WINTER HABITAT SELECTION BY SITKA BLACK-TAILED DEER

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Abstract: Identifying and managing Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) habitat has been an important wildlife issue for many years on the Tongass National Forest of southeastern Alaska, USA. We evaluated habitat selection of Sitka black-tailed deer in the central portion of the region during a winter with snowfall 43% above average using telemetry relocations from 30 individuals that survived the winter. Ivlev indices for habitat selection within home ranges indicated that deer used less than expected, based on availability, north, east, and west aspects, areas >244 m elevation, noncommercial forests, and the low-timber volume stratum while selecting south aspects, areas <153 m elevation, and areas within 305 m of saltwater. Deer used less than expected moderately coarse-canopied forests in the medium- and high-timber volume strata typically found on north slopes while selecting moderately fine-canopied forest in the high-timber volume stratum on south slopes. The lower than expected use of higher volume gap-phase old growth was likely because these were on north aspects where snow accumulated and persisted due to protection from maritime storms. Point relocations suggested less use than expected in clearcuts <41 years of age, while data from 7.2-ha error polygons showed deer were neutral to clearcuts. This suggests that if deer do avoid clearcuts they remain close to the forest-clearcut edge. Of 4 habitat-mapping methods evaluated, the method that incorporated timber volume strata and a wind disturbance-related aspect had greatest utility in identifying areas selected for or used disproportionately little by deer during the deep snow winter. We found that deer exhibited marked changes in habitat use during deep snow conditions compared to a low snow winter, and agree with previous researchers that providing habitats selected by deer during deep snowfall is an important consideration in Sitka black-tailed deer habitat management.

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Key words: clearcutting, deer habitat management, habitat selection, *Odocoileus hemionus sitkensis*, old growth, southeastern Alaska.

The effect of logging Sitka black-tailed deer habitat in the Tongass National Forest of southeastern Alaska, USA, is a contentious management issue. Although year-round nutrition is known to strongly influence deer growth, reproduction, and survival (Klein 1965, Parker et al. 1999), it is commonly thought that suitable habitat during winters with deep snowfall is the limiting factor in the western hemlock (*Tsuga heterophylla*)-Sitka spruce (*Picea sitchensis*) biome of southeastern Alaska (Hanley and McKendrick 1985, Hanley and Rose 1987, Kirchhoff and Schoen 1987). Schoen and Kirchhoff (1990) conducted a telemetry study of deer on an unlogged area of northern Admiralty Island and concluded that low elevation (<300 m), high-volume (>74 thousand board feet (mbf)/ha) old growth on all aspects provided the most important habitat for deer during deep snow conditions. They also concluded that timber harvest in low-elevation old growth would negatively affect deer populations; however, commercial timber harvest was rare on their study area. Yeo and Peek (1992) studied deer on a heavily logged landscape on Prince of Wales Island and found that clearcuts <11 years old were selected by female deer during winter. Their study was not conducted during a deep snow winter, however.

We investigated black-tailed deer habitat selection during a winter with deep snow conditions on a landscape with extensive clearcutting. Our study was designed to complement the 2 telemetry studies cited and to address winter habitat ecology issues beyond the scope of these previous efforts. A second study objective was to test the utility of 4 habitat mapping schemes for identifying deer use during deep snow winters.

STUDY AREA

Our study was conducted on Mitkof Island (56°38′N, 132°50′W; Fig. 1), centrally located in the Tongass National Forest and representative of the temperate island rainforest of southeastern Alaska. The vegetation is predominantly late-successional western hemlock and Sitka spruce forest, with stands of Alaska yellow cedar (*Chamaecyparis nootkatensis*), mountain hemlock (*Tsuga*

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mertensiana), and western red cedar (*Thuja plicata*) making up a smaller component (Klein 1965, Alaback 1982, Alaback and Juday 1989). A relatively dense shrub understory is found in canopy openings. Extensive muskegs and numerous streamside riparian forests occur throughout the area. The area is steep and rugged with elevation extending from sea level to 1,005 meters.

Mitkof Island is approximately 518 km^2. The community of Petersburg (population ca. 3,500) is located at the north end of the island. The annual snowfall for Petersburg averages approximately 275 centimeters with dramatic yearly variability. During this study, the winter of 1997–1998 had snowfall 68% below normal, while 1998–1999 had snowfall 43% above normal.

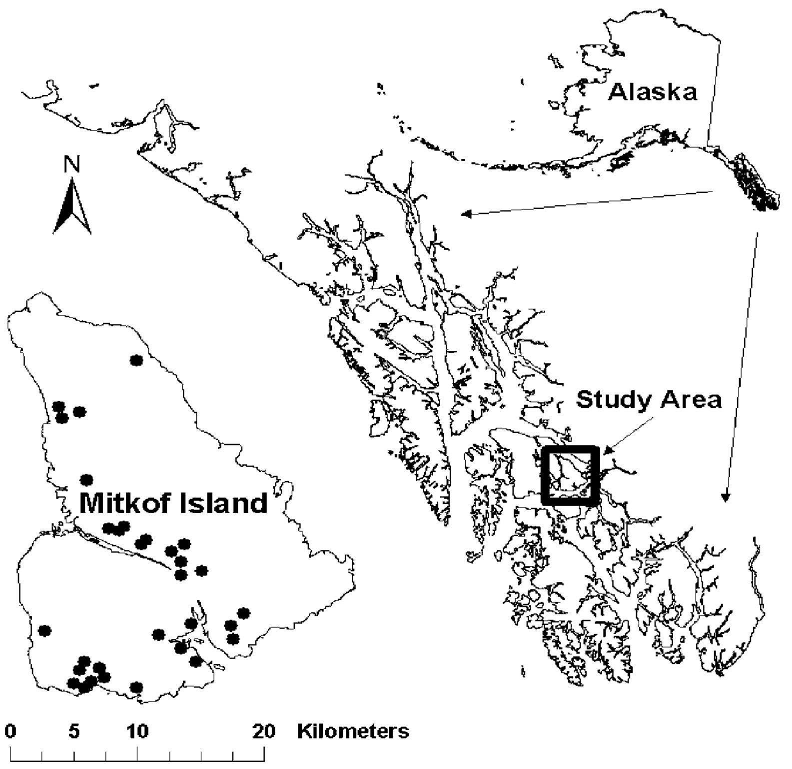

Fig. 1. Mitkof Island showing the approximate center of deer winter home ranges (black dots).

Extensive clearcutting over much of the island has changed about 20% of the original productive forest into an early successional stage. Most watersheds are accessible by a 320-km road system. Logging occurred primarily during 1960–1985 with limited timber harvesting since then. About 80% of the island is under U.S. Forest Service jurisdiction with the remainder in state, city, or private ownership.

METHODS

Field Methods

We captured deer in drop traps or by immobilizing them with rifle-fired darts in 1997 and 1998. Because darting proved much more effective than drop traps, we used only darting as a capture method in 1998.

We captured deer adjacent to roads in a wide variety of habitats throughout Mitkof Island. We captured 38 deer at elevations <152 m, 8 at elevations 152–244 m, 4 at elevations 244–366 m, and 1 above 366 m elevation. Because most roads were at lower elevations, our captures may have been biased toward deer that occupied lower elevations. We captured 16 on south, 16 on east, 10 on north, and 9 on west aspects.

We fitted deer with radio collars (Advanced Telemetry Systems, Isanti, Minnesota, USA) and relocated them from fixed-wing, Cessna aircraft (models 180, 185) with side-looking Yagi antennas. We attempted to locate each deer weekly, weather permitting, usually between 0800 and 1700 hr, except during the deep snow period from January to April 1999 when we flew every day possible to obtain a minimum of 30 relocations per deer for analysis of habitat use (Yeo and Peek 1992).

We plotted deer locations on 1:17,300 scale aerial photos. We also recorded the time, habitat composition (e.g., commercial old growth, clearcut, muskeg), confidence in the relocation (low, medium, high, or visual), percent snow cover in the opening nearest the relocation, and estimated snow depth in the opening. Because snowfall within the study area varied greatly with aspect, elevation, and region of the island, these estimates provided a rough measure of the winter severity in the immediate vicinity of individual animals. We field-checked our aerial estimates of snow depths whenever possible and found them to be reasonably accurate at low snow depths. During late winter 1998–1999, we tended to underestimate snow depths in high snow areas. When deer were located in forested cover with no nearby openings at that elevation, we estimated approximate snow cover and depth from snow conditions in openings above and below the relocation point.

During the deep snow period in 1999, we obtained 2.6 and 3.5% of the relocations from ground triangulation and walk-ins (Yeo and Peek 1992), respectively, when it was not possible to fly. We only used triangulation relocations when we obtained consistent results from at least three points. In ground tracking, we were able to get close to the animals (obtaining visual sightings about 50% of the time) and had high confidence in the relocations.

We conducted 51 trials and found no significant differences in aerial relocation error between observers. We did observe greater error among medium confidence locations relative to high confidence locations; median errors for high and medium confidence relocations were 140 m and 404 m, respectively.

Data Analysis

We used all locations to estimate minimum convex polygon (MCP) home ranges (White and Garrott 1990), but we limited habitat use and selection analysis to relocations with a confidence of medium, high, or visual. Van Horne (1983) showed that relative density could be a misleading index of habitat quality, especially in terms of reproductive success. Therefore, as a measure of fitness, we evaluated only individuals that survived the winters.

We used 2 methods to identify deer habitat selection in deep snow conditions. We first compared deer habitat use during the low snow winter of 1997–1998 and the deep snow winter of 1998–1999 (Schoen and Kirchhoff 1990). We combined all point relocation data and compared 14 female deer between periods, testing for differences in use with chi-squared test for goodness of fit (Steel and Torrie 1960). Although this test suffers from pseudoreplication (Hurlbert 1984), it provides a metareplication comparison (Johnson 2002) to the only other evaluation of Sitka black-tailed deer habitat use between low snow and deep snow winters (Schoen and Kirchhoff 1990).

We also analyzed selection of habitats within the home range among individual deer during the deep snow period (Jan–Apr 1999) using Ivlev selection indices (Yeo and Peek 1992). In this approach, we treated each deer as an experimental unit, and we defined available habitat as the MCP home range. We defined winter as 1 January–31 March (or ending the last date in Apr that we observed 100% snow cover near where the animal was located). For habitats that comprised at least 5% of the year-round MCP home range, we calculated Ivlev selection indices as (U–A)/(U+A), where U = percentage of habitat j among winter relocations of individual i and A = percentage of habitat j within the year-round MCP home range of individual i. We calculated the percentage of habitat j among winter relocations using both relocation "point" data and habitat within a 152-meter radius around the relocation (7.2-ha error polygon data). We excluded saltwater from the percent available habitat if it occurred within the MCP home range.

Ivlev ratios estimate third-order habitat selection (Yeo and Peek 1992) and range from –1 (no use) to 1 (high selection). We tested whether selection indices for each habitat category differed from zero (neutral selection) at $\alpha = 0.05$ using a Student's t-test. In addition, we used a chi-squared analysis to test whether more individuals had positive or negative selection for a habitat category. We required that ≥5% of a habitat be within a deer's home range to avoid high negative Ivlev ratios due to chance associated with uncommon habitats. However, we also wanted to discern whether uncommon habitats might be highly selected by deer. Therefore, we calculated Ivlev ratios for all habitats within each deer's home range and compared the results to the 5% habitat criterion.

Habitat Classification

The first mapping method we evaluated was the traditional land and timber type forestry map. This map categorizes standard land and vegetation features for productive and unproductive (noncommercial) stands. Productive stands are defined as capable of producing 1.4 meters^3/ha/yr and are subdivided into 4 timber volume classes based on aerial photo interpretation (VOLC 4 = 19.8–49.4 mbf/ha, VOLC 5 = 49.4–74.1 mbf/ha, VOLC 6 = 74.1–123.5 mbf/ha, and VOLC 7 > 123.5 mbf/ha) (Esca-Tech Corporation. 1977. Unpublished report to U.S. Forest Service, Juneau, Alaska, USA). Because VOLC 7 was rare on Mitkof Island, we combined the last 2 categories into VOLC 6+.

The second mapping method we assessed was VOLSTRATA, which combines volume class information with soil data to create 3 discrete volume strata for productive forests (Julin and Caouette 1997). Soil information was used to identify forest types associated with wetland soils. In the southern island sub-region of southeastern Alaska, which includes Mitkof Island, VOLSTRATA categories low (L), medium (M), and high (H) have estimated mean timber volumes of 34.3, 52.1, and 72.4 mbf/ha, respectively (J. P. Caouette, personal communication). Limitations and strengths of VOLC and VOLSTRATA as indices of forest structure and timber volume are described by Caouette et al. (2000).

The third mapping method we investigated, called VEGCODE, subdivides VOLSTRATA categories using soil and aspect data. South-facing aspects (67.5–292.5 degrees) tend to be more exposed to prevailing winds (Harris 1989) and are classified as south. All other aspects are classified as north. Stands on south aspects tend to have smaller trees and higher stem densities than stands on north aspects (Kramer et al. 2001; J. P. Caouette, personal communication). VEGCODE classifies canopy texture on alluvial soils as coarse, whereas stands on north and south aspects have canopies classified as moderately coarse and moderately fine, respectively. The VEGCODE categories are high- volume strata on alluvial soils, north aspects, or south aspects (H-alluvial, H-north, and H-south, respectively) and medium-volume strata on hydric soils, north aspects, or south aspects (M-hydric, M-north, and M-south, respectively).

We also tested a more refined model reflecting wind disturbance (WINDSTORM; Kramer et al. 2001). Unlike the VEGCODE model, WINDSTORM identifies topographically wind-protected lands using a 60-m digital elevation model. In general, the higher the elevation of a south-facing stand, the higher the predicted wind exposure.

RESULTS

We captured 32 deer (24 females, 8 males) from late February to July 1997 and 19 deer (13 females, 6 males) from April to June 1998. A total of 3,241 locations were recorded for 51 deer from February 1997 to May 1999, including capture locations, mortality locations, incidental sightings, and relocations. Fifteen deer were monitored during both a low snow and a deep snow winter, 40 deer were relocated for at least 12 consecutive months, and 33 deer were intensively relocated during the deep snow period of 1999. Of 1,127 relocations used for winter habitat analysis, 1,059 (94%) were of high confidence, 45 (4%) were of moderate confidence, and 23 (2%) were visual sightings.

During the winter of 1998–1999, snow accumulation in low elevation areas was bimodal with peaks in early February and 8 March. The average maximum snow depth in openings near marked deer during this winter was about 85 centimeters (range 60–140 cm, $n = 30$ deer). The last date that we recorded 100% snow cover near marked deer ranged from 18 March to 26 April ($\bar{x} = 2$ Apr). During the winter of 1997–1998, the average maximum snow depth in openings near marked deer was about 30 centimeters (range 20–36 cm, $n = 15$ deer), and 100% snow cover occurred near marked deer on no more than 30 days during that period.

We found significant differences for 22 of 34 habitat variables tested between low and deep snow winters ($n = 14$ female deer, Table 1). During deep snow conditions, there was a 4-fold increase in use of areas within 152 horizontal meters of saltwater, 62% greater use of elevations <152 m, 56% greater use of exposed WINDSTORM areas, and 50% greater use of south aspects. There was 75% and 28% less use of north and east aspects, respectively, during deep snow conditions, and 63% and 18% less use of sheltered and intermediate WINDSTORM areas. Deer increased use of M-south, H-south, VOLC 5, and productive old growth by 95%, 67%, 34%, and 17%, respectively, during the deep snow winter. During that winter, deer decreased use of M-north, H-north, and clearcuts 26–40 years of age by 59%, 56%, and 49%, respectively. Increased use of medium and high VOLSTRATA and decreased use of low VOLSTRATA during the deep snow winter were close to significant at the 0.05 level. No differences in use of VOLC 4, VOLC 6+, and clearcuts 11–25 years of age were noted between low and deep snow winters.

Ivlev ratios for habitat selection derived from point relocations during the deep snow winter generally were similar to ratios derived from error polygon relocation data (Table 2). However, Ivlev ratios from point relocation data for clearcuts age 9–40 were lower than ratios from polygon relocation data (–0.26 vs. 0.0, $n = 20$). Mean Ivlev ratios were similar for clearcuts 9–25 years old and 26–40 years old for both point data (–0.27, $n = 10$ vs. –0.35, $n = 9$, respectively) and polygon error data (–0.01, $n = 10$ vs. –0.07, $n = 9$,

Table 1. Habitat use during low snow winter (Jan–Mar 1998) and deep snow winter (Jan–Mar/Apr 1999)[a] for 14 radio-collared female deer on Mitkof Island (point relocation data).

	Percent of relocations		
Habitat parameters	Low snow winter (*n* = 197)	Deep snow winter (*n* = 421)	Significance level
Meters from saltwater			
0–152	5.1	21.6	<0.001
153–305	11.2	15.7	0.135
306–457	9.1	12.6	0.210
458–610	7.1	13.1	0.028
611–762	9.6	9.3	0.880
763–915	4.1	10.5	0.008
916–1,067	5.1	5.2	0.938
1,068–1,220	5.6	1.4	0.003
>1,220	43.1	10.7	<0.001
Aspect			
North	18.3	4.5	<0.001
South	42.6	64.1	<0.001
East	24.4	17.6	0.048
West	14.7	13.8	0.753
Elevation class (m)			
0–152	47.2	76.5	<0.001
153–244	26.9	14.3	0.001
245–366	18.8	6.9	<0.001
367–457	6.6	2.1	0.005
>457	0.5	0.2	no test[b]
WINDSTORM exposure class			
1 (sheltered)	20.3	7.6	<0.001
2 (intermediate)	54.3	44.7	0.025
3 (exposed)	30.5	47.7	<0.001
Productive old growth[c]	56.3	65.6	0.027
Timber volume class (VOLC)			
4	31.5	34.2	0.502
5	22.3	29.9	0.049
6+	2.5	1.4	no test
Timber volume strata (VOLSTRATA)			
L (low)	12.7	8.1	0.069
M (medium)	20.3	26.6	0.090
H (high)	23.4	30.9	0.053
Timber VEGCODE class			
M-north & M-hydric	8.1	3.3	0.010
M-south	12.2	23.8	<0.001
H-alluvial	0.0	0.5	no test
H-north	7.1	3.1	0.023
H-south	16.2	27.1	0.003
Nonforest	0.0	0.0	no test
Noncommercial forest	15.2	11.4	0.182
Clearcuts by age of stand			
All years	28.4	22.8	0.130
11–25 years	18.3	17.6	0.833
26-40 years	10.2	5.2	0.023

[a] End of winter defined as 31 Mar or the last date in Apr that we observed 100% snow cover in openings near where the animal was located, whichever date was latest.

[b] Chi-squared tests were not done where expected values of use were less than 5 (Cochran 1954).

[c] Forests with >19,759 board feet/hectare.

Table 2. Ivlev ratios for third-order habitat selection (selection within the year-round home range) for Sitka black-tailed deer during a deep snow winter in central southeastern Alaska, USA. Data in parentheses are from males. All other data are from females.

Habitat categories	No. deer[a]	Mean Ivlev ratio[b]	No. low use[c]	No. select[d]
Clearcuts				
(9–40 yrs old)	20 (0)	**–.26**	10	10
		–.00	8	12
Timber volume class				
(VOLC) 4	26 (4)	.03 (.03)	10 (2)	16 (2)
		–.02 (–.01)	13 (1)	13 (3)
5	21 (3)	.16 (.13)	**6** (1)	**15** (2)
		.16 (.08)	8 (1)	13 (2)
6+[e]	5 (0)	.30	1	4
		.18	2	3
Timber VOLSTRATA				
L (low)	20 (4)	**–.37** (–.17)	14 (3)	6 (1)
		–.33 (–.19)	**15** (3)	**5** (1)
M (medium)	25 (4)	.01 (–.07)	10 (3)	15 (1)
		–.01 (–.06)	14 (2)	11 (2)
H (high)	20 (4)	**.25** (.29)	**3** (1)	**17** (3)
		.21 (.24)	**5** (1)	**15** (3)
Timber VEGCODE class				
M-north & M-hydric	14 (2)	**–.56** (–.32)	**12** (2)	**2** (0)
		–.43 (–.15)	**12** (2)	**2** (0)
M-south	22 (4)	.10 (–.04)	7 (2)	15 (2)
		.05 (–.09)	10 (2)	12 (2)
H-alluvial & H-north	7 (1)	–.25 (–1.0)	4 (1)	3 (0)
		–.28 (–1.0)	6 (1)	1 (0)
H-south	17 (3)	**.22** (.19)	**4** (1)	**13** (2)
		.18 (.14)	**3** (1)	**14** (2)
H & M with coarse and moderately coarse canopies[f]	17 (4)	**–.37** (–.35)	**13** (3)	**4** (1)
		–.33 (–.17)	**14** (2)	**3** (2)
Noncommercial forest	24 (4)	**–.51** (–.64)	**20** (3)	**4** (1)
		–.41 (–.49)	**20** (3)	**4** (1)
Non-forest	6 (2)	**–.73** (–1.0)	5 (2)	1 (0)
		–.77 (–.87)	6 (2)	0 (0)

[a] Only deer with at least 5% of their total home range containing the habitat category are included. All data are derived from 26 females and 4 males.

[b] In bold are Ivlev ratios for females that are not equal to zero (Student's *t*-test, $P < 0.05$). The first row for each category is derived from point relocation data; the second row is from 7.2-ha error polygon data.

[c] Number of individuals with Ivlev ratio <0. In bold are categories where the number of females with negative and positive Ivlev ratios are not equal (chi-squared test, $P < 0.05$). Chi-squared test was not done for less than 10 individuals.

[d] Number of individuals with Ivlev ratio >0. In bold are categories where the number of females with negative and positive Ivlev ratios are not equal (chi-squared test, $P < 0.05$).

[e] VOLC 6 and 7 were combined.

[f] VEGCODES H-alluvial, H-north, M-north, and M-hydric.

respectively). Therefore, both age classes of clearcuts were combined. One female deer with 8-year-old clearcuts in its home range avoided these areas during the deep snow winter (Ivlev ratios = –1 and –0.74 for point and polygon relocation data, respectively).

Deer used areas >244 m elevation, the sheltered WINDSTORM class, and north, west, and east aspects less than expected (mean Ivlev ratios for point data = –0.68, –0.64, –0.56, –0.44, and –0.40, respectively, Table 3). Deer selected areas <153 m elevation, south aspects, and areas within 305 m of saltwater (mean Ivlev ratios for point data = 0.16, 0.13, and 0.12, respectively). Deer also showed significant selection for VEGCODE H-south (mean Ivlev ratio for point data = 0.22), and used nonforest, noncommercial forests, and low VOLSTRATA less than expected (mean Ivlev ratios for point data = –0.73, –0.51, and –0.37, respectively). Deer used VEGCODE M-south relative to its availability. VEGCODES H-alluvial, H-north, M-north, and M-hydric individually comprised <5% of most home ranges and were combined. Deer showed little affinity for this reduced category, which represents coarse and moderately coarse canopied forests (mean Ivlev ratio for point data = –0.37). Deer selected VOLC 5 (mean Ivlev ratio for point data = 0.16), but were neutral to VOLC 4. Of 5 deer with at least 5% VOLC 6+ in their home range, 3 or 4 selected for VOLC 6+, depending if point or polygon data are considered. When all 16 deer with VOLC 6+ in their home range were considered, 8 used VOLC 6+ less than expected. Statistical comparisons were based on females only due to the small number of males in our study. However, the general pattern of use was similar for both sexes with respect to the various habitat categories (e.g., increasing use from north to south aspects, low to high VOLSTRATA, high to low elevations, and sheltered to exposed WINDSTORM areas).

In no case did we find evidence of selection for any uncommon habitats that may have been overlooked by the 5% criterion. We ranked the strength of the habitat selection for various parameters considering both the proportion of females selecting the category and the absolute value of the mean Ivlev ratio (Table 4).

Table 3. Ivlev ratios for third-order selection for microclimate variables by Sitka black-tailed deer during a deep snow winter in central southeastern Alaska, USA (point relocation data). Data in parentheses are from males. All other data are from females.

Microclimate variables	No. deer[a]	Mean Ivlev ratio[b]	No. low use[c]	No. select[d]
Aspect				
North	22 (4)	**–.56** (–.97)	**19** (4)	**3** (0)
South	26 (4)	**.13** (–.04)	**6** (2)	**20** (2)
East	17 (3)	**–.40** (–.11)	**15** (1)	**2** (2)
West	20 (4)	**–.44** (–.16)	**15** (2)	**5** (2)
Elevation (m)				
0–152	26 (4)	**.16** (.34)	**6** (2)	**16** (2)
153–244	17 (3)	–.14 (.18)	11 (1)	6 (2)
>244	14 (3)	**–.68** (–.48)	**14** (3)	**0** (0)
WINDSTORM exposure class				
1 (sheltered)	22 (4)	**–.64** (–.93)	**19** (4)	**3** (0)
2 (intermediate)	26 (4)	–.10 (.06)	16 (1)	10 (3)
3 (exposed)	25 (4)	.06 (.28)	9 (1)	16 (3)
Meters from saltwater				
0–305	19 (2)	.12 (.38)	**5** (0)	**14** (2)

[a] Only deer with at least 5% of their total home range containing the habitat category are included. All data are derived from 26 females and 4 males.

[b] In bold are Ivlev ratios for females that are not equal to zero (Student's *t*-test, $P < 0.05$).

[c] Number of individuals with Ivlev ratio <0. In bold are categories where the number of females with negative and positive Ivlev ratios are not equal (chi-squared test, $P < 0.05$).

[d] Number of individuals with Ivlev ratio >0. In bold are categories where the number of females with negative and positive Ivlev ratios are not equal (chi-squared test, $P < 0.05$).

DISCUSSION

During the low snow winter, female deer were generalists, occupying a wide variety of habitats. Selection patterns during the deep snow winter appeared to primarily reflect microclimatic variables associated with snow depth including elevation, aspect, and proximity to the saltwater beach fringe. Increasing snow depth negatively affects the winter energy balance by covering nutritious evergreen forbs and half-shrubs, and forcing deer to consume greater amounts of woody browse, and by greatly increasing the cost of locomotion, particularly when sinking depths exceed 25 cm (Parker et al. 1984, 1999; Hanley and McKendrick 1985). The selection by deer of habitats that would reduce energy loss in response to the high snowfall that occurred in the winter of 1998–1999 is consistent with reductionist studies of nutritional and physiological considerations (Parker et al. 1999).

Schoen and Kirchhoff (1990) similarly found selection for low elevations during deep snowfall. Use of areas near saltwater is related to low elevations, but also reflects the additional moderating effect of the marine environment (Klein and Olson 1960, Klein 1965). Schoen and Kirchhoff

Table 4. Ranking of parameters with respect to relative degree of positive or negative selection by female Sitka black-tailed deer during a deep snow winter in central southeastern Alaska, USA.

Relative preference	Habitat selection	Mean Ivlev ratio[a]
High positive or negative selection Criteria: >66% of individuals have positive or negative Ivlev ratios and mean Ivlev ratio $\neq 0$ ($P < 0.05$); Ranked in order of highest absolute value of the mean Ivlev ratio	Against non-forest	–.73
	Against >244 m elevation	–.68
	Against sheltered WINDSTORM	–.64
	Against M-north and M-hydric	–.56
	Against north aspect	–.56
	Against noncommercial forest[b]	–.51
	Against west aspect	–.44
	Against east aspect	–.40
	Against high and moderate VOLSTRATA w/ coarse and moderately course canopies[c]	–.37
	Against low VOLSTRATA	–.37
	For high VOLSTRATA, all types combined	.25
	For H-south	.22
	For 0–152 m elevation	.16
	For south aspect	.13
Moderate positive or negative selection Criteria: Not above and either Ivlev ratio $\neq 0$ ($P < 0.05$) or the number of individuals with negative and positive Ivlev ratios are not equal (Chi-squared test, $P < 0.05$); Ranked in order of highest absolute value of the mean Ivlev ratio	Against clearcuts 9–40 years old (point relocation data)	–.26
	For timber volume class 5	.16
	For 0–305 m distance from saltwater	.12
No demonstrated positive or negative selection Criteria: Mean Ivlev ratio not different than 0 and the number of individuals with negative and positive Ivlev ratios is not different (α = 0.05)	Medium VOLSTRATA, all types combined	
	M-south	
	Timber volume classes 4 and 6+	
	Clearcuts 9–40 years old (7.2-ha error polygon data)	
	Intermediate and exposed WINDSTORM	
	153–244 m elevation	

[a] Point relocation data unless specified otherwise.
[b] Forests with <19,759 board feet/hectare.
[c] VEGCODES H-alluvial, H-north, M-north, and M-hydric.

(1990:376) dismissed the importance of south aspect stands, contending that "because of the high northerly latitude of southeastern Alaska and the low angle of the sun in winter, this influence (southerly aspect) is less pronounced than in more southerly regions." We observed that relatively warm maritime storms that originated from southerly directions played a major role in dissipating snow pack on Mitkof Island. Low use of sheltered WINDSTORM areas relative to availability was among the strongest patterns we found during deep snow conditions (Table 4). Perhaps we did not detect selection of exposed WINDSTORM areas because many of these areas were at high elevations where deep snow accumulates regardless of periodic maritime storms.

Similar to Schoen and Kirchhoff (1990), we found very low use of unforested habitats and noncommercial forests relative to availability during deep snow winters. These areas lack overstory canopies that can effectively intercept the snow. Numerous studies have suggested that, in deep snow, deer use of commercial forests depends on the net timber volume of the stand (Kirchhoff and Schoen 1987, Schoen and Kirchhoff 1990, Yeo and Peek 1992). Timber volume class (VOLC) has been widely used by forest managers to represent this relationship (Suring et al. 1993). Deer in our study were neutral to VOLC 4, but showed some selection for VOLC 5. The apparent importance of VOLC 6+ to deer was equivocal due to the relatively low occurrence of this habitat in the study area, but it appeared that overall deer were neutral to VOLC 6+ during deep snow winters. Julin and Caouette (1997) determined that VOLC cannot distinguish between medium- and high-volume stands of productive forest. Therefore, the lack of a relationship between winter deer use and VOLC is not unexpected. By contrast, we found a consistent relationship in habitat selection using timber volume strata (VOLSTRATA). Deer used low VOLSTRATA less than expected, were neutral to medium VOLSTRATA, and selected high VOLSTRATA during deep snow winters. Since VOLSTRATA can distinguish timber volume (Julin and Caouette 1997), our study supports previous work that timber volume information can help indicate the quality of deer winter habitat. This relates, at least in part, to the ability of forests with higher timber volume to more effectively intercept snowfall in the overstory canopy (Kirchhoff and Schoen 1987).

VEGCODE mapping was effective in distinguishing deer use within individual timber volume stratum. Deer used VEGCODE classes reflecting predominantly north-facing, coarse-canopied, and moderately coarse-canopied forests in medium- and high-volume strata less than expected, were neutral to M-south, and were highly selective for H-south, which tends to be a moderately fine-canopied forest. Earlier studies did not assess the influence of canopy texture on deer winter use. However, general descriptions of deer winter range (Kirchhoff and Schoen 1983, 1987; Bunnell and Klein 1984; Parker et al. 1999) suggested that gap-phase old growth provides important deer winter habitat. Deer in our study showed little affinity for such stands. We believe the low use of gap-phase old growth is because such stands occur primarily on north aspects protected from maritime storms (Nowacki and Kramer 1998, Kramer et al. 2001), where snow accumulates. Forests on more favorable south aspects are affected by frequent, small-scale wind disturbances punctuated by occasional severe cyclonic windstorms (Harris 1989, Nowacki and Kramer 1998, Kramer et al. 2001). Due to the periodic nature of catastrophic storm events, most south-facing forests in our study area are not at an old-growth stage as defined by Oliver and Larson (1990).

Deer did not select the clearcut-forest edge in one study (Kirchhoff and Schoen 1983) but did in another (Chang et al. 1995). We believe our data suggest deer overall used clearcuts less than expected during the deep snow winter. However, they remained in such close proximity to clearcuts that analysis of 7.2-ha error polygon data indicated neutral use of past timber harvest units.

The current forest-wide deer habitat model predicts that clearcuts >25 years of age have little value as deer winter range, and lumps clearcuts 1–25 years of age into one category (Suring et al. 1993). Yeo and Peek (1992) separated clearcuts into three successional classes: (1) deciduous seral shrub (1–10 years of age), (2) sapling conifer (11–30 years of age), and (3) closed-canopy pole stands (>30 years of age). They found that deer chose clearcuts <11 years old during relatively mild winters. In our study, we had one deer with >5% of its MCP home range in 8-year-old clearcuts, and this deer avoided these areas during deep snow conditions. Seven deer in our study had only a few clearcuts 9 and 10 years of age in their MCP home range. Clearcuts 9–10 years of age were transitioning to a sapling conifer stage and were included in the 11–25 year old category in our analysis. Clearcuts from 11 to 40 years of age were well-represented in the study area. We found use of clearcuts 9–25 years of age was similar to use of clearcuts 26–40 years of age. Alaback (1982) showed that, on soils with high site indices, understory forage will substantially decline about 25–35 years after clearcutting. Our general observations indicated that, on soils with lower site indices, understory forage persisted longer because of slower tree growth. Furthermore, the majority of clearcuts older than 25 years in our study area were precommercially thinned. Doerr and Sandburg (1986) found that thinning prolonged understory vegetation. Most clearcuts 26–40 years of age had considerable understory forage and appeared to have a habitat value similar to younger sapling communities during deep snow conditions.

Our finding of reduced winter use of clearcuts is similar to results derived from pellet count comparisons (Wallmo and Schoen 1980, Rose 1982, Kirchhoff and Schoen 1983). However, the observation of some winter use in older clearcuts suggests that silvicultural methods to prolong understory forage in pole stands may have some value to deer during deep snow winters. Based on pellet counts, Doerr and Sandburg (1986) also found, following the deep snow winter of 1981–1982, greater deer use in 34-year-old thinned clearcuts containing high understory forage than in unthinned stands lacking forage.

MANAGEMENT IMPLICATIONS

Because we observed marked changes in habitat selection during a deep snow winter compared to a low snow winter, we think that providing habitats selected by deer during deep snow winters is important to deer habitat management in southeastern Alaska. Microclimate variables, including prevailing maritime wind patterns, and aspects of forest structure emerged as important indicators of deer habitat use during deep snow. Timber volume strata should be used in place of volume class in the forest-wide model, as it seems to more effectively represent forest types chosen or used disproportionately little by deer during deep snow conditions, especially when combined with elements of forest structure (i.e., VEGCODE). Clearcut use extended later in the sere than the current deer habitat model predicts. We recommend the model be adjusted to account for prolonged understory associated with lower site index and thinning treatments. Managers should endeavor to better understand how windstorm dynamics influence forest structure and snow pack conditions in southeastern Alaska and how that affects deer habitat. In particular, developing microclimate models that could accurately map island-wide snow accumulation and persistence patterns would seem to have great importance in identifying preferred deer wintering areas.

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