

NEST-SITE CHARACTERISTICS AND HABITAT SELECTION OF SHOREBIRDS BREEDING IN NORTHWEST ALASKA

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ABSTRACT: Nest-site characteristics and habitat selection were studied during 1991-1992 for shorebirds nesting in northwestern arctic Alaska. Ninety three nests of ten different shorebird species were quantified. Nesting densities varied between habitat types, with dwarf ericaceous shrub tundra (DEST) being the most productive both years. Significant differences were found between years in the abundance of shorebird species nesting within the DEST habitat. Semipalmated sandpipers (*Calidris pusilla*) were the most abundant shorebird in 1991, but least abundant in 1992. Conversely, western sandpiper (*Calidris mauri*), dunlin (*Calidris alpina*), and red-necked phalarope (*Phalaropus lobata*), were more abundant on DEST habitats in 1992 than 1991. Cover types and vegetation structure differed between nests and random sites and between nest cups and immediately surrounding habitat for dunlin, western sandpiper, semipalmated sandpiper, and red-necked phalarope. Interspecific differences in nest-site vegetation physiognomy were summarized by the first two factors of a principal components analysis, which accounted for 41 and 21% respectively, of the variation in the data. Species were portrayed within two axes which represented a gradient according to cover type, and vegetation density, height, and heterogeneity.

INTRODUCTION

Arctic breeding shorebirds comprise a significant portion of the non-passerine avifauna which breed in North America, but winter in neotropical areas (AOU 1983, Marchant et al. 1986). While shorebirds breeding in northern arctic latitudes have until now experienced very little loss of habitat due to the relatively low human populations and associated development pressures in these areas, degradation and destruction of critical staging and wintering areas continues to the south of these breeding grounds. As Alaska experiences pressures from business interests to develop its lands for oil and other natural resources, these arctic breeding areas will become increasingly subject to direct impacts from construction activities, roads, and pollution from oil and chemical spills.

Although arctic shorebirds spend only a small proportion of their annual cycle on the breeding grounds (ca. six to ten weeks), the resulting recruitment of juvenile birds into the population is a necessary requirement if healthy populations are to be maintained. Therefore, understanding the interannual variation in arctic shorebird

nesting distributions and the associated habitat preferences and nest-site selection criteria are important if we are to detect changes in shorebird populations and base management decisions on good baseline data. These parameters are currently poorly understood for most shorebirds nesting in Alaska.

Relatively few studies have been done on migratory birds in northwestern Alaska. Most studies have concentrated in areas to the southwest or northeast of Kotzebue. Gill and Handel (1990) established that the central Yukon-Kuskokwim delta is an extremely important post-breeding area for shorebirds. They estimated that 1-2 million shorebirds use the central delta each year. They also determined nesting densities, but did not examine nest-site variables. Farther north, Mickelson et al. (1978), studied the avian community in Cape Espenberg on the Seward Peninsula. During two years, they recorded 85 species of birds. The mosaic marsh of the Cape, although small in total area, provided ideal nesting habitat for waterfowl and shorebirds, with an estimated 14,000-16,000 chicks produced each summer. No data on specific nesting habitat preferences were collected however.

The only in-depth avian work to date on Cape Krusenstern National Monument was conducted as part of the NOAA Outer Continental Shelf Environmental Assessment Program. Connors et al. (1979) established study sites in Shishmaref, Cape Krusenstern, Barrow, and Prudhoe Bay. The Cape Krusenstern portion was conducted over two field seasons and established a general phenology of bird arrivals and departures, relative densities of birds on transect routes, and collected 22 birds for food habit studies. No collections of shorebird prey were made nor was nesting studied in detail during their studies at Cape Krusenstern.

When nesting habitat has been mentioned in shorebird studies, it is usually described in a general sense, e.g. patches of dwarf shrub-heath tundra that contain numerous hummocks, ridges, and well-drained slopes, or low-lying marshy areas (Holmes 1971). Because the primary task in avian conservation has been to identify areas for protection that are the most important for nesting, staging, and wintering, workers have by necessity, concentrated on evaluating large geographical areas. This has precluded being able to focus on fine-grained aspects of nesting habitats such as what components within a nesting habitat are important for a particular shorebird species.

Recent studies are beginning to address this need. Nest-site characteristics of prairie shorebirds were studied in Saskatchewan by Colwell and Oring (1990). They found significant differences between shorebird species in the composition of the plant flora at nests. In addition, cover types and vegetation structure differed between nest sites and random locations and between nest sites and the area immediately surrounding the nest. Colwell (1992) found at the same Saskatchewan site that for Wilson's phalarope (Phalaropus tricolor),

no relationship existed between nest success and vegetation density, height, or heterogeneity. He concluded that the data did not support the hypothesis that concealment of clutches deterred predation.

This paper examines nesting distributions, habitat preferences, and nest-site characteristics for ten species of arctic shorebirds that breed in northwestern Alaska.

METHODS

Breeding shorebirds were studied during 1991 and 1992 at Cape Krusenstern National Monument in northwest Alaska (67°7'N;163°15'W). This study was one aspect of a broader NPS program to inventory coastal avifauna, assess seasonal habitat use by migratory bird species, and establish a long-term monitoring program. During 1991, emphasis was placed on obtaining quantitative data on the nesting and feeding ecology of shorebirds and on fall habitat use by waterfowl. In 1992, emphasis again was placed on breeding shorebirds and fall waterfowl habitat use, but waterfowl brood surveys were conducted also.

The study area encompassed 130 km² and includes Krusenstern Lagoon, a shallow 48 km² coastal barrier lagoon adjacent to the Chukchi Sea, and the terrestrial tundra habitats that border it. A narrow barrier bar, 3.8 km in length, protects the lagoon from the Chukchi Sea on its western shore. Krusenstern Lagoon is fringed by diverse habitats and moderate topographical relief along its inland shore (max 283 m summit), and includes tussock tundra, heath tundra, wet sedge meadow, dryas tundra, and small lagoons and brackish lakes interspersed with numerous small islands and peninsulas.

This close juxtaposition of diverse habitats near Krusenstern Lagoon supports an impressive assemblage of tundra breeding shorebirds, including Baird's sandpiper, (Calidris bairdii), bar-tailed godwit (Limosa lapponica), black-bellied plover (Pluvialis squatarola), black turnstone (Arenaria melanocephala), common snipe (Gallinago gallinago), dunlin (Calidris alpina), lesser golden plover (Pluvialis dominica), long-billed dowitcher (Limnodromus scolopaceus), pectoral sandpiper (Calidris melanotos), red-necked phalarope (Phalaropus lobatus), red knot (Calidris canutus), semipalmated sandpiper (Calidris pusilla), western sandpiper (Calidris mauri), and whimbrel (Numenius phaeopus).

To investigate shorebird nesting habitat preferences and nest densities, random stratified sampling was used. Six nest plots (100 m x 500 m) were randomly chosen in each of five habitat strata (30 total plots). Habitat strata were delineated using the classification of Vierek et al. (1986) and the aid of LANDSAT maps and aerial photographs. The five habitat strata and the abbreviations used in

this paper hereafter are: dryas tundra (DT), wet sedge meadow (WSM), tussock tundra (TT), mixed shrub-sedge tussock tundra (MST), and dwarf ericaceous shrub tundra (DEST). In 1991, all five strata were searched, while in 1992, because of time limitations associated with other study aspects, only the DEST and WSM plots were surveyed.

Habitat Strata

Terrestrial habitat near Krusenstern Lagoon was stratified according to structural components for the purpose of examining shorebird nesting ecology and determining shorebird nesting densities. Habitats were classified as follows:

Dryas Tundra (DT) - Dryas sp. is dominant but sparse (10-50 %) on stony well-drained soils at windswept alpine sites. Graminoids and herbaceous perennials (e.g. Anemone, Carex, Pedicularis, Poa, Potentilla) are common but not codominant. DT plots 1 through 6 are located in this habitat. Solifluction and wind erosion are the primary landscape processes in this habitat.

Dwarf Ericaceous Shrub Tundra (DEST) - Mesic lowland tundra composed of 25-35 % dwarf (< 10 cm.) and low shrub (< 20 cm.), 30-35 % non-tussock forming sedges, 10-20 % tussock-forming sedges, 10-15 percent moss, 5-10 percent lichen, and 10 percent non-sedge graminoid on some plots. DEST plots 1-6 are located on low islands and peninsulas along the fluvial channels that drain Krusenstern Lagoon. These islands and peninsulas are elevated about 1 meter above the slough channels, lagoons, brackish lakes, unvegetated mudflats, and margins of wet sedge meadow and other wet graminoid types that fringe them.

Willow-Sedge Shrub Tundra (MST) - Upland tundra structurally similar to mixed shrub-sedge tussock tundra, but tufted grasses and sedges more important than tussocks. The shrub component is 25-30% Salix sp. commonly occurring in stringers along frost heaves. Tufted grasses and sedges compose 45 %. Eriophorum vaginatum composes 25 % and moss compose 5 %. Willow stringers and hummocks, oriented in long rows in the direction of the slope are a prominent feature in this habitat and are probably indicative of subsurface drainage patterns. Small triangular-shaped thaw puddles line occur in pockets along the willow stringers. Aerial photographs exhibit characteristics of fluvial action perhaps originating with solifluction lobes high on adjacent Dryas slopes. Soil creep retards the development of tussocks in this habitat. MST plots 1-3 were located in this habitat.

Mixed Shrub-Sedge Tussock Tundra (MST) - Upland tundra with at least 25% shrub cover and co-dominated by tussock-forming sedges. Similar to tussock tundra but with a greater shrub component. Structural composition is 25 % Salix sp., 30 % Eriophorum vaginatum, 15 % Carex sp., 15 % Dryas sp., and 15 % moss and lichen. Frost heave and frost boil account for the hummocky character of this terrain. MST plots 4-5 were located in this habitat.

Tussock Tundra (TT) - Dominated by Eriophorum vaginatum (60 %), a tussock-forming cottongrass, and Carex bigelowii (10 %). Low birch and ericaceous shrubs constitute up to 25 % of the cover, growing up between tussocks but usually lower than the tops of the sedges. Ledum

palustre comprises 20 % while lichens and mosses make up 10 % of cover. TT plots 1 through 6 are located in this habitat. TT 3 most closely resembled Vierick's definition of tussock tundra. TT1 and TT2 included hummocky stringers and some wet sedge habitat, TT plots 4-6 were located in well- developed polygonal tussock tundra with a strong shrub component.

Wet Sedge Meadow Tundra (WSM) - Dominated by Carex aquatilis and Eriophorum angustifolium in standing water with occasional hummocks of moss, graminoid and dwarf woody vegetation. These wetlands associated hydrologically with Tulilik Lake describe a long curved sickle, arcing out from the southeast corner of the lake and hooking back in a point 1 km west of the lake. WSM plots 1-6 follow the arc around. Frost wedging is an important process in this habitat.

Plot boundaries within the five strata were staked with 1" wooden stakes down the center axis and at each end to establish a grid coordinate system for relocating nests. Geographical coordinates were also recorded with a Global Positioning System for relocation of plots in future years.

To assure that equivalent efforts were made while searching for nests, a 25 m rope (3/4" diameter) was dragged between two people walking down the long axis of the plot, and an observer trailed behind the rope in the middle, keeping alert for flushing birds. Three aluminum cans containing rocks, nails, etc. were attached by 3 m of parachute cord to the dragging rope at 6 m intervals. The cans were used as noisemakers to simulate an advancing line of searchers and increase the likelihood that a concealed shorebird would flush. Once a bird was flushed and a species identification made, the nest was located and marked using a combination of tongue depressors and the staked grid coordinate system.

Nest-Site Variables

After each nest was located, several parameters characterizing nest-site features were measured. Vegetation at nests was assessed in a manner similar to that of Colwell and Oring (1990), and Wiens and Rotenberry (1981) using a point-intercept technique in combination with a 1 m² quadrat. This involved centering a 1 X 1 m cross over the nest cup using a random compass bearing. Four 5 mm diameter rods marked at 10 cm intervals were placed perpendicularly at the end of each section of the cross so that they passed vertically through the vegetation, thereby establishing four sample points 0.5 m away from the nest cup. Similarly, a 5 mm rod was dropped vertically from the cross so that it touched the outer perimeter of the cup. Consequently, there were eight sampling points; four at the nest cup perimeter 90° apart (inner points), and four 0.5 m away from the nest cup (outer points). The quadrat was centered over the nest cup using the same random compass orientation used for the cross.

At these eight sample points were measured: cover type where the rod met the ground (grass, woody plants, lichen, moss, forb, water, rock), litter depth, maximum vegetation height, and the number of contacts

made by grass, woody vegetation, lichen, and forb in each 10 cm section of the 5 mm diameter rod. The quadrats were used to record plant species composition, number of tussocks, and relative cover in the vicinity of each nest. Grid coordinates for each nest were digitized and inter- and intraspecific nest distances were computed. Other data noted were number of eggs, evidence of and source of egg mortality, qualitative nest cup description, date of hatch and number of eggs hatched (when appropriate) and a photograph of each nest. To assess whether a particular nest-site microhabitat was being selected, a random, paired "nest site" was chosen on the plot for each nest found and an identical set of measurements made.

Following Wiens and Rotenberry (1981) several variables were derived that summarized the physiognomy of vegetation at nest sites. The vertical structure was summarized by TOTALHIT, a measure of plant density that equaled the sum total of contacts made by all vegetation on the 5 mm rod, and XTOTMXHT, the mean maximum height of vegetation within a 6 cm radius of the rod. Horizontal structure was described by TOT10HIT, the number of contacts made by all vegetation in the first 10 cm section of the rod. Vertical and horizontal heterogeneity of vegetation was described by CVMAXHT and CVHITTOT, the coefficients of variation for XTOTMXHT and TOTALHIT, respectively. A similar set of variables was derived for each plant category (i.e. grass, woody vegetation, lichen, and forb).

Approaches for statistical analyses followed Sokal and Rohlf (1981) and Zar (1984) using software by SYSTAT (1990). Densities of nests were compared between habitat types using the G-test, a log-likelihood goodness of fit test. Comparisons of cover types between real nests and random sites were also made using the G-test. All other data possessed sufficient heteroscedasticity and non-symmetrical distributions that nonparametric methods had to be used for analysis.

Distances between nests of conspecific shorebirds, other shorebirds and non-shorebirds were tested using Mann-Whitney U tests. Differences in vegetation structure between real nests and random sites and between nest cups and the vegetation immediately surrounding the cup were tested using Wilcoxon paired signed-rank tests. Interspecific differences in vegetation structure at real nests and random sites were tested using Kruskal-Wallis ANOVA. Principal components analysis (PCA) was used to further analyze differences in nest characteristics between shorebird species. PCA reduces the numbers of variables within a multi-variate data set to a smaller number of derived factors which are uncorrelated but still account for a large proportion of the variability found in the original data. In all cases, a comparison was assumed to be statistically significant if $P \leq 0.05$.

RESULTS

Nest numbers and location

Habitats differed significantly in numbers of nests for both shorebirds and nonshorebirds (Fig. 1 and 2; $G = 85.4$ $df = 4$, $P < 0.0001$). In 1991, the DEST plots contained more than four times the number of nests than in any other habitat type. Total numbers of nests were higher on DEST plots in 1992 also, but since not all other habitats were surveyed, it is not

possible to compare with those habitats. While the DEST plots had similar numbers of shorebird nests in both years, the species composition was different between years (Table 1). Shorebird nest densities differed significantly within the DEST plots in both 1991 and 1992 (1991: $G = 22.8$ $df = 4$, $P < 0.001$; 1992: $G = 18.4$ $df = 4$, $P = 0.003$). Whereas semipalmated sandpipers were the most abundant nesting shorebird in 1991, they became the least abundant species in 1992. As expected with species that defend territories such as western sandpipers, semipalmated sandpipers, dunlin, and red-necked phalaropes, distances between nests of conspecifics were greater than distances to nests of other shorebirds or nonshorebirds (Wilcoxon test, all $P < 0.01$). Inter-nest distances for other species could not be tested because of low sample sizes.

Plant cover at nest sites

Nest site cover types were significantly different between species (Fig. 3; $G = 204.8$ $df = 45$, $P < 0.001$). Cover at dunlin, long-billed dowitcher, red-necked phalarope, semipalmated sandpiper, and western sandpiper nests differed significantly from that of random locations (G test, all $P < 0.01$). Cover was not significantly different between real nests and random sites for lesser golden plover, black turnstone, common snipe, Baird's sandpiper, and bar-tailed godwit. Cover in the immediate vicinity of nest cups (inner points) consisted of significantly more graminoid vegetation than cover 0.5 m away (outer points) in dunlin, red-necked phalarope, semipalmated and western sandpiper nests (Wilcoxon test, all $P < 0.05$). Cover did not differ significantly between the nest cup and outer sample points at real nests for lesser golden plover, black turnstone, common snipe, Baird's sandpiper, bar-tailed godwit, and long-billed dowitcher.

Vegetation structure at nest sites

There was considerable variation in the structure of vegetation at real nests and random sites, and these differences varied between species. Compared with random sites, nests of dunlin, red-necked phalarope, and western sandpiper were found in vegetation that was taller, denser, and more vertically heterogeneous. Semipalmated sandpiper nests had a greater density of low stature plants (i.e. < 10 cm) and a greater degree of horizontal heterogeneity than random sites, but did not differ in plant height or overall density (Wilcoxon test, $P < 0.05$). Nests of lesser golden plover, black turnstone, common snipe, Baird's sandpiper, bar-tailed godwit, and long-billed dowitcher were not included in these analyses because of small sample sizes.

Further examination revealed differences in the densities of various plant types at real nests and random sites. Dunlin nests had greater densities of graminoid and dwarf woody vegetation than random sites, while red-necked phalaropes nests had greater densities of graminoid, lichens, and dwarf woody vegetation. Western sandpiper nests differed in the density of graminoids and mosses, as compared to random locations (Mann-Whitney U test, all $P < 0.05$). There were no differences in plant density between real semipalmated sandpiper nests and random sites (Mann-Whitney U test, $P > 0.1$).

Vegetation structure also differed between nest cups (inner points) and the surrounding habitat 0.5 m away (outer points) for many species. For instance, dunlin, red-necked phalarope, and western sandpiper nest cups

had taller, denser, more homogeneous vegetation than surrounding habitat (Wilcoxon test, all $P < 0.04$). Semipalmated sandpiper nest cups had taller, more heterogeneous vegetation than surrounding habitat (Wilcoxon test, $P < 0.05$).

Interspecific differences in vegetation structure

Interspecific differences in nest-site characteristics at real nests were found to be significant for three variables summarizing vegetation structure: height, density, and horizontal heterogeneity (Figs. 4 & 5; Kruskal-Wallis ANOVA, $P < 0.003$). There were not, however, any interspecific differences in vegetation structure at the random sites associated with actual shorebird nests ($P > 0.2$). There were significant interspecific differences in graminoid, lichen, and woody vegetation densities at real nests (Kruskal-Wallis, $P < 0.02$), but not at random sites (Kruskal-Wallis, $P > 0.14$).

These differences are summarized by the first PCA factors, which explain 41 and 21% of the variance in the data, respectively (Fig. 6 and Table 2). Species are depicted along Factor 1 as lying on a spectrum varying from increased graminoid density and overall plant height and density at one end, to increasing plant heterogeneity (especially vertical) at the other. Factor 2 shows a trend of species choosing nest sites with increasing dwarf woody and lichen densities.

DISCUSSION

Arctic breeding shorebirds display a wide range of preferences for nesting within tundra habitats. These preferences include distinctions made between broad tundra types and also at more fine-grained scales within a particular tundra type. Differences in nest-site characteristics vary between shorebird species and considerable interannual variation exists in the species composition of nesting shorebird assemblages. In both 1991 and 1992, the dwarf ericaceous shrub tundra (DEST) was by far the habitat most preferred by nesting shorebirds. However, the assemblage of shorebirds nesting in this habitat varied considerably between 1991 and 1992.

Semipalmated sandpipers went from being the most abundant shorebird on DEST study plots in 1991, to the least abundant in 1992. This decrease in 1992 may have allowed greater densities of shorebirds of other species to nest in 1992, as compared with 1991. Many other researchers have reported on the great spatial and interannual variation associated with nesting shorebirds (Risenborough 1979, Gill 1990). However, semipalmated sandpipers have also been reported to have high nest site fidelity (Grotto et al. 1985), usually nesting less than 100 m from the site used the previous year if the nest attempt was successful in that year. Since data collected in 1991 suggests that nest success was high in that year, the decrease of semipalmated sandpipers on DEST plots in 1992 may reflect a widespread decrease of semipalmated sandpipers in this area, and not simply an artifact of sampling error from birds nesting away from plots.

The DEST habitat was the type most preferred by nonshorebirds as well (Tables 3 - 6). In 1991, in addition to twenty-nine shorebird nests, there were twenty nests of gulls, terns, waterfowl and ptarmigan recorded. A similar trend was also found on DEST plots in 1992; thirty-

five shorebird nests and eighteen nests of gulls, terns, and waterfowl. DEST plot #1 in particular showed a consistently greater density and diversity of nesting birds: 1991 - eight shorebird and ten nonshorebird nests; 1992 - fifteen shorebird and seventeen nonshorebird nests.

Unanswered by this study is why the DEST habitat is so preferred for nesting over other areas, and why DEST plot #1 was more preferred than other DEST plots. One explanation of why this habitat type had the highest nesting densities of any within the study area is that it simply was the habitat type most available to arriving birds that were physiologically ready to nest. In 1991, the DEST strata was the first sizeable land area to emerge from the falling ice and flood waters that covered the lower lagoon, thereby providing foraging opportunities for large numbers of waterfowl and shorebirds that were arriving from migration. However, the spring breakup and melting pattern in 1992 was different than 1991, with a greater percentage of areas within other habitat types being snow-free in 1992. Since the DEST plots were again most preferred in 1992, other factors are undoubtedly involved in nest-site selection. These factors could include differences in prey availability and/or predator densities, but there are insufficient data to test any of these hypotheses.

Densities of nesting shorebirds in this study generally fall within those ranges found in other published studies. Semipalmated sandpiper nest densities documented in this study during 1991 (43 nests/km²) fall within the upper range found for this species in other northern latitudes. Grotto et al. (1985) found 50 nests/km² at La Perouse Bay in Manitoba, Canada, while Troy (1988) reported a range of 20 nests/km² along the Prudhoe Bay Alaska coast to 17 nests/km² a few kilometers inland. Safriel (1971) found 50 to 70 nests in each of four seasons in a 25 km² area at Barrow, Alaska.

Densities of dunlin (20-33 nests/km²) nesting at Cape Krusenstern were comparable to those found by Holmes (1966) near Barrow (17 pairs/km²). However, western sandpipers densities in Cape Krusenstern (6.7-33.3 nests/km²) fall well below the 500-700 nests/km² densities reported by Holmes (1971) in western coastal Alaska. Those densities are the highest reported for a calidrine sandpiper, and probably represent exceptional habitat for western sandpipers. The values reported from the Cape Krusenstern study may be more typical of most breeding habitat in coastal Alaska.

Species differed in which tundra habitat types they nested in. Semipalmated sandpipers appeared to be the least selective of nesting habitat, being found during 1991 in all five habitat types, except wet sedge meadow. All other species were found in one, or at most two, habitat types. Black turnstone, dunlin, Baird's sandpiper, and western sandpiper were found to nest exclusively in the DEST habitats.

Differences in habitat vegetation variables between real and random sites and between nest cups and surrounding vegetation suggests that fine-grained distinctions for nest-sites are made within habitats by some species. Dunlin, red-necked phalarope, and western sandpipers nested in sites with tall, dense vegetation with a higher proportion of graminoids and dwarf woody plants than both random sites and areas immediately surrounding the nest cups. Semipalmated sandpiper nests, on the other hand, showed few differences in vegetation parameters as compared to

random sites. The main difference at semipalmated sandpiper nests was that nest cups possessed taller vegetation than the immediately surrounding habitat 0.5 m distant. A similar trend is shown in the PCA plot. Red-necked phalaropes are clumped in a group at the end of the spectrum depicting increased plant density and height. Semipalmated sandpipers are found across the range of parameters depicted on both axes, suggesting a lack of correlation with any combination of vegetation parameters.

The vegetation parameter data for semipalmated sandpipers corroborates with the other data showing that this species nested in four out of five habitat types. That this species seems to be more of a nesting habitat generalist than other species is reflected in the few differences detected between nest-site variables and random locations for semipalmated sandpipers. Semipalmated sandpipers weave a thatch-like covering of grasses over the nest cup during incubation (Ashkenzie and Safriel 1979), which may help concealment in suboptimal habitats and expand the range of possible nesting habitats. It is unknown whether other species also weave a similar nest covering. It may be that during years of high abundance, intraspecific competition forces semipalmated sandpiper individuals to nest in habitats that may be suboptimal for other species. However, these otherwise suboptimal habitats may be considered suitable for semipalmated sandpipers because of their broad nesting habitat preference range and grass-weaving behaviors.

The role that intra- and interspecific competition plays in influencing choice of nest sites must also be considered. Dunlin, red-necked phalarope, western and semipalmated sandpipers have all been found to be territorial during nesting season in other studies (Johnson and Herter, 1989). Data from this study implies the same holds true here, since greater distances were found between conspecific nests, as compared to distances to nests of other shorebird species. Therefore, exclusion of some individuals from preferred habitats by other dominant individuals likely occurs. Assuming that the DEST habitat is the optimal, preferred nesting habitat, two alternate explanations can be put forward to explain the differences in species composition and abundance that occurred between 1991 and 1992:

- 1) Semipalmated sandpipers were the most numerous species on DEST plots in 1991 because they are the dominant shorebird among the species nesting around Cape Krusenstern, thereby forcing other species to nest in other, suboptimal habitats. During 1992, numbers of semipalmated sandpipers were down; their absence permitted the other less dominant species to nest in the optimal habitat in higher numbers.

- 2) Dunlin, red-necked phalarope, and western sandpipers dominate over semipalmated sandpipers. These species were much less numerous in 1991 than 1992, thereby permitting the less dominant semipalmated sandpipers to nest in higher densities in the absence of interspecific competitors. During 1992, there were higher numbers of these species, forcing semipalmated sandpipers to nest in habitats considered to be suboptimal by the dominant species.

Testing of these hypotheses might be difficult to justify from a conservation standpoint since it would most likely require a manipulative experimental design that removed some species from some plots to examine competitive interactions. Interspecific differences in nest-site

selection are difficult to interpret because these differences usually reflect many factors acting simultaneously. It is difficult to distinguish a situation where a bird's selection of a nest site represents choosing a preferred optimal habitat from the situation arising from a bird nesting at a site because previous unfavorable competitive interactions has resulted in having to nest in a suboptimal site or not at all.

CONCLUSIONS

1. In both 1991 and 1992, the dwarf ericaceous shrub tundra (DEST) was by far the habitat most preferred by both nesting shorebirds and nonshorebirds. The species assemblage of shorebirds using this habitat varied considerably from 1991 and 1992.
2. Possible explanations of why the DEST habitat is so preferred for nesting include availability of food, availability of snow-free habitat upon arrival in spring, and factors relating to predator densities/avoidance, but there are insufficient data to test any of these hypotheses from this study alone.
3. Densities of nesting shorebirds in this study generally fall within those ranges found in other published studies in Alaska.
4. Differences in habitat between real and random sites and between nest cups and surrounding vegetation suggests that habitat selection does occur for some species. Semipalmated sandpipers were the least selective of nesting habitat, while red-necked phalaropes the most selective.
5. Baseline data gathered from this study can now be used along coastal areas in Cape Krusenstern National Monument to make vulnerability assessments from future oil and chemical spills, and development activity. Also, a long-term bird monitoring program is now in place from which future comparisons can be made of nesting shorebird assemblages.

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