Alaska Department of Fish and Game
Division of Wildlife Conservation
Federal Aid in Wildlife Restoration
Research Progress Report

EVALUATION OF METHODS FOR ASSESSING DEER POPULATION TRENDS IN SOUTHEAST ALASKA

by
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Project W-23-1
Study 2.9
December 1989

STATE OF ALASKA
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PROGRESS REPORT (RESEARCH)

State: <u>Alaska</u>
Cooperators: <u>U.S. Forest Service, ADF&G Area Biologists, Mike Thomas, Rod Flynn</u>.

Project No.: W-23-1 Project Title: Wildlife Research and Management

Study No.: 2.9 Study Title: Evaluation of Methods for Assessing Deer Population Trends in Southeast Alaska

Period Covered: <u>1 Jan 1987-30 June 1988</u>

SUMMARY

The primary objective of this study is to evaluate methods for assessing Sitka black-tailed deer (<u>Odocoileus hemionus sitkensis</u>) population trends in Southeast Alaska. Emphasis is placed on the pellet-group technique that is in widespread use throughout the region.

Preliminary analysis of pellet-group data and methodology show that for every 3 pellet-groups counted by field crews, 1 pellet-group is typically missed (24%). This error probably overstates the true one, because check plots were run when large numbers of pellet-groups were present and/or the counter had made an obvious error. The differences between observed and true counts was not significant at low sample sizes ($\underline{N}$ = 107). Errors of this magnitude, if consistently made, should not affect pellet-group density comparisons from year to year or among areas.

Analysis of counting error by type of old-growth habitat showed no significant differences by volume class, although there is an apparent trend towards increasing levels of error (i.e., more groups missed) in higher volume stands. More check plots are needed before this trend can be statistically evaluated. Although experienced counters missed fewer pellet-groups than inexperienced ones, these differences were not significant at low sample sizes.

On 21 August 1986, 13 adult deer were transported from Admiralty Island to a 0.4-ha island in Auke Bay; i.e, Portland Island. A total of 1,538 deer-use days had accumulated there when pellet-groups were counted on 12 May 1987. The mean pellet-group density was 0.99 per 20 m^2. Using these data, an average defecation rate of 12.9 pellet-groups per deer per day was computed. Generally, this value agreems with values reported in the literature for mule deer (*<u>O. h. hemionus</u>*).

Persistence of marked pellet-groups on Portland Island was 10 to 11 months, which is significantly longer than the 7.5 months established by previous studies in Southeast Alaska. This

difference is attributable to drier weather conditions promoting longer pellet life and marked pellets allowing easier relocation.

Cover data for herb-layer vegetation on Portland Island prior to the deer transplant indicated a total biomass of 62.9 kg/ha. Analysis of basal stem diameters for shrub layer species indicate a total biomass of 1753.7 kg/ha. Both values are relatively high for old growth in Southeast Alaska.

On 29 May 1987, 188 randomly marked plants (Vaccinium spp.) were revisited and checked for evidence of browsing. Browsing was evident on 43 (22.8%) of the marked plants. Although the frequency of browsing was high, the intensity was quite low. Only 4.1 stems were browsed on each plant, and the terminal stem diameter of browsed stems averaged 1.01 mm. To be useful as an index of deer numbers, browse surveys must incorporate some measure of available biomass as well as the percentage utilized.

To develop relationships between plant dimensions and biomass, 33 *Vaccinium* plants on Portland Island were collected, separated into stem and leaf components, and oven-dried. Preliminary relationships between basal stem diameter and total biomass of V. ovalifolium, V. parvifolium, and Vaccinium spp. combined are presented.

A paper (Seasonal habitat preference of Sitka black-tailed deer on Admiralty Alaska) covering research conducted under a previous contract has been submitted to the Journal of Wildlife Management. The manuscript is attached as the Appendix to this report.

Key words: black-tailed deer, Odocoileus hemionuseters sitkensis, biomass, browse, old growth, pellet-groups, population assessment, Southeast Alaska.

CONTENTS

BACKGROUND

The primary objective of this study is to develop a method or combination of methods for effectively monitoring changes in size, trend, and composition of deer populations from site to site and year to year for individual planning areas within the Southeast region. Particular emphasis has been placed on critically evaluating the technique for counting pellet-groups. The estimation of winter surviorship and identification of limiting factors for deer are secondary objectives. A review of pertinent literature and background information are found in Pitcher and Kirchhoff (1986) and Kirchhoff and Pitcher (1988).

Job 1. Evaluate the pellet-group monitoring program from 1981 through the present.

The job has been completed. The objectives, methods, and results of pellet-group surveys conducted by the Alaska Department of Fish and Game (ADF&G) in Southeast Alaska from 1981 to 1987 were evaluated by Kirchhoff and Pitcher (1988). They concluded that the current pellet-group data appeared adequate for assessing population trends within individual VCU's (watersheds) and for making coarse comparisons of relative deer numbers among VCU's. Kirchhoff and Pitcher (1988) serves as the final report for Fed. Aid Wildl. Rest. W-22-6, Job 2.9, Objective 1. Results of 1988 pellet-group surveys have been reported in Kirchhoff and Kirchhoff (1988).

Job 2. Establish and monitor a know-size deer population on an Island near Juneau.

This job has been completed. A number of key segments hinged on successfully establishing a known-size, nonreproducing population of deer on an island near Juneau, where evaluation of various deer censusing techniques were to be made.

On 20-21 August 1986, 13 deer (i.e., 7 males, 6 females) were captured on Admiralty Island and transported to Portland Island, an isolated, 0.4-km^2 forested island in Auke Bay. Death and emmigration of individual deer were monitored using mortality-sensing radio collars.

Of the 13 deer transplanted, 3 died and 10 eventually swam off the island. A total of 1,538 deer-use days were accumulated on the island between 21 August 1986 and 12 May 1987. This level of use is equivalent to a stable population of 14.5 deer/km^2 over the 264-day period. The deer remained on the island long enough to answer certain research questions adequately, but their departure necessitated suspension or modification of other questions, which are noted in this report.

Results of this research segment are detailed in Pitcher and Kirchhoff (1988). No additional deer have been introduced to Portland Island, and there are no plans to do so.

JOB 3. Quantify sampling biases associated with pellet-group counts.

This job will continue into the next reporting period. The use of pellet-group counts to assess changes in relative deer numbers over time or between areas has been criticized (Longhurst and Robinette 1981, Collins and Urness 1981, Harestad and Bunnell 1987, Nyberg et al. 1988). The criticism centers on the following factors: (1) pellet-groups are more or less visible in different habitats, making comparisons of densities between them unreliable; (2) pellet-groups deteriorate at different rates, depending on environmental conditions (i.e., snow cover, rainfall, temperature, shading); (3) persons counting pellet-groups miss a significant and variable number of them; (4) defecation rates vary from year to year and place to place as a function of diet and behavior; and (5) it is difficult to adequately identify the appropriate land area to sample.

The objective of this research segment was to quantify biases in the pellet-group technique in Southeast Alaska and evaluate how those biases might limit applications. Additional background discussion is found in Pitcher and Kirchhoff (1988).

Biases in the pellet-group counting technique were evaluated during regular spring pellet-group census activities. A typical field crew consisted of 2 individuals. The line "puller" pulled a poly-clad steel cable in contiguous 20-meter increments along a straight-line compass course, stopping at the end of every 20-meter plot to record vegetative information. The puller was followed by a "counter" who counted the number of pellet-groups whose center fell within 0.5 meter of either side of the steel cable. This sequence was repeated, with the puller and counter switching duties every 5 plots, until an elevation of 1500 meters or a distance of 2.5 kilometers inland was reached (Kirchhoff and Pitcher 1988).

Periodically the line puller would anounce a "check plot" after the counter had reported the number of pellet-groups counted. Both the counter and the puller would then return to the plot's starting point, thouroughly searching and recounting groups on the plot from both directions. Differences between the initial count and the "true" count were attributable to missed pellet-groups as well as different opinions about whether the "center" of a group was in or out of the 0.5-meter range and whether scatterings of pellets represented 1 or more groups.

During the spring field season in 1987, a total of 107 plots were checked by 16 crew members. Although the crews were instructed to "check" plots randomly, plots were more likely to be checked when (1) pellets were being counted in moderate-to-high numbers and (2) the line puller thought the counter had "missed" pellet groups; check plots were not usually called on steep terrain that would have necessitated relatively difficult backtracking. Original plans to sample plots according to a strictly random schedule were changed when it became apparant that without at least some discretion on the part of the line puller, most of the check plots would have yielded observed and actual values of zero (i.e., most plots have zero pellet-groups).

The mean "initial" count on check plots was 3.16 pellet-groups (SD = 3.36), while the true count (obtained after carefully reexamining the plot) was 4.0 pellet-groups (SD = 3.66)--a difference of 24% (Fig. 1). Because of a low sample size, the difference was not significant ($\underline{P} \geq 0.05$). For our purposes, the magnitude of the error is relatively unimportant because we are concerned primarily with the relative numbers of pellet-groups counted (Kirchhoff and Pitcher 1988). What *is* of concern, however, is that the percentage of pellet-groups missed (i.e., the error) not vary greatly from year to year or from one area to the next.

Pellet-groups exposed to the drying effects of the sun, sheltered from the rain, frozen, and/or buried under snow will persist relatively longer (Fisch 1979, Harestad and Bunnell 1987), making pellet-group comparisons between distinctly different habitats (e.g., alpine and lowland forest) suspect. The significance of this concern has not been well documented in Southeast Alaska. For example, although some factors favor more *rapid* deterioration in open habitats (e.g., exposure to driving rains), there are other factors favoring *slower* deterioration (e.g., exposure to drying effects of the sun or prolonged coverage by snow) that are compensatory. Although interpretation of subtle differences in pellet-group counts can be blurred by such considerations, large differences in measured pellet-group densities are still meaningful. For example, differences in pellet-group densities of 600-700% have been measured in old-growth and 2nd-growth habitats in Southeast Alaska (Wallmo and Schoen 1980, Rose 1982). These differences are statistically and biologically significant.

Ideally, population differences of much lesser magnitudes (30% or less) should be detectable from pellet-group counts. Recognizing that habitat-related biases may affect between-area comparisons, efforts have been made to lay out transects in similar and, therefore, comparable habitats. For example, pellet-group transects are generally restricted to lands forested with old growth, while extensive clearcuts and muskegs are avoided.

Within old-growth areas there are significant differences in terms of canopy cover and understory composition (Brady 1982, Martin et al. 1984). One expression for the type of old-growth forest is volume class; i.e., the amount of merchantable wood volume a stand contains. The Forest Service classifies all forested land into 1 of 5 volume classes: (1) noncommercial forest land (less than 8,000 board feet (MBF) per acre), (2) low volume (8-20 MBF/acre), (3) mid-volume (20-30 MBF/acre), (4) high volume (30-50 MBF/acre), and (5) very high volume (over 50 MBF/acre). Owing to the rarity of high volume and very high volume stands, the 2 upper categories have been combined for this analysis.

An analysis of the percentage of error by forested habitat type (Fig. 2) reveals no significant differences among type ($\underline{P} \geq 0.05$). Of particular interest is the apparent trend towards greater error as one moves from the noncommercial to higher volume classes. Counters appear to be missing more pellet-groups in the higher volume stands than in the lower ones. This was unexpected, because lower volume stands are usually characterized by a brushier understory that would presumably obscure more pellet-groups. High volume stands, however, usually have a denser canopy and lower ambient light levels that might account for more missed groups. If this apparent bias is substantiated (more data are needed), deer populations in watersheds with relatively high volume old-growth forests may be underestimated, relative to those areas where low-volume old growth is predominate.

The effect of varying environmental conditions on pellet-group deterioration rates represents another potential bias affecting interpretation of these data. For example, pellet-group densities measured on Prince of Wales Island may not be directly comparable to those on Chichagof Island, because Prince of Wales generally has more rain, warmer temperatures, and less snow. It was hoped that the deer transplanted to Portland Island would stay on the Island for several years so that pellet-group deterioration rates under a range of weather conditions could be evaluated. Because the deer didn't stay on the island, that work was suspended and the question remains open. The effect of weather-related bias is of minimal concern when pellet-group data are used to evaluate long-term population trends in a single area (Kirchhoff and Pitcher 1988).

Variability among observers is another potential bias common to all survey techniques. Some observers are consistently able to find more pellet-groups, count more deer, or more accurately estimate browse use than others. Survey methods are designed to minimize this problem. For example, each VCU is sampled by three 2-person crews. Crew composition is changed daily, and members of each crew change line-pulling and pellet-counting duties every 5 plots. Also, the use of "check plots" helps ensure consistency and maintain alertness.

Of the 107 plots checked in 1987, four of the 17 counters were checked on 10 or more plots. Two counters had 6 or more consecutives years of experience on the pellet-group crew and were labeled "experienced". The other two were either counting pellet-groups for the first time or had not worked on the field crew for 3 years. These people were labeled "inexperienced". Analysis of percentage of error by observer shows that the most experienced observer missed an average of 11% of the pellet-groups, while the most error-prone missed 32% (Fig. 3). Although the differences are not significant ($\underline{P} \geq 0.05$) at these low sample sizes, there is some evidence that experienced counters are more accurate than less-experienced counters. Because pellet-group density for any one VCU is the product of the efforts of 6 counters, individual differences of this magnitude are not likely to create a significant overall bias.

Another concern with pellet-group counts is the possibility that defecation rates may differ from area to area or between years, leading to noncomparable counts. Such differences, if they exist, would most likely reflect differences in diet. For example, on south Kuiu Island succulent evergreen forbs are relatively available throughout the winter season, while in other areas where winters are more severe and/or deer more abundant, populations probably depend to a greater extent on woody browse (*Vaccinium* spp. and *Menzesia* spp.). Higher handling times and lower passage rates are expected in deer whose diets have a high woody component (Spalinger et al. 1986), but resultant pellet-groups may persist somewhat longer. Had deer remained on Portland Island over a period of years, the effects of their foraging on the island's vegetation and, subsequently, on their diet and defecation rates could have been monitored. No further work on the Portland Island segment is planned.

Job 4. Quantify assumptions used in calculating deer densities from pellet-group counts

This job has been completed. Calculating absolute deer densities from pellet-group counts requires knowledge of the following length of time: (1) pellet-groups persist; (2) mean pellet-groups deposited per deer per day; and (3) area used by the population being censused. On Portland Island, the area used by the population was known (0.4 km^2). The objectives of this job were to experimentally determine defecation rates and pellet-group persistence rates.

A total of 1,538 deer-use days had accumulated on Portland Island between the release date (21 August 1986) and the date when pellet groups were counted (12 May 1987). The measured pellet-group density at that time was 0.99 pellet groups per 20-m^2 plot (95% CI = 0.87-1.12)(Pitcher and Kirchhoff 1988). The island was intensively sampled (N = 381 plots, representing 38% of the total island area). Check plots were frequent, and the true or "checked" value was recorded to ensure an accurate estimate of pellet-group density. Extrapolating that density over the 0.4-km^2 area yielded a total of 19,800 (95% CI = 17,400-22,400) pellet-groups on the entire island. Because pellet-groups marked the day of release were still clearly visible on 12 May, we assumed that no pellet-groups deteriorated or disappeared. If 1,538 deer use days yield 19,800 pellet-groups, the resultant defecation rate is 12.9 pellet-groups per deer per day (95% CI of 11.3-14.6). This range is consistent with defecation rates reported for Mule deer by Neff (1968: Table 1). Based on these results, 13 pellet-groups per deer per day is a reasonable approximation of the true defecation rate of Sitka black-tailed dear during the October-April time period.

To determine the length of time pellet-groups persist, half of the plots on Portland Island were to be selected at random and cleared of pellet-groups. Gradually, over time, pellet-groups on cleared and uncleared plots would have become equal (P < 0.05), indicating the persistence time of a recognizable pellet-group (Schoen and Kirchhoff 1983). Because the deer left the island after less than 1 year, this research segment could not be completed.

Using a similar approach, Schoen and Kirchhoff (1983) reported a persistence period of 7.5 months. Other studies that have examined marked pellet-groups over time reported longer persistence rates (Fisch 1979, Rose 1982, Harestad and Bunnell 1987), and pellet-groups marked in our study were still recognizable after 10 to 11 months. This discrepancy may be partially due to the fact that when a pellet-group's location has been marked, the chances of encountering it are higher than for unmarked pellet-groups on a transect. I suspect, however, that there are significant differences in pellet-group persistence that are related primarily to moisture. Further work is needed to document the effects of environmental conditions on pellet persistence.

Job 5. Develop a snowpack index which can be used to predict winter deer distribution on individual watersheds

This job will continue into the next reporting period. Accurately sampling pellet-group densities requires knowledge of the area available to deer during the preceding winter. The actual distribution of deer in a given area or year will vary as a function of winter weather conditions. Location data from 51 radio-collared deer on Admiralty Island (Schoen and Kirchhoff 1984) were analyzed. For this analysis, we assumed the winter period ran from 1 November through 30 April. During that time period, 92 percent of all deer relocations (536/581) were below an elevation of 455 meters (1500 ft); however, deer are found at significantly higher elevations during low snowfall winters than durring high snowfall winters (ADF&G files).

Further analysis of telemetry data will be made to determine if elevational distribution of deer can be predicted from snowpack and weather data. Until then, the current practice of sampling winter range to an elevation of 455 meters should be continued.

Job 6. Estimate sex- and age-specific mortality rates in a deer population.

This job, which called for radio-collaring and monitoring a number of deer in the Sitka area and following age- and sex-specific mortality rates over time, has been suspended. The size of the sample required and the cost of conducting this research were deemed prohibitive. No work has been done on this job segment, and none is anticipated.

Job 7. Develop a winter severity index which can be used to predict deer mortality.

Because successful completion of this job hinged on results obtained from Job 6, it has been suspended. Summary information on winter weather conditions, as reported in by the Soil Conservation Service (SCS), appears useful as a standardized indicator of winter severity in the region (Kirchhoff and Kirchhoff 1988).

Job 8. Evaluate data available from spring beach transects as a measure of population mortality.

This job will continue into the next reporting period. Beach mortality transects have been walked annually in Southeast Alaska for many years. This work was discontinued in the early 1980's, when analysis of existing data showed them to be relatively insensitive indicators of population mortality (memorandum from M. Thomas, 31 Aug 1983). Suspected high winter mortality during the winter of 1988-89 prompted biologists to resume these mortality transects. To revaulate their utility, results of those transects will be compared with pellet-group data and winter aerial beach surveys. Original plans called for comparing beach mortality transect data with known mortality information (Job 6). With suspension of Job 6, further work in that regard has been suspended.

Job 9. Determine the relationship between hunter effort, hunter success, and deer population density.

This job will continue into the next reporting period. Hunter success per unit effort may be a reliable indicator of population size and trend, at least for areas that are regularly hunted. Previous attempts to examine hypothetical hunter-deer relationships on three areas (Nakwasina, Woronkofski, and Gravina Island) were unproductive, because deer density and hunter success were uniformly high (Pitcher and Kirchhoff 1988). With recent changes in population density apparent from preliminary results of 1989 pellet-group sampling (ADF&G files), we may begin to see related changes in hunter effort and success. These data will be examined in the next reporting period.

Job 10. Evaluate the utility and feasibility of alternative trend monitoring and density estimating techniques.

This job will continue into the next reporting period. Alternative trend-monitoring and density-estimating techniques include mark-recapture estimaters, night spotlight counts, track counts, beach counts, alpine surveys, and browse utilization surveys. Except for mark-recapture work, all have been used to monitor deer populations in Southeast Alaska (Merriam 1960, 1966, 1968; Mankowski and Peek 1989; Smith et al. 1986). Existing data will be reanalyzed, and the accuracy, precision, and cost of each survey technique will be evaluated in the next reporting period.

Job 11. Evaluate the impact of a known density deer population on existing forage supplies.

Browse utilization surveys are commonly used as an index to range condition and animal abundance. Interpretation, however, can be difficult because the degree of utilization observed is both a function of the number (density) of deer and the amount of forage available, including nonbrowse species. The introduction of deer to Portland Island afforded an opportunity to document the amount of forage there before the introduction and to monitor subsequent changes in forage composition, biomass, and browse utilization over time.

A series of 100 permanently marked points (i.e., numbered stakes) was established at 17-meter intervals along a transect running the length of Portland Island. A 30-x 60-centimeter plot frame, with the long axis oriented north and south, was placed at each marked point, and the percentage of the plot area covered by each understory species was estimated. Biomass estimates for herb-layer species were computed from these cover estimates (Alaback 1986). Biomass of shrub species was calculated from the measured basal diameter of stems rooted in each plot (Alaback 1986). The biomass of herb- and shrub-layer plant species on Portland Island is given in Table 1. These values are relatively high, compared with those reported for old-growth stands in Southeast Alaska (Alaback 1982).

The effects of deer browsing on Vaccinium were monitored on a sample of randomly selected plants. Four quadrats bounded by north-south and east-west azimuths were located at each of the 100 sample points. The nearest Vaccinium plant over 40 centimeters tall in each quadrat was located and flagged, and the species, distance, height, and basal diameter of each plant recorded. Measurements were discontinued at sample points where Vaccinium was rare (i.e., when the distance to the nearest plant in any one quadrat exceeded 15 m). Flagged plants were revisited on 29 May 1987. Measurements included (1) the number of stems browsed, (2) the terminal diameter of each browsed stem, and (3) the length of each browsed stem; i.e.,distal from lignified growth.

Of the 188 plants examined for evidence of browsing, 43 (22.8%) showed evidence of at least some browsing (4.11 stems browsed per plant). The mean terminal diameter of browsed stems was 1.01 millimeters. Although a significant percentage of plants showed evidence of browsing, browsing pressure on individual plants was extremely light. It is unlikely this level of use would be noticed in cursory field observations or quantified without time-consuming measurements and complete inspection of individual plants. To be useful as an index of deer numbers, browse surveys must incorporate some measure of available biomass as well as percentage of use.

To develop relationships between biomass and various plant dimensions, 33 Vaccinium plants were collected from Portland Island. Plants were selected to represent a range of species, heights, basal stem diameters, and vigor. The species, age, basal stem diameter, height, total dry weight, and dry weight of the stem-only and leaf-only components of each plant were measured. Dry weights were measured after the plants had been oven-dried at 50 degrees C for 24 hours.

The relationship between basal stem diameter and total biomass of *V. ovalifolium*, *V. parvifolium*, and both *Vaccinium* species combined is shown in Figs. 4-6. The equations developed here differ from those previously published for Southeast Alaska (Alaback 1986); however, as Alaback (1987) notes, differences among various sites are expected and development of dimension-biomass equations for local populations or for specific stand structures is recommended.

To develop twig diameter/biomass relationships, 10 stems (distal from lignified growth) were randomly selected and clipped from each plant. Small plants with fewer than 10 stems were used in their entirety. All stems were cut into 3 equal lengths, and the basal diameter and oven-dried weight of each segment recorded. Lab work has been completed; however, the terminal diameter/twig biomass regression equation has not yet been computed. Further analysis of these data and an evaluation of browse surveys as a deer census technique will be made in the next reporting period.

Job 12. Evaluate the potential of determining sex and age composition sampling from classification of living animals and examination of hunter-killed deer.

No further work on this research segment has been planned. Live deer can only be observed in large numbers in alpine habitats in summer or along beaches during deep-snow periods in winter. In both instances, counts are known to vary greatly over time and an unbiased sample with respect to either age or sex is unlikely (Merriam 1960). Similar problems arise with respect to examination of hunter-killed deer (Mankowski and Peek 1969).

Attempts to identify age and sex of deer on beaches during 3 aerial surveys conducted in the winter of 1988-89 yielded unreliable data because of difficulty in identifying age and sex from the air. More reasonable estimates could probably be obtained by asking hunters (via the annual deer hunter questionnaire) to estimate the proportion of male:female and adult:yearling deer encountered during their hunts.

Job 13. Evaluate lungworm as a potential limiting factor in deer populations in southeast Alaska.

No further work on this research segment has been planned. According to Johnson and Larson (1986) the 13 fawns (10 months of age) collected in the Hoonah Sound Area in 1985 harbored heavy and probably fatal infections of lungworm (Dictyocaulus viviparous). The geographic extent of this problem, and the importance of lungworm in limiting deer populations in southeast Alaska are unknown.

Job 14. Prepare for publication an article on habitat selection by black-tailed deer in southeast Alaska.

This job has been completed; a paper titled "Seasonal habitat preference of Sitka black-tailed deer on Admiralty Island, Alaska" (Appendix) has been submitted to the Journal of Wildlife Management.

Job 15. Report Writing.

A final report covering Project W-22-6, W-23-1, and W-23-2 will be submitted by 30 June 1990. A proposal for new research will be drafted during 1989.

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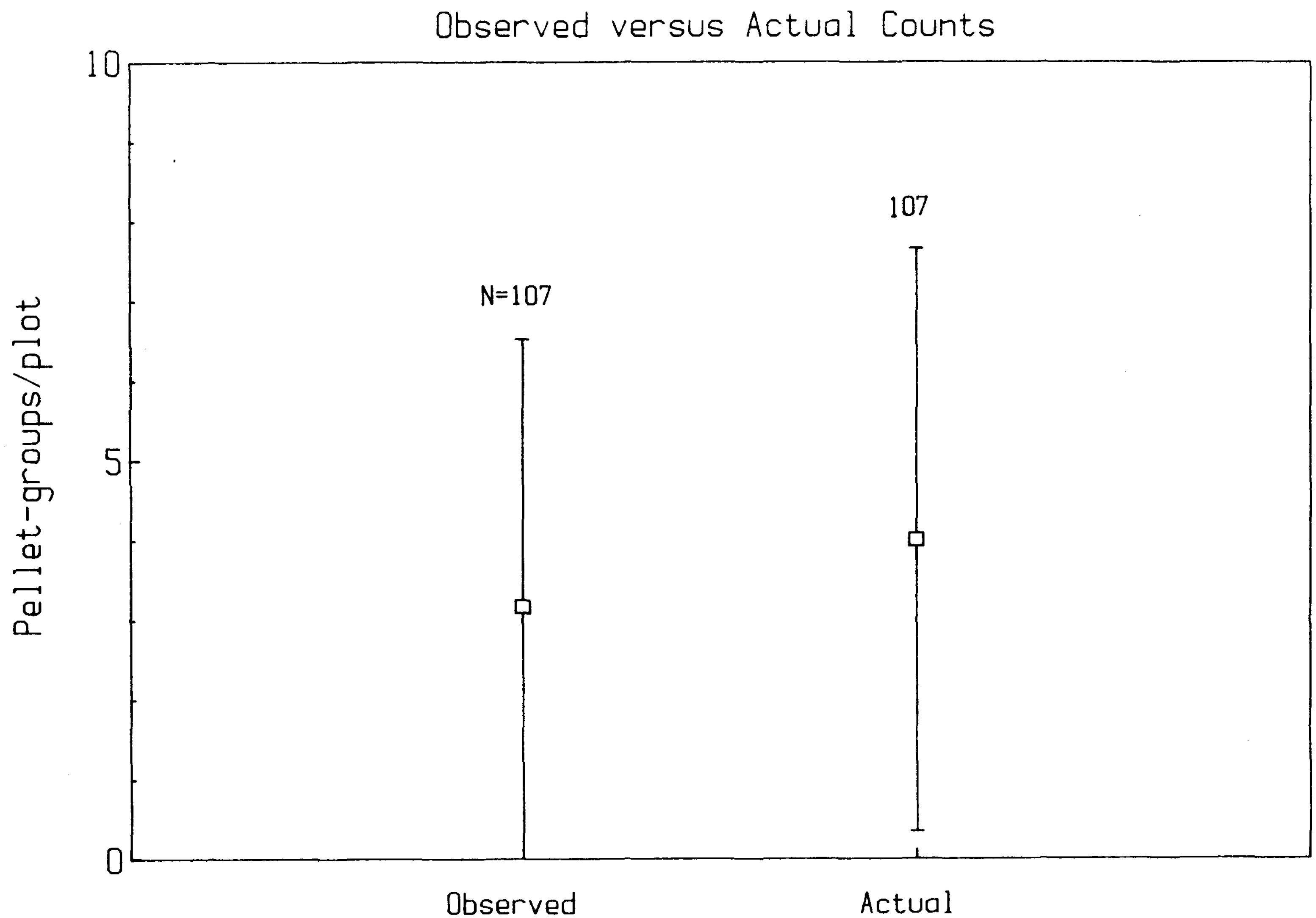

Figure 1. A comparison of observed versus actual pellet-group counts as measured on "check" plots during 1987 pellet-group surveys.

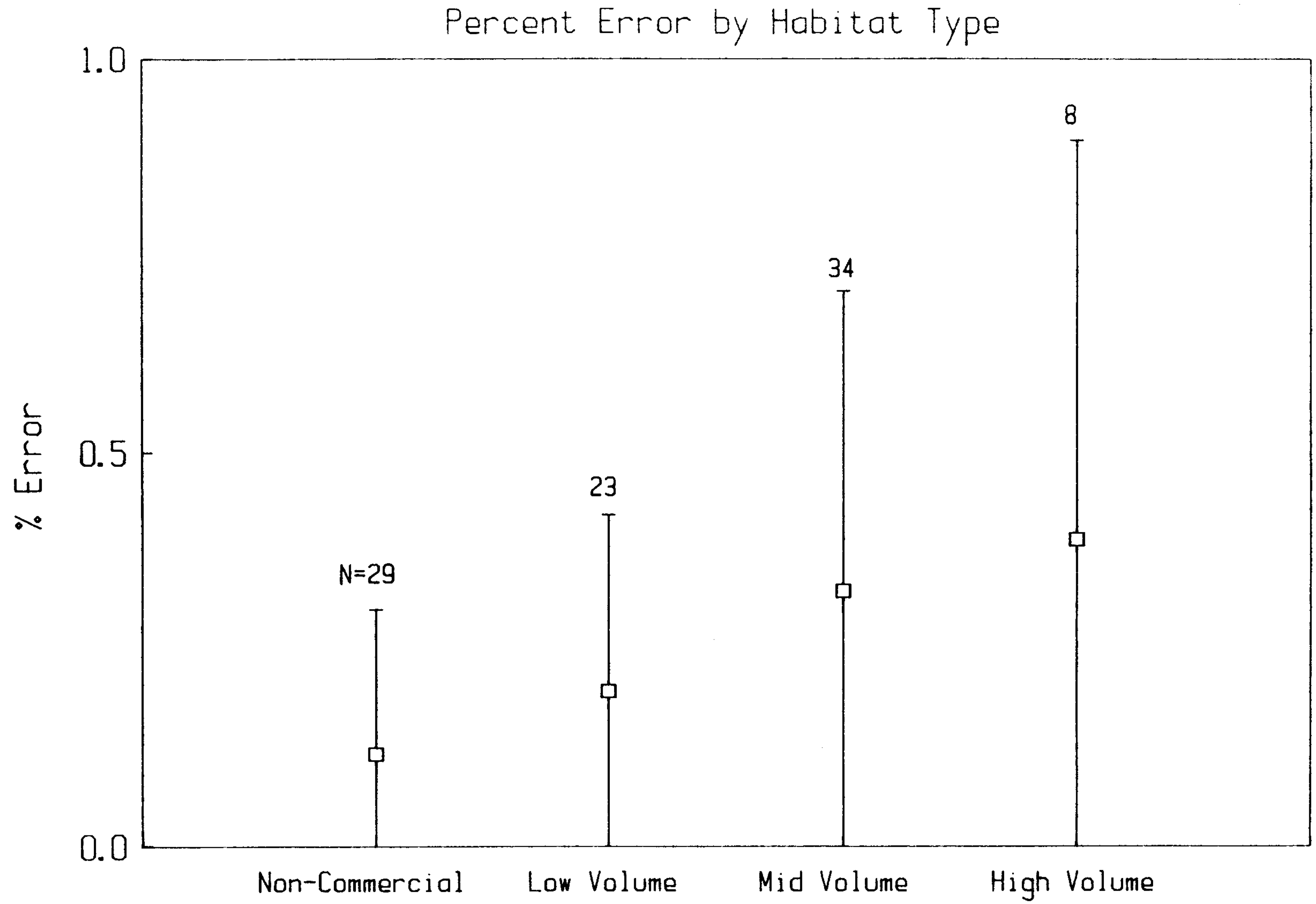

Figure 2. A comparison of percent error as a function of old-growth habitat type as measured on "check" plots during 1987 pellet-group surveys.

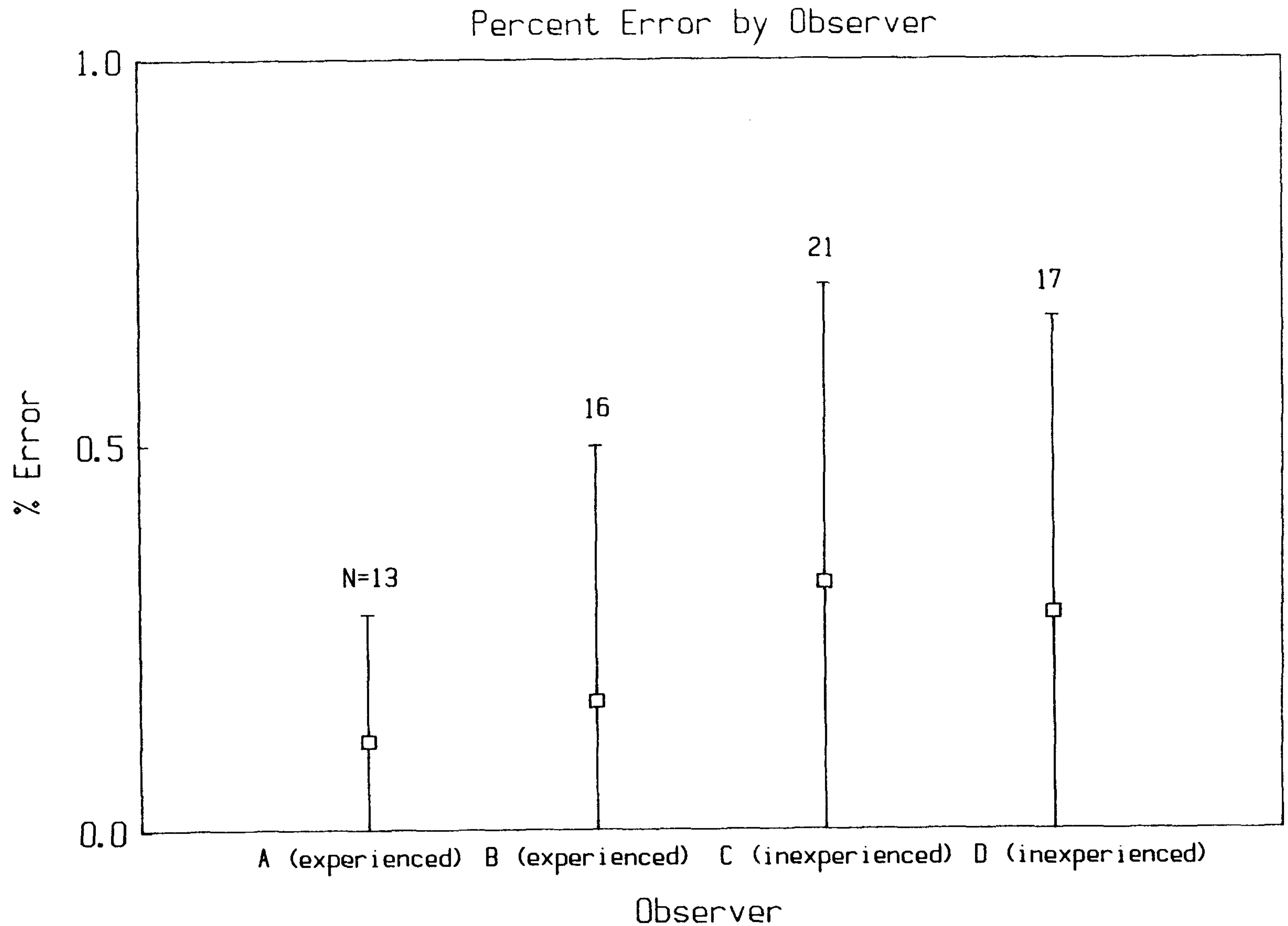

Figure 3. A comparison of percent error as a function of observer as measured on "check" plots during 1987 pellet-group surveys.

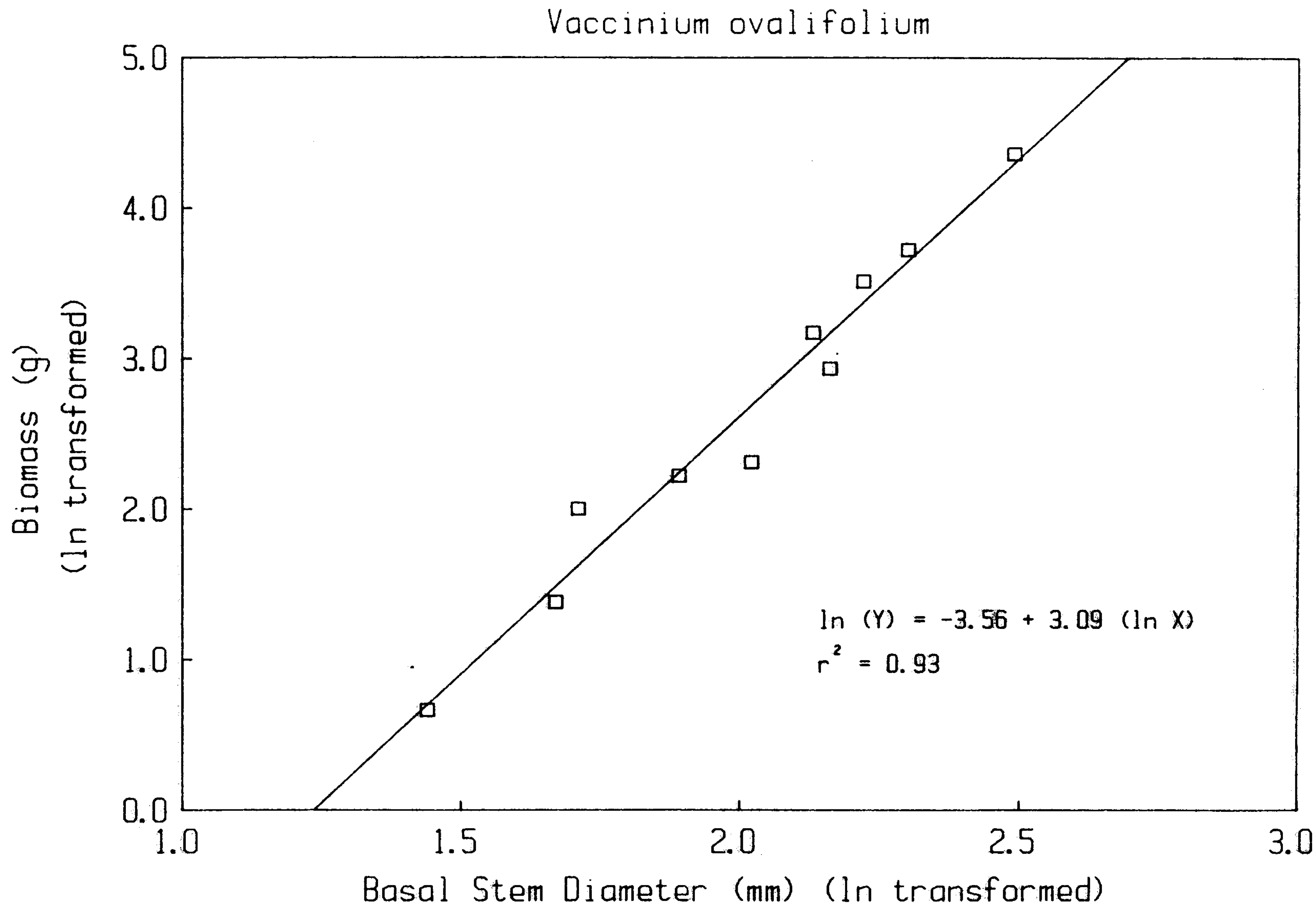

Figure 4. Relationship between basal stem diameter of *Vaccinium ovalifolium/alaskense* and total biomass.

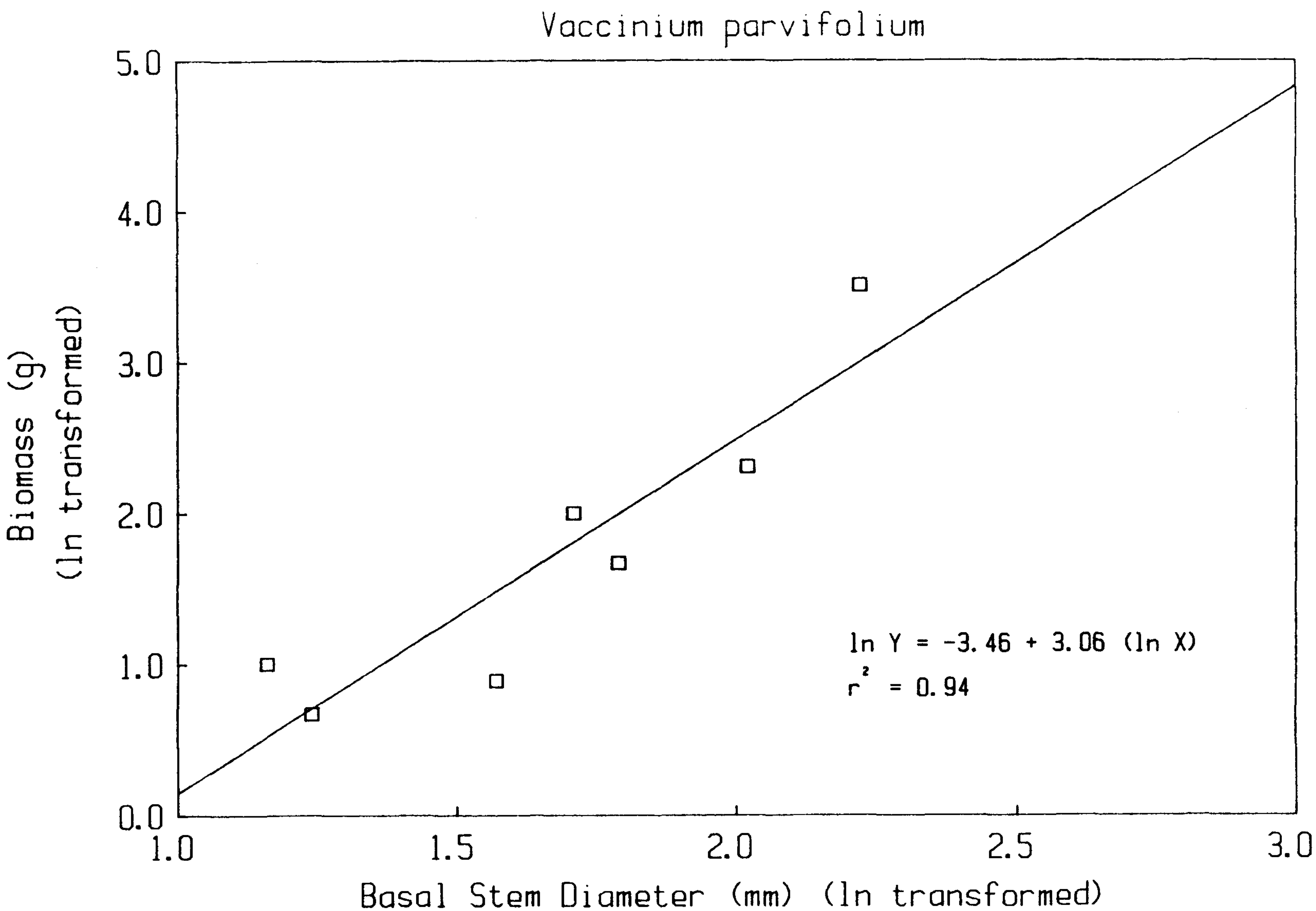

Figure 5. Relationship between basal stem diameter of *Vaccinium parvifolium* and total biomass.

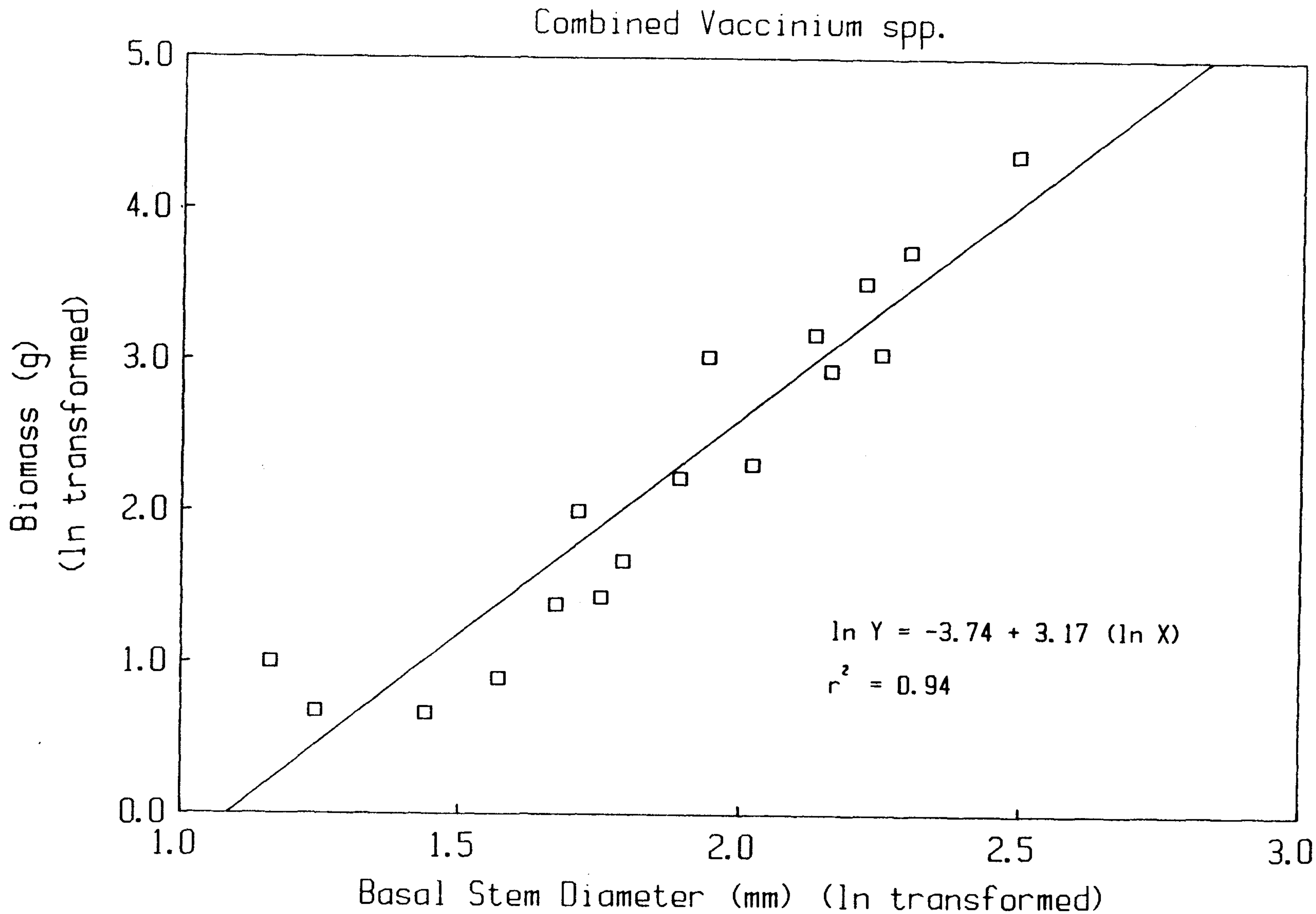

Figure 6. Relationship between basal stem diameter of combined *Vaccinium spp.* and total biomass.

Table 1. Composition of understory on Portland Island, southeast Alaska. Biomass estimates were generated from equations in Alaback (1986).

Species	Frequency[a] (%)	Cover (%)	Biomass[b] $\bar{x}$	SD
Herbs				
Actea rubra	2	0.1	0.7	0.6
Cornus canadensis	31	2.2	18.6	5.3
Goodyera oblongifolia	10	0.4	3.6	1.2
Listera cordata	10	0.3	0.3	0.3
Lysichiton americanum	2	1.4	–[c]	
Maianthemum dilatatum	52	4.6	14.5	3.8
Moneses uniflora	9	0.2	2.6	0.8
Pyrola secunda	1	0.1	0.3	0.3
Rubus pedatus	20	1.2	0.6	0.1
Streptopus spp.	12	1.2	–[c]	
Tiarella trifoliata	54	4.0	19.2	3.7
Unknown sp.			1.9	1.0
Subtotal			62.9	15.0
Shrubs				
Menziesia ferruginea	9	2.5	340.4	
Oplopanax horrida	32	13.2	271.2	120.6
Ribes laxiflorum	1	0.1	–[c]	
Rubus spectabilis	3	0.6	–[c]	
Sambucus canadensis	1	0.1	–[c]	
V. alaskaense/ovalifolium	33	11.0	1053.7	392.4
V. parvifolium	22	2.1	–[c]	
Subtotal			1753.7	
Total			**1816.6**	

[a] Frequency based on percent cover.
[b] Total above ground biomass in kg/ha using percent cover for herbs and basel stem diameter for shrubs.
[c] No plants were rooted in plots for biomass estimation.

22 January 1990
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SEASONAL HABITAT USE BY SITKA BLACK-TAILED DEER ON ADMIRALTY ISLAND, ALASKA

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Abstract: We measured seasonal habitat use by 30 radio-collared Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) on northern Admiralty Island in southeastern Alaska from February 1979 to July 1982. Habitat use varied seasonally as deer moved from low-elevation (<300 m), heavily forested winter ranges to higher elevation (>600 m) summer ranges in open canopy subalpine and alpine habitats. Deer used old-growth forest almost exclusively during winter and spring, and high-volume old growth (>74 mbf/ha) was used in much greater proportion than its abundance. To minimize the impacts of timber harvesting on deer populations, emphasis should be placed on maintaining stands of high-volume old growth on low-elevation deer winter ranges.

J. WILDL. MANAGE. 0(0):000-000

Key words: Admiralty Island, Alaska, habitat relationships, logging, *Odocoileus hemionus sitkensis*, old-growth forest, radio telemetry, Sitka black-tailed deer, snow.

The Sitka black-tailed deer in southeastern Alaska occurs at the northern limit of its natural range (Wallmo 1981). This subspecies inhabits a densely forested coastal environment where deep winter snows are the major factor limiting population size (Klein and Olson 1960). In high snowfall regions of the Pacific Northwest and in southeastern Alaska, low-elevation old-growth forest has been identified as essential deer winter range (Bloom 1978, Wallmo and Schoen 1980, Bunnell and Jones 1984). The 6.8 million-ha Tongass National Forest encompasses over 80% of the land area of southeastern Alaska. Approximately 7,000 ha of old growth on National Forest lands, as well as additional thousands on state and private lands, are scheduled for harvest annually (U.S. For. Serv. [USFS] 1988). Converting old-growth forests to younger seral forests in Alaska will reduce forage availability and consequently deer carrying capacity (Wallmo and Schoen 1980, Alaback 1982).

In southeastern Alaska, the old-growth forest is variable in structure and composition on a fine-grained (<1 ha) scale (Schoen et al. 1984). Timber harvesting in this region has been concentrated in the most economically valuable old-growth stands, specifically on low-elevation, high-volume sites (Hutchison and LaBau 1975, Schoen et al. 1988). An understanding of the seasonal habitat use of deer, including their use within the forest mosaic, will help managers identify important habitats and guide modeling efforts aimed at predicting the effects of timber harvesting on deer populations in southeastern Alaska. We assume that current habitat preferences are indicative of long-term habitat requirements or needs (Fagen 1988, Ruggerio et al. 1988). Our objectives were to determine seasonal habitat use of radio-collared deer and to describe the implications of harvesting timber on deer populations in southeastern Alaska.

Our project was supported by the Alaska Department of Fish and Game through Federal Aid in Wildlife Restoration Project W-17, W-21, and W-22, and the U.S. Forest Service, Pacific Northwest Forest and Range Experiment Station. We recognize the late O. C. Wallmo for his cooperation, advice, and encouragement during the initial stages of this study, G. G. Fisch, L. R. Beier, L. H. Holton, L. J. Johnson, and J. W. Lentfer for their assistance during this study, and D. A. Anderson, R. W. Flynn, L. M. McManus, and W. L. Regelin for reviewing this manuscript. D. R. McCullough and an anonymous reviewer offered valuable editorial suggestions.

STUDY AREA

The indigenous range of deer in southeastern Alaska extends from Dixon Entrance at the Canadian border 500 km north to Glacier Bay. This area, located primarily in the Tongass National Forest, encompasses the islands of the Alexander Archipelago and a narrow band of mainland bounded on the west by the Gulf of Alaska and on the east by coastal mountains and ice fields. Admiralty Island (4,426 km^2), in the northern portion of the archipelago, is the third largest island in southeastern Alaska. The Hawk Inlet study area (300 km^2) is located approximately 25 km southwest of Juneau on northern Admiralty Island (58°N 135°W).

Admiralty Island has a cool, maritime climate. Elevations >600 m are generally covered by deep snow for 6-9 months per year. Snow accumulations >30 cm at sea level are common during winter but vary annually in duration and depth. The average annual snowfall for the nearby city of Juneau ranges from 81 to 546 cm. During our study, annual snowfall in Juneau varied from 160 cm to 300 cm (Natl. Weather Serv., Juneau, unpubl. data), and daily winter snow accumulation at sea level varied from 0 to >80 cm.

Temperate coniferous rain forest dominates the landscape of southeastern Alaska, occurring from sea level to about 600 m. Subalpine forest and alpine occur above this elevation. The old-growth western hemlock-Sitka spruce (Tsuga heterophylla-Picea sitchensis) forest is characterized by an uneven-aged, multilayered overstory, old (>300 yr) dominant trees, and an abundant, structurally diverse understory (Schoen et al. 1981, Alaback 1982). Old growth varies in structure from scrub or low-volume stands of short (<10 m), small diameter (<0.5 m dbh) trees with open canopies and dense shrub-dominated understories that grow on poorly drained sites to high-volume stands of tall (>60 m), large diameter (>3 m dbh) trees and herb-dominated understories that grow on well-drained, productive soils. Muskeg bogs occur throughout the forest at lower elevations, and brush-dominated avalanche tracts are common on steep, mid- to high-elevation slopes (Harris and Farr 1974).

Deer densities on the winter range (<150 m elevation) were about $26/km^2$ in 1982 (Schoen and Kirchhoff 1985). The only deer predator on Admiralty Island is the brown bear (Ursus arctos).

METHODS

Deer were captured by darting with immobilizing drugs on winter range and by netting from a helicopter on the summer range (Schoen and Kirchhoff 1985). Aircraft were used for all radio-telemetry relocations because there were no roads in the study area. Telemetry relocations were made during daylight approximately once per week throughout the year, weather permitting, from a Helio Courier aircraft (Schoen and Kirchhoff 1985). Deer were classified as migratory if they moved to high-elevation (>600 m) alpine or subalpine ranges and resident if their winter and summer ranges overlapped at elevations <500 m. Four resident (236 relocations), 24 migratory (848 relocations), and 2 deer (14 relocations) of unknown distributional status were radiocollared. Approximately 75% of the Hawk Inlet deer population was believed to be migratory (Schoen and Kirchhoff 1985). Deer were classified as adults if they were yearlings or older.

Locations of individual deer were plotted on USGS 1:63,360-scale topographic maps. Topographic and vegetative variables were estimated from the air at the time of relocation. Elevation was estimated in 30-m intervals. Slope was estimated in 5^{o} intervals, and aspect was classified as north ($293-67^{o}$), east ($68-113^{o}$), south ($114-247^{o}$), and west ($248-292^{o}$). Vegetative cover was classified into 6 general types: beach, old-growth forest, avalanche slope, subalpine forest, alpine, and muskeg. Percent canopy cover and percent spruce composition of the conifer overstory were visually estimated to the nearest 5%.

Old-growth forest was categorized by volume class using definitions established and mapped by the U.S. Forest Service. These definitions are based on the amount of merchantable wood volume a given stand will yield in terms of board feet per unit area. Because the yield in board feet does not include wood volume lost to saw kerf thickness, side slabs, or other unmerchantable wood, board feet are not convertible to metric wood volumes. Four categories were recognized in our study: scrub or noncommercial forest (<20 thousand board feet [mbf]/ha), low-volume (20-49 mbf/ha), mid-volume (49-74 mbf/ha), and high-volume (>74 mbf/ha) forest. Timber volume and spruce composition were not estimated before June 1980.

We estimated the abundance of topographic attributes--elevation, slope, and aspect--by overlaying a dot-grid ($\underline{n}$ = 2,495) on a 1:63,360-scale USGS topographic map of the study site. Vegetative attributes, including cover type, percent canopy cover, percent spruce composition, and net inventory volume class, were also estimated from a dot-grid ($\underline{n}$ = 2,030) overlayed on 1:12,000-scale color aerial photographs. Computer-generated random samples (20%) of topographic and vegetative points were selected from the dot-grid sample following Marcum and Loftsgaarden (1980).

Recognizing the difficulty associated with demonstrating habitat selection outside a strictly experimental context, we did not use the terms preference and avoidance. Instead, we compared deer use of habitat attributes relative to their abundance within the study area. Significant differences between use and abundance of habitat variables were determined using the Chi-square test for goodness-of-fit and the Bonferoni $\underline{Z}$-test (Neu et al. 1974, Marcum and Loftsgaarden 1980). To avoid low sample sizes in our Chi-square analysis, habitat variables were aggregated into 3-4 categories that we considered biologically meaningful. Significant differences in the proportion of habitat use relative to abundance for individual categories were determined at 99% confidence levels. Simultaneous confidence levels (i.e., the probability that behavior displayed for all categories of a specific attribute in a given season are simultaneously correct) were 96% for 4 categories/attribute (e.g., elevation, habitat type) and 97% for 3 categories/attribute (e.g., aspect).

Many of the topographic and vegetative variables influencing habitat use by deer were intercorrelated. For example, steeper slopes are at higher elevations and high-volume stands typically have high canopy cover and tall, large diameter trees (Kirchhoff and Schoen 1987). To reduce the confounding effect of highly correlated variables, we calculated product-moment correlation coefficients between all pairwise combinations of interval-level variables, and we eliminated 1 of the pair if $\underline{r}$ > 0.60. Only volume class and canopy cover ($\underline{r}$ = 0.75) exceeded this criterion, and we eliminated canopy cover in favor of volume class because volume is measured with greater accuracy and precision (Kirchhoff and Schoen 1987).

The possible effects of snow on deer habitat use were assessed by comparing a winter with little snow (1 Jan-31 Mar 1981) to a winter with relatively deep snow (1 Jan-31 Mar 1982). Otherwise, data for all years were combined and analyzed by (calendar) season. Differences in seasonal and annual habitat use by deer were tested by Chi-square contingency tables. Significance tests of 2-sample comparisons were conducted with a Mann-Whitney $\underline{U}$-test.

RESULTS

From February 1979 through July 1982, 1,098 relocations were recorded from 30 radio-collared deer (1 M fawn, 15 ad M, and 14 ad F). The highest relocation frequency occurred in spring (31%), with 29% of relocations in winter, 21% in summer, and 19% in autumn. Deer use of all topographic and vegetative variables varied significantly among seasons (Chi-square test, $\underline{P} < 0.01$).

Seasonal Habitat Use

<u>Spring</u>.--Elevations <300 m were used by deer during spring in greater proportion than their abundance and represented 73% of deer relocations; elevations >600 m were seldom used (Table 1). Most (88%) deer relocations occurred on slopes $<20^{0}$. Deer used southern aspects in greater proportion and northern aspects in lesser proportion than their abundance.

Most (93%) deer relocations during spring occurred in old growth, which was used significantly more than its abundance (Table 1). Deer used high-volume old-growth stands significantly more and scrub old growth significantly less than their abundance.

<u>Summer</u>.--Deer were most widely distributed during summer with most relocations (73%) occurring at elevations >300 m. Deer used elevations >600 m significantly more and elevations <300 m significantly less than their abundance (Table 1). However, migratory deer spent summers significantly (Mann-Whitney $\underline{U}$-test, $\underline{P} < 0.001$) higher (582 ± 13.9 m [$\bar{\underline{x}} \pm$ SE], $\underline{n} = 176$) than resident deer (122 ± 14.7 m, $\underline{n} = 59$). During summer, we observed migratory deer foraging in high-elevation subalpine habitat dominated by park-like meadows of herbaceous vegetation. Deer continued to use slopes $<10^{0}$ in greater proportion than their abundance. Southerly aspects were used significantly more than their abundance, whereas east, west, and northerly aspects were used in proportion to their abundance.

Deer used the greatest variety of habitats during summer (Table 1). Subalpine accounted for 33% of the relocations and was used significantly more than its abundance. Deer use of old growth declined to its lowest level (57%) during summer and 58% of those relocations occurred in scrub-forest stands. Deer used mid- and high-volume stands significantly less than their abundance. Old-growth stands of <5% spruce composition were used more (68%) than their abundance.

Autumn.--Deer began moving to lower elevations during autumn with 64% of their use occurring between 100 and 600 m (Table 1). Deer were relocated significantly more on slopes <10^{0} and those with south aspects than on slopes >20^{0} and aspects of north, east, and west.

During autumn, deer used (88%) old growth more than its abundance; other habitats received little use at this time (Table 1). Fifty-seven percent of the relocations occurred in mid- to high-volume stands. However, only high-volume stands were used significantly more than their abundance.

Winter.--Most deer relocations (54%) during winter occurred at elevations <100 m (Table 1). Elevations <300 m were used significantly more than their abundance. Deer used (53%) slopes <10^{0} in greater proportion than their abundance.

Deer used old-growth habitat almost exclusively (99%) during winter (Table 1). High-volume old-growth stands were used in significantly greater proportion than their abundance. Mid-volume stands also received substantial (35%) winter use by deer. Lower volume, old-growth stands were used significantly less than their abundance. Old-growth stands of 5-30% spruce composition received 68% of winter deer use.

Influence of Snow on Winter Habitat Use

From January through March 1981, there were 10 days with snow accumulation at sea level (including only 2 days >10 cm). During the same period in 1982, there was snow accumulation at sea level for 85 days (including 52 days >48 cm).

Although deer wintered significantly lower (Mann-Whitney $\underline{U}$-test, $\underline{P} < 0.002$) during the deeper snow conditions of 1982 (128 $\pm$ 10.8 m, $\underline{n}$ = 102) than in 1981 (198 $\pm$ 17.0 m, $\underline{n}$ = 87), their relative use of broad elevation categories was similar ($\underline{x}^2$ = 4.0, 3 df, $\underline{P}$ = 0.26) between the 2 winter periods (Table 2). Deer increased their use of slopes <20 degrees and southerly aspects in 1982. Deer used northern exposures less than their abundance during both years.

Winter deer use of volume class and percentage spruce differed between years of low and high snowfall ($\underline{x}^2$, $\underline{P} < 0.001$) (Table 2). High-volume stands were used during both years in greater proportion than their abundance. Deer increased their use of stands with 15-30% spruce composition during 1982. Under deep snow conditions, 65% of deer relocations occurred in high-volume sites, a 2.5-fold increase over the mild winter of 1981. Both low-volume and scrub forests (which represented nearly 60% of the habitat) received only 8% of deer use during 1982.

DISCUSSION

The shift in habitat use from winter to summer ranges varied annually with timing of snow melt. Spring dispersal of deer to high-elevation sites covered by deep snow occurred primarily after warm weather resulted in a dense snowpack capable of supporting travel. On Vancouver Island, deer used sites with deep snow only when crusty snow conditions supported travel (Bunnell and Jones 1984, Harestad 1984).

As the snow pack receded in late spring-early summer, deer moved out of stands of high-volume old-growth forest into low-volume and scrub stands and moist meadows at higher elevations. The increased use of slopes >30^{0} probably reflected deer use of steep subalpine habitat. Although they still used southern exposures, deer used northerly exposures more in summer than in any other season. The highly dissected topographic relief of these subalpine meadows may have created microsite diversity that produced a variety of phenological stages that may have provided deer an opportunity for selectively foraging on the most nutritious vegetation (Klein 1965).

Deer moved off their summer ranges during autumn as snow began to accumulate at higher elevations. However, following heavy rainfall and melting, migratory deer generally moved back to higher forested slopes until a solid snowpack became established. Migratory deer generally moved as high as snow conditions allowed (Barrett 1979, Schoen and Kirchhoff 1985). These elevational shifts probably are a response to greater food availability at higher than lower elevations.

Deer were most limited in their habitat use in winter when they concentrated in dense canopy, high-volume old growth on southern slopes <300 m. Bloom (1978) and Barrett (1979) also reported that low-elevation, high-volume stands of old growth were heavily used by deer in Alaska during deep snow conditions. As in other seasons, migratory deer ranged higher during winter than did resident deer (Schoen and Kirchhoff 1985).

When snow depth in the open was >15 cm, deer concentrated their activities in the highest volume old-growth stands available within their home ranges. Although we did not specifically measure deer use relative to upland and riparian stands of high-volume old growth, most winter deer use probably occurred in hemlock-dominated upland stands with relatively little deer use in riparian spruce stands. Muskegs were little used (<2%) by deer throughout the year, presumably because forage is unavailable when snow accumulates and the dominant plants found in muskegs (e.g., Empetrum nigrum, Ledum groenlandicum, Sphagnum spp.) are relatively low in digestibility (Hanley and McKendrick 1983).

The contrast in habitat use of radio-collared deer between the low-snow winter of 1981 and deep-snow winter of 1982 reflected a relationship between timber volume and snow. Kirchhoff and Schoen (1987) found that mean snow depth on the ground was negatively correlated with timber volume. When snow accumulated, high-volume old-growth stands (exclusive of riparian spruce) were the optimum foraging sites for deer (Kirchhoff and Schoen 1987). Availability of nutritious evergreen forbs (e.g., Cornus canadensis and Rubus pedatus) was a major criterion in determining the quality of the winter range for deer in Alaska (Schoen and Wallmo 1979, Hanley and McKendrick 1985).

Although deer used scrub stands more during the low-snow winter, scrub stands were used significantly less than their abundance. We think forage quality may have reduced the value of these sites even in the absence of snow. Cornus plants collected during early December in high-volume old growth had significantly higher nitrogen content and higher digestibility than plants collected in scrub stands (Schoen and Kirchhoff 1984). Although deer avoided scrub and low-volume forests during winter, they used them substantially during late spring, summer, and early fall. This pattern of use suggests that a variety of habitats may satisfy deer requirements at those times.

Southerly exposures melt more frequently during winter and earlier in the spring than other exposures because of their increased insolation. Thus, winter carrying capacity for deer should theoretically be higher (other things being equal) on slopes with southerly aspects. However, because of the high northerly latitude of southeastern Alaska and the low angle of the sun in winter, this influence is less pronounced than in more southerly regions. We contend that elevation and overstory characteristics (e.g., timber volume or canopy cover), rather than aspect, are more sensitive variables for identifying deer winter ranges.

MANAGEMENT IMPLICATIONS

In southeastern Alaska, high-volume old-growth forest <300 m elevation is productive habitat for deer in winter. These stands, however, are rare (4% of the Tongass National Forest) in southeastern Alaska. The same stands are economically most valuable to the timber industry and have consequently already been harvested or are scheduled for harvest in much greater proportion than their forest-wide abundance (USFS 1978, Schoen et al. 1988). Harvesting timber in the most productive old-growth stands may exacerbate the long-term declines already predicted for Sitka black-tailed deer populations as a result of logging in southeastern Alaska (Wallmo and Schoen 1980, Kirchhoff and Schoen 1987, Fagen 1988).

To minimize the impacts of timber harvesting on deer populations, emphasis should be placed on maintaining productive winter habitat, particularly stands of high- and mid-volume old growth on low-elevation winter ranges. If deer populations are to be maintained during periodically severe winters, a high percentage of the natural (prelogging) distribution of low-elevation, high-volume old growth must be maintained. Harvesting timber volume classes in proportion to their natural occurrence would preserve the diversity of forest types in a drainage and would provide deer habitat under a wide variety of environmental conditions. Where possible, old growth should be retained in large blocks extending from sea level to the subalpine zone so that deer can make elevational movements in response to changing snow conditions. Where maintenance of deer populations is the highest priority, excluding timber harvesting from entire watersheds would maximize habitat capability in those watersheds (Schoen et al. 1984).

The impacts of timber harvesting on deer could be substantially reduced by shifting a greater proportion of harvest to the lowest volume commercial forest lands, particularly at higher elevations. These stands are poor winter habitat and at higher elevations (>300 m) contribute relatively little to winter carrying capacity. Converting these low-volume stands to a mix of young clear-cuts and older second growth would have less impact on deer than focusing harvests in the mid- to high-volume old-growth stands at lower elevations.

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Received: 20 April 1989.

Accepted: 23 December 1989.

Associate Editor: Morrison.

Table 1. Habitat abundance and use by radio-collared deer on Admiralty Island, Alaska, December 1978-July 1982.

Habitat attribute	Abundance (%)	Deer use (%)			
		Spring	Summer	Autumn	Winter
Elevation (m)	(n = 491)[a]	(n = 336)[b]	(n = 235)[b]	(n = 213)[b]	(n = 314)[b]
≤100	21	37+[c]	15-	22	54+
101-300	18	36+	12-	29+	35+
301-600	29	23-	33	35	11-
>600	32	4-	40+	14-	1-
Slope (°)	(n = 491)	(n = 336)	(n = 235)	(n = 213)	(n = 314)
≤10	25	55+	46+	43+	53+
11-20	39	33	28-	39	33
21-30	25	10-	15-	15-	11-
>30	11	2-	11	3-	3-
Aspect	(n = 491)	(n = 301)	(n = 192)	(n = 196)	(n = 282)
N	39	21-	32	26-	20-
S	28	44+	41+	58+	42+
E-W	33	35	27	16-	38
Cover type	(n = 467)	(n = 331)	(n = 235)	(n = 213)	(n = 301)
Old growth	76	93+	57-	88+	99+
Subalpine	8	3-	33+	9	0-
Alpine	10	0-	8	0-	0-
Other[d]	6	4	2-	3-	1-
Timber volume	(n = 406)	(n = 189)	(n = 134)	(n = 160)	(n = 206)
(mbf/ha)	27	14-	58+	21	4-
Scrub (<20)	32	28	20-	22-	12-
Low (20-49)	33	32	18-	31	35
Mid (49-74)	8	26+	4-	26+	49+
High (>74)					
Spruce (%)	(n = 406)	(n = 189)	(n = 134)	(n = 156)	(n = 180)
≤5	44	44	68+	40	25-
6-15	26	29	21	27	42+
16-30	19	15	7-	19	27+
>30	11	12	4-	14	6-

[a] Number of random habitat points.

[b] Number of deer relocations.

[c] A "+" and "-" indicate use significantly greater or less than abundance, respectively (Bonferoni Z-test, P < 0.01).

[d] Includes avalanche slopes, beach, and muskeg.

Table 2. Habitat abundance and use by radio-collared deer on Admiralty Island, Alaska, contrasting the low-snow winter of 1981 to the deep-snow winter of 1982.

Habitat attribute	Abundance (%)	Deer use(%)	
		Low snow	Deep snow
Elevation (m)	(n = 491)[a]	(n = 87)[b]	(n = 102)[b]
≤100	21	40+[c]	49+
101-300	18	40+	38+
301-600	29	19-	13-
>600	32	1-	0-
Slope (^{o})	(n = 491)	(n = 87)	(n = 102)
≤10	25	36+	56+
11-20	39	31	35
21-30	25	23	7-
>30	11	10	2-
Aspect	(n = 491)	(n = 79)	(n = 100)
N	39	18-	24-
S	28	30	52+
E-W	33	52+	24-
Timber volume (mbf/ha)	(n = 406)	(n = 86)	(n = 99)
Scrub (<20)	27	7-	2-
Low (20-49)	32	23	6-
Mid (49-74)	33	44	27
High (>74)	8	26+	65+
Spruce (%)	(n = 406)	(n = 87)	(n = 99)
≤5	44	36	18-
6-15	26	38+	35
16-30	19	8-	38+
>30	11	18	91

[a] Number of random habitat points.

[b] Number of deer relocations.

[c] A "+" and "-" indicate use significantly greater or less than abundance, respectively (Bonferoni Z-test, $P < 0.01$).

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