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SEASONAL DISTRIBUTION AND HABITAT USE BY SITKA BLACK-TAILED DEER IN SOUTHEASTERN ALASKA

By
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Volume IV

Progress Report
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PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperators: Lars Holton and Thomas A. Hanley

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Period Covered: July 1, 1981 through June 30, 1982

SUMMARY

Deer pellet groups were counted on 115 0.4-ha study plots in Hawk Inlet, Admiralty Island during October 1981 and May 1982. Based on comparisons of pellet group densities and cleared and uncleared plots, pellet group surveys conducted in spring accurately represented deer use over the preceding 7½-month (winter) period. Pellet group surveys conducted in fall, however, did not accurately represent deer use for the preceding 4½-month (summer) period. Understory plant associations were tentatively identified using a cluster analysis. No significant relationships ($P < 0.05$) were observed between timber volume and pellet group density during either winter or summer.

During winter, track counts, snow depth measurements, and canopy closure estimates were made on 269 20-m plots along 2 transects on the west side of Hawk Inlet. Each transect followed a straight line from an elevation of 450 m to the beach. Snow depth and elevation were the best predictor of track counts, but elevation, timber canopy, volume, and spruce composition influenced snow depth.

Twenty-one deer were captured during this report period. A shoulder-held net gun fired from a helicopter was the most efficient technique utilized for capturing deer.

Six of 15 instrumented deer (40%) captured prior to December 1981 died during winter 1982. Mortality was confined entirely to males, representing 67% of the male sample. Only 1 of the 6 winter mortalities died within the range of transects used in spring beach mortality surveys.

The accuracy of aerial location telemetry and estimates of habitat variables were tested and found to be reasonably accurate.

Winter and summer home range fidelity of instrumented deer continued to be high.

Over 1,650 relocations of 39 instrumented deer have been recorded since November 1978. This report contrasts the habitat preference of deer during January through March of 1981 and 1982 (N = 198 relocations). During the mild winter of 1981, deer were more widely dispersed, using higher elevations farther from the beach, and occurring in lower volume timber stands than in the more rigorous winter of 1982. In 1982, instrumented deer preferred higher volume stands (>30 MBF/acre), between sea level and 305 m, and between 0.4 and 1.6 km from the beach.

Key words: distribution, habitat use, Sitka black-tailed deer, Southeastern Alaska.

CONTENTS

BACKGROUND

Background and justification for this study were outlined previously (Schoen et al. 1979).

OBJECTIVES

To develop capture and telemetry techniques for Sitka black-tailed deer (*Odocoileus hemionus sitkensis*), and evaluate seasonal distribution and preference within natural (unlogged) and modified (logged) habitats.

STUDY AREA

The study area has been described previously (Schoen 1978, Schoen et al. 1979).

Forest Habitat Study

Introduction:

The forest habitat study was initiated in 1979 to determine how deer respond to various old-growth forest types, and to identify specific features of old growth which are important for their overwinter survival. Having studied deer/forest relationships in several study areas and over varying winter regimes, we recognize that there are no simple answers to these questions. This progress report presents interim results of work conducted during fiscal year 1982 and contrasts these results with those presented in earlier progress reports (Schoen et al. 1981, 1982). With completion of spring 1982 fieldwork, the data collection phase of this study will be largely complete. Comprehensive data analysis and reporting will be undertaken in the coming year.

Procedures:

Pellet groups were counted in fall (October 1981) and spring (May 1982) on 115 0.4-ha (1-acre) study plots at Hawk Inlet and Youngs Bay on Admiralty Island. Extensive measurements of forest characteristics (topography, overstory, and understory vegetation) and initial pellet group sampling on these same study plots were completed during the previous spring and are reported in Schoen et al. 1982. No additional vegetative data were collected. Permanently marked pellet plots were established on 65 (57%) of the 0.4-ha plots, and all fecal pellets within the marked plots were removed during both spring (1981) and fall (1982) sampling.

Pellet groups were categorized as either old or new according to criteria established the previous spring (Schoen et al. 1981). "New" pellets were assumed to represent deer use during the 2 weeks prior to sampling when snow was not a significant factor in their habitat selection.

Results and Discussion:

The relative abundance of individual understory plant species on Hawk Inlet study plots was similar to that found in other study areas on Admiralty and Chichagof Islands in 1979 and 1980 (Schoen et al. 1981, 1982). In comparing mean frequency of occurrence data for individual species, the only notable deviation was in *Oplopanax* which occurred less frequently at Hawk Inlet (1981) than at the other study areas (4% vs. 12% and 11% frequency). This reflects the relatively small number of study plots located in riparian spruce stands at Hawk Inlet.

A cluster analysis (Hartigan 1979) was run on plant frequency data to identify groupings or clusters of plants which tend to occur together on the study plots. This analysis was limited to plant species which are readily identifiable in early spring soon after snow melts (including evergreen forbs, shrubs, and *Lysichiton americanum*). Results are shown in the form of a dendrogram (Fig. 1).

There were far fewer significant relationships between deer use and specific habitat characteristics during summer than during winter. Deer use in summer (total pellet counts in fall) was positively correlated with the percentage of high-risk trees in the stand and the percent occurrence of *Oplopanax* in the stand (Kendall Rank Correlation, $\underline{P} < 0.05$). Summer deer use was inversely related to the percentage of low-risk trees, the combined basal area of all sawtimber, and the net timber volume of the stand. In general, deer preferred open, low-volume stands of relatively low vigor.

Winter deer use ("old" pellets counted in spring) was positively correlated with the frequency of occurrence of *Oplopanax*, the mean diameter (DBH) of sawtimber trees in the stand, mean crown ratio (% of tree height supporting live, green foliage), and percentage of high-risk trees (Kendall Rank Correlation, $\underline{P} < 0.05$). Winter deer use was inversely correlated with the frequency of occurrence of *Listera*, frequency of occurrence of seedlings, and the percentage of low-risk trees in a stand (risk is a subjective classification inversely related to the vigor, or health, of a tree). Generally, in winter, deer preferred high- risk stands with dense, multi-layered canopies including trees of large diameter.

"New" pellets, which represent late spring use, were correlated more frequently with understory variables and less frequently with overstory variables. This reflects deer movements out of areas with high snow interception capacity and into areas of greater forage production. Deer use in spring was positively correlated with the percentage occurrence of *Coptis*, *Rubus*, *Cornus*, *Maianthemum*, and mean crown ratio. Spring deer use was inversely related to percentage occurrence of seedlings, *Moneses*, percentage of dead and down material, mean canopy cover, percentage hemlock, and timber volume (both net and gross).

There was no significant relationship (Kendall Rank Correlation, $\underline{P} < 0.05$) between either winter deer use ("old" pellets counted in spring) or summer deer use (all pellets counted in fall) and timber volume.

Vegetative and topographic characteristics of cleared and uncleared study plots were found to be very similar. Of 50 characteristics measured, including timber volume, defect, tree heights, diameters, tree species composition, percent occurrence of 15 understory species, mean stand slope, elevation, and others (see Schoen et al. 1981), only 4 variables (8%) showed significant differences between the 2 groups (Mann-Whitney U Test $\underline{P} < 0.05$). In addition, pellet group densities on cleared and uncleared plots were not significantly different on initial clearing.

Because pellets were first cleared from marked plots in spring 1981, those pellets found during the subsequent fall represent deer use through the 4½-month summer period. Pellets were again cleared in fall 1981, meaning that pellets found in the following spring were deposited during the intervening 7½-month winter period.

We found significantly more pellets on uncleared plots than on cleared plots following the 4½-month summer period (Mann-Whitney U Test, $P < 0.05$). This suggests that a certain percentage of pellets counted on uncleared plots were not deposited in summer but were left over from the previous winter's or spring's use. Following the longer winter period, however, the number of pellets on cleared and uncleared plots was not significantly different (Mann-Whitney U Test, $P < 0.05$). This indicates that most pellets counted in spring were deposited after October and therefore accurately reflect winter deer use.

Snow Relationships

Introduction:

The winter shift in deer distribution to lower elevations in Southeast Alaska has been attributed primarily to increased snow accumulation at higher elevation (Klein 1965). The movement to lower elevations in winter has been observed using radio-collared deer (Schoen et al. 1979, 1981), however, the extent of this movement to lower elevations remains quite variable among individuals. The reasons why some deer winter within 50 m of the beach and others spend much of the winter above 300 m elevation are not known. Habitat selection by deer is probably a function of snow depth and forage availability, which in turn may be influenced by elevation, exposure, slope, and structual characteristics of the forest canopy and associated understory vegetation. The purpose of this study was to 1) compare the elevational distribution of deer as measured by track counts with the distribution of telemetered deer; 2) relate the distribution to snow depth, topography, and vegetative characteristics; and 3) explore the relationships between snow depth and characteristics of the forest overstory. Additional snow depth data collected during 1981 and 1982 are included in Appendix A.

Procedures:

Two separate line transects were established on the west side of Hawk Inlet running from 460 m elevation down to the shoreline. Sampling (on 3 March 1982) followed several snowless days, ensuring that tracks would be both numerous and visible. Field crews of 2 were transported to the upper transects by helicopter and walked straight-line courses down the slope, trailing a 20 m poly line to mark each transect.

Snow depth measurements were taken at arm's length on alternate sides of the line by plunging a pointed, calibrated stick through the snow to solid ground. Measurements were made every 2.5 m along each 20 m segment of the transect and averaged to reflect snow depth over that 20 m. At the mid-point of each 20 m segment, habitat variables associated with a 0.03 ha circular area (10 m radius) centered on that point were measured or estimated. These variables included elevation (m), slope (°), estimated percentage spruce composition (≤5, 6-15, 16-30, 31-50, 51-75, >75), estimated percent canopy cover (≤5, 6-25, 26-50, 51-75, 76-95), and estimated timber volume (<8, 8-20, 20-30, 30-50, >50 MBF/acre). Deer tracks crossing the transect line within each 20 m segment line were counted. Where it was obvious that tracks crossing the line several times were made by a single deer, only 1 set was counted. Tracks were rarely so concentrated that the numbers of individual trails crossing the transect could not be easily distinguished.

Results and Discussion:

Habitat variables were measured on 269 20-m segments distributed between the 2 transects. Eighty-eight sets of tracks were counted on 52 (19%) of the 20-m segments. Mean elevation of the tracks was 172 ± 143 m ($\bar{x}$ ± SD). The mean elevation of 17 radio-collared deer surveyed at Hawk Inlet the day before was 132 ± 135 m ($\bar{x}$ ± SD), and was not different (Mann-Whitney U Test, $P < 0.05$) than the elevational distribution of deer as indicated by track counts. This suggests that track counts may offer an alternative to radio telemetry as a means of determining winter distribution of deer. Track counts may prove particularly useful in situations where distribution information on total populations (resident and migratory) is needed for relatively small, site-specific areas.

A stepwise multiple regression analysis was used to select the habitat variables which best explained the distribution of track counts along the transects. The single best predictor of track counts was elevation, which displayed a significant, inverse relationship to track abundance. The next best predictor was percentage spruce composition, followed by mean snow depth, and then slope, all of which were inversely related to track abundance (Table 1). The inverse relationship between track counts and percentage spruce composition is similar to the relationship reported between percent spruce and pellet group density (Schoen et al. 1981, 1982) and is presumably related to the snow interception capability and understory assemblage associated with the high spruce type. Elevation and slope, both of which were inversely related to track densities in this study, were <u>positively</u> correlated with pellet group densities in earlier work (Schoen et al. 1981, 1982). The reason for this appears to be that pellet group work was restricted to lower elevation winter range (0-150 m), while the track surveys covered a much wider elevational range (0-460 m).

Interestingly, 2 factors, elevation and percentage spruce composition, were better predictors of deer distribution than mean snow depth which intuitively should exert primary control over deer distribution. One explanation may involve differential snowpack characteristics at different elevations or in different forest types and their attendant effect on deer locomotion and distribution. When the analysis was restricted to commercial quality forested sites (volume >8 MBF/acre) which occur primarily at lower elevations, snow depth became the best predictor of track density, followed by elevation, percentage spruce composition, and slope (Table 2).

We expect structural characteristics of the forest canopy to exert significant influence on the depth, quality, and duration of the snow pack on the forest floor. Stepwise multiple regression analysis indicates that elevation provides the best explanation for variation in snow depth, followed by percent canopy cover, volume class, and finally percent spruce composition (Table 3). As expected, snow depth decreases at lower elevations and in stands with high canopy closure.

The relationships of snow depth to timber volume and spruce composition are weak, yet significant (Table 3). Given 2 old-growth stands with comparable elevation and canopy, the higher volume stand with taller trees and larger limb structure should intercept more snow. In high spruce stands (>50% composition), individual trees may intercept snow, but the stand as a whole may average higher snow depth than hemlock stands because of the single-layered canopy and widely spaced trees. Other studies (Schoen et al. 1981, 1982) have indicated that even if snow were not a factor, the understory plant assemblage associated with high-composition spruce stands may not be desirable to deer. In general, we consider that deer forage availability, in winters with average-to-above-average snow accumulation, is highest in low-elevation, high-volume, hemlock stands or hemlock-spruce stands.

Telemetry Study

Introduction:

The telemetry study is designed to assess seasonal distribution and home range characteristics of instrumented deer as well as to define seasonal habitat use and preference. Additionally, deer capture and telemetry techniques are being developed and/or improved as this study proceeds.

Telemetry data, in combination with forest and pellet group sampling, will provide the framework for developing a conceptual model of the seasonal habitat requirements of Sitka black-tailed deer in Southeast Alaska.

Procedures:

Procedures have been previously described (Schoen et al. 1979, 1981) except as follows.

Capture Techniques.

During late summer 1981, deer were captured in the alpine using a shoulder-held net gun (Mountain Helicopters, Greymouth, New Zealand) fired from an Allouette helicopter. This technique required precision low-level flying with the gunner firing out an open door. When located in an open area, deer were rapidly approached from above, followed within 3-5 m distance, and the shot executed. Once the net entangled the animal, the gunner and assistant were immediately landed at the site to contain the animal before it could escape. Deer were then blindfolded and processed without the use of drugs or tranquilizers and quickly released.

Field Testing Accuracy of Telemetry Locations and Estimates of Habitat Variables.

To estimate the accuracy of our telemetry techniques, we verified our aerial locations with ground truthing. During spring 1982, ground crews carrying telemetry transmitters visited 9 permanent forest plots in Hawk Inlet. Measurement data for the variables of elevation (m), slope (°), spruce composition (%), and timber volume (MBF/acre), as well as ground estimates of overstory canopy cover (%) had been recorded previously (Schoen et al. 1982). An aircraft with 4 observers located each of the 9 sites by standard telemetry techniques (Schoen et al. 1979). Once a location was determined, aircraft personnel requested the ground crew to raise a helium balloon located at the center of the forest study plot. The error between the aerial location and actual transmitter location was estimated followed by estimates of the elevation, slope, canopy cover, spruce composition, and timber volume for that site.

Habitat Preference.

To evaluate habitat preference, it was necessary to determine the availability of specific habitat variables. Habitat availability relative to elevation, slope, distance to the beach, and aspect was determined from 2,495 points systematically located over a grid of USGS 1:63,000 scale topographic map of the study area. Habitat type and timber variables were recorded in the same manner from USFS timber type maps. Habitat preference was expressed using Ivlev's (1961) Electivity Coefficient, $E = \frac{r_i - p_i}{r_i + p_i}$ where E equals the coefficient of electivity or preference index, r_i equals the proportion of the variable which was utilized and P_i equals the proportion of the variable occurring within the environment or study area. Negative values represent avoidance; positive values represent preference.

Results and Discussion:

Capture Results.

Twenty-one deer were captured during this report period (Table-4). Netting deer in the alpine from a helicopter has been the most successful and efficient technique attempted. Thirteen deer were captured in less than 4 man-days' effort. Sixty-two percent of our shots hit deer, and 54% of those hit resulted in successful captures. Eleven deer escaped after being hit with the net because we were unable to immediately constrain them. Mechanical difficulties with the net gun itself reduced our efficiency in several instances. Nevertheless, this technique has the potential for capturing large numbers of deer during late summer when they are in the alpine.

Darting deer from a skiff is the 2nd most efficient technique for capturing Sitka black-tails. This procedure is most effective during winter when deer are concentrated near the beach. Optimal conditions include a flooding mid to high tide, little or no wind, snow depth in the forest >15 cm, and sunlight on the beach. The greatest limitation to this technique is the high mortality due to relatively poor condition of deer on the beach and the high stress during capture. Of the 6 deer captured on the beach during winter 1982, 4 died within 10 days. This problem becomes more acute as winter advances and the severity of the weather increases. From November 1978 to date, a total of 53 deer have been captured by various techniques (Table 5).

Winter Mortality.

Winter 1982 was more severe than prior winters during this investigation. Total snow accumulation was 49 cm in 1981 and 272 cm in 1982. Snow was on the ground from the 1st week of January until early May, greatly reducing the availability of herb layer evergreen forage to deer. Of 15 radio-instrumented deer captured prior to October 1981, 6 (40%) died (Table 6) during the subsequent winter. Mortality was confined entirely to males, making up 67% of the male sample. Seven deer were captured on the beach between 31 January and 2 February. Only 2 of these (both females) survived the winter. All winter-captured deer died at sea level within approximately 5 m of the beach. In comparison, 5 of 6 winter mortalities of deer captured prior to winter occured in areas above 20 m elevation and greater than 100 m from the beach. Spring beach mortality transects conducted in the Hawk Inlet area yielded 3.4 dead deer/1 km of beach; according to Loyal Johnson (pers. commun.), this was the highest mortality recorded in the Tongass Forest during 1982. In this area, telemetry data indicate beach mortality transects provide only a relative index of winter mortality since 83% of our instrumented sample died beyond beach count areas.

Accuracy of Telemetry Locations.

The mean error of 9 aerial telemetry location trials conducted in forest habitat was 24 ± 11 m. No significant difference (P < 0.05, Wilcoxon Match Pairs Test) was observed between air estimates and ground measurements for the variables of elevation, slope, canopy, spruce composition, or timber volume for any of the 4 observers. Mean deviations of observer estimates of these variables were calculated (Table 7). Accuracy of estimates was strongly related to experience. Percent composition of spruce was consistently underestimated and showed the largest degree of error. Timber volume was slightly and consistently overestimated (average = 7.5 MBF/acre). Schoen, the primary observer, had the closest estimates to measured values. Seventy-eight percent of his volume estimates were classified correctly into 5 categories. Relative to the 3 broad categories of noncommercial, low-volume, and high-volume commercial forest (0-8, 8-30, 30+ MBF/acre), he classified 89% correctly. These estimates were considered within acceptable limits.

Home Range Fidelity.

Telemetry relocations of instrumented deer continued to support the hypothesis of strong summer and winter home range fidelity (Table 8). Fifteen deer have used the overlapping winter ranges in at least 2 consecutive years. Four of these deer have used the overlapping range for 3 or more years. Summer range fidelity followed a similar pattern.

Habitat Preference.

Since November 1978, we have accumulated over 1,650 relocations from 52 instrumented deer. In this report, we contrast the winters (January through March) of 1981 and 1982. The mean monthly temperatures (°C), January through March, were 3.1, 0.4, and 4.1 during 1981, and -10.1, -5.9 and -0.1 during 1982. Total snow accumulation during this same period was 49 cm in 1981 and 272 cm in 1982.

During both winters 1981 and 1982, over 98% of instrumented deer relocations ($\underline{N}$ = 198) occurred in old-growth forest habitat. This general habitat type makes up approximately 67% of the study area. Other habitats represented include subalpine, alpine, deciduous brush, muskeg, rock, and second-growth forests. During this period of the year, deer prefer and almost exclusively utilize old-growth forest habitat.

The mean elevation of instrumented deer locations was 203 ± 163 m ($\bar{x}$ ± SD) in 1981 and 132 ± 116 m during 1982. The downward shift in 1982 reflected increased snow accumulation that year. Habitat selection relative to elevational categories was similar during both years (Table 9). Deer preferred elevations below 300 m (1,000 ft) and avoided higher elevations.

The mean slope of deer relocation during winters 1981 and 1982 was 18° and 12°, respectively. Selectivity relative to slope class is presented in Table 10. Slopes between 0° and 10° were preferred, while no significant selectivity was demonstrated for slopes between 11° and 20° during both 1981 and 1982. In 1981, substantial use of 21° to 30° slopes occurred, but no significant preference or avoidance was displayed. In 1982, however, slopes greater than 20° were avoided. The difference reflects the lower elevational distribution of deer in 1982.

During both winters, deer avoided northerly exposures (NW-N-NE) (Table 11). Southerly exposures (SW-S-SE) were preferred in 1981 and 1982. East and west exposures were preferred in 1981 and avoided in 1982. During winter, we would expect southerly exposed slopes to receive more deer use than northerly slopes which receive less solar insolation when other variables are equal. Some of the differences between these 2 years may be attributed to the fact that 13 new deer were captured and monitored in 1982. Because an individual deer's home range may be located entirely within a northerly (or southerly, westerly, etc.) exposed drainage, these deer would likely remain there regardless of winter conditions.

During the mild winter of 1981, our sample of instrumented deer avoided areas within 0.4 km (0.25 mi) of the beach (Table 12). During the next winter, which had greater snow accumulation, 37% of the deer locations occurred within 0.4 km of the beach. Although more use occurred closer to the beach in 1982, this zone was not significantly selected ($\underline{P} < 0.05$) by deer in either winter. During both years, the zone between 0.4 and 1.6 km (1 mi) from the beach was preferred, while areas beyond 1.6 km were avoided.

Winter deer use occurred almost entirely in old-growth forest. We know, however, that old growth is highly variable (Schoen et al. 1981, 1982). A relationship has been observed between winter deer distribution and the timber volume in old-growth stands (Schoen et al., 1982, Leopold and Barrett 1972, Barrett 1979). Comparative winter deer use relative to volume class was strikingly different between the mild winter of 1981 and the more rigorous winter of 1982 (Table 13). In 1981, the 8-20 MBF/acre class received 23% of our sample deer use, with use occurring nearly in proportion to availability. In contrast, during 1982, deer significantly avoided ($\underline{P} < 0.05$) this volume class which received only 6% of the deer use. During 1981, the 20-30 MBF/acre class was preferred and also received the heaviest use. In 1982, use of this class was in proportion to availability. The 30-50 MBF/acre class received preferential use both years relative to availability. However, in 1982, this class received the highest use (57%) of any class. The 50 MBF class was not used during 1981 but in 1982 was highly preferred. Although non-commercial forest (<8 MBF/acre) was avoided both years, it was utilized 4 times more than during the heavy snow year of 1982.

Based on telemetry locations, deer exhibit a strong preference for high-volume, old-growth stands during winters of high snow accumulation. We believe that high, broad-canopied, old-growth stands (high volume) intercept more snow than low canopy, smaller diameter old-growth stands (low volume), other things remaining equal. These results support our preliminary findings based on pellet group counts (Schoen et al. 1981, 1982) as well as those of Bloom (1978) and Barrett (1979). It is interesting, however, that the pellet group data (collected in 1982 and reported herein) do not conform to the pattern identified in the telemetry study. A closer look at deer distribution during winter 1981-82 helps explain this apparent contradiction. Prior to the 1st snow (3 January , 1982), deer were widely dispersed and utilized a variety of forest communities, including low-volume sites. From January through March, most deer use (64%) was in high-volume (<30 MBF/acre) stands (Table 11). After March, deer began to disperse and utilize a greater variety of sites, including low volume sites. From our pellet group data, new and spring pellet groups were most abundant in low-volume (<30 MBF/acre) sites. These data indicate that during the 7-month pellet deposition period, there was a shift by deer from low to high and back to low-volume sites. Thus, overall pellet groups densities, which are an average of use over 7 months, do not reflect preference over short time intervals (e.g., January, February, March). This emphasizes the importance of time-specific telemetry information in identifying habitat preference.

CONCLUSIONS

A shoulder-held net gun fired from a helicopter is the most efficient technique tested thus far for capturing large numbers of deer in Southeast Alaska. A major limitation of this technique is that it can only be used effectively in open alpine/ subalpine habitats and thus restricts sampling to the migratory portion of the population.

Deer pellet groups deposited in October and counted in early May accurately reflect winter deer use during that 7-month period. Summer deer use determined over a 4-month period, however, overestimates use during this period since some pellets persist from winter.

Snow depth and elevation were identified as the best predictor of deer track counts, but elevation, timber canopy, volume, and spruce composition also control snow depth. More research needs to be undertaken on these important relationships.

Winter 1982 mortality of instrumented deer indicated that a large percentage (>80%) of deer died beyond range of the transects surveyed during spring beach mortality surveys. Future research should be directed at developing improved monitoring programs for winter deer mortality.

Aerial location telemetry of deer and estimates of habitat variables are reasonably accurate techniques which can be efficiently applied in Southeast Alaska.

Results of telemetry studies continue to support the conclusion that old growth is optimal winter deer habitat. Telemetry is a much more effective technique than pellet group counts for identifying changes in deer distribution during winter. Habitat preference changes as environmental conditions, such as snow accumulation, vary. We perceive serious difficulties in attempting to specifically characterize and identify "critical" winter deer habitat. The forest is a mosaic, and deer preference for elements of this mosaic varies between winters, as well as within a winter as conditions change. Additionally, habitat availability during other seasons can also influence winter survival. Deer-forest relationships in Southeast Alaska and their implications for management are presented in Appendix B.

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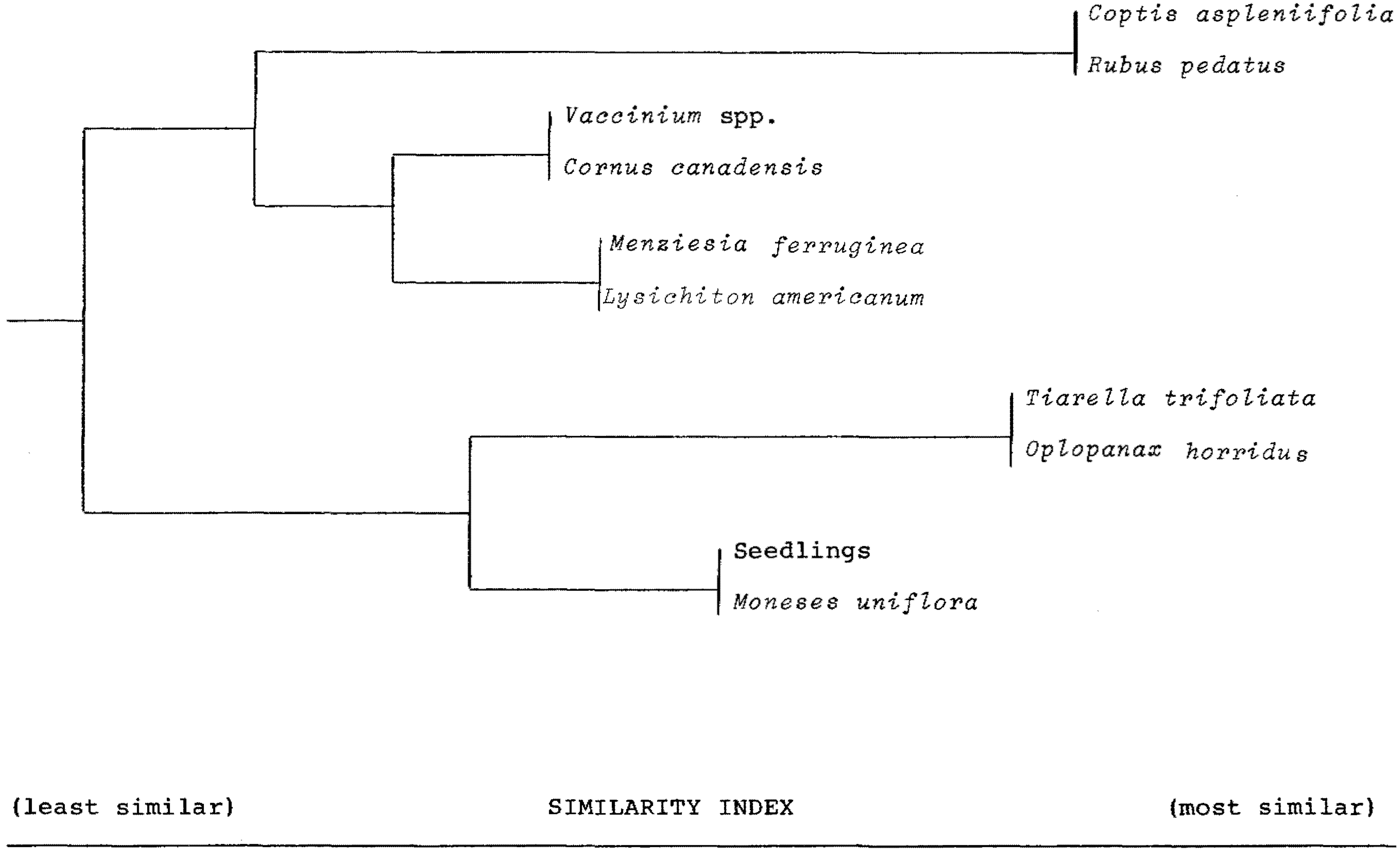

Figure 1. Dendrogram showing understory plant species associations among 115 stands at Hawk Inlet and Admiralty Island.

Table 1. Multiple regression analysis showing the relationship between track counts and habitat characteristics measured at Hawk Inlet, 4 March 1982.

ANALYSIS OF VARIANCE

		DF	Mean square
$r^2 = 0.35$	Regression	4	33.5
	Residual	264	0.94

Variable	r^2 change	Beta
Elevation	0.21	-0.392*
% spruce	0.05	-0.302*
Snow depth	0.05	-0.300*
Slope	0.04	-0.209*

* Significant at 0.00.

Table 2. Multiple regression analysis showing the relationship between track counts and habitat characteristics measured on commercial quality old-growth forest, Hawk Inlet, 4 March 1982.

ANALYSIS OF VARIANCE

		DF	Mean square
$r^2 = 0.38$	Regression	4	33.1[a]
	Residual	205	1.1

Variable	r^2 change	Beta
Snow depth	0.22	-0.366*
Elevation	0.07	-0.336*
% spruce	0.05	-0.244*
Slope	0.04	-0.202*

* Significant at 0.00.

Table 3. Multiple regression analysis showing the relationship between snow depth and habitat characteristics measured on commercial quality old-growth forest, Hawk Inlet, 4 March 1982.

ANALYSIS OF VARIANCE

		DF	Mean square
$r^2 = 0.32$	Regression	4	2197.2*
	Residual	205	90.1

Variable	r^2 change	Beta
Elevation	0.18	-0.391*
% canopy	0.11	-0.282*
Volume class	0.02	-0.187*
% spruce	0.01	-0.145**

* Significant at 0.00.

** Significant at 0.02.

Table 4. Summary of black-tailed deer capture results, August 1981 to March 1982.

Method	Man-days	Shots	Hits	Misses	Captures
Helicopter netting in alpine	4	39	24	15	13
Darting deer on beach from skiff	6	--	6	--	6
Miscellaneous techniques					2

Table 5. Summary and status of captured deer as of June 1982.

Capture date	Study site	Deer No.	Age	Sex	Status
11-2-78	Winning Cove	6	1	F	Not located since summer 1981
11-7-78	Winning Cove	20	2+	M	Spring 1980 mortality
11-8-78	Winning Cove	80	1	M	Not located since summer 1981
1-3-79	Winning Cove	33	<1	M	Winter 1979 mortality
1-3-79	Winning Cove	90	2+	M	Hunter kill 11-80
1-4-79	Winning Cove	70	<1	F	Not located since summer 1981
1-18-79	Winning Cove	89	<1	M	Winter 1979 mortality
2-14-79	Winning Cove	13	2+	M	Winter 1982 mortality
2-14-79	Winning Cove	51	2+	M	Never located
2-14-79	Winning Cove	46	2+	F	Winter 1979 mortality
2-16-79	Winning Cove	29	1	M	Not instrumented, hunter kill 10-81
2-21-79	Hawk Inlet	24	1	M	Found dead 2 weeks later
2-22-79	Hawk Inlet	5	2+	M	Spring 1980 mortality
2-22-79	Hawk Inlet	74	2+	F	Not located since 11-81
2-22-79	Hawk Inlet	25	2+	M	Not located since 6-81
2-23-79	Hawk Inlet	17	2+	M	Hunter kill 12-80
2-23-79	Hawk Inlet	3	2+	M	Spring 1980 mortality
2-23-79	Hawk Inlet	18	1	F	Radio functional
2-24-79	Hawk Inlet	43	2+	F	Winter 1980 mortality
2-24-79	Hawk Inlet	16	1	F	Not located since 1979
3-6-79	Winning Cove	61	2+	F	Not located since summer 1981
1-8-80	Winning Cove	8	1	F	Summer 1980 mortality
1-22-80	Hawk Inlet	12	2+	M	Radio functional
1-22-80	Hawk Inlet	19	<1	M	Dead 2 weeks later
1-24-80	Hawk Inlet	41	2+	F	Dead 2 weeks later
1-24-80	Hawk Inlet	42	2+	F	Fall 1981 mortality
4-16-80	Bug Island	1	2+	F	Spring 1980 mortality
4-16-80	Bug Island	2	2+	F	Not located since 10-80
8-26-80	Hawk Inlet	66	2	M	Winter 1982 mortality
9-11-80	Young Bay	69	1	M	Not located since 3-81
9-11-80	Young Bay	15	1	M	Radio functional
12-31-80	Hawk Inlet	35	2+	F	Spring 1981 mortality
8-17-81	Hawk Inlet	87	1	M	Spring 1982 mortality
8-17-81	Hawk Inlet	57	2	M	Winter 1982 mortality

Table 5. Continued.

Capture date	Study site	Deer No.	Age	Sex	Status
8-17-81	Hawk Inlet	63	2+	M	Spring 1982 mortality
8-18-81	Hawk Inlet	51	1	F	Radio functional
8-18-81	Hawk Inlet	47	1	F	Radio functional
8-18-81	Hawk Inlet	11	2+	M	Winter 1982 mortality
8-18-81	Hawk Inlet	56	2	M	Fall 1981 mortality
8-18-81	Hawk Inlet	59	2+	F	Not located since fall 1981
8-18-81	Hawk Inlet	55	1	F	Radio functional
8-18-81	Hawk Inlet	14	2+	F	Radio functional
8-18-81	Hawk Inlet	77	2+	M	Spring 1982 mortality
9-1-81	Hawk Inlet	28	1	F	Radio Functional
9-1-81	Hawk Inlet	71	1	M	Radio functional
9-2-81	Hawk Inlet	27	2+	F	Dead 10 days later
1-31-82	Hawk Inlet	60	1	F	Radio functional
1-31-82	Hawk Inlet	99	<1	M	Winter 1982 mortality
1-31-82	Hawk Inlet	75	1	F	Dead 10 days later
1-31-82	Hawk Inlet	28a	1	M	Died 1 day later
1-31-82	Hawk Inlet	73	2+	M	Died 1 day later
2-2-82	Hawk Inlet	98	2+	F	Radio functional
2-2-82	Hawk Inlet	28b	2+	M	Died several days later

Table 6. Summary of 1981 winter mortality of radio-instrumented deer at Hawk Inlet.

Deer No.	Sex	Age (estimate)	Date of mortality (approximate)	Estimated elevation (m)	Estimated distance from beach (m)
57	M	2	3-2-82	122	400
11	M	2+	3-23-82	61	400
66	M	3	4-5-82	183	400
63	M	2+	4-7-82	46	800
87	M	1	5-4-82	8	90
77	M	2+	5-15-82	23	200
15	M	2	Survived winter		
18	F	4	Survived winter		
14	F	2+	Survived winter		
12	M	2+	Survived winter		
55	F	1	Survived winter		
28	F	1	Survived winter		
47	F	1	Survived winter		
51	F	1	Survived winter		
71	M	1	Survived winter		
59[1]	F	1	Survived winter		
98[1]	F	2+	Survived winter		
28a[1]	M	1	2-1-82	0	<5
28b[1]	M	2+	2-2-82	0	<5
73[1]	M	2+	2-1-82	0	<5
99[1]	M	<1	2-14-82	0	<5
75[1]	F	1	2-10-82	0	<5

[1] Captured end of January 1982.

Table 7. Average difference between aerial estimates and actual ground measurements of selected babitat variables.

Aerial observer[a]	Elevation (m)	Slope (°)	Canopy (%)	Spruce (%)	Timber volume (MBF/acre)
Schoen	13[b]	4	9	14	6
Holton	--	5	12	13	7
Fisch	--	6	13	24	9
Beier	--	7	12	19	8

[a] Listed in order of experience.

[b] Only 1 estimate made based on aircraft altimeter.

Table 8. Winter and summer home range fidelity of instrumented deer, 1979-82.[a]

Deer No.	Age at capture	Sex	Winter Range overlap: N years	Summer Range overlap: N years	Resident/ Migratory
6	1	F	2:3	3:3	M
20	2+	M	2:2		M
80	1	M	2:3	3:3	M
90	2+	M	2:2	2:2	M
70	<1	F	3:3	3:3	R
5	2+	M	2:2		M
74	2+	F	3:3	3:3	R
25	2+	M	2:3	2:2	M
3	2+	M	2:2	4:4	M
18	1	F	4:4	4:4	M
61	2+	F	3:3	3:3	R
12	2+	M	3:3	3:3	R
42	2+	F	2:2	2:2	M
66	2	M	2:2	2:2	M
15	1	M	2:2	3:3	M
51	1	F	--	2:2	M
47	1	F	--	2:2	M
55	1	F	--	2:2	M
14	2+	F	--	2:2	M
71	1	M	--	2:2	M
28	1	F	--	2:2	M

[a] Fidelity to home ranges was determined if there were overlapping seasonal home ranges between years.

Table 9. Habitat preference relative to elevation for radio-instrumented deer, January-March 1981 and 1982.

Elevation (m)	Habitat availability (%)	Deer use (% relocations) 1981 (*N* = 87)	1982 (*N* = 111)	Preference index[a] 1981[b]	1982[b]
0-150	30	48	69	+0.23*	+0.39*
150-300	14	35	23	+0.43*	+0.24*
300-450	15	7	8	-0.36*	-0.30*
>450	41	10	0	-0.61*	-1.0*

[a] Ivlev (1961) Electivity Coefficient.

[b] Significant (* $P < 0.05$) selection or avoidance determined by analysis of residuals (Everitt 1977).

Table 10. Habitat preference relative to slope for radio-instrumented deer, January-March 1981 and 1982.

Slope (°)	Habitat availability (%)	Deer use (% relocations) 1981 (N = 87)	Deer use (% relocations) 1982 (N = 111)	Preference index[a] 1981[b]	Preference index[a] 1982[b]
0-10	24	36	56	+0.20*	+0.40*
11-20	39	31	37	-0.11NS	-0.03NS
21-30	26	23	7	-0.06NS	-0.58*
31+	11	10	0	-0.05NS	-1.0*

a Ivlev (1961) Electivity Coefficient.

b Significant (* P < 0.05) selection or avoidance determined by analysis of residuals (Everitt 1977); NS = Not Significant.

Table 11. Habitat preference relative to aspect for radio-instrumented deer, January-March 1981 and 1982.

Slope aspect	Habitat availability (%)	Deer use (% relocations) 1981 (N = 87)	1982 (N = 111)	Preference index[a] 1981	1982
NW-N-NE	39	18	25	-0.37	-0.22
SW-S-SE	29	30	50	+0.02	+0.27
E-W	32	52	25	+0.24	-0.12

[a] Ivlev (1961) Electivity Coefficient.

Table 12. Habitat preference relative to distance from beach for radio-instrumented deer, January-March 1981 and 1982.

Distance from beach (km)	Habitat availability (%)	Deer use (% relocations) 1981 (N = 87)	1982 (N = 111)	Preference index[a] 1981[b]	1982[b]
<0.4	37	20	37	-0.30*	0NS
0.4-1.6	24	72	49	+0.50*	+0.34*
>1.6	39	8	14	-0.66*	-0.47*

[a] Ivlev (1961) Electivity Coefficient.

[b] Significant (* $P < 0.05$) selection or avoidance determined by analysis of residuals (Everitt 1977); NS = Not Significant.

Table 13. Habitat preference relative to timber volume for radio-instrumented deer, January-March 1981 and 1982.

Timber volume (MBF/acre)	Habitat availability (%)	Deer use (% relocations) 1981 (N = 87)	Deer use (% relocations) 1982 (N = 111)	Preference index[a] 1981[b]	Preference index[a] 1982[b]
<8	43	8	2	-0.69*	-0.91*
8-20	20	23	6	+0.07NS	-0.54*
20-30	25	43	28	+0.26*	+0.01NS
30-50	11	26	57	+0.41*	+0.68*
50+	1	0	7	-1.0NS	+0.75*

[a] Ivlev (1961) Electivity Coefficient.

[b] Significant (* $P < 0.05$) selection or avoidance determined by analysis of residuals (Everitt 1977); NS = Not Significant.

APPENDIX A. Summary statistics for snow measurements recorded near Juneau, Alaska, 1981-82.

Date	Site	Elevation (m)	Habitat type[a]	Mean snow depth (cm)	Standard deviation	Coefficient of variation	Range	Sample plots
2-17-81	Lemon Creek (Juneau)	5	Meadow	25.0	5.0	20	20-32	4
		15	Clearcut	21.3	9.2	43	0-35	36
		20	Second growth	8.9	3.6	40	5-21	24
		20	Second growth (thinned)	9.1	5.4	59	2-23	28
		20	Old growth (>25 MBF/acre)	5.6	5.9	106	0-20	19
		20	Old growth (>25 MBF/acre)	6.3	3.5	56	0-12	36
		5	Old growth (<20 MBF/acre)	10.9	5.6	52	1-28	36
1-17-82	Mendenhall Pen. (Juneau)	0	Meadow	45.5	4.9	10.8	29-58	50
		25	Old growth (>25 MBF/acre)	24.3	8.0	32.8	6-48	50
1-30-82	Hawk Inlet Admiralty Island,	0	Upper beach	54.0	6.2	11.4	46-60	10
	outer coast	5	Old growth (>25 MBF/acre)	23.5	7.7	32.8	12-35	10
	Greens Creek	0	Meadow	58.5	4.5	7.7	50-67	20
		5	Old growth (>25 MBF/acre)	23.5	9.9	42.1	4-47	26

APPENDIX A. Continued.

Date	Site	Elevation (m)	Habitat type[a]	Mean snow depth (cm)	Standard deviation	Coefficient of variation	Range	Sample plots
2-28-82	Mendenhall Pen. (Juneau)	0	Meadow	65.5	4.1	6.2	60-74	12
		10	Old growth (20-30 MBF/acre)	30.5	8.2	27.8	18-46	12
		60	Old growth (20-30 MBF/acre)	54.6	11.6	21.2	25-76	24
		65	Old growth (<8 MBF/acre)	78.2	17.5	22.4	46-102	24

[a] Timber volumes estimated.

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SITKA BLACK-TAILED DEER - OLD-GROWTH FOREST RELATIONSHIPS IN SOUTHEAST ALASKA: IMPLICATIONS FOR MANAGEMENT

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Abstract: Population levels of Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) are expected to decline as timber harvest of old-growth forests in southeast Alaska proceeds. The extent of this decline will vary in accordance with the quantity and quality of old-growth acres harvested. Old growth in southeast Alaska is likened to a fine-grained mosaic of habitat patches that deer utilize selectively - seasonally, and annually. Impacts of harvesting of certain timber stands on long range deer carrying capacity, and on other wildlife in southeast Alaska will be difficult to assess until wildlife old-growth habitat relationships are better understood. This paper reviews deer forest relationships in southeast Alaska, and outlines current forest management practices. Two approaches for allocation of old growth as deer habitat are compared: (1) allocation-by-stand, and (2) allocation-by-watershed. We conclude that allocation-by-watershed is the more appropriate management approach in southeast Alaska.

Key Words: *Odocoileus hemionus sitkensis*, old growth, southeast Alaska.

INTRODUCTION

Abundance and distribution of Sitka black-tailed deer (Odocoileus hemionus sitkensis) in southeast Alaska will be strongly influenced by future forest management. Commercial-quality forest lands within the Tongass National Forest dominate the land base of southeast Alaska and still exist predominantly as old growth. Approximately 142,450 ha of old growth have already been harvested, and with passage of the Alaska National Interest Lands Conservation Act in 1980, Congress mandated a future harvest of 2.4 million m^3 (450 million board ft.) per year, or about 7,000 ha each year.

On multiple-use forest lands, certain stands will be allocated to timber production while others will be designated for retention to help meet wildlife habitat needs. We consider this concept an "allocation-by-stand" approach to forest wildlife management. Given our knowledge on deer-old growth relationships, and our lack of knowledge for other species' habitat needs, this approach may not optimally meet the habitat needs of deer and other wildlife on these lands. This paper reviews deer-forest relationships, discusses current forest management practices, and evaluates an alternative approach for allocation of old growth as deer habitat in southeast Alaska.

DEER-FOREST RELATIONSHIPS

Old-growth forests (in sensu Bormann and Likens 1979, Franklin et al. 1981) in southeast Alaska are steady-state forests where mortality generally balances growth, and individual trees range in age from seedlings to a thousand years. Variable tree diameter and height produce a broken, multilayered canopy. An abundant and variable understory, snags, and woody debris on the forest floor, contribute to the structural heterogeneity of the old-growth forest. Variable soil conditions, topography, drainage patterns, understory composition, and frequency and degree of prior disturbance (e.g. wind) can dramatically alter the character of the forest. Size of affected areas is variable with small patches contributing to the fine-grained variability of old growth. A forest patch is defined here as a small (0.5-5 ha) portion of a stand. A patch has relatively homogeneous understory and overstory characteristics. Numerous patches make up larger (2-50 ha) stands identified by a generally homogeneous overstory. The time required for a forest stand to develop old-growth characteristics in the Pacific Northwest and Alaska ranges from 200 to 300 years (Harris and Farr 1974, Alaback 1981, Franklin et al. 1981). A variety of quality and size of forest stands, muskeg, alpine, rock, and ice make up a watershed.

In winter, deer in southeast Alaska prefer old growth over earlier stages of forest succession (Wallmo and Schoen 1980, Schoen et al. 1981, Kirchhoff et al. in press, Rose these proceedings). This occurs because the old-growth overstory provides both snow interception and understory development. More winter forage is available than in earlier seral stages. Similar findings have been reported for Columbian black-tailed deer (O. h. columbianus) on portions of Vancouver Island (Jones 1975, Weger 1977, Harestad 1979, Hebert 1979) and for northwest white-tailed deer (O. virginianus ochrourus) in the northern Rockies (Mundinger these proceedings).

Old growth is variable in structure, and, depending on the season, suitability as deer habitat. Deer prefer specific understory associations as indicated by distribution of use (Barrett 1979, Schoen et al. 1981) and composition of diet (Schoen et al. 1982). Availability of understory species is influenced by stand age, and structure, (Barrett 1979, Wallmo and Schoen 1980, Schoen et al. 1981, Alaback 1981), and snow accumulation (Bloom 1978, Schoen and Kirchhoff unpublished data). High-volume old-growth stands appear most suitable for deer during winters of heavy snow accumulation. Data from Barrett (unpublished), Schoen et al. (1981) and Schoen and Kirchhoff (1983) suggest that, old-growth stands exceeding 396 m^3 per ha receive greater use in winters with average to high snow accumulation than do lower volume stands.

Survival of deer through winter is dependent principally on their condition upon entering winter, energy intake of forage, and energy expended. Although deer normally draw on stored energy during winter, a prolonged and excessive intake deficit results in death or reduced productivity. Winter energy requirements of deer on northern Vancouver Island are best met in old-growth forests (Harestad et al. 1982). The same appears true in Alaska by inference as well as from a theoretical review of deer bioenergetics (Hanley et al. in review). The greater the expanse of suitable old-growth habitat, the greater is the opportunity for winter concentrated deer to obtain sufficient energy.

In summer, Sitka black-tails are dispersed from sea level to alpine. Their foraging strategy in summer functions to maximize intake of succulent, nutrient- and energy-rich forage to regain lost weight, resume body growth, nurse fawns, achieve good reproductive health, and store fat for the following winter. Old-growth forest and nonforest lands contribute to this potential, as do recent (< 20 years) clearcuts. In even-age regrowth stands (> 20-30 years), however, forage is substantially reduced below old-growth levels

(Harris and Farr 1979, Wallmo and Schoen 1980, Alaback 1981). These stands contribute little toward deer carrying capacity at any time of the year for the remainder of the rotation. On the basis of existing knowledge, there is little reason to expect that silvicultural techniques such as thinning, as currently practiced, will significantly improve this situation (Kessler 1982).

FOREST MANAGEMENT

All timber management in southeast Alaska is based on even-aged silviculture with a 90- to 125-year rotation. Of 2.3 million hectares of commercial quality forest land on the National Forest in southeast Alaska, only 0.7 million hectares (31%) is scheduled for clearcutting over the next 100 years. However, it is important to consider the types of forest that those old-growth hectares represent. Commercial forest land (> 106 m^3/ha) is classified into 4 volume classes (Fig. 1). The highest class (> 659 m^3/ha) makes up less than 2% of the commercial forest land, 1% of the total forest area, and 0.6% of the total land area of the Tongass National Forest (USDA Forest Service 1978). This relatively rare forest class, which is important to wintering deer, has received the greatest harvest pressure. Economic considerations dictate that the higher volume classes (> 396 m^3/ha) will continue to receive proportionately greater harvest than the lower volume classes.

Approximately 72,000 ha of forest were clearcut between 1956 and 1972. Average volume cut was approximately 659 m^3 per ha (from Hutchison and LaBau 1975). Projected harvest will remove 66% of today's high volume stands (> 659 m^3/ha over the next 100 years. On lands designated for multiple use the loss will be 72%. Relative to conditions prior to industrial-scale logging (circa 1950), the loss, forest-wide, will approach 80% (USDA Forest Service and ADF&G, unpublished data).

This trend will have serious consequences for deer. If, for example, approximately 30% of the operable forest is harvested during the first entry into a watershed, and that harvest is concentrated in the higher volume timber stands, up to 90% of the most important deer winter range (during heavy snow years) may be lost. The habitat loss will be cumulative over successive entries. These impacts will be permanent because old growth is nonrenewable on a 100-year rotation.

Two basic approaches toward resolution of the old-growth allocation issue have been advocated. The U.S. Forest Service, through its Tongass Land Management Planning (TLMP) process, has approached the problem by allocating stands within any given watershed or value comparison unit (VCU) to timber production or old-growth retention (Phillips 1982). In contrast, the Alaska Department of Fish and Game, through its Forest Habitat Integrity Plan (FHIP), has advocated the allocation of entire watersheds or VCUs, rather than individual stands, to either timber production or old-growth retention (Matthews and McKnight 1982).

These 2 forest management strategies are different and their advantages and disadvantages need to be compared. Our discussion is restricted to black-tailed deer, but the concepts may apply to other wildlife species. For this discussion, we refer to the TLMP process as "allocation by stand" and the FHIP process as "allocation by watershed (or VCU)."

The existing inventory base and habitat use relationships are not adequate to quantitatively predict the consequences to wildlife of altering the forest landscape. Forest managers require this knowledge in order to plan the spatial and temporal cutting patterns in a way that would have predictable consequences on wildlife populations. "Old-growth forest" is too broad a category of habitat to allow effective forest planning for the Sitka black-tailed deer because old growth is highly variable and deer preferences for specific old-growth associations vary with winter conditions. Bioenergetic theory (Hanley et al. in review) and preliminary data (Schoen et al. 1982, Schoen and Kirchhoff 1983) suggest that a variety of forest stands on the winter range is critical to deer carrying capacity.

Managing a landscape to provide variety is the objective of the allocation by stand approach for old-growth retention. However, unless inventory data are adequate, and habitat use relationships sufficient to manage for habitat variety, such an approach is taken at relatively high risk of eliminating an adequate habitat mosaic. In this sense, allocation by watershed is more conservative and less dependent on inventory data and knowledge of habitat relationships. Its principal assumption is that entire watersheds, left intact, will support current deer populations indefinitely.

The propriety of one allocation system over the other is analogous to a marginal yield problem (Fig. 2). The question is: "How will the deer carrying capacity of a watershed respond to allocation of increasing proportions of land to timber production?" If the response is linear, then the choice between allocation by stand versus allocation by watershed is insignificant. If the relationship is curvilinear, however, the choice is important, and the degree of importance is directly related to the shape of the curve. If medium to high levels of deer are the objective, then the choice of allocation is more important than if low levels are acceptable. If the relationship is convex (B), allocation by stand is the most appropriate system because some portion of the watershed can be allocated to timber production with negligible effects on deer. The optimal allocation level is at point b of the curve where a small increase in harvest results in a disproportionately larger decrease in deer carrying capacity. If, however, the relationship is concave (C), the optimal proportion allocated to timber production is either 0 or 100% (since even a small harvest would result in a large decline in deer carrying capacity), and allocation by watershed is the most appropriate system. The interaction of many factors determines the shape of the curve for any given watershed and logging system. Two such factors are the degree of dependence of deer on specific forest stands or communities and the probable cutting sequence in the watershed. For example, if deer are highly dependent on the availability of low-elevation, high-volume (e.g., > 396 m^3/ha) old-growth stands during winters with heavy snow accumulation, and if these stands are the first to be harvested in the watershed, then the yield curve will be steeply concave, and allocation by watershed is the most appropriate system. If, however, deer are not dependent on low-elevation, high-volume old growth, or if timber harvest begins with high-elevation and/or low-volume old growth, the yield curve is convex, and allocation by stand is appropriate. As used above, deer "dependence" on particular forest stands is the relative importance of those stands in determining the carrying capacity of a landscape for deer. The relative importance of different stands may vary with changing winter conditions, but the limiting nature of the landscape, in a long-term sense, is determined by the most severe conditions and the rate of population increase during recovery from severe conditions.

Because all forest stands are not of equal value as deer habitat, the characteristics of retained areas are critical when allocated by stand; size and spatial location being very important. If widely scattered, these areas might represent "islands" of optimal habitat in a "sea" of marginal habitat. During a winter of deep snow, for example, a clearcut might be a physical barrier to deer dispersal. Muskegs, non-commercial forest, and low volume forest stands may pose similar problems. Although second-growth stands do not pose a physical barrier, they are avoided by deer because forage is minimal. Some high quality "islands" of habitat, if surrounded by unusable habitat, may receive heavy pressure every year and overuse of these areas might result. Consequently, when deer need them most, their forage resources would already be depleted. An additional factor to consider is the potential for concentrating predation on a few small areas of high quality habitat. This situation may, in fact, be occuring on Vancouver Island (Hebert, B.C. Fish and Wildlife Branch, personal communication 4-12-82) and Annette Island (Rose, Annette Natural Resource Center, personal communication 4-5-82) where logging has concentrated deer onto remaining old growth areas easily accessible by wolves.

Because reserves of optimal habitat surrounded by altered, suboptimal habitat resemble a system of islands, certain principles of island biogeography may apply (MacArthur and Wilson 1967, Diamond 1975, MacClintock et al. 1977). Diamond (1975) notes that for the purposes of maintaining the maximum number of species in equilibrium, habitat reserves are better if they are bigger and closer together. Small, disjunct patches of high quality wildlife habitat, surrounded by low quality habitat may be of relatively little value to wildlife.

Permanency of retention is an important management consideration because old growth in southeast Alaska is nonrenewable under current management. Permanency is subject to administrative changes in land allocation as well as natural disturbance. Additional old-growth harvest is relatively easy once a watershed has been entered and roaded. As old-growth stands become smaller and more isolated, they also become more susceptable to windthrow that further reduces their size.

In the short term, it would probably be more cost efficient to allocate old growth by stand if all multiple-use watersheds were entered and the best timber taken first. Initially under this strategy fewer acres would be cut since a greater number of high-volume stands would be harvested. Additionally, the visible impact would be less apparent under allocation by stand, at least for the initial portion of the rotation period.

Under allocation by watershed, entire areas would essentially become unavailable to old-growth-dependent wildlife. Additionally, if those drainages were harvested in a single entry, it might take 1 or more rotations to reintroduce a stand mosaic of varying ages. Thus, it would be preferred ecologically to harvest those drainages designated for intensive forestry in multiple entries.

RESEARCH AND MANAGEMENT IMPLICATIONS

In southeast Alaska, deer and timber production cannot be maximized simultaneously on the same area. Even moderate timber harvesting can have adverse effects on deer in a greater proportion than the area harvested if that harvest occurs on certain forest stands. Our ability to prescribe the habitat mix necessary for maintaining an optimal balance between acres of deer habitat retained and acres of timber harvested within any given watershed, is currently inadequate.

The Forest Habitat Integrity Plan (FHIP) proposed by Matthews and McKnight (1982) would provide for deer, on watersheds selected for retention, the natural mix of habitats that contribute to their year-round welfare. The FHIP approach can also ensure protection of those watersheds most important to the production of anadromous fish. It has the additional advantage of protecting natural ecosystems for the potential benefit of species whose habitat requirements are still unknown.

Meanwhile, the information necessary to determine whether or not we are approaching our goals of deer (or more generally wildlife) management, depends upon realistic inventories of wildlife populations and habitat resources. Such inventory programs should be initiated and expanded. Hopefully, we will some day be better able to relate landscape mosaics to carrying capacity of wildlife, and provide multiple-use land managers with better guidelines. Continuing research will be necessary to accomplish that goal. A rigorous ecological and economic assessment of the feasability of enhancing second growth for wildlife is also an important research need. If second-growth enhancement proves feasible, watersheds committed to intensive forestry might be manipulated to provide some benefits that are currently unavailable. However, this possibility must be demonstrated rather than assumed.

Because of the critical nature of this resource allocation issue, a coordinated management and research effort to monitor the results of alternative old-growth allocation should be considered. Wildlife and other resources within 3 adjacent, and similar, watersheds could be monitored. The short and long term results of allocations by stand within 1 watershed could then be compared to the net results of allocation by watershed in the other 2. However, such a program would require a major commitment by numerous agencies and/or universities since final conclusions would require that monitoring be continued throughout an entire rotation (100 years). In the interim, harvest of old growth will proceed on multiple use forest lands.

Whatever approach is taken to maintain deer and other fish and wildlife habitat on the Tongass National Forest, major trade-offs are inevitable if the proposed level of nonrenewable old-growth habitat is extracted from the forest. The challenge will be in developing an allocation plan which will minimize the long term trade-offs as well as provide an opportunity to increase our understanding of deer and other wildlife habitat requirements before all multiple-use watersheds have been permanently altered.

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Figure 1. Number of hectares of commercial forest land (CFL) in each of four volume classes on the Tongass National Forest in southeast Alaska. (Volume classes in M^3/ha: 1=106-264, 2=264-396, 3=396-659, 4=659+)

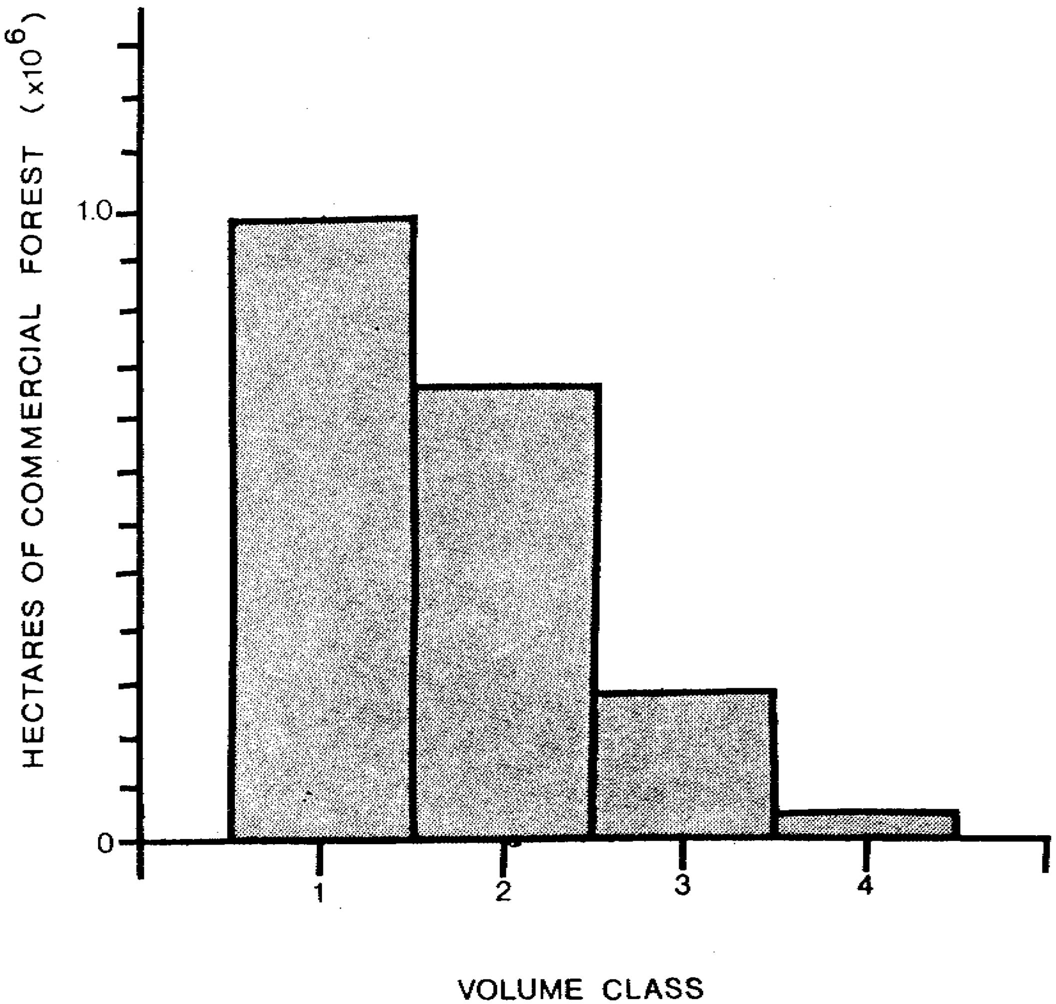
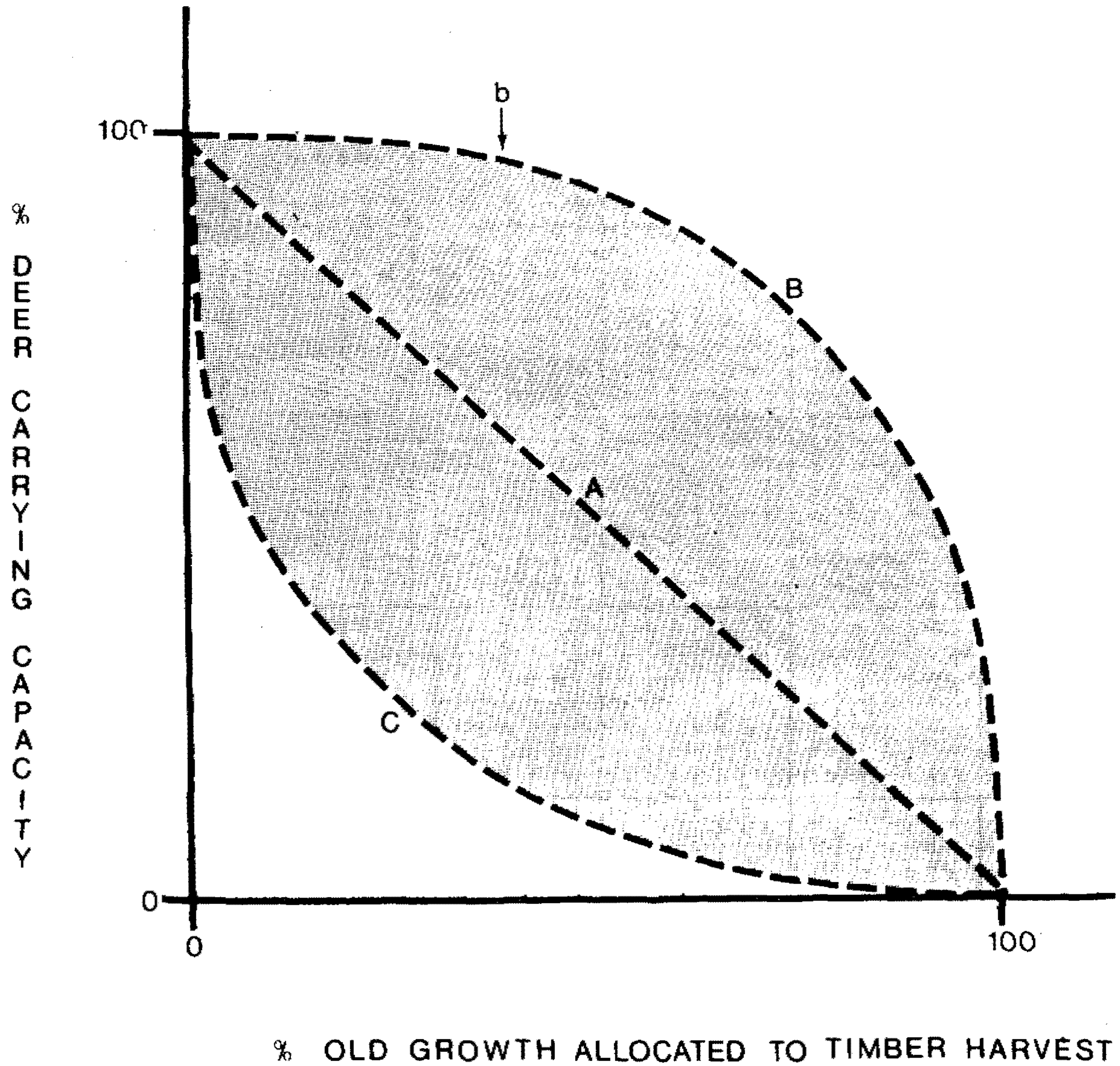

HECTARES OF COMMERCIAL FOREST (x10^6)
1.0
0
1
2
3
4
VOLUME CLASS

Figure 2. A marginal yield model displaying possible responses of deer to timber harvesting (from Hanley, in review). If the response is linear (line A), then the choice between allocation-by-stand or allocation-by-watershed is insignificant. If the relationship is convex (line B), then allocation-by-stand is most appropriate since some harvest can occur (to point b) with minimal effects on deer. If, however, the relationship is concave (line C) the optimal proportion allocated to timber production is either 0% or 100% and allocation-by-watershed is most appropriate.



b
100
B
A
C
0
0
100
% DEER CARRYING CAPACITY
% OLD GROWTH ALLOCATED TO TIMBER HARVEST