The Wilson Journal of Ornithology 120(3):582–593, 2008

NEST HABITAT SELECTION OF WHITE-WINGED SCOTERS ON YUKON FLATS, ALASKA

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ABSTRACT.—Breeding bird surveys indicate a long-term decline in numbers of scoters (*Melanitta* spp.) breeding in North America. Little is known about the breeding habitat and reproductive life history of White-winged Scoters (*M. fusca*) in their primary breeding areas in the boreal forest of Alaska and northern Canada. We characterized selection of nest habitats and attributes within those habitats by measuring variables at nests and random sites on the Yukon Flats National Wildlife Refuge, Alaska. White-winged Scoters avoided nesting in meadows, but nested in scrub or forested habitat types in proportion to their availability (χ^2_5 = 9.7, P = 0.08). Nests of radio-marked females were farther from water and edge (+210 ± 43 and +10 ± 4 m, respectively), and in slightly thicker cover (+6 ± 4%) than nests located without aid of radio transmitters. Females selected sites with more variable and abundant overhead and lateral cover, and sites closer to edge and water than random sites. The results imply nearly random use of scrub and forested habitat types within the study area, but selective use of attributes within those habitat types. This generalist approach to nest site selection at a larger scale may be an adaptive response to reduce detection by nest predators. Nests located without use of radio-marked females may not be representative of the population of nests at a study site. White-winged Scoters often selected nest sites with dense cover far from water, which may increase nest survival. However, concealed sites are difficult for heavy-bodied birds to escape and females may be trading productivity against their own mortality. *Received 3 November 2006. Accepted 26 December 2007.*

White-winged Scoters (*Melanitta fusca*) breed from the Canadian prairies north and west through the boreal forest of Canada into interior Alaska (Bellrose 1980). The majority of the 884,000 scoters surveyed in North America breed in the northern boreal forest of Canada and Alaska (Canadian Wildlife Service Waterfowl Committee 2006). The Yukon Flats National Wildlife Refuge (hereafter Yukon Flats) in eastern interior Alaska has one of the densest populations of breeding White-winged Scoters in North America (Bellrose 1980). North American surveys of scoters (Black [*Melanitta nigra*], Surf [*M. perspicillata*], and White-winged scoters) indicate breeding populations have declined 1.1% per year in areas surveyed since 1961 (Canadian Wildlife Service Waterfowl Committee 2006). The Alaska population of breeding scoters has been stable or gradually declining (−0.4%/year, $P > 0.05$), whereas scoter populations in the western Boreal Canada and Canadian Prairie strata have been declining more rapidly (−1.3 and −4.6%/year, respectively) since 1961 (Canadian Wildlife Service Waterfowl Committee 2006).

Studies of breeding White-winged Scoters (hereafter scoter) in North America are almost exclusively limited to island nesting populations in the prairie-parkland of Saskatchewan and Alberta (Brown and Brown 1981, Kehoe 1989, Traylor et al. 2004). However, the landscape and plant communities of prairie parkland, grasslands and agricultural fields interspersed with groves of deciduous trees are quite different from the northern boreal forest, which is dominated by coniferous trees and includes a much lesser extent of grasslands (Johnson et al. 1995). Nest sites in the boreal forest may differ from those in the southern portion of the breeding range where less forested area is available. Characterizing the breeding habitat of White-winged Scoters in Alaska and Canada is an information need identified by the Sea Duck Joint Venture Management Board (2001). Oil and gas development has been proposed on both the Mackenzie Delta (Haszard 2001) and Yukon Flats (USDI 2005), both important scoter breeding areas. Describing patterns of nest habitat use in the northern boreal forest will provide baseline information important to managers developing future conservation plans (Haszard 2001, 2004).

Nest site selection is also important in un-

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derstanding population dynamics because nest location can affect nest (Martin 1993b, Filliater et al. 1994, Gloutney and Clark 1997) and female survival; thus, individual females may have trade-offs between selecting sites that maximize nest survival while minimizing their own mortality risk (Hoekman et al. 2002a). This trade-off may have population-level effects because both nest and female survival are relatively important factors affecting population growth (Hoekman et al. 2002b).

Nest site characteristics that can affect survival include habitat type and vegetation layers (Crabtree et al. 1989; Martin 1993a, 1995); nests on islands often have higher survival than those on the mainland (Lokemoen and Woodward 1992, Walker et al. 2005). Distance of nests from water and edge (Clark and Shutler 1999, Traylor et al. 2004), vegetative heterogeneity (Crabtree et al. 1989), and cover at nest sites (Badyaev 1995, Clark and Shutler 1999, Traylor et al. 2004) can also affect nest survival. White-winged Scoters in previous studies have been observed nesting far from water in dense and often thorny shrubs, and on islands (Brown and Brown 1981, Brown and Fredrickson 1989, Traylor et al. 2004); following the general patterns of nest site selection in waterfowl. We believed that scoters in the boreal forest would select similar sites to those in prairie-parkland and predicted we would observe greater vegetative cover and variability, greater distances to water and edge, and more scrub plant communities at scoter nests than at random sites.

Quantifying habitat differences between nests and random sites has revealed patterns of habitat use that have improved survival of nests and females over evolutionary time (Clark and Shutler 1999). Additionally, because selection can be quantified hierarchically (Johnson 1980), we believed it would be useful to investigate differences between nests and random sites at multiple scales. The objectives of this study were to examine patterns of site use for nesting White-winged Scoters in the northern boreal forest at two spatial scales: (1) comparison of used and available habitat types, "third-order" selection or the selection of specific habitat components within a home range (Johnson 1980); and (2) comparison of the site attributes of nests and random points, "fourth-order" selection or a more specific level of use within that habitat type (Johnson 1980).

METHODS

Study Area.—We collected data during the breeding season (May–Aug) from 2002 to 2004 on the Yukon Flats, ~170 km north of Fairbanks, Alaska (Fig. 1). The Yukon Flats includes ~3.5 million ha along the Yukon River floodplain in east-central Alaska and encompasses the largest interior wetland basin in Alaska (Heglund 1988). This basin is an area of major importance under the North American Waterfowl Management Plan (USDI 1986). We studied breeding ecology at the Scoter Lake complex (66° 14′ N, 146° 23′ W) in south central Yukon Flats. This area includes a series of relatively large (~1.5 km long) inter-connected lakes and boreal forest (taiga) habitat covering ~4,400 ha. The forest habitats are dominated by: white and black spruce (*Picea glauca* and *P. mariana*, respectively), paper birch (*Betula papyrifera*), and trembling aspen (*Populus tremuloides*). Willow (*Salix* spp.), shrub birch (*Betula glandulosa*), alder (*Alnus* spp.), and immature or stunted tree species dominate the scrub habitats. Grasses (e.g., *Calamagrostis* spp. and *Hordeum* spp.), sedges (*Carex* spp.), and emergent plants (e.g., *Typha* spp., *Scirpus* spp., and *Nuphar* spp.) predominate in herbaceous habitats.

Nest Searching.—White-winged Scoters often nest far from water or in thick cover (Brown and Brown 1981) and we used two different methods to locate nests: foot searches with the aid of a dog (Kehoe 1989) and tracking of females marked with radio transmitters prior to nesting. We captured scoters by driving them into floating mist nets (Kaiser et al. 1995), modified for duck capture, from 31 May to 13 June 2002–2004. We outfitted females with prong and suture radio transmitters (Model A4430, 9 g, Advanced Telemetry Systems, Isanti, MN, USA; Mauser and Jarvis 1991, Rotella et al. 1993) modified with glue. Each female was tracked daily from the ground and once or twice weekly from an airplane until we either found her nest or confirmed her as a failed or non-breeder. We attempted to ascertain the status of females located on water (paired or not paired) without

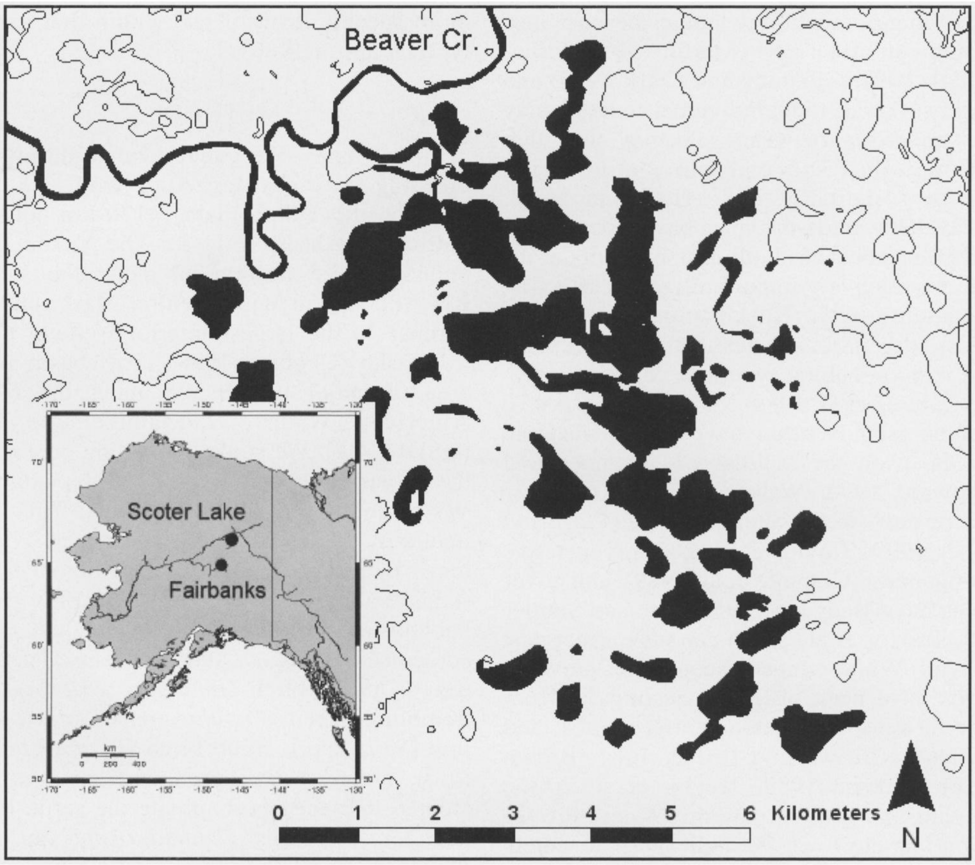

FIG. 1. Scoter Lake complex, south central Yukon Flats National Wildlife Refuge, Alaska. Darkened areas indicate water in the study area, 2002–2004.

flushing them. We attempted to find nests of females on land without flushing them.

We searched lakeshores, islands, peninsulas, bog perimeters, and areas within 600 m of water for nests on foot from 0800 to 1600 hrs ADT from 21 June to 17 July each year. We defined a scoter nest as a depression with either down, eggs, or contour feathers identified as White-winged or Surf scoter. We found nests initiated in the current or previous year and included active, destroyed, and hatched scoter nests in our sample. We were able to include nests initiated in the previous year because typically sufficient feathers and/or egg shells remained in the depression to positively identify the nest. We recorded latitude and longitude data for all nests with a compact Global Positioning System (GPS) unit (± 6 m accuracy).

Nest Habitat.—We entered GPS coordinates of all nests from 2002 to 2004 into a data base and plotted them on ArcView 3.3 (Environmental Systems Research Institute, Redlands, CA, USA) geographic information system program. We used the Animal Movement extension (Hooge and Eichenlaub 2000) to draw a minimum convex polygon for the entire sample of nest sites and generated 80 random locations within this polygon. Random sites were spaced at least 200 m apart with no distance to polygon border restrictions. We excluded random sites in lakes, but visited all sites within 50 m of the mapped lakeshore, as lake levels have changed since U.S. Geological Survey maps were developed in 1956.

We visited all nest and random sites from 28 July to 14 August in 2003 and 2004 to record site characteristics. We recorded (1) habitat type, (2) edge type, (3) distance to edge, (4) distance to water, (5) overhead cover, and (6) lateral cover at each site. We measured this suite of variables because we predicted they would affect female, nest, and duckling survival and, potentially, the process of site selection. We classified habitat type using the level II categories in the Alaska Vegetation Classification (Heglund 1992, Viereck et al. 1992) defined as the proportion of cover types in a 10-m radius circle centered on the nest or random point. We defined distance to edge as the distance to the nearest change in habitat type (Clark and Shutler 1999, Clark et al. 1999) and edge type as the habitat type present beyond that change or nearest different habitat type (Clark et al. 1999). We measured distance to water (Clark and Shutler 1999, Traylor et al. 2004) as the minimum distance to a body of water sufficiently large to appear on infrared photographs of the area.

We marked additional points 5 m from the nest or random location to better characterize each site. In 2003, we visited nests found in 2002 and 2003, and marked four additional points in the cardinal directions around these nests. In 2004, we visited nests located that year and all random points marking two additional points at random bearings around each site. We reduced additional points (from 4 to 2) in 2004 because of logistical constraints associated with the four-fold increase in number of sites to visit that year.

We recorded overhead and lateral cover only at each of the two (four) outside points (Fig. 2.) We measured overhead cover (Clark and Shutler 1999, Traylor et al. 2004) with a spherical convex crown densiometer placed on the ground and averaged from the four cardinal directions. We measured lateral cover as the average percent obstruction of five white 6.5-cm^2 blocks on a black cardboard square (Clark and Shutler 1999) viewed 2 m from the side at a height of 60 cm taken from the four cardinal directions. Each site was characterized by the average value of overhead and lateral cover measured at the center and outside points. We defined overhead and lateral cover variation as the standard deviation of the three or five measurements of overhead and lateral cover at each site. We sampled additional random sites in the dwarf tree and tall scrub habitats after visiting all random sites, because they were rare. We needed to increase the sample of random sites in the two rare habitat types to be greater than or equal to the number of nests in rare habitat types.

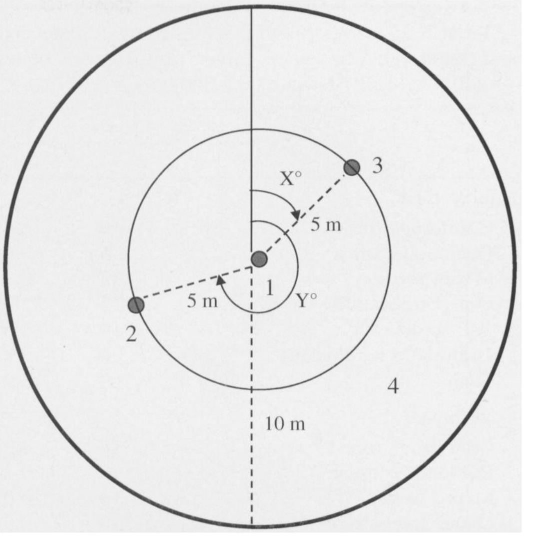

FIG. 2. Sampling protocol for nests and random points. 1 = nest site or GPS coordinates of the random point, 2 and 3 are additional sampling points 5 m from the center, and 4 is the habitat type of the 10-m circle around the center point. X and Y are random bearings for additional points.

Use versus Availability.—We performed all statistical analyses using SAS software (SAS Institute 1999). We used a Chi-square test of homogeneity (PROC FREQ) to test for equal proportions of nests and random sites in each habitat type because availability was estimated from random sites (Marcum and Loftsgaarden 1980, Thomas and Taylor 1990). We performed the analysis with and without habitat types that were commonly available but rarely used (Thomas and Taylor 1990). We also performed a test of homogeneity on the proportion of edge habitat types at both nest and random sites in habitat types used for nesting. We verified that expected frequencies were greater than one and the average expected frequencies were greater than six to assure appropriateness of the Chi-square test (Zar 1999).

Effects of Sampling Design and Nest Searching Method.—We examined differences in mean cover and variation values at nests in 2003 and 2004 (5 and 3 sampling points per site, respectively; PROC TTEST) to ascertain if both protocols provided sufficiently similar results to warrant their combination in the

TABLE 1. Proportion of White-winged Scoter nests and random points in each habitat and edge type with associated cell Chi-square values from the test of homogeneity; Scoter Lake complex, Yukon Flats National Wildlife Refuge, Alaska, 2002–2004.

	Nests			Random sites			Overall	
	n	%	Cell χ^2	*n*	%	Cell χ^2	Total χ^2	*P* value
Habitat type								
Coniferous forest	16	40	0.0	26	43	0.0		
Deciduous forest	2	5	0.1	4	7	0.0		
Mixed forest	13	33	0.1	17	28	0.1		
Dwarf tree scrub	5	13	2.9	1	2	1.9		
Tall scrub	4	10	0.0	6	10	0.0		
Graminoid herbaceous	0	0	2.8	7	12	1.8		
Totals	40	100	5.9	61	100	3.9	9.7	0.08
Edge type								
Coniferous forest	7	18	0.2	7	13	0.2		
Deciduous forest	3	8	0.2	6	11	0.1		
Mixed forest	7	18	0.0	10	19	0.0		
Dwarf tree scrub	4	10	0.9	2	4	0.6		
Tall scrub	4	10	2.0	15	28	1.4		
Graminoid herbaceous	5	13	0.4	4	7	0.3		
Water	9	23	0.1	10	19	0.1		
Totals	39	100	3.8	54	100	2.7	6.5	0.37

analysis. We also investigated differences in nest site characteristics attributable to the search method (radiotelemetry or ground searches with aid of dogs; PROC TTEST) to understand how method used may affect subsequent analyses.

Site Attributes.—We used logistic regression (PROC LOGISTIC) to characterize which habitat features affected selection (Alldredge et al. 1998) within habitat types. Our sampling protocol was consistent with a use-availability study as an approximation to a case-control design, which requires the assumption that use of available sites is rare (Keating and Cherry 2004). We interpreted the results of logistic regression as odds ratios and not resource selection functions as we were making the rare use assumption (Keating and Cherry 2004).

The explanatory variables used in the models were habitat type, distances to edge and water, lateral and overhead cover, and variation of lateral and overhead cover. We included 12 additional random points to increase sample size in rare habitat types to achieve a sample of available sites in approximate proportion to use. We used habitat type to explain variation in the logistic regression models because we sampled in proportion to use, but not to infer selection of habitat types themselves. We investigated correlations among explanatory variables with correlation analysis (PROC CORR) and scatter plots. We chose an *a priori* model set of 41 biologically relevant models and all models with more than two parameters included only additive effects. We used Akaike's Information Criteria (Akaike 1973) adjusted for small sample size (AIC_c; Burnham and Anderson 1998) for model selection. We tested goodness-of-fit to the logistic model with the Hosmer and Lemeshow (1989) statistic. Values reported are means ± SE.

RESULTS

Use versus Availability.—We visited random sites that were on land (n = 61) in all six terrestrial habitat types: coniferous, deciduous, and mixed forest; dwarf tree and tall scrub; and graminoid herbaceous. We located scoter nests (n = 3, 17, and 20 [one of which was a Surf Scoter] in 2002, 2003, and 2004, respectively) in five of the six terrestrial habitat types on the study area; only graminoid herbaceous habitat was unused (Table 1). The edge habitat at nests and random points included all six terrestrial habitats plus water (Table 1). Nests (n = 40) and random sites (n

TABLE 2. Site attributes of White-winged Scoter nests and random points; Scoter Lake complex, Yukon Flats National Wildlife Refuge, Alaska, 2002–2004.

	Nests (n = 39)		Random points (n = 62)			
Parameter[a]	Mean	SE	Mean	SE	Difference[b]	SE
Distance to edge	12.3	2.0	29.2	5.3	*−16.9	6.9
Distance to water	144.3	26.1	240.6	23.3	*−96.3	35.9
Overhead cover	78.9	1.8	73.8	1.9	5.1	2.8
Overhead cover variation	12.1	1.4	11.0	1.0	1.1	1.7
Lateral cover	55.7	2.4	45.1	2.5	*10.6	3.7
Lateral cover variation	16.3	1.2	13.9	1.0	2.4	1.6

[a] Distance in meters, cover as percent obstruction, and variation in cover as standard deviation of percent obstruction.
[b] * P-value <0.01.

= 54 without graminoid sites, n = 61 with graminoid points) were present in the same proportions among habitat types (Table 1) whether or not we included the graminoid herbaceous habitat type that was available but unused (without graminoid; $\chi^2_4 = 4.7$, $P = 0.32$). The proportion of edge type at nests (n = 39) and random sites (n = 54) was equal among the seven edge habitat types (Table 1).

Effects of Sampling Design and Nest Searching Method.—We located 40 nests of which six were initiated the year prior to discovery; 15 nests were found by monitoring radio-marked females and 25 nests were found while conducting ground searches with a dog. There were minimal differences in mean overhead cover (2 ± 4%) and lateral cover (7 ± 5%) between nests with three sampling points (n = 19) and five sampling points (n = 20). Mean variation in overhead (0 ± 3%) and variation in lateral cover (−2 ± 2%) did not differ between nests with three sampling points (n = 19) and five sampling points (n = 20). Sampling design differences between years did not affect parameter estimates in the regression model and combining sampling designs was warranted. However, mean distances to water and edge were greater at nests found using telemetry (+210 ± 43 and +10 ± 4 m, respectively) than at nests found with ground searches; there was some evidence that overhead cover was also greater (+6 ± 4%).

Site Attributes.—We included random points (n = 50) in the five habitat types that scoters used for nesting: coniferous, deciduous, and mixed forest, dwarf tree and tall scrub, and additional points in dwarf tree and tall scrub (n = 9 and 3, respectively). Four random points had water within 5 m and were not included in the analysis because water restricted the directions available to place the additional points. Nests were closer to edge and water, and had denser and more variable cover than random points (Table 2).

The best approximating model in the logistic regression was that site use depends on the additive relationship of all measured variables (distance to edge and water, overhead and lateral cover, variation in both overhead and lateral cover, and habitat type simplified into 2 categories, forest or scrub). Five other models were within seven AIC_c units, but none was within two AIC_c units of the most parsimonious model (Table 3). The top three models were similar and all included distance effects (edge and water) and cover effects (overhead and lateral). The top model included habitat and variation in cover effects, whereas the next best model added only variation in cover effects. The Hosmer and Lemeshow goodness-of-fit test indicated the most parameterized model fit the logistic model ($\chi^2_8 = 4.6$, $P = 0.80$). Probabilities predicted by the top model were 85% concordant and 15% discordant with the observed data. Coefficient and odds ratio estimates from the top model (Tables 4, 5) indicated all variables explain variation in the data with the exception of variation in lateral cover. The odds of site use decreased at sites farther from water and edge; however, odds of site use increased with greater lateral and overhead cover as well as variation in lateral and overhead cover. In the top model, distance to water changed the odds ratio of use much slower than distance to edge (Fig. 3); the same relationship was true for the odds ratios of lateral and overhead cover (Fig.

TABLE 3. Model selection from logistic regression of White-winged Scoter nest site attributes and location (nest or random point); Scoter Lake complex, Yukon Flats National Wildlife Refuge, Alaska, 2002–2004. Models are shown with sources of variation in location; plus symbols indicate additive relationships among parameters. Number of parameters (k), -2*log likelihood ($-2log(l)$), the difference in Akaike's information criterion adjusted for small sample size from the best approximating model (ΔAIC_c), and the coefficient of determination (R^2) are included with results from models with $\Delta AIC_c \leq 7$.

Model[a]	k	$-2\ log(l)$	ΔAIC_c	R^2
De + Dw + Oc + Ocv + Lc + Lcv + Hab2	8	94.1	0.0	0.33
De + Dw + Oc + Ocv + Lc + Lcv	7	99.2	2.7	0.30
De + Dw + Oc + Lc	5	105.6	4.6	0.25
De + Dw + Oc + Ocv + Lc + Lcv + Hab5	11	92.7	6.0	0.34
De + Dw + Oc	4	110.1	6.9	0.22
De + Dw + Lc	4	110.2	7.0	0.22

[a] Model parameters are distance to edge (De), distance to water (Dw), overhead cover (Oc), overhead cover variation (Ocv), lateral cover (Lc), lateral cover variation (Lcv), coarse level habitat type, two classes (Hab2), and habitat type, five classes (Hab5).

4). Overhead cover variation increased the odds ratio of use ~100 times over its range making its effect size larger than lateral cover, but smaller than overhead cover (Fig. 5).

The only two highly correlated variables were overhead cover and variation in overhead cover ($r = -0.67$, $P < 0.001$). Despite this correlation, the top model (Table 3), which included both overhead cover and variation in overhead cover, fit the data much better than models with one of these parameters missing. The ΔAIC_c for the top model without overhead cover included was 7.1 and the top model without overhead cover variation was 4.5 suggesting these correlated variables reduced the deviance sufficiently to warrant their joint presence in the logistic regression models.

DISCUSSION

Use versus Availability.—Scoters used nesting and edge habitats proportional to their availability. There were no significant differences between use and availability, but there is some biologically meaningful information to be gleaned from this analysis. Of the total Chi-square statistic from the nest habitat analysis, 97% was the result of the deviation of the graminoid and dwarf tree scrub observations from their expected values. This high proportion provided evidence of nesting preference for dwarf tree scrub and avoidance of graminoid habitat. Dwarf tree scrub was rare on the study area as it normally occurred only in a narrow area around lakes, which have been decreasing in size over multiple years, and in bogs. However, 13% of the nest sites occurred in this habitat type. This cover type was likely selected because it provided dense woody cover relatively close to water and edge. Graminoid habitats were not rare on the study area (Table 1), but were not used for nesting. While some nests were in a grami-

TABLE 4. Parameter estimates from logistic regression analysis of White-winged Scoter site use as a function of site characteristics at Scoter Lake complex, Yukon Flats National Wildlife Refuge, Alaska, 2002–2004.

Parameter[a]	Estimate	95% Confidence intervals[b]		Standardized estimate[c]
Intercept	−9.72	−16.48	−3.99	
Distance to edge	−0.04	−0.08	−0.01	−0.81
Scrub habitat	−1.60	−3.15	−0.21	
Distance to water	0.00	−0.01	0.00	−0.43
Overhead cover	0.09	0.03	0.16	0.71
Overhead cover variation	0.13	0.03	0.25	0.59
Lateral cover	0.05	0.01	0.09	0.50
Lateral cover variation	0.01	−0.06	0.08	0.03

[a] Beta parameters from the best approximating model.
[b] Profile likelihood confidence intervals.
[c] Beta parameters standardized with respect to different measurement units of site attributes.

TABLE 5. Odds ratio estimates and 95% profile likelihood confidence intervals from the top model of a logistic regression analysis of White-winged Scoter site use vs. site characteristics at Scoter Lake complex, Yukon Flats National Wildlife Refuge, Alaska, 2002–2004.

Effect	Odds ratio	Confidence interval	
Distance to edge	0.96	0.92	1.00
Habitat type (scrub/forest)	0.20	0.05	0.87
Distance to water	1.00	0.99	1.00
Overhead cover	1.10	1.03	1.17
Overhead cover variation	1.14	1.03	1.27
Lateral cover	1.05	1.01	1.09
Lateral cover variation	1.01	0.94	1.08

noid patch, there were sufficient trees or shrubs in the 10-m circle around the nest to classify the habitat as forest or scrub.

This pattern of little selection among forest and scrub types, and avoidance of graminoid habitat showed the importance of woody cover at or near a nest. Scoters selected woody cover without regard to habitat type in which it occurred. This apparent random use of woody habitat types for nesting may greatly reduce the search efficiency of potential nest predators (Martin 1993b) reducing the probability that any predator can find scoter nests. This generalist pattern of site selection may also make it difficult to develop management strategies to minimize the effects of development activities on nesting scoters.

Effects of Nest Searching Method.—Some of the site characteristics we measured at

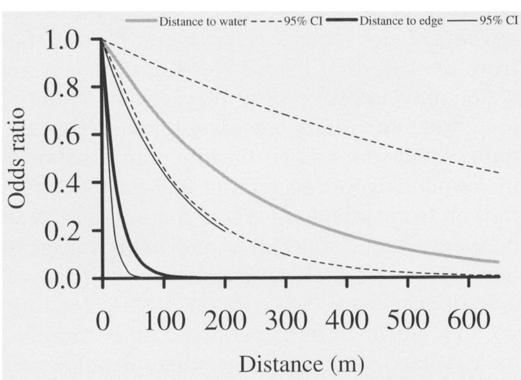

FIG. 3. Effects of distance to water and edge on the odds ratio of use for breeding White-winged Scoters, Scoter Lake complex, Yukon Flats National Wildlife Refuge, Alaska, 2002–2004.

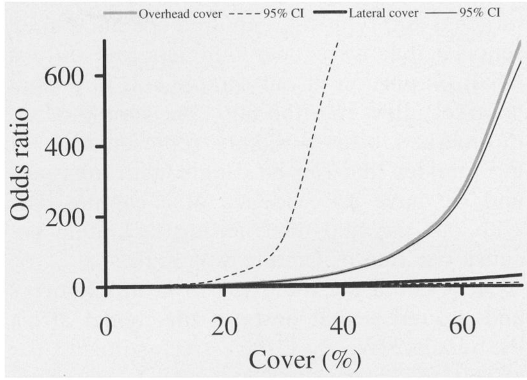

FIG. 4. Effects of overhead and lateral cover on odds ratio of use for breeding White-winged Scoters, Scoter Lake complex, Yukon Flats National Wildlife Refuge, Alaska, 2002–2004.

nests, especially distance to water, varied by search method. We searched some areas more intensively than others, particularly those habitats close to edges, shorelines, and islands. The farther we searched from water, the more area was available to search, and the lower our probability of detecting a nest. Our probability of finding nests also decreased with increasing distance to edge and overhead cover. Therefore, our sample of nests found by ground searches was likely a biased sample of nests on the study area with respect to the site characteristics we measured, whereas we assumed the sample of nests from radio-marked birds would be representative of the population. We

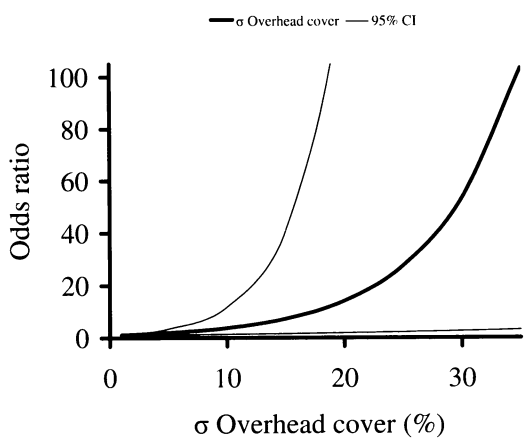

FIG. 5. Effects of overhead cover variation on odds ratio of use for breeding White-winged Scoters, Scoter Lake complex, Yukon Flats National Wildlife Refuge, Alaska, 2002–2004.

targeted and typically captured specific paired females that were near our nets and only a small proportion of our sample was birds that passively flew into the net. Our sample of radio-marked birds is likely representative of the females that can be caught with mist nets and we have no evidence of a capture bias with our targeted mist netting technique because our rate of capture was high.

How could the inclusion of both telemetry and ground search nests in the model affect the results? We may have overestimated the effects of distance to water on site selection, but we could not quantify the magnitude of this bias. However, the distance to water effect is relatively small with all nests included. If only nests located through use of telemetry had been included, it is likely that distance to water would no longer explain variation in site use. The effect of distance to edge would decrease if we included only telemetry nests, but because mean distance to edge only changes +6 m from the mean of all nests (12.3 ± 2.0 m), distance to edge for scoter nests found with telemetry (18.6 ± 4.2 m) would still be lower than the mean value of random sites (29.2 ± 5.3 m); this bias would not change the results dramatically. Similarly for overhead cover, the anticipated change would be small, 4% from the overall mean, and the resulting odds ratio curve would be slightly steeper. Thus, we may be underestimating the effect of overhead cover by including all nests in the analysis.

Site Attributes.—White-winged scoters selected nest sites with more cover and variation in cover, and closer to edge and water than random points at the Scoter Lake complex. Odds of use changed quickly for some parameters in the model over their sampled range, whereas others changed slowly or not at all. Distance to edge and overhead cover were the parameters we measured with the strongest effects on odds of use, while overhead cover variation, lateral cover, and distance to water all had moderate to low (respectively) effects on the odds of use (Figs. 3–5).

The odds of use approached zero when distance to edge values were >120 m; a negative effect. A negative distance to edge effect was also reported for Ring-necked Pheasants (*Phasianus colchicus*) (Clark et al. 1999), and White-winged Scoters nested closer to edge than random sites at Redberry Lake, Saskatchewan (Traylor et al. 2004). In contrast, distance to edge did not differ between nests and unused sites for Wild Turkeys (*Meleagris gallopavo*) (Badyaev 1995), and in five species of dabbling ducks (Clark and Shutler 1999).

Distance to edge for scoters has important implications for nest and female survival. Being farther from edge may improve nest survival (Clark and Shutler 1999) but decrease female survival as they are farther from suitable escape cover often present at edges. If edge habitat is lower or more open than nesting habitat, it may form an opening sufficient for these heavy-bodied birds with "relatively low and slow take-offs" (Brown and Fredrickson 1989: 245) to fly safely from approaching nest predators. Nesting near openings may be extremely important for female survival. Most nests were within 10 m of an opening suitable for escape, but often this opening was too small to be recorded as a unique edge at the scale used in this analysis.

The odds of use slowly decreased as distance to water increased. Nests were on average closer to water than random points (142.7 ± 25.5 m and 231.3 ± 22.8 m, respectively), but sufficient nests were farther from water than random points (18% of the sample) to produce a gradually declining odds ratio. This pattern is similar to that of White-winged Scoters in Saskatchewan, which selected nest sites approximately the same distance from water as random points (~107 m; Traylor et al. 2004). Scoters are known to nest long distances from water (Bellrose 1980, Brown and Brown 1981, this study), but what advantage do scoters receive for nesting far from the safety of lakes? Nesting farther from water may improve nest survival sufficiently to offset potentially negative impacts on females and ducklings during long distance movements to brood rearing habitats. Nesting farther from travel routes of mammalian nest predators (e.g., shorelines and habitat edges) may improve female and nest survival (Brown and Fredrickson 1989, Paton 1994). Nesting scoters appear to be generalists; individual females place their nests varying distances to water and edge in most habitat types, and then seek thick cover at those sites.

Scoters nested in sites with more overhead and lateral cover than random sites, similar to other waterfowl species (Lokemoen et al. 1984, Clark and Shutler 1999, Traylor et al. 2004). High levels of cover were likely selected by females because they improved nest survival (Badyaev 1995, Clark and Shutler 1999, Traylor et al. 2004). This strategy may reduce detection of the nest, but well-concealed sites are more difficult for these heavy-bodied ducks to exit. Relatively high female mortality (survival probability of 0.80) was observed during the nesting period for White-winged Scoters on this study area as females often nested in heavy cover (Safine 2005). Therefore, females need dense cover to conceal nests and less dense cover nearby for escape, which could be edge habitat or a small opening. The use of escape cover is likely the reason overhead cover variation was an important variable in the model, higher levels of which increased the odds of use. On average, the three points sampled at random sites tended to be more similar to each other, indicating more uniform cover at random sites. Scoters not only selected for high overhead cover, but they chose to place their nests at sites with more heterogeneity in cover.

Scoters selected nest sites from a continuum of available cover densities and distances to water and edge at the Scoter Lake complex. Placement of nests at various levels along this continuum constitutes different solutions to trade-offs in female, nest, and brood survival. Scoters represent waterfowl at one extreme of the cover and distance continuum, often nesting at sites with dense cover far from water (D. E. Safine, pers. obs.). Thus, we would expect scoters to have the highest nest survival and lowest female survival during nesting. Dabbling ducks (Tribe Anatini) are in the center of the continuum and pochards (Tribe Aythyini) are on the other extreme, typically nesting in open sites with floating nests or near the water. We expect pochards to have the lowest nest survival because of the open habitat they select, but high female survival during nesting, as females may easily escape from nests. Despite their poor take-off capabilities and longevity, White-winged Scoters at the Scoter Lake complex often nested at the extreme of the cover and distance continuum. Over the long-term they must experience relatively high nest survival compared to dabbling ducks and pochards; otherwise, this strategy would not persist.

Nesting White-winged Scoters on the Yukon Flats had little selectivity at a larger scale (for specific habitat types) other than avoidance of graminoid meadows. However, scoters appear to be selective at a smaller scale (specific sites within those habitats). This lack of selectivity at a larger scale may improve nest survival over other more selective duck species as predators cannot focus search efforts on scoter nests.

ACKNOWLEDGMENTS

This project was made possible through financial support from the U.S. Fish and Wildlife Service, Yukon Flats National Wildlife Refuge; University of Alaska Fairbanks, Department of Biology and Wildlife and Institute of Arctic Biology; the Jay Hammond Scholarship Fund; and the Sea Duck Joint Venture. We extend our gratitude to our field assistants for their hard work despite the difficult field conditions: K. H. Martin, H. F. Knudsen, J. E. Minerva, S. J. Dufford, James Akaran, C. M. Harwood, Jessica Mensik, A. J. Leppold, K. A. Sesser, J. G. Carlson, Johann Walker, Casey Quitmeyer, S. L. Freeman, L. L. Kennedy, C. S. Van Stratt, M. R. Bertram, B. D. Whitehill, E. T. Heuer, S. W. Wang, Emma, and Minto. We thank the staff of Yukon Flats National Wildlife Refuge for their enthusiastic project support and providing extensive field equipment, and extend a special thanks to M. R. Bertram for assuring we had the equipment, personnel, and logistical support to achieve our goals, and M. T. Vivion for countless hours of aircraft logistical support and radio-telemetry flights. We thank D. H. Rosenberg and M. J. Petrula, Alaska Department of Fish and Game, and P. L. Flint and J. L. Schamber, U.S. Geological Survey, for use of bird capture equipment. We appreciate the GIS assistance provided by S. J. Dufford and N. J. Pamperin. J. W. Hupp, C. P. H. Mulder, E. C. Murphy, and two anonymous referees provided valuable reviews of previous versions of this manuscript.

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