Seasonal Habitat Relationships of Adult Female Deer on Kodiak Island, Alaska

A
Thesis

Master of Science

By

Jeffrey S. Selinger, B.S.

Fairbanks, Alaska
December 1995

SEASONAL HABITAT RELATIONSHIPS OF ADULT FEMALE DEER ON KODIAK ISLAND, ALASKA

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Presented to the Faculty

of the University of Alaska Fairbanks

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ABSTRACT

Movements of adult female deer (*Odocoileus hemionus sitkensis*) were monitored using radio-collars ($\underline{n}$ = 21) in a region lacking old-growth conifer forest on Kodiak Island, Alaska, from 17 July 1990 to 8 July 1991. Mean distance between seasonal ranges for 7 deer that migrated from the study area during winter was 22 km (SD = 10.2 km), whereas ≤ 5 km separated seasonal ranges of 14 deer that remained in the study area throughout the year. Mean movement date to winter range was 30 October (SD = 38 days), and to summer range, 29 May (SD = 18 days). Overall habitat use differed significantly ($\underline{P}$ < 0.001) between seasons. Habitats used more than available ($\underline{P}$ ≤ 0.01) were tall shrub closed in summer and tall shrub open in winter. Using the 95% adaptive kernel method (Worton 1989), mean summer home range (454 ha, $\underline{n}$ = 11, range 134 - 819 ha, SD = 227 ha) was larger ($\underline{P}$ < 0.001)than the mean winter home range (107 ha, $\underline{n}$ = 9, range 67 - 217 ha, SD = 56 ha).

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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INTRODUCTION

The current population of Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) inhabiting the Kodiak Archipelago, Alaska, originated from three introductions (totaling 25 animals) between 1924 and 1934 (Burris and McKnight 1973). Since that time, deer have expanded their distribution throughout the island complex and are now the most abundant large mammal occurring in the area. An overview of the history of the introduction, establishment, and expansion of deer on the Kodiak Archipelago was compiled by Smith (1979). Other than surveys from hunter harvests, few data are available concerning deer ecology in the Kodiak Archipelago. In contrast, Sitka black-tailed deer have been studied extensively on their native range in Southeast Alaska where old-growth coniferous forest is a critical component of habitat for winter survival (Schoen and Kirchhoff 1984, Rose 1982, Schoen et al. 1981, Bloom 1978, Leopold and Barrett 1972). On Kodiak Island, similar habitat is limited to the northeastern portion of the island, consequently deer ecology in nonconiferous regions of Kodiak is expected to differ from that of Southeast Alaska. This study is a first attempt to gain a better understanding of deer habitat relationships on Kodiak Island using radio-collared animals.

Objectives

While reviewing literature concerning deer habitat relationships in Southeast Alaska the contrasts of two studies became particularly interesting. Schoen and Kirchhoff (1984) reported that in an area with abundant old-growth coniferous forest, home-range size did not differ significantly between seasons, the presence of migratory (seasonal ranges of an individual deer do not overlap) and resident (seasonal ranges of an individual deer overlapped) deer populations, and deer using old-growth almost exclusively in winter and a mostly in summer. Yoe and Peek (1992), working in an area where availability of old-growth had been reduced by logging, reported a significant difference in core seasonal home-range, only resident deer (core seasonal ranges for all individual deer overlapped), and a decline in the use of old-growth. I chose to investigate further this question of contrasting patterns of habitat use and focused on habitat relationships of Sitka black-tailed deer where old-growth forests do not exist. The study would provide baseline information concerning deer ecology on Kodiak Island and information on strategies deer used to adapt to a region with habitat differences from that of their native range. The specific objectives I addressed were to determine seasonal movements, seasonal habitat use, and seasonal home-range size for adult female Sitka black-tailed deer in a region lacking old-growth coniferous forests on Kodiak Island, Alaska. The relative null hypotheses were: 1) adult female deer do not make seasonal movements, 2) habitat use does not change seasonally for adult female deer, and 3) home range size does not change seasonally for adult female deer.

Additional information collected included experience with helicopter darting and data associated with deer capture, winter diet composition, and sex and age composition of winter mortality. Summaries of these data are provided in Appendices 1-3, respectively.

STUDY AREA

The Kodiak Archipelago is situated in the western Gulf of Alaska between 56-58° N and 152-157° W. Kodiak is the largest island in the group encompassing about 9,600 km^2. The study area was located approximately 105 km west of Kodiak city and included 34 km^2 of the Spiridon Peninsula (Fig. 1). The region has a maritime climate characterized by overcast skies, cool temperatures, fog, and wind. Annual precipitation for Kodiak city averages 157 cm, and the average temperature ranges from 13-18°C in summer to ±4°C in winter.

Topographic features of the study area include a central inland valley bordered by moderate to steep mountainous terrain reaching a maximum elevation of 635 m. Mountain termini at the ocean varied from abrupt drops to broad gently sloping flats. The entire area contained numerous creeks and drainages that provided an ample supply of summer water.

The study area was divided into nine habitat types (Fig. 2), based on associations of dominant vegetation (Table 1). Vegetation from sea level to 500 m elevation was a mosaic of dense shrubs, forbs, and grasses, with occasional stands of cottonwood and birch, whereas alpine communities were dominated by heath associations. The more common species included cottonwood (*Populus balsamifera*), birch (*Betula kenaica, B. nana*), alder (*Alnus crispa*), willow (*Salix alaxensis, S. planifolia, S.glauca*), elderberry (*Sambucus racemosa*), salmonberry (*Rubus spectabilis*), rose (*Rosa nutkana*), cow parsnip (*Heracleum lanatum*), angelica (*Angelica* sp.), helebore (*Veratrum viride eschscholtzii*), fireweed (*Epilobium* sp.), skunk cabbage

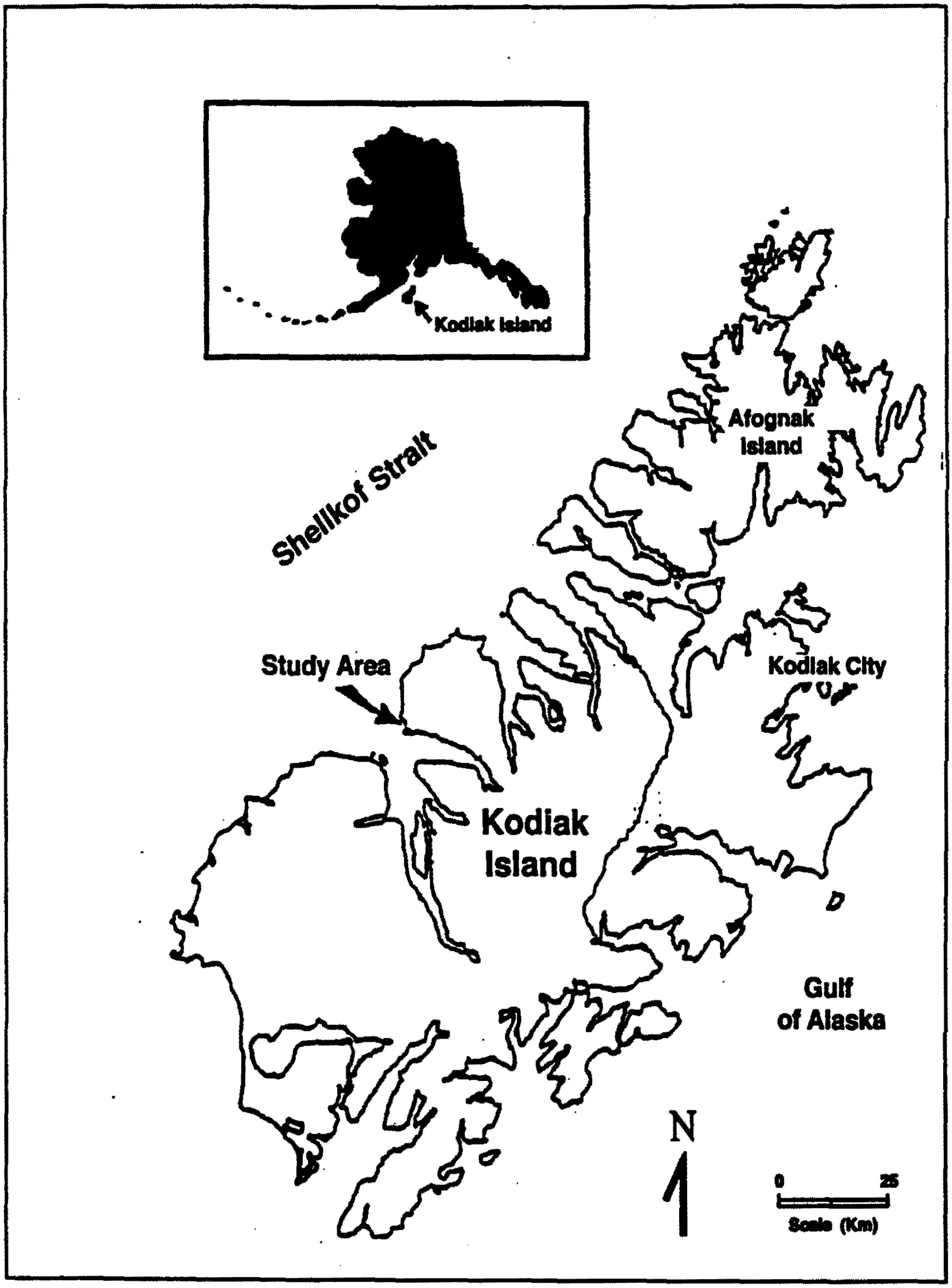

Fig. 1. Kodiak Island Study Area.

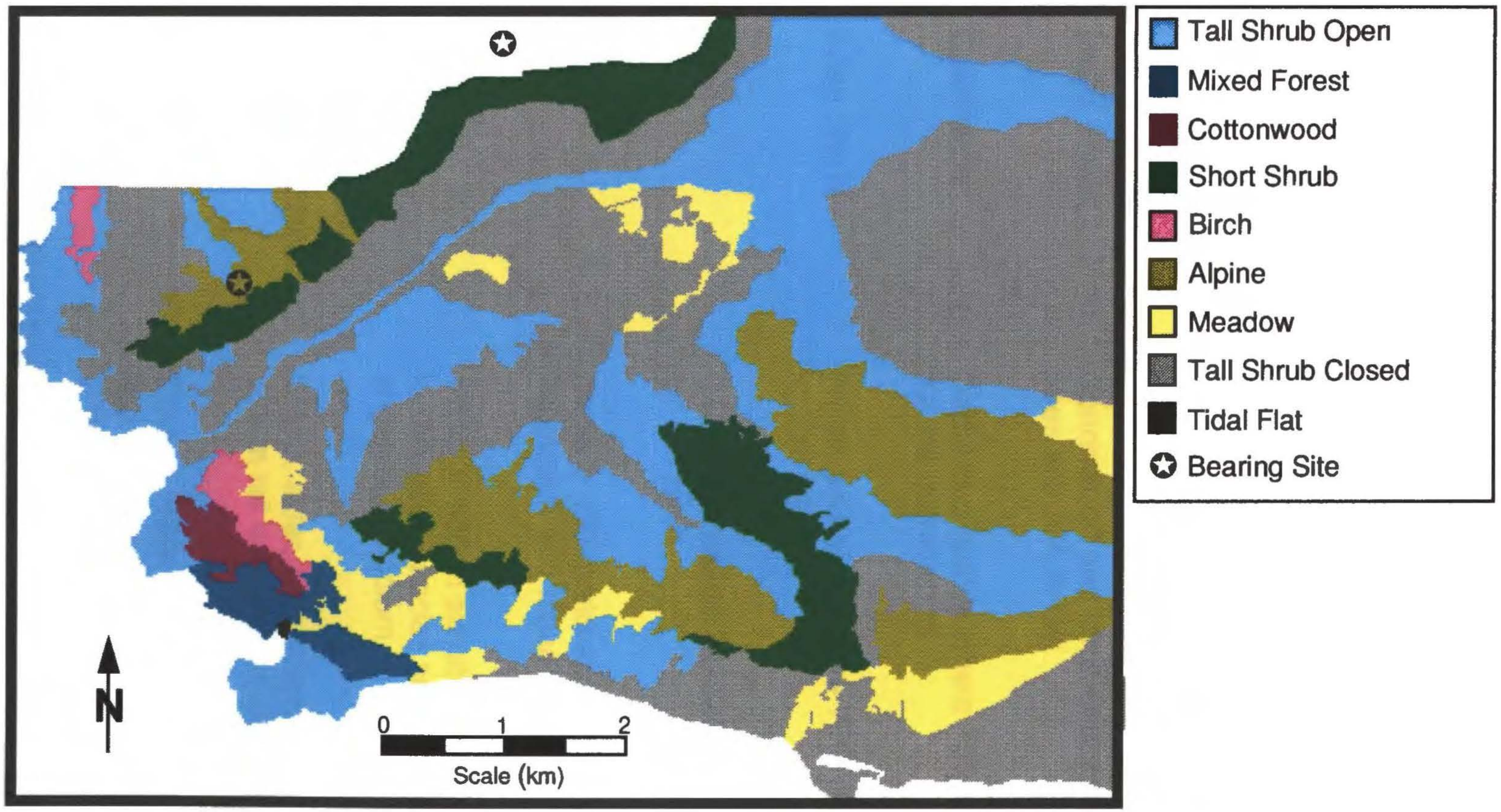

Fig. 2. Distribution of habitat types on the northwestern Spiridon Peninsula, Kodiak Island, Alaska.

Table 1. Descriptions of habitat types occurring on the northwestern Spiridon Peninsula, Kodiak Island, Alaska.

HABITAT TYPE	DESCRIPTION OF DOMINANT VEGETATION
Tall Shrub Open	Willow, alder, and elderberry association > 2 m tall with canopy cover < 75%.
Mixed Forest	Cottonwood and birch association where trees are > 4 m tall.
Cottonwood	Deciduous stands where 75% of trees > 4 m tall are cottonwood.
Short Shrub	Willow and birch where 75% of coverage is ≤ 2 m tall.
Birch	Deciduous stands where 75% of trees > 4 m tall are birch.
Alpine	Areas ≥ 450 m elevation dominated by heath vegetation and meadows.
Meadow	Areas < 450 m elevation consisting of ≥ 75% herbaceous species such as heracleum, angelica, epilobium, and bluejoint grasses.
Tall Shrub Closed	Willow, alder, and elderberry associations > 2 m tall with canopy cover ≥ 75%.
Tidal Flat	Coastal areas periodically flooded during high tides, dominated by sedges and grasses.

(*Lysichiton americanum*), bluejoint grass (*Calamagrostis canadensis*), and crowberry (*Empetrum nigrum*). A comprehensive species list of vascular plants in the study area was prepared by Talbot (1991) and a detailed description of the vegetation on Kodiak is provided in the Kodiak National Wildlife Refuge final comprehensive conservation plan, and environmental impact statement, wilderness review (U. S. Fish and Wildlife Service 1987).

METHODS

Locations

This study focused on obtaining locations from 21 adult (≥ 2 years old) female deer that were captured and fitted with radio collars (capture technique and associated data are provided in Appendix 1). I made attempts to locate these animals every 2-3 days (weather permitting) from 17 July 1990 to 8 July 1991 (excluding 9 Sep. - 28 Sep. 1990, 13 Dec. 1990 - 7 Jan. 1991, 15 Apr - 14 May 1991, and 12 June - 26 June 1991 when I was away from the study area). Three different methods were used to obtain locations; ground bearings from two permanent sites during summer, ground bearings in winter, and occasional aerial telemetry. All locations were plotted on 1:63,360 topographic maps. To estimate locational error obtained by triangulation of radio bearings (Springer 1979), I analyzed 336 randomly selected summer locations using the SAS (SAS Inst. Inc. 1988) program developed by White and Garrott (1990). To facilitate future analyses, I calculated the average area of the resulting polygons and determined that circle with a radius of 57.8 m would enclose the same area. This radius was used to produce a circular buffer encompassing each deer location and these buffered locations of points were used for habitat analyses.

Summer locations: Ground bearings were taken from two permanent sites (Fig. 2) using a hand-held H antenna, a Telonics receiver-scanner and hand-held compass. I arrived at the first site, recorded bearings from as many collared animals as possible, then walked to the second site and repeated the process. There was a delay of approximately 90 minutes between successive bearings for individual animals and all bearings were taken during mid-day (1030 -1500 h., Alaska standard time), which is a period of inactivity for *Odocoileus* (Beier and McCullough 1990). Each bearing was corrected for magnetic declination and triangulation was used to determine animal locations (White and Garrott 1990).

Winter locations: All but one of the animals that remained in the study area during winter moved to slopes where topography made it prohibitive to obtain bearings from permanent sites. Instead, I walked parallel to and approximately 300 m from the base of the slope with a hand-held H antenna and a Telonics receiver-scanner. Using this equipment, I determined the animal's vertical position on the slope, then I walked up the slope to determine its elevation. I considered this procedure acceptable for two reasons: the patchiness of the vegetation and topographic features allowed for relatively accurate placement of locations (±100 m), and on several occasions I obtained visual confirmation of the deer in question after recording its location. The one animal that remained in a low-lying area was on a small peninsula and its locations were determined by walking the periphery and taking periodic bearings. All locations were obtained during mid-day (1030 - 1500 h., Alaska day-light time).

Aerial telemetry: Seven animals that moved out of the study area were located occasionally using standard aerial-telemetry techniques. These data were used to record movements, but were omitted from all habitat use and home-range analyses due to the limited number of locations obtained.

Locations were compiled for individual animals during each season (summer and winter). Each data set was examined for auto-correlation using the MRSP option (Solow 1989) of the BLOSSOM computer software package (Slauson et al. 1991). When a data set was determined to be significantly auto-correlated ($\underline{P} < 0.05$), locations were omitted until auto-correlation was reduced to the acceptable level ($\underline{P} > 0.05$). All data associated with habitat use and home-range analyses were corrected for auto-correlation.

Mapping

During a 4 -week period in summer 1990, S. Talbot of the U. S. Fish and Wildlife Service collected and identified plant specimens, and verified data from aerial photographs by ground truthing habitat types. He produced a voucher collection of vascular plants (Talbot 1991) occurring in the study area and prepared a habitat map that I modified (i.e., I combined small, discrete habitats into general habitat types) using PC ARC\INFO (Environmental Systems Research Institute, Redlands, CA). The revised map (Fig. 2) was used for analyses of habitat use by deer and is based on descriptions of nine habitat types (Table 1).

Seasonal Movements

For the purpose of this study, a movement occurred when a deer was located in a new area (at least 1 km from the previously used area) and remained there for a minimum of 2 weeks. By plotting locations of animals on topographic maps, it became evident that two discrete clusters appeared and these corresponded roughly to calendar seasons. Thus, a designation of summer or winter was assigned to locations depending on the cluster in which that location occurred. Due to the variation in dates when animals initiated movements, different seasonal dates were used for individual deer.

Habitat Use

To investigate habitat use, I produced two data sets (one representing summer locations, and another winter locations) by pooling seasonal locations of individual collared deer. Each location was buffered as previously described, overlaid onto the habitat map, and the total representation (use) of each habitat type was recorded. Additionally, random sets of locations were generated that corresponded spatially and numerically to the pooled data sets. These data were subjected to the same treatment as the pooled data and were used to predict seasonal availability of habitats. Seasonal habitat selection was determined by comparing the proportion of recorded locations (use) with the proportion of random locations (availability) in each habitat type, during each season.

When the area of a buffered point location included more than one habitat type, the relative proportion of each habitat type was recorded. When the buffered location was situated within a single habitat a value of one was recorded for that habitat type.

Habitat availability changed with season. During summer, the entire study area was considered to be available, whereas habitats available in winter were restricted to a band along the coast (Fig. 3). "Winter range" was defined by encompassing 95% of all winter locations and applying slight modifications to take topographic features into account (i.e., I used mountain ridge lines as borders in some instances).

To determined whether there was a seasonal effect for habitat use, I compared pooled data set of summer locations to pooled data set of winter locations. These data were then compared to corresponding random data sets to determine if habitat use was different from habitat availability. All comparisons were accomplished by performing a multi-variate analysis of variance (MANOVA) using SAS (SAS Inst. Inc. 1988).

Seasonal Home Ranges

Seasonal home ranges were estimated by the 95% adaptive kernel method (Worton 1989) using a beta test version of CALHOME computer software (Kie et al. 1994). Only those data sets that had an adequate sample size to give an accurate home-range estimation (i.e., produced a plot of number of locations verses area that reached a plateau value that varied by no more than ± 10%) are included in the results. This process reduced the usable number of summer ranges for deer from 20 to 11 (mean number of locations per data set = 26, SD = 8.5, and range 14-39 locations) and the number of usable winter ranges from 14 to 9 (mean number of locations per data set = 30, SD = 6.7, and range locations).

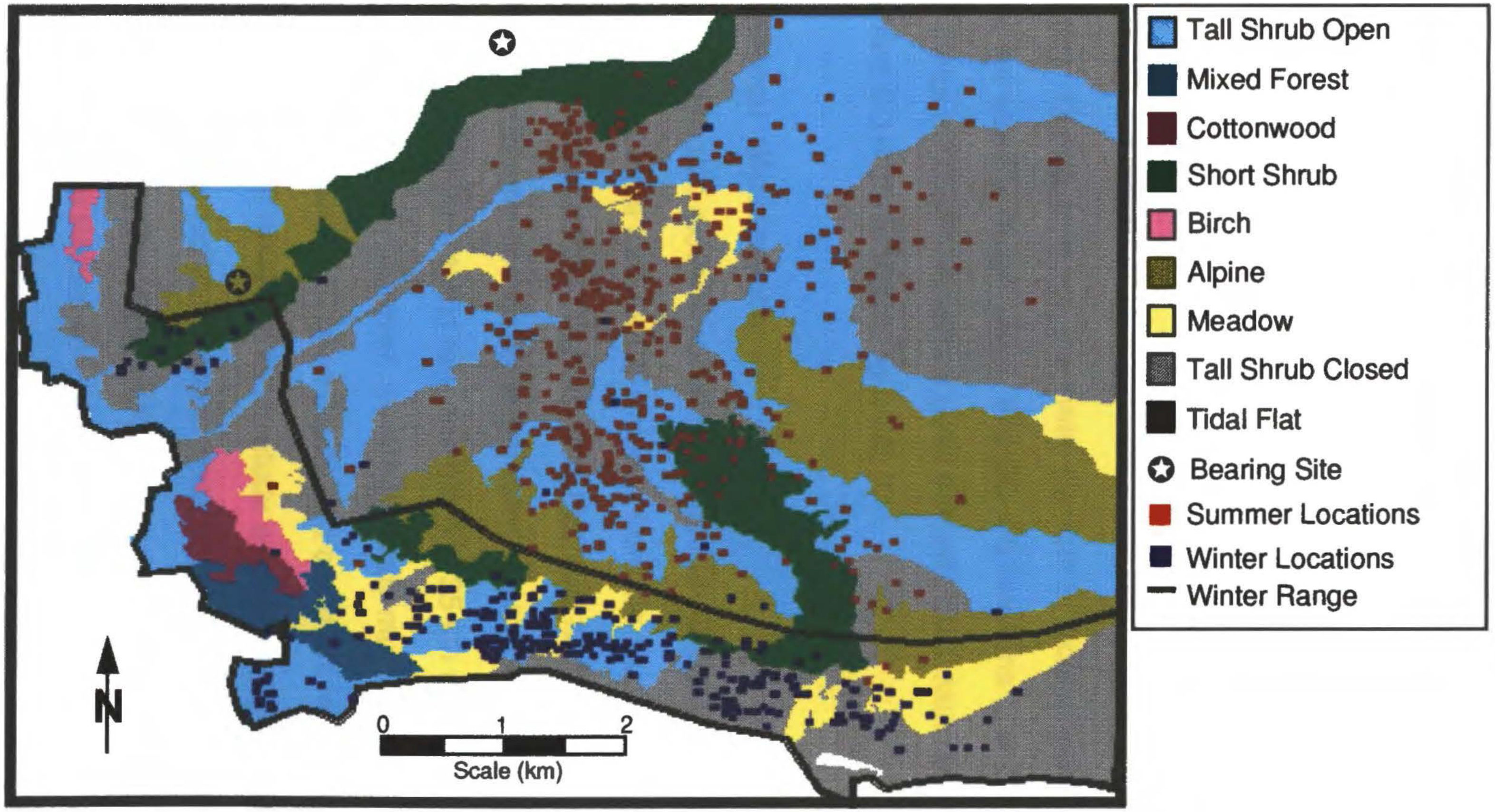

Fig. 3. Seasonal locations for adult female Sitka black-tailed deer on the northwestern Spiridon Peninsula, Kodiak Island, Alaska (17 July 1990 - 8 July 1991).

RESULTS

Locations

A total of 658 summer and 464 winter locations was recorded from collared deer, but correcting for auto-correlation within individual data sets reduced the usable location numbers to 508 and 369, respectively (range of reduction for individual deer data sets was 0-46% in summer and 0-42% in winter). During summer, the mean number of locations used per individual data set was 25, range 14-39, and SD = 8 locations (n = 20). During winter, the mean number of locations used per individual data set was 26, range 8-38, and SD = 8.5 locations (n = 14).

Seasonal Movements

Seasonal movements were evident for all collared deer. Of the 21 animals that were monitored, 7 moved from the study area during winter. Of those 7, 4 returned to the same area that they had occupied the previous summer. Straight-line distance between summer and winter ranges for these deer averaged 22 km and ranged from 5 to 35 km (SD = 10.2 km). Actual distances traveled, however, were potentially much greater in some instances because of expanses of open ocean that could prevent direct movements. The 14 deer that remained in the study area all made movements to winter ranges, but returned to the same areas they occupied the previous summer. Straight-line distance between these summer and winter ranges were ≤ 5 km.

Dates when individual collared animals initiated their winter movement and when they returned to their summer ranges were variable. Movements from summer to winter range of 20 collared deer occurred from mid-August to late January with a mean date of movement 30 October (SD ± 38 days) and winter to summer range movements of 18 collared deer occurred from mid-April to late June with a mean date of movement date 29 May (SD ± 18 days).

Habitat Use

The relative importance rating (Bowyer and Bleich 1984) of habitats was dominated by tall shrub open and tall shrub closed during both seasons, and meadow also rated relatively high in winter (Fig. 4). MANOVA indicated a significant difference ($\underline{P} < 0.001$) in habitat use for combined data sets of summer verses winter locations (Fig. 5). To determine habitat selection and avoidance, recorded locations (use) were compared with random locations (availability) for both seasons (Table 2). Including availability (determined from random location data sets) in the MANOVA produced significant differences ($\underline{P} < 0.05$) in habitat use between seasons for tall shrub open, mixed forest, cottonwood, birch, and tall shrub closed habitat types (Fig. 5). This analysis also showed significant differences ($\underline{P} < 0.05$) for habitat use within season. During summer, mixed forest and alpine were avoided, (used significantly less than available), whereas tall shrub closed was selected (used significantly more than available). During winter, mixed forest, cottonwood, birch, alpine, and tall shrub closed were avoided, whereas tall shrub open was selected (Fig. 5).

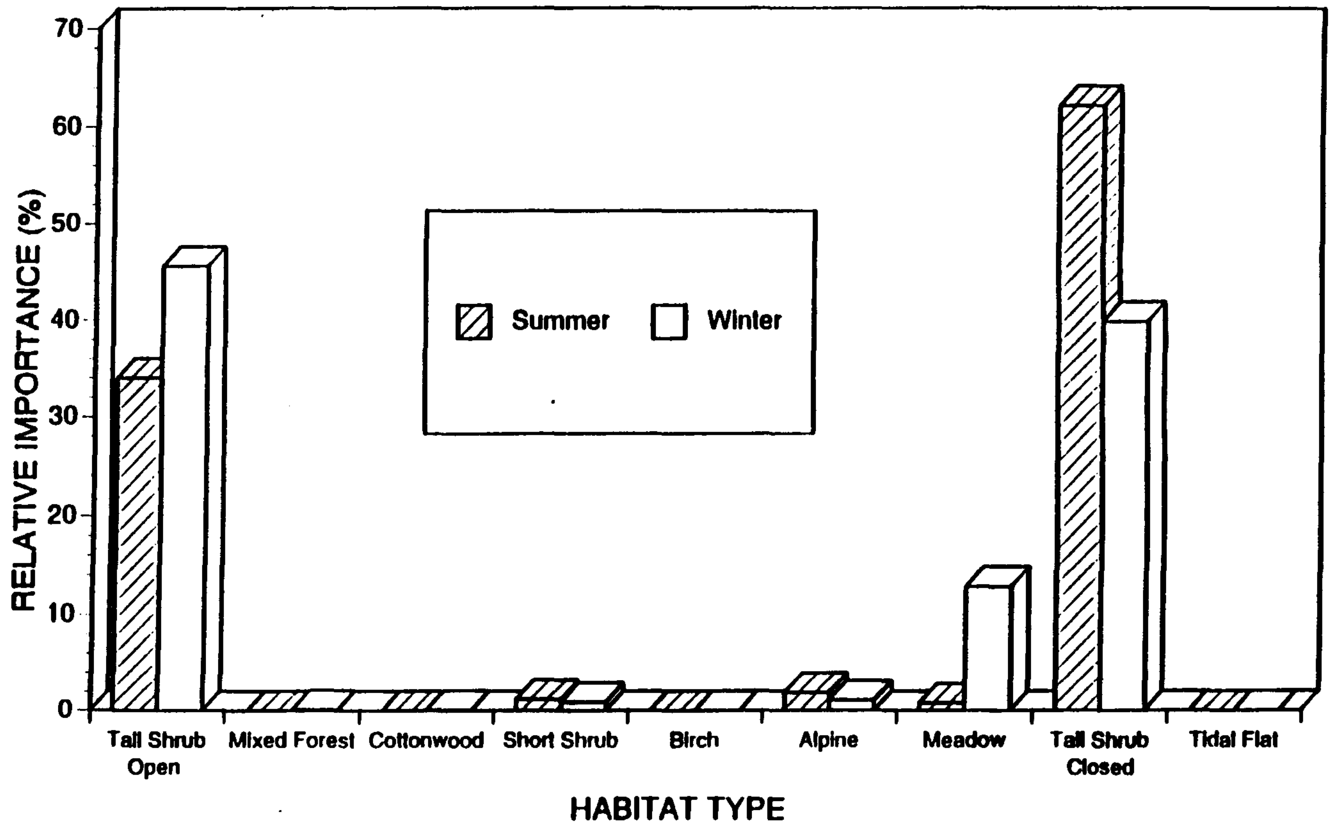

Fig. 4. Relative importance (use x available, rescaled to 100%) of seasonal habitats for adult female Sitka black-tailed deer on the northwestern Spiridon Peninsula, Kodiak Island, Alaska (17 July 1990 - 8 July 1991).

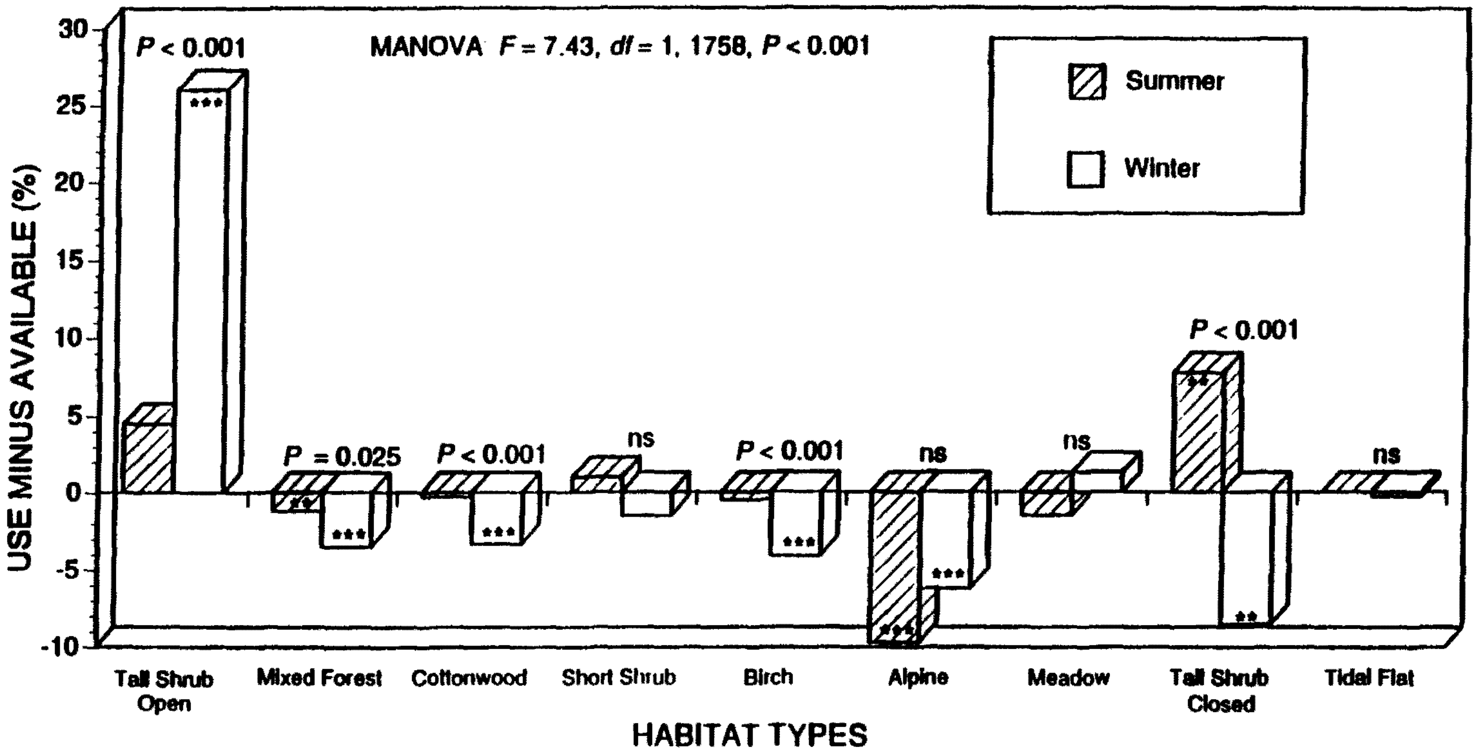

Fig. 5. Summary of MANOVA for between and within season differences of habitat selection for adult female Sitka black-tailed deer on the northwestern Spiridon Peninsula, Kodiak Island, Alaska (17 July 1990 - 8 July 1991). P values indicate significance of between seasonal selection for habitats, and * indicates significance of within season selection of habitats (** indicates $P \leq 0.01$, and *** indicates $P \leq 0.001$).

Table 2. Comparison of seasonal habitat use (recorded %) versus seasonal habitat available (random %) for adult female Sitka black-tailed deer on the northwestern Spiridon Peninsula, Kodiak Island, Alaska (17 July 1990 - 8 July 1991).

	SUMMER LOCATIONS		WINTER LOCATIONS	
HABITAT TYPE	Recorded (%)	Random (%)	Recorded (%)	Random (%)
Tall Shrub Open	36	31	48	22
Mixed Forest	0	1	1	4
Cottonwood	0	0	0	4
Short Shrub	7	6	4	5
Birch	0	0	0	4
Alpine	4	14	3	9
Meadow	4	6	18	17
Tall Shrub Closed	49	42	26	35
Tidal Flat	0	0	0	0

Note: All numbers are rounded to the nearest percent.

Seasonal Home Ranges

Data sets for 11 deer in summer and 9 deer in winter had adequate sample sizes for accurate estimations of home range. On average, the area of summer home ranges was significantly larger than the area of winter home ranges ($\underline{P} < 0.001$, Mann-Whitney U) for both the 95% adaptive kernel and 95% minimum convex polygon methods. The 95% adaptive kernel method produced mean home range areas of 454 ha in summer (range 134-819 ha, SD = 227 ha), and 107 ha in winter (range 67-217 ha, SD = 56 ha), whereas the 95% minimum convex polygon method produced mean home range areas of 252 ha in summer (range 57-538 ha, SD = 145 ha) and 73 ha in winter (range 30-153 ha, SD = 41 ha).

Most collared deer wintered on coastal mountain slopes having a southwest aspect (Fig. 3). Exceptions were 2 deer that wintered outside the study area on slopes with northeast aspects and 1 deer that wintered outside the study area on an interior lowland (< 300 m elevation).

DISCUSSION

Deer ecology in nonconiferous regions on Kodiak Island may contrast from that of Southeast Alaska simply because habitats of the two areas differ in structure and species composition. In the landscape of Southeast Alaska where deer occur, coniferous forests and alpine meadows predominate, whereas the study area on Kodiak was dominated by extensive brush lands and low-land meadows. Deer have responded to differences in available forage species, forest cover and winter snow characteristics on Kodiak, through changes in diet, use of cover, habitat selection, and seasonal movements. This study provides insights to what some of these adaptations are, but should be viewed as an initial step for understanding the dynamics of the ecology of Sitka black-tailed deer in areas lacking old-growth coniferous forest on Kodiak Island.

Seasonal Movements

Schoen and Kirchhoff (1985, 1990) identified 2 populations of Sitka black-tailed deer in Southeast Alaska and classified them as migratory and resident. The criteria they used to distinguish between these populations was whether their summer and winter ranges overlapped. Individual deer belonging to the migratory population had summer and winter ranges that did not overlap, whereas seasonal ranges of resident deer were overlapping. Yoe and Peek (1992), also conducted a study of deer in Southeast Alaska, but their study area was in a logged habitat, and they reported only resident deer. The contrast in the two studies led to the development of my first null hypothesis that deer do not make seasonal movements. Based on the studies mentioned above, I was uncertain if there would be both migratory and resident deer populations in my study area. Using the criterion identified by Schoen and Kirchhoff (1985, 1990), all deer from my study would be classified as migratory and I reject my first null hypothesis.

I advise using caution when interpreting these results, because several events suggest that resident deer may have been missed. One collared deer moved from her original summer range to a winter range and stayed there the following summer, but it is not known if she made a winter movement that year;

deer were seen in coastal areas (traditional winter ranges) throughout the year; the sample of collared deer was probably biased towards migratory animals because all deer were captured during the summer in an interior valley, and it is possible that some movements of collared deer were not detected.

The variability of dates of seasonal movement for individual deer could not be explained from data gathered during this study. Environmental factors (i.e., forage nutrition and availability, snow depth, etc.) undoubtedly influence the timing of seasonal movements for deer, but alone do not explain why summer to winter range movements occurred from August to January, and winter to summer range movements occurred from April through June. Mating behavior, maternal status, associations with other deer, and individuality must also contribute to timing of movements. Unfortunately, detailed information for these factors were not recorded. That movements from summer to winter range were more than twice as variable as winter to summer range movements (SD ± 38 days verses SD ± 18 days) suggests that associations with other animals may be important (i.e., deer are dispersed in summer and congregated in winter), but range characteristics also must contribute to this pattern. Perhaps, some deer arrive at their winter range early so they can obtain the highest quality foods before other deer arrive and food availability decreases. Conversely, other deer may have found it beneficial to remain on their summer range as long as possible. As more deer migrate to the winter range more food becomes available per individual remaining on the summer range. Data concerning environmental, physiological, and social interactions is difficult to obtain, but is needed to gain insights to complex behaviors such as the timing of seasonal migrations.

Habitat Use

I reject the second null hypothesis that habitat use by adult female deer does not change seasonally, based on the results of the MANOVA (Fig. 5). Differences also existed for seasonal habitat use in Southeast Alaska (Schoen and Kirchhoff 1990), but habitats available in the two areas were different. Schoen and Kirchhoff (1990) located deer in old-growth forests almost exclusively in winter (99% of locations), and during summer deer were usually located in old-growth forests or sub-alpine habitats (57% and 33% of locations, respectively). On Kodiak, tall shrub open habitat was selected in winter whereas tall shrub closed habitat was selected in summer (Table 2.).

Results from analysis of the habitat selection and avoidance data (Fig. 5) were unanticipated. I did not expect alpine habitats to be avoided in summer and expected tall shrub closed and tidal flats to be selected in winter. During summer deer tend to be less active during mid-day (Beier and McCullough 1990), and females with fawns tend to seek areas with cover. Also, nutritional value of alpine forage species, or abundance of forage species may be lower than that found in and around the tall shrub closed habitat. I do not believe that time of day when locations were taken in summer contributed significantly to the avoidance of alpine, because evidence of deer use (sightings, tracks, beds, and pellet groups) in this habitat was minimal. Nonetheless, during winter, I believe that time of day when deer were located could have contributed to the avoidance of tall shrub closed habitat. In the absence of old-growth conifers, I would have expected deer to seek out the limited protection offered by dense alder and willow stands. Indeed, there was evidence that deer used this habitat regularly (beds, pellet groups, and browsing). I noticed deer activity increased during the warmer mid-day period in winter, and often observed deer foraging in meadows and tall shrub open habitats. I believe that deer used the tall shrub closed habitat primarily for resting and cover during inclement weather and that use of this habitat was underestimated by my sampling design. The best explanation for tidal flats not being selected is that little of this type was available in the study area (Table 2).

Deer were introduced to Kodiak Island into habitats that differed in structure and species composition from Southeast Alaska when they were introduced to Kodiak Island. That deer flourished and dispersed into habitats that lacked a critical component (i.e., old-growth coniferous forest) of their native range, is testimony to their adaptability. Several factors must have contributed to the success of deer on Kodiak. On average, monthly temperatures from November through February are 1.2 to 3.7°C warmer and annual snowfall is 56 cm less at Kodiak compared with Juneau, Alaska (National Weather Service data). Milder winters relative to Southeast Alaska, is probably a major reason deer are able to survive on Kodiak without old-growth cover, but I also believe that nutritional value and abundance of summer forage are important. Unfortunately, data for these variables on Kodiak are lacking.

Seasonal Home Ranges

In Southeast Alaska, Schoen and Kirchhoff (1985) reported no significant difference in seasonal home range size for adult female deer in an area that had large expanses of old-growth forest, whereas Yoe and Peek (1992) reported core summer range to be significantly larger than core winter range (45 ha summer verses 32 ha winter) in a region where available old-growth forest was reduced by logging. For the Kodiak study, average summer range also was significantly larger than average winter range (95% adaptive kernel areas were 454 ha summer verses 107 ha winter), but the difference was more than 400%. Therefore, the third hypothesis, that home range size does not change seasonally, was rejected (Mann - Whitney U, $\underline{P} < 0.001$). Comparing the proportional difference of seasonal home-range size for the three studies suggests that Sitka black-tailed deer increase summer range size relative to winter range size as the amount of old-growth coniferous forest habitat declines (i.e., no significant difference with abundant old-growth; summer 1.4 times larger with limited old-growth, and summer > 4 times larger with no old-growth).

A primary benefit of old-growth forest is that the canopy intercepts snow, allowing the forest floor to provide food and relative ease of travel for deer during winter. Without similar habitat available over most of Kodiak, each centimeter of snow that falls has a higher potential to restrict deer movements and cover winter food. A possible strategy to overcome restrictions of snow cover would be to enter winter with greater fat reserves. Increasing the size of summer range may allow deer on Kodiak to be more selective in their summer diets (increasing ingestion of high-quality forage) and accumulate greater fat reserves. This would permit deer to reduce the size of their winter range (conserving energy) and rely on stored fat when snow cover becomes restrictive. The multiplicative effect of increasing the size of summer range while reducing winter range size would explain the proportional difference in seasonal range size identified in the preceding paragraph. Data supporting this strategy are; average 100% minimum convex polygon home-ranges of 82 ha summer, and 102 ha winter, reported for deer occupying old-growth habitat in Southeast Alaska (Schoen and Kirchhoff 1985), compared with 95% minimum convex polygon home-ranges of 252 ha summer, and 73 ha winter for the Kodiak study.

Deer are among the most studied wildlife species, but understanding deer ecology on Kodiak Island is still in its infancy. This study identified adjustments deer have made to the habitats of Kodiak Island through seasonal movements, habitat selection, and seasonal home-range characteristics, and results of the study provide a basis for more intensive investigations of deer habitat relationships there. Future studies focusing on deer habitat impacts, diets (and forage quality), seasonal nutrition cycles, and population dynamics are needed to increase understanding of deer ecology and their ecosystem relationships on Kodiak Island.

APPENDIX 1. Capture techniques and data recorded from adult female deer immobilized on the Spiridon Peninsula, Kodiak Island, Alaska.

INTRODUCTION

In late June of 1989 and 1990, 24 adult female deer (5 and 19 respectively) were captured and fitted with Telonics (Telonics Telemetry-Electronics Consultants Mesa, AZ) model 500 S6A butyl/butyl radio transmitters equipped with mortality censors. Locations and movements of the deer were subsequently monitored as a part of a study of their habitat relationships.

METHODS

Deer were captured using standard helicopter darting techniques. A Cap-Chur XLR extra-long range (powder) projector equipped with a 22 caliber blank adapter, fired darts made up of a 3/4 inch barbed needle, rubber stopper containing an internal charge, a tail-piece, and a 5 cc cylinder filled with 3.5 mg etorphine, 20 mg xylazine, and sterile water. Both green (low range) and brown (very low range) 22 caliber blank powder loads were used in the adapter, but the use of brown loads was ceased after 3 attempts due to insufficient power to compensate for the helicopter prop-wash. The capture equipment (i.e.; projector, 22 caliber blank adapter, 22 caliber powder loads, internal charges, and dart components) came from the Palmer Chemical & Equipment Co., Inc. (Douglasville, GA).

After a dart was delivered successfully (from approximately 5 m above and 10-15 m behind the deer), the helicopter would pull off, and with the aid of a PA-18 fixed-wing aircraft, the darted animal was followed until the drugs took effect. Capture efforts for individual deer were aborted after 10 minutes if the deer did not show any drug effects. The processing of immobilized deer included cleaning the dart wound with a dilute betadine solution, injection of 5 cc flocillin, weighing, measuring, taking a blood sample, estimating age from tooth development and erosion, and fitting a radio collar around the animal's neck. Throughout this effort deer were placed in sternal recumbency whenever possible, vital signs were monitored, and deer were cooled with water when necessary. After processing was completed deer were injected with an antidote of 3.5-3.8 mg diprenorphine and monitored until they stood up and walked away. Processing time took 30-45 minutes per animal.

RESULTS

Chase time (when the deer began running from the helicopter until it was darted) averaged 2.7 minutes and ranged from 0.5 to 4.8 minutes (sample size 18). Immobilizing time (from the time the deer was darted until it went down) averaged 8.6 minutes, ranging from 4.0 to 25.0 minutes (sample size 23) and 7 deer were hit by darts, but did not go down (visual contact for 2 of these deer was lost after 8.0 minutes). Overall recovery time (injection of diprenorphine until deer got up) averaged 10.7 minutes, ranging from 3 to 40 minutes (sample size 23), but averaged almost 3 times longer in 1989 (21.6 vs 7.7 minutes).

A summary of weights and measurements recorded from deer captured in 1990 is provided in Table A1-1. Measurements included length (tip of the nose to the base of the tail measured along the vertebral column), chest girth (immediately behind the front shoulders perpendicular to the vertebral column), hindfoot (tip of the calcaneum to the hairline on the bottom of the hoof), tail (base of the tail to the last vertebra), head (greatest length), and ear (base of the notch below ear opening to tip of ear excluding hair). Blood sera samples were sent to the Alaska Department of Fish and Game (Fairbanks Office) where they were analyzed by Randall Zarnke for infectious bovine rhinotracheitis (IBR), bovine viral diarrhea (BVD), parainfluensa 3 (PI3), respritory syncytial virus (RSV), epizootic hemorrhagic disease (EHD), bluetongue, brucella, and leptospirosis; all results were negative. The estimated age of captured deer ranged from 4 to 12 years and averaged 7 years (sample size 21).

Capture mortality rate over both years was 12% (3 of 26). One animal suffered a broken back while running from the helicopter, another deer broke a tibia after it was darted, and a third animal appeared to recover after the capture process, but was found dead a week later approximately 200 m from the capture site. The first 2 animals were destroyed using a large caliber rifle and it is believed that the third animal died from renarcosis.

Table A1-1. Summary of weights and measurements recorded from adult female Sitka black-tailed deer captured in late June 1990 on the Spiridon Peninsula, Kodiak Island, Alaska.

	Weight (Kg)	Length (cm)	Chest Girth (cm)	Hind Foot (cm)	Tail (cm)	Head (cm)	Ear (cm)
Sample Size	12	17	17	14	18	16	17
Mean	48	134.9	83.8	33.1	13.6	28	14.7
Range	45-54	128-147	79-87.1	31-36	11-16.5	26.5-29.5	13.6-15.8
SD	3.5	5.3	2.6	1.2	1.5	0.8	0.6

DISCUSSION

This was the first time that aerial darting for deer capture was attempted on Kodiak and it was the first time members of the capture team (including pilots) were involved with aerial darting of deer. A total of 89 darts (3.4 darts per captured deer) were used and all but a few were lost because they either missed the deer or dislodged when the animal was running. In 1990, when 19 deer were collared, the helicopter and PA-18 logged 21.1 and 35 hours respectively. People involved included helicopter and fixed-wing pilots, fixed-wing observer, helicopter darter, and a ground crew of 2.

I believe that the efficiency of future aerial deer capture efforts on Kodiak can be increased if the effort to dart a running deer is extended up to 5 minutes (if climatic conditions are right, i.e., cool temperatures and overcast skies) in order to get an opportunity for an effective shot. It takes longer to reload and try for a second shot after a hastily made and missed first shot than waiting for a single quality opportunity. If there is no opportunity for a clear shot after about 5 minutes, then the chase should be stopped and search begun for another deer. This would reduce aircraft time, darts used, and the amount of immobilizing drugs needed.

APPENDIX 2. Winter diets of deer inhabiting the Spiridon Peninsula, Kodiak Island, Alaska, determined from microhistological analysis of fecal pellets.

METHODS

Samples of deer pellet groups were collected opportunistically in the study area from 20 October 1990 - 12 April 1991. Individual samples were dated, dried, and combined into bimonthly composite groups ranging from 10-50 samples per group. A sample consisted of 10 pellets or an equivalent amount of fecal matter (if necessary large clumps were broken into pellet sized pieces) from a fresh pellet group. A sub-sample of each composite group (20-30 pellets) was sent to the Wildlife Habitat Laboratory at Washington State University for microhistological analysis (Davitt and Nelson 1980) at level B (identifying genera and major species within food categories) with 150 views per slide.

I also obtained paired fecal and rumen samples (20-30 pellets and about 0.25 liters of rumen contents) from 10 deer harvested by sport hunters and 5 deer that died from starvation (determined by femur marrow condition). Fecal samples were dried and rumen contents were preserved with formalin before being subjected to the analysis described in the previous paragraph.

RESULTS

Food items were grouped into one of four food categories. The plant genera that were most frequently encountered in the fecal and rumen material according to their forage category are: **shrubs** - *Salix spp.*, *Viburnum*, *Arctostaphylos*, *Cassiope*, *Empetrum*, *Sambucus*, *Populus*, *Rubus*, *Rosa*, *Phyllodoce*, and *Dryas* ; **forbs** - *Epilobium*, *Heracleum*, *Lysichitum*, *Rumex*, and *Lupinus*; **ferns** - fern leaf and fern rhizome; **miscellaneous** - grasses, sedges, kelp, lichens, and moss.

Percent occurrence of the different food categories reflected dietary shifts throughout winter (Fig. A2-1). Shrub occurrence increased through mid-February then gradually declined; forb occurrence remained relatively constant; fern occurrence started high , decreased rapidly, then increased in March; miscellaneous items increased gradually through January then decreased.

Comparisons of the paired fecal and rumen sample analyses are presented in Table A2-1. Comparing average fecal percent vs average rumen percent for the 4 food categories (i.e., shrub, forb, fern, and misc.) shows that the percent occurrence of shrubs was always greater in fecal samples, forbs and ferns were always greatest in rumen samples, and the misc. category was greatest in rumen samples for all samples combined and for deer that died of starvation, but was lower in rumen samples from sport hunters.

Complete copies of the composite fecal and paired fecal/rumen sample analyses are on file at the Kodiak National Wildlife Refuge headquarters, 1390 Buskin River Road, Kodiak, Alaska 99615.

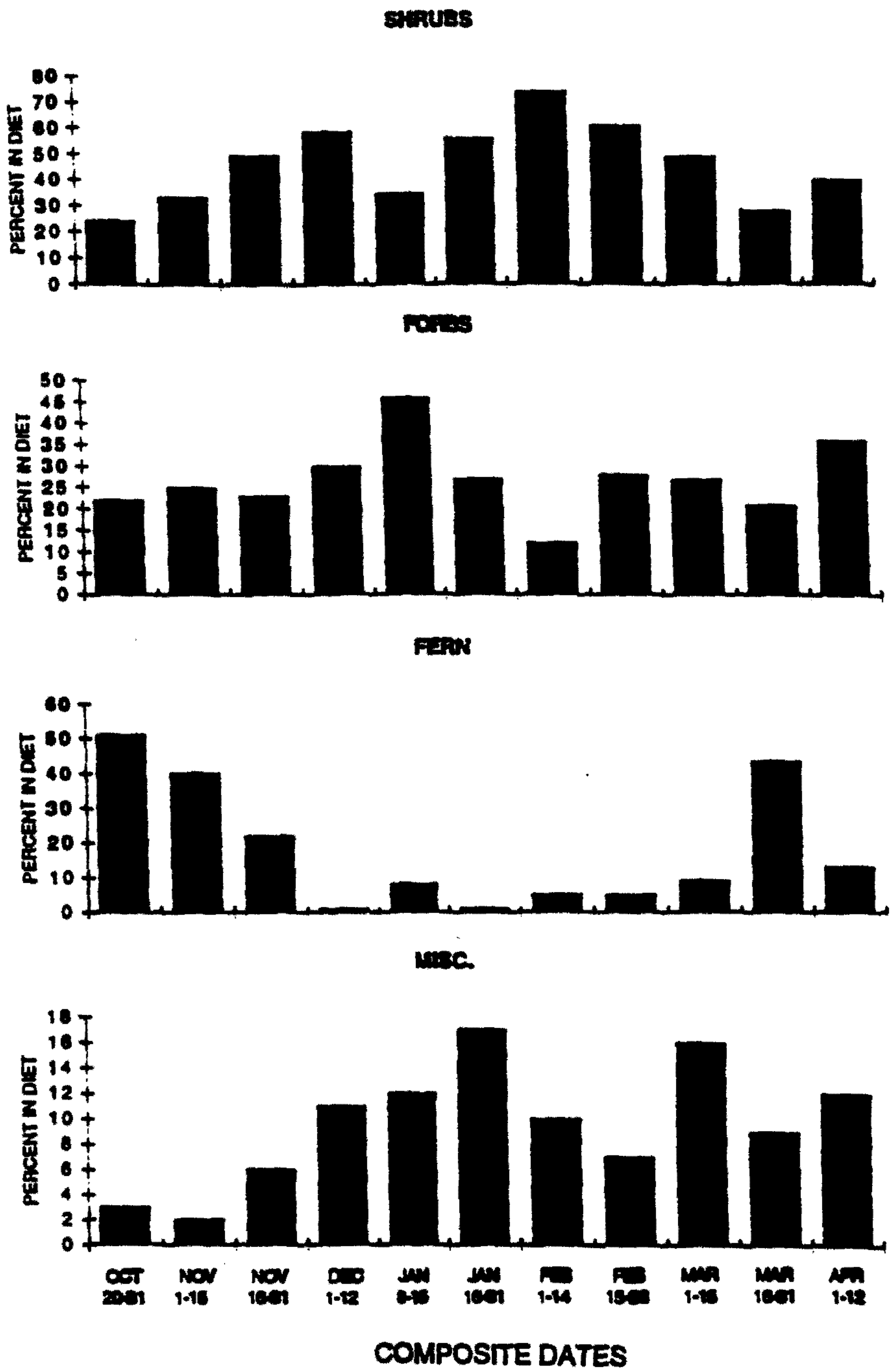

Fig. A2-1. Percent occurrence of major food categories in composite fecal samples for Sitka black-tailed deer inhabiting the northwestern Spiridon Peninsula, Kodiak Island, Alaska (20 October 1990 - 12 April 1991).

Table A2-1. Comparison of percent occurrence for food categories in paired fecal (f) and rumen (r) samples obtained from Sitka black-tailed deer that were killed by sport hunters (90) and that died of starvation (91) on the northwestern portion of the Spiridon Peninsula, Kodiak Island, Alaska.

Date	Age Class	Sex	Shrub % f	Shrub % r	Forb % f	Forb % r	Fern % f	Fern % r	Misc % f	Misc % r
26 Oct 90	Adult	F	25	34	22	11	50	48	3	7
30 Oct 90	Fawn	F	31	25	34	20	34	47	1	8
31 Oct 90	Adult	F	40	10	19	19	23	69	18	2
13 Nov 90	Adult	F	64	44	16	45	2	0	18	11
14 Nov 90	Adult	F	33	39	61	55	1	3	5	3
16 Nov 90	Adult	F	46	36	28	55	18	5	8	4
21 Nov 90	Adult	M	47	10	18	34	30	50	5	6
24 Nov 90	Adult	M	69	38	19	49	0	1	12	12
30 Nov 90	Adult	M	40	28	44	40	1	16	15	16
4 Dec 90	Adult	M	59	62	37	27	0	0	4	11
Mean 1990			**45**	**33**	**30**	**35**	**16**	**24**	**9**	**8**
2 Feb 91	Fawn	M	60	33	26	26	1	1	13	40
17 Feb 91	Fawn	M	52	77	36	11	0	0	12	12
23 Feb 91	Fawn	F	71	54	20	35	0	5	9	6
13 Mar 91	Fawn	F	77	64	9	27	5	0	9	9
21 Mar 91	Fawn	M	82	66	13	27	0	1	5	6
Mean 1991			**68**	**59**	**21**	**25**	**1**	**1**	**10**	**15**
Grand Mean (1990,1991 Combined)			**53**	**41**	**27**	**32**	**11**	**17**	**9**	**10**

APPENDIX 3. Summary of data collected during deer winter mortality surveys on the Spiridon Peninsula, Kodiak Island, Alaska.

METHODS

From 1989-91 deer winter mortality surveys were conducted in and adjacent to the study area. Surveys were conducted as near the onset of spring as possible before green-up occurred (end of March-late April). Areas were surveyed by 2 people walking meandering transects approximately 60 m apart that ran parallel to coastlines. All surveys began at the coast and in 1989 and 1991 ran 300-400 m inland, but they were limited to 200 m inland during 1990 due to time constraints. During surveys complete coverage of the area was attempted and efforts were made to determine the sex and age class of all carcasses. Age class of a carcass was determined by dental patterns and sex was determined by examining the skull for antler pedicels or the pelvis for suspensory tuberosities. In order to be included in the count, there had to be enough skeletal material present to identify it as a carcass site. Because scavengers often scattered bones and skin, occasional stray bones or pieces of skin were not included in the carcass counts. All carcasses were examined to minimize the possibility of including deer that had been killed by sport hunters. This included checking the condition of the bone marrow (we used the femur when present), and all of the carcasses included in the count had bone marrow that was essentially depleted of fat.

During the 1989 survey, measurements were recorded from femurs, hindfeet, and mandibles. Femurs were measured from the distal tip to the low point on the superior side of the femoral neck. Both hindfoot measurements began at the distal tip of the calcaneum, but hindfoot A terminated at the hairline on the bottom of the hoof while hindfoot B extended to the tip of the hoof. The mandible measurement recorded was the greatest length.

RESULTS

Table A3-1 provides annual summaries of the sex and age class distribution for all carcasses. Number of carcasses found varied from 161 in 1989 to 8 in 1991, and fawn carcasses had the highest representation in all years.

Bone measurements recorded in 1989 for known sex and age class deer are summarized in Table A3-2.

Table A3-1. Sex and age class of Sitka black-tailed deer carcasses found during annual winter mortality surveys on the northwestern Spiridon Peninsula, Kodiak Island, Alaska (1989-1991).

	FAWN				YEARLING				ADULT				UNKNOWN		
YEAR	M	F	Unk	%	M	F	Unk	%	M	F	Unk	%	Number	%	TOTAL
1989	41	29	28	61%	2	4	0	4%	13	0	3	10%	41	25%	161
1990[a]	8	7	62	69%	0	0	0	0	8	12	14	30%	1	1%	112
1991	3	1	3	88%	0	0	0	0	0	0	0	0	1	12%	8

[a] All information provided by Roger Smith, ADF&G.

Table A3-2. Summary of skeletal measurements from known sex and age class Sitka black-tailed deer carcasses found during the 1989 winter mortality survey on the northwestern Spiridon Peninsula, Kodiak Island, Alaska.

		SEX AND AGE CLASSES					
MEASUREMENT		Female Fawn	Male Fawn	Female Yearling	Male Yearling	Female Adult	Male Adult
Femur	n	28	39	4	2	1	12
	Mean	17.9	18.1	19.1	18.7	22.8	23.8
	Range	16.7-18.8	17.1-18.9	18.3-19.9	18.5-18.8	*	22.3-25.3
	SD	0.6	0.5	0.7	*	*	1.1
Hindfoot A	n	23	31	3	2	2	12
	Mean	29.6	30.3	31.5	31.6	35.5	37.1
	Range	27.2-32.8	24.7-32.6	30.0-33.2	31.5-31.7	34.1-36.8	34.9-40.1
	SD	1.3	1.3	1.6	*	*	1.4
Hindfoot B	n	23	31	3	2	2	12
	Mean	34.7	35.7	37.1	37.3	42.3	44.2
	Range	32.3-38.3	32.6-37.8	35.7-39.0	37.0-37.5	41.3-43.3	41.7-47.7
	SD	1.5	1.2	1.7	*	*	1.6
Mandible	n	13	18	3	2	1	12
	Mean	13	13.2	13.8	13.5	16.2	16.8
	Range	12-14	12.3-14.2	13.6-14.0	13.4-13.6	*	16.0-18.0
	SD	0.6	0.4	0.2	*	*	0.7

* No statistic given due to small sample size.

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