishes contributions covering goose research and monitoring projects, project proposals, status and progress reports, information about new literature concerning geese, as well as regular reports and information from the Goose Database.
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The results of autumn counts of Lesser White-fronted Goose and other geese species in the Ob valley and White-sea-Baltic flyway in September 2015

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Introduction

In recent years, a significant body of data on the numbers and status of Lesser White-fronted Goose *Anser erythropus* populations has been obtained during spring and autumn goose migration periods in the Dvuobie, bounded by the Yamalo-Nenetski Autonomous District (YaNAD) and Khanty-Mansiiski Autonomous District (KhMAD, or Yugra), as well as in the Yamal Peninsula (ROZENFELD & STRELNIKOV 2011; ROZENFELD 2014; ROSENFELD et al. 2015). At the same time, our knowledge of the state of other populations of Lesser White-fronted Goose including those in Fennoscandia, Western Russia and particularly in the Nenets Autonomous District remains highly insufficient. We here present a brief review of the available data at present.

Nesting

Recent publications cite two nesting sites for the Lesser White-fronted Goose on the tundra west of the Pechora River delta: 1) in the upper reaches of the Neruta River; and 2) in the Velt River basin on the Malozemelskaya Tundra. There are also reliable records of nesting Lesser White-fronted Geese from Bilshezemelskaya Tundra (Nenets Automonous District NAD, Arkhangelsk Province) on the Padimeityvis River (MINEEV & MINEEV 2013). These authors estimated the population density in the Padimeityvis River basin at 0.2 individuals per square kilometer (MINEEV & MINEEV 2014). In addition, the same researchers (MINEEV & MINEEV 2011) supposed that Lesser White-fronted Geese could nest in Vorkuta District (Komi Republic), on the Seida River, which runs along the NAD boundary in its middle reaches. In this area, the authors had seen single individuals, pairs and groups of Lesser White-fronted Geese, sometimes in flocks of Bean Geese *Anser fabalis*. Some Lesser White-fronted Geese were also seen to exhibiting nesting behaviour. The habitats where the birds had been encountered were those typically preferred by Lesser White-fronted Geese for nesting. The density of Lesser White-fronted Goose populations in those tundra habitats was reported to be 0.2 individuals per square kilometer on the Seida River itself and 2.1 individuals per square kilometer on the streams surrounding the main watercourse of the Seida River (MINEEV & MINEEV 2011).

In the east of Bilshezemelskaya Tundra, Lesser White-fronted Geese breed in the upper reaches of the Bolshaya Rogovaya River and the middle reaches of the Khey-Yakhi River (MOROZOV 2006). There, the abundance of Lesser White-fronted Geese is rather low, and some sites where the species used to nest in large numbers in the past no longer exist (MOROZOV 1995; MOROZOV & SYROYECHKOVSKI, 2002). There are no data relating to nesting Lesser White-fronted Geese from the Kanin Peninsula in the past 50 years.

Spring migration

In the past, Lesser White-fronted Geese were observed in many parts of the Nenets Autonomous District during spring migration. Based on data obtained by A.YA. MOSKVIN, Lesser White-fronted Geese occur during their spring migration on the Barents Sea coast around Kolokolovaya Bay and in the lower reaches of the Neruta River (MINEEV & MINEEV 2009). In spring, some Lesser White-fronted Geese have been recorded flying along the Barents Sea coast in the even more distant past, near the Strait of Senegei (MINEEV 1986).

Autumn migration

In contrast to spring observations, the autumn migration of Lesser White-fronted Geese is almost unstudied in the territory of NAD. One place where Lesser White-fronted Geese are known to regularly rest during their autumn migration is at the confluence of the Shoina and Torna Rivers. Satellite imagery showed that similar habitats exist in the southeast of the Kanin Peninsula and in the coastal area of the Malozemelskaya Tundra (LITVIN 2014). Some summer records of non-breeding Lesser White-fronted Goose have been reported from marshes at Lake Toravey and on Dolgi Island (MOROZOV 2006).

Fifteen years ago, MOROZOV & SYROYECHKOVSKI (2002) estimated 500–700 Lesser White-fronted Geese before the breeding season and 500–1,000 individuals in autumn in tundra areas between the Kanin Peninsula and the Polar Urals in the territory of NAD (MOROZOV 2006).

Fig. 1. Layout of the routes and the surveyed area

Materials, methods and the survey period

The autumn counts were conducted on 7–29 September 2015 using an A-27 ultra-light hydroplane to survey the Dvuobie as well as the coastal areas of the Kara, Barents and White Seas (Fig. 1).

The total length of our count routes was 12,400 km. This was the first time that such an extensive bird count had been undertaken using an ultra-light aircraft within the Russian part of the range of the western population of Lesser White-fronted Geese.

All the birds were counted within a 2 km strip off the aircraft (1 km on each side) at a height of 30-50 m. The routes were plotted according to the requirement that the distance between them should be more than 2 km. For more precise number estimations and detailed assessment of the specific composition of the flocks, photographs were taken with a 7D *Canon* camera equipped with a 100–400 mm. lens. If the number of birds in a group exceeded 100 individuals, a series of photographs of different parts of the group were taken and the proportion of various species and young-to-adult ratio estimated. These data were then extrapolated to the entire group. To ensure reliable photograph geo-tagging, the time settings in the camera and in the GPS navigator had been synchronized beforehand. The photographs were then linked to their respective tracks using *GEOSETTER* (open source software). In total, we analyzed 11,549 photographs.

All GIS layers used for analytical work were created in *MapInfo* format (scale 1:100,000).

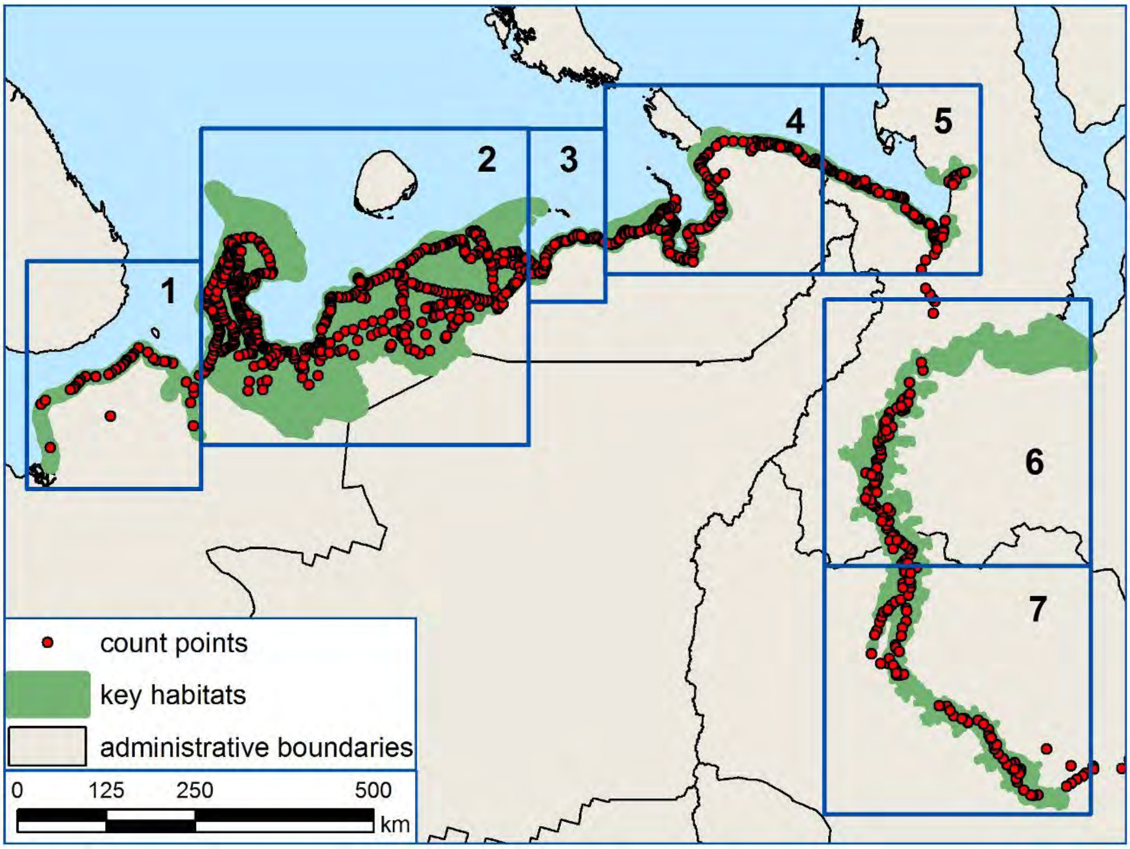


Fig. 2. Distribution of waterfowl on the habitat map of the surveyed area (small-scale overview). Red dotes shows the distribution of geese

Estimations of the total numbers

We consider all quantitative count data to represent minimal numbers of birds present. The location of encountered birds (on the ground, on water, or in mid-air) was ignored in this analysis. We took the number of birds counted along each route as individual samples and assessed the population number in the region based on the sum of samples weighed relative to the lengths of the routes.

To assess the degree of underestimation associated with this method and to choose an appropriate method for extrapolation, it was necessary to take in consideration the mosaic structure of the landscape in the surveyed territory, the areas of the biotopes suitable for waterfowl, as well as the density of each species in each delineated biotope. To solve this problem we used a landscape map made from satellite image interpretation. The landscape map was created on the basis of freely accessed *Landsat* satellite images. A total of 45 *Landsat-8* images (2013–2014) and 17 *Landsat-5* images (2009–2011) were used to cover the entire territory.

The analysis of satellite images and class delineation was first carried out using the automatic neural-network classification method (with teaching) in *ScanEx IMAGE Processor* software. Additional processing and refinement of the obtained vector layers and the area counts was made using *Quantum GIS* software. For primary classification of biotope we also used the Landscape map of the USSR 1: 2,500,000 (1980), and Legend to Landscape map of the USSR (1987).

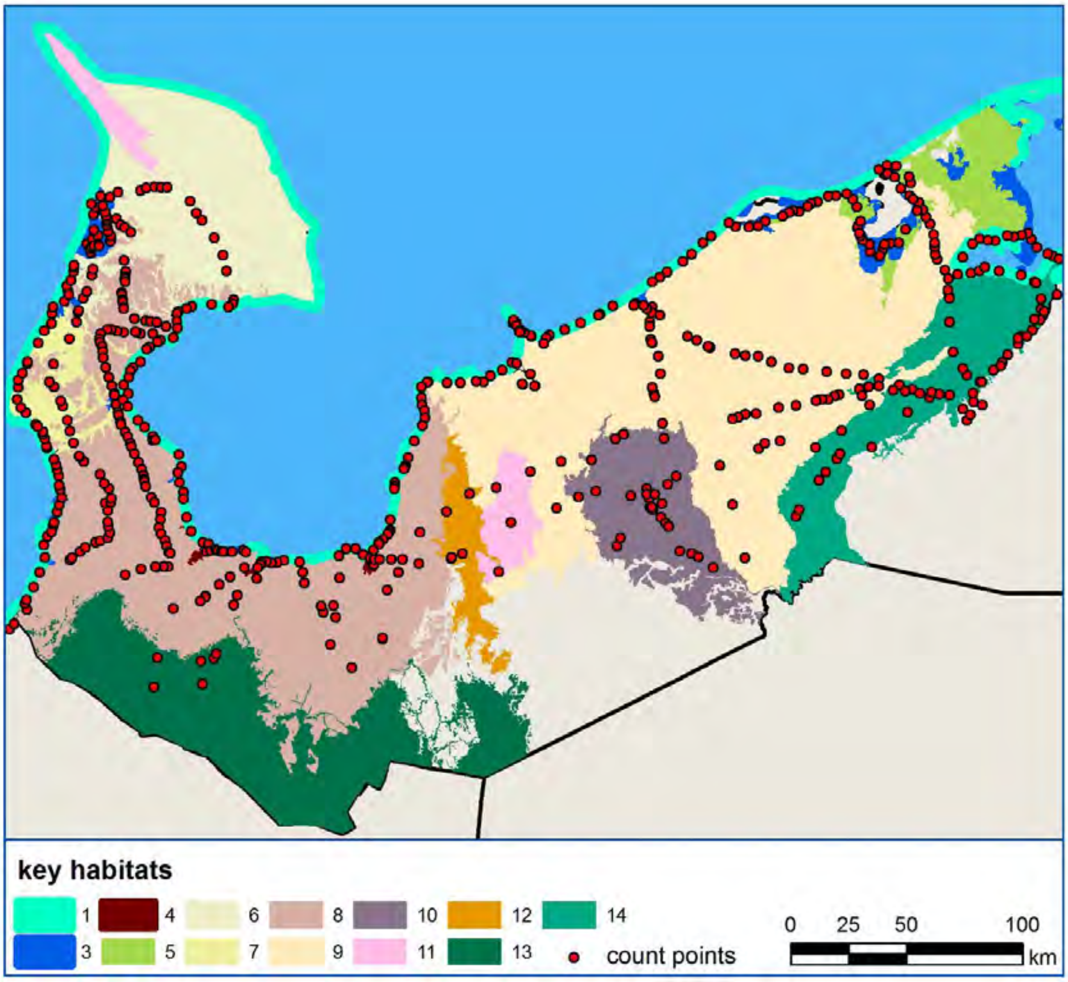


Fig. 3. Distribution of waterfowl on the habitat map of the surveyed area (close-up of part 2). For a description of each habitat type see text.

As a result, we created a landscape map of the study area within which we delineated 17 habitat types. We then overlaid all the points where geese had been encountered upon the map catgories (Figs. 2-3). The final total area over which our quantitative data could be extrapolated was 9,150,674 hectares.

Description of the key habitats

1. Coastal zone 500 m in width (from coastal line inland). The zone was delineated to include any shore habitats adjacent to the sea excluding marshes (3), and river estuaries (4). This habitat was considered as a key one for all the migratory birds, being the main land corridor within which most waterfowl migrate. It was also used for bird total number calculations to separately assess the parameter of migration intensity. Total area: 1 298 km^2.
2. The floodplain of the Mezen River (to the mouth of the Peza River inland) covered with grass-sedge meadows (inundated or otherwise), patches of small-leaved mixed forests, or, less frequently, spruce forests and stands of willow and alder on banks. Total area: 205.3 km^2.
3. Intertidal coastal plains (i.e. flooded during high-water periods), with a large number of river meanders, streams, kettle holes and lakes; covered with halophytic marshy meadows dominated by grasses and sedges, or with tundras of dwarf shrubs and grasses or, otherwise, with cotton-grass bogs. These habitats also include adjacent marine littoral zones. Total area: 3 376.8 km^2.
4. Estuaries or river outlets with halophytic grass-sedge meadows, combined with adjacent lowland bogs dominated by grasses and green mosses. Total area: 460.2 km^2.
5. Transitional bogs and lowland bogs with hummocky microrelief and small shallow hollows; dominated by sedges, cotton grasses and mosses. Total area: 3 602.4 km^2.
6. Flat and undulating, terraced, partly bogged plains with small hills and ridges, numerous thermokarst kettles and lakes, frost-heavings and polygons; covered with different types of tundra formed by dwarf birches or willows, dwarf heather shrubs, grasses, sedges and mosses. Total area: 6 542.7 km^2.
7. Undulating plains with small hills and ridges, karst lakes, thermokarst lakes or residual lakes; covered with different types of birch or willow tundras combined with various types of humpy or ridgy bogs formed by small birches and willows, grasses and dwarf heather shrubs, sometimes with minor lakes. In the south of the study area this landscape type includes open woodlands and low forests formed by birch and spruce. Total area: 1 315.8 km^2.
8. Upland bogs and transitional bogs of tussocky or hummock-ridge structure (including complex aapa-type bogs), sometimes with small lakes (primarily of thermokarst origin); dominated by grasses, sedges, cotton grasses dwarf heather shrubs, mosses (including *Sphagnum* species), and lichens. Combined with tundras formed by dwarf birches or willows, dwarf heather shrubs, grasses, sedges and mosses. In river floodplains there are more species rich grass-sedge meadows, lowland grassy or mossy bogs and open woodlands formed by pine, spruce and birch. Total area: 14 675.3 km^2.

9. Undulating and flat plains with scattered hills and ridges, thermokarst kettles and lakes, frost-heave and polygons; covered with tundras dominatd by dwarf birches or willows, dwarf heather shrubs, grasses, sedges and mosses in combination with various bog types including upland bogs, transitional bogs and lowland bogs, all with smoothed or hummocky microrelief, ridges, hollows and small lakes; dominated by grasses, sedges, cotton grasses dwarf heather shrubs, mosses (including *Sphagnum* species in hollows). In the southern part of the study territory there are low isolated stands of spruce and birch. Total area: 17 705.5 km^2.
10. Upland bogs and transitional bogs of tussocky or hummock-ridge structure (including complex aapa-type bogs) sometimes with small lakes (mostly of thermokarst origin); overgrown with grasses, sedges, cotton grasses dwarf heather shrubs mosses (including *Sphagnum* species in hollows), and lichens. Combined with patches of tundras formed by dwarf or small willows and birches dwarf heather shrubs, and mosses. There are also isolated low stands of birch-spruce forests around lakes Korgovoye, Bolshoye, Srednee, Nizhnee, Urdyuzhskoye, Tyrabeito as well as patches of floodplain with wet diverse grass-sedge meadows, minor small-leaved stands, spruce stands or mixed stands; sandy banks are overgrown with willow and/or alder. Total area: 3 518.0 km^2.
11. Plains with ridges, hills, rocky outcrops, cliffs and outliers; dominated by tundras formed of dwarf birches or willows, dwarf heather shrubs, mosses and lichens, with grassy/mossy bogs and patches of open woodlands formed by birch. Total area: 1 013.8 km^2.
12. Flat plains with thermokarst lakes; mostly covered by low spruce-birch forest or open woodlands of birch or/and spruce. This complex landscape also includes tundras dominated by small birches or willows, dwarf shrubs, grasses and mosses or grassy/mossy bogs. Total area: 1 206.9 km^2.
13. Lowland bogs and transitional bogs of tussocky or hummock-ridge structure (including complex aapa-type bogs) sometimes with small lakes, in particular, of thermokarst origin; formed by grasses, sedges, cotton grasses dwarf heather shrubs mosses (including *Sphagnum* species), and lichens; combined with birch-spruce forests or larch forest with the undergrowth formed of dwarf shrubs, mosses and lochens. Total area: 7 615.6 km^2.
14. Floodplain of the Pechora River (in limits of Nenets Autonomous District), with ridges and lowlands with numerous river arms and oxbows and lakes; covered with diverse grass-sedge meadows, grassy or mossy bogs, patches of small-leaved or mixed forests; more rarely with spruce forests, interrupted by willow-alder stands on sandy banks. Total area: 4 545.2 km^2.
15. The watercourse of the Ob River, with numerous tributaries and lakes in the floodplain; becomes visible only in periods when the water level is at its lowest. Total area: 4 425.7 km^2.
16. The most elevated parts of the Ob River floodplain with elevated banks, small and rare bogs; overgrown with willow or willow-alder forests often with a large proportion of birch, or otherwise, with pine-larch forests and spruce-birch forests. Total area: 6 695.8 km^2.
17. Regularly flooded part of the Ob River floodplain, extensively bogged, with muddy and sandy banks; covered with halophytic diverse grass-sedge meadows often dominated also by bent grasses or rushes, sometimes with patches of shrubby willow stands. Total area: 17 956.8 km^2.

Calculation of bird densities and estimated numbers of species

We calculated the densities of bird species in different habitats as well as their estimated density and abundance using a GIS project made up of the following four layers:

1. delineated habitats;
2. count localities;
3. territories surveyed from aircraft;
4. administrative borders of (NAD).

The quantitative data were taken from summary tables containing all the count results. Calculations requiring the use of geographic operators were made in the *GIS Manifold System* (version 8.00); other calculations were made in the *Paradox* 9.0 database management system. Data processing for each of the count areas included the following stages:

1. Calculating the total area of all polygons belonging to all habitats within each studied territory.
2. Calculating the total area of all polygons belonging to each certain habitat within each studied territory.
3. Calculating the surveyed area within each studied territory (identified as the total area of intersection of the following two layers: delineated habitats (1) and territories surveyed from aircraft (4).
4. Calculating the total area occupied by each habitat within the surveyed part of each studied territory (identified as the total area of intersection of the following two layers: delineated habitats (1) and territories surveys from the aircraft (4), the latter being grouped by habitats.
5. Identifying the habitat type for every count locality.
6. Calculating the total number of birds belonging to each species counted within each habitat type in each studied territory.
7. Adding the sum of the area calculated at step 4 to the resulting table compiled at the end of step 6.
8. Calculating bird densities typical for each habitat within the surveyed part of each studied territory.
9. Calculating bird estimated numbers in different habitats within the surveyed part of each studied territory (obtained by multiplying the density of birds typical for a habitat (as calculated at step 8) to the area occupied by the habitat within each studied territory (as calculated at step 4). The bird-estimated number is identified as the result of extrapolation of the bird number counted from the aircraft for the entire area of each studied territory (i.e. including the parts not covered by direct field counts).
10. Calculating the total estimated number of each bird species in all the habitats (identified as a sum of all the above parameters calculated at step 9).

    The analytical maps of estimated density of birds were made by the ranking method (Fig. 4) using different range width depending on the maximum number of counted birds. If the maximum number was less than 1001, we used the following ranges: 0–101; 101–201; 201–301; 301–401; 401–501; 501–601; 601–701; 701–801; 801–901; 901–1001;

    If the maximum number was more than 1000 but less than 5001, we used the following ranges: 0–501; 501–1001; 1001–1501; 1501–2001; 2001–2501; 2501–3001; 3001–3501; 3501–4001; 4001–4501; 4501–5001;

    If the maximum number was more than 5000 but less than 10001, we used the following ranges: 0–501; 501–1001; 1001–2001; 2001–3001; 3001–4001; 4001–5001; 5001–6001; 6001–7001; 7001–8001; 8001–10001.

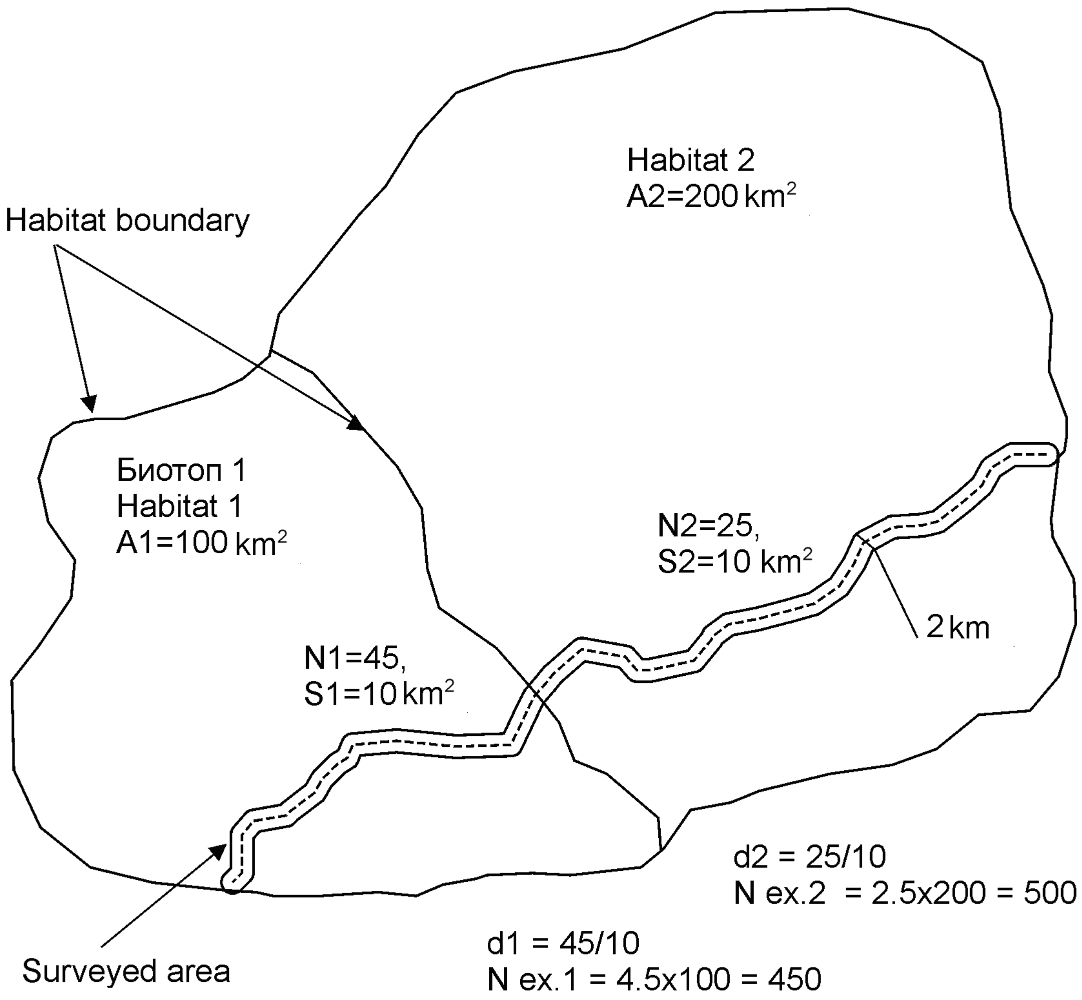


Fig. 4. Calculation of densities and estimated numbers of birds in delineated biotopes

Human impact assessment

Human impact on waterfowl populations in the study area mainly comprised hunting and reindeer breeding. To assess the latter, we registered all the herds of domestic reindeer. To estimate the former, we registered all the hunters encountered in the study area, boats, hides, cabins and hunting bases. The hunting pressure was estimated by analyzing data on ring recoveries of waterfowl species, marked as «bird was shot», available from the database of Bird Ringing Center of Russia.

Results

The data presented here are of significance to enable comparison of waterfowl species richness and bird numbers between different geographical regions. Such information is also crucial to enable a better estimation of numbers of Lesser White-fronted Geese in this area and in the longer term generate population trends. During the autumn counts we counted a total of 7 177 Lesser White-fronted Geese, 38 278 Greater White-fronted Geese, 20 162 Bean Geese, 50 546 Brent Geese, 144 586 Barnacle Geese, and 1 514 Red-breasted Geese (Fig. 5), although we consider these counts to be representing the absolute minima present.

The total proportion of Lesser White-fronted Geese among all the counted geese was around 3% (Fig. 5).

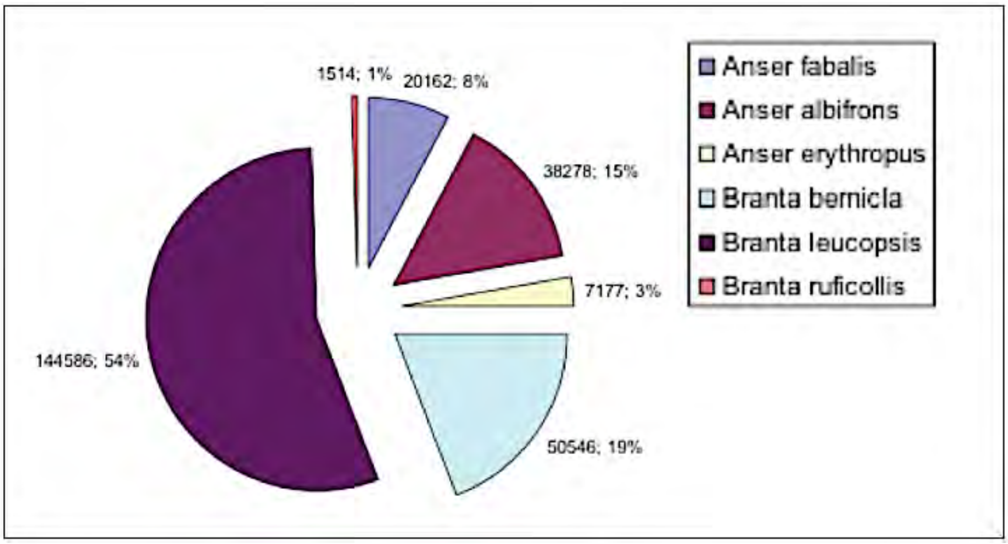


Fig. 5. Relative abundance (%) of four goose species in the study area according to field counts

Assessments of reproductive success of this species have shown that the proportion of young among Lesser White-fronted Geese amounted to 31% (*n*=757). For comparison, the proportion of young birds was 33% (*n* =1,060) for Barnacle Geese, 36% (*n* =676) for Brent Geese, 29% (*n* =139) for Red-breasted Geese, 26% (*n* =1,209) for Greater White-fronted Geese, and 24% (*n* =537) for Bean Geese.

Information on autumn migration

September 2015 was exceptionally warm, with no frosts occurring throughout the month. Most of the observed geese moved within limited territories. We did not encounter any flocks flying high in the sky; nor did we record the previously well-reported southerly migration of any waterfowl species. All the registered gatherings of geese and ducks were at pre-migration stage; the birds never flushed far by our presence (being in the state of pre-migration hyperfagy). We therefore contend that the distances between our tracks were large enough to be sure that no birds were counted twice during successive aerial counts over several days. Evidently, most birds left the survey area after we had finished the autumn counts in 2015.

Lesser White-fronted Goose in the study area

During the autumn waterfowl migration period, Lesser White-fronted Geese were encountered within the study area in most of the localities where we conducted our aerial counts, both in YaNAD and NAD. Lesser White-fronted Geese sometimes formed single species flocks (fig. 6), elsewhere they joined groups of other duck and goose species (fig.7).

Fig. 6. Flocks of Lesser White-fronted Goose

Fig. 7. Lesser White-fronted Geese in a flock of Barnacle Geese and Bean Geese and in gatherings of wigeon *Anas penelope*

At the present time, we have no data relating to the Lesser White-fronted Goose migration in the north of the European part of Russia, with the exception of one known stopover site (registered from a satellite transmitter) at the western coast of the Kanin Peninsula (LITVIN 2014). The distribution and numbers of Lesser White-fronted Geese in the study area (Fig. 8) demonstrate the important role played by marine marshes along the coast of Baydaratskaya, Khaidypurskaya, Pakhancheskaya and Bolvanskaya bays for this species. West of the Pechora River delta, and in the delta itself, there were fewer records of Lesser White-fronted Geese, they are not very numerous on the marshes, and most of the encounter sites were situated on the Kanin Peninsula, southwest coast of Cheshskaya Bay, Lake Toravey and adjacent marshes. It seems obvious that the first birds ready to undertake their autumn migration had gathered in the Dvuobie during the observation period.

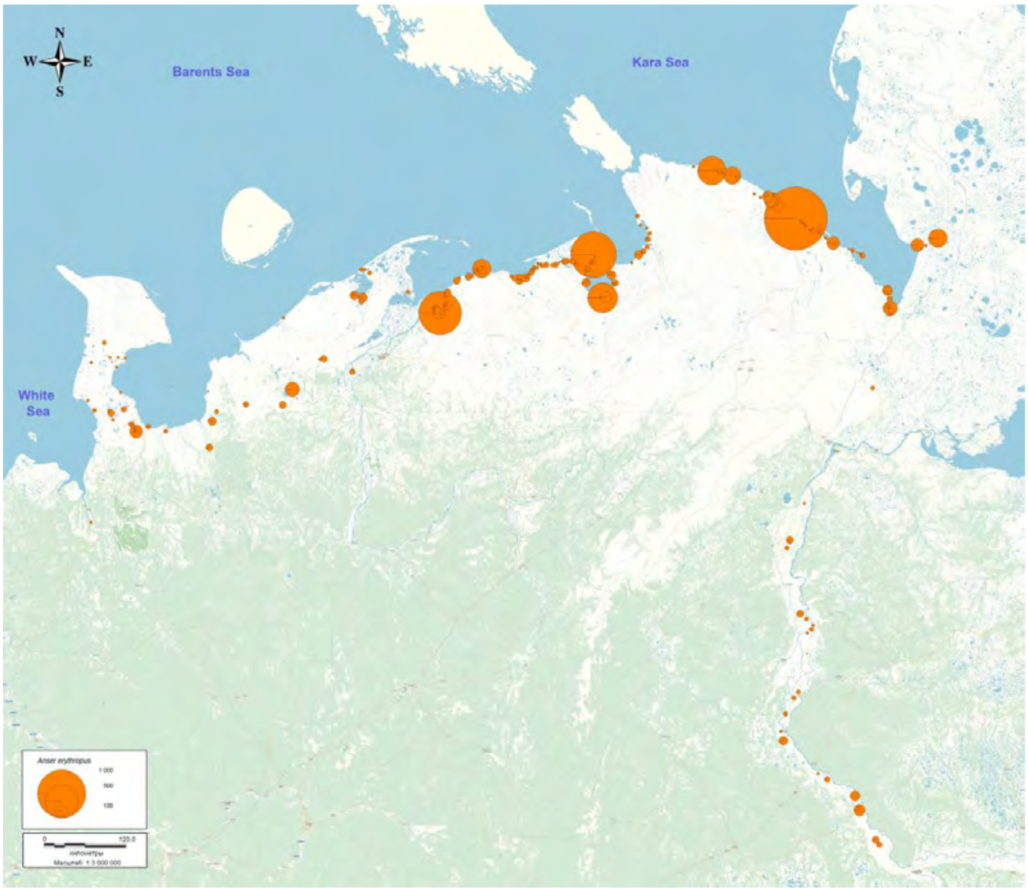


Fig. 8. Distribution and numbers of Lesser White-fronted Goose in the study area

Gatherings of Lesser White-fronted Geese and their key stopover sites
The mapped quantitative data from field observations of Lesser White-fronted Goose flocks delineate several highly important areas where they were staging prior to their autumn migration.

Among these key sites (defined as sites where numbers of Lesser White-fronted Goose exceeded 1,000 individuals), were the following areas: Khaidypurskaya Bay, Pechorskaya Bay (with adjacent coastal zones); entire western coastal zone of Baidaratskaya Bay, as well as all the marshes along the and the eastern coast of Baydaratskaya Bay outside the Yuribey River mouth (Fig. 8).

The density of Lesser White-fronted Geese in the study area
The distribution of densities of Lesser White-fronted Geese in the study area during autumn migration (table 1) show that biotopes 1,3 and 4 were crucially important.

Table 1. Calculations of Lesser White-fronted Goose population density and number.

Biotope	Number (N)	Surveyed Area (SA)	Density (D=N/SA)	Total Area (TA)	Estimated Number (DxTA)
1	1 662	665.3	2.50	1 298.3	3 243
2	6	278.3	0.02	205.3	4
3	4 091	1 580.5	2.59	3 376.8	8 741
4	174	130.8	1.33	460.2	612
5	224	378.9	0.59	3 602.4	2 130
7	5	204.9	0.02	1 315.8	32
8	325	1 906.5	0.17	14 675.3	2 502
9	34	1 336.0	0.03	17 705.5	451
10	122	472.0	0.26	3 518.0	909
11	22	117.4	0.19	1 013.8	190
14	25	1 061.2	0.02	4 545.2	107
15	14	260.7	0.05	4 425.7	238
16	8	738.7	0.01	6 695.8	73
17	376	2 849.1	0.13	17 956.8	2 370
	7 088	11 980.3	0.59	80 794.9	21 602

Large numbers of Lesser White-fronted Geese were encountered on tundras and coastal marshes, and rather small numbers in the Dvuobie support our conclusion that the 2015 autumn migration began exceptionally late. According to data obtained by our colleagues in Kazakhstan, mass migration of geese occurred there during the first ten-day period of October 2015 (A. TIMOSHENKO, pers.com.).

The estimated numbers of Lesser White-fronted Geese in the entire area was 21 600 individuals. These figures for Lesser White-fronted Geese numbers can be compared to previous assessments of population size. Compared our 2014 data with previous data based on autumn counts conducted in Northern Kazakhstan (table 2), we concluded that in Kazakhstan, in average, up to 23 000 birds are present but this number is subject to strong fluctuations depending on the annual proportion of young individuals and detection probabilities associated with the different census methods applied.

Table 2. Results of Lesser White-fronted Geese counts in Northern Kazakhstan (2010-2014)

Year	Number	Source
2010	18 786	ROZENFELD 2011
2011	17 516	TIMOSHENKO 2011; ROSENFELD 2011
2012	30 788	ROSENFELD, TIMOSHENKO & VILKOV 2012
2013	28 044	ROSENFELD & TIMOSHENKO 2013; ZUBAN & VILKOV 2013
2014	19 963*	TIMOSHENKO & VOLKOV 2014, ZUBAN & VILKOV 2014
2015	21 600	THIS STUDY

* Only 50% of the territory was surveyed in 2014.

The low estimated numbers of some, previously abundant, game species of geese have also caused serious concern since these results may suggest the overall negative trend in their abundance.

In this connection, it seems appropriate to take immediate measures to limit both autumn and spring waterfowl hunting in two key Federal Districts in the area of our research. There is also an urgent need for further monitoring, preferably following the methods developed here on a regulr basis. Such regular standardised monitoring data should be used to underpin flexible adjustments to hunting regulations and improve measures aimed at Lesser White-fronted Goose conservation in the adjacent regions.

Hunting impact on goose population in spring and autumn (estimated by ring returns)

Data on ringing recoveries were available to help assess the impact of hunting on waterfowl. It remains impossible to provide direct quantitative data on kill rates since in the absence of any bag information from the study area.

Based on analysis of ringing recoveries provided by the Russian Bird Ringing Centre, it was concluded that the intensity of spring hunting in the study area was much higher than the intensity during autumn hunting. For example, out of 2,064 rings recoveries of shot waterfowl, 1 710 (83%) were reported after the spring hunting period, compared to only 354 (17%) in autumn. Therefore, the advere impact caused by autumn hunting on waterfowl population may be interpreted as relatively minor despite its longer duration.

Spring hunting is thought to be one of the most important limiting factors for Lesser White-fronted Geese and should be regulated. Unfortunately, we lack any data from which to calculate the proportion of Lesser White-fronted Goose shot among the total numbers of waterfowl killed during both hunting periods: we urge that this is made a key objective for further studies.

Assessment of anthropogenic impacts on waterfowl during the survey period

We assessed the distribution of anthropogenic impacts on Lesser White-fronted Goose in the study area by combining the species' distribution with observations of any signs of the presence of hunters discovered in different habitat types, including people, boats, bungalows and hides as well as Nenets outposts and herds of domestic reindeer.

In the western part of the surveyed territory, the most vulnerable staging sites for Lesser White-fronted Geese were on the western coast of the Kanin Peninsula from Konushinsaya Korga Cape to Shoina settlement; in the mouth of the Torna River, and on the western and southern coasts of Cheshskaya Bay.

In the central part of the surveyed territory the greatest impact was found in the mouth of the Indiga River, on the lakes Toravey and Urdyuzhskoye; on Bolvanskaya Bay coast and along the coastal line of Pecherskaya Bay from Cape Bolvanski Nos to Cape Konstantinovski, as well as on the Khaidypurskaya Bay coast.

In the eastern part of the surveyed territory the threats were highest for places around Kara Bay and in the environs of Ust-Kara settlement.

As for the southern part of the surveyed territory, it appeared that the anthropogenic impacts were likely of almost similar intensity over the entire territory of the Ob River floodplain.

At the same time, it was obvious that the currently existing protected areas cannot function properly for waterfowl conservation, and their number as well as the area covered by them was insufficient for Lesser White-fronted Geese protection in the period of autumn migration, both in NAD and YaNAD.

Almost all large gatherings of Lesser White-fronted Geese were situated outside the limits of the existing protected areas. Only nine rather small gatherings of Lesser White-fronted Geese were recorded within the protected areas: four of them were encountered in the Nenetski State nature reserve and Nenetski State wildlife sanctuary (NAD), three in the Yamalski wildlife sanctuary and two in the Kunovatski wildlife sanctuary (YaNAD).

The proportions of Lesser White-fronted Goose among gatherings of geese during their autumn migration period were sometimes substantial. There were a significant number of places where negative anthropogenic impacts were considered to be especially high which coincided with very high Lesser White-fronted Goose abundance, where the species cannot disperse and remain undetected amongst other geese. Such places included, for instance, the southern seaside of Cheshskaya Bay (the middle reaches of the Bolshaya Krutaya River), the southern coastal area of Bolvanskaya Bay, the coast of Pechorskaya Bay (from Cape Bolvanski Nos to Cape Konstantinovski), all coastal zones of Khaidypurskaya Bay, Kara Bay and the surroundings of Ust-Kara settlement.

In contrast, there were no such large gatherings of geese in the Dvuobie; Lesser White-fronted Geese primarily migrate there in dispersed flocks or together with Red-breasted Geese. For these reasons, all the territory of the Dvuobie should be considered as a zone where the risk of illegal kill of Lesser White-fronted Goose is increasingly high.

For these reasons, although the hunting impact on geese in autumn is significantly less than that in spring, the adverse effects of hunters and the level of disturbance caused by hunting are high anyway, so this allows us to list hunting among the important limiting factors for all geese populations in the region, and for Lesser White-fronted Geese in particular.

Fig. 9. Lesser White-fronted Geese in a hydrocarbon production area

Impact of oil production

When surveying the study area we regularly saw Lesser White-fronted Geese in flocks of Greater White-fronted Geese, Barnacle Geese and Bean Geese in areas of oil development. Neither construction activities nor the infrastructure itself appeared to exert any observable negative influence on the birds. On the contrary, many waterfowl species appear to like gathering around and within areas where oil wells are active (Fig. 9). One possible reason for this is that hunting is entirely prohibited in the immediate vicinity of such places because of associated risks, so disturbance appears very low very close to such developments, but higher about their periphery.

Reindeer breeding impact

The impact of reindeer herding on Lesser White-fronted Goose is difficult to evaluate at the current stage of research. We can only state that the numbers of domestic or domesticated reindeer is increasing in both Autonomous Districts, which may become a serious environmental problem. The number of reindeer grazing on the coastal marine marshes, the key staging sites of Lesser White-fronted Geese, is still small; however, in the future, if the population of domestic reindeer grows uncontrolled (as it currently is), these key feeding habitats of Lesser White-fronted Geese may fall under threat of degradation from overgrazing.

Conservation measures

The progressive fragmentation of the nesting habitats of Lesser White-fronted Geese and the decrease in the abundance of the species make it necessary to organize permanent monitoring of the extant Lesser White-fronted Goose populations as well as all its key habitats. The results of existing periodic monitoring have shown that Lesser White-fronted Geese migrate through the study area very extensively. As often as not they will join flocks and groups formed by different hutable species of geese, and their proportion in such gatherings can occasionally be very high. The main reason for the recently observed decrease in the number of Lesser White-fronted Goose in Russia is considered to be the high bird mortality due to hunting or poaching. The most effective measure for the conservation of the species would be the creation of several protected areas (at the local or federal level) in all the key nesting sites of the species as well as at its migratory stopover sites. A network of protected areas covering all stopover sites is needed where a significant number of Lesser White-fronted Geese have been observed during spring and autumn migration.

At the present time, there are no protected areas in NAD for Lesser White-fronted Goose to nest. Nor are there any protected areas specifically created for Lesser White-fronted Goose conservation or to save their habitats from destruction. It is therefore important to create several protected areas at the level of Federal wildlife sanctuaries in the study region as a measure to contribute to the territorial protection of the species. These should be added by two or three specially protected areas at the level of State nature reserves or, otherwise, by expanding the areas of existing state nature reserves so that their newly created sections ensure conservation of all the major breeding groups of Lesser White-fronted Geese in their nesting areas.

The measures are especially urgent because some VIP hunting bases have been built in the Kanin Peninsula and in the environs of the Ust-Kara settlement (Fig. 10).

As soon as they are open to use, the level of disturbance will significantly increase in several key areas of Lesser White-fronted Geese, and the number killed will increase, particularly in spring, a period especially popular for hunting in the study area.

Fig. 10. Greater White-fronted Geese and Lesser White-fronted Geese at a hunting base near Ust-Kara settlement.

Development and implementation of a system of conservation measures is required to prevent geographical range shrinkage in all goose populations (including those of rare and protected species) and a decrease in their numbers. The system of already existing protection measures must be extended and improved. That can be done by modifying current conservation laws or adopting new, better ones; by making amendments to territorial protection system, both in the nesting areas and migration stopovers, and also by improving hunting regulations.

An extremely effective measure could be to ban spring hunting and strongly limit autumn hunting in all the key areas; as well as introduce effective measures against poaching in areas where the exploration and production of oil, gas and other mineral resources is taking place.

Suggestions for creation of new protected areas for Lesser White-fronted Goose protection

Suggestions for the creation of six seasonal wildlife sanctuaries (or even more strictly protected areas) in the study territory for conservation of migratory populations of Lesser White-fronted Goose in autumn are given below. These areas are illustrated by a generalized map and a series of more detailed maps for all six sectors described above (Fig. 11).

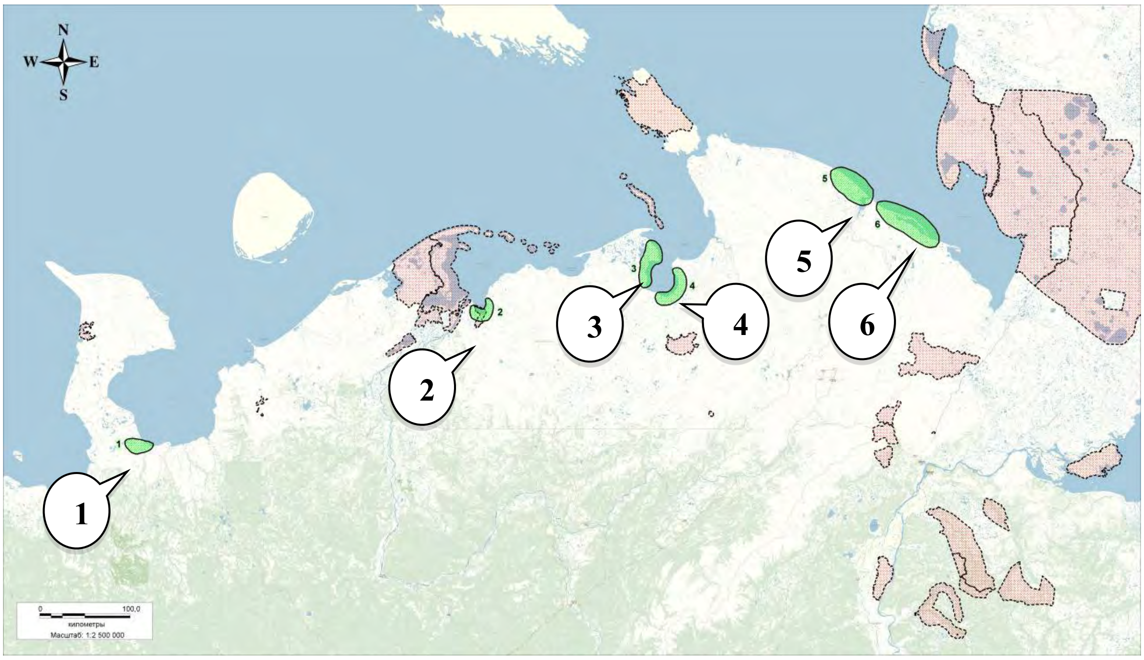


Fig. 11. Location and boundaries of six key stopover sites of Lesser White-fronted Geese where hunting waterfowl must be prohibited or strictly limited

Note: existing protected areas are filled with red; the areas where it is necessary to limit hunting for conservation of migratory Lesser White-fronted Geese (i.e. the new protected areas we have proposed) are filled with green.

Recommendations for NAD and YaNAD administration

One of the most efficient ways to protect the Lesser White-fronted Goose will be to create several hunting-free zones for waterfowl covering the key migratory stopovers in the Kanin Peninsula and on the coasts of the Strait of Pomorie, Cheshskaya Bay and Mezenskaya Bay. All the particularly important sites used by Lesser White-fronted Goose during autumn migration are located along the entire coastal line of Bolvanskaya Bay and Pechorskaya Bay from Cape Bolvanski Nos to Cape Constantinovski, plus the coast zones of the Khaypurdskaya Bay, Kara Bay and the environments of Ust-Kara settlement. We recommend creating protected areas in all the territories delineated on (ROSENFELD et al. 2015). In addition, we suggest that hunting all goose species in spring should be prohibited in the following areas (or parts therein):

1. From Arkhangelsk Province boundary in the west in a northerly direction along the Ice Ocean coast to the mouth of the Bolshaya Bugryanitsa River, then along the straight line up to the Cape Western Ludovaty Nos, along the sea coast to the mouth of the Vigas River, further along the coast of Cheshskaya Bay to the mouth of the Snopa River, then southwest to Vigas settlement and back westwards to Arkhangelsk Province boundary (key zones 1–4 on Fig.11);
2. In the mouth of the Indiga River and over the entire territory of Cape Svyatoi Nos (key zone 5 on Fig. 11);
3. On the lake Toravey and in the mouth of the Welt River (key zone 6 on Fig. 11)
4. In a one-kilometer wide zone along the costs of Khaypudyrskaya, Pakhancheskaya and Bolvanskaya bays;
5. In a one-kilometer wide zone along the cost of Kara Bay;
6. In a one-kilometer wide zone along the cost of Pechorskaya Bay;
7. In the Dvuobie within the boundaries described in Part 3 in ROSENFELD et al. (2015).

List of high priority measures to improve hunting regulations and enhance *Anseriformes* conservation

1.1. Create a Bolshezemelski State nature reserve as a first-priority measure to protect large nesting groups of the Lesser White-fronted Goose. The reserve should include the following parts:
   – the valley of the middle reaches of the More-Yu River;
   – the basin of the upper and middle reaches of the Khe-Yakha River, a eastside tributary of the Korotaikha River;
   – the valley and adjacent tundras in the upper reaches of the Bolshaya Rogovaya River

1.2. The reserve boundaries within all three above-mentioned parts should be kept in accordance with the initial project of Bolshezemelski reserve as it was proposed in 1994.

1.3. To protect moulting gatherings of Lesser White-fronted Goose, all known key moulting sites should be included in the territory of Yamalski Peninsular regional wildlife sanctuary.

1.4. Hunting-free zones for autumn period should be allocated in the Dvuobie along the boundaries of all the hunting-free zones proposed for spring period (see Part 3 in ROSENFELD et al. (2015) for details).

2.1. It is essential to develop special regulations for hunting waterfowl in spring.

2.2. New terms of spring hunting should be set to prevent extermination of the nesting waterfowl populations; namely, the closing date for the spring hunting season should be changed to 1 June.

2.3. An analytical study of existing information should then be carried out to determine the beginning dates of nesting periods for all waterfowl species found in the region, as well as how the dates depend on weather conditions and other factors.

2.4. Then, based on the above information, the opening and closing dates for waterfowl hunting period in spring should be adjusted more precisely for each region.

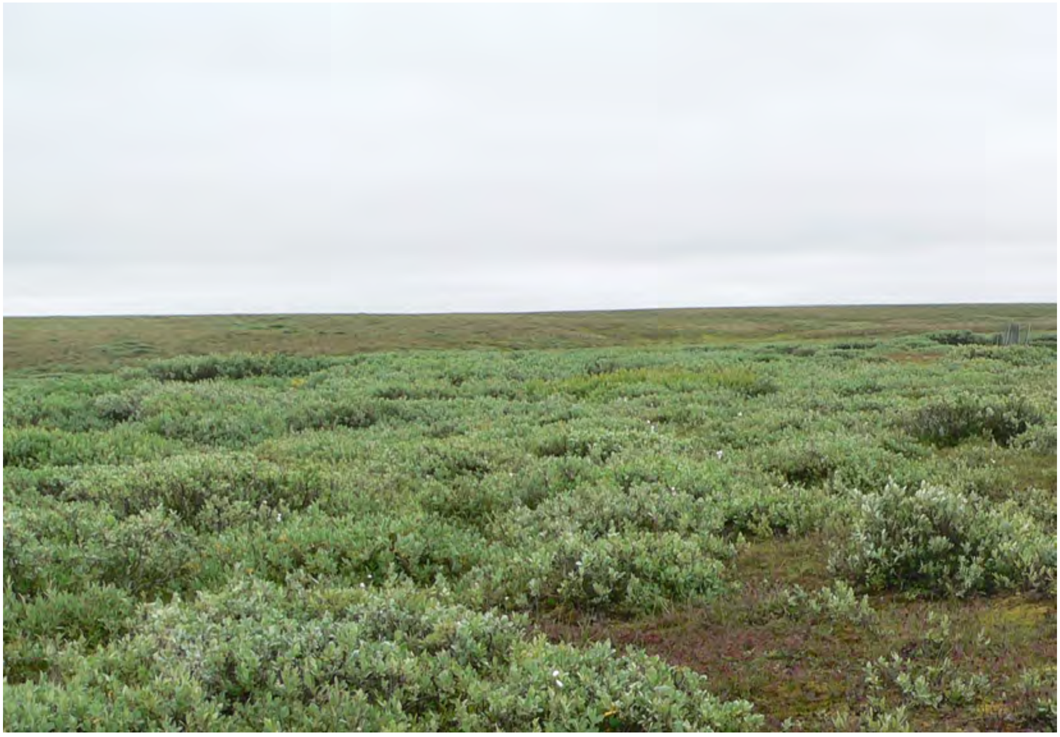
3. It is also important to set the opening day of autumn hunting period not earlier than 1 September. In the tundra zone, it is advisable to open the autumn hunting between mid-September and late October, within the period of mass migration of Bean Geese and Greater White-fronted Geese, in order to give better chances for rare goose species (especially for Lesser White-fronted Goose) to disperse among the waterfowl flocks after joining the mass groups of goose game species.

4. Hunting quotas during both hunting periods should be set for a day, not for a trip.

Conclusions

The current study has revealed the feasibility of Lesser White-fronted Geese aerial monitoring in vast and remote areas of the Russian Extreme North. Using this approach:

1. we obtained new and reliable data on the numbers and the distribution between different biotopes of Lesser White-fronted Goose during their autumn migration within a major part of the range occupied by the western population of the species;
2. a number of key sites were discovered during the period of autumnal hyperphagia and the following migration;
3. we could develop advanced practical measures for Lesser White-fronted Goose conservation in the study area;
4. appropriate suggestions were put forward for policy makers concerning the protection of all the key stopover sites of Lesser White-fronted Geese identified in both Autonomous Districts. The suggestions include, among other items, proposals for stricter limitation of hunting in the study area, as well as some necessary changes in hunting regulations.



The results of our extensive aerial surveys made over a large area show that this method is much more effective and less expensive in searching for key places for staging waterfowl species than marking a few bird individuals with satellite transmitters. New key sites identified using transmitters will require an additional field survey to confirm their status; whereas, during aerial surveys we immediately gathered a large amount of actual data about the abundance of birds, the habitat they used and its condition, their conservation status, as well as the hunting pressure on the populations. Therefore, aerial surveys provide much more reliable instantaneous information about the key habitats of the species in their breeding areas and about the main zones used during their autumn migration. Furthermore, we believe that it is aerial surveys that should be applied in future for further studies aimed at Lesser White-fronted Goose research and monitoring all over the territory of Russia. This will allow researchers to react in an operational way to all the changes and threats occurring to the populations of this endangered species.

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