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Quantitative assessment of the nesting habitat of Wilson's Phalarope.—The nesting habitat of Wilson's Phalarope (*Phalaropus tricolor*) has been described as short grass or sedge meadows near sloughs and temporary or permanent lakes and ponds in the prairie regions of North America (Bent, U.S. Natl. Mus. Bull. 142, 1927; Hohn, Auk 84:220–244, 1967; Howe, Condor 77:24–33, 1977; Johnsgard, The Plovers, Sandpipers and Snipes of the World, Univ. Nebraska Press, Lincoln, Nebraska, 1981).

Methods.—I examined quantitatively the nest-site characteristics and apparent nesting habitat selection criteria of Wilson's Phalarope at Crescent Lake National Wildlife Refuge, Garden Co., Nebraska. Crescent Lake is located in the Nebraska Sandhills, an extensive area of stabilized sanddunes oriented at right-angles to prevailing westerly winds. Small lakes, marshes, and meadows are located in the interdune valleys. The vegetation surrounding lakes and in marshes consists predominantly of inland saltgrass (*Distichlis stricta*), Baltic rush (*Juncus balticus*), chair-maker's rush (*Scirpus americanus*), hardstem bulrush (*S. acutus*), clustered-field sedge (*Carex praegracilis*), spike rush (*Eleocharis macrostachya*), and common cattail (*Typha latifolia*). Bomberger (M.S. thesis, Univ. Nebraska, Lincoln, Nebraska, 1982) presented a more complete description of the area. The most common nesting associates of Wilson's Phalarope in these Sandhills areas were American Avocets (*Recurvirostra americana*), Willets (*Catoptrophorus semipalmatus*), Blue-winged Teal (*Anas discors*), Gadwall (*A. strepera*), Northern Shovelers (*A. clypeata*), American Coots (*Fulica americana*), Red-winged (*Agelaius phoeniceus*) and Yellow-headed (*Xanthocephalus xanthocephalus*) blackbirds, and Marsh Wrens (*Cistothorus palustris*).

Observations were made during the breeding seasons of 1980 and 1981. Nests were located by systematically searching the meadows and marshes. All nests were marked and visited periodically to check their progress. As each nest was located, a 50-m transect was laid out parallel to the lake, with the nest being the center point. Since plant communities may change as distances from water change, all transects were laid out parallel to lakeshores with all points on each transect the same distance from water. Ten 1-m^2 sampling quadrats were randomly placed along each transect. In both 1980 and 1981, I measured average and maximum vegetation height, percent bare area, stem density, shoreline slope, distance to standing water, compass vector of the nest relative to the nearest lake, and the lake surface area. In addition in 1981, I measured percent grass cover, thickness of the litter mat, plant-stem diameter, above-ground biomass, and interstem distance.

For comparative purposes, in 1981, all variables were also measured for sites in the meadows and marshes where phalaropes were not found nesting and where their behavior did not indicate an interest in nesting. "Non-nesting" transects did not overlap any "nesting" transect. Non-nesting transects also were oriented so as to parallel lakeshores at the same distance from the water as the average nesting transect. An effort was made to select non-nesting transects as randomly as possible. They were sampled at approximately the same time in the season as were nest-sites.

Nesting and non-nesting habitat measurements were analyzed in the following ways. A Chi-square test was performed on the compass vector of the nest relative to the center of the nearest lake to determine if birds showed a preference for a particular side of the lake or a compass orientation. Shannon-Weaver species diversity indices (H') were calculated for the nesting and non-nesting habitat plant communities and compared with a *t*-test to determine if they were significantly different (Poole, An Introduction to Quantitative Ecology, McGraw-Hill, New York, New York, 1974). All multivariate analyses were performed using the SAS package (Helwig and Council, Statistical Analysis System [SAS] User's Guide,

TABLE 1

MEAN ± SE (RANGE), AND SIGNIFICANCE LEVELS OF NESTING AND NON-NESTING HABITAT CHARACTERISTICS

Character	Nesting		Non-nesting		
	1980	1981	1981	F	$P<$
Average veg. height (cm)	31.7 ± 1.8 (24.9–45.8)	25.6 ± 1.3 (15.5–36.3)	68.3 ± 4.0 (45.7–88.7)	105.78	0.001
Maximum veg. height (cm)	55.0 ± 2.9 (38.8–71.9)	45.7 ± 2.3 (30.2–64.9)	112.7 ± 5.2 (77.0–137.6)	135.74	0.001
Percent bare area (%)	22.5 ± 1.4 (12.5–31.1)	17.6 ± 2.0 (6.5–42.0)	31.7 ± 4.5 (6.0–59.0)	9.71	0.005
Percent grass cover (%)	–	99.9 ± 0.03 (99.6–100.0)	98.6 ± 0.7 (91.5–100.0)	4.27	0.05
Stem density (stems/m^2)	3876 ± 381 (1059–5900)	4385 ± 271 (1497–6410)	2935 ± 480 (665–7240)	4.54	0.05
Thickness of litter mat (cm)	–	0.74 ± 0.14 (0.0–2.7)	3.0 ± 0.4 (0.8–5.5)	33.68	0.001
Shoreline slope	0.21 ± 0.02 (0.10–0.34)	0.16 ± 0.02 (0.08–0.38)	0.32 ± 0.07 (0.06–0.96)	4.61	0.05
Distance to water (m)	4.6 ± 0.9 (1.8–11.5)	4.2 ± 0.8 (2.1–16.8)	–	1.84	0.2
Stem diameter (mm)	–	1.5 ± 0.04 (1.3–1.8)	5.1 ± 0.7 (1.7–7.9)	36.02	0.001
Above ground biomass (g/m^2)	–	829 ± 50.0 (548–1472)	1446 ± 172.0 (688–2812)	11.86	0.002
Interstem distance (cm)	–	1.7 ± 0.5 (0.9–2.3)	3.0 ± 0.5 (1.2–4.8)	20.25	0.001
Lake surface area (ha)	43.7 ± 39.6 (0.03–399.7)	32.2 ± 21.8 (0.03–399.7)	102 ± 36.5 (1.9–399.7)	1.73	NS

SAS Institute Inc., Cary, North Carolina, 1979, 1981) and the SPSS package (Nie et al., Statistical Package for the Social Sciences [SPSS], 2nd ed., McGraw-Hill, New York, New York, 1975). A multivariate analysis of variance (MANOVA) was performed on all of the habitat measurements to test for differences between nesting and non-nesting habitat in 1981 and between nest-site habitat in 1980 and 1981. Any overall differences found were tested with univariate F-tests to identify variables which were significantly different between habitat sites (Kleinbaum and Kupper, Applied Regression Analysis and other Multivariable Methods, Duxbury Press, North Scituate, Massachusetts, 1978).

Stepwise discriminant function analysis (SDFA), in two forms, was performed on the 1981 nesting and non-nesting habitat measurements to identify variables providing the best discrimination between the two areas. In order to identify all of the variables which contributed significantly ($P < 0.05$) to the discrimination the backward-elimination procedure of stepwise DFA was performed. The forward-selection procedure of stepwise DFA was performed to identify the three variables which were the most critical ($P < 0.05$) to the discrimination.

Results and discussion.—Twelve nests in 1980 and 10 in 1981 were found and habitat associated with them was measured quantitatively. Twelve non-nesting areas were sampled in 1981. The compass vectors of the nest-sites relative to the nearest lake did not differ significantly from random in either 1980 ($\chi^2 = 0.22$, df = 7, NS) or 1981 ($\chi^2 = 0.57$, df = 7, NS). Nine of 19 plant species found in non-nesting areas also grew in the nesting areas. The species diversity indices (H') did not differ significantly ($t = 1.43$, df = 137, NS) between the nesting and non-nesting area plant communities. H' ± SE for nesting habitat was 2.31 ± 0.08 and for non-nesting habitat was 2.48 ± 0.095.

Means ± SE, ranges, and significant differences between the variables are presented in Table 1. The MANOVA showed a significant overall difference between the nesting and non-nesting areas ($F[18,7] = 67.56$, $P < 0.001$). Ten variables were significantly different between the two areas as shown by univariate F-tests. The MANOVA indicated no significant overall difference between the results for 1980 and 1981 ($F[8,20] = 1.61$, $P < 0.19$). Because Wilson's Phalaropes do not appear to return to the same site year after year (M. A. Howe, pers. comm.), this result is likely based primarily on selection of appropriate nesting vegetation.

Seven variables—maximum vegetation height, stem density, percent bare area, percent grass cover, above ground biomass, interstem distance, and average vegetation height—were shown to contribute significantly to the discrimination by the backward-elimination procedure of stepwise discriminant function analysis. All of these variables were also shown to be significantly different between nesting and non-nesting areas. Shoreline slope, stem diameter, and thickness of the litter mat, all significantly different between the two sampling areas, did not make significant contributions to the discrimination.

The three variables shown to provide the best discrimination between nesting and non-nesting areas by the forward-selection procedure of stepwise DFA are maximum vegetation height, percent grass cover, and average vegetation height. It can be seen in Table 1 that large differences in average and maximum vegetation heights existed between nesting and non-nesting areas. The means of both the average and maximum vegetation height were approximately 2.5 times greater in the non-nesting areas than in the nesting areas. However, the means of percent grass cover in the two areas differed by only 1.3%. The relative magnitude of these three differences imply that vegetation height is the major nesting habitat selection criterion for Wilson's Phalarope in Nebraska. Although these birds usually nest in meadows in the vicinity of a lake or pond, characteristics of the vegetation, especially vegetation height, are seemingly more important selection criteria than proximity of a nest-site to a body of water. This should be borne in mind when managing habitat for Wilson's Phalaropes.

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