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DEER RESPONSE TO FOREST SUCCESSION ON ANNETTE ISLAND,
SOUTHEAST ALASKA

UNIVERSITY OF ALASKA M.S. 1982

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DEER RESPONSE TO FOREST SUCCESSION ON ANNETTE ISLAND, SOUTHEAST ALASKA

A

THESIS

Presented to the Faculty of the

University of Alaska in partial fulfillment

of the requirements

for the Degree of

MASTER OF SCIENCE

By

Cathy Lynn Rose, B.S.

Fairbanks, Alaska

December 1982

DEER RESPONSE TO FOREST SUCCESSION ON ANNETTE ISLAND,

SOUTHEAST ALASKA

RECOMMENDED:

Chairman, Advisory Committee

Program Head

Director, Division of Life Sciences

APPROVED:

Vice Chancellor for Research and Advanced Study

December 23, 1982.
Date

ABSTRACT

Winter habitat preferences of deer were tested in a region of low snowfall in southern Southeast Alaska to determine the importance to deer of old-growth forests versus logged habitats. Quantitative measurements were made of the relationships between deer use and the variables which characterize old-growth forests. A regression equations was developed for predicting deer use of old-growth forests and included the variables elevation, frequency of *Cornus canadensis*, and canopy cover variability. Deer use of old-growth forests in winter was positively correlated with elevation, slope, and the frequency of *Cornus canadensis*, *Rubus pedatus*, *Vaccinium* spp., and *Coptis aspleniifolia*. Old-growth forests received 7 times greater use by deer than did clearcuts or second-growth forests. These findings were in general agreement with results from studies in regions of high snowfall in the Pacific Northwest and northern Southeast Alaska where old-growth forest has been identified as the optimum habitat for deer during winter.

ACKNOWLEDGEMENTS

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Work was begun on the project in January, 1979, by the Annette Natural Resource Center as the first phase of a comprehensive deer research and management program for the Annette Islands Reserve. Greg Argel and Gordon Thompson, Director and former Director of the Annette Natural Resource Center, respectively, the late Dr. Olof C. Wallmo, then Research Wildlife Biologist, Forestry Sciences Laboratory, Juneau, Dr. John W. Schoen and Matt Kirchhoff, Game Biologists, Alaska Department of Fish and Game, Juneau, and Dr. David R. Klein, Leader of the Alaska Cooperative Wildlife Research Unit, Fairbanks, provided critical support for the project and assisted with it's planning. Dr. Thomas A. Hanley Research Wildlife Biologist, Forestry Sciences Laboratory, Juneau, Louis Brown, Computer Programmer, Alaska Department of Fish and Game, Juneau, and Matt Kirchhoff contributed valuable guidance with research design and data analysis. Field work was accomplished with the assistance of Debaran Kelso and C.E.T.A. employees in Metlakatla.

My committee members, Drs. David R. Klein, Peter Mickelson, and Robert G. White, as well as Dr. John W. Schoen, Matt Kirchhoff, and Dr. Thomas A. Hanley reviewed the manuscript and made many helpful suggestions. Norma Mosso attended to the myriad of administrative and financial details involved with this endeavor.

I extend my sincere appreciation to these agencies and individuals for contributing to the completion of this thesis.

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INTRODUCTION

Previous studies of deer habitat relationships in the Pacific Northwest have for the most part supported the assumption that clearcut logging improves deer habitat while 'old-growth' coniferous forests support few deer (Cowan 1945, Einarsen 1946, Leopold 1950, Dasmann and Hines 1959, Brown 1961, Gates 1968). Consequently, the belief that logging benefits deer has served as a premise of deer management in North America since the turn of the century. However, recent studies in Alaska and the Pacific Northwest have documented negative effects on deer resulting from clearcutting of old-growth forests, thus prompting researchers to reevaluate the evidence supporting the traditional concepts of deer-forestry interactions. An investigation of historical accounts of logging activities and deer abundance conducted by Schoen et al. (1981 a) indicated that many of the early conceptions of deer-habitat relationships were based on studies conducted after the demise of extensive areas of North American virgin forests and prior to the advent of ecological research. This situation persisted due to the lack of a consistent definition of 'old-growth' forest. In Southeast Alaska, where large areas of unaltered pristine forests still exist, Wallmo and Schoen (1980) identified the following criteria for describing old-growth forests: 1) healthy dominant trees at least 300 years old 2) evidence of mortality of trees spread over a long period of time 3) well-advanced subdominant trees, and 4) uneven canopy coverage. As in Schoen et al. (1981 a), this study uses Bormann and Likens' (1979) concept of "Shifting-Mosaic Steady State" to describe the old-growth forest ecosystem. Old-growth forests (!300 years old) exhibit complex spatial and temporal heterogeneity in structure and support a diverse and abundant understory plant community. In contrast, even-aged forests (20-300 years old) are characterized by uniform spacing of trees, dense canopy cover, and a deeply shaded forest floor which precludes vascular plants. The clearcut stage (0-20 years old) produces a dense herb and shrub layer until conifers dominate the site.

Deer usually respond favorably to logging where there is access to early successional vegetation. However, in Alaska, accumulations of snow and dense logging slash or shrub growth can limit the availability of forage plants to deer in clearcuts. Further, in the Pacific Northwest and Alaska the benefits of increased forage production are short-lived. After 20-30 years, second-growth stands produce little deer forage (Gates 1968, Wallmo and Schoen 1980, Alaback 1980). Hebert (1979) noted that in low snowfall regions of Vancouver Island deer numbers increased in response to timber harvesting, similar to deer in Oregon and Washington (Hebert 1976). In contrast, deer inhabiting high snowfall areas of the island required mature old-growth forests for winter range. Wallmo (1978) stated that although he had observed a favorable response of deer to logging in Arizona and central Colorado, different conditions in Alaska tended to negate the benefits of logging and exerted detrimental impacts on deer. He suggested that because habitat quality is largely a function of forage production, recent clearcuts do not comprise optimal habitat since much of the forage remains unavailable to deer during both winter and summer.

Subsequent studies by Wallmo and Schoen (1980) at the northern end of Southeast Alaska, measuring relative deer use of old-growth forests, clearcuts, and second-growth forests demonstrated that deer used old-growth forests to a greater extent that either clearcut or second-growth forests during winter. They hypothesized that because deep snow in clearcuts and a lack of forage in second-growth forests limits the value of these habitats to deer, logging will have long-term negative impacts on deer in Southeast Alaska. However, Longhurst and Robinette (1981) have suggested that the north-south (latitudinal) and east-west (maritime) climatic gradients of Southeast Alaska moderate winter weather (less snowfall) and reduce the importance of old-growth forests to deer as winter range on the southern and western islands of Southeast Alaska.

Objectives and Hypotheses

The primary objective of this investigation was to determine if the patterns of deer use of winter habitat observed in the northern region of Southeast Alaska also occur in the southern region. If similar trends in habitat use by deer occur throughout the climatic range of Southeast Alaska, prescriptions for managing deer would have broad applicability. In order to meet this objective I tested the null hypothesis that deer use of old-growth forest was no significantly different from use of clearcuts and second-growth forests on Annette Island.

Old-growth forest is a very diverse community, varying markedly in both overstory and understory characteristics between areas. Thus, the second objective of this study was to measure deer response to attributes of old-growth forests on Annette Island in southern Southeast Alaska, and to provide a basis for comparison with similar studies in northern Southeast Alaska. Therefore, a second null hypothesis was tested stating that deer preference for different types of old-growth forests independent of topographic, understory, and overstory attributes.

Study Area

This study was conducted on Annette Island at the southern end of the Alexander Archipelago (55° 00' N, 131° 20' W), approximately 7 km southwest of Ketchikan (Fig. 1). The Metlakatla Indian Community on Annette Island, was founded in 1881 by Father William Duncan and a group of Tsimpshean Indians who had fled from cultural and religious persecution in Canada. In 1887, the U.S. Congress formally recognized the community by creating the Annette Islands Reserve for the Tsimpshean Indians and other Alaskan Natives. The jurisdiction of the Reserve includes Annette Island (total area of 350 km^2), several smaller adjacent islands, and coastal waters within 914 m of Annette Island (Pacific Rim Planners 1979).

The island's topography is mountainous with sharp relief except for a 62 km^2 peninsula dominated by muskegs on which the town of

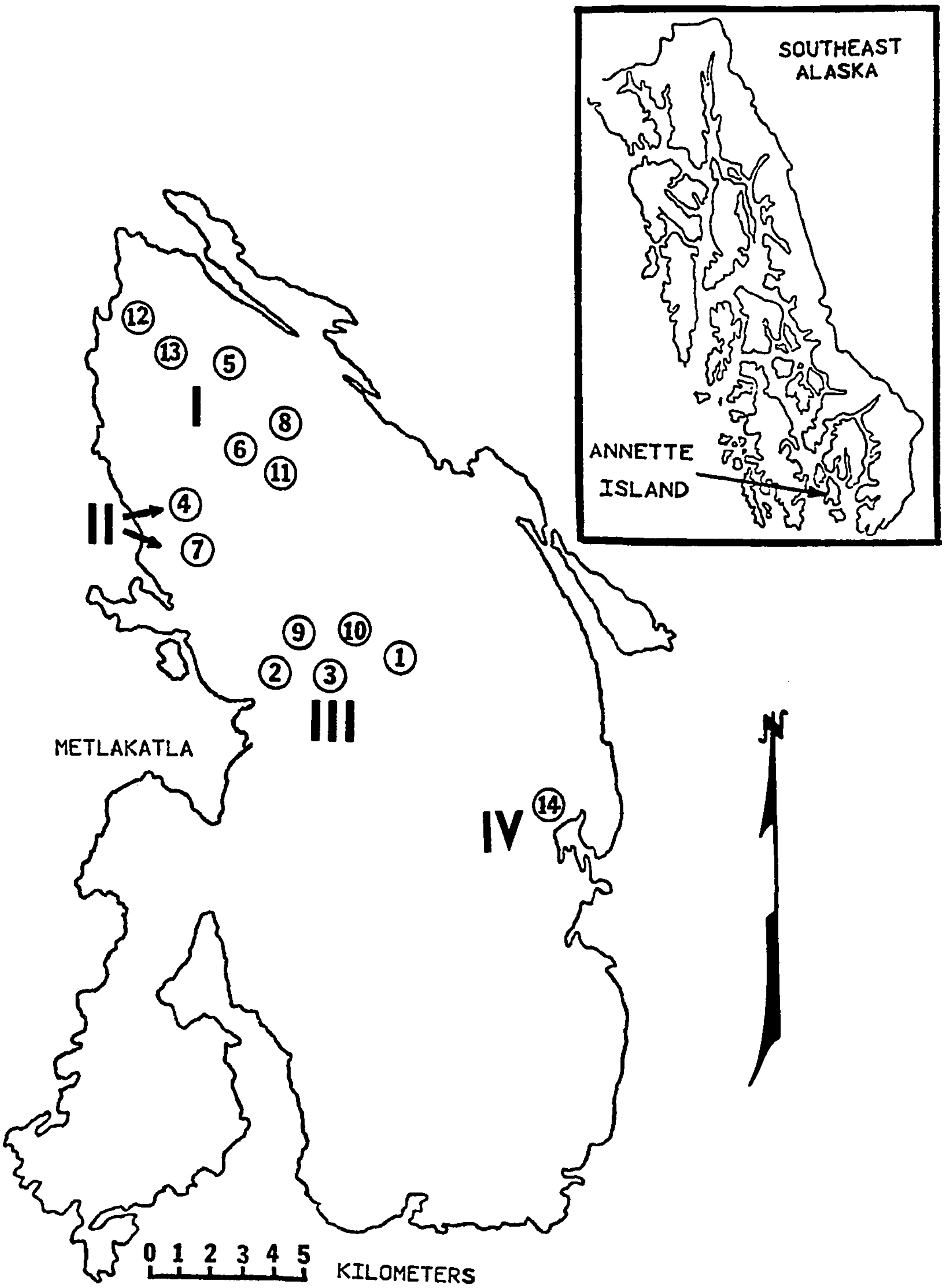

Fig. 1. Map of Annette Island showing the location of study areas I–IV and study sites 1–14.

Metlakatla is located. Mountain ranges rise to elevations of 500 to 800m with a maximum height of 1097 m on Tamgas Mountain. The island's more than 160 km of coastline contains 2 large harbors and numerous bays, estuaries and inlets. Freshwater habitats include over 60 streams and 20 large lakes, many of which are important for fisheries production. Soils are highly organic and shallow with underlying granitic and metamorphic bedrock frequently exposed. Soils on steeper slopes are unstable and moderately susceptible to avalanching and slope failure.

The climate of Annette Island is maritime with heavy precipitation and moderate temperatures. Because Annette Island is located in the path of easterly-moving storms crossing the Gulf of Alaska, the island receives a mean annual rainfall of 287 cm. Snowfall on the island is highly variable, fluctuating from year to year and between inland and coastal regions. Prevailing winds are south to southeasterly averaging 1.6 km per hour with frequent strong gusts throughout the year. During the period 1943-1980, Annette Island experienced 55% lower snowfall and 5°C warmer temperatures during winter than the northern region of Southeast Alaska. During the winter of 1979-1980, both the northern and southern regions of Southeast Alaska averaged 20 cm lower annual snowfall and 1°C warmer temperatures than the annual mean (Appendices Ia, b) (National Oceanic and Atmospheric Administration 1981 a, b). Snow depths greater than 15 cm were present for a mean of 10 days on Annette Island and for 38 days in northern Southeast Alaska during the period 1959-1980.

Vegetation cover types on Annette Island include old-growth forests of spruce (Picea sitchensis) and hemlock (Tsuga heterophylla) interspersed with muskeg, alpine and subalpine plant communities. Typical species composition of the old-growth forests in western hemlock 50%, Sitka spruce 27%, western redcedar 10% and Alaska-cedar 8%. Hardwoods such as alder and Oregon crabapple comprise less than 1% of the forests. Muskeg, a prominent cover type on Annette Island, occurs on benches and basins with less than a 15% slope and over non-porous substrata. Above elevations of 450 m the stunted forms of trees delineates the boundary of the subalpine zone. Alpine plant communities develop above elevations of 550 m, but due to limited soil development, there are few extensive areas of alpine vegetation on Annette Island.

Secondary succession on Annette Island has been initiated both by natural and by human disturbances. Landslides and blowdown occur frequently on steep slopes and in logged-over sites. These areas are rapidly colonized by alder, pioneer forbs and shrubs, and later by conifers. The major factor of natural disturbance is wind; fire is relatively unimportant.

Wolves are the only predator of deer on Annette Island except for occasional groups of free-ranging dogs near Metlakatla.

A total of 8,568 ha or 24% of Annette Island is classified as commercial forest land compared to 33% for the surrounding Tongass National Forest. Commercial forest lands on Annette Island total 1,800 hectares. Under Federal management in the 1960's, a timber operating plan was developed for Annette Island. Because of erroneous assumptions concerning timber values and logging costs, the plan overestimated the annual allowable cut on Annette Island at 107 ha (Pacific Rim Planners 1979, Bureau of Indian Affairs 1979). In 1979, the annual allowable cut on Annette Island was recalculated to be 21 ha. However, due to an overcut of almost 150% during the first 15 years of timber harvesting on Annette Island, the annual harvest for the remaining 65 years of the 80-year rotation is reduced to only 13 ha. Thus only about 2.5% of the entire island area remained as marketable timber by 1979 (Pacific Rim Planners 1979, Bureau of Indian Affairs 1979).

The standard silvicultural system on Annette Island is clearcutting with other methods such as helicopter and balloon logging used when cost-effective.

METHODS

Field work for this investigation was conducted in two phases. During May-September 1979, a general reconnaissance of Annette Island was undertaken to examine potential study sites and locate logged stands. Techniques for conducting pellet-group counts and measuring forest variables were tested at this time. Data collection was accomplished during the period March-June 1980 with the exception of one study site which was sampled in May 1979 prior to being logged.

Twelve paired old-growth and logged sampling sites were chosen by reviewing timber sale records, examining aerial photos, and by ground reconnaissance of each area (Fig. 1). Forests meeting the criteria of 'old-growth' forest defined by Wallmo and Schoen (1980) and having adjacent or nearby logged stands were chosen as study sites. Old growth stands were commercial-grade spruce-hemlock forests with an estimated volume range of 49,420 - 111,195 Bf/ha (20,000 - 45,000 Bf/ac). Clearcuts and second-growth forests ranged in age from 1 to 270 years and were the result of logging except for a 73-year-old burned site and a 200 and 270-year-old forest, probably of windthrow origin. Second-growth forests were aged by counting annual rings on 10 increment borer samples in each stand.

Deer use of paired old-growth forests, clearcuts, and second-growth forests was measured using the pellet-group count technique (Neff 1968). Pellet-group densities were assumed to be directly proportional to deer habitat use. Each stand was sampled using contiguous 1m X 10m plots in parallel belt arranged perpendicular to land contours randomly.

Approximately 300 plots were sampled per stand. From preliminary sampling, it was determined that this sample size provided a sampling accuracy to ± 10% with 95% confidence.

Pellet-group sampling was conducted in the spring (mid-April to mid-May) 1980, after forests were free of snow, to reflect winter habitat use by deer. The sampling period was based on a study of deer pellet-group decomposition rates on Annette Island (Appendices II a-c) which found pellet groups persisting for about 6 months under a forest canopy and for up to 8 months in the open. This corresponds with a similar study in northern Southeast Alaska by Fisch (1979). Early in the sampling period, fresh spring pellet groups were counted separately from winter pellet groups. Spring pellet groups were identified by their greener color, higher mucous content and finer consistency.

Deer response to attributes of old-growth forests was measured on 78 forest stands on Annette Island between 1 March and 30 June 1980. Stands were located in four major areas (I-IV, Fig. 1) with approximately 20 0lots per area. Stands were placed in commercial-grade old-growth spruce-hemlock forests (!49,420) Bf/ha (20,000 Bf/ac), each stand covering a 0.4-ha area with uniform vegetation and topographic characteristics. At each stand, topographic, overstory, and understory variables were measured and pellet groups were counted at 9 sampling points following Schoen et al. (1981 b) (fig. 2). Topographic variables were elevation, slope and aspect. Deer preference for aspect was examined by comparing winter pellet-group densities in similar stands on northerly and southerly exposures. Three study sites provided adjacent or nearby old-growth stands on north- and south-facing slopes.

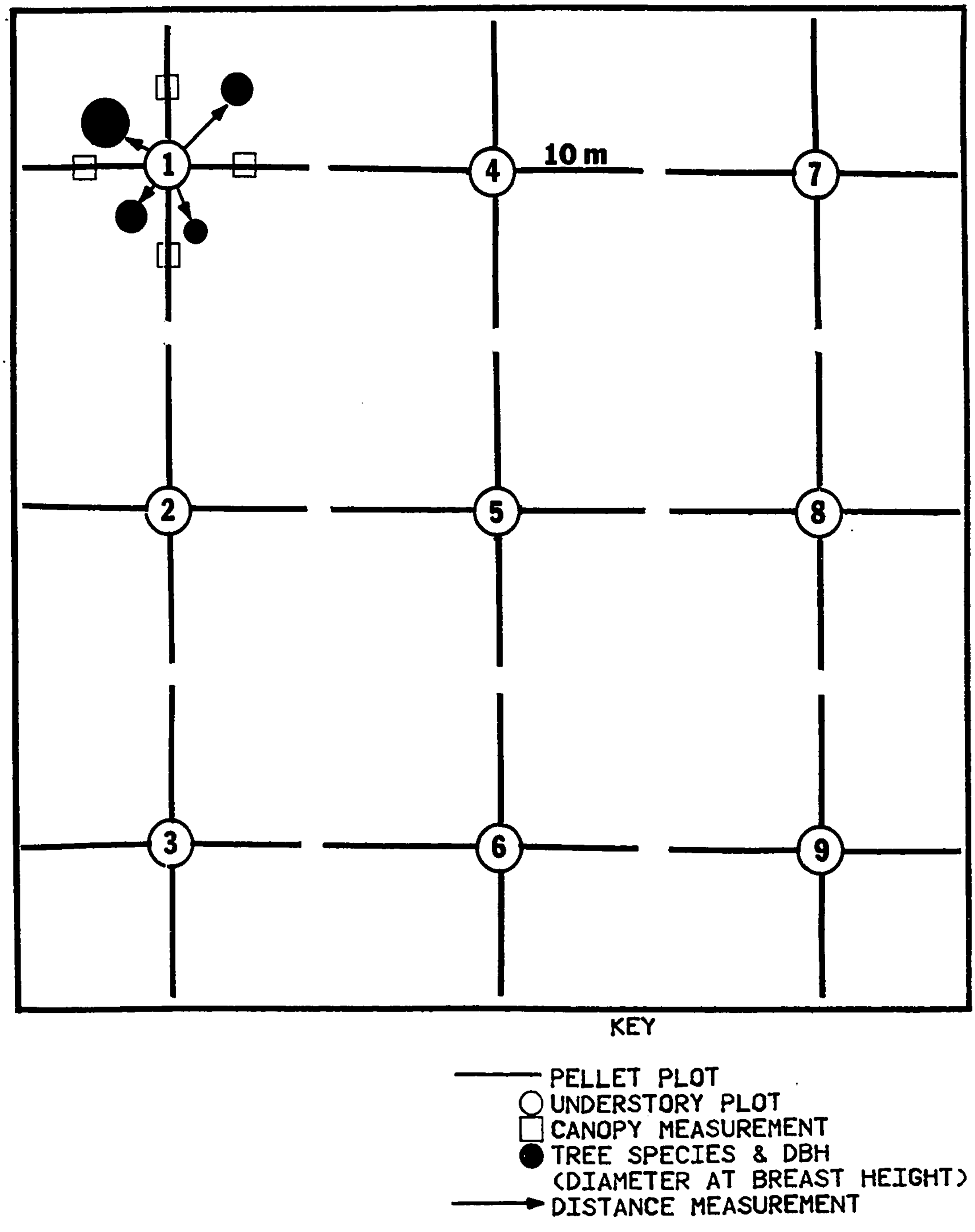

Fig. 2. Sampling design for measuring forest variables (after Schoen et al. 1981 b).

Overstory variables measured for trees selected by the point-centered quarter technique (Cottam and Curtis 1956, Ohmann and Ream 1971) were tree species, canopy cover, tree diameter, and distance from point to tree. From these data, mean tree density (number of trees per hectare), tree diameter variability (c.v.), and tree spacing variability (c.v.) were calculated. Understory vegetation diversity and abundance were measured by recording the presence or absence (frequency of occurrence) of 23 understory plants (Appendix III) on 0.5-m radius circular plots located at the center of 9 sampling points in the 0.4-ha stand. Schoen et al. (1981 b) found this sampling method to reflect accurately the abundance of most understory plant species. Deer use was measured by counting numbers of pellet groups within 1 m x 10 m plots radiating at right angles from each of the 9 sampling points. At the midpoint of each pellet-group plot, overstory canopy cover was recorded using a visual estimate of percentage of the overstory space occupied by tree foliage. A measure of the relative amount of deer browsing in the stand was estimated by assigning ordinal values for browsing intensity (1=heavy, 2=medium, 3=light) to the nearest *Vaccinium* spp. shrub at each sampling point.

RESULTS

Forest Successional Stage

Results of the pellet-group counts were grouped into four categories representing major successional stages after logging (Fig. 3). Clearcuts 1-7 years old produced a high biomass of forbs and appeared to provide the best foraging conditions for deer unless access to forage was limited by snow. Clearcuts 9-12 years old produced abundant forage, but access was limited by dense shrub growth. Even-aged stands from 45 to 200 years old were nearly devoid of vascular plants in the understory. Only the 270-year-old forest appeared to have abundant and accessible forage throughout the year.

Winter pellet-group densities were significantly greater in old-growth forests than in adjacent logged stands for each of twelve paired sites ($P<0.01$, Approximate t-test) (Table 1). Additionally, pellet-group densities were significantly greater (7 times) in old-growth forests for all pairs of study sites combine ($P<0.01$, Wilcoxon paired-sample test). Ratios of pellet-group densities on paired old-growth forest and logged sites showed no correlation with age of the logged stands (1-270 years). In no case were pellet-group densities in clearcut or second-growth stands equal to or greater than densities in adjacent old-growth forests. Spring pellet-group densities exceeded winter densities by 30-65% in clearcuts 1-7 years old, and by 13% in an even-aged forest 270 years old. Old-growth study sites and postlogging stands of other ages received little use by deer during spring.

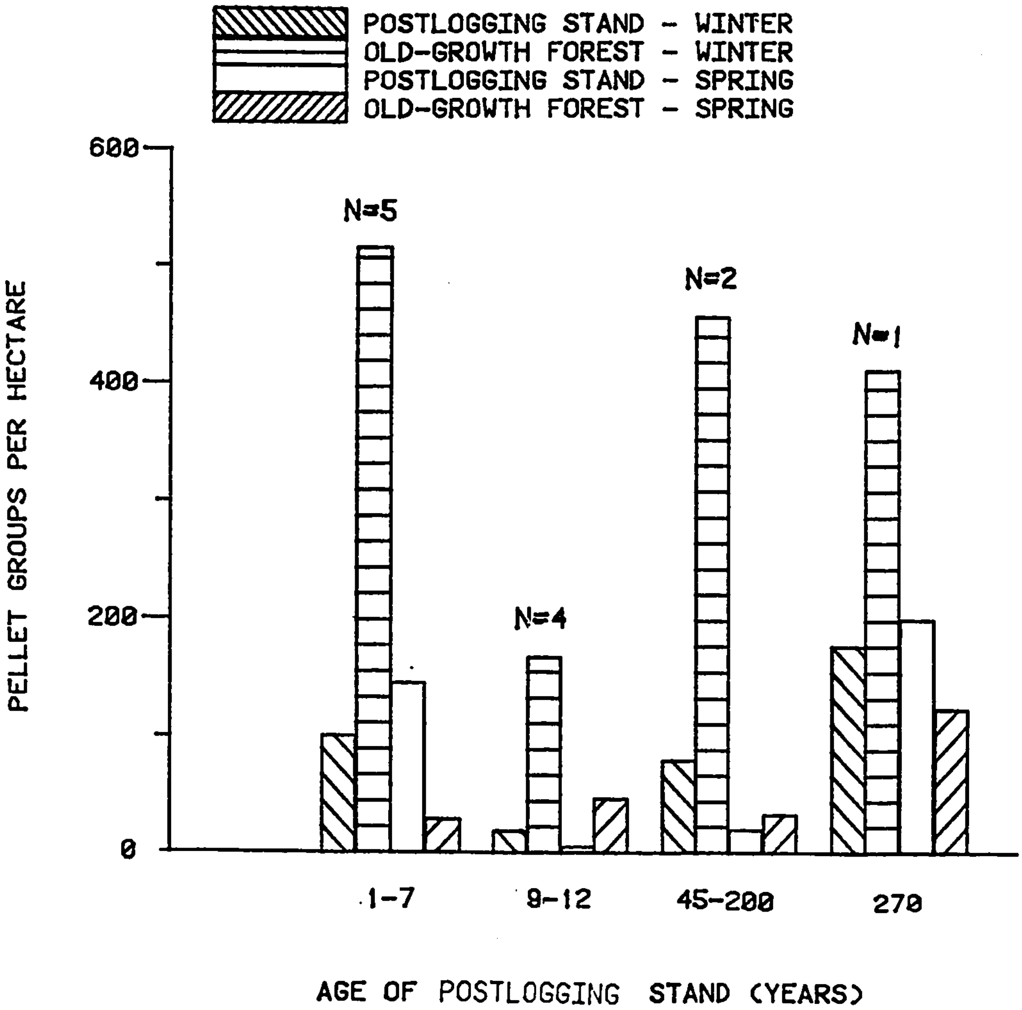

Fig. 3. Mean winter and spring pellet-group densities per hectare in paired old-growth forests, clearcuts, and second-growth stands on Annette Island during 1979–1980.

Table 1. Winter and spring pellet-group densities in old-growth forests, clearcuts, and second-growth forests.

Study Site	Stand Age (years)	Date Sampled	Elevation (m)	Number of Plots	Winter Pellet Groups/ha	Winter Ratio of Old-to Second-Growth	Significance of Winter Pellet Density Comparison	Spring Pellet Groups/ha
2	> 300	5/18/79	100-300	305	413	7.9	***	11
	< 1	5/12/80		305	53			69
9	> 300	4/12/80	150-250	301	312	6.8	***	28
	3	4/14/80		306	46			78
5	> 300	5/ 8/80	150-300	330	918	8.6	***	34
	7	5/16/80		300	107			162
6	> 300	5/15/80	180-250	340	659	3.1	***	16
	7	5/ 9/80		300	213			291
8	> 300	4/19/80	100-250	306	278	3.6	***	56
	7	4/21/80		300	77			128
11	> 300	5/ 3/80	180-250	310	261	13.1	**	78
	9	5/ 5/80		300	20			3
7	> 300	4/28/80	180-270	300	73	4.1	**	14
	12	4/30/80		337	18			6
12	> 300	5/11/80	90-180	305	721	12.2	***	23
	45	5/13/80		320	59			9
4	> 300	4/24/80	150-330	300	630	5.2	***	47
	73	4/25/80		307	124			17
10	> 300	4/15/80	100-250	301	140	10.7	**	10
	160	4/16/80		305	13			7
1	> 300	4/30/80	90-300	300	343	2.9	***	52
	200	5/ 1/80		303	119			48
3	> 300	5/12/79	100-300	305	413	2.3	***	123
	270	5/14/79		300	177			200
13	> 300	5/10/80	150-240	300	60	-	-	
14	> 300	5/23/80	50-150					

[a] Statistical significance determined with Approximate t-test. ** $P < 0.01$, *** $P < 0.001$.

[b] Old-growth stand sampled in May 1979, prior to being logged. Clearcut sampled in March 1980, less than 1 year after logging.

[c] Old-growth stands used in comparing deer use of aspect.

[d] Study site sampled during spring 1979, prior to being logged.

[e] Old-growth study site used for measuring deer response to attributes of old-growth forests.

Old-growth Forest Characteristics

Winter pellet-group densities were significantly greater on southerly than on northerly exposures for individual paired sites (P<0.01), Approximate t-test) and for all three study areas combined (P<0.001, Wilcoxon paired-sample test).

Pellet group density was most strongly positively correlated with stand elevation, slope, and frequency of Cornus canadensis Rubus pedatus, spp., and Coptis aspleniifolia, and was negatively correlated with the frequency of Tiarella trifoliata, Moneses uniflora, Picea sitchensis, and Lysichiton americanum (Fig. 4). The latter four variables were positively correlated with each other and negatively correlated with plants of the former group. Forest overstory variables were not significantly correlated with pellet-group density and showed little correlation with either topographic or understory variables.

Mean pellet-group density and percentage frequencies of understory plants were markedly lower on Annette Island than in the Admiralty Island study of Schoen et al. (1981 b) (Table 2). Mean elevation and slope of selected stands were greater on Annette Island, while values for the overstory variables were comparable at both locations.

Cluster analysis (complete linkage) was used to identify major groupings of understory plants in old-growth forests. The most similar plants, based on their degree of correlation (percent similarity) were Rubus pedatus and Vaccinium spp. (Fig. 5). Cornus canadensis and then Coptis aspleniifolia joined this group at a similarity value of 63% (A, Fig. 5) to form a cluster of four species which were positively correlated with pellet group density. The plants Menziesia ferruginea,

	Pellet Groups	Elevation (m)	Slope (%)	*Coptis asplenifolia* (%)	*Cornus canadensis* (%)	*Lysichiton americanum* (%)	*Moneses uniflora* (%)	*Rubus pedatus* (%)	*Tiarella trifoliata* (%)	*Vaccinium* spp.
Elevation (m)	0.60***									
Slope (%)	0.46***	0.70***								
Coptis aspleniifolia (%)	0.25*	0.30**	--							
Cornus canadensis (%)	0.50***	0.34**	--	0.28*						
Lysichiton americanum (%)	-0.23**	-0.61***	-0.41***	--	--					
Moneses uniflora (%)	-0.26*	--		--	-0.26*	--				
Rubus pedatus (%)	0.39***	0.52***	0.23*	0.54***	0.51***	-0.26*	-0.29**			
Tiarella trifoliata (%)	-0.36***	-0.22*	-0.28*	--	-0.31**	--	0.43***	-0.26*		
Vaccinium spp. (%)	0.39***	0.40***	0.25*	0.29**	0.34**	--	-0.29**	0.59***	-0.44***	
Picea sitchensis (%)	-0.23*	-0.34**	-0.35***	--	--	0.34*	0.29**	--	0.20*	-0.34**

Fig. 4. Matrix of zero-order correlation coefficients showing the relationships between forest variables. (* = significant at $P < 0.05$, ** = $P < 0.01$, *** = $P < 0.001$).

Table 2. Means($\overline{X}$) and 90% confidence intervals for variables measured in old-growth forests on Admiralty Island (March–July 1979) (Schoen et al. 1981 b) and on Annette Island (March–July 1980).

Variable Measured	Admiralty Island(N=120) [a] $\overline{X}$[b]	90% C.I.	Annette Island(N=78) $\overline{X}$	90%C.I.
Mean pellet-group density	42.0	(0.0— 89.0)	22.0	(0.0— 61.0)
Elevation (m)	55.7	(0.0—151.0)	189.0	(0.0—383.0)
Slope (%)	31.0	(0.0— 75.0)	40.0	(0.0— 73.0)
Clintonia uniflora	—	—	10.0	(0.0— 22.0)
Coptis aspleniifolia	25.0	(0.0— 66.0)	8.5	(0.0— 26.0)
Cornus canadensis	55.0	(6.4—100.0)	22.0	(0.0— 63.0)
Fauria crista-galli	—	—	0.0	(0.0— 0.0)
Ferns				
Polystichum munitum	53.0	(5.0—100.0)	32.0	(0.0— 73.0)
Blechnum spicant	—	—	—	—
Gaultheria shallon	—	—	2.0	(0.0— 18.0)
Listera cordata	—	—	8.0	(0.0— 32.0)
Lysichiton americanum	--	--	8.0	(0.0-- 41.0)
Maianthemum dilatatum	28.0	(0.0— 72.0)	27.0	(0.0— 78.0)
Menziesia ferruginea	22.0	(0.0— 57.0)	7.0	(0.0— 30.0)
Moneses uniflora	21.0	(0.0— 52.0)	2.0	(0.0— 12.0)
Oplopanax horridus	12.0	(0.0— 39.0)	4.0	(0.0— 19.0)
Pyrola secunda	—	—	1.0	(0.0— 1.0)
Rubus pedatus	51.0	(5.0— 97.0)	32.0	(0.0— 89.0)
Rubus spectabilis	—	—	2.0	(0.0— 12.0)
Sambucus racemosa	—	—	0.0	(0.0— 3.0)
Streptopus spp.	—	—	28.0	(0.0— 78.0)

Table 2. (Continued)

Variable Measured	Admiralty Island(N=120)[a] X̄[b]	90% C.I.	Annette Island(N=78) X̄	90%C.I.
Tiarella trifoliata	24.0	(0.0— 63.0)	19.0	(0.0— 56.0)
Trientalis europaea	—	—	1.0	(0.0— 7.0)
Vaccinium ovalifolium or V. parvifolium	68.0	(25.0—100.0)	50.0	(0.0—100.0)
Viola spp.	—	—	3.0	(0.0— 16.0)
Picea sitchensis	—	—	8.0	(0.0— 30.0)
Tsuga heterophylla	—	—	84.0	(54.0—100.0)
Thuja plicata or Chamaecyparis nootkatensis	—	—	7.0	(0.0— 30.0)
Mean tree diameter (cm)	49.0	(34.0— 66.0)	52.0	(34.0— 70.0)
Mean spruce diameter (cm)	—	—	53.0	(0.0—146.0)
Mean hemlock diameter (cm)	—	—	46.0	(24.0— 67.0)
Mean cedar diameter (cm)	—	—	55.0	(0.0—116.0)
Mean tree spacing (m)	5.0	(4.0— 6.0)	5.0	(3.0— 6.0)
Mean canopy cover (%)	58.0	(44.0— 72.0)	49.0	(36.0— 62.0)
Tree diameter variab.(%)	56.0	(32.0— 81.0)	59.0	(35.0— 83.0)
Tree spacing variab. (%)	50.0	(39.0— 60.0)	55.0	(41.0— 69.0)
Canopy cover variab. (%)	48.0	(22.0— 73.0)	34.0	(15.0— 52.0)
Tree density (stems/ha)	175.0	(89.0—262.0)	192.0	(94.0—290.0)

[a] N is the number of 0.4-ha forest stands sampled.

[b] All table values for X̄ represent means for variables on N, 360-m^2 plots within 0.4-ha forest stands. Values for plant species are the mean percentage (%) frequency of plants. Variab. = coefficient of variation.

Rubus spectabilis and Oplopanax horridum formed a cluster at B (Fig. 5) which were uncorrelated with pellet-group density. At C (Fig. 5), Tiarella trifoliata, Moneses uniflora and Lysichiton americanum ferns, and Gaultheria shallon formed a cluster of plants which were negatively correlated with pellet-group density.

The dendrogram was further separated into 2 distinct plant associations by performing cluster analysis only with understory plants which were significantly correlated with pellet-group density and had a frequency of occurrence greater than 10% (Fig. 6). Plant species in group A (Fig. 6) were positively correlated with pellet-group density whereas group B plants (Fig. 6) were negatively correlated.

A multiple regression model (forward stepwise inclusion) was developed for predicting pellet-group densities as a function of topographic, understory and overstory attributes. Initially, the model included all variables which were correlated with deer use and variables which were not significant, but which were believed to be related to deer habitat preferences. Partial correlation coefficients were calculated with the effects of elevation and slope controlled. Variables which exhibited spurious correlations with pellet-group density were thereby eliminated. Polynomial squared terms for canopy cover and tree density were added to account for possible non-linear relationships between these variables and pellet-group density. An interaction term (canopy cover X density) was included in the analysis because of possible non-additive influences of these factors on habitat selection by deer.

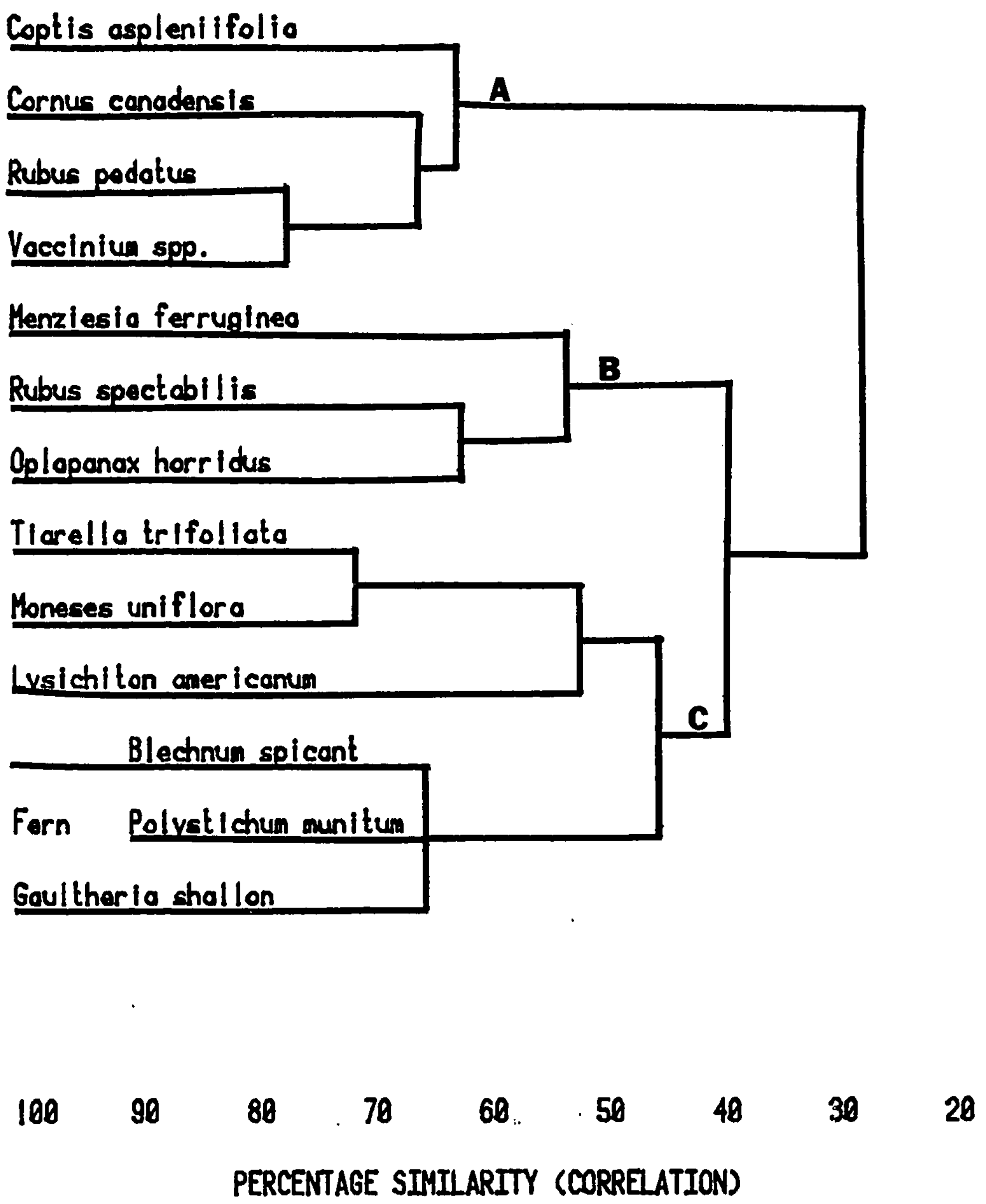

Fig. 5. Dendrogram of understory plant associations including all plant species with greater than 5% frequency of occurrence. Groups A, B, and C denote plants which were positively correlated, uncorrelated, and negatively correlated (respectively) with pellet-group density.

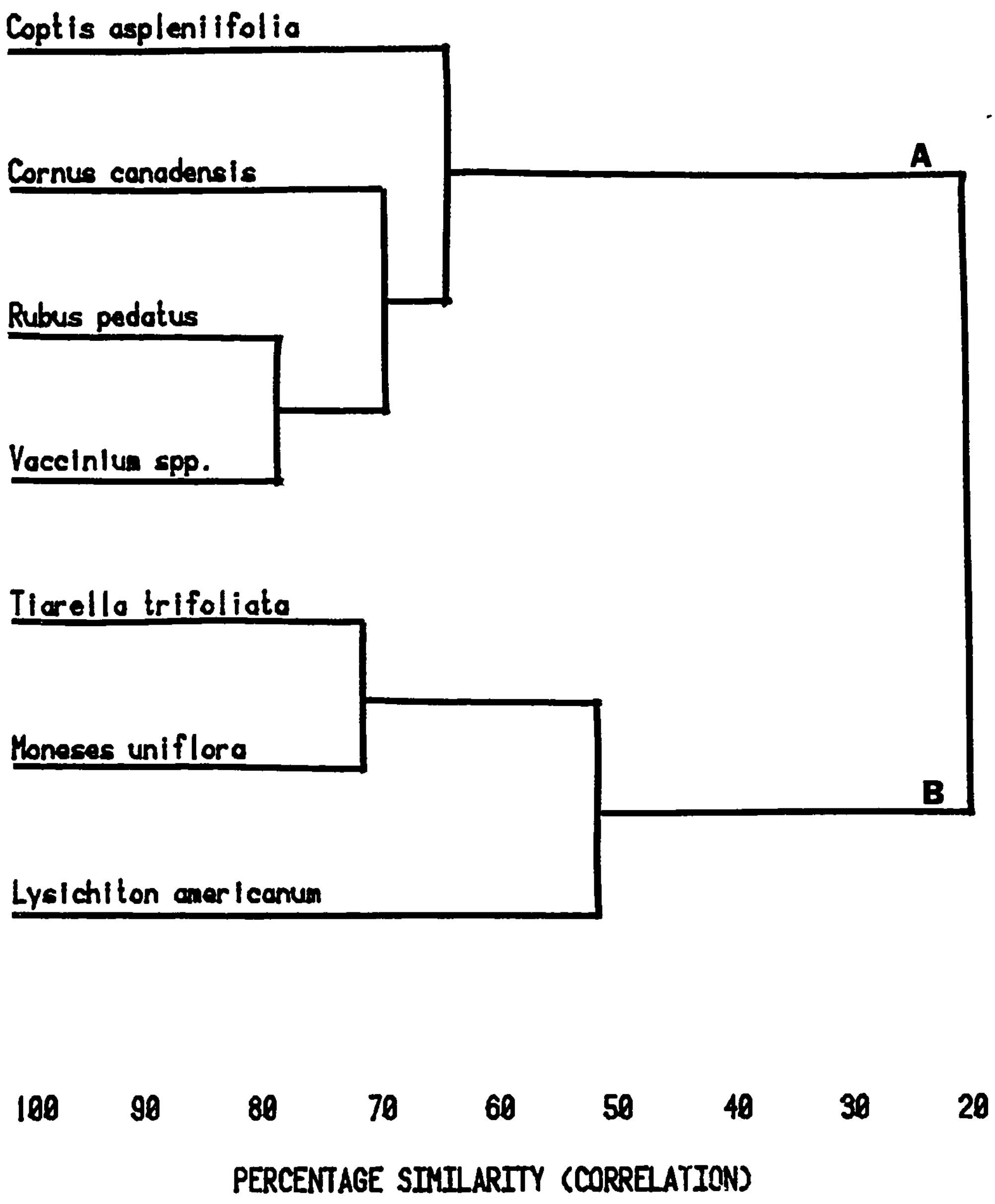

Fig. 6. Dendrogram of understory plant associations including plant species significantly correlated with pellet group abundance. Group A - well-drained forest sites; plant species positively correlated with pellet-group density. Group B - wet forest sites; plant species negatively correlated with pellet-group density.

Three dummy variables were included in the model to remove any effects on the regression due to different deer densities on the four different study areas on Annette Island. The final set of variables subjected to regression analysis included elevation, slope, mean canopy cover, $(\text{canopy cover})^2$, tree density, $(\text{tree density})^2$, canopy cover X tree density, 3 dummy variables, and the frequency of *Cornus canadensis*, *Coptis aspleniifolia*, *Menziesia ferruginea*, *Rubus pedatus*, *Tiarella trifoliata*, *Vaccinium* spp., and *Picea sitchensis*.

The resulting regression equation included the variables (in decreasing order of significance) stand elevation, frequency of *Cornus canadensis*, and canopy cover variability. The regression model had a multiple R^2 value of 0.59 ($P<0.001$) (Table 3).

Schoen et al. (1981 b) performed regression analysis on forest variables which were correlated with deer use on Admiralty Island. The resulting regression equation included the variables frequency of *Cornus canadensis*, elevation, frequency of *Menziesia ferruginea*, *Maianthemum dilatatum*, and conifer seedlings, with a multiple R^2 value of 0.41. To test whether these same regression variables would be useful in predicting deer habitat use at the southern end of Southeast Alaska, the preliminary variables were subjected to regression analysis using data from Annette Island. Significant variables in the resulting equation were elevation, tree spacing variability, and frequency of *Cornus canadensis* with an R^2 value of 0.51. This equation includes 2 of the 3 variables (frequency of *Cornus canadensis* and elevation) in the overall regression for Annette Island forests.

Regression procedures were repeated for each of four study areas on Annette Island to compare patterns of winter habitat preference among the areas. Results of the separate regressions generally agreed with the overall regression in identifying elevation, canopy cover variability and plants of the *Cornus canadensis* understory association (Group A, Fig. 6) as important variables in predicting deer use (Table 4).

Table 3. Summary of the multiple regression model (forward stepwise inclusion), including analysis of variance statistics and significant ($P < 0.05$) independent variables. Model is of the form $Y = B_o + B_1X_1 + B_2X_2 + B_3X_3$, where Y is the expected pellet-group density per 360 m^2, B_i are regression coefficients, and X_i are habitat variables.

Analysis of Variance	D.F.	Sum of Squares	Mean Square	F	Prob.
Regression	3	17,462.57	5,820.86	36.17	0.001
Residual	74	11,907.38	160.91		

Variables in the Equation	B	Std. Error B	F	Prob.	R^2
Elevation	0.036	0.005	50.884	0.001	0.374
Frequency of *Cornus canadensis*	0.272	0.065	17.752	0.001	0.542
Canopy Cover Variability	0.227	0.081	7.929	0.020	0.594
Constant	-13.362				

Table 4. Summary of regression equations showing significant ($P < 0.05$) variables for each of the 4 study areas on Annette Island.

Study Area	Significant Regression Variables	R^2	F	Signif. Level
Nubbins Mtn. I	Y = 8.18 + 1.298(% *Vaccinium* spp.) + 0.042(% *Menziesia ferruginea*)	0.43	8.25	0.001
Sylburn Harbor II	Y = 83.33 + 1.143(% *Menziesia ferruginea*) + 1.504(% *Vaccinium* spp.)	0.80	8.35	0.001
Trout Lake III	Y = 13.89 + 5.755(% Canopy Cover) Variability + 0.343(% Slope) - 0.187(% *Tiarella trifoliata*) + 0.046(Elevation) + 0.168(% *Cornus canadensis*)	0.72	7.23	0.001
Crab Bay IV	Y =-29.04 - 0.581(% *Thuja plicata* and *Chamaecyparis nootkatensis*) + 0.024(Elevation) + 0.042 (% *Rubus pedatus*)	0.79	17.97	0.001

DISCUSSION

Deer Response to Forest Succession

Results of the pellet-group counts demonstrate that even during a mild winter, deer on Annette Island preferred old-growth forests to both clearcuts and second-growth forests. These findings parallel those of Wallmo and Schoen (1980) on Admiralty and Chicagof Islands in northern Southeast Alaska, as well as studies further south on Vancouver Island (Jones 1974, 1975, Weger 1977, Bunnell 1979, Harestad 1979, Hebert 1979, Rochelle 1980) in identifying old-growth forest as preferred winter range for deer.

Deer preference for forested habitats versus clearcuts in winter is attributed to shallower snow depths beneath a forest canopy than in openings (Merriam 1971, Jones 1975, Weger 1977, Schoen and Wallmo 1979). During snow-free seasons, deer in the Pacific Northwest often prefer clearcuts to old-growth forests (Harestad 1979, Hanley 1980). Conversely, in northern Southeast Alaska Wallmo and Schoen (1980) found greater use by deer of old-growth forests than of clearcuts in summer. This they attributed to dense shrub growth which restricted deer access to forage. Information provided by Alaback (1980) and Hanley (1980) has disclosed that in Alaska, clearcuts produce a much lower biomass of the highly nutritious forbs and a much greater biomass of shrubs than do clearcuts in the Pacific Northwest. On Annette Island, between these geographical extremes, deer exhibited a preference in spring for open clearcuts (1-7 years old) producing a high biomass of forbs. However, old-growth forests were still preferred by deer over shrub-dominated clearcuts 9-12 years old.

Also, preliminary data presented by Billings and Wheeler (1979), and Van Horne (1982) suggests that a higher nitrogen content of plants in old-growth forests versus clearcuts may be another factor influencing deer habitat preferences.

Closed-canopy, even-aged forests received little use by deer during winter or spring on Annette Island. The poor quality of even-aged forests for deer has been observed throughout the Pacific Northwest and Alaska (Gates 1968, Willms 1971, Jones 1974, 1975, Bunnell and Eastman 1976, Bunnell 1979, Hebert 1979, Hanley 1980, Rochelle 1980, Alaback 1980). In Southeast Alaska, studies by Wallmo and Schoen (1980) and Alaback (1982) have demonstrated that closed-canopy, even-aged forests have impoverished understories that provide little forage for deer. On Annette Island, the 270-year-old forest was the only even-aged stand which exhibited higher pellet-group densities in spring than in winter. Also, this transitional forest was the only even-aged stand with an appreciable abundance and diversity of understory plants.

Old-growth forest in optimal winter range for deer since it produces an abundant understory as well as providing snow interception.

Deer use of old-growth forests sampled on Annette Island dropped sharply in spring, however a concurrent increase in the use of lower timber-volume old-growth forests was observed. These open-canopy hemlock-cedar forests (timber volume < 49,420 Bf/ha [<20,000 Bf/ac]) provide little snow interception in winter but produce an abundance of forbs that are early to initiate growth in spring, such as <u>Lysichiton</u>

americanum, *Maianthemum dilatatum*, and *Cornus canadensis*, and are sought by deer at this time. Deer preference for low timber-volume stands in spring also has been reported by Jones (1975) and by Schoen et al. (1982).

Deer Preference for Attributes of Old-growth Forests

Deer preference for southerly exposures in winter has been attributed to such factors as forage quality and quantity, and to better snow and temperature conditions for deer on south-facing slopes. (Taber and Dasmann 1958, Julander 1966, Jones 1975, Schoen 1979, Taber and Hanley 1979). Southerly aspects receive a greater intensity and duration of sunlight during winter than do northerly aspects. Also, southerly exposures are more directly exposed to southeasterly storms and as a result have lower snow depths and earlier snow melt in the spring than northerly exposures.

Although the frequency of occurrence of most understory plants was substantially lower on Annette Island compared to Admiralty Island, overstory characteristics were similar on both islands. Speculatively, lower forage abundance on Annette Island may be the result of a phenomenon described by Klein (1965) on Coronation Island whereby deer populations in regions of low snowfall periodically exceed the carrying capacity of their range bringing about a sharp reduction in forage abundance. Also, the greater cloud cover in southern southeast Alaska which results in less light reaching the forests floor may account for the lower plant frequencies on Annette Island. The nearly 50% lower pellet-group densities on Annette Island compared to Admiralty Island could be a function of high deer mortality during a series of severe winters in the late 1960's and early 1970's, followed by several years of high wolf numbers. Nonetheless, the mean density of 22 pellet groups per 360 m^2 was considered adequate for measuring deer response to forest variables on Annette Island.

The linear associations indicated by the correlation coefficients relating pellet-group density to topographic, understory and overstory variables agree with trends expected within the range of habitat values sampled in this study. High linear correlations between forage availability and deer use have been reported in the Pacific Northwest by Harestad (1979) and Hanley (1980). Willms (1971) found a linear response of deer to increasing vegetation cover only when plant species at 100% cover did not restrict deer movement. The weak association of overstory variables with pellet-group density and with understory and overstory variables in this study is not surprising considering the finegrained structure of plant communities within old-growth forests. McCune and Antos (1981) have found overstory and understory structure to be poorly correlated in forest ecosystems because the different vegetation strata do not change composition across environmental gradients at the same rate or in the same pattern.

The significant positive correlation between deer use and elevation is believed to be related to greater forage abundance at higher elevations on Annette Island. In addition, field observations have disclosed that some low-elevation winter ranges on Annette Island have been heavily browsed by deer in the past. Using pellet-group counts, radio telemetry tracking and research relating deer habitat use to "edge" habitats, Schoen et al. (1979, 1981 b) have suggested that some deer increase their foraging opportunities by wintering as high as possible and using beach fringe forests only when forced there by snow. A secondary effect of this pattern of habitat use is that it reduces browsing pressure by deer on 'critical winter ranges'. When deer are concentrated throughout the winter, rapid depletion of available forage may occur on isolated winter habitats as has been documented in forests along beach fringes backed by clearcuts (Schoen et al. 1979). The positive correlation between deer use and slope may be a function of the greater abundance of several preferred forages on well-drained (i.e. steeper) slopes.

Of the 23 understory plants sampled in this study, winter deer use was most strongly positively correlated with the frequency of shrubs and evergreen forbs, specifically Cornus canadensis, Coptis aspeniifolia, Rubus pedatus, and Vaccinium spp. This was expected since most forbs do not retain living tissues above the ground in winter and are therefore unavailable to deer. On Admiralty Island, Schoen et al. (1981 b) also identified positive correlations between deer use and the frequency of Cornus canadensis and Rubus pedatus. The researchers described these plants as indicator species of well-drained old-growth forests providing important winter range for deer.

This investigation on Annette Island identified significant negative correlations between deer use and the frequency of Moneses uniflora, Picea sitchensis, Tiarella trifoliata, and Lysichiton americanum. Schoen et al. (1981 b) have identified the latter three plants as indicator species of poorly-drained old-growth forests. The plant Moneses uniflora had a low frequency of occurrence (@ 20%) on the study plots thus further study is needed to determine the relationship of this plant to other understory plant species. On Annette Island, plants which were negatively correlated with pellet-group density in winter were commonly found in poorly-drained forests and in well-drained but moist sites such as spruce forests adjacent to streams and rivers, and in cedar forests. The major understory plant clusters (A and B, Fig. 6) represent plant associations found in well-drained and poorly-drained old-growth forests, respectively.

Results of the regression analyses indicate that in winter, deer on Annette Island prefer old-growth forest habitats at higher elevations (to 396 m) having an abundance of Cornus canadensis and high variability in canopy cover. Cornus canadensis is an indicator species of the Group A (Fig. 6) plant association which includes the most nutritious forages available to deer in winter (Gates 1968, Schoen and Wallmo 1979, Hanley 1980, Rochelle 1980, Appendices IV, V).

An important corollary between these results on Annette Island and studies by Schoen et al. (1981 b) on Admiralty Island is the identification of Cornus canadensis as the single most reliable predictor of preferred winter range for deer. Using partial correlation to control for variation in the other forest variables, Cornus canadensis was determined to be the best variable for predicting deer use of old-growth forests on Annette Island. Schoen et al. (1981 b) have suggested that preference by deer for habitats with abundant Cornus canadensis in winter is due not only to the nutritional value of the plant, but also to the fact that the plant is often found in forest environments which intercept snow, thus making the forage readily available to deer. On both Annette and Admiralty Islands, old-growth forests of spruce and hemlock produce an abundance of Cornus canadensis. Therefore, when snow is a limiting factor for deer, old-growth forests provide an important component of the winter range.

The similar regression models for predicting deer use of old-growth forests on Annette and Admiralty Islands suggest that deer may prefer the same types of old-growth forest for winter range in both the northern and southern regions of Southeast Alaska.

The results of the separate regressions for the different study areas on Annette Island demonstrate that in each location deer selected habitats which had an abundance of plants of the Cornus canadensis cluster. The significance of increasing canopy cover variability and decreasing canopy cover (to 35%) in the regression models suggests that deer prefer forests which are more uneven-aged in structure.

An important contrast in deer-forest interactions is evidenced by comparing regression equations for study areas 2 and 14 with areas 5 and 7. Old-growth forest study sites extended from sea level to approximately 200 m in elevation on areas 2 and 14, and from 200-400 m in elevation on areas 5 and 7. During the winter prior to this study, snow depths in low elevation forests were shallow whereas at higher elevations, snow was sufficiently deep to cover most ground-growing plants. The resulting regression equations for areas 2 and 14 suggest that at low elevations, deer responded to a variety of topographic, understory, and overstory attributes. However, the regression equations for areas 5 and 7 predict deer use solely on the abundance of shrubs.

Because of the small sample size at each of the study areas (20 plots), the results of these separate regressions may not be conclusive. Regardless, these results suggest that in winter deer prefer old-growth forests which produce an abundance of shrubs and evergreen forbs in the Group A cluster (Fig. 6).

Influence of Weather on Habitat Selection

Heavy snowfall and a resulting lack of forage are major limiting factors to deer in Southeast Alaska (Klein and Olson 1960, Merriam 1970, Leopold and Barrett 1972). As little as 8-25 cm of snow buries low-grading forages and limits the use of these plants by deer (McCullough 1964, Jones 1974, Johnson 1976). In addition, snow depths greater than 60 cm impose major limitations on deer movement (Bunnell 1979, Harestad 1979). Prolonged periods of subfreezing temperatures and deep snow accumulations are highly correlated with winter deer mortality, especially for fawns (Klein and Olson 1960, Jones 1975, Hebert 1979). Weather conditions thereby exert an important influence over winter habitat selection by Sitka black-tailed deer.

This study describes deer habitat relationships during a mild winter on Annette Island. Yet, during harsh winters deer are more dependent upon old-growth forest habitats because of reduced forge supplies (Jones 1975, Weger 1977, Harestad 1979, Wallmo and Schoen 1980). Although winters are generally more severe at the northern than at the southern end of the Alexander Archipelago (Appendix Ia-c), weather patterns are highly variable throughout Southeast Alaska. Therefore, detailed weather information is needed to assess winter conditions for deer throughout the range of latitudinal, longitudinal and elevational gradients in Southeast Alaska.

CONCLUSIONS

The results of this study on Annette Island agree with findings from northern Southeast Alaska by identifying old-growth forest as preferred winter range for deer. During a mild winter, deer preferred old-growth forests at higher elevations (to 400 m) which had irregular and broken canopy cover and an abundance of evergreen forbs.

Although clearcutting creates early successional habitats preferred by deer during spring, the loss of old-growth forests on Annette Island will likely decrease the range carrying capacity for deer. Residents of Annette Island have reported decreasing harvests of deer over the past decade. The decline in deer numbers coincides with the commencement of large-scale logging on Annette Island, and with a series of severe winters during the late-1960's to mid-1970's. This study presents evidence that the elimination of preferred winter ranges by clearcut logging may be an important factor contributing to the decline of deer on Annette Island.

The major goal of forest management on Annette Island is to provide income and employment through logging and timber processing to the Metlakatla Indian Community. Another goal of forest management is retention of critical wildlife habitats (Pacific Rim Planners 1979). It is apparent from this investigation that in relation to management of deer, these goals of forest management are mutually exclusive.

Old-growth forest is an important component of deer winter range in both the northern and southern regions of Southeast Alaska. Therefore, measures should be taken to ensure that adequate areas of old-growth forest are retained where management for deer is a primary goal.

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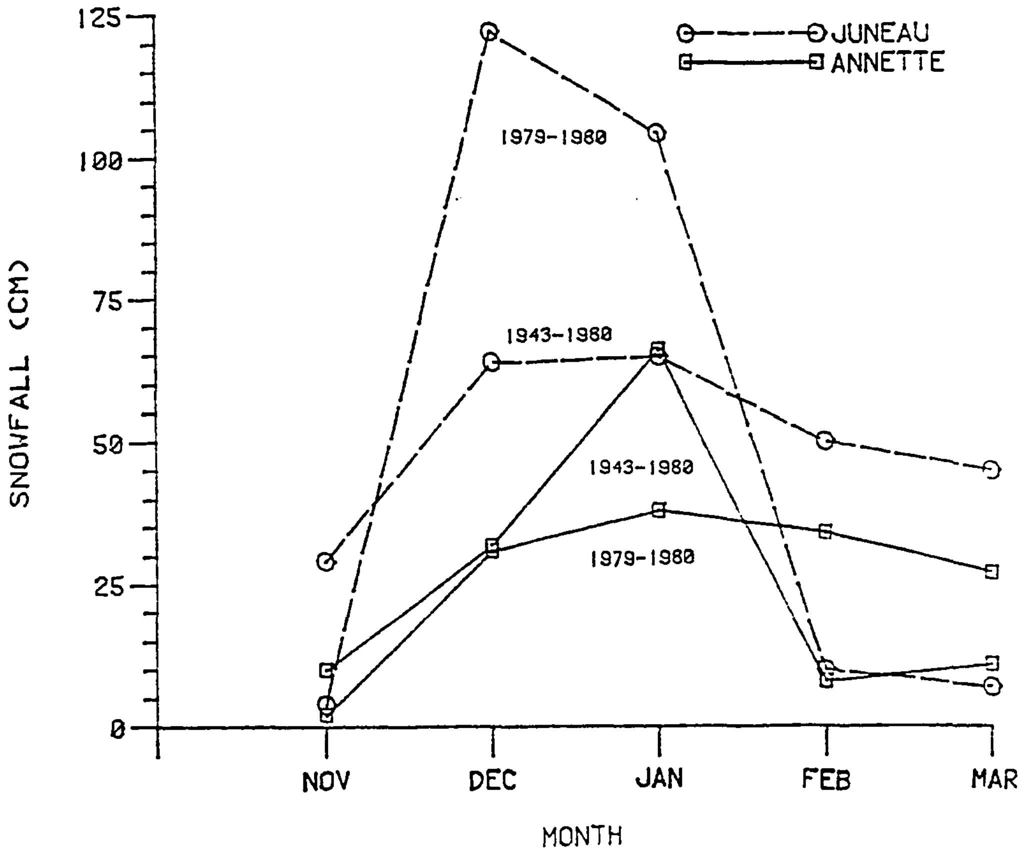
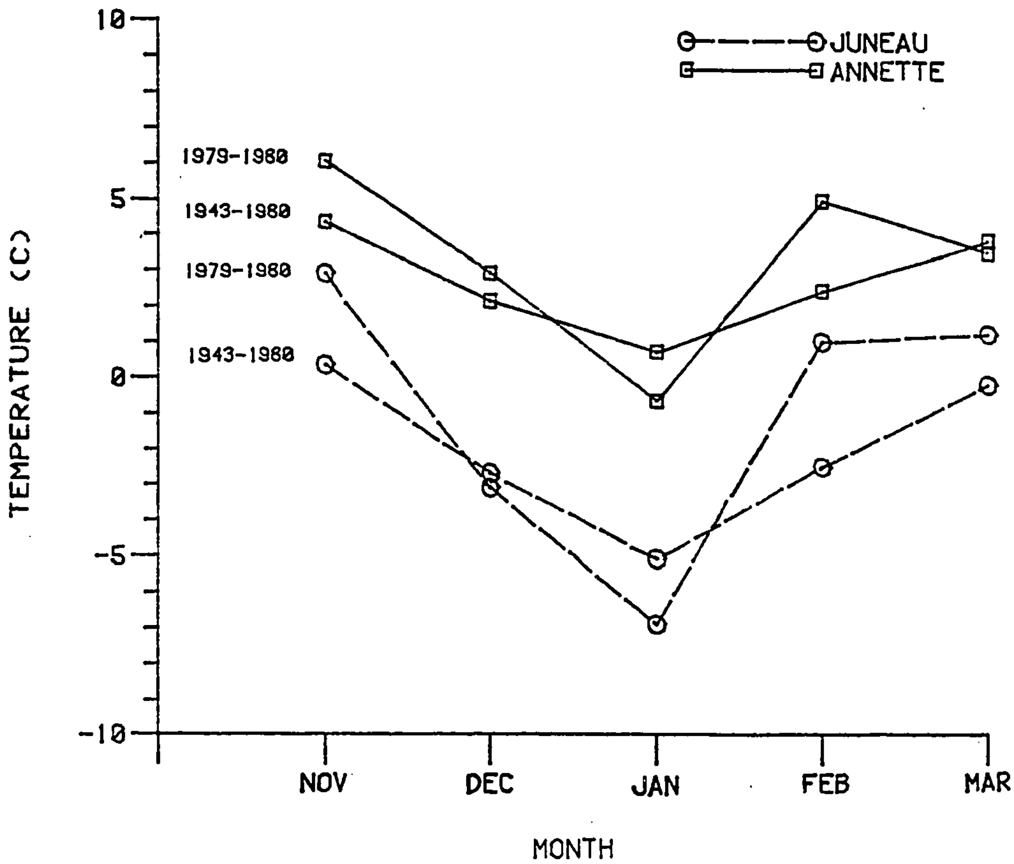
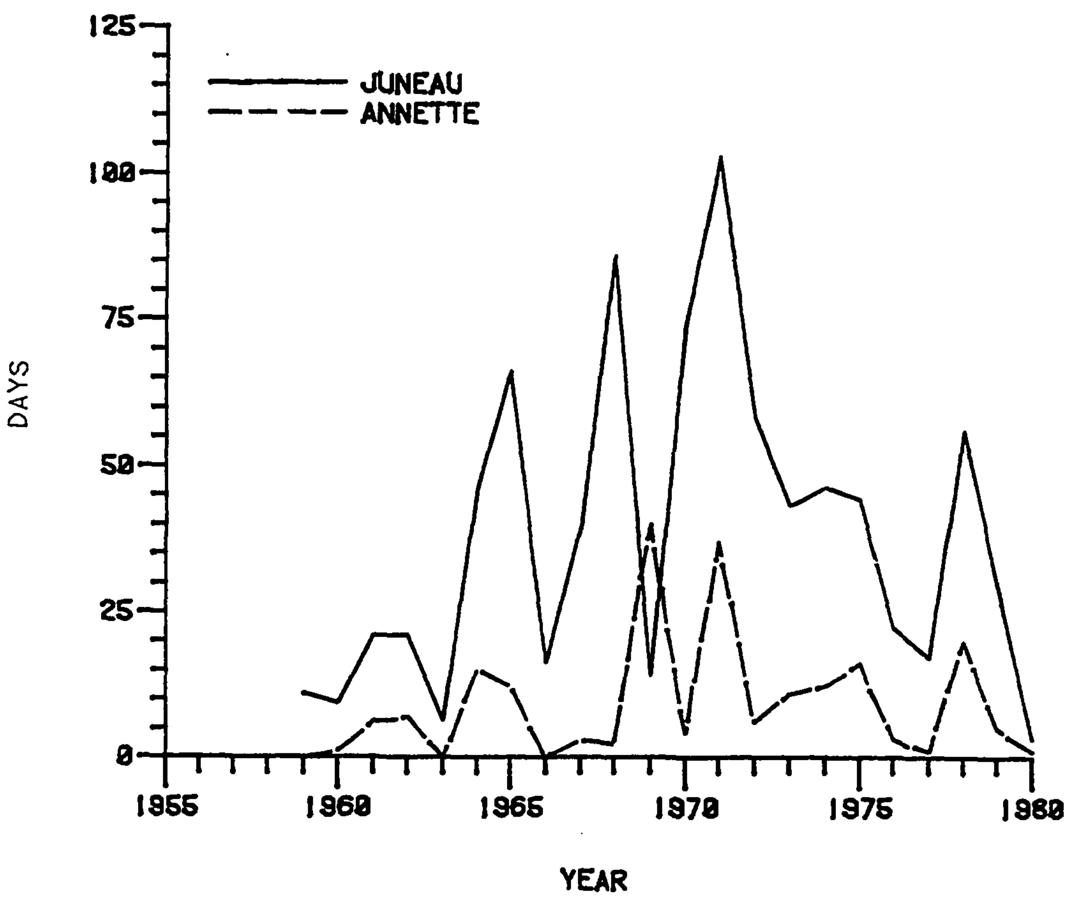


Appendix Ia. Comparison of monthly snowfall on Annette Island with Juneau during the periods 1943–1980 and 1979–1980.



Appendix Ib. Comparison of monthly winter temperatures on Annette Island with Juneau during the periods 1943–1980 and 1979–1980.



Appendix Ic. Comparison of winter snow depths (number of days annually with greater than 15 cm of snow on the ground) on Annette Island with Juneau during November through March 1959–1980.

Appendix IIa. (Continued)

Plots were checked each month from January through November 1980. At each interval, the number of visible pellets per plot and number of recognizable pellets groups were recorded.

Results

Of 960 pellets deposited on 25 plots in each of the forest and muskeg study sites, nearly 50% of the pellets had disappeared within 6 and 8 months, respectively (Appendix Ib), and most of the pellets were gone after 9 months. Pellet disappearance rates varied little between the dry and moist sites on each study area.

Of 24 pellet groups deposited in the forest, 79% were recognizable after 6 months (Appendix IIc). In comparison, 63% of the pellet groups were still present after 8 months. Pellet group persistence rates were similar in forest and muskeg habitats regardless of drainage conditions.

Conclusions

Pellet-group counts for measuring the habitat preferences of deer on Annette Island can be conducted for 6 to 8 months after deposition in forest and muskeg habitats, respectively. Disappearance rates of 25% in old-growth forest (at 6 months) and 35% in muskeg (at 8 months) can be expected.

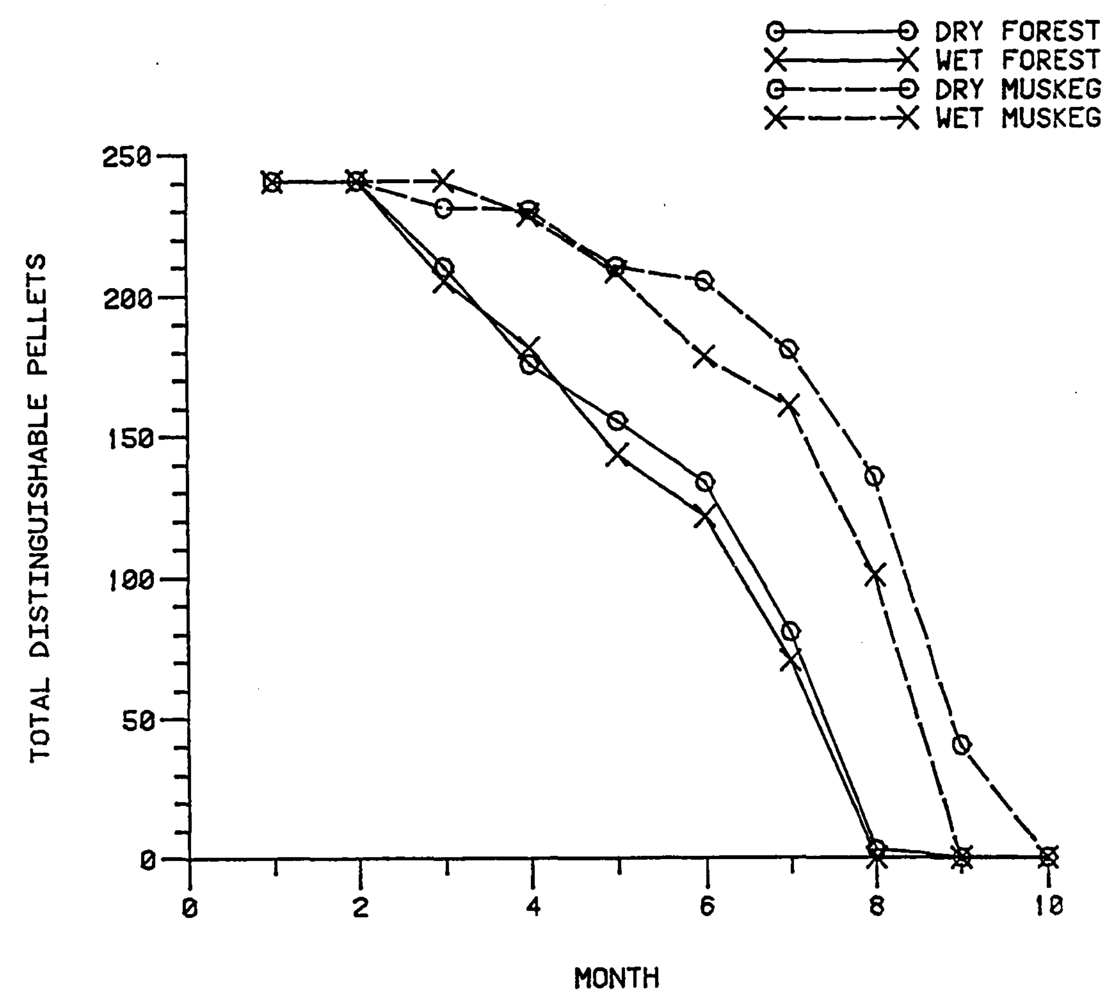
Appendix IIa. Winter Pellet-Group Disappearance Rates on Annette Island.

Introduction

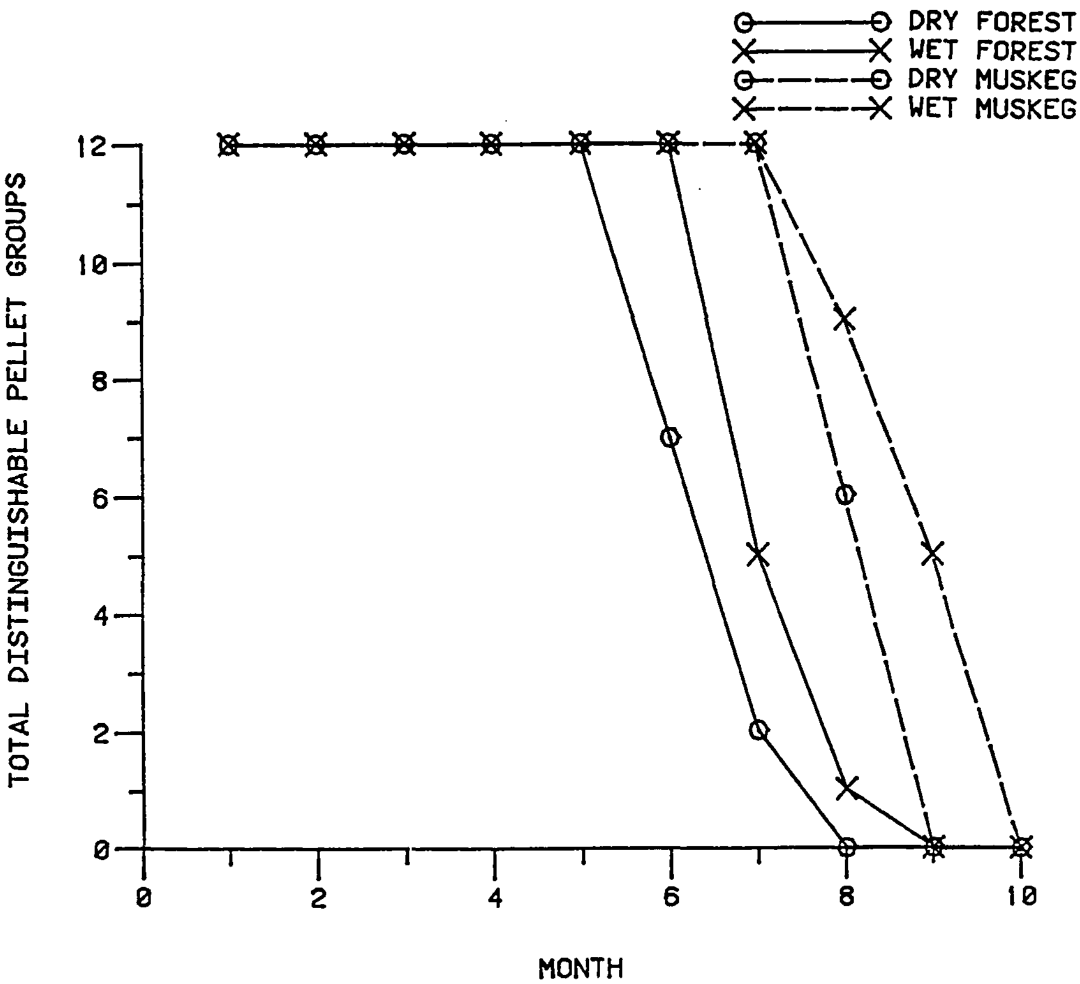
Successful use of the pellet-group count technique for assessing deer habitat preferences requires knowledge of the differential rates of pellet-group disappearance in various habitats. The purpose of this investigation was to measure pellet-group persistence in different habitats and to determine when pellet-groups should be counted in order to reflect the winter habitat preferences of deer on Annette Island.

Methods

During 1-7 January 1980, 48 fresh pellet groups were collected in the field and transferred to four study areas near Metlakatla on Annette Island. Twenty pellets were placed on each of 12 plots at each area. Pellets were uniformly arranged within permanently marked 30.5-cm diameter plots. Two forests and 2 muskeg sites were chosen to provide different exposure and moisture regimes for monitoring pellet-group persistence. One forest was located on a well-drained bottomland, within old-growth forests with 85-95% canopy cover. Muskeg sites included a dry sphagnum and a wet sedge ground cover type with less than 5% tree cover.



Appendix IIb. Disappearance rates of individual pellets in forest and muskeg habitats on Annette Island.



Appendix IIc. Disappearance rates of pellet groups in forest and muskeg habitats on Annette Island.

Appendix III. Understory plant species sampled in old-growth forests.

Common Name	Scientific Name
-Ferns-	
Deer Fern	*Blechnum spicant*
Sword Fern	*Polystichum munitum*
-Forbs-	
Queen's Cup	*Clintonia uniflora*
Goldthread	*Coptis aspleniifolia*
Bunchberry	*Cornus canadensis*
Deer Cabbage	*Fauria crista-galli*
Twyblade	*Listera cordata*
Skunk Cabbage	*Lysichiton americanum*
Deerberry	*Maianthemum dilatatum*
Single-delight	*Moneses uniflora*
Wintergreen	*Pyrola secunda*
Trailing Bramble	*Rubus pedatus*
Twisted-stalk	*Streptopus* spp.
Laceflower	*Tiarella trifoliata*
Starflower	*Trientalis europaea*
Violet	*Viola* spp.
-Shrubs-	
Salal	*Gaultheria shallon*
Devil's Club	*Oplopanax horridus*
Menziesia	*Menziesia ferruginea*

Appendix III. (Continued)

Common Name	Scientific Name
Salmonberry	*Rubus spectabilis*
Pacific Red Elder	*Sambucus racemosa*
Blueberry	*Vaccinium ovalifolium*
Huckleberry	*Vaccinium parvifolium*

Appendix IV. Seasonal variation in nitrogen and phosphorous content of deer forages collected in two low-elevation winter ranges on Annette Island.

Forage Species	Date	Nitrogen	Phosphorous
Cornus canadensis [a]	15 January	1.0	0.1
" "	15 April	2.9	0.3
" "	15 July	1.6	0.2
" "	15 September	1.8	0.2
Coptis aspleniifolia [a]	15 March	1.4	0.1
" "	15 July	5.3	0.1
Maianthemum dilatatum [b]	15 May	3.7	0.5
	15 July	1.7	0.2
	15 September	1.9	0.2
Rubus pedatus [a]	15 March	1.3	0.2
" "	15 April	2.1	0.2
" "	15 July	1.7	0.2
" "	15 September	1.8	0.2
Streptopus spp. [a]	15 May	3.6	0.5
" "	15 September	2.0	0.2
Tiarella trifoliata [a]	15 March	1.1	0.3
" "	15 April	2.0	0.3
" "	15 July	1.4	0.2
" "	15 September	2.0	0.2
Vaccinium ovalifolium [c]	15 February	1.3	0.2
" " [d]	15 May	1.9	0.2
" " [d]	15 July	1.9	0.1

Appendix IV. (Continued)

Forage Species	Date	Nitrogen	Phorphorous
Vaccinium ovalifolium [e]	15 July	1.2	0.1
" " [d]	15 September	1.3	0.1
Usnea barbata [a]	15 February	0.4	0.0
Gaultheria shallon [b]	15 March	0.8	0.1

[a] Sample includes entire above ground portion of plant.

[b] Sample includes leaves

[c] Sample includes terminal stems.

[d] Sample includes leaves and terminal stems.

[e] Sample collected from a clearcut 7 years old; sample includes leaves and terminal stema.

Appendix V. Seasonal variation in results of detergent analyses of deer forages collected in two low-elevation winter ranges on Annette Island. Detergent analyses were performed using Van Soest procedures (Van Soest and Wine 1967).

Forage Species	Date	T.N.C.[a]	D.M.[b]	N.D.F.[c]	A.D.F.[d]	Lignin	Cellu- lose	Ash
Cornus canadensis [e]	15 January	11.3	95.3	35.3	27.8	11.3	16.5	0.0
" "	15 April	4.6	95.9	26.2	23.2	3.8	17.8	1.5
" "	15 July	10.8	94.9	29.3	23.3	10.5	12.2	0.7
" "	15 September	3.6	95.6	50.2	34.2	16.2	17.9	0.0
Coptis aspleniifolia [e]	15 March	17.2	94.9	39.8	30.6	6.6	24.0	0.0
" "	15 July	11.7	95.8	39.5	30.1	5.6	24.4	0.0
Maianthemum dilatatum [f]	15 May	7.7	93.3	27.9	20.8	3.8	16.9	0.0
" "	15 July	15.2	94.7	37.8	22.4	8.7	13.6	0.1
" "	15 September	4.8	95.2	41.5	29.6	7.0	21.6	1.0
Rubus pedatus [e]	15 March	7.2	95.3	32.2	23.4	5.3	17.6	0.5
" "	15 April	5.3	95.0	33.0	23.2	3.9	18.3	1.0
" "	15 July	5.4	95.9	35.4	22.6	4.8	17.2	0.6
" "	15 September	2.2	95.4	38.5	26.4	6.0	20.4	0.0

Appendix V. (Continued)

Forage Species	Date	T.N.C.[a]	D.M.[b]	N.D.F.[c]	A.D.F.[d]	Lignin	Cellu-lose	Ash
Streptopus spp.[e]	15 May	4.8	93.9	32.0	27.0	2.1	23.1	1.7
" "	15 September	9.7	94.5	39.4	37.2	2.5	31.7	3.0
Tiarella trifoliata [e]	15 March	5.0	95.9	27.6	23.5	4.4	18.7	0.5
" "	15 April	13.5	95.3	28.6	23.4	4.7	18.1	0.6
" "	15 July	3.1	96.7	33.8	28.7	8.5	20.0	0.2
" "	15 September	3.1	94.9	37.2	28.1	7.0	23.0	0.4
Vaccinium ovalifolium [g]	15 February	---	94.8	61.2	48.7	15.8	33.0	0.0
" " [h]	15 May	6.1	97.4	59.5	44.4	13.2	31.2	0.0
" " [h]	15 July	7.7	97.0	58.5	40.1	14.6	25.4	0.0
" " [i]	15 July	13.9	97.1	46.6	31.4	11.6	19.8	0.0
" " [h]	15 September	6.4	97.2	64.4	44.3	15.4	29.0	0.1
Usnea barbata [e]	15 February	8.9	97.2	54.0	7.0	2.4	4.4	0.2
Gaultheria shallon [f]	15 March	8.1	96.0	39.7	32.5	8.8	23.7	0.0

Appendix V. (Continued)

[a] Total Nonstructural Carbohydrates

[b] Dry Matter

[c] Neutral Detergent Fiber

[d] Acid Detergent Fiber

[e] Sample includes entire above ground portion of plant.

[f] Sample includes leaves.

[g] Sample includes terminal stems.

[h] Sample includes leaves and terminal stems.

[i] Sample collected from a clearcut 7 years old; sample includes leaves and terminal stems .