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# DISTRIBUTION, DENSITIES, AND ECOLOGY OF SIBERIAN CRANES IN THE KHROMA RIVER REGION OF NORTHERN YAKUTIA IN NORTHEASTERN RUSSIA

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# DISTRIBUTION, DENSITIES, AND ECOLOGY OF SIBERIAN CRANES IN THE KHROMA RIVER REGION OF NORTHERN YAKUTIA IN NORTHEASTERN RUSSIA

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***Abstract:*** The Siberian crane (*Grus leucogeranus*) is the third rarest crane species in the world with a breeding range now centered on 3 core areas and a buffer zone in the arctic of northern Yakutia in northeastern Russia. During 16 July-2 August 2009, we undertook ground surveys within the Khroma River core breeding area, surrounding buffer zone, and lands lying to the west of the known breeding range to estimate densities and determine habitat use and social status of Siberian cranes. A total of 142 Siberian cranes were sighted (including 55 pairs) at 54 locations with 32 cranes (including 13 pairs) sighted outside the currently known breeding range in the lower drainages of the Syalakh and Syuryuktyakh Rivers. After adjusting for a probability of detection of 0.484 (95% CI = 0.281-0.833), Siberian crane densities in the Khroma core area and the buffer zone averaged 0.0921 cranes/km$^2$ and 0.0363 cranes/km$^2$, respectively. A majority of cranes ($n$ = 93 [65%]) occurred in complexes of large basin wetlands, with use centered in those having extensive beds of pendant grass (*Arctophila fulva*). Of the 142 cranes seen, 110 (77%) were paired, 21 (15%) were singles, and 11 (8%) were in groups of 3-5**.** The Khroma core supports 1 of 2 large concentrations of breeding Siberian cranes remaining in the wild; therefore, we recommend that consideration be given to designating a nature reserve that would encompass the Khroma core, adjacent buffer zone, and lands to the west (including coastal tundra areas along the lower drainages of the Syalah and Syuryuktyah Rivers). Further research is needed to gain additional insight into Siberian crane distribution and numbers on lands beyond the currently delineated western boundary of the Siberian crane breeding range in the Ust-Yana District of northern Yakutia. Important gaps remain in information needed to effectively guide conservation efforts for the Eastern Population, and recent advances in remote tracking technology offer potential opportunities to help address several key information needs.

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**Key words:** breeding grounds, coastal tundra, crane densities, endangered species, *Grus leucogeranus,* Khroma River, Khroma core, Russia, Siberian crane, social status, surveys, wetland use, Yakutia.

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The Siberian crane (*Grus leucogeranus*) is designated as endangered under International Union for the Conservation of Nature (IUCN) guidelines (Meine and Archibald 1996). An estimated 3,000 Siberian cranes remained in the wild in the mid-1990s (Song et al. 1995) including remnant Western and Central populations wintering along the Caspian Sea in Iran and at Keoladeo National Park in India, respectively. However, by fall 2011 only 1 wild bird from the Western Population returned to Iran during fall (S. S. Zadegan, personal communication). Siberian cranes have not returned to traditional wintering grounds in India in recent years (G. Sundar, personal communication). Attempts are underway to restore the Western and Central Populations of Siberian cranes by involving release of hand-reared birds (Y. Markin, personal communication). As a result, the Eastern Population remains the only viable wild population. The Eastern Population winters primarily at Poyang Lake in northern Jiangxi Province, China (Li et al. 2012) and breeds across parts of northern Yakutia in northeastern Russia (Degtyarev and Labutin 1991). Concern for the continued survival of this species is growing, considering the near extirpation of the Central and Western Populations and threats to the Eastern Population from various forms of development, particularly on the species' wintering grounds (Meine and Archibald 1996). Recognition of a need for gaining greater insight into the current breeding distribution and habitat needs of the Eastern Population led to this study.

Historically, Siberian cranes were reported breeding in northern Yakutia beginning in the mid-19th century (Dement'ev et al. 1968). In modern times, Siberian cranes have been found breeding primarily from the Kolyma River Delta west to the vicinity of the Khroma River. In the second half of the 20th century, as aircraft became more widely used for monitoring wildlife populations in arctic Russia, information began to accumulate on breeding distribution of Siberian cranes in northern Yakutia. The most detailed information came from sightings of cranes made during aerial surveys specifically searching for Siberian cranes and incidentally while conducting surveys to determine the status of caribou (*Rangifer tarandus*) and polar [arctic] fox (*Vulpes lagopus*) populations. In the Khroma/Yana Region, distribution of crane sightings was recorded during flights over parts of this region during 1963-1966 (Egorov 1971), 1965, and 1971-1973 (Flint and Kistchinski 1975), 1977 (Perfiliev and Polyakov 1979), 1977-1979 (Flint and Sorokin 1981), and during 1978 (Vshivtsev et al. 1979) (Fig. 1A).

The first published evidence of Siberian cranes existing at high densities in the Khroma core area was reported by Egorov (1971) who referred to 2 isolated core areas used by Siberian cranes in the vicinity of the Khroma River (20,000 km$^2$) and the Alazeya River (12,000 km$^2$). The first rough outline of distribution of breeding Siberian cranes across northern Yakutia was prepared by Flint and Kistchinski (1975) using personal observations, published literature, and interviews with people living within this region. Within the Khroma River core, only a small part of lands west of the Khroma River (the focus of current studies) was covered and only 3 instances of nesting were reported, along with a pair not known to have nested and a single bird. Flint and Sorokin (1981), relying on information gained during aerial surveys, identified 3 aggregations: 1) west of the Khroma River on lands south of Lake Soluntakh, 2) west of the Indigirka River across an area of large lakes, and 3) 30-40 km north of the village of Berelekh. Degtyarev and Labutin (1991) pulled together information from the published literature and their own aerial (primarily) and ground surveys from 1978 to 1989 to identify 3 core breeding areas centering on the Khroma, Indigirka, and Alazeya rivers (Fig. 2). Outside each of the 3 core areas, the authors designated a buffer zone where fewer Siberian cranes were thought to exist based on results from aerial surveys in 1980 and 1989 (Fig. 1B) which helped refine the boundaries of the Khroma core area. Of the 3 core breeding areas, the Khroma core is the largest (Degtyarev and Labutin 1991) and least studied with no recent information available on crane distribution, densities, or habitat associations.

Our objectives were to: 1) estimate densities of Siberian cranes occupying the Khroma core and buffer zone in northern Yakutia and compare these data to previous estimates from across the main breeding range, 2) identify wetland habitat types used by cranes within the Khroma core and buffer zone, 3) examine social status of cranes within the Khroma core and the buffer zone, and 4) assess status of Siberian cranes within the lower drainages of the Syalah and Syuryuktyah Rivers including coastal areas which lie outside of the breeding range of Siberian cranes as currently defined for northern Yakutia.

## STUDY AREA

Our study area was located in the eastern Ust-Yana District of the Sakha Republic (Yakutia) in the high arctic of northeastern Russia (Fig. 2 [inset showing location within Russia]), approximately 500 km southeast of the Lena River Delta and 200 km east of the Yana River Delta. Our survey route included parts of the Khroma core breeding area, the buffer zone, and lands lying west of the buffer zone which are outside the delineated breeding range (e.g., Neustroevo Station, Fig. 2).

The study area is situated within the arctic coastal plain, and is a non-glaciated, emergent region of the continental shelf with low relief (Bergman et al. 1977). Annual precipitation averages 217 mm and mean January and July temperatures are -37.1ºC and 8.9ºC, respectively (Alisov 1956). Because of the remoteness from the Atlantic Ocean and Pacific Ocean and proximity to the cold Laptev Sea, frost is possible throughout the summer. Perennial permafrost reaches a depth of 500-600 m and the thickness of the frost-free layer in summer reaches 50-75 cm (Karpov 1991). Typical relief features include lakes and other wetland types, rivers, hills (edomas), and large mounds called pingos (bulgannyakh in Yakut language). Edomas are a common feature of the subarctic plains of Eastern Siberia and consist of fossil buried ice underneath a hummocky surface. Bulgannyakhs are mounds of earth up to 70 m in height and 200 m in diameter and formed by ground ice which develops during the winter as temperatures fall (Perfiliev et al. 1991). Slopes bordering lakes and rivers frequently have exposed soils due to collapse of the banks from permafrost melt and solifluction resulting from climate change. Steep eroded banks

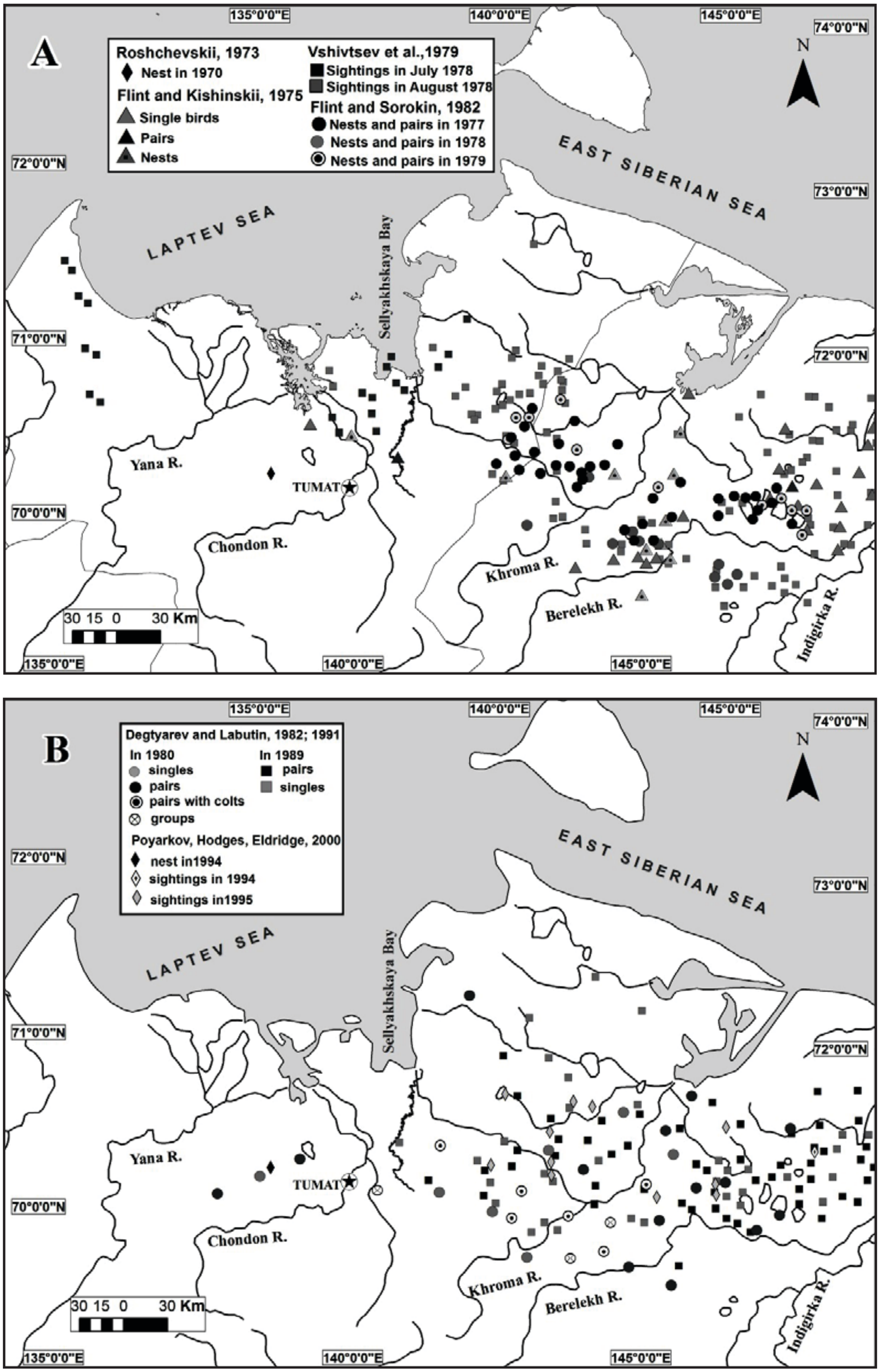


**Figure 1. (A) Sightings of Siberian cranes and their nests in the Ust-Yana District of northern Yakutia, Russia, during 1970-1979. (B) Sightings of Siberian cranes in the Ust-Yana District during 1980 and 1989.**

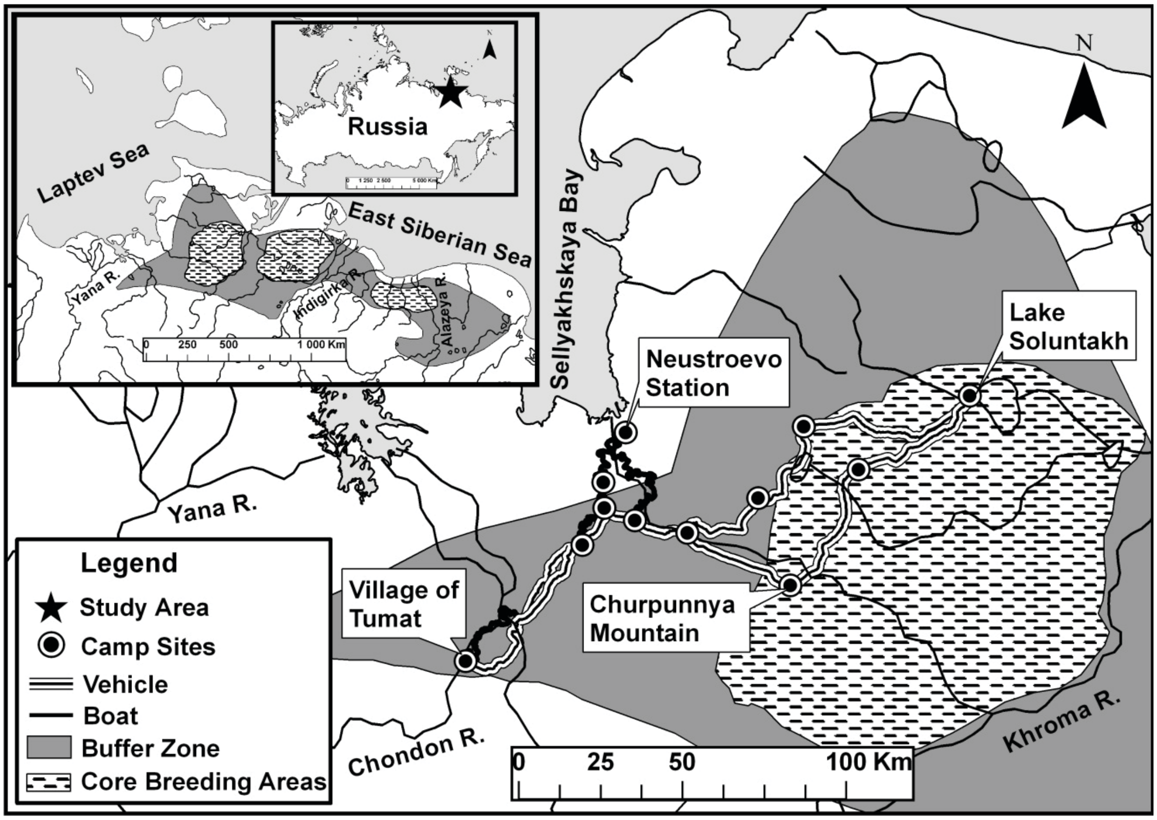


**Figure 2. Map showing survey route followed during the current study of Siberian cranes in the Ust-Yana District of northern Yakutia, Russia. Southern edge of survey area was in the taiga/coastal tundra ecotone. The survey route was on the arctic coastal plain and most was located within the coastal tundra. Segments of the survey route crossing the Khroma core, buffer zone, and lands outside of the buffer zone are identified. Insets show the locations of the Khroma, Indigirka, and Alazeya core breeding grounds and buffer zone, and the location of our study area in Russia.**

caused by bank collapse contain ledges which in some cases serve as nest sites for birds of prey. Many small rivers on the coastal plain contain channels that are connected with countless lakes resulting in lake-river complexes. River valley lowlands are characterized by an abundance of elongated and crescent-shaped oxbow lakes, which are confined to the floodplains and river terraces of medium and large rivers. Distinctive meteorological characteristics during summer in this region of the tundra are relatively high humidity, frequent fog and drizzling rain, which saturates shallow permafrost tundra soils (Desyatkin et al. 2009).

The dominant plant species in the uplands of the study area are cotton grasses (*Eriophorum vaginatum* and *E. angustifolium*) with an understory of dwarf birch (*Betula exilis*), labrador tea (*Ledum decumbers*), and numerous species of sphagnum moss (*Sphagnum* spp.). Narrow strips of willow (*Salix* spp.) occur on the lower slopes of edomas and on banks and along shores of rivers and some lakes and reach a maximum height to ~1 m. The southern edge of the study area lies within the taiga/tundra ecotone and is characterized by sparse stands of stunted larch (*Larix cajanderi*, *L. gmelinii*) which form the overstory. The vegetation understory of the taiga-forest ecotone consists of most of the same dominant plants as occur in the coastal tundra.

Several wetland types on our study area were similar to those occurring on the arctic coastal plain of Alaska and were classified using the wetland classification system developed by Bergman et al. (1977) for that region. The Bergman wetland classification system was used previously to classify wetland habitats on the Indigirka River Delta (see Pearse et al. 1998). Class II wetlands were broadly distributed across the study area and consisted of shallow depressions that varied widely in size and were dominated by *Carex concolor* and *C. chordorrhiza* sedges. Class III wetlands were relatively small in size with centers dominated by pendant grass (*Arctophila fulva*) and bordered by a zone of *Carex aquatilus.* Class IV ponds were relatively small with deep, open centers surrounded by a zone of pendant grass. Class V wetlands were large, deep lakes, with several on the study area being elongate with the long axis oriented 10 to 15 degrees west of true north. Regularity in basin orientation results from a system of circulating currents set up in the lakes by prevailing northeasterly winds (Carson and Hussey 1962). Complexes of large relatively shallow basins, with 1 or more central zones vegetated by stands of pendant grass interspersed with open water and bordered by stands of *Carex aquatilus,* occurred widely across the study area.

Coastal wetlands ranged from lagoons confluent with the sea to ponds periodically inundated by high wind tides. Riverine wetlands were widely distributed on our study area where large and small rivers crossed the landscape. The Syalyakh and Syuryuktyakh Rivers from which we conducted crane surveys by boat contained low terraces of alluvial origin that supported extensive wetland habitat ranging from tundra bogs to pendant grass swamps (Perfiliev et al. 1991). Bottoms of small river valleys of alluvial origin also contained sedge (*Carex* spp.), tundra bogs on floodplains, and low terraces along with pendant grass swamps.

Siberian cranes shared the study area with numerous other species of water birds. Waterfowl species we observed included whooper swan (*Cygnus cygnus*), Bewick's swan (*Cygnus bewickii*), bean goose (*Anser fabalis*), lesser white-fronted goose (*Anser erythyropus*), greater white-fronted goose (*Anser albifrons*), black brant (*Branta nigricans*), king eider (*Somateria spectabilis*), long-tailed duck (*Clangula hyemalis*), pintail (*Anas acuta*), common teal (*Anas crecca*), Eurasian wigeon (*Anas penelope*), greater scaup (*Aythya marila*), and Baikal teal (*Anas formosa*). Bean geese were the most common waterfowl species we encountered along the survey route with most other species being present in relatively low numbers. Hunters we interviewed stated spectacled eider (*Somateria fisheri*) and Steller's eider (*Polystica stelleri)* occur in low numbers on the study area, but we did not observe these species (also see Hodges and Eldridge 1995). Siberian cranes shared the study area with sandhill cranes (*Grus canadensis*) which occur in low densities (G. Krapu, unpublished data). Three species of loons (*Gavia* spp.), numerous species of shorebirds, 3 species of jaegers (*Storcorarius* spp.), and several species of gulls also were present.

## METHODS

To determine Siberian crane distribution, estimate density, and identify social status, surveys were conducted by amphibious vehicle (total distance traveled = 460 km) and boat (125 km) during 16 July-2 August 2009. The survey route began at the village of Tumat near the northern edge of the forest tundra ecotone (Fig. 2). About 20 km north of the village and extending to the coast, the landscape is coastal tundra. From Tumat, the survey route first proceeded toward Nuestroevo Station near Sellyakhskaya Bay on the Laptev Sea, then east to Lake Soluntakh, and from there southwest toward Churpunnya Mountain, and then finally west and south back to Tumat (Fig. 2).

To allow the driver of the amphibious vehicle to stay on the designated survey route, coordinates of the planned route were programmed into 2 Delorme GPS units in advance of field work. Landscape imagery of the arctic coastal plain along the survey route was programmed into each GPS unit before the expedition to provide crane surveyors with an aerial view of the landscape outward from the vehicle to a distance of 8 km. This width of imagery provided crane surveyors with detailed knowledge of the surrounding landscape and allowed crane locations to be plotted with greater precision. Plastic laminated NASA images of the study area were carried during surveys and crane locations were plotted at appropriate locations as a backup in the event of failure or loss of the GPS units.

Siberian cranes were often first sighted with binoculars. Confirmation that species identification was correct occurred by observation of each individual through the lens of a 60× Bausch and Lomb spotting scope. Whooper and Bewick's swans nest at low densities across the study area which made higher magnification necessary to verify correct species identification especially at long distances. We frequently stopped to scan the landscape from the highest elevations available (e.g., standing on top of the vehicle or other elevated sites such as edomas) to maximize opportunities for sighting cranes present along the transect routes.

The land survey route crossed parts of both the Khroma River core area and buffer zone (Fig. 2) delineated by Degtyarev and Labutin (1991). The survey route was divided into transects, defined by the section of the survey route driven each day. The Khroma core and buffer zone contained 5 and 9 transects totaling 149.8 and 240.9 km, respectively. Boat surveys were conducted adjacent to lower parts of the Syalakh and Syuryuktyakh Rivers where terrain prevented crane surveys by tracked vehicle. During boat surveys, cranes on wetlands adjacent to the river channel were visible only during stops where observers could climb on top of elevated river banks bordering the river. River stops to search for cranes generally were made where large wetlands bordered the river and elevated river banks offered an opportunity for viewing across extensive wetland habitat. The boat survey method was effective in locating cranes on major wetlands along rivers, but cranes may have been missed in areas adjacent to stretches of river where no elevated viewing sites were available. As a result, we did not attempt to estimate crane densities for landscapes where surveys were conducted only by boat.

Density estimates of Siberian cranes for the Khroma core and buffer area were computed as the number of individuals per $km^2$ using distance sampling methods (Buckland et al. 2001). When a crane was sighted, the location of the crane was plotted on the base map of the study site which had been uploaded to the screen of the DeLorme GPS unit and the distance from the vehicle to the crane (in km) was computed by the GPS unit. At the point on the transect route where the line from the vehicle to the crane was perpendicular to the first line of sight from vehicle to crane location, the distance from the vehicle to the crane was also computed. These measurements were used to estimate probability of crane detection during surveys to provide a more reliable estimate of crane density along the survey route than if we had assumed all cranes were sighted. Six models suggested by Buckland et al. (2001; models: half normal key with cosine adjustments, half normal key with Hermite polynomial adjustments, uniform key with cosine adjustments, uniform key with simple polynomial adjustments, hazard-rate key with cosine adjustments, and hazard-rate key with simple polynomial adjustments) were used for modeling the detection function in Distance 5.0 (Thomas et al. 2010). Akaike's Information Criterion (AIC) was used to evaluate the suitability of these 6 models; if multiple models found suitable, model averaging techniques were used to compute all estimates (Burnham and Anderson 2002). Since cranes were observed in clusters, the density of crane clusters was first computed and then the density of cranes was computed as the density of clusters times the average cluster size. A combined density estimate of cranes for the Khroma core and buffer zone was computed as a weighted average of these 2 estimates, using the total transect length surveyed (in km) as the weight. Following Buckland et al. (2001), we truncated the longest 10% of the distances of observations, resulting in a truncation width of 4,188.9 meters.

Wetland types used by Siberian cranes were identified after taking into consideration depth, size, and vegetation using the wetland classification system of Bergman et al. (1977), developed for the arctic coastal plain of Alaska, or where appropriate, wetlands were classified using the landscape classification developed for northern Yakutia by Fedorov et al. (1989). Siberian cranes also were recorded by their social status, i.e., as pairs, singles, and groups (3+ cranes). Supplemental information on status of Siberian cranes on the study area was obtained from interviews with hunters, fishermen, and reindeer herders encountered during crane surveys or during time spent at the village of Tumat.

We evaluated whether density of Siberian cranes found on transects in the Khroma core was representative of the entire Khroma core by examining if the habitat within the survey route was representative of the habitat outside the survey route. Forty random points were selected from within the survey route and 60 random points were selected from outside the survey route, in both the Khroma core and buffer zone. The survey route was defined as the width of 5.6 km on either side of the vehicle path. For each of these points, the habitat composition (% wetland, % open water, and % upland) was identified within 1, 2, 3, 4, 5, and 6-km radii from each point. Landsat imagery of the Khroma core and buffer zone provided the baseline information used to assess habitat composition. To evaluate whether our crane density estimates within the survey route could be used to provide a reliable estimate of the number of Siberian cranes present across the entire Khroma core and buffer zone, we compared the habitat composition of the random points within the survey route to the random points outside of the survey route across the entire Khroma core and buffer zone. We used histograms, empirical distribution plots and Kolmogorov-Smirnov's test to determine if the distribution of each composition variable was the same inside and outside the survey route.

## RESULTS

Weather conditions were suitable for conducting surveys on 18 of the 20 survey days. Snowfall during surveys was limited to flurries on the evening of 20 July, and the snow melted soon after falling. The winter snow accumulation had melted completely by the date of our arrival on the study area, eliminating a potential major limitation to sighting large white birds on the tundra landscape.

Of the 142 cranes surveyed, 110 (77%) were paired, 21 (15%) were singles, and 11 (8%) birds were in groups of 3-5 (Table 1). The pair/single crane ratio averaged 2.6:1 across the Khroma River core area, the buffer zone, and outside the breeding range (Table 1). The pair to single ratio in the Khroma core and buffer zone averaged 2.8:1 and 1.8:1, respectively. No flightless young were sighted during surveys. Some of the paired adults exhibited behaviors suggesting they may have been accompanied by colts, but confirmation was not possible. Interviews with local reindeer herders, hunters, and fishermen along the survey route indicated that Siberian cranes have occurred on the study area for as long as they could remember with adult pairs often being accompanied by colts.

Nineteen crane clusters ($n$ = 36 birds) were sighted on the 9 transects located in the buffer zone, and 39 clusters ($n$ = 69 birds) were seen on the 5 transects of the Khroma core area. Thirty-two cranes, including 13 pairs, were sighted outside of the known breeding range during boat surveys in the lower drainages of the Syalakh and Syuryuktyah Rivers. Eleven cranes were recorded, including 4 pairs, on a large coastal wetland at the mouth of the Syalakh River adjacent to Sellyakhskaya Bay of the Laptev Sea (Fig. 3). Though cranes were widely distributed throughout the coastal tundra area (Fig. 3), none were seen on transects within the taiga/tundra ecotone. Crane clusters consisted of 1-5 birds with an average size of 1.8 (SE = 0.1) cranes per cluster.

All 6 models considered for modeling the detection function fit well (all ΔAIC < 2). Therefore, all estimates given are model averaged estimates using all 6 models. The estimated probability ($P$) of detection of Siberian crane clusters was 0.48 (95% CI = 0.281-0.833, Fig. 4). Siberian crane densities in the Khroma core and buffer zone were estimated to be 0.09 cranes/km$^2$ and 0.04 cranes/km$^2$, respectively (Table 2). After accounting for probability of detection, crane density averaged 0.06 cranes/km$^2$ across both the Khroma core and buffer zone. We did not extrapolate our findings to estimate total number of cranes for the entire Khroma core because the proportion of the landscape in preferred crane habitat observed within the survey route was lower than that proportion outside the survey route. Conversely, preferred crane habitat formed a higher proportion of the habitat within the transect area of the buffer zone than in the non-surveyed part of the buffer zone.

Siberian cranes in the coastal tundra zone were most often associated with complexes of often interconnected large wetlands (Table 3). Siberian cranes typically occurred in the central zone of large wetland basins, low terrace wetlands adjacent to the Syalah and Syuryuktyah Rivers, and to a lesser extent, wetlands located in valleys of small rivers. Eleven cranes, including 4 pairs were observed in 1 of 2 Class VIII coastal wetlands that bordered Sellyahkskaya Bay (near the Nuestroevo Station, Fig. 3 and Table 3). The largest wetland occupied by Siberian cranes along the coast was approximately 1,000 ha. In wetland

**Table 1. Social status of Siberian cranes sighted along transects on the Khroma River core breeding area, the buffer zone surrounding the Khroma River core breeding area (see Degtyarev and Labutin 1991), and lands lying to the west of the delineated breeding range in the Ust-Yana District of northern Yakutia. Percentages of Siberian cranes are listed by social status. Number of cranes in each social status category is listed in parentheses.**

| Crane social status | Khroma River core breeding area | Khroma River buffer area | Outside known breeding range | Total |
|---|---|---|---|---|
| Pairs | 28 (56) | 14 (28) | 13 (26) | 55 (110) |
| Singles | 10 | 8 | 3 | 21 (21) |
| Ratio (pairs/singles) | 2.8:1 | 1.8:1 | 4.3:1 | 2.6:1 |
| Groups (3-5) | 1(3) | 1(5) | 1(3) | 3 (11) |
| Totals | 69 | 41 | 32 | 142 |

**Table 2. Densities of clusters and individual Siberian cranes on the Tamut study area in the eastern Ust-Yana District of northern Yakutia after adjustment for probability of detection. Ground surveys were conducted during 16 July-2 August 2009.**

| Area | Density of clusters (no./km$^2$) | Density of individuals (no./km$^2$) | 95% CI |
|---|---|---|---|
| Buffer | 0.0202 | 0.0363 | (0.0150-0.0877) |
| Khroma core | 0.0513 | 0.0921 | (0.0350-0.2429) |
| Overall | 0.0321 | 0.0577 | (0.0256-0.1300) |

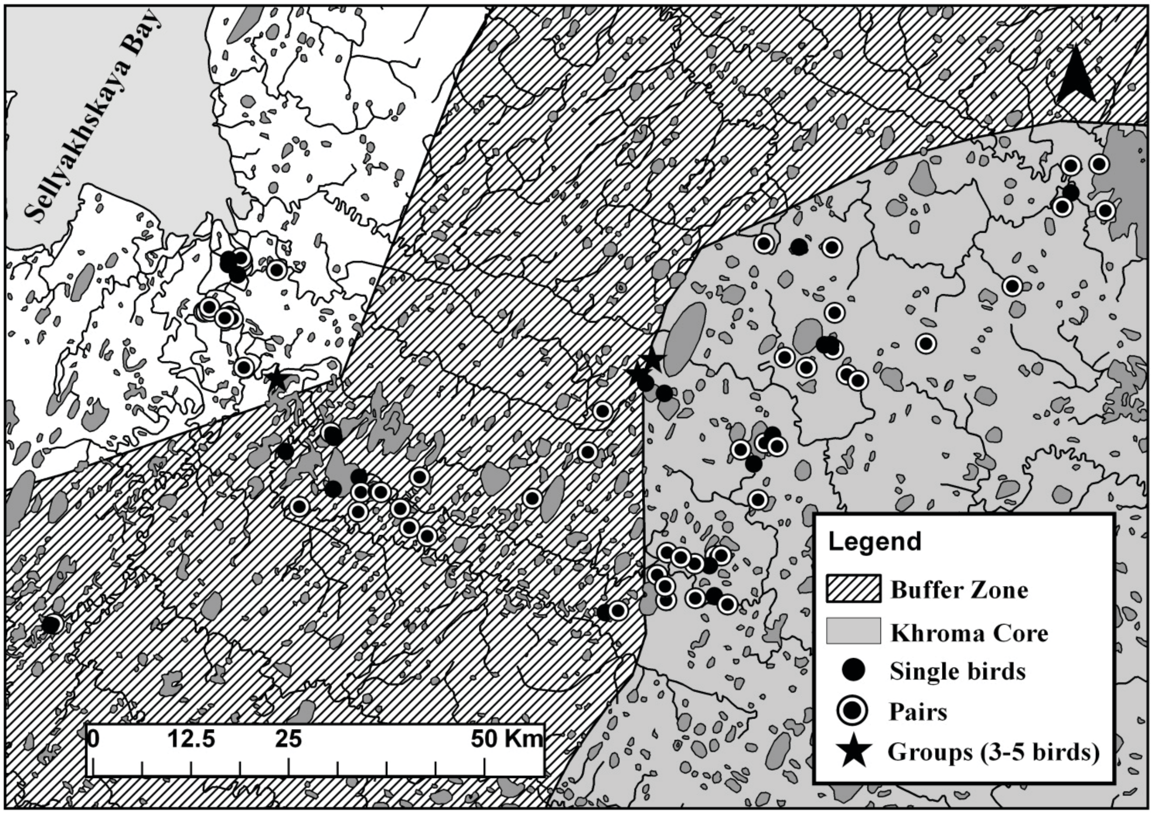


**Figure 3. Distribution of sightings of Siberian cranes in the western part of the Khroma core, buffer zone, and to the west of the buffer zone during surveys conducted 16 July-2 August 2009 in the Ust -Yana District of northern Yakutia, Russia.**

types occupied, Siberian cranes were most often found in stands of pendant grass surrounded by open water. Although large temporary wetlands dominated by *Carex* spp. were widespread on the study area, Siberian cranes generally avoided these habitats. Only 1 of the 142 cranes (0.7%) was observed on a non-wetland site.

## DISCUSSION

### Breeding Distribution and Densities

Siberian cranes were a common species within transects located in the coastal tundra zone of the Ust-Yana District. Distribution of Siberian cranes we observed suggests some changes in breeding distribution when compared to the distribution reported by Flint and Kistchinski (1981), who did not find Siberian crane nesting on the arctic tundra lowlands of river deltas near the sea, on river floodplains, or on uplands. We similarly did not find Siberian cranes in the uplands. However, we found breeding pairs to be relatively common in large wetlands on arctic tundra north of the forest tundra ecotone, along with significant numbers of pairs occurring in wetlands located on river floodplains near the sea, and on a large coastal wetland. No previous records have been reported for Siberian crane pairs occupying coastal wetlands in northern Yakutia (A. G. Sorokin, personal communication). Inland from the coast, a few sightings of Siberian cranes had been previously reported west of the designated breeding range including 2 nesting records: a nest found in 1970 along the lower reaches of the Chondron River (Fig. 1A, Flint and Kistchinski 1981) and a second nest found on 26 June 1994 (Fig. 1A, Poyarkov et al. 2000). A pair with a colt was sighted west of the Sellyakh River in 1980 (Degtyarev and Labutin 1991). Other large wetlands we did not visit outside the delineated breeding range in the same general area likely also supported Siberian cranes. Presence of numerous breeding pairs in the areas described suggests the breeding range be extended about 20-25 km northwest from the currently

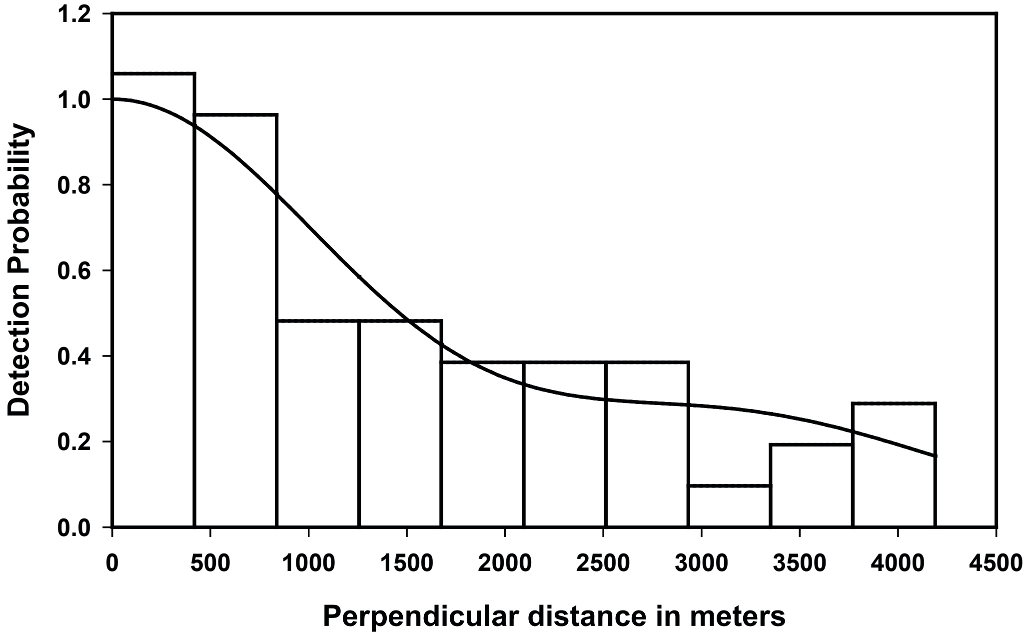


**Figure 4. Probability of a Siberian crane being detected based on the model fit with a half normal key function and cosine adjustment. Six models with varying key functions and adjustments to model the detection function were considered and fit using Distance 5.0 (Thomas et al. 2010). The model fit for the other 5 models considered were similar to that displayed here. Density estimates were computed by model averaging estimates from these 6 models. The model averaged estimate of the probability of detection (*P*) is 0.484 (CI: 0.281-0.883).**

designated range boundary (Degtyarev and Labutin 1991).

Distribution differences of Siberian cranes in the Khroma region noted between our study and Flint and Kistchinski (1981) suggest birds have moved into wetland habitat closer to the Laptev Sea over the past 40 years, and this shift may have been linked to climate change. Our inspection of meteorological data collected from this region over the past 70 years shows a major lengthening of the ice-free period and growing season in this region as ambient temperatures have increased (G. Krapu, unpublished data). An earlier and more extensive melting of the polar ice pack of the Laptev Sea in recent decades has caused the climate along the coast to moderate, creating conditions more conducive to crane breeding. Climate change may also pose increased risks to Siberian cranes due to modifications in the tundra landscape and increased weather unpredictability (Pshennikov and Germogenov 2001). Population growth may have contributed to higher than

**Table 3. Habitat use by 142 Siberian cranes sighted along transects in the Ust-Yana Region of northern Yakutia during 16 July-2 August 2009.**

| Wetland type | No. cranes | % | Pairs | Singles | Groups |
|---|---|---|---|---|---|
| Complexes of large wetlands | 93 (38)[a] | 65 | 37 | 11 | 2 [3, 5] |
| Low terrace[b] | 21 (5) | 15 | 10 | 1 | 0 |
| Small valley[b] | 14 (18) | 10 | 4 | 3 | 1 [3] |
| Coastal (VIII)[c] | 11 (1) | 8 | 4 | 3 | 0 |
| Other (flying, upland) | 3 (0) | 2 | 0 | 3 | 0 |
| Totals | 142 (62) | 100 | 55 | 21 | 3 |

[a] Number of wetlands by wetland type used by cranes listed in parentheses.
[b] Permafrost landscape classification by Fedorov et al. (1989).
[c] Wetland classification of Bergman et al. (1977).

expected crane densities in the Khroma core and buffer zone.

Aerial surveys of Siberian cranes undertaken prior to 1980 on their main breeding grounds in northern Yakutia produced Siberian crane density estimates much lower (Table 4) than we found on our study area (Table 2). However, Degtyarev and Labutin (1991) based on work that began in 1980 reported average densities as high as 0.038 cranes/km$^2$ on the Alazeya core (1985), 0.025 cranes/km$^2$ on the Indigirka core (1985), and 0.028 cranes/km$^2$ for the Khroma core, estimates that more closely approached crane densities gained during this study. Hodges and Eldridge (1995) from aerial surveys of a 43,300 km$^2$ area between the western edge of the Indigirka Delta to about the western edge of the Khroma core estimated a Siberian crane density of 0.023 cranes/km$^2$. Their survey route included areas outside the Khroma and Indigirka cores and buffers, and when crane density was estimated only for the southern half (21,650 km$^2$ area) of their surveyed area where all 10 Siberian cranes were sighted, crane density increased to 0.049 cranes/km$^2$, which approaches our estimate of 0.058 cranes/km$^2$ for the area we surveyed. Higher densities of Siberian cranes reported by Degtyarev and Labutin (1991), Hodges and Eldridge (1995), and this study when compared to pre-1980 surveys might reflect growth in the Eastern Population of Siberian cranes over the past 30 years, but differences in methods used and areas covered prevent a direct comparison.

We found evidence that sufficient breeding occurs beyond the boundaries of the delineated breeding range on the west edge to recommend this area be included within the breeding range probably through expansion of the buffer zone. The low densities obtained from aerial surveys of the Yakutia breeding grounds prior to 1980 may reflect, in part, less attention given to sampling methods and probability of detection than during the 1980s (Degtyarev and Labutin 1991), 1990s (Hodges and Eldridge 1995), and the current study. Results from our survey, when compared to previous findings, suggest ground surveys provide a reasonable alternative method for estimating crane densities on areas surveyed within cores and the buffer zone in northern Yakutia. However, the wide distribution of lakes and other wetlands in the Khroma region make ground travel difficult, reducing ability to obtain a sample of lands representative of the core area or the buffer zone limiting the area of inference to lands surveyed.

## Habitat Use

Siberian cranes (especially pairs) were observed using large basin, river terrace, and small valley wetlands (Table 3) and occurred principally in extensive stands of pendant grass where present in central parts of wetlands. At Kytalyk Nature Reserve, Siberian cranes also utilized large wetlands (see Watanabe 2006, Fig. 5), and all 3 nests that were located were in *Carex* spp. Our surveys were conducted after the nesting period and we did not search for or locate nests, but because of the close affinity to pendant grass beds, we suspect most nesting on our study area occurred in this cover type.

Large relatively shallow wetlands with extensive stands of pendant grass allow Siberian cranes to nest over water at considerable distances from shore which likely

**Table 4. Estimated numbers of Siberian cranes in the main breeding areas in northern Yakutia, 1957-1980, based on indicated studies.**

| Information source | Period | Area of main habitat (km$^2$) | Density (no./km$^2$) |
|---|---|---|---|
| Vorobyov (1963) | 1957-1960 | | 400-500 |
| Uspenski et al. (1962) | 1960 | 2,500-3,000 | 1,000-1,400 |
| Egorov (1965) | 1963 | 20,000 | 900 |
| Egorov (1971) | 1963-1964, 1966 | 32,000 | 1,500 |
| Flint and Kistchinski (1975) | 1971 | 130,000[a] (30,000)[b] | 300 (0.0051) |
| Flint and Sorokin (1982)[a,b] | 1977-80 | | 250-300 |
| Perfiliev (1965) | 1960-1962 | | 600-700 |
| Perfiliev and Polyakov (1979) | 1975, 1977 | 130,000[a] (30,000)[b] | 700 (0.007) |
| Vshivtsev et al. (1979) | 1978 | >130,000[a] (51,000)[b] | 325 (0.0058) |
| Labutin et al. (1982) | 1980 | 65,560[a] | 433 (0.0075) |

[a] Total area of distribution of the main part of the Siberian crane population.
[b] Regular nesting area of the Siberian crane population.

helps to deter mammalian predators from destroying nests while also providing suitable foraging habitat. Most cranes we observed were foraging in pendant grass stands but at distances too great to determine foods being taken. Polar (arctic) fox, the primary mammalian predator on the study area, generally avoid having to travel long distances over water to reach nests of species nesting in wetlands (Vorobyov 1963). Siberian crane nests typically are located in 25-60 cm of water (Vorobyov 1963, Flint and Kistchinski 1975) although nests can occur at more shallow depths. For example, Watanabe (2006) recorded an average water depth of 10.5 cm at Siberian crane nests ($n$ = 3) on his study area in the Kytalyk Nature Reserve. Wetlands used by Siberian cranes on our study area were shared with 3 species of jaegers and several species of gulls, all potential egg or young chick predators. As a result, crane eggs or newly hatched young become highly vulnerable if left unattended; such losses are likely low as Siberian cranes generally do not leave nests unattended (Flint and Kistchinski 1975). Adults are seldom captured by predators, and from interviews with people living in the region, Siberian cranes appear to rarely be shot or otherwise taken by humans.

## Social Status of Siberian Cranes

Pairs accounted for 77% of the birds we surveyed (Table 1) compared to 80% of birds observed in 1973 on Yakut breeding areas by Flint and Kistchinski (1981). Flint and Kistchinski (1981) concluded that only 62% of pairs were territorial and half of the territorial birds actually nested. Degtyarev and Labutin (1999) and Pshennikov and Germogenov (2000) found 4.3-64.5% (mean = 34.6, SD = 18.5) of pairs sighted actually nested across 9 years of data collection. Comparing results from Flint and Kistchinski (1981) to our study area would mean that of the 55 pairs we surveyed, only 34 pairs would have been territorial, of which about half ($n$ = 17 pairs) would have nested. We did not have an opportunity to study individual pairs for a sufficient length of time to confirm whether pairs were territorial or nesting occurred. According to Flint and Kistchinski (1981), about 34% of Siberian cranes on the Yakut breeding grounds they studied were 3 years old and 42% were 4+ years old. Single birds which represented 15% of the birds on our study area generally are 1 or 2 years old (Flint and Kistchinski 1981). Groups of 3 or more consisted of unmated birds.

## Research Needs

Detailed knowledge of the distribution, density, and habitat use on breeding grounds of Siberian cranes in northern Yakutia continues to be an important research need that will help guide future habitat protection efforts. Further research will be needed to determine extent of expansion in breeding range boundaries, particularly along the western edge of the breeding range. Obtaining a more comprehensive understanding of Siberian crane distribution and habitat use on the breeding grounds, staging areas, or wintering grounds, along with gaining better insight into the effect of climate change, and other factors on annual productivity in the Eastern Population has become more feasible with recent advances in satellite telemetry technology. It is now possible to monitor sites used by tagged cranes on a daily basis throughout the annual cycle, allowing a comprehensive assessment of sites used in meeting Siberian crane needs. Solar-powered transmitters are being used to collect similar types of data on the endangered whooping crane (*Grus americana*) in North America, where only about 300 individuals remain in the wild Aransas-Wood Buffalo flock (G. Krapu, unpublished data). The improved ability to obtain detailed information on distribution of tagged individuals throughout the annual cycle, including daily activity movements, also would be useful when deciding when and where to conduct aerial and ground population surveys of Siberian cranes.

## Conservation Issues

The large number and high density of Siberian cranes we encountered during surveys of the Khroma core and the high ratio of pairs among cranes sighted on the Khroma core are of special significance in light of the endangered status of this species. The Khroma and Indigirka cores are the largest (Fig. 2) and most important breeding grounds of the Siberian crane remaining in the world. The high densities of Siberian cranes observed on the Khroma core, buffer zone, and adjacent area reflect that wetland habitats present are exceptionally productive and well suited to meeting the birds' needs. We recommend that consideration be given to providing formal protection through establishing a nature preserve on a major portion of lands lying between the east bank of the Syalakh River and the western boundary of Kytalyk Nature Reserve and from the south boundary of

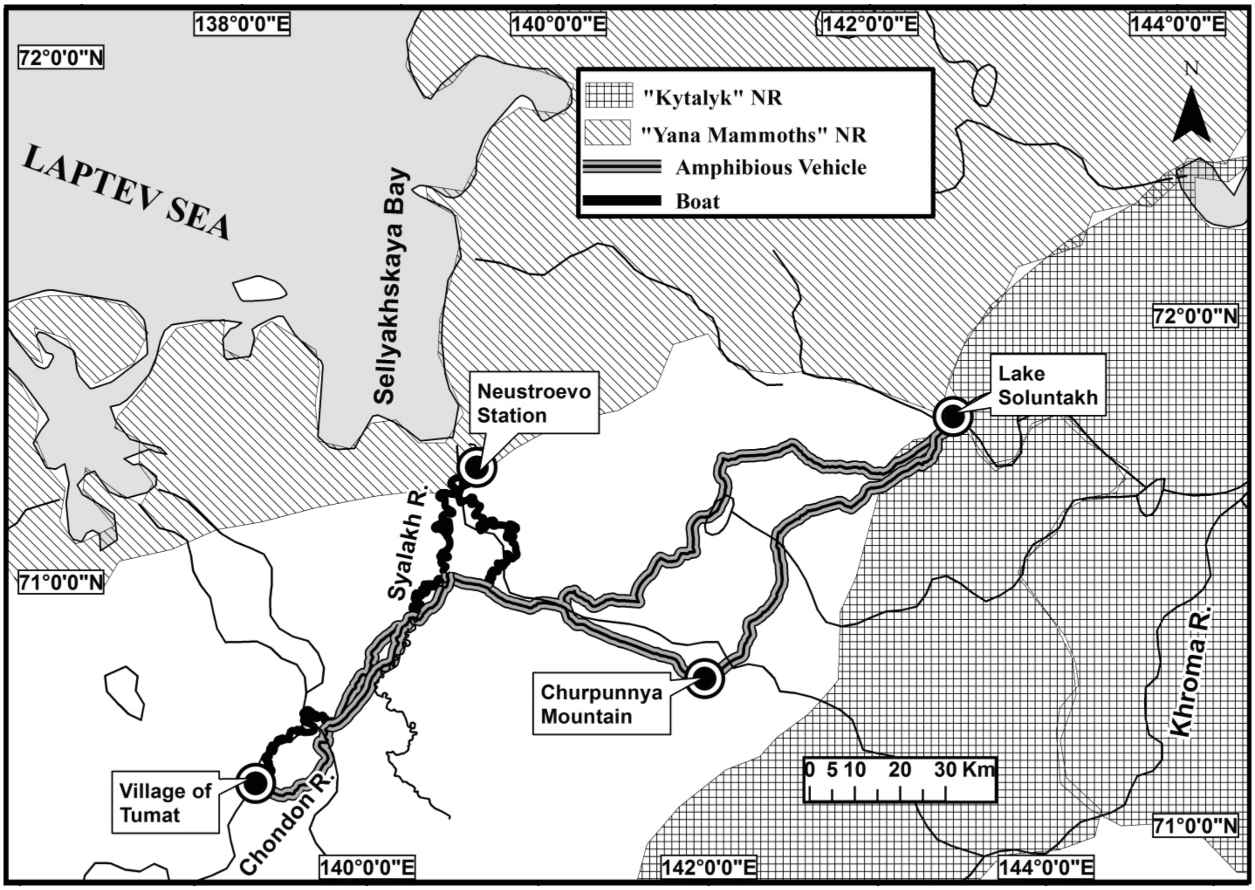


**Figure 5. Location of our study area between Kytalyk Nature Reserve and Yana Mammoths Nature Reserve in the eastern Ust-Yana District in northern Yakutia, Russia. The authors propose a nature reserve be established to protect key breeding habitat of Siberian cranes that currently remains unprotected between the existing nature reserves.**

Mammoths Nature Reserve to the southern boundary of the Khroma core and adjacent buffer zone (Fig. 5). This reserve would focus on currently unprotected parts of the Khroma core, adjacent buffer zone, and lands lying to the west of the designated breeding range and would represent a major step ensuring the protection of a key breeding ground of the Eastern Population of Siberian cranes. These lands also serve as important breeding and staging sites for numerous species of Eurasian shorebirds and waterfowl.

Our study area lies within a part of the eastern arctic of Asia that was not glaciated, was grassland steppe throughout the Pleistocene Epoch, and in the absence of continental glaciers was populated by woolly mammoths (*Mammuthus primigenius*) and numerous other large prehistoric mammals which flourished for much of the last million years (Hopkins et al. 1982). Mammoth bones and carcasses are widespread in this region along with the remains of other species of prehistoric mammals adding to the significance of the natural history of the study area. With the remains of mammoths present and their tusks valuable, tracked vehicles are being used to search for mammoth tusks leaving deep ruts particularly in or near wetlands and causing damage to the fragile tundra environment. Failure to limit tracked vehicle traffic on the tundra during the period when the surface is not frozen is likely to lead to severe erosion and washouts as water accumulates in the tracks and permeates downward as the permafrost melts. To the extent feasible, use of vehicle types that destroy the tundra vegetation exposing the tundra soils should be avoided particularly during the months when surface soils are not frozen.

The wilderness character of the study area along with the well-being of wildlife populations inhabiting the region studied would be enhanced by a cleanup of the abandoned tin mine on Churpunnya Mountain. This privately-owned mine had gone bankrupt and had been abandoned a few months prior to our arrival at the site in late July 2009. Discarded equipment and other debris from the mining operation were strewn over a large area on the northeast slope of the mountain. Polluted water contained in holding ponds in the mined area poses a potential threat to cranes and other wildlife living in the area should this water drain into wetlands located north and east of the site. In 2 instances, single Siberian cranes had been found dead in the vicinity of Churpunnya Mountain in years just preceding our visit (Y. P. Stoyan, personal communication). Ten Siberian cranes (5 pairs) were observed from the north slope of the mountain, reflecting the area supports a high density of this species. One potential option in conjunction with a cleanup would be to establish a biological research station at this site focusing on studies of tundra-nesting Siberian cranes and other wildlife indigenous to this region. The site would be well suited for studies evaluating effects of climate change on the biota of this region.

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