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EVALUATIONS OF METHODS FOR ASSESSING DEER POPULATION TRENDS IN SOUTHEAST ALASKA

by
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SUMMARY

In August 1986, 13 deer (7 males, 6 females) were transplanted to Portland Island; i.e., an isolated 40-ha forested island near Juneau that had been uninhabited by deer prior to the transplant. Males were given vasectomies to ensure that the population would not increase, and all animals were radio-collared with mortality-sensing transmitters so the number of deer-days spent on the island was known. When pellet-groups were surveyed on the island 264 days after the release, 4 deer remained on the island, three of the original 13 deer had died, and six had swam to nearby islands. From time of release to the time pellet-groups were surveyed, a total of 1,573 deer days were accumulated, representing an average population density of 15 deer/km^2 (40 deer/mi^2).

Pellet-groups were counted using standardized techniques on 381 1- x 20-m plots systematically placed across the island. After 264 days pellet-group density on the island was 495 pellet-groups/ha (95% CI = 435-560). Extrapolated to the island area, total pellet-group count was 19,800 groups (95% CI = 17,400-22,400). The total pellet-group count was divided by deer days use to yield a defecation rate of 12.6 pellet-groups/deer/day (95% CI = 11.1-14.2). This value is in close agreement with deer defecation rates reported in the literature.

A pellet-group persistence period of 11 months was determined by monitoring 12 known-age pellet-groups deposited within days of the deer's release. This value is higher than persistence periods reported in other studies in Southeast Alaska. Assuming a constant defecation rate (12.6 groups/deer/day), a constant population density (15 deer/km^2), and a persistence period of 11 months, the expected pellet-group density at 11 months was 594 groups/ha (95% CI = 522-672). Each pellet-group counted on a standard 1- x 20-m plot represented use by 12 deer/km^2 (95% CI = 10.7-13.8).

Analysis of the percentage of cover data for herb-layer vegetation on Portland Island prior to the transplant indicated a total biomass of herbs of 62.9 kg/ha. Analysis of basal stem diameters for shrub-layer species indicate a total biomass of shrubs of 1753.7 kg/ha. Both values are relatively high for old growth in Southeast Alaska. In May 1987, 188 randomly marked plants *(Vaccinium* spp.) were revisited and checked for evidence of browsing. Browsing was evident on 43 (22.8%) of the marked plants. Although the frequency of browsing was high, the intensity was low. Only 4.1 stems were browsed per plant, and the terminal stem diameter of browsed stems averaged 1.01 mm. To be useful as an index of deer density, browse surveys must incorporate measures of available biomass as well as percentage of utilization.

To develop relationships between plant dimensions and total biomass, 33 *Vaccinium* plants on Portland Island were collected, separated into stem and leaf components, and oven-dried. Although relationships between basal stem diameter and total biomass of *V. Ovalifolium, V. parvifolium,* and *Vaccinium* spp. exhibit high r^2 values (> 0.90), they differ from those reported for other Southeast Alaska sites. For purposes of determining the amount of browse available to deer, site-specific regressions should be developed.

Accuracy of the pellet-group count technique was evaluated on routine Department surveys during the spring of 1987. Without advance notice, selected sample plots in different habitats were "checked" for missed groups after the initial count had been reported. Of 107 plots checked, initial counts averaged 3.16 groups and second counts averaged 4.00 groups (21% error). Because check plots were nonrandom, this experiment likely overstated the true error associated with the technique. Pellet-group counts should be corrected for missed groups to compute population size; corrections are not necessary for determining relative deer numbers or population trend.

The percentage of error varied significantly ($\underline{P}$ < 0.05) among volume classes and plant association overstory types. Accuracy was relatively high (10-15% error) in noncommercial forest, mixed conifer, and lodgepole pine (*Pinus contorta*) stands. Accuracy was low (33-48% error) in high-volume Sitka spruce (*Picea sitchensis*) and hemlock (*Tsuga heterophylla*) stands. Greater accuracy in open-canopy habitats is attributed to higher light levels, making pellet-groups more visible. Habitat-related bias should be quantified in studies where pellet-group comparisons on unproductive and productive (or open-canopy and closed-canopy) sites are intended.

The percentage of error for each of 4 individuals on the crew (two were experienced and two were inexperienced) was compared on 67 plots. Inexperienced counters missed significantly more groups (34%) than experienced counters (15%) ($\underline{P}$ < 0.05). Observer bias can be minimized by switching counting duties between crew members every 5 plots. As long as the collective experience of the 6 or more people sampling various areas does not change greatly over time, the effects of observer error on precision of the pellet-group means will be small.

The objectives, assumptions, and methods used in the Department's pellet-group monitoring program from 1981 to 1987 were evaluated by Kirchhoff and Pitcher (1988), who determined that (1) pellet-group surveys as currently conducted are adequate for assessing relative population trends of deer at the watershed level; (2) comparisons of relative pellet-group densities among watersheds are valid, assuming habitat characteristics and environmental conditions are generally similar; (3) because of habitat-specific differences in defecation rates, persistence times, and observability, pellet-group data may not accurately reflect habitat preference or importance; and (4) pellet-group densities should only be extrapolated to deer densities in cases where the winter range is well defined and can be adequately sampled (e.g., on small, low-relief islands). The methodology used in the current sampling program was judged to be appropriate given the objectives.

The relationship between the annual deer harvest, hunter success (%), deer/hunter day, and pellet-group density was investigated on Gravina, Shelter, and Lincoln Islands and the Sitka area. Pellet-group densities were measured using standard techniques applied to a single watershed within the larger hunt area. All hunt statistics were significantly correlated ($\underline{P} < 0.01$) with pellet-group densities for the 3 areas combined; the deer/hunter-day statistic showed the strongest relationship ($\underline{r} = 0.61$). Within individual areas, however, none of the hunt statistics were significantly correlated with pellet-group densities. A number of factors other than the size of deer populations influence hunter success. Pellet-group data appear to offer a more reliable and accurate estimate of deer density.

Key Words: black-tailed deer, browse, hunters, *Odocoileus hemionus sitkensis*, old growth, pellet-groups, population assessment, Southeast Alaska.

CONTENTS

INTRODUCTION

Determining population densities of Sitka black-tailed deer in Southeast Alaska is a difficult task. The islands that compose this 500-mile-long archipelago are generally steep, rugged, and covered by old-growth forest. Roads are limited, except where clear-cut logging has taken place, and much of the region is remote wilderness. These conditions limit the effectiveness and practicability of many deer census methods that may be successfully used elsewhere.

Over the years, biologists in Southeast Alaska have developed and used many different census techniques: (1) simple counts of winter-killed deer along the beaches, (2) pellet-group counts, (3) browse utilization surveys, and (4) aerial surveys using sophisticated heat-sensing cameras. No single technique is the "best." The most appropriate technique depends on many factors, including specific management or research objectives, the degree of accuracy or precision required, the equipment, money, and manpower available as well as the experience and skill of the personnel involved. All of these factors should be given careful consideration before a census project is designed.

Deer surveys in Southeast Alaska have been conducted by both state and federal biologists for at least the last 40 years. Unfortunately, the value of this work has been diminished because of incomplete documentation and inconsistent methodology. As a result, much of our historical data cannot be compared with current data. With public concerns over the conflict between logging and wildlife increasing, it is imperative that the status and trend of wildlife populations be accurately monitored. Biologists must develop and utilize census methods that yield the most accurate, cost-effective, and comparable results possible.

The main objective of this research project is to evaluate the available methods of assessing deer population size and trend in Southeast Alaska. The assumptions and possible biases associated with the various techniques will be identified and, where possible, quantified so that corrections to standard methods can be applied.

BACKGROUND

Most population estimation techniques in use today were developed in the 1940's or earlier. With the exception of infrared sensing techniques (Croon et al. 1968, Graves et al. 1972, Parker and Harlan 1972), the methodology has changed little over the years. There is a large body of published literature on the subject, including several reviews (e.g., Connolly 1981, Miller and Gunn 1981, Davis 1982).

Census techniques for deer consist of two basic types: (1) those in which deer are directly observed and counted and (2) those in which persistent sign left by deer are counted (e.g., tracks, browsed stems, pellet-groups). Examples of direct counts include sample area counts (Dasman and Taber 1955, 1956), aerial counts (Caughley and Goddard 1972, Caughley et al. 1976, Samuel et al. 1987), strip censuses (Robinette et al. 1974, Anderson et al. 1976), night counts (Litton 1972, Harestad and Jones 1981), and Lincoln indices (Strandgaard 1967, Rice and Harder 1977, McCullough and Hirth 1988). Indirect measures include track counts (Daniel and Frels 1971, McCaffery 1976, Barrett 1979), pellet-group counts (Neff 1968, Fairbanks 1979, Stordeur 1984), browse utilization surveys (Bobek and Bergstrom 1978, Telfer 1981, Pitt and Schwab 1988, 1990), and hunter effort and success (Merriam 1961d, 1966, Connolly 1981).

In Southeast Alaska, assessing changes in deer populations has been a major activity of the research-management program since before statehood (1959). Deer mortality transects, which have provided the oldest and most consistently collected information were sampled fairly regularly from 1950 (Olson 1951) until the early 1980's; however, a combination of relatively mild winters and questions about their usefulness (Merriam 1960, 1961c; Schoen et al. 1979) caused them to be discontinued.

Klein (1957, 1958) proposed to "develop and test direct and indirect census methods" for deer in Southeast Alaska, but a final report or evaluation was apparently never made. Merriam (1966) noted that none of the many techniques tried over the years provided the information necessary for population estimates, concluding that harvest information was still the best measure of deer abundance in Southeast Alaska. Through the 1960's determinations of deer population levels, structures, and trends remained a high priority in Southeast Alaska (Merriam 1961a, 1961b, 1963, 1966, 1967).

In the middle 1960's the Department began including indirect measures of deer sign in its surveys. In 1964 and 1965 pellet-group transects were established, extending from sea level to elevations of 1,200 feet in 10 areas in Southeast Alaska. A researcher who subsequently evaluated the technique (Merriam 1966) identified several problems: (1) pellets persisted for 2 years or more, requiring that plots be permanently marked and cleared each year, (2) defecation and decomposition rates varied greatly with season and diet, and (3) results were strongly influenced by the amount of time deer spent on the winter range. These methodological problems along with the high manpower requirements discouraged continued work in this area.

In conjunction with the beach mortality transects monitored each spring, biologists in 1966 began noting the degree of browsing on *Vaccinium* plants as an indicator of deer population density (Merriam 1967). Initial results were summarized by Merriam (1967, 1968); however, browse utilization data appear to have been inconsistently collected and reported in subsequent years. Browse utilization indices have been used more recently in deer habitat studies in the southern archipelago (DeGaynor and Fisher 1985, Mankowski and Peek 1989, Yeo and Peek 1989).

In 1977 following 4 years of inactivity, the Department initiated a new deer research program in Southeast Alaska. The emphasis shifted from studying population trends to studying patterns of habitat selection in logged and unlogged habitats (Schoen 1978). Initial work relied on pellet-group counts to assess patterns of habitat use (Schoen and Wallmo 1979, Wallmo and Schoen 1980, Kirchhoff et al. 1983). Pellet-group decomposition rates in Southeast Alaska have been determined using marked pellet-groups (Fisch 1979, Rose 1982) and by comparisons of cleared and uncleared plots (Schoen and Kirchhoff 1983).

Since 1981 the Department and the Forest Service have been monitoring pellet-group densities on the winter range of selected watersheds throughout the region. The primary objective of that program has been to monitor relative deer population sizes and trend over time. On several more intensively sampled areas, the objective has been to develop relationships between deer population density and hunter effort and success.

Although this report touches on the strengths and weakness of most census techniques used in Southeast Alaska, emphasis is placed on the pellet-group technique that is used throughout the region. This research project (i.e., Study No. 2.9) is terminating 1 year ahead of schedule; the loss of transplanted deer from the main study site near Juneau has prevented work on several long-term objectives. The following section documents the final results of each of 14 job segments outlined in the original research proposal (Pitcher and Kirchhoff 1986).

<u>Job 1: Evaluate the pellet-group monitoring program from 1981 to 1987</u>.

The objectives, methods and results of pellet-group surveys conducted in Southeast Alaska from 1981 to 1987 are contained in a separate document (Kirchhoff and Pitcher 1988) that serves as the final report for Objective 1 of this study. Copies of this report are available at the ADF&G regional office in Douglas.

From 1981 to 1990 a total of 90 watersheds in Southeast Alaska were surveyed. These watersheds were selected for sampling based on level of human use, accessibility, habitat characteristics, and the need for management information. Many watersheds were sampled every year or every other year to provide population trend information; others were sampled less regularly, primarily to provide an indication of relative deer density.

Within each watershed, 3 to 18 transects were located in representative deer winter range, running from the beach to elevations of 457 m (1,500 ft) or 2.5 km (1.6 mi) inland. Transects were permanently marked, and ideally included 300 or more plots (1- x 20-m) per watershed. On each plot, pellet-groups were counted and a variety of topographic and vegetative characteristics measured. Results were reported annually, including summary pellet-group statistics, description of population trends, and habitat descriptions for each watershed (Kirchhoff and Pitcher 1988; Kirchhoff and Kirchhoff 1988, 1989). Pellet-group statistics were also used by area biologists in preparing annual Federal Aid reports.

Pitcher and Kirchhoff (1988) reached the following conclusions: (1) pellet-group surveys as currently conducted are adequate for assessing relative population trends of deer at the watershed level; (2) comparisons of relative pellet-group densities among watersheds are valid, assuming habitat characteristics and environmental conditions are generally similar; (3) evaluation of habitat preference or importance may be confounded by differences in defecation rates, pellet-group persistence, and observability among habitats; (4) Pellet-group densities can be extrapolated to deer densities in special cases where the winter range is known with certainty and can be adequately sampled (e.g., on small, low relief islands). The pellet-group monitoring program in Southeast Alaska satisfactorily met needs of management.

Job 2: Establish and monitor a known-size deer population on an island near Juneau.

The question of which census technique provides the greatest accuracy can only be answered when the true population size is known (e.g., Ryel 1959, Downing et al. 1965). In these cases, not only can a variety of census methods be tested for accuracy and efficiency, but the relationship between indicators of deer use (e.g., pellet-groups, trails, browse utilization) and population density under specific environmental conditions can be quantified. The objective of Job 2. was to establish a known-size deer population on a small island near Juneau.

Portland Island in Auke Bay was selected as the experiment site; it is 40.0 ha, has a maximum elevation of 20 m, and is relatively isolated (i.e., lying 2.4 km from Douglas Island, 4.0 km from Admiralty Island, 4.7 km from Shelter Island, 3.8 km from the mainland, and 2.8 km from the nearest small island [Figures 1-2]). Although deer were reported on Portland Island in the 1970's, field reconnaissance confirmed that no deer had inhabited the island for at least 1 year prior to the release.

The vegetative characteristics of the island are typical of high-quality deer winter range found in Southeast Alaska. The island is completely forested with commercial quality (8-30 mbf/ac) old growth. Predominant forest types include western hemlock (*Tsuga heterophylla*), Sitka spruce (*Picea sitchensis*), and hemlock/spruce (*Tsuga heterophylla/Picea sitkensis*). The understory is well developed, providing an abundance of important deer forage plants, such as *Cornus canadensis* and *Vaccinium* spp. (Table 1).

On 20-21 August 1986, 13 deer (i.e., 7 males, 6 females) were captured by net gun from a helicopter in alpine habitat on Admiralty Island. The deer were immobilized with an intramuscular injection of ketamine hydrochloride (Vetalar, Parke-Davis, Detroit, Mich.) and xylazine hydrochloride (Rompun, Haver-Lockhart, Shawnee, Kans.) and transported to Portland Island by helicopter. There, bucks were given vasectomies by a Department veterinarian. This insured that bucks would still go into the fall rut, associated changes in feeding and defecation rates would occur, and no successful reproduction would result. Deer were fitted with mortality-sensing radio transmitters (Telonics Inc, Mesa, Az.) so that the loss of individuals, either by swimming from the island or by natural death, could be noted. The island was closed to deer hunting.

Deer radio signals were regularly monitored from a skiff and occasionally from aircraft. Radio signals from Portland Island could also be picked up intermittently from the Juneau road system. Within 5 days of release, 1 male returned to Admiralty Island; throughout the fall, others (mostly males) also returned. By 1 November, 6 deer (5 females, 1 male) remained on the island. The population remained stable at five (4 females, 1 male) throughout the winter months, but with the coming of spring, deer again began leaving the island. When pellet-group transects were run on 12 May, the population was down to 4 female deer, and by 1 July all of the transplanted deer had left the island.

Of the 13 deer released, 3 died on the island. One buck died within 12 hours of release from capture-related causes. The 2nd buck was in very poor physical condition when it died in late October. An autopsy revealed no fat reserves, an empty small bowel, and evidence of an infection in the trachea and bronchial tree (Memorandum from Dave Anderson, 6 Nov 1986). A third female deer was found dead on 31 December from undetermined causes; she appeared to be in good physical condition at the time of death.

Of the 10 deer that swam from the island, eight made it safely to land. Two of the radio-collared females died from apparent drowning (their carcasses washed up on Shelter Island and the reef north of Portland Island) shortly after field crews surveyed the island for pellet-groups. Of the deer that successfully made land, five (63%) returned to Admiralty Island where they had been originally captured. Two deer ended up on Douglas Island, and one deer swam to Coghlan Island. None of the radio-collars on these deer are currently transmitting.

To calculate the residence time of each deer on Portland Island, I assumed an individual deer had left the island (or died) midway between the date it was last located and the date it was first discovered either missing or dead. From the release date (21 August) to the date pellet-groups were surveyed (12 May) a total of 1,573 deer days were spent on the island (Table 2). That amount of use is equivalent to 6 deer (or more precisely, 5.98 deer) spending the entire 264-day period (21 Aug-12 May) on the island. Over the time period pellet-groups were being deposited, the mean population density on Portland Island was 15 deer/km^2 (40 deer/mi^2).

Job 3: Determine deer defecation rate and pellet-group decomposition rate for deer in Southeast Alaska.

Calculating absolute deer densities from pellet-group counts normally requires knowledge of (1) how long pellet-groups persist (persistence period), (2) the number of pellet-groups deposited per deer per day (defecation rate), (3) the area used by the deer population during the persistence period, and (4) the percentage of pellet-groups missed by observers. These variables are relatively difficult to quantify.

Alternatively, if population density on a well defined area is known, pellet-group density can be measured using standard sampling techniques and a direct relationship between the two derived. This approach eliminated the need to know absolute defecation rates, persistence rates (assuming population is stable and deposition approximately equals deterioration), and percentage of pellet-groups missed. The deer density/pellet-group density relationship determined experimentally can be extended to other areas, assuming that defecation rates, persistence rates, and observability in those other areas are similar.

The pellet-groups deposited on the island were censused 12 May 1986 by a series of 10 equally spaced transect lines extending from shore to shore across the island. Transects consisted of contiguous 1- x 20-m rectangular plots laid end to end. Although plots were surveyed using standardized methods (Kirchhoff and Pitcher 1988), accuracy was improved because crews were aware of the importance of the results, and all pellet-groups were in relatively good condition at the time of the survey. After 264 days (8.8 months) the mean pellet-group density measured on the island was 495 pellet-groups/ha (95% CI of 435-560, $\underline{N}$ = 381).

Knowing the pellet-group density and the deer population, the daily defecation rate can be computed. Based on the measured pellet-group density, a total of 19,800 pellet groups (95% CI = 17,400-22,400) were deposited over 1,573 deer-days on the island. This translates into a defecation rate of 12.6 pellet-groups per deer per day (95% CI = 11.1-14.2). This finding is well within the range of 12-16 pellet-groups per deer per day reported for mule deer (*O. hemionus*) (referenced in Neff 1968, Armleder 1984), and matches the most frequently cited defecation rate in the literature (12.7 groups/day) (Longhurst and Connolly 1982).

To determine pellet-group persistence rates, all 1- x 20-m plots were permanently marked and every other plot cleared of pellet-groups. We assumed that pellet-groups deposited by deer after that time would be deposited equally on cleared and uncleared plots. As the "old" pellet-groups on uncleared plots deteriorated over time, the difference between pellet-group density on cleared and uncleared plots would approach zero. By sampling both the cleared and uncleared plots at regular intervals and testing for significant differences, one could theoretically determine how long it took for the "old" pellet-groups to effectively disappear. This approach has advantages over "marking" pellet-groups because it takes into account the procedures and search effort of the survey and allows an objective means of determining when the pellet-group has, in a practical sense, disappeared.

Because deer left the island shortly after the plots were counted and cleared, this means of experimentally determining pellet-group decomposition rates could not be completed. Fortunately, however, 5 days after the deer were released, 12 fresh pellet-groups were marked with yellow wands and flagging. These groups were monitored throughout the year, providing an alternate means of determining pellet persistence. When the island was surveyed 264 days after the release, all 12 of the pellet-groups were distinctly visible and showed minimal deterioration (i.e., crumbling of individual pellets). When the pellet-groups were examined at 10 months, traces of all were still visible but noticeably deteriorated. When next examined at 12 months, half of the groups were completely gone, and the remainder were very deteriorated or covered by moss. If the exact locations had not been marked, the residue from those pellet-groups would have been undetectable. On this basis I assumed the pellet-groups on Portland Island persisted in countable form for approximately 11 months.

After 8.8 months, the mean pellet-group density measured on Portland Island was 495 pellet groups/ha. If the same mean population of deer (6) had stayed on the island for 11 months, pellet-group density would have increased up to 11 months, after which time pellet-group deposition and disappearance would have been in equilibrium. Knowing the defecation rate (12.6 groups counted per deer per day), the density of pellet-groups counted on the island after 11 months can be extrapolated to 594/ha (95 % CI of 522-672).

Knowing the equilibrium pellet-group density as well as the absolute deer density allows us to compute a conversion factor between the two. The mean population density on Portland Island was 15 deer/km^2 (40 deer/mi^2), and the projected pellet-group density (at equilibrium) was 594/ha (1.2 pellet groups per 20-m^2 plot). On that basis, every pellet-group counted on a typical 1- x 20-m sample plot represents approximately 12 deer per km^2 (95% CI = 10.7-13.8) or 32 deer per mi^2 (95% CI = 28.6-36.7).

The conversion factor should be useful for general management purposes; however, caution is advised in instances where a high degree of accuracy is required and the consequences of being wrong are great. Depending on the need and on how dissimilar an area is from Portland Island, the additional cost and effort needed to quantify site-specific persistence rates and observer error may well be justified.

JOB 4. Quantify sampling biases associated with pellet-group counts.

The use of pellet-group counts to assess changes in relative deer numbers over time or between areas is subject to a number of potential biases: (1) Pellet-groups are more or less visible in different habitats; (2) individuals miss a significant and variable number of pellet-groups; (3) pellet-groups deteriorate at different rates, depending on environmental conditions (i.e., snow cover, rainfall, temperature, shading); and (4) defecation rates vary as a function of diet and behavior (Neff 1968, Stordeur 1984).

The objective of this research segment was to quantify biases associated with points 1 and 2 above. Although variability in defecation rates and deterioration rates could not be quantified, some likely patterns are discussed. Additional discussion is found in Kirchhoff and Pitcher (1988).

Biases in the pellet-group count technique were evaluated during regular spring pellet-group census activities. Each watershed was sampled by 3 crews of 2 people each. The line "puller" pulled a poly-clad steel cable in contiguous 20-m increments along a straight-line compass course and recorded vegetative information at the endpoint of each plot. The puller was followed by a "counter" who counted the number of pellet-groups whose center fell within 0.5 m of either side of the steel cable. This sequence was repeated, with the puller and counter switching duties every 5 plots, until an elevation of 1,500 m or 2.5 km inland was reached (Kirchhoff and Pitcher 1988). Periodically the line puller would announce a "check plot" after the counter had reported the number of pellet-groups counted. Both the counter and the puller would then return to the plot's starting point, thoroughly searching and recounting groups on the plot from both directions. Differences between the initial count and the "true" count were attributable to missed pellet-groups as well as mistaking whether the "center" of a group was in or out or scatterings of pellets represented 1 or more groups.

During the spring field season of 1987, a total of 107 plots and 16 crew members were checked. Original plans to check counts randomly were changed when it became apparent that without some discretion on the part of the line puller, the large majority of check plots would have yielded observed and actual values of zero (i.e., most plots have zero pellet-groups). Plots were infrequently checked on steep terrain, because it necessitated relatively difficult backtracking. Otherwise, plots were checked without regard to habitat type or pellet observability.

The mean "initial" count on check plots ($\underline{X}$ = 3.16 groups, SD = 3.36) was not significantly different than the true count obtained after carefully reexamining the plot ($\underline{X}$ = 4.00 groups, SD = 3.66) (Mann-Whitney U-test, $\underline{P} < 0.05$). The relatively high degree of error (21%, or 1 group missed for every four counted) is probably not fairly representative of the technique. Because "check" plots were left to the discretion of the line puller, they were much more likely to be called when pellet-group counts were either high or when the line puller thought the counter had "missed" pellet-groups. This was particularly evident with more competitive individuals. With those factors in mind, I would estimate that typical surveys underestimated true pellet-group density by approximately 15%. Other research has documented errors of 8-34%, depending on plot size and shape, habitat type, and experience and motivation of field personnel (Ryel 1971, Fairbanks 1979).

Whether certain levels of precision and accuracy are acceptable or not depends on the survey's objectives. If the objective is knowing how many deer inhabit a given island, an accurate estimate of pellet-group density is needed. If, on the other hand, the objective is knowing whether their numbers are changing slightly from one year to the next, a more precise estimate is needed. Often, efforts to increase accuracy (e.g., more time per plot) can result in lower precision (i.e., fewer plots per year). Given the objectives of the current pellet-group monitoring program (Kirchhoff and Pitcher 1988), the accuracy of these pellet-group counts is acceptable.

Because environmental conditions (e.g., precipitation, shading, snow) and understory growth vary among certain habitat types, rates of pellet-group deposition, decomposition, and observability may vary as well (Neff 1968, Fisch 1979, Harestad and Bunnell 1987). Within Southeast Alaska, canopy cover and understory conditions of old growth vary widely (Martin 1989, Alaback 1989). U.S. Forest Service timber-type maps classify old-growth on the basis of stand volume, or site productivity. Five volume classes are recognized: noncommercial (less than 8 thousand board feet per acre), low volume (8-20 MBF/acre), mid volume (20-30 MBF/acre), high-volume (30-50 MBF/acre), and very high-volume (over 50 MBF/acre). Important characteristics of low and high-volume stands are described in Schoen et al. (1988) and Alaback and Juday (1989).

The Forest Service also classifies old growth according to "plant associations". These overstory and understory plant assemblages reflect site variation in temperature, moisture, light, and nutrients (Martin et al. 1985). There are approximately 30 plant associations identified on the Tongass, falling within 6 to 7 overstory "series" or types. On the Chatham area (northern Southeast Alaska), the 6 overstory series are western hemlock, mountain hemlock (*Tsuga mertensiana*) mixed conifer, western hemlock-yellow cedar (*Chamaecyparis nootkatensis*), sitka spruce, and lodgepole pine (*Pinus contorta*). Important characteristics of these overstory series types are described in Martin (1989).

The difference between observed and actual pellet-group counts was determined for each volume class and each overstory series from "check" plots surveyed in 1987. Plant associations were identified in the Chatham area using the key and type descriptions in Martin et al. (1985). Volume class was identified by personnel who either had experience measuring net inventory volume (Schoen et al. 1982, Kirchhoff and Schoen 1987) or were trained by those who did. Overstory conditions within an approximate 40-m radius area (0.5 ha) centered on each plot were used in determining plant association and volume class.

The error averaged 24% for all volume classes (Table 3) and was significantly different among volume classes (ANOVA $\underline{P}$ = 0.03). The error averaged 36% for all overstory series (Table 4); among types it was nearly significantly different (ANOVA $\underline{P}$ = 0.07). Despite the high variability within groups, there appears to be a tendency of greater error (more groups missed) in higher volume stands and in the more productive overstory series types (spruce, hemlock, and cedar). Presumably, the open canopy associated with low-site stands provides more light and better visibility so fewer groups are missed. In some areas, particularly at higher elevations, the snowpack is deeper and more persistent on open-canopied sites. Snow cover may minimize pellet-group deterioration and result in more readily recognizable pellet-groups.

Variability among observers is another potential bias common to the pellet-group survey techniques (Ryel 1971, Stordeur 1984). Of the 107 plots checked in 1987, 4 of 17 individuals were checked on 13 or more plots and selected for this analysis. Two of those individuals had 6 or more consecutive years of experience on the pellet-group crew and were labeled "experienced". The other two were either counting pellet-groups for the first time or had not worked on the field crew for 3 years. These individuals were labeled "inexperienced". Analysis of the percentage of error by observer shows the most experienced observers missed an average of 12% of the pellet-groups, while the most error-prone observer missed 35% (Table 5). The percentage of error did not differ significantly among the 4 individuals (ANOVA $\underline{P}$ = 0.19).

The experienced counters collectively missed 15% of the pellet-groups, while inexperienced counters missed 34% (Table 5). The difference between experienced and inexperienced counters was significant (ANOVA $\underline{P}$ = 0.03). This finding underscores the importance of rotating counting duties within a crew (e.g., every 5 plots) and having 3 or more crews collecting data within any single watershed. In addition, calling unexpected "check plots" helps to ensure consistent decision-making and maintain alertness. Besides minimizing error, these procedures insure that no single individual has an inordinate influence on the measured pellet-group density in a single area. As long as the collective experience of the crew does not change greatly from area to area or over time, the effect of observer error on precision of the mean can probably be ignored.

Job 5: Evaluate the impact of a known density deer population on existing forage supplies.

Browse utilization surveys are commonly used as an index to range condition and animal abundance (Telfer 1981, Connolly 1981); however, interpretation is sometimes difficult because the degree of utilization is a function both of the density of deer and the amount of forage available, including nonbrowse species (Pitt and Schwab 1988). The introduction of deer to Portland Island afforded an opportunity to document the amount of forage there before the introduction and to monitor subsequent changes in forage composition, biomass, and browse utilization over time.

A series of 100 permanently marked points (numbered stakes) were established at 17-m intervals along a transect running the length of Portland Island (Figure 2). A 30- x 60-cm plot frame, with the long axis oriented N-S, was placed at each marked point, and the percentage of the plot area covered by each understory species was estimated. Biomass estimates for herb-layer species were computed from these cover estimates (Alaback 1986). Biomass of shrub species was calculated from the measured basal diameter of stems rooted in each plot (Alaback 1986). The biomass of herb- and shrub-layer plant species on Portland Island is given in Table 1. These values are relatively high, compared with that reported for old-growth stands in Southeast Alaska (Alaback 1982).

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

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

Vaccinium by this moderate-density deer population (15 deer/km^2) would be easy to miss if careful stem-by-stem examination of individual plants were not made, particularly if browse estimates were made in summer when new annual growth and leaves obscure browsed twigs. Estimates of browse utilization that do not include twig counts or measurements may be unreliable.

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

The relationship between basal stem diameter and total biomass of *V. ovalifolium, V. parvifolium,* and both *Vaccinium* species combined is shown in Figures 3-5. The equations developed here differ from those previously published for Southeast Alaska (Alaback 1986), but as Alaback (1987) notes, differences among various sites are expected and development of dimension-biomass equations for local populations or for specific stand structures is recommended.

To preserve representative (preintroduction) vegetation for future comparative work, a 0.01-ha, 10- x 10- x 2-m-high deer exclosure was constructed near the middle of Portland Island. That structure is still standing, and it will be maintained should deer relocate or be introduced again to the island. The departure of deer from the island prevented continuation of this job segment.

<u>Job 6: Develop a snowpack index which can be used to predict winter deer distribution on individual watersheds</u>.

Monitoring changes in deer population density requires knowledge of the area used by the population from year to year. Snowpack is probably the single-most-important factor influencing winter habitat suitability and deer distribution (Kirchhoff and Schoen 1987, Schoen and Kirchhoff 1990); however, without frequent on-site visits throughout the winter, snowpack conditions are difficult to predict. The approach taken in the past has been to generously assume that most of the deer use in winter takes place below a certain elevation and sample that area accordingly. Merriam (1966) sampled to elevations of 1,200 feet (365 m), while current transects are run to 1,500 feet (456 m) (Kirchhoff and Pitcher 1988). The objective of this job was to determine whether a better estimate of deer distribution through the winter months was needed, and if so, how it might be predicted from existing weather information.

To check the appropriateness of 455 m (1,500 ft) as the upper limit of a sampling area, location data from 51 radio-collared deer on Admiralty Island (Schoen and Kirchhoff 1985) were analyzed for the winter period; i.e., 1 November through 30 April. During that time period, 92% of all deer relocations (536/581) occurred below an elevation of 1,500 feet (455 m). It appears that under most scenarios, sampling to an elevation of 455 m will capture 90% or more of the winter deer use.

Although deer may be distributed over a narrower elevation range on some watersheds during more severe winters or on north-facing slopes, site-specific weather information is currently unavailable. Collecting that information with remote sensing devices is technically possible (e.g., with Acoustic Snow Depth Sensors, Campbell Scientific, Inc. Logan, UT) but expensive. More importantly, it is probably not necessary. Experience shows that in areas or years with deep snowfall, crews typically do not reach 455 m anyway (i.e., sampling is terminated when >50% snow cover occurs on 3 consecutive plots). In general, snowpack conditions encountered in the spring can safely be assumed to be indicative of snow conditions (and thus deer distribution) during the preceding winter.

For interpreting changes in pellet-group densities, it is still useful to have some objective means for determining and expressing relative winter severity. Snowfall and temperature data collected at sea level, for example, do not necessarily reflect winter severity at higher elevations where many deer winter. One source of useful information is the Soil Conservation Service (Anchorage, AK), which provides monthly summaries for selected locations and elevations in Southeast Alaska. Data include depth of snowpack, departure from normal (20-year mean), and historic maximum and minimum. These summaries are now being included in the annual pellet-group survey reports (Kirchhoff and Kirchhoff 1988, 1989) as a general index of winter severity throughout the region.

Job 7: Estimate sex- and age-specific mortality rates in a deer population.

Status: Suspended. This job called for radio-collaring a large number of deer and determining age and sex-specific mortality rates from that sample over time. Ken Pitcher originally planned to conduct this work out of Sitka. The size of the sample required and the cost of conducting this research were deemed prohibitive, and the project was suspended.

Job 8: Develop a winter severity index which can be used to predict deer mortality.

Status: Suspended. The objective of this job was to develop a model whereby known mortality from Job 7 could be predicted, using a combination of weather variables. With suspension of Job 7, this job was suspended as well.

Job 9: Evaluate the accuracy of beach transects as a measure of population mortality.

Status: Suspended. The purpose of this job was to determine whether population mortality (from Job 7) was reflected in beach mortality data gathered in the same areas. With suspension of Job 7, this job was suspended as well.

Currently, beach mortality transects are being conducted by area biologists on a limited basis, primarily to confirm subjective impressions of winter severity and resultant deer mortality in localized areas. The quantitative relationship between these data and actual population mortality is uncertain (ADF&G files).

Job 10. Determine the relationship between hunter success and deer population density.

Merriam (1966) suggested that hunter success was the most reliable indicator of population size and trend, at least for areas of Southeast Alaska that are regularly hunted; however, his conclusion appears based more on the perceived shortcomings of other deer survey techniques than on any objective analysis of population trend data and hunter statistics. The purpose of this job is to evaluate the relationship between hunter success and deer population density in Southeast Alaska.

From 1982 to 1989, some deer harvest ticket holders in Southeast Alaska were mailed a questionnaire after the hunting season, asking them to identify areas hunted and the number of deer killed. The responses, which were coded to hunt areas, allowed calculation of numerous statistics, including hunter effort, total harvest, harvest per unit effort, harvest per hunter, and success (%). Based on the response rate, results from the sampled hunters were expanded to the population of harvest ticket holders.

Three areas were identified for this analysis. The first, Shelter-Lincoln Island, is relatively small (2,320 ha) and is located near Juneau. The area includes 2 wildlife analysis areas (WAA 2620 and WAA 2621), and because of it's small size, it sustains one of the highest harvests/km^2 land area in Southeast Alaska. The second, "Sitka Area" (WWA 3001 and WAA 3002), is readily accessible by skiff from Sitka and also heavily hunted. It is characterized by one of the highest "deer/hunter" and success rates in the region. The third, Gravina Island (WAA 101), is located across Tongass Narrows from Ketchikan, and it is a popular hunting destination for local residents. Deer populations there have increased significantly since 1980.

From 1984 to 1990, pellet-group densities on individual watersheds or VCU's within these 3 reporting areas were sampled by field crews, using standard survey methods (Kirchhoff and Pitcher 1988). Sampling was intensive from 1984 to 1986, with >1,000 plots on as many as 18 transects surveyed in each area.

In recent years, only 300 plots on 3 transects per area have been surveyed. To make the data comparable, pellet-group means and confidence intervals for the 1984-86 period have been recalculated using the same transects sampled in 1987-89. Spring pellet-group data are staggered back 1 year for proper comparison with fall hunt statistics (i.e., 1989 pellet-group data were collected in 1990).

For the period 1982 to 1989, all 3 areas exhibited a wide range of pellet-group densities; deer populations in high years were twice as abundant as those in low years. On Gravina and Shelter Islands, populations peaked in 1985, 1986, and 1987, dropping sharply in 1988 and 1989. In the Sitka area, populations were highest during 1984 and 1985, dropping significantly in 1986, 1987, and 1988. Pellet-group data in all cases follow a relatively gradual progression of change (Table 6).

Hunter statistics were more variable, but the trends (increase or decrease) from year to year have been fairly consistent. Exceptions are evident on Gravina island where, for example, deer density, harvest, and success all increased significantly between 1983 and 1984; however, deer per hunter and deer per hunter-day declined slightly. On Shelter-Lincoln, deer per hunter-day and success increased from 1987 to 1988, while all other statistics indicated a decline (Table 6). Of 21 year-to-year comparisons possible in the dataset, 13 (62%) had 4 or more statistics (out of 5) indicating the same population trend.

Correlations between pellet-group density and hunter statistics from 1982 to 1989 for the 3 hunt areas are all highly significant ($P < 0.01$), with "deer per hunter-day" most highly correlated with pellet-group density ($\underline{r} = 0.61$) (Table 7). All hunting statistics were highly intercorrelated ($\underline{P} < 0.001$); however, the correlations were not significant when examined on individual hunt areas (Tables 8-10). Although the lack of significance can be partially attributed to the small sample sizes ($\underline{N} = 5$ or 7), even with much larger sample sizes many of these correlation coefficients would still be insignificant.

Contradictory trends suggested by these various statistics may simply be an artifact of sampling problems. For example, the pellet-group and hunt data are not collected over the same area, and respondents to the deer harvest questionnaire do not represent an unbiased sample. If the statistics are true, other factors may explain the results. For example, in a year in which early snow concentrates deer at lower elevations success will be high, even though overall pellet-group density (measured from the beach to an elevation of 455 m) is low; and if hunting conditions are good for only a brief period in the season, the total harvest may be down, even though deer per hunter-day is up. Recognizing the many factors influencing hunter statistics and the resultant variability in the data, pellet-group density probably provides the most reliable indicator of deer population trend.

Job 11. Evaluate the potential of determining sex and age composition sampling from classification of living animals and examination of hunter-killed deer.

Live deer can only be observed in large numbers in alpine habitats in summer or along beaches during deep-snow periods in winter. In both instances counts are known to vary greatly over time, and an unbiased sample with respect to either age or sex is unlikely (Merriam 1960). Similar problems with respect to sampling bias apply to hunter-killed deer (Mankowski and Peek 1989).

During the winter of 1988-89, 2 aerial deer surveys were conducted along beaches on Admiralty and Chichagof Islands. Both yielded reasonably good deer counts, but sex and age data were unreliable. When flown at low altitude near the beach, individual animals passed through the field of view too quickly to be classified. At greater distances, ages were identified reliably only when adults and yearlings occurred together and some deer were undoubtedly missed. Identifying sex from the air is impossible. Accurate data on sex, age, and condition of deer can probably be better collected from a small boat.

Studies of fecal-pellet dimensions in moose (*Alces alces*) have showed that nearly all pellet-groups could be correctly identified as originating from adult males, adult females, or yearlings (MacCracken and Van Ballenberghe 1987). The technique may not be as useful in deer, where males and females are of more similar size, but it could prove useful for monitoring adult:yearling ratios. Collection of fecal pellet-groups from free-ranging, known-age deer would be required to test this hypothesis.

Job 12. Evaluate lungworm as a potential limiting factor in deer populations in Southeast Alaska.

Collections of female deer in the Hoonah Sound Area in 1985 revealed that all 13 fawns (10 months of age) collected harbored heavy and probably fatal infections of lungworm (*Dictyocaulus viviparous*) (Johnson 1987). Subsequent analysis of sera from these deer showed no evidence of epizooic hemmorrhagic disease, bluetongue, or contagious ecthyma, but all of the samples tested for Q fever ($\underline{n}$ = 8) had low levels of antibody (memorandum from R. Zarnke, 14 Dec 1987). This disease is capable of causing reproductive problems, including abortion. Because the antibody levels found were quite low, the implications for the deer population are uncertain.

The geographic extent and severity of lungworm and Q fever in the Southeast Alaska deer population is unknown. No additional systematic collections of deer have been made; however, incidental to pellet-group surveys in Sea Otter Sound (NW Prince of Wales Island), a recently-dead 11-month-old female deer was found in the woods and autopsied. She was in poor physical condition (no subcutaneous, mesentary, or kidney fat and pink, gelatinous marrow in tibia) despite a full and apparently functioning rumen. She was also heavily infected with both lungworm and nasal bots (*Cephenemyia jellisoni*). Nasal bots have been found in the pharyngeal pouches of Sitka black-tailed deer in early spring on Coronation and Woronkofski islands, and they have contributed to the winter mortality (Klein 1965).

<u>Job 13. Prepare for publication an article on habitat selection by black-tailed deer in Southeast Alaska</u>.

A paper titled "Seasonal habitat preference of Sitka black-tailed deer on Admiralty Island, Alaska" was submitted to the Journal of Wildlife Management. It has been accepted and is scheduled for publication in Fall 1990.

<u>Job 14. Report writing</u>.

Two papers on related work are in progress: (1) "A test of the deer pellet-group technique on an area with known population size" (Journal of Wildlife Management) and (2) "Census techniques for monitoring deer populations in Southeast Alaska" (submission to proceedings of a monitoring symposium scheduled for Fall 1990 in Juneau).

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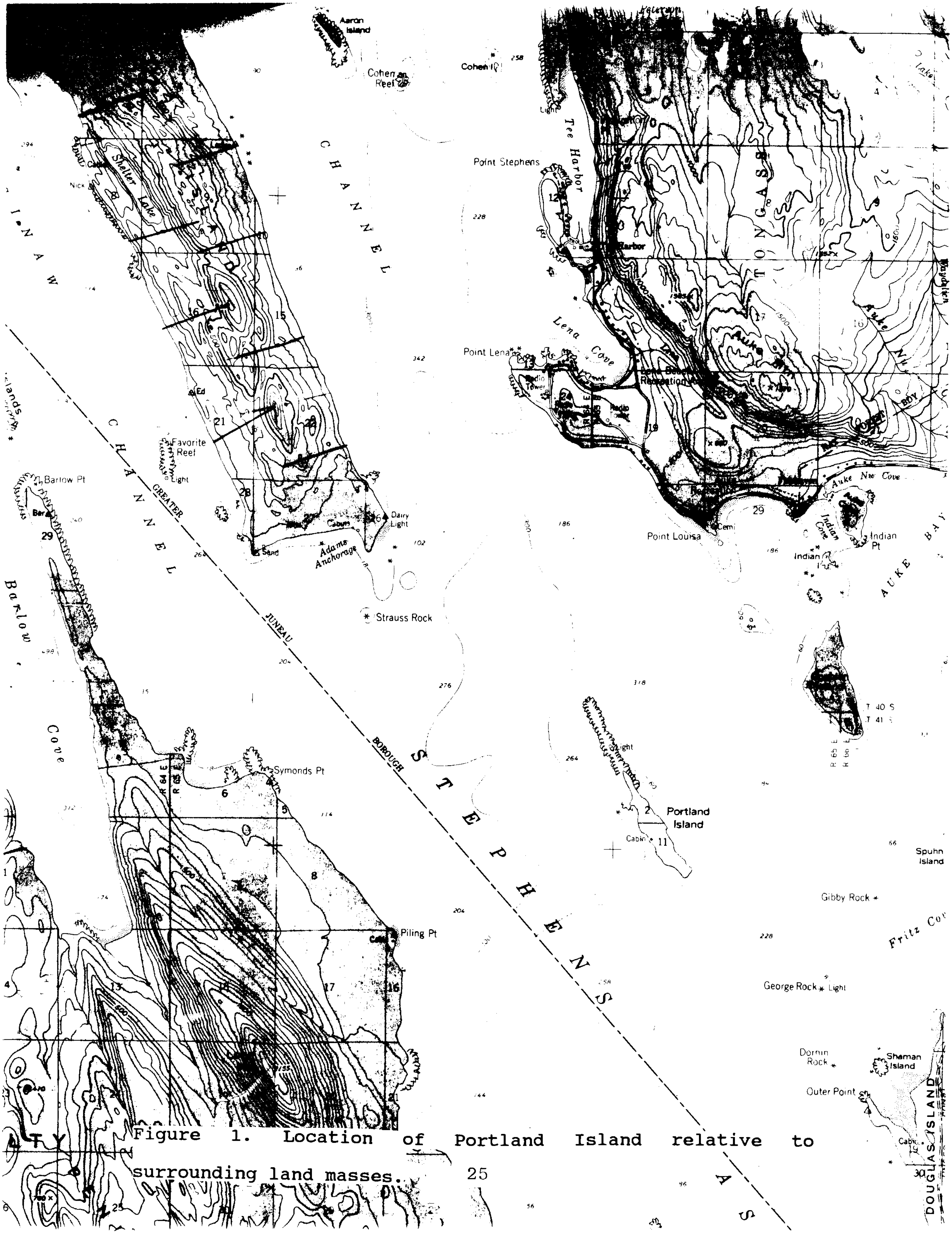

Figure 1. Location of Portland Island relative to surrounding land masses.

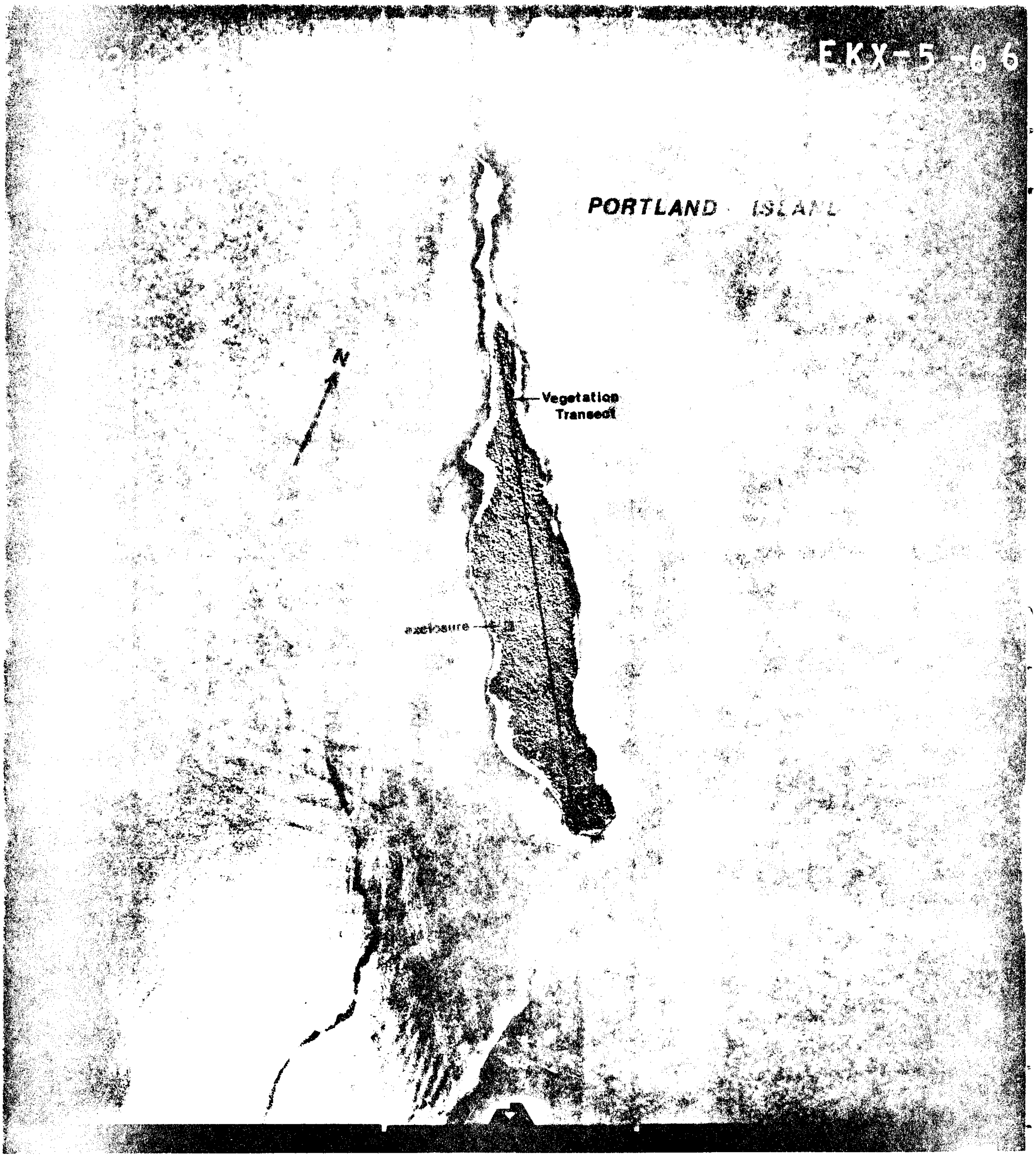

Figure 2. Portland island showing forest overstory, location of vegetation transect, and deer exclosure.

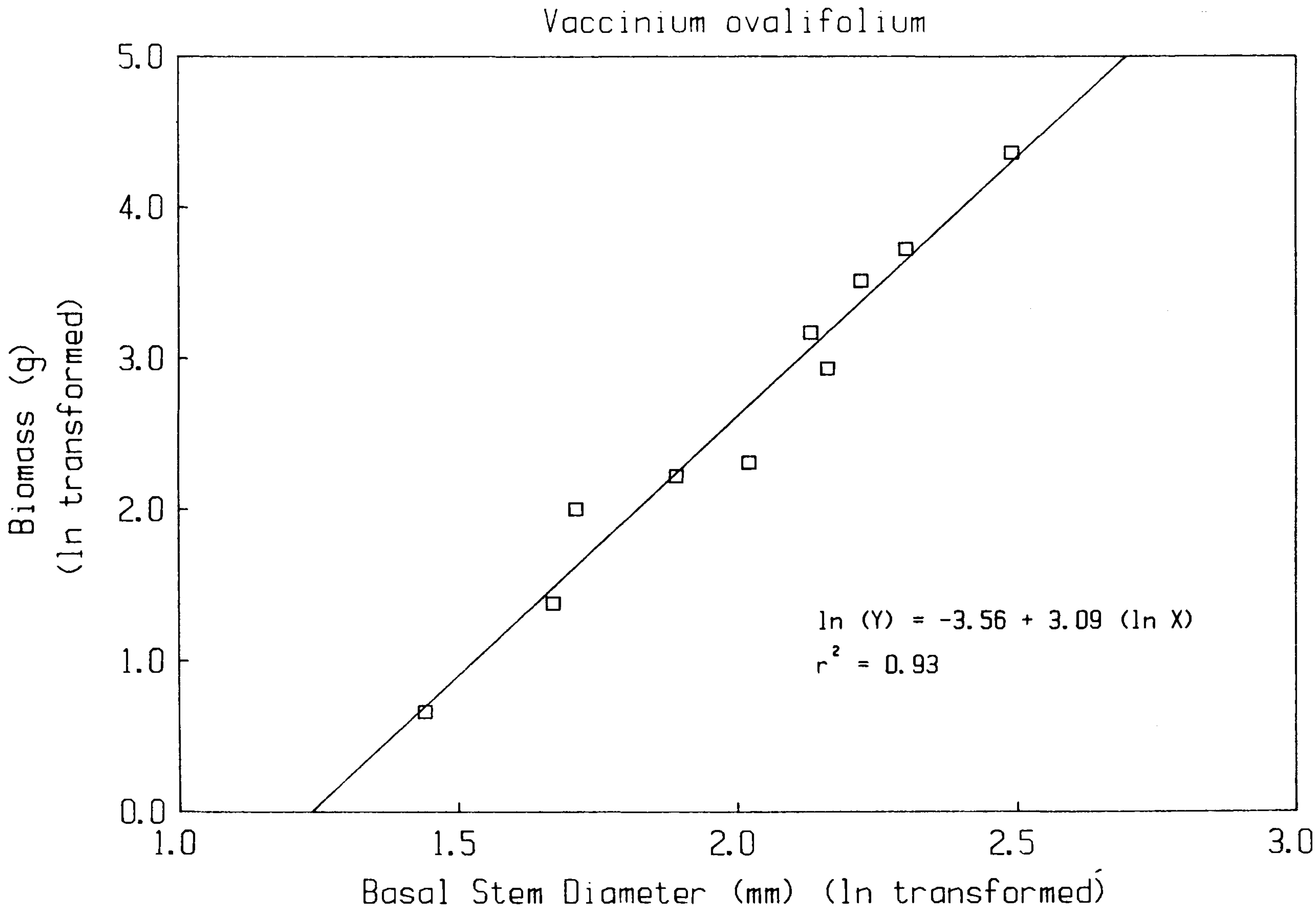

Figure 3. Relationship between basal stem diameter of *Vaccinium ovalifolium/alaskense* and total biomass.

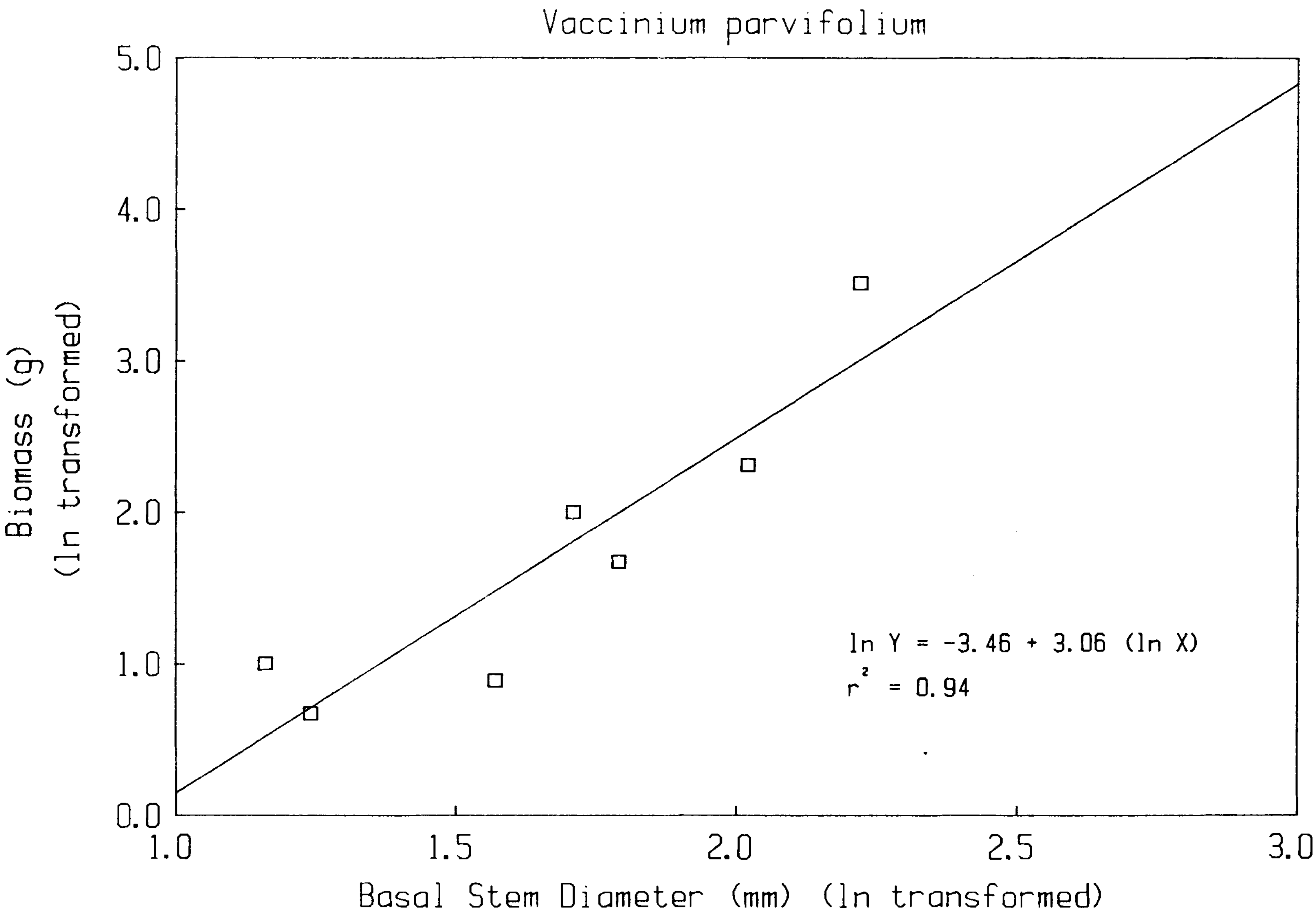

Figure 4. Relationship between basal stem diameter of Vaccinium parvifolium and total biomass.

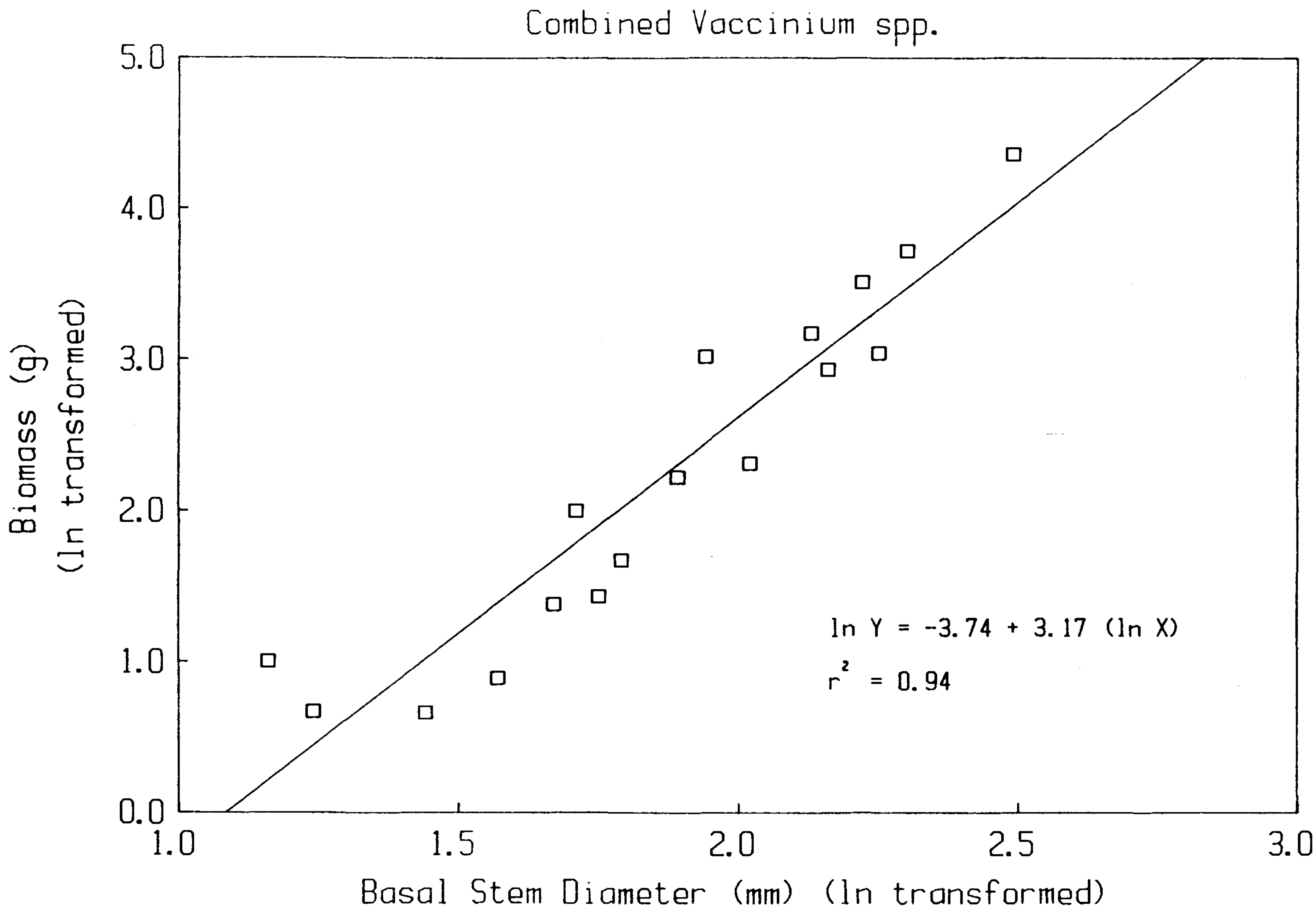

Figure 5. Relationship between basal stem diameter of combined *Vaccinium* spp. and total biomass.

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

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

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

Table 2. Calculated length of residency of 13 deer on Portland Island, Juneau, 1986-87.

Deer No.	Sex	Last located	First missing (or died)	Days on a island[1]
150.590	M	8-21-86	(died) 8-22-86	0
150.500	M	8-21-86	8-25-86	3
150.540	M	8-25-86	9-11-86	13
150.150	F	9-11-86	9-13-86	22
150.750	M	9-13-86	9-26-86	30
150.800	M	9-26-86	10-07-86	42
150.760	M	10-07-86	(died) 10-30-86	59
151.490	F	12-08-86	(died) 12-31-86	120
150.730	M	2-23-87	5-01-87	220
150.710	F	5-14-87	7-01-87	(266)
150.780	F	5-14-87	7-01-87	(266)
150.600	F	5-14-87	7-01-87	(266)
150.570	F	5-14-87	7-01-87	(266)
			Total Deer Days	**(1538)**

[a] Days on Island. (Days to date of pellet-group survey).

Table 3. Differences between observed and actual pellet-group counts, by volume class, as determined from "check" plots during 1987 pellet-group surveys.

Volume class	X (SD) Difference	X (SD) % Error	N
< 8,000 bf/ac.	0.55 (0.78)	0.13 (0.19)	29
8,000-20,000 bf/ac.	1.13 (1.32)	0.20 (0.22)	23
20,000-30,000 bf/ac.	0.88 (0.91)	0.35 (0.39)	34
Over 30,000 bf/ac.	0.50 (0.53)	0.39 (0.51)	8
TOTAL	**0.81 (0.99)**	**0.24 (0.33)**	**94**

Table 4. Differences between observed and actual pellet-group counts, by overstory series, as determined from "check" plots during 1987 pellet-group surveys.

Overstory series	$\bar{X}$ (SD) Difference	$\bar{X}$ (SD) % Error	N
Lodgepole Pine	0.50 (0.71)	0.10 (0.15)	10
Mixed Conifer	0.69 (0.95)	0.15 (0.21)	15
W. Hemlock-Y. Cedar	1.40 (1.01)	0.33 (0.38)	10
Western Hemlock	0.95 (1.18)	0.33 (0.38)	19
Sitka Spruce	0.73 (0.65)	0.48 (0.50)	11
TOTAL	**0.85 (0.98)**	**0.36 (0.28)**	**65**

Table 5. Differences between observed and actual pellet-group counts, by observer, as determined from "check" plots during 1987 pellet-group surveys.

Observer	$\bar{X}$ (SD) Difference	$\bar{X}$ (SD) % Error	N
A (experienced)	0.50 (0.63)	0.18 (0.34)	16
B (experienced)	0.54 (0.66)	0.12 (0.17)	13
Subtotal	0.52 (0.63)	0.15 (0.27)	
C (inexperienced)	1.10 (1.77)	0.35 (0.39)	21
D (inexperienced)	0.59 (0.71)	0.32 (0.40)	17
Subtotal	0.87 (1.07)	0.34 (0.39)	
Total	**0.72 (0.92)**	**0.25 (0.35)**	**67**

Table 6. Pellet-group and hunter statistics from 1982-89 for 3 hunts in Southeast Alaska[a].

	82	83	84	85	86	87	88	89
Gravina Island								
Deer kill	120	150	205	186	294	71	136	101
Deer/hunter	.27	.43	.41	.34	.71	.30	.49	.42
Deer/h-day	0.07	0.12	0.10	0.12	0.15	0.11	0.13	0.17
% success	0.25	0.35	0.41	0.27	0.45	0.20	0.31	0.25
P.G./plot	--	0.88	1.44	1.62	1.63	2.06	1.13	1.40
Shelter-Lincoln Islands								
Deer kill	60	50	100	155	131	112	61	124
Deer/hunter	0.21	0.36	0.59	0.62	0.42	0.48	0.36	0.56
Deer/h-day	0.07	0.09	0.18	0.21	0.16	0.18	0.22	0.16
% success	0.14	0.25	0.53	0.38	0.27	0.33	0.36	0.28
P.G./plot	--	1.52	2.52	3.24	2.91	3.16	1.43	1.60
Sitka Area								
Deer kill	1160	1410	1810	1847	1659	1683	1620	1192
Deer/hunter	0.92	1.16	1.25	1.32	1.14	1.07	1.16	1.04
Deer/h-day	0.17	0.23	0.27	0.38	0.22	0.25	0.37	0.39
% success	0.52	0.55	0.73	0.68	0.60	0.54	0.61	0.56
P.G./plot	--	2.51	3.65	3.38	2.31	--	2.32	2.99

[a] Spring pellet-group data are staggered back 1 year for proper comparison with fall hunt statistics.

Table 7. Corellations between pellet-group and hunter statistics from 1982-89 for 3 hunt areas (Gravina, Shelter/Lincoln, and Sitka) in southeast Alaska ($\underline{N}$ = 19).

	Pellet-group density[a]	Deer harvet	Deer per hunter	Deer per hunter day
Deer kill	0.53[b]			
Deer per hunter	0.58[b]	0.97[c]		
Deer per h-day	0.61[b]	0.81[c]	0.83[c]	
% success	0.56[b]	0.88[c]	0.92[c]	0.78[c]

[a] Pellet-group data collected from VCUs within the larger hunt areas.
[b] significant at 0.01
[c] significant at 0.001

Table 8. Corellations between pellet-group and hunter statistics from 1982-89 for Gravina Island (Minor Harvest Area 101), Southeast Alaska ($\underline{N}$ = 7).

	Pellet-group density[a]	Deer harvest	Deer per hunter	Deer per hunter day
Deer kill	-0.06			
Deer per hunter	-0.21	0.76		
Deer per h-day	-0.11	0.06	0.49	
% success	-0.34	0.88[b]	0.77	0.02

[a] Pellet-group data from northeast Gravina Island.
[b] significant at 0.01

Table 9. Corellations between pellet-group and hunter statistics from 1982-89 for Shelter/Lincoln Islands (minor harvest units 2620 and 2621), southeast Alaska ($\underline{N}$ = 7).

	Pellet-group density[a]	Deer harvest	Deer per hunter	Deer per hunter day
Deer kill	0.74			
Deer per hunter	0.50	0.75		
Deer per h-day	0.33	0.39	0.36	
% success	0.26	0.10	0.55	0.53

[a] Pellet-group data from north Shelter Island.

Table 10. Corellations between pellet-group and hunter statistics from 1982-89 for Sitka Area (minor harvest areas 3001 and 3002), Southeast Alaska (N = 5).

	Pellet-group density[a]	Deer harvest	Deer per hunter	Deer per hunter day
Deer kill	0.74			
Deer per hunter	0.88	0.77		
Deer per h-day	0.24	0.48	0.56	
% success	0.89	0.91	0.77	0.36

[a] Pellet-group data from VCU 300, Nakwasina Passage.

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