

# Distribution, trends and threats to Eastern Taiga Bean Goose *Anser fabalis middendorffii* in the River Lena basin, East Siberia

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## Abstract

Recent studies suggest that the Eastern Taiga Bean Goose *Anser fabalis middendorffii* is showing accelerated declines in abundance over the last 20 years, despite protection from hunting in the River Lena basin, northeast Russia. An understanding of its distribution and current threats throughout its breeding range therefore is required for the effective conservation of this subspecies, some of which is provided here through field research, together with a review of scientific publications and reports from local people. Currently, the geese occupy streams in remote sub-montane and plateau areas, a distribution pattern unlikely to be natural but the result of long-term overhunting. Historically-occupied habitats were associated with lowland, large river valleys which used to form the major part of its breeding grounds, but the improvement and accessibility of weapons and transportation led to increasing fragmentation of the Eastern Taiga Bean Goose's breeding range, so that the large rivers and more accessible reaches of the streams are no longer used for nesting. Fishing and tourism can also have a negative effect on breeding by geese, factors which may continue to contribute to the decline of the Eastern Taiga Bean Goose to this day. More rigorous enforcement of anti-poaching legislation, and modification to hunting and protected area regulation, should be undertaken to reduce unintentional shooting of Taiga Bean Geese by law-abiding hunters. Recent observations and reports from local people suggest that arrival in autumn of tundra-breeding geese migrating through the Eastern Taiga Bean Goose's breeding range is now later than in the 20th century. Data therefore are needed to inform adjustments to the hunting regulations, for instance by developing telemetry studies to track the timing and stopovers used by of birds during migration, as well as providing insights into their movements on the breeding and wintering grounds. Under the current flexible protection regime, the most important streams used by Eastern Taiga Bean Geese in protected areas should be closed to any visitors during the summer months, particularly areas important for the geese

and other species in the eastern Aldan highlands and on the Vilyuiskoe Plateau in eastern Siberia.

**Key words:** breeding distribution, geese, hunting regulations, overhunting.

The Eastern Taiga Bean Goose *Anser fabalis middendorffii*, a subspecies of the Eurasian Taiga Bean Goose *A. fabalis*, was first described by Middendorff in the mid-19th century (Middendorff 1853). Since then, the subspecies' legal quarry status, morphological features, its East Siberian breeding range (from the Taimyr Peninsula eastwards) and, most recently, its genetic status, have been studied and reported (Severtsov 1873; Buturlin 1934; Delacour 1951; Dement'ev *et al.* 1967; Sangster & Oreel 1996; Ruokonen *et al.* 2008; Ruokonen & Aarvak 2011; Fox & Leafloor 2018; Ottenburghs *et al.* 2020). Whilst the different subspecies of the Bean Goose complex have varying conservation status, their identification in the field is a difficulty which challenges hunting management and conservation practice (Dement'ev *et al.* 1967; Sangster & Oreel 1996; Emel'yanov 2000; Fox & Leafloor 2018). A decline in Bean Goose numbers in the River Lena basin, East Siberia has however been evident since the mid-20th century (Andreev 1974), and more recent estimates of the abundance of *A. f. middendorffii* suggest a minimum of *c.* 18,000 individuals with the population decline continuing into the 21st century (Miyabayashi & Mundkur 1999; Fox & Leafloor 2018; Li *et al.* 2020). All goose species in East Siberia have traditionally been harvested, but since 2003 the Eastern Taiga Bean Goose has been listed as protected from hunting at the regional level (Vinokurov 2019) and since

2019 it has been included in the national Red Data Book (Pavlov 2021). Whilst the Eastern Taiga Bean Goose has not been a game bird in Yakutia for the last 20 years, other sympatric geese occurring there are legally hunted. Effective conservation measures and hunting control required to protect the subspecies therefore necessitate careful decision-making, similar to that of the conspecific Western Taiga Bean Goose *A. f. fabalis* in Europe (Jensen *et al.* 2018; Fox & Leafloor 2018; Heldbjerg *et al.* 2020). This study aims to give a better understanding of the current trends in the distribution of and threats to the Eastern Taiga Bean Goose, as well as providing information on its conservation in the River Lena basin, which forms the largest part of its current breeding range (Fox & Leafloor 2018).

## Methods

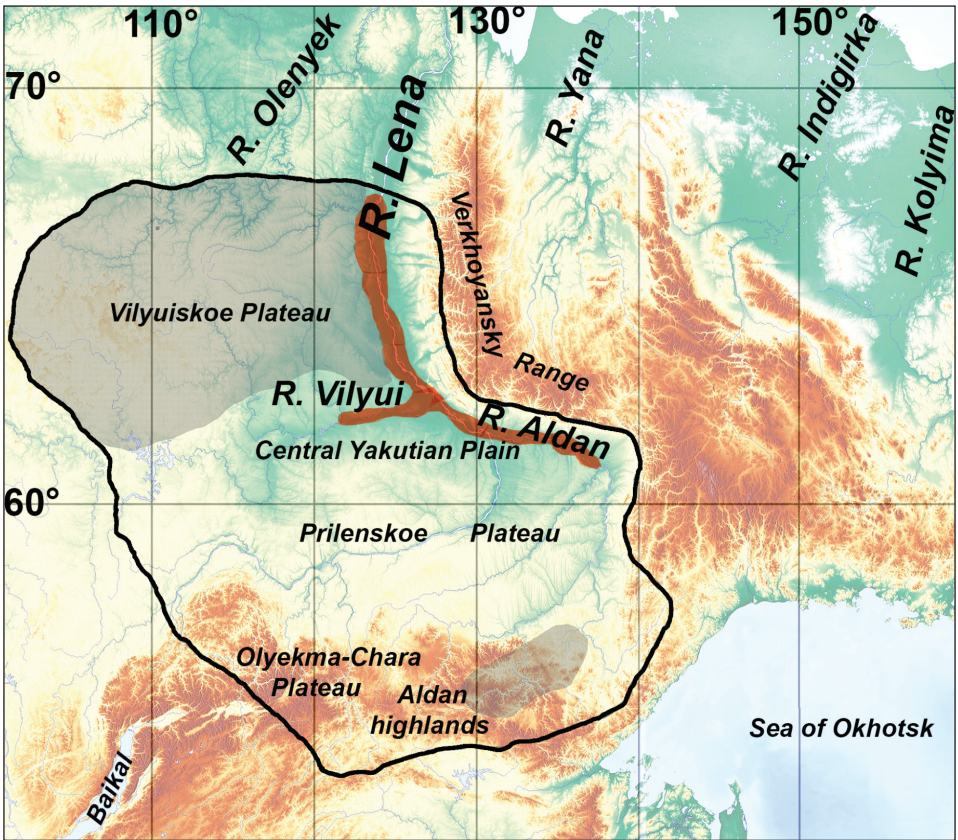
This study is based on data derived from field surveys, historical and recent publications, an anonymous questionnaire survey and social media, which are described in further detail below. It should be noted that comparable data, which would be needed to support an estimation of trends in the abundance of Eastern Taiga Bean Geese over time, and also variation in the threats to these birds, are lacking. All the historical quantitative estimates use quantifiers such as “significant amount” and “often nest”, or report on observations of the birds without reporting on the length of

the survey route. They do however offer insights into the historical breeding grounds of the Eastern Taiga Bean Goose and provide a basis for describing changes in its distribution. All information available on the presence/absence of Eastern Taiga Bean Geese in a surveyed wetland therefore was examined.

There are two main sources of data on Eastern Taiga Bean Goose breeding sites. The first is historical publications, which describe surveys made of the River Vilyui and several of its tributaries flowing from the Vilyuiskoe Plateau in 1854 and 1927 (Maack 1886; Vorob'eva 1928) and again during the 1950s–1960s (Andreev 1974). In the southern part of the region, there are also reports of geese along the Rivers Tokko and Tyanya flowing down from the Olyekma-Chara Plateau visited in 1956 and 1961 (Vorob'ev 1963). The second, and more recent, is fieldwork undertaken in the middle and lower reaches of the Rivers Aldan, Uchur, Gonam and Maya during the 1970s–2020s (Supporting Materials Table S1), together with scientific publications and internet sources from this time, which provide data on: (i) the northern section of the River Lena basin – *i.e.* the lower reaches River Lena and a few its tributaries from Verkhoyansky Range during the 1970s–1980s (Labutin *et al.* 1988; Pozdnyakov *et al.* 1996); (ii) the northwestern and central sections of the basin – *i.e.* the lower reaches of the River Vilyui, middle reaches of the River Lena, the River Aldan, the River Amga and 18 streams of the Vilyuiskoe Plateau during the 1970s–2000s (Labutin 1992; Degtyarev *et al.* 2008; Emelyanov *et al.* 2018); and (iii) the southern section of

the basin – *i.e.* in the Olyekminski Nature Reserve (Tirsky 2019; Chronicle of Nature 2021) and the Verkhne-Charskaya depression in 1975 (Tolchin & Pyzh'yanov 1979) and 2011, the upper reaches of the River Olyekma in the 2000s–2010s (Vischnyakov 2012), and also in the upper reaches of the River Lena and the Vitimski Nature Reserve (Karataev 2009; Volkov 2015). Data from studies of prehistoric regional fauna (Zelenkov 2008; Ponomarev *et al.* 2021; Zelenkov & Boeskorov 2021; Alekseev *et al.* 2022) were additionally screened for reports of geese.

Field data were collected during the long-term study of waterbirds in the River Lena basin and included data gathered during simultaneous surveys being made of wetlands in the region during 1979–2023 (Degtyarev 2007a; Degtyarev *et al.* 2008; Supporting Materials Tables S1, S2, S3). As a result of the orographic heterogeneity of the basin (Fig. 1), its river network consists of different types of watercourses, which are highly variable in their current, drop, bed materials and transverse valley profiles, affecting whether or not some stretches of the river are habitable by geese (*e.g.* with presence or absence of sloping riverbanks, pools, riverine meadows and valley terraces). The term “semi-mountain stream/river” is used here to designate the intermediate stage between mountain and lowland types of watercourses, specific to foothills, submontane areas and plateau slopes. The River Syan (a medium-sized tributary of the Vilyui which rises on the Vilyuiskoe Plateau 65°26'N, 109°07'E), a typical semi-mountain stream, was surveyed from head to its confluence with the Vilyui in 2002, to record

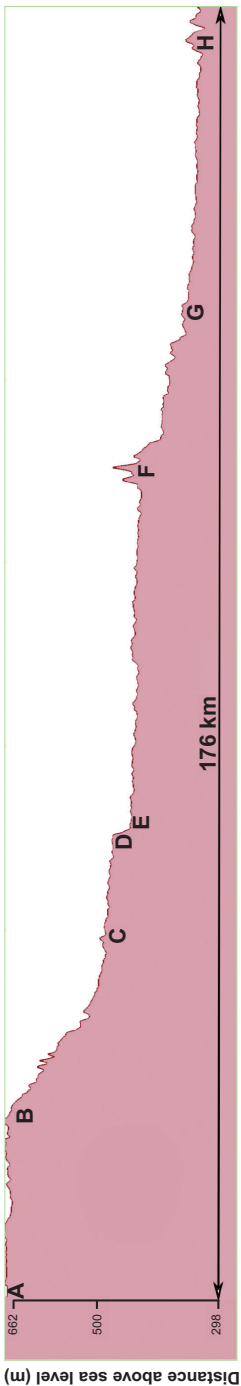


**Figure 1.** Eastern Taiga Bean Goose breeding range in the River Lena basin. Core remnant concentrations during the 2000s–2020s (grey shading), suggest historical areas where mass breeding by the geese occurred in valleys of the large rivers (dark brown shading), and the full extent of their breeding range (black line) are shown (from Vorob'ev 1963; Andreev 1974; Tolchin & Pyzh'yanov 1979; Egorov *et al.* 2002; Mel'nikov 2004; Degtyarev *et al.* 2008; Karataev 2009; Vischnyakov 2012; Volkov 2015; Emelyanov *et al.* 2018; Vinokurov 2019; Shemyakin *et al.* 2021).

variation in goose distribution along the stream in relation to changes in the slope and valley profile. These rough longitudinal and transverse profiles of the stream were modelled and visualised using Google Earth Pro (Fig. 2).

Large rivers (*i.e.* the Lena and its tributaries the Aldan and Vilyui, Fig. 1,

Supporting Materials Table S1) were surveyed from a motorboat primarily in July–August travelling along the riverbank or through narrow river channels. Medium-size and small streams with a maximum width of 300 m (at low water levels) were surveyed from inflatable rowing boats in summer, also in July–August. Within the same time-



**Figure 2.** Rough longitudinal profile of the River Syan, on the Vilyuiskoe Plateau. **A–B** = the watershed depression; **B–C, D–E, F–G** = cobble riffles; **C–D, E–F, G–H** = stream pools.

frame surveys of watershed depressions, lakes and bogs in river terraces and along the lower reaches of tributaries of streams were carried out on foot, by walking along shorelines and through tundra, scrub and meadows in the vicinity of waterbodies. We also searched for any evidence (*e.g.* footprints, traces of foraging, moulted feathers and calls) of geese and their predators occurring in the riparian zone (Degtyarev *et al.* 2008, 2013). All Eastern Taiga Bean Goose habitats and breeding locations in the River Lena basin previously reported (Maack 1886; Vorob'ev 1963; Andreev 1974) were surveyed, along with other wetland types potentially occupied by other Bean Goose subspecies throughout its breeding range (del Hoyo *et al.* 1992; Johnsgard 2010; BirdLife International 2018) to determine the presence/absence of Eastern Taiga Bean Geese in the surveyed wetlands.

Data on the occurrence of the geese and of goose hunting were collected through an anonymous questionnaire survey, and from the sporadic examination of hunter bags and waterfowl body parts obtained from locals during fieldwork. The questionnaire survey, undertaken to collect qualitative information on the occurrence and main nesting sites of rare species, was made in 1984 and 1985 with help of the regional hunting administration. Of 700 questionnaires sent, 105 were returned, with 9 reporting occurrences of breeding geese in the Vilyuiskoe Plateau, the Aldan highlands, and a piedmont area of the Verkhoyanskiy Range during the mid-1980s. Additionally, during fieldwork in 1979–2023, local people were interviewed whenever practicable to

obtain information on the occurrence of the geese and wildfowl harvesting (337 respondents and examination of 974 shot wildfowl). Much information on goose hunting, and on human activity in the area more generally, was obtained from blogs/forums and videos on YouTube relating to hunting, fishing and ecotourism, available on the internet (the most representative are cited and included in the references) found using a search engine. The basic initial textual web search queries (in the Russian and Yakut languages) were “a river name, rafting, water tour, a trip along river”, “hunting, geese, Yakutia”, “fishing on mountain rivers, Yakutia”, and “fishing for taimen, Yakutia”. Websites from the result lists were then screened for any reference to geese, by using key words in the blogs/forums and scrolling through videos.

## Results

### Prehistoric and 1800s–1960s occurrence records

Five records of large goose skeleton fragments dating back to the Pleistocene–late Holocene periods provide some historical background for the presence of geese in the region. In the middle reaches of the Lena River, a Greylag Goose *Anser anser* bone was found in the Kullaty burial site (from the Early Iron and Bronze Ages; Gureev 1950), and bones of large Bean Geese, *A. fabalis* sp., were retrieved from the Mukhatta site (11,500–2,900 years before present), whilst bones most likely of *A. f. middendorffii* were found in the Ogonyek burial site (5,000 BP; Ponomarev *et al.* 2021; Alekseev *et al.* 2022). In the middle

and lower reaches of the Aldan River, a new fossil species – the Djuktai Goose *A. djuktaiensis* – was discovered with human cultural remains in the Djuktai Cave (12,000–14,000 BP) and at the Ikhine-2 Site (31,000–24,000 BP). Based on the series of bones of the wing and pectoral girdle, including the coracoid of > 84 mm length, this new species is larger than contemporary Greylag Geese (Zelenkov 2008; Zelenkov & Boeskorov 2021).

Maak (1886) surveyed the lower reaches of the River Vilyui and its tributaries in the Vilyuiskoe Plateau in late April–August 1854, where he reported Bean Geese to be numerous and a common source of food for local subsistence hunters. Apparently, following Middendorff (1853), he used the scientific names *A. grandis* and *A. segetum* for Eastern Taiga and Eastern Tundra Bean Geese (the latter now *A. f. serrirostris*), reporting that both (sub)species bred throughout the areas covered along his expedition route.

There were no reports of breeding Eastern Taiga Bean Geese on the middle reaches of the River Lena in 1925 and 1926, though specimens dated May and August were listed as having been collected there (Ivanov 1929).

Vorob'eva's (1928) and Andreev's (1974) survey data from the mid-20th century support Maak's observations completely: until the late 1960s, with exception of an area of non-riverine thermokarst wetlands, Eastern Taiga Bean Geese occurred and bred throughout almost the whole of the River Vilyui basin, including the main river floodplain and the western periphery of the Prilenskoe Plateau (Fig. 1). They listed five

large islands in the lower reaches of the river as being occupied by hundreds of geese in August 1927 and by 40–50 nesting pairs in the 1950s, where geese were said to be harvested *en masse*. By 1965, only 5–6 pairs were reportedly breeding there (Andreev 1974).

According to five people responding to the questionnaires, solitary pairs were breeding in the upper reaches of the River Aldan (between 58°48'N, 127°16'E and 58°35'N, 130°27'E) and in the lower reaches of its tributaries (the Rivers Baibakan and Tukanan), until the 1960s.

In the piedmont and bottomlands of the Olyekma-Chara Plateau, breeding and moulting geese were observed in the Rivers Tyanya and Tokko in 1956 and 1961 (Vorob'ev 1963).

### **Distributional records (presence/absence) in the 1970s–2020s**

Regarding the large rivers, the entire length of the Lena, the middle and lower reaches of the Aldan and the lower reaches of the Vilyui are typical lowland rivers at < 300 m a.s.l., with sandy and pebble beds with branches, bayous and islands. The upper reaches of the Aldan and Vilyui, at 250–500 m a.s.l., are predominantly of semi-mountain type with faster flowing water, pebble beds, gravel riffles and steep stretches. With the exception of five broods moving from the Rivers Baibakan and Tukanan to the Aldan in August 1979, no breeding Eastern Taiga Bean Geese were observed during 1976–2023 in the middle reaches of the Lena; in the upper, middle and lower reaches of the Aldan; in the upper and middle reaches of the Amga; or in the

lower reaches of the Vilyui. Eastern Taiga Bean Geese with broods were recorded in 2002 in the upper reaches of the Vilyui, upstream of the Vilyuisky Reservoir, from their footprints on sandy sediments and by shed feathers. The geese were also commonly mentioned in three raftsmen's blogs/forums on their trips along the upper reaches of the Vilyui (Wind of Change 2017, 2018; Mitrofanov 2019). Summering geese were reported in the lower reaches of the Lena in the 1980s (Labutin *et al.* 1988). In the basin of upper reaches of the River Lena a proven record of Eastern Taiga Bean Goose dates back to 1970 (Mel'nikov 2004; Karataev 2009), and based on the area having suitable breeding habitat, it was considered that single pairs might breed in the Vitimski Nature Reserve (57°11'N, 116°48'E) and nearby areas in 2012–2014 (Volkov 2015).

Medium-sized and small semi-mountain streams are widespread throughout the plateaux and sub-montane areas of the River Lena basin, and in highland bottomlands at 300–700 m a.s.l. Based on previous field data (Labutin 1992; Degtyarev *et al.* 2008; Emelyanov *et al.* 2018) and reports on YouTube and blogs in the 1980s–2010s (Dick 2015; Wind of Change 2017, 2018; Mitrofanov 2019; Borisov 2023), broods and moulting Eastern Taiga Bean Goose flocks were abundant along the gently sloping stretches of rivers throughout the Vilyuiskoe Plateau (including tributaries of the River Olenyek) and the nearby Syiverma Plateau to the west (Fig. 1), in the areas between 65°54'N, 103°45'E to 64°56'N, 124°36'E to 61°48'N, and 109°39'E to 68°11'N, 122°20'E (on the Rivers Alakit, Arga-Sala, Chilly, Khannya, Kudu,

Lakharchana, Markha, Motorchuna, Muna, Munakan, Nakyin, Nizhnyaya Tomba, Olenyek, Sokhsolokh, Syan, Tyung, Tyungkyan and the Ulakhan Vava).

In piedmont areas, on either side of the Verkhoyanskiy Range, breeding geese occurred up to altitudes of 250–420 m a.s.l., below the tree line along streams flowing down the extended mountain ridge to the River Lena (Baibakan, Dyanishka, Kele, Tukulan, Undulyung), and within bottomlands sandwiched between mountain blocks (Dulgalakh, Echiy and Oyume) in the basin of the headwaters of the River Yana. Supposedly also in those of the Rivers Indigirka and Kolyma (Labutin *et al.* 1988; Pozdnyakov *et al.* 1996; Degtyarev 2007b; Vinokurov 2019).

In the piedmont and bottomlands of the Aldan highlands, breeding Eastern Taiga Bean Geese were found to be more common in the upper reaches of the River Uchur and its tributaries (the Rivers Algama, Gonam and Sutam) in 2000 and 2010. Ermakov (2018) filmed a few broods and reported on them as “numerous” in the upper reaches of the Uchur in August 2018, at between *c.* 56°9'N, 134°7'E to 57°15'N, 132°49'E. In the middle and lower reaches of the Uchur (between 58°47'N, 130°35'E–57°20'N, 131°16'E; 266 km) no geese were observed during our river surveys in 2010. The surveys also failed to find it above the tree line in these highlands (Egorov *et al.* 2002; Shemyakin *et al.* 2021). Eastern Taiga Bean Geese were however reported by local people to occur in the Yudoma-Maya highlands, and to summer regularly on the Aim and some other tributaries of the River Maya.

In the piedmont and bottomlands of the Olyekma-Chara Plateau and nearby areas, Eastern Taiga Bean Geese were only rarely reported during the breeding season in the 2000s. Notably, this included the Olyekminski Nature Reserve (an 8,500 km<sup>2</sup> area designated with the highest level of protection in 1983; Supporting Materials Fig. S1), where the Eastern Taiga Bean Goose was the rarest potential breeding species in the 1980s–2000s (Tirsky 2019), and also the Vitimski Nature Reserve and its environs during 2012–2014 as Volkov (2015) suggested.

On the central Prilenskoe Plateau, no breeding geese were observed during boat-based surveys in 1986, 1989 and 1990 along the Markhachan and Tuolba Rivers, nor in the lowermost reaches of adjacent streams, the Tuolbachan, Malyikan and Sanyiakchtakh, where Eastern Taiga Bean Geese were said by local people to have bred 20–30 years ago. Moreover, there were no breeding geese present in 1992 and 1993 along the upper and middle reaches of the Amga River (between 60°52'N, 131°52'E and 58°57'N, 122°48'E; 860 km), where they were reported as rarely occurring back to the early 1970s (Degtyarev & Larionov 1981).

No breeding geese were found in the lowland lake-bog complexes and streams which characterise the Central Yakutian Plain, nor in associated watershed areas and the large depressions of the Prilenskoe and Vilyuiskoe Plateaux, during the late 20th century and into the 21st century (Degtyarev & Larionov 1981; Degtyarev 2007b; Degtyarev *et al.* 2008). It is especially notable that there were no recent and historical records on Eastern Taiga Bean



Goose breeding in non-riverine thermokarst wetlands, which are widely distributed across the Central Yakutian Plain on the interfluvium of the Lena and Vilyui Rivers, as well as on the Lena and the Aldan interfluvium (Andreev 1974; Degtyarev 2007b; Vinokurov 2019).

### Habitat use

The 176 km survey of the entire length of the River Syan (one of the least accessible of the Vilyuiskoe Plateau) in 2002 found that the Eastern Taiga Bean Goose occupied exclusively the reaches characterised by gentle inclines, with sections of stream pools interspersed with smooth gravel riffles (areas C–D, E–F and G–H in Fig. 2), within a U-shaped, flat-bottomed valley. No geese were present along the steep stretches of the river with its long cobble riffles (B–C, D–E, F–G), nor in section A–B in the headwaters, where the river flows slowly in the watershed depression. Similar habitat selection has been reported along other streams where the geese are known to breed in the River Lena basin (Labutin *et al.* 1988; Labutin 1992; Pozdnyakov *et al.* 1996; Egorov *et al.* 2002; Emelyanov *et al.* 2018; Ermakov 2018; Vinokurov 2019).

Based on the survey of the lower reaches of the River Vilyui in June 2002, where in 1927 and prior to the 1950s, Eastern Taiga Bean Goose breeding densities were highest (Vorob'eva 1928; Andreev 1974), the goose no longer occurs. Here the species historically nested across the Central Yakutian Plain, occupying a wide (2–5 km) valley of branching river channels with numerous multi-level islands and a floodplain with terraces rich in riparian meadows,

shallow waters, lakes, bogs and marshes at > 100 m a.s.l. (Fig. 1). While the lower reaches of the River Vilyui is easily accessible for human, this wetland has not obviously been affected by man-induced changes, and it appears to remain suitable breeding habitat for the geese.

### Predators

In the plateau areas surveyed, the commonest predators that prey on, or are able to catch, geese included White-tailed Eagle *Haliaeetus albicilla*, Golden Eagle *Aquila chrysaetos*, Red Fox *Vulpes vulpes*, Wolf *Canis lupus* and Brown Bear *Ursus arctos*. The last two were frequently seen and their footprints found at goose brood-rearing and moulting sites. For instance, along the River Syan (mentioned above), in all three sections occupied by the geese (91 km in total), two wolves were sighted in the field and their footprints were also evident in patches of fine sediment at the confluences of the Syan with its tributaries. We observed a Wolf catching a moulting goose and at least four single wolves lying in ambush for geese 15–20 m from shallow waters, as well as witnessing frequent predator footprints in all areas used by geese on the Vilyuiskoe Plateau (Degtyarev *et al.* 2008).

### Harvesting

Legislation divides the spring waterfowl hunting period in the taiga zone into the following categories: (i) a 10-day goose hunting period, mainly between 9 May–6 June (with a hunter bag limit of seven geese/season); (ii) hunting for drakes around these dates; (iii) hunting for male ducks using decoy ducks from 21 April–

10 June; and (iv) hunting for White-winged Scoter *Melanitta deglandi* between 29 May–4 June (Sakha Republic 2021b). The undifferentiated (by timing and waterbird species) summer–autumn hunting season is from 15–20 August (bag limit: 10 geese/season), although some species (including the Eastern Taiga Bean Geese) are legally protected from hunting at this time.

The Eastern Taiga Bean Geese was traditionally a quarry species in the River Lena basin, harvested *en masse* by indigenous people, originally during driven hunts with dogs and later using shotguns (Maak 1886; Andreev 1974). Having now vanished from the most accessible areas, the Eastern Taiga Bean Goose has become less subjected to hunting, with hunting for geese using shotguns in the taiga zone now concentrating more on migrating tundra-nesting species (predominantly, Eastern Tundra Bean Geese and Greater White-fronted Geese *A. albifrons*) passing through on autumn migration. Based on 337 respondents and examination of 974 shot wildfowl, since the 1970s the Eastern Taiga Bean Goose has become a rare trophy for most hunters, and even in the most densely populated areas the proportion of hunters which specialised in taking geese during migration (albeit harvesting less than a dozen birds annually) did not exceed 1–2% of those interviewed, due to the poor equipment available to them. Geese, including Eastern Taiga Bean Geese, were previously hunted annually (reportedly up to dozens of geese) by a few locals from some remote settlements, mostly in or near the highlands. Although legally protected from hunting since 2003 because of its unfavourable conservational

status, all people interviewed who responded will shoot Eastern Taiga Bean Geese if it falls into the sight because “it has been hunted for traditionally”, and “a goose is the most-coveted waterfowl for trophy”.

From the early 2000s onwards, economic development in the region has meant hunters can afford and have greater accessibility to highly efficient multi-charge, longer-range weapons and ammunition with greater killing power, as well as thermal imagers, powerful lights and other equipment which greatly improves their efficiency when hunting geese. This has coincided with their increased mobility, using GPS navigation devices, cross-country vehicles, powerful motorboats, hydro-jet engines, hovercrafts, light aircraft and improved regional logistics, including affordable commercial local transportation. All this, combined with an increase in websites dedicated to goose hunting in the region (*e.g.* Borisov 2011, 2018), has made the goose hunts more popular and effective. Hunters now hunt geese using numerous decoys and other luring devices at various wetlands. As Eastern Tundra Bean and Greater White-fronted Geese are relatively abundant, it is likely that these dominate the kill, but at present the proportion made up by Eastern Taiga Bean Goose remains unknown.

In summer, it is suspected that the numerous tourists do not miss an opportunity to shoot geese during their rafting trips in the taiga zone (*e.g.* Dick 2015; Mitrofanov 2019), despite this being a breach of hunting legislation for species protected from hunting, and it also occurs outside the dates set for the hunting season.

## Mineral exploration and mining

The mining industry is again dominant after periods of inactivity/activity in the region. Gold mining first started in the southwest parts of the Aldan highlands in the 1920s. From the 1940s and again in the 1990s, gold, diamond, coal, gas, oil and other mineral deposits were mined or otherwise exploited, resulting in new settlements, hydropower stations, thermal power plants, energy and transport infrastructure (Kovalev *et al.* 2016; Marshintsev & Gadiyatov 2021). A road was constructed across the Prilenskoe and Vilyuiskoe Plateaux from the upper reaches of the River Lena to almost reach the River Olenyek, along which several settlements of 4,000–35,000 people were established. In contrast, Eastern Taiga Bean Goose breeding sites were only locally and slightly (at regional rates) affected by industrial development in the upper reaches of the River Vilyui, except for the construction of Vilyuiky Reservoir built in 1965–1967, which flooded 600–700 km of the goose stream habitats there.

## Discussion

Based on the information presented here, the Eastern Taiga Bean Goose breeds exclusively in semi-mountain medium and small sized streams in the upper River Lena basin. Meanwhile, habitat along the larger rivers, especially the Aldan and Vilyui, and probably the Lena itself, which until recently supported the largest densities of Eastern Taiga Bean Geese (Maak 1886; Vorob'eva 1928; Andreev 1974), is now totally unoccupied (Fig. 1). In stark contrast to the semi-mountain streams currently used by the geese, historically the valleys of the large

rivers were the major breeding grounds of this subspecies and other large geese (*e.g.* the Greylag Goose) in the late Holocene period and the fossil Djuktai Goose in the late Pleistocene epoch (Gureev 1950; Zelenkov 2008; Ponomarev *et al.* 2021; Zelenkov & Boeskorov 2021; Alekseev *et al.* 2022). At present, Eastern Taiga Bean Goose distribution is severely fragmented in this region, with core remnant concentrations breeding on the stream networks of the Vilyuiskoe Plateau and adjacent areas (Fig. 1), although they also regularly occur in the eastern Aldan highlands, adjacent areas in the Yudoma-Maya highlands, and in the piedmont areas around the Verkhoyanskiy Range.

As described above, Eastern Taiga Bean Geese may also occur in similar areas in neighbouring river basins, located in the upper reaches of the Yana, Indigirka and Kolyma Rivers. Sporadic pairs breed in the Olyekma-Chara and Prilenskoe Plateaux where numbers have not increased within the Olyekminski and the Vitimski Nature Reserves, despite enjoying the highest degree of protection during the last 40 years (Volkov 2015; Tirsky 2019; Chronicle of Nature 2021). The current distribution pattern in no way reflects its natural earlier range but is likely the result of long-term overhunting which has made a major contribution to the contraction of range and population decline of the Eastern Taiga Bean Goose population in the region. Large geese have always been among the most sought after of birds by subsistence hunters, and it remains the most coveted hunter's trophy to the present day. Even in the 19th century, the species began to nest in remote

locations (Maak 1886), but as shotguns became more available and widespread, and as weaponry and equipment improved, so the harvest pressure increased. By the 1960s, a steady decline in goose numbers was evident, documented especially in the areas of densest human population in the River Vilyui basin and in areas associated with new settlements and the mining industry (Andreev 1974). In the following 20–30 years, the subsequent introduction of motorboats, although primitive at first, made large rivers and the more easily sailable reaches of small- and middle-sized streams accessible, with the result that these areas ceased to be used as breeding sites. Eastern Taiga Bean Geese survived in the most remote and difficult to access areas that spontaneously became wildlife refuges. Although subsistence hunting has fallen out of practice since the 1970s, hunting and poaching pressure has grown in popularity since the 1990s. This is the result of a rapid growth in the accessibility of highly efficient shotguns and transportation, and improved regional logistics, providing accessibility to even the more remote areas.

While regional industrial development has not directly affected habitats and breeding sites used by the geese, the attraction of large numbers of people into formerly pristine areas has displaced geese and resulted in more human activity (including hunting) along formerly undisturbed streams where the effects have been even more dramatic (Degtyarev 2007a). Fishing and ecotourism have also recently arrived and become rapidly very popular along semi-mountain streams flowing through the plateaux and highlands (Dick 2015; Wind

of Change 2017, 2018; Ermakov 2018; Mitrofanov 2019; Borisov 2023), further contributing to Eastern Taiga Bean Goose population declines in the River Lena basin. Besides shooting, such activities disturb and force goslings and moulting geese to move to and hide themselves in riparian forests where they are more susceptible to the numerous predators there in summer. Based on the frequency of Wolf occurrence and behaviour, as well as Andreev's (1974) and two locals' reports of husky dogs frequently hunting down fledglings and moulting geese, we suppose that the Wolf forages on geese for most of the summer and potentially contributes significantly to overall goose mortality at this time.

The contemporary rate of range contraction for Eastern Taiga Bean Geese on the breeding grounds is worsening as a result of continued exploration and mine development in the region. The discovery of new deposits in the highlands and plateaux during the 2000s–2010s, including new diamond fields in the Vilyuiskoe Plateau (Alrosa 2015; Kovalev *et al.* 2016; Marshintsev & Gadiyatov 2021) has resulted in further development of the transport infrastructure. These threaten the remaining refuges for geese, as they become more and more accessible to hunters/poachers, fisherman and tourists (as foreseen by Andreev 1974).

As in Europe (Jensen *et al.* 2018; Fox & Leafloor 2018; Heldbjerg *et al.* 2020), hunters do not distinguish Tundra and Taiga Bean Geese when seen in flight, so even law-abiding hunters cannot be sure that they avoid shooting the latter subspecies. During the peak migration period of the Eastern Tundra Bean Geese (in mid-May, and late

September–early October), Eastern Taiga Bean Geese are less likely to present and therefore succumb to a hunter's shot. However, outside this period, it is the only goose species present to be poached in the taiga zone. Some internet resources (*e.g.* Anonymous 2021) records shooting at pairs and small flocks of locally moving geese which cannot be anything other than Taiga Bean Goose. Many streams used by geese lie within regional and municipal protected areas (Sakha Republic 2021a; Supporting Materials Fig. S1). The flexible nature of protection in these areas, such as partial prohibition and restriction of human activities to allow some traditional nature management and recreation, including the existence of huntable areas and also fishing and water-born access (Sakha Republic 2011) can, however, result in poaching and disturbance to the geese.

There is an urgent need for more effective conservation and implementation of an adaptive management programme. Strengthening of anti-poaching measures, amending hunting and protected area regulations and improving enforcement should reduce both the unintentional shooting by law-abiding hunters and the illegal hunting of Eastern Taiga Bean Geese. Eastern Tundra Bean and Greater White-fronted Geese only occur in the taiga during their migration time, so hunting on waterfowl should be restricted to: (i) duck hunting within the current dates for hunting season from mid-August; and (ii) the goose hunting season should not be opened earlier than 25 September to coincide with the mass migration of tundra geese. The spring goose hunting in the forest zone should be

limited to 3–4 days, timed to coincide with the year-to-year mass migration of either Eastern Tundra Bean or Greater White-fronted Geese. The most important streams used by Eastern Taiga Bean Geese in the protected areas under the flexible protection regime should be closed to any summer visiting. Primarily, this applies to protected areas in the eastern Aldan highlands and the Vilyuiskoe Plateau where important concentrations of geese remain (Fig. 1, Supporting Materials Fig. S1). One of them, for example, is the River Muna which holds a small local taiga-breeding population of the Lesser White-fronted Goose alongside the Eastern Taiga Bean Goose (Degtyarev *et al.* 2008, 2013).

In addition to the ongoing decline and fragmentation of Eastern Taiga Bean Goose numbers and distribution, recent observations and locals' reports have suggested a delay in the autumn migration phenology of tundra geese compared to those in the 20th century (Labutin *et al.* 1988; Degtyarev 2007b; Andreev 1974). Therefore, data for adjusting the hunting regulations are needed, perhaps by implementing telemetry to track the timing of the birds' migration, and also gain insight into their movements on the breeding and wintering grounds.

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