Nest Density of Shorebirds Inland from the Beaufort Sea Coast, Alaska

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Because scant information exists on the distribution, abundance, and habitat use of shorebirds nesting in the National Petroleum Reserve-Alaska, we determined nest densities of shorebirds in tundra habitats at Inigok, Alaska. We searched for shorebird nests on 29 plots (4 ha each) between 10 June and 18 July 1998 and surveyed for plover pairs on a 12.8-km^2 plot. Thirteen shorebird species bred at Inigok, and nest density was highest in drained-lake basins (mean = 80.0 nests/km^2). Semipalmated Sandpipers (*Calidris pusilla*) and Pectoral Sandpipers (*C. melanotos*) were the most abundant shorebirds breeding at Inigok and nested exclusively in drained-lake basins (mean = 30.0 nests/km^2 each). Only American Golden-Plovers (*Pluvialis dominica*) nested in appreciable numbers (2.57 pairs/km^2 on a single plot) in tussock/ridge tundra. Although constituting a relatively small proportion of the tundra at Inigok (10.5%), drained-lake basins supported a disproportionate number of breeding species and individuals and may support sizable portions of the populations of Semipalmated Sandpipers and Pectoral Sandpipers breeding on the North Slope. Development plans for inland sites on the North Slope should consider the importance of drained-lake basins to nesting shorebirds.

Key Words: *Calidris*, Sandpipers, shorebirds, density, nest, tundra, breeding, Alaska.

On Alaska's North Slope, an area that extends north from the Brooks Range to the Arctic Ocean, the National Petroleum Reserve-Alaska (NPR-A) provides some of the most productive shorebird habitat in northern Alaska. Thirty-one species of shorebirds are known to have bred on the North Slope and nearly 6 million shorebirds are thought to spend the summer in the 95 800 km^2 NPR-A (Pitelka 1974; Gusey 1979*). Despite the high diversity of breeding shorebirds, little quantitative information exists on their distribution and abundance among tundra habitats in NPR-A.

Our knowledge of North Slope shorebirds has come mainly from multiple-year studies in a few locations that include recent work at Prudhoe Bay (e.g., Troy 1996) and the Colville River Delta (Andres 1994; J. R. Bart, U.S. Geological Survey, personal communication) and earlier studies in the Arctic National Wildlife Refuge (Martin 1983; Oates et al. 1985*) and at Barrow (e.g., Myers and Pitelka 1980*). Most studies were restricted to coastal areas within the Arctic Coastal Plain province (Wahrhaftig 1965), whereas work inland from the coast in the Arctic Foothills and Arctic Mountains provinces has been largely neglected. Furthermore, few data on shorebird nest densities are available for the NPR-A; previous investigators combined counts of individuals during breeding and nonbreeding seasons, did not sample all habitats shorebirds used, did not design studies to yield estimates of nest density, or focused on coastal-zone use during migration (e.g., Connors et al. 1984*; Derksen et al. 1981; King 1979*; Myers and Pitelka 1980*). Lastly, much of the information on nest densities and habitat use of shorebirds on the North Slope exists only in unpublished sources.

Because of increasing oil development pressure within the NPR-A (U. S. Department of the Interior 1998*), habitats that support high densities of nesting shorebirds need to be identified. Information currently available is inadequate to assess the importance of regions or habitats to shorebirds breeding there. We therefore initiated a field study at Inigok, a site located inland from the Beaufort Sea coast, to determine nest densities of shorebirds in tundra habitats.

Study Area

Inigok is located 65 km from the Beaufort Sea (70°00′ N, 153°05′ W; Figure 1) and is dominated by tussock tundra with relatively high relief (elevations ranged from 30 to 80 m). The area has numerous large lakes and ponds that lie in an ancient dune complex oriented in an east-west direction. Lakes are often bordered on the east and west by drained-lake basins (former lakes that have gradually drained over time) and on north and south by bluffs (5–10 m). Patterned ground (polygons) is rare in the area but is sometimes associated with drained-lake basins and former stream channels. Tapped lakes (lake basins

*See Documents Cited section.

Figure 1. Location of shorebird nesting study at Inigok on the North Slope of Alaska, 1998.

that are breached by a stream and have rapid drainage) and beaded streams (streams interrupted by numerous pools) feed the Fish and Inigok creek drainages. A gravel airstrip constructed in 1978 to support the drilling of an oil exploration well provided access to the site.

Methods

We used a vegetation classification map of the NPR-A generated by the Bureau of Land Management and Ducks Unlimited (BLM/DU; Kempka et al. 1995*) to define three major vegetation cover types at Inigok: drained-lake basin, tussock tundra, and ridge tundra. Drained-lake basins comprised a mosaic of aquatic, wet, and moist tundra and were usually associated with large lakes. Tussock tundra dominated gradual slopes and consisted of moist to dry sedge and prostrate shrubs. This was the most common vegetation type at Inigok and it formed a transition between drained-lake basins and ridge tundra. Ridge tundra occurred in narrow bands of hummocky, disturbed soil colonized by *Dryas* spp., *Cassiope* spp., and lichens.

To compare shorebird nest densities among inland sites on the North Slope, we collapsed the habitat classification scheme used on the Arctic National Wildlife Refuge (ANWR) by Oates et al. (1985*) into two major vegetation types — upland and lowland tundra. Four of their vegetation types (flooded, wet sedge, moist sedge, and mosaic tundra), derived from Walker et al. (1982), constituted lowland tundra cover types that were similar to drained-lake basins at Inigok. Upland tundra comprised moist sedge-shrub and tussock classes of Oates et al. (1985*) and was similar to combined tussock/ridge tundra at Inigok.

We delineated 29 survey plots within 7 km of camp; random plot locations were selected by GIS-based stratification of vegetation types. Within each of the three tundra vegetation types, we placed several 4-ha plots for intensive nest searching. Dimensions of drained-lake basin and tussock plots were 200 m × 200 m, and dimensions of ridge plots were 400 m × 100 m (designed to more closely follow natural delineations of ridge habitat). Plot-corner (tussock and basin plots) or center-line (ridge plots) locations were determined by PLGR-GPS (Precision Lightweight Ground Receiver — Global Positioning System), and all plots were delineated on the BLM/DU vegetation map. Boundaries were marked with wire flags to aid navigation on the plot. Ten plots (40 ha total) each were placed in drained-lake basin and tussock tundra, and nine plots were placed in ridge tundra (36 ha total).

Between 10 June and 8 July 1998, we searched plots at 7- to 10-day intervals to locate all shorebird nests. Intensive nest searching was performed by a single observer who walked the plot in a "zig-zag" manner in an attempt to record all nests within plot boundaries; rope-dragging was not performed. Duration of plot surveys varied from 1 to 6 hours and depended on nest density, bird abundance, and plot vegetation type; drained-lake basin plots required the most time, and ridge plots required the least. Besides finding nests, observers recorded the number, species, and sex (when possible) of all shorebirds present during each plot visit. To minimize bias due to differences in nest-finding ability, we rotated

assignments to avoid sequential searches of a plot by the same observer.

We used a two-sample randomization procedure to compare species-specific nest density among the tussock/ridge tundra and drained-lake basins (Manly 1991). We performed 5000 iterations for each test to compute a mean difference between habitats (D) and associated P-values. Standard errors of mean nest density, using normal equations, were calculated for each cover type. We used the relative distribution of tussock/ridge tundra and drained-lake basins, computer-derived from the BLM/DU map, to define stratum weights and used a stratified random sample estimator to determine the mean nest density for the entire Inigok area.

In addition to intensive plot surveys, we searched for American Golden-Plover (*Pluvialis dominica*) and Black-bellied Plover (*P. squatarola*) pairs on a 12.8-km² plot, within the study area boundaries, during a single, intensive nest-searching period (20 – 23 June). For each plover pair found, we attempted to locate a nest to confirm breeding; all pair and nest locations were plotted on 1:63 000 aerial photos. Plover surveys were made across all vegetation types and yielded an absolute density of nesting plovers at Inigok (we did not include lakes, ponds, the airstrip, or other disturbed areas in our calculation of plover density).

Results

Thirteen shorebird species bred at Inigok in 1998. Ten of these nested on our 4-ha plots (Table 1), and one additional species, the Black-bellied Plover, nested on the plover study area. The Western Sandpiper (*Calidris mauri*) and Ruddy Turnstone (*Arenaria interpres*) nested in low densities at Inigok but were not recorded on plots. Although shorebirds nested in all vegetation types sampled on 4-ha plots, the density of all species was highest in drained-lake basins and was significantly higher there than in tussock/ridge tundra (randomization test, $D = 68.2$, $P = 0.0002$). Semipalmated Sandpipers (*C. pusilla*) and Pectoral Sandpipers (*C. melanotos*) were the most abundant shorebirds nesting at Inigok, and both nested exclusively in drained-lake basins (Table 1). Thus, nest densities of these two species were significantly higher in drained-lake basins than in tussock/ridge tundra ($D = 30.0$, $P = 0.0002$). Nest density of Red-necked Phalaropes (*Phalaropus lobatus*) tended to be higher in drained-lake basins than in upland tundra ($D = 10.0$, $P = 0.0568$). Too few nests of other shorebird species were found to detect significant, species-specific differences in density between tundra vegetation types (Table 1).

We found 20 American Golden-Plover nests (1.56 nests/km²) of 33 probable breeding pairs (2.57 pairs/km²) within the plover study area but only three pairs (0.23 pairs/km2) and two nests (0.16 nests/km²) of Black-bellied Plovers. Most nests of American Golden-Plovers were found in ridge tundra or on sparsely vegetated hummocks in tussock tundra, whereas nests of Black-bellied Plovers were located on sparsely vegetated hummocks in drained-lake basins or in a similar vegetation type found in abandoned creek channels.

Discussion

Our study at Inigok is only the second in the NPR-A to furnish nest densities of shorebirds breeding inland from the Beaufort Sea coast. The other site, Atkasook (located 48 km from the coast), was surveyed for three years in the late 1970s (Myers et al. 1978, 1979, 1980), and the lowland habitats sampled there closely corresponded to drained-lake basins at Inigok. Although nest density of all shorebirds in drained-lake basins at Inigok exceeded that found in lowland tundra at Atkasook (48.3 nests/km²), nest density across the entire Inigok area was about 50% lower.

Overall nest density at Inigok was also lower than at coastal locations on the North Slope. Mean density (nine years) on randomly selected plots at Pt. McIntyre, Alaska, was 39.8 nests/km² (Troy 1996); nest density of Semipalmated Sandpipers there (12.6

TABLE 1. Mean nest densities (nests/km²) and (± standard errors) of shorebirds found in tussock/ridge tundra and drained-lake basin vegetation types at Inigok, Alaska, in 1998.

Species	Tussock/ridge tundra ($n = 19$)	Drained-lake basin ($n = 10$)	Study area ($n = 29$)
American Golden-Plover	5.26 ± 2.40		4.52 ± 2.06
Bar-tailed Godwit (*Limosa lapponica*)		2.50 ± 2.50	0.36 ± 0.36
Semipalmated Sandpiper		30.0 ± 8.2	4.26 ± 1.16
Pectoral Sandpiper		30.0 ± 6.2	4.26 ± 0.89
Dunlin (*Calidris alpina*)	1.32 ± 1.32		1.13 ± 1.13
Stilt Sandpiper (*Calidris himatopus*)	1.32 ± 1.32	2.50 ± 2.50	1.48 ± 1.18
Buff-breasted Sandpiper (*Tryngites subruficollis*)	1.32 ± 1.32		1.13 ± 1.13
Long-billed Dowitcher (*Limnodromus scolopaceus*)	2.63 ± 2.63	5.00 ± 5.00	2.97 ± 2.37
Red-necked Phalarope		10.0 ± 7.6	1.42 ± 1.08
All species	11.8 ± 4.0	80.0 ± 13.8	21.3 ± 3.9

nests/km²) was three times higher than overall nest density of this sandpiper at Inigok. Similarly, mean nest density of Semipalmated Sandpipers on randomly selected plots on the Canning River Delta, a coastal site in the ANWR, was 15.7 nests/km² (Martin 1983). Pair density of American Golden-Plovers, the only common shorebird breeding in tussock/ridge tundra, was similar to nest density recorded at Atkasook (Myers et al. 1978, 1979, 1980) and Pt. McIntyre (Troy 1996). Compared to a coastal site, Jones et al. (1980) also found reduced densities of shorebirds on a 100-ha plot 70 km inland along the Sagavanirktok River. Breeding shorebird richness at all inland sites, however, was as high, if not higher, than at coastal sites of a corresponding longitude. The number of shorebirds breeding at Inigok in a single year represented 87% of all species breeding 110 km to the northeast on the Colville River Delta over a 10-year period (Jonathan Bart, U.S. Geological Survey, personal communication).

Nest densities of all shorebirds varied almost eight-fold between drained-lake basins and tussock/ridge tundra at Inigok. Semipalmated Sandpipers, Pectoral Sandpipers, and Red-necked Phalaropes nested exclusively in drained-lake basins. The concentration of Red-necked Phalaropes in drained-lake basins is consistent with their use of lowland tundra at other sites on the North Slope (Oates et al. 1985*). The disparity in nest density of Pectoral and Semipalmated Sandpipers between tussock/ridge tundra and drained-lake basins at Inigok differed from more equitable nest densities between upland and lowland tundra found in the ANWR (Oates et al. 1985*; Table 2). The difference in habitat use between ANWR and Inigok may reflect variation in topographic features of their respective landscapes and, to a lesser extent, the vegetation classification used in each study. The study area at Inigok was characterized by higher elevations and had steeper hydrological gradients from uplands to lowlands than did sites in the ANWR. Poor drainage in upland tundra in the ANWR resulted in a mosaic of moist and dry habitat patches that was suitable for nesting by Semipalmated Sandpipers and Pectoral Sandpipers (Oates et al. 1985*). Higher density and numbers of breeding shorebirds recorded at Atkasook, relative to coastal Barrow, were also attributed to the juxtaposition of upland and lowland tundra (Myers et al. 1978). Nest selection in many calidrine sandpipers is likely based on food availability and proximity to feeding areas, such as ponds, lakes, and wet tundra, where aquatic and semi-aquatic insects are abundant (Holmes and Pitelka 1968). At Inigok, moist foraging areas were restricted to drained-lake basins; consequently, nesting shorebird densities there were high.

The densities of shorebirds nesting in drained-lake basins at Inigok were some of the highest recorded on the North Slope. Nest densities of Pectoral Sandpipers can vary considerably among years (Oates et al. 1985*, Troy 1996). However, nest density of Pectoral Sandpipers in drained-lake basins at Inigok was only exceeded in a single year at Pt. McIntyre (33 nests/km² on random coastal plots; Troy 1996), the Jago Delta (40 nests/km² on plots in moist sedge; Oates et al. 1985*), and Niguanak (33 nests/km² on plots in moist sedge-shrub; Oates et al. 1985*). No site surveyed on the North Slope had a higher nest density of Semipalmated Sandpipers than drained-lake basins at Inigok. Annual variation in nest density of Semipalmated Sandpipers and of most other shorebird species is much less than for Pectoral Sandpipers (Oates et al. 1985*; Troy 1996). Although nest densities of Pectoral Sandpipers based on a single-year study at Inigok should be viewed cautiously, relative use among tundra vegetation

TABLE 2. Nest density (nests/km²) of shorebirds at inland sites on the National Petroleum Reserve — Alaska (Atkasook) and Arctic National Wildlife Refuge (Niguanak, Jago Bitty, Aichilik), North Slope, Alaska.

	Lowland tundra				Upland tundra		
Species	Atkasook[1]	Niguanak[2]	Jago Bitty[3]	Aichilik[4]	Niguanak	Jago Bitty	Aichilik
Black-bellied Plover	2.68						
American Golden-Plover	1.32	5.00	1.67	4.15	0.84	3.33	5.84
Semipalmated Sandpiper	21.3	1.67				6.67	1.67
Pectoral Sandpiper	8.00	11.7	10.9	3.35	17.5	5.00	10.9
Dunlin	6.68	1.67					
Stilt Sandpiper		1.67	3.33	0.84			
Buff-breasted Sandpiper			0.84				
Long-billed Dowitcher		1.67					
Red-necked Phalarope	2.68	8.33	0.84		1.67		0.84
Red Phalarope (*Phalaropus fulicaria*)	5.60	1.67					

[1]48 km inland from the coast, surveyed 3 yr, primarily includes lowland tundra types (Myers et al. 1978, 1979, 1980).
[2]24 km inland from the coast, surveyed 1 yr (Oates et al. 1985*).
[3]40 km inland from the coast, surveyed 2 yr (Oates et al. 1985*).
[4]35 km inland from the coast, surveyed 2 yr (Oates et al. 1985*).

types of this and other species should be representative of similar inland sites; habitat use patterns of post-breeding shorebirds were invariant between years on the Colville River delta (Andres 1994).

Although drained-lake basins constitute a relatively small proportion of shorebird habitat at Inigok (10.5%), they support a disproportionate number of breeding species and individuals. The large disparity between densities in drained-lake basins and tussock/ridge tundra indicate that little suitable nesting habitat exists outside of basins. If Semipalmated Sandpiper and Pectoral Sandpiper nest densities at Inigok are typical, inland drained-lake basins may provide habitat for a sizable portion of their North Slope breeding populations. Because of earlier snow melt, inland drained-lake basins may provide alternative breeding sites in years of late snow melt or cold temperatures on the coast. Clearly, oil development plans on the North Slope inland from the Beaufort Sea coast should consider the importance of drained-lake basins to breeding shorebirds and avoid these areas.

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