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

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SUMMARY

Throughout the last decade, Sitka black-tailed deer (Odocoileus hemionus sitkensis) research in southeast Alaska has indicated that clear-cutting old-growth forest will reduce carrying capacity of deer winter range. The extent of local deer population decline due to logging is difficult to determine experimentally because the full impacts are not realized until 30-100 years after logging. Nonetheless, there is an immediate management need for information relating differing levels of timber harvest to changes in deer populations in Southeast. We address that need with a model based on habitat use by deer under different snow conditions. We assume that the winter habitats most preferred by deer will, over time, support the highest numbers of deer. Adjustments to predicted carrying capacity as a function of habitat preference and snow conditions are incorporated in the model.

The model operates on a watershed scale, partitioning winter range into 6 habitat types: clear-cut (0-25 yr), 2nd-growth (26-150 yr), and 4 old-growth types, noncommercial (<8 mbf/acre), low volume (8-20 mbf/acre), mid volume (20-30 mbf/acre), and high volume (>30 mbf/acre) stands. The extent of each habitat type available on a watershed was determined from existing USFS inventory data.

As timber is cut, acres are moved from the appropriate old-growth habitat type into young clear-cut status, then into 2nd-growth status, and eventually (at 250 years) back into the original old-growth type. The habitat mosaic available to deer changes continually as a function of how frequently timber is cut, how many acres are cut in each entry, and which old-growth habitat types are cut. By comparing a watershed's prelogging habitat values with post-logging habitat values under fixed snow conditions, we can project changes in relative carrying capacity as a consequence of logging.

This model is intended to offer managers a tool for systematically comparing the impacts of different timber management alternatives on deer populations in southeast Alaska. Our model draws on deer/habitat data collected in southeast Alaska, uses readily accessible inventory information, and yields easily interpreted (though general) predictions. We believe this model serves an immediate management need--to relate ongoing timber harvest activities to potential, long-term changes in deer numbers.

Key words: Sitka black-tailed deer, *Odocoileus hemionus sitkensis*, model, populations, logging, old growth, habitat, southeast Alaska.

CONTENTS

BACKGROUND

The distribution of Sitka black-tailed deer (Odocoileus hemionus sitkensis) in southeast Alaska coincides with a narrow band of forested land between the coastal icefields to the east and the Pacific Ocean. Western hemlock-Sitka spruce (Tsuga heterophylla- Picea sitchensis) forests dominate the lower elevations below 2,000 ft, with subalpine and alpine habitats above. During the snow-free summer and early fall, many deer migrate to summer ranges in the alpine and subalpine. However, for 7 to 9 months of the year deer are restricted to lower elevation forested habitat. The availability of high-quality winter habitat is the key to maintaining current population levels of Sitka black-tails, the major big game species in the region.

The hemlock-spruce forests of southeast Alaska are also an important resource for a major timber industry. Timber harvesting is the dominant land management activity in the region and has a substantial influence on the habitat of deer and other wildlife species. Because of this influence it has become increasingly important to better understand the relationships between deer and forest management.

In 1977, the Alaska Department of Fish and Game, in cooperation with the Forestry Sciences Laboratory of the U.S. Forest Service, began investigating the forest habitat relationships of Sitka black-tailed deer. The 1st phase of this work was reported in Schoen (1978), Schoen and Wallmo (1979), and Wallmo and Schoen (1980). The current phase of this investigation was reported in Schoen et al. (1979, 1981a, 1982, in press), Schoen and Kirchhoff (1983a, 1984, in press), Kirchhoff et al. (1983), and Kirchhoff and Schoen (1985).

This report summarizes the old-growth habitat relationships of deer in southeast Alaska and presents a management oriented model designed to predict changes in deer populations as a result of logging in southeast Alaska. A preliminary version of this manuscript was presented as a paper at the April 1984 meeting of the Northwest Section of the Wildlife Society.

OBJECTIVES

To develop capture and telemetry techniques for Sitka black-tailed deer and evaluate seasonal distribution, and determine habitat utilization and preference within natural (unlogged) and modified (logged) habitats.

STUDY AREA

Southeast Alaska encompasses the mainland coast from the Canadian border at Dixon Entrance to Yakutat, including the islands of the Alexander Archipelago. Deer inhabit all the larger islands and most of the mainland coast as far north as Juneau. Admiralty and Chichagof Islands in the northern archipelago were selected as the major study area. Several sites on both islands were chosen to study forest characteristics and deer distribution based on pellet groups (Schoen et al. 1979, 1981a, Kirchhoff et al. 1983). Radio telemetry studies of deer movements and habitat use were conducted on Admiralty Island at Hawk Inlet and Winning Cove (Schoen and Kirchhoff, in press).

The study area is dominated by a cool maritime climate. Heavy snow accumulations occur during most winters, and elevations above 2,000 ft are usually snow-covered 7-9 months of the year. Conifer forest covers about 50% of the land area. This forest is composed of a mosaic of different stands reflecting differences in site characteristics and stand history. Of the total land area within this northern region, about 25% is commercial forest land. Industrial-scale timber harvesting began during the 1950's, and current forest plans schedule an annual harvest of about 18,000 acres.

PROCEDURES

Deer pellet group sampling was used to estimate deer use of various forest types. Forest understory and overstory variables were sampled on 1-acre study stands. Deer were captured on the winter range from the ground by darting with an immobilizing drug. Deer were also captured on the summer range by darting or using a net gun from a helicopter. Captured deer were instrumented with radio-collars. Deer were located approximately once a week throughout the year from a fixed wing aircraft. Their location was plotted on a topographic map and habitat variables associated with the location were recorded. Seasonal habitat preference was determined by comparing habitat use versus the occurrence of that variable within the study area. Forest overstory-snow relationships were investigated by measuring snow accumulation under 20 1-acre forest stands with measured overstory characteristics. Detailed procedures are reported in Schoen et al. 1979, 1981a, 1982, Schoen and Kirchhoff 1983, 1984, and Kirchhoff and Schoen 1985.

PREDICTING POPULATION CHANGES IN SITKA BLACK-TAILED DEER AS A RESULT OF LOGGING IN SOUTHEAST ALASKA: A MODEL

Introduction

Research in southeast Alaska indicates that clear-cutting old-growth forest will reduce habitat carrying capacity for Sitka black-tailed deer (Leopold and Barrett 1972, Bloom 1978, Barrett 1979, Schoen and Wallmo 1979, Wallmo and Schoen 1980, Schoen et al. 1981b, Alaback 1982, Rose 1982, Kirchhoff et al. 1983, Hanley et al. 1984, Schoen et al., in press). Although deer populations in Southeast will decline as even-aged, 2nd-growth stands replace old-growth habitat, no data exist to quantify the extent of that decline. Attempts to collect such data experimentally are impractical for 2 reasons. First, large annual fluctuations in deer numbers due to natural causes (e.g., snowfall) can mask logging-related changes. This is particularly true in Southeast where winters are highly variable and timber harvesting is widely dispersed, both geographically (i.e., lower impacts per drainage, but many drainages entered) and over time (i.e., 3 entries over 100 years). Secondly, the full effects of logging on deer are expected to occur late in the rotation. Industrial-scale logging in Southeast has a 30-year history, and although populations in areas where earlier logging occurred may have declined, prelogging population levels are unknown. If an experimental approach were initiated now, it would be decades before meaningful results were available.

Resource managers in southeast Alaska have an immediate need for information that may be used to predict changes in deer population levels in response to various timber harvest alternatives. As Thomas (1979) stated: "The National Forest Management Act of 1976 requires that detailed and holistic plans be prepared for management of National Forest System lands....One of the weakest aspects of such planning and examination has been the inability of forest managers to predict the effects of management alternatives on wildlife populations....better techniques are needed to help predict the consequences, whether good or bad, of timber management on wildlife....With intensified forest management, impacts on wildlife will be magnified. The need is critical. The time is now."

In this model, we use radio-telemetry data and pellet group data to generate indices of relative habitat quality. We assume that the preference shown by deer for a particular habitat type is related to the quality, or value, of that type. With this approach, the deer themselves dictate which habitat types, under what snow conditions, are most valuable. The values thus assigned to individual habitats are relative--the model does not compute the number of deer a Value Comparison Unit (VCU) can carry. Output is expressed as a percentage change in carrying capacity (relative to average prelogging levels) as a function of timber harvest activities and snow.

We wish to emphasize that the main utility of the model is as a tool to compare the effects of timber management between watersheds, or among various harvest alternatives proposed for an individual watershed. The absolute change in deer numbers may be lesser or greater than is predicted by the model, depending on variability in annual snowfall.

Available habitat base. Because habitat loss in 1 watershed will likely not result in significant dispersal by deer into adjacent watersheds (Schoen and Kirchhoff, in press), deer in individual watersheds ($\bar{x} \cong 15{,}000$ acres) are viewed as closed populations. Winter carrying capacity, therefore, is a function of the quality and quantity of winter habitat within each watershed, and all deer are assumed to have equal access to all habitats within the watershed. Our choice of variables used to describe winter deer habitat was constrained by the need to use variables common to both the forest inventory and deer relocation data sets. At the finest level of resolution, accepting the above constraint, the habitat available to deer in any watershed can be described in terms of 7 habitat types: nonforest, noncommercial old-growth forest, commercial quality low, medium, and high volume old growth, clear-cuts (<25 years), and 2nd growth (>25 years).

Although proportions of different habitat types may vary substantially from 1 watershed to the next, in most watersheds noncommercial forest lands and low volume old-growth comprise most of the available habitat, while 2nd-growth and high volume old-growth stands are relatively rare (Table 1). Nonforest land, consisting largely of high elevation alpine and muskeg, was assumed to have negligible value as deer winter range because of deep snow accumulations, and therefore was not incorporated into the model.

Snowfall patterns. The value of individual habitat types and the carrying capacity of the watershed as a whole are strongly influenced in any given year by the depth and duration of snow on the ground. While it is generally acknowledged that average winter temperatures in the archipelago are lower to the north and east, recent attempts to construct snowpack isohyets or isotherms have been unsuccessful (Bowling and Slaughter 1983). Snowfall, which varies as a function of both temperature and precipitation, is especially difficult to predict. Weather stations exposed to a strong maritime influence typically exhibit warmer temperatures and higher levels of precipitation than other stations. These stations have, during colder than average winters, displayed some of the deepest snows on record for the archipelago. Snow depths in excess of 70 inches have been recorded at central and western stations in the archipelago, and snow accumulations of 20-40 inches have been recorded at sea level throughout the region (Climatological Data Summaries, National Weather Service, Juneau).

Although weather records indicate heavy snows can occur throughout Southeast, it is difficult to predict when and how frequently such events will occur. When one examines the annual snowfall reported at Juneau from 1890 to the present (Lomire 1979), we see little evidence of a consistent pattern (Fig. 1). Juday (1984), however, plotted a 5-year running average of mean annual temperature, and these data show a regular series of colder periods occurring on a 15-20 year cycle (Fig. 2). This phenomenon is also evident in the weather record of Ketchikan (C. Smith, Alaska Dep. Fish and Game, unpubl. data).

The most recent heavy snow years for the archipelago as a whole occurred in 1968-69, 1970-71, and 1971-72, when snowfall in some of the more maritime and southern weather stations was relatively high (Table 2). Following these winters, deer populations declined sharply throughout Southeast (Olson 1979). Since then, populations on Admiralty, Baranof, and

Chichagof Islands have responded favorably to the succeeding series of mild winters, while deer populations on the southern half of the archipelago (south of Frederick Sound) have been relatively slow to recover and are still very low on some islands (Alaska Dep. Fish and Game, unpubl. data). The slow recovery in the latter areas is generally attributed to predation by wolves (Canis lupus) (Olson 1979, R. Wood, Alaska Dep. Fish and Game, pers. commun.).

It appears that while years of deep snow may be less frequent, and/or less severe on some southern islands in the archipelago, historical data clearly show that the potential for deep snow accumulations exists, and such events can be expected several or more times during the course of a 100-year cycle. Furthermore, the consequences of deep snow conditions on southern islands may be relatively long-lasting, owing to the presence of wolves (Van Ballenberghe and Hanley, in press).

We model deer response to timber harvesting as a function of 3 specific snowfall regimes: snow-free, intermediate, and deep. The telemetry data upon which this model is based were collected during winter 1981 and 1982 under "snow-free" and "deep snow" conditions respectively, as represented by (Fig. 3). "Intermediate" snow conditions are assumed to fall midway between these values. Although snow depths for the 1982 sampling period (January-March) were comparable to those recorded in Juneau for the severe winters of 1968-69 and 1970-71, the duration of the snowpack in 1982 was much less, with almost no accumulation during the months of November and December. This distinction is noted for purposes of later discussion.

Determination of habitat values. A central assumption of this model is that habitat quality (i.e., the capacity of the habitat to produce/support deer) is related to the amount of use that habitat receives. High quality habitats are highly preferred and low quality habitats are not. This assumption is well founded on theoretical grounds (see references in Hanley et al. 1984) and is commonly accepted in the field of wildlife science. Social interactions have been shown to result in increased use of inferior habitats by subadult and juvenile small mammals (Van Horne 1983), but similar factors do not appear to be operating on the winter deer population. All of our radio-collared deer were adults with established home ranges. During the winter (January-March), the only major predator on deer (the brown bear, Ursus arctos) is inactive and sport hunting is closed. The validity of habitat-based models is supported by evidence of actual declines in deer populations on Northern Vancouver Island (Hebert 1979) following logging.

Old-growth. In this model, the relative value of each of 4 old-growth habitat types in the Hawk Inlet study area (non-commercial forest, 8-20 mbf/acre, 20-30 mbf/acre, and over 30 mbf/acre) was based on measured habitat use as a function of its availability. To determine the amount of use each habitat type received, 9 radio-collared deer in 1981 and 17 radio-collared deer in 1982 were tracked weekly throughout the study period. A systematic sampling of points (*N* = 353) located on color aerial photographs of the study area was used to determine relative availability of individual habitat types. Sampling was restricted to potential winter range, and excluded nonforest types (muskeg and all habitats above approximately 2,300 ft). Details of this sampling methodology are presented in Schoen and Kirchhoff (1983*a*).

An electivity index (Ivlev 1961) was computed for each habitat under snow-free (1981) and deep snow conditions (1982) using the equation:

$$E = \frac{r_i - p_i}{r_i + p_i}$$

where:

E = the electivity coefficient (preference index)
r_i = the proportion of the observed use in category i
p_i = the proportion of category i in the study area.

To avoid negative numbers, the resultant indices were transformed to a scale from 0 to 1 using the equation:

$$E_t = \frac{r_i}{r_i + p_i}$$

where:

E_t = transformed electivity index

Habitat selection under intermediate snow conditions was represented by the average of the values under snow-free and deep snow conditions for each habitat type.

Deer used high volume stands extensively during periods of deep snow (Table 3). Because high volume stands are scarce in the study area (and in the forest as a whole), the observed level of use represents a very strong preference for this habitat type.

During periods of low snowfall, high volume stands are still preferred by deer, though not as strongly (Table 4). Low volume and non commercial old-growth receive much greater use when little snow is present than under deep snow conditions.

This behavior is consistent with deer habitat selection patterns documented elsewhere in Southeast using pellet group sampling or track count techniques (Bloom 1978, Barrett 1979, Schoen et al. 1981a).

Preference by deer for high volume old-growth under deep snow conditions appears related to the ability of high volume stands to intercept greater quantities of snow than either 2nd-growth or low volume stands. During the winter of 1983-84, snow depth was monitored on 20 1-acre study plots on the Mendenhall Peninsula near Juneau. Forest characteristics of each plot were measured, including canopy cover, mean tree spacing, mean tree height, mean percent defect, basal area and gross and net timber volume. Many of these variables were highly correlated with each other, and were inversely correlated with mean snow depth. Of these, net timber volume had the highest correlation with snow depth (Spearman rank correlation, $r = -0.90$). Volume integrates a variety of variables such as tree diameter, tree height, tree vigor, species mix, and stem density to describe a stand which effectively intercepts snow. This generalization is applicable specifically to forests of the hemlock and hemlock-spruce type. The relationship between mean snow depth and net timber volume is shown in Fig. 4. A more detailed treatment of the field methodology, data analysis, and results of this work is reported in Kirchhoff and Schoen (1985).

Although much of the preference by deer for high volume timber is logically attributable to snow relationships, we note that even in the absence of snow, deer preferentially use high volume timber (Table 4), rather than recent clear-cuts (Wallmo and Schoen 1980). The key factor, we believe, may be forage quality. Studies by Billings and Wheeler (1979), Van Horne (1982), and Rose (1982) indicate nitrogen content of understory plants is greater beneath old-growth than in clear-cuts. Research on *Cornus canadensis*, an important winter forage species for deer, showed that nitrogen content and digestibility were highest in high volume old-growth, intermediate in low volume old-growth, and lowest in recent clear-cuts (Schoen and Kirchhoff 1983b; R. Flynn, Alaska Dep. Fish and Game, unpubl. data). These differences may be due to variation in soil productivity among sites, and/or phenological differences brought about by contrasting temperature/light regimes among clear-cuts, low volume, and high volume stands.

Second-growth. Because recent clear-cuts and 2nd-growth habitat types were not available to deer in the Hawk Inlet study area, we determined their habitat values based on pellet group distribution in clear-cut, 2nd-growth, and old-growth habitats (Wallmo and Schoen 1980, Kirchhoff et al. 1983). When pellet groups are counted in the spring, they provide information on the relative use each habitat type received on average through the preceding 6-7 months (Schoen and Kirchhoff 1983b). These data illustrate general trends in habitat selection but are less sensitive to short-term behavior patterns. The winter periods sampled in the above-cited studies were neither uniformly mild nor uniformly severe, but were typical of "average" winters in Southeast where periodic snowfall is interspersed with warmer, rainy periods. During these winters, clear-cuts received one-third the use measured in adjacent old-growth, and 2nd-growth received one-tenth the use measured in adjacent old-growth (Table 5). These factors can be scaled to old-growth values by assuming the old-growth sampled was, on average, 20-30 mbf/acre. The habitat preference value of that type was 0.52 in average winters (mean of value in snow-free and deep snow winters). The comparably scaled habitat preference values of clear-cuts and 2nd-growth (in average winters) then become 0.17 and 0.06, respectively (i.e., 0.32 x 0.52, and 0.11 x 0.52).

With the relative values of clear-cuts and 2nd-growth under average snow conditions fixed by existing pellet group data, it is still desirable to assign relative values to these habitat types under snow-free and deep snow conditions as well. This exercise is necessarily subjective, but by considering related data on forage availability, forage quality, and energetic costs, reasonable approximations can be made.

Second-growth stands are, almost without exception, of limited value to deer in any season. Understory production in closed canopy 2nd-growth is very low (Wallmo and Schoen 1980, Alaback 1982, Alaback 1984), and deer forage is essentially absent. Because the value of 2nd-growth is a function of low forage production rather than low forage availability, we assigned the same relative habitat preference value (0.06) to 2nd-growth under both low and high snow conditions.

Precommercial and commercial thinning of dense 2nd-growth stands is a potential management technique to improve the forage for deer. It is based on the premise that opening up the dense canopy will result in increased forage production (Kessler 1982, U.S. Forest Service 1981). Recent research on the effects of thinning on forage production (Alaback and Tappeiner 1984), however, found generally poor understory response to thinning, particularly for important herb-layer forage species. Because there is little evidence to date that thinning will significantly improve 2nd-growth for deer, we make no distinction between managed and unmanaged 2nd-growth in the model. Such changes can be incorporated if future thinning studies provide evidence of habitat improvement.

Clear-cuts. Unlike 2nd-growth stands, clear-cuts are very productive of understory vegetation (Alaback 1982), but whether that forage is available to deer or not is strongly linked to snow conditions. Under snow-free conditions, all of the forage produced in a clear-cut is available. Although total biomass levels in clear-cuts greatly exceed those found in old-growth, a large percentage of that biomass is composed of conifer saplings and woody shrubs (Alaback 1982) which have relatively limited nutritional value to deer (Hanley and McKendrick 1983). Studies of winter deer forage species, Vaccinium sp. and Cornus canadensis, reveal that the forage quality in clear-cuts is significantly lower than that in old-growth (Billings and Wheeler 1979, Schoen and Kirchhoff 1984). Therefore, we assumed clear-cuts under snow-free conditions are comparable to average quality old-growth habitat. Accordingly, we assigned clear-cuts under snow-free conditions the same relative value as mid-volume old-growth (0.57 from Table 2) under snow-free conditions.

Under deep snow conditions, young clear-cuts have very little value to deer. Even small amounts of snow make herb-layer vegetation unavailable, and at depths like those recorded in January-March 1982, all but the tallest shrubs are unavailable. Concurrent with the reduction in forage availability is the greatly increased cost to deer of moving through snow (Mattfield 1974, Parker 1983). When deep snow is underlain by logging slash, the energetic costs of locomotion are further compounded. Considering these factors, we assumed the relative value of clear-cuts in deep snow is very low, or, equivalent to 2nd-growth (0.06).

Each watershed on the forest can be viewed as a mosaic of different habitat types. The quantity, quality, and variety of winter habitat can vary markedly among watersheds. The relative "value" of any given watershed is a function of how many acres and what type of acres that watershed contains. Thus, total watershed value is the summation of acres in each habitat type multiplied by the value of that type under the assumed snow conditions. The relative values for all 6 winter habitat types, under low, intermediate, and high snow conditions, are presented in Table 7. Although we recognize factors such as habitat interspersion and juxtaposition may affect the "value" of a given watershed to wildlife in general (Leopold 1933) and deer in particular (Thomas 1979), the importance of these factors in a quantitative sense is unknown. We have assumed for this exercise that the effects of such factors in our model are equal among watersheds and harvest alternatives, and the net effects, therefore, are negligible.

Carrying capacity. Ricklefs (1973) defines carrying capacity as "the total resources available divided by the minimum maintenance requirement of each individual." In theory, where "available resources" are relatively stable over time, the population reaches an upper asymptote and is assumed to be in equilibrium--or at carrying capacity. In the case of deer, "available resources" are a function of both productivity and availability of forage supplies. The forage productivity of a given site is relatively stable over time, with the most significant changes occurring in response to timber harvest. Forage availability, on the other hand, may change fivefold from one winter to the next, depending on the depth and duration of snowfall. In this context, the carrying capacity of every watershed in Southeast varies from year to year.

Although deer select those habitats which offer them the greatest chance of survival, the relationship between habitat value (e.g., see Table 6) and actual carrying capacity, is not necessarily linear. The relationship changes depending on local snow conditions. In Fig. 5, we propose 4 hypothetical curves relating changes in habitat value to changes in relative carrying capacity under a range of snow conditions. Curve C (Fig. 5) depicts the proposed relationship between changes in habitat value and carrying capacity under deep snow conditions. When snow is deep and the winter prolonged, we predict high winter deer mortality even if they are using high volume, old-growth habitat. In the extreme case (Curve D in Fig. 5), the curve is steeply concave and depicts very high mortality. At the other extreme, under a snow-free winter scenario (Curve A in Fig. 5), the curve is convex, whereby reductions in habitat value (e.g., converting old-growth to clear-cuts) do not result in significant decline in deer populations. In this instance, even though deer may still prefer old-growth habitats, recent clear-cuts and non commercial forest have unrealized potential to support additional deer.

Curves A and D on Fig. 5 represent extremes. The severe winter scenario (Curve D) might be viewed as applicable to the winters of 1968-69, 1970-71, and 1971-72 in Petersburg, when over 5 ft of snow was on the ground at tidewater and deer populations crashed. The mild winter scenario (Curve A) might be applicable to the situation on several small, heavily clear-cut islands near Petersburg, where deer are moderately abundant because recent winters have been mild, and the clear-cuts are in an early stage of succession (Schoen et al. 1982).

We were able to establish 1 data point (x on Curve C in Fig. 5) which serves as a valuable point of reference. Using Tongass Land Management Plan (TLMP) (U.S. Dep. Agric. 1978) inventory data, and the habitat preference indices in Table 4, we calculated the relative value of Hawk Inlet during the snow-free period in 1981 and the deep snow period in 1982. We found a 25% difference in the value of the watershed between the mild and hard winters. This figure can be related to a corresponding increase in mortality between these years (i.e., decrease in carrying capacity) estimated from our radio-collared deer.

In winter and early spring 1981, and 1982, the mortality rates based on our radio-collared deer were 0% and 39%, respectively. Because our radio-collared deer included only adults captured before November, these mortality estimates probably underestimate mortality in the population as a whole. Klein and Olson (1960) reported age-specific mortality rates in southeast Alaska to be highest in fawns. We assumed winter fawn mortality in 1981 to be about 20%, and to be about 85% in 1982. If fawns represented 30% of the prewinter population, then total population mortality (adults plus fawns) was 6% and 66% for the winters 1981 and 1982, respectively. We attribute the large difference to the contrasting weather conditions between years. Although the assumptions can be argued, and the mortality estimates will vary, we feel it is likely that over time, populations may vary by as much as 75% from the mean and that declines of greater than 50% are likely between winters such as 1981 and 1982.

As the above exercise suggests, a 25% reduction in habitat value caused by deep snow conditions resulted in an approximate decrease in carrying capacity of 60%. We plotted this point on line C of Fig. 5 and the relationship predicts large reductions in deer for a given change in habitat value. On the average, however, winter conditions throughout southeast Alaska are not as rigorous, and deer mortality would likely be less for a given reduction in habitat value. For general application throughout southeast Alaska, a more moderate curve may be more appropriate (e.g., Line B, Fig. 5). If, however, maintaining deer populations at harvestable levels every year is a management goal on selected watersheds, then managers should base decisions on a more conservative relationship (e.g., Line C, Fig. 5).

The snow-free relationship between habitat value and carrying capacity (Line A, Fig. 5) is presented for purposes of discussion only; we would not recommend management be based on this curve. Forest management practices affect habitat values for more than a century following logging--a time frame sufficiently long to ensure at least several series of hard winters. Where wolves are present, even with mild winters, the long-term effects of occasionally severe winters will be magnified (Hanley et al. 1984). Management should logically be directed at maintaining habitat to prevent declines in deer, rather than trying to reverse deer declines after they occur (Van Ballenberghe and Hanley, in press).

Validation

Ideally, the predictions of any model are compared with an independent data set to test the model's accuracy. Our model predicts changes in deer numbers as a result of habitat manipulation and snow. As stated in the introduction, the data needed to test these predictions experimentally are not available, and would take decades to acquire. More commonly in model testing, independent datasets are used to test key relationships or assumptions within a model. In the present case, the fundamental assumption that preference for a given habitat is correlated with carrying capacity can be tested.

We used the model to calculate the habitat value of 6 watersheds from which information on winter deer density (i.e., carrying capacity) had been independently collected. Habitat values for each watershed were calculated assuming snow-free, average, and deep snow conditions. If our assumption is valid, we would expect those watersheds with the highest habitat values to also have the highest winter deer densities.

Deer pellet group densities were measured on the winter range of 6 watersheds during spring 1982 and spring 1983 (J. W. Matthews, unpubl. data, Alaska Dep. Fish and Game). In 1982, 3 watersheds were sampled on north Admiralty Island, including our deer study area. Transects composed of contiguous, 3 x 66 ft plots were run from the beach to 1,500-ft elevation or 1.5 mi inland from the beach, whichever was reached first. These limits were assumed to coincide roughly with the limits of important deer winter range. Transects were spaced at 0.25-0.5 mi intervals along the shoreline of the drainages being sampled. In spring 1983, 3 more drainages were sampled on Chichagof Island using the same technique. Watersheds from both years were ranked collectively in decreasing order based on mean pellet group density.

Habitat values were computed by multiplying the value per acre of each habitat type (Table 6) times the proportional area that habitat type occupies in the watershed's winter range (TLMP inventory data). This gives an index of the quality of habitat on each watershed. Ideally, this computed habitat value should be based on the proportion of each habitat type within the same area sampled for pellet groups (1.5 mi inland or 1,500-ft elevation). Nonetheless, we believe information based on the model's definition of winter range (i.e., the 6 habitat types) and Matthews' definition of winter range (distance inland and elevation) is similar enough to yield meaningful comparisons.

Model predictions of habitat values per acre and actual pellet group densities for the 6 watersheds are presented in Table 7.

A comparison of the rank order of VCU's based on predicted and measured values is presented in Table 8. The results show a reasonable match between predicted and observed rank order under all 3 winter scenarios, the notable exception being VCU 211 which was ranked 3rd by the model, but had the highest pellet group density. If we look at rankings on Admiralty and Chichagof Islands separately, however, there was a good match between the predicted and observed rank under all 3 winter scenarios.

These results support the assumption that relative carrying capacity is reflected in the predicted habitat values of individual watersheds, particularly when comparisons are made during the same year and/or watersheds are not widely separated geographically. Pellet group monitoring on these and other watersheds will be conducted annually by the Game Division management staff. As these data become available, they will be used to test the model's accuracy under a broader range of watershed types and snow conditions.

Example

As an example of how the model might be applied in management, we used it to predict changes in the carrying capacity in the Kadashan drainage (VCU 235) as a result of scheduled timber harvesting. The timber harvest schedules evaluated are those proposed in Alternatives 2, 4, and 6 in the Alaska Lumber and Pulp (ALP) 1986-90 Timber Sale Operating Plan (unpubl. draft). The effects of timber harvest on deer carrying capacity are projected for 25 years post-logging under snow-free, intermediate, and deep snow conditions.

There are 28,421 acres of winter range in Kadashan, as defined by the 6 habitat types identified in this model. Of that, 17,787 acres are classified as commercial forest land. The 3 alternatives in the logging plan call for a harvest of between 5% and 11% of the commercial forest land on the 1st entry. The model predicts this level of harvest will result in reductions in carrying capacity ranging from 0 to 29% depending on the alternative chosen and the assumed snow conditions (Table 9).

In addition to comparing alternatives on a single VCU, the model can also be used to compare the impacts of scheduled timber harvesting among numerous VCU's. In the appendix we present model output showing the anticipated effects of timber harvesting on deer populations in drainages where logging is currently scheduled (TLMP, Rideout et al. 1984)

CONCLUSION

This model was developed in response to the needs of resource managers in southeast Alaska. It should not be viewed as an infallible tool for predicting the consequences of logging on deer. As Grobstein (1983) suggested, "What often is needed is the best available advice for a complex decision arena." This is particularly true when, as with deer and logging in Southeast, decisions are being made which will have significant long term effects on the wildlife resources. Hopefully, this model addresses that need, and will help establish a common ground from which management decisions can be made.

Our model presents a framework for using existing inventory and timber harvest information, along with data on deer/habitat relationships collected in southeast Alaska, to predict logging-related impacts on local deer populations. Based on the results of sample runs made to date, and the similarity between predicted and observed deer habitat values on selected watersheds, we believe this model offers managers a valid tool for making and evaluating resource decisions.

ACKNOWLEDGMENTS

The framework of this model evolved during work sessions with the late O. C. Wallmo over 5 years ago. His contribution, both to the conceptual model and to our knowledge of deer/old-growth relationships, is gratefully acknowledged.

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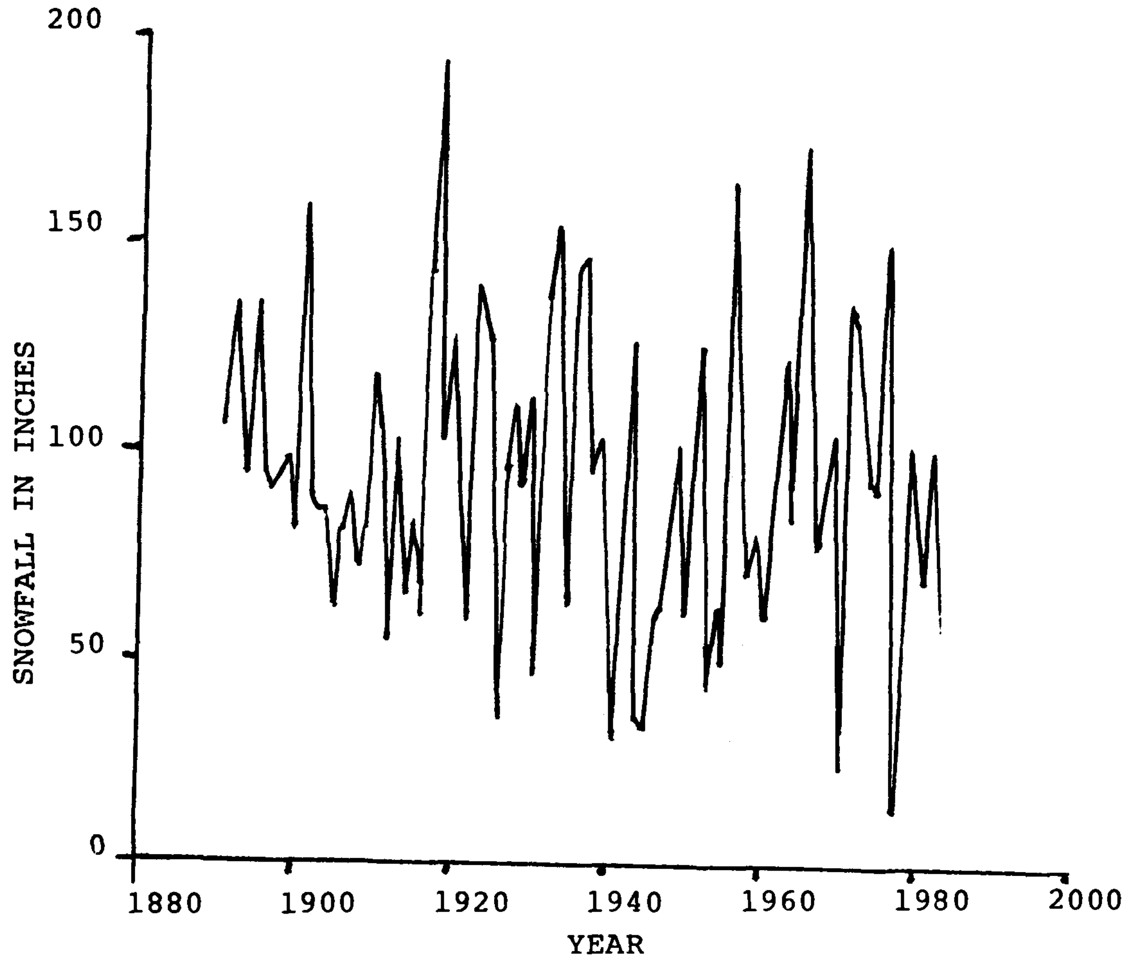

Fig. 1. Annual snowfall at Juneau, Alaska, 1888-1983. (Source: Lomire 1979 and recent Climatological Data Summaries, National Weather Service, Juneau.)

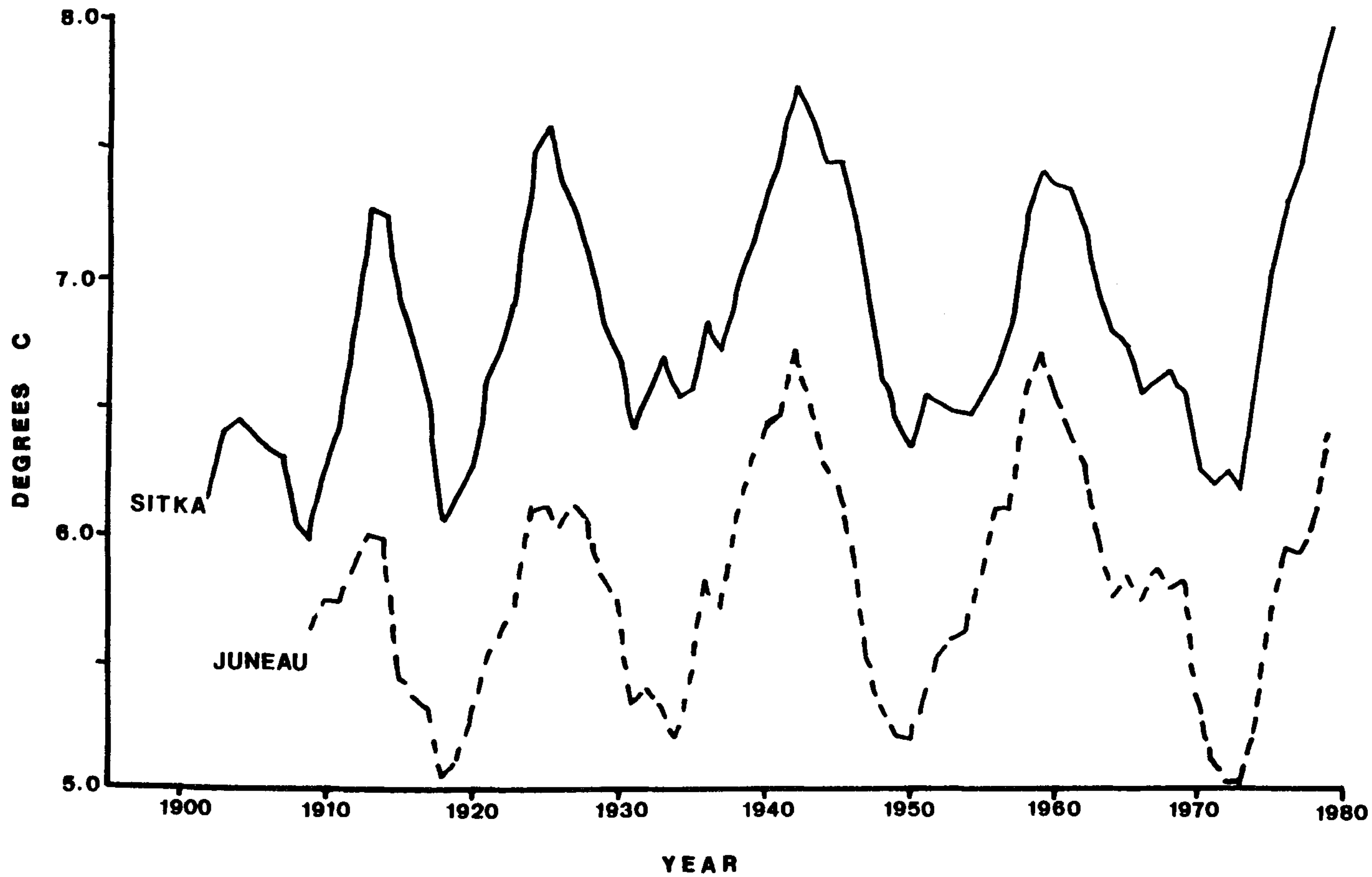

Fig. 2. Five year running mean of mean annual temperature at Juneau 1907-1980, and Sitka 1900-1980. (Source: Juday 1984.)

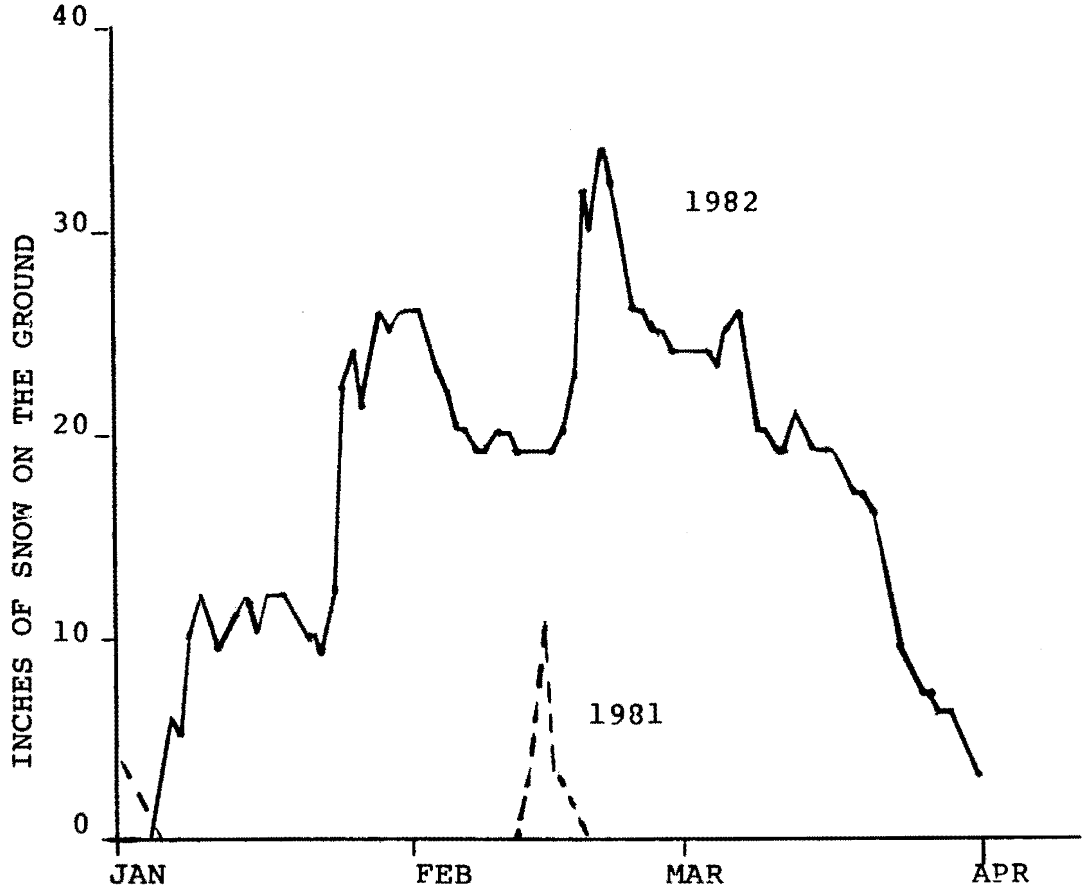

Fig. 3. Daily snow depth at Funter Bay, Admiralty Island, January-March 1981-1982. (Source: Climatological Data Summaries, National Weather Service, Juneau.)

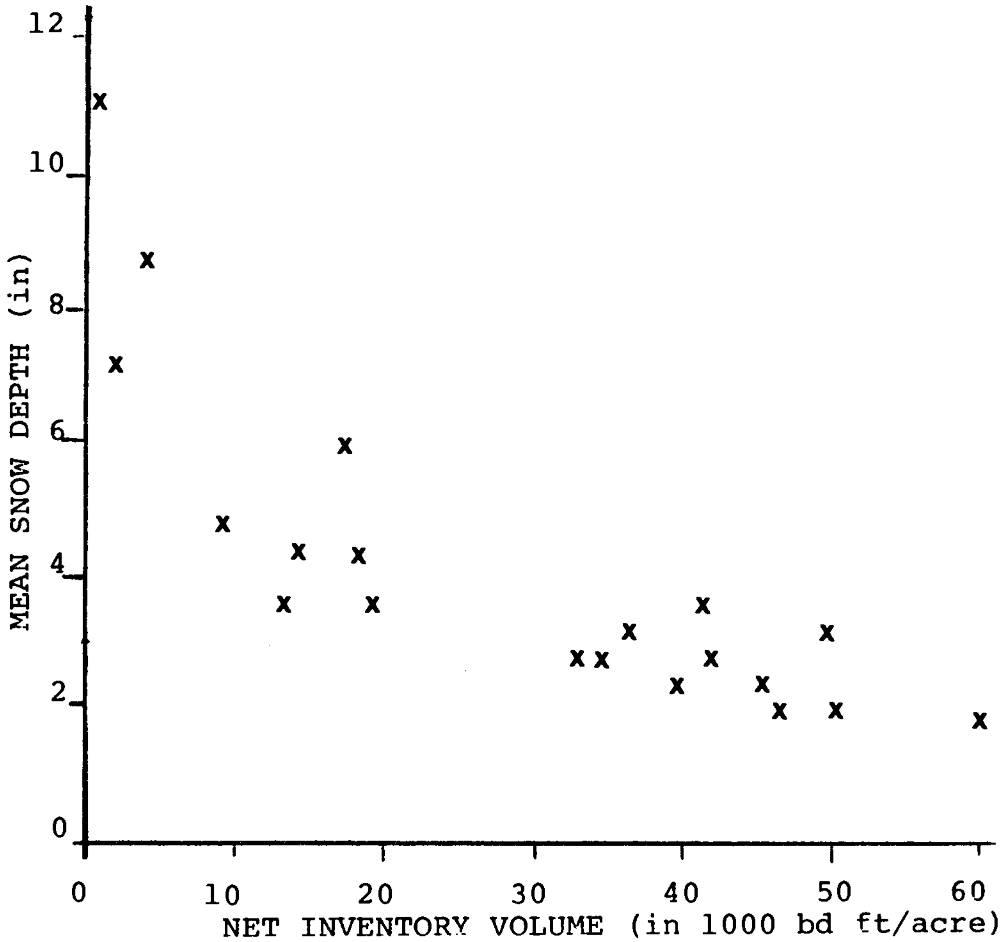

Fig. 4. Relationship between net inventory volume and mean snow depth in 20 stands, Mendenhall Peninsula, Juneau, December-February 1983-84. (Source: Kirchhoff and Schoen, 1985.)

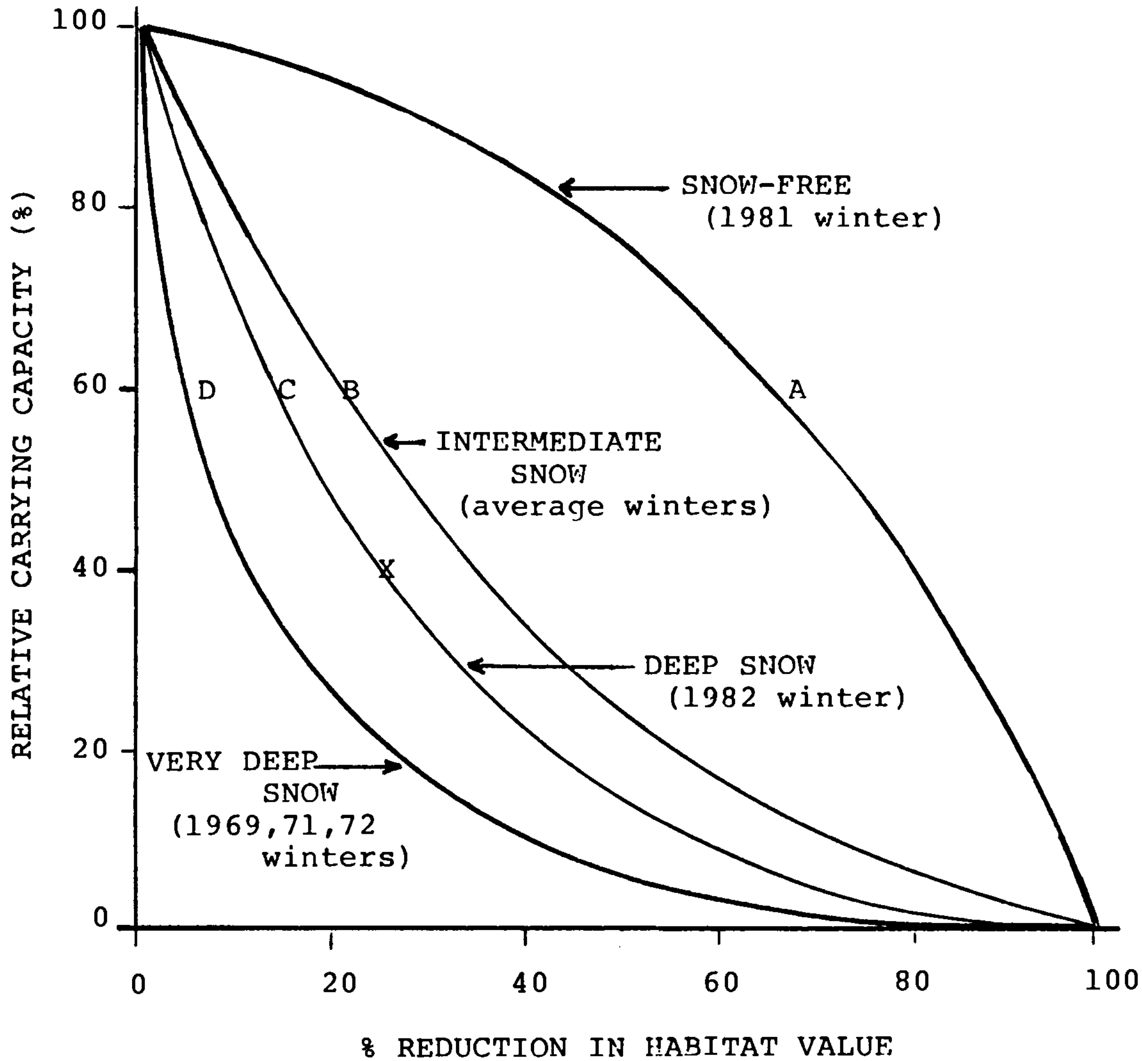

Fig. 5. Hypothesized relationship between habitat value and carrying capacity under various snow conditions. Point x represents a 60% decrease in carrying capacity corresponding to a 25% reduction in habitat value under deep snow conditions at Hawk Inlet, 1982.

Table 1. Extent of various land and timber types on the Tongass National Forest.[a]

Land/timber type	Acres	% of total
Nonforest land	5,851,433	38
Noncommercial forest (<8mbf/a)	4,431,849	29
Low Volume old growth (8-20mbf/a)	2,351,567	15
Mid-volume old growth (20-30mbf/a)	1,719,295	11
High-volume old growth (>30mbf/a)	647,912	4
2nd growth	317,377	2

[a]Source: U.S. Forest Service (1978).

Table 2. Monthly snowfall (inches) in Juneau, Sitka, Petersburg and Ketchikan during winters of 1968-69, 1970-71, and 1971-1972 from Climatological Data Summaries, National Weather Service.

		Juneau	Sitka	Petersburg	Ketchikan
1968-69					
Nov		7.3	4.0	2.5	ND[a]
Dec		42.2	47.0	38.9	ND[a]
Jan		29.8	27.0	38.8	38.0
Feb		15.6	15.5	18.5	21.5
Mar		10.3	7.3	7.2	0.0
Apr		0.0	tr[b]	0.4	0.0
	Totals	105.2	100.8	106.3	
1970-71					
Nov		10.7[c]	10.3	7.5	7.5[c]
Dec		27.3	27.4	57.0	31.5
Jan		43.2[c]	37.0	66.3	45.1
Feb		14.5	15.3	16.6	17.0
Mar		40.1	30.0	41.3	30.0
Apr		tr[b]	6.4	7.5	ND[a]
	Totals	135.8	126.5	196.3	
1971-72					
Nov		20.5	4.6	11.6	ND[a]
Dec		26.8	20.0	51.3	31.5
Jan		51.1	31.4	48.9	31.2
Feb		31.1	27.8	53.4	40.0
Mar		32.6	12.1	35.0	11.0
Apr		10.3	17.7	20.5	ND[a]
	Totals	172.4	113.6	220.7	

[a] ND = data not recorded.
[b] tr = trace amount.
[c] Data incomplete (3 or fewer days missing).

Table 3. Winter deer use relative to availability for 4 old-growth volume classes at Hawk Inlet, Admiralty Island, during high snowfall conditions, January-March 1982.

Volume class (mbf/acre)	Availability (%) N = 353[a]	Use (%) N = 108[b]	Use/ avail.	E[c]	Transformed value
< 8	26.8	1.9	0.07	-0.86	0.07
8-20	32.3	5.6	0.17	-0.70	0.15
20-30	33.0	27.8	0.84	-0.09	0.46
> 30	7.9	64.8	8.20	0.78	0.89

[a]Number of randomly sampled points on study area.
[b]Number of deer relocations.
[c]Electivity coefficient (Ivlev 1961).

Table 4. Winter deer use relative to availability for 4 old-growth volume classes at Hawk Inlet, Admiralty Island, during low snowfall conditions, January-March 1981.

Volume class (mbf/acre)	Availability (%) N = 353[a]	Use (%) N = 94[b]	Use/ avail.	E[c]	Transformed value
< 8	26.8	6.4	0.23	-0.61	0.20
8-20	32.3	23.4	0.72	-0.16	0.42
20-30	33.0	42.6	1.29	0.13	0.57
> 30	7.9	27.7	3.51	0.56	0.78

[a]Number of randomly sampled points on study area.
[b]Number of deer relocations.
[c]Electivity coefficient (Ivlev 1961).

Table 5. Winter deer use of 2nd-growth relative to old-growth forest on Chichagof and Admiralty Islands, 1978-1980[a].

Successional stage	Age	Ratio (young:old) $\bar{x}$	$\pm$ SE	No. comparisons
Clear-cut	0-25	0.322	0.13	14
2nd-growth	26-150	0.112	0.08	12

[a] From data presented in Wallmo and Schoen (1980) and Kirchhoff et al. (1982).

Table 6. Relative value[a] of 6 winter habitat types under snow-free, intermediate, and deep snow conditions in southeast Alaska.

Habitat Type	Winter Snow Conditions Snow-free	 Intermediate	 Deep
Clear-cut (0-25 yr)	0.57[a]	0.17	0.06
2nd-Growth (26-150 yr)	0.06	0.06	0.06
Noncommercial forest (<8 mbf/acre)	0.20	0.14	0.07
Low-volume old growth (8-20 mbf/acre)	0.42	0.29	0.15
Mid-volume old growth (20-30 mbf/acre)	0.57	0.52	0.46
High-volume old growth (>30 mbf/acre)	0.78	0.84	0.89

[a]Values (0-1) for old growth were derived from a habitat preference index for radio-collared deer under different snow conditions. Clear- cut and 2nd-growth volumes were derived from deer pellet group ratios in regrowth/ old growth.

Table 7. Comparison of predicted and measured habitat value indices for 6 watersheds on Admiralty and Chichagof Islands. Watersheds are ranked based on predicted value per acre under snow free, intermediate and deep snow conditions. Measured values are measured pellet group densities on the winter range.

Watershed (VCU)	Predicted Value Snow Levels Snowfree	Intermediate	Deep	Measured Value Pellet groups/Plot ($\bar{x}$ ± SE)	N plots
127	0.54	0.53	0.50	1.65 ± 0.06	1054
128	0.53	0.49	0.44	1.21 ± 0.05	1605
211	0.44	0.40	0.35	1.78 ± 0.08	757
247	0.39	0.32	0.25	1.17 ± 0.03	2145
125	0.37	0.32	0.26	1.07 ± 0.03	3567
208	0.31	0.25	0.18	1.11 ± 0.05	1155

Table 8. Rank order (high to low) of 6 VCU's based on predicted and measured habitat values during snowfree, intermediate, and deep snow conditions.

Measured VCU Order		Predicted VCU Order					
Admirality	Chichagof	Snow-free		Intermediate		Deep	
1982	1983	Admiralty	Chichagof	Admiralty	Chichagof	Admiralty	Chichagof
	211	127		127		127	
127		128		128		128	
128			211		211		211
	247		247		247	125	
	208	125		125			247
125			208		208		208

Table 9. Predicted changes in deer carrying capacity in the Kadashan drainage 25 years after logging, under snow-free, intermediate, and deep snow scenarios. Harvest schedules are those proposed by Alternatives 2, 4, and 6 in the Alaska Lumber and Pulp 1986-90 Timber Sale Operating Plan, (unpubl. draft).

	Acres to be cut				Reduction in carrying capacity (%)		
Alternative	8-20 (mbf)	20-30 (mbf)	>30 (mbf)	% Commercial forest land Scheduled	Snow-free	Intermediate	Deep snow
2	470	970	590	11	0	15	29
4	215	385	295	5	0	7	14
6	355	835	365	8	0	11	23

Appendix A. Predicted changes in deer populations over 100 years as a result of logging in southeast Alaska watersheds.

The data and assumptions used to generate this appendix follow:

1. The percent Commercial Forest Land (CFL) already harvested is based on the percentage of CFL classified in recent cutover status, seedling/sapling status, and pole-timber status as of the Tongass Land Management Plan (TLMP) land-type timber photo inventory in 1978. Since that inventory, approximately 65,000 additional acres have been harvested on USFS lands (data on file, USDA Forest Service, Region 10, Juneau).

2. The acres of each volume class scheduled for harvest are from Rideout et al. (1984). These figures reflect the TLMP data base as of 1980. Thus, some state- and native-owned acreages are included. For those Value Comparison Units (VCU's) so affected, the impacts on deer may vary, depending on whether the new owners schedule more or less of their lands for logging.

3. We display the percentage of CFL in each VCU "scheduled" for harvest whereas some sources refer to this percentage as "suitable" for harvest. In fact, the 2 are equivalent (Rideout et al. 1984). To meet the mandated harvest level of 4.5 billion board feet per decade on the Tongass (ANILCA, Sec. 705), all suitable acres must be harvested. As actual logging plans are developed, the amount of harvest in any 1 VCU can be lowered substantially, but only if the difference is picked up in another VCU.

4. In the following table, the percentage CFL scheduled <u>includes</u> the percentage already logged.

5. Since specific logging plans have not been developed for most of the VCU's, the model assumes that the total number of acres scheduled in each volume class will be harvested over 3 entries, 33 years apart. One third of the acres scheduled in each volume class are harvested in each entry.

6. Effects of logging on deer will vary with the frequency and severity of hard winters. Because we are dealing with long-term population responses, we assume deep snow winters will periodically be a factor throughout the archipelago. To focus on general population trends, we report the predicted deer remaining while assuming intermediate snow conditions. "Percent deer remaining" refers to the percentage of the long-term average population level prior to 1980. At any point in time, deer levels may actually be higher or lower than predicted, depending on recent weather conditions.

Appendix A. Table 1. Predicted changes in deer populations over 100 years as a result of logging in southeast Alaska watersheds.

VCU	#	PERCENT CFL ALREADY HARVESTED	PERCENT CFL SCHEDULED FOR HARVEST	PERCENT DEER REMAINING AFTER 100 YEARS
SAWMILL CREEK	17	0.0	17.0	75.1
CANYON CREEK	23	1.2	46.3	42.1
COWEE CREEK	24	0.0	41.6	41.4
ECHO COVE	25	0.0	43.5	31.4
RHINE CREEK	38	8.4	38.8	62.7
TAKU INLET	41	0.0	28.8	66.5
LONG LAKE	50	0.0	8.0	96.9
SLOCUM INLET	51	0.9	55.6	28.7
TAKU HARBOR	52	1.1	50.1	35.6
LIMESTONE INLET	53	0.0	10.7	86.8
WEBSTER PEAK	54	0.0	19.6	71.6
PORT SNETTISHAM	55	0.0	19.9	83.4
MEIGS PEAK	56	0.0	6.7	90.8
GILBERT BAY	57	0.0	56.7	42.4
SPEEL ARM	58	0.0	54.4	68.2
WHITING RIVER	61	0.0	46.8	61.9
SAND BAY	68	0.0	75.7	17.7
DRY BAY	69	0.0	59.4	36.0
PT WINDHAM	70	0.0	38.1	52.5
WINDHAM BAY	71	0.0	68.6	43.4
WINDHAM CREEK	72	0.0	73.3	35.7
SUNSET ISLAND	73	0.0	66.3	26.2
LIBBY CREEK	74	0.0	72.9	21.6
HOBART BAY	75	0.0	75.8	29.5
CHUCK RIVER	76	0.0	32.2	63.5
HOBART CREEK	77	0.0	62.6	59.4
SALT CHUCK	79	0.0	71.1	54.2
ALICE LAKE	80	0.0	93.1	31.6
PT HOT	81	0.0	69.4	39.3
NEGRO LAKE	82	0.0	81.7	19.5
PORT HOUGHTON	83	0.0	93.7	26.7
SANDBORN CANAL	84	0.0	77.1	31.8
FIVE FINGERS	85	0.0	54.3	37.9
FANSHAW	86	0.0	55.7	48.5
CAT	87	0.0	53.8	44.3
TANGENT	88	0.0	47.2	41.8
BAY POINT	89	0.0	58.8	44.3
SULLIVAN ISLAND	94	7.9	83.2	15.9
SULLIVAN MOUNTAIN	95	13.3	72.6	43.1
S DAVIDSON GLACIER	96	75.1	100.0	27.5
WEST SULLIVAN	97	20.0	100.0	48.0
SULLIVAN DELTA	98	0.0	67.5	74.3
PT CAN	99	0.0	85.0	95.4
WILLIAM HENRY BAY	107	0.0	49.6	78.5
NUN MOUNTAIN	112	0.0	64.4	58.9
LYNN SISTERS	113	0.0	78.4	17.4
NO NAME BASIN	114	0.0	32.7	76.0
EARTH STATION	115	0.0	45.4	59.3
COUVERDEN LAKE	116	0.0	31.3	76.0
COUVERDEN ISLAND	117	0.0	41.9	87.2
ANSLEY BASIN	118	0.0	76.9	35.4
HUMPY CREEK	119	0.0	51.2	51.8
PORPOISE ISLAND	120	9.0	76.7	70.9
EXCURSION INLET	121	0.0	19.2	71.5
122 CREEK	122	54.3	98.6	26.6

Appendix A. Table 1. Continued.

VCU	#	PERCENT CFL ALREADY HARVESTED	PERCENT CFL SCHEDULED FOR HARVEST	PERCENT DEER REMAINING AFTER 100 YEARS
RIPOFF	123	50.0	78.0	29.9
BARLOW COVE	125	2.0	48.3	60.6
FUNTER BAY	126	0.0	50.2	38.4
CALM STATION	127	0.0	33.2	45.1
HAWK INLET	128	5.1	78.6	12.6
LONE MOUNTAIN	129	0.0	61.9	27.0
HORSE MOUNTAIN	130	13.0	57.8	46.4
FOWLER CREEK	131	1.7	76.0	12.1
YOUNG BAY	132	0.0	48.4	37.8
EAGLE PEAK	133	0.0	60.5	23.3
MOUNT ALTHROP	188	0.0	51.9	68.7
PORT ALTHROP	189	0.0	54.1	40.9
GULL COVE	191	0.0	74.5	34.4
GOOSE ISLAND	192	0.0	59.2	44.1
MUD BAY	193	0.0	57.6	35.2
LOON LAKES	194	0.0	65.9	9.0
PT ADOLPHUS	195	0.0	73.4	13.3
CHICKEN CREEK	196	0.0	64.4	32.6
EAGLE POINT	197	0.0	57.3	28.5
FLYNN COVE	198	3.3	64.4	23.8
HUMPBACK CREEK	200	1.3	58.5	23.8
NEKA BAY	201	2.6	65.2	29.8
PORT FREDERICK	202	2.4	47.0	37.7
SEAGULL CREEK	203	0.0	67.1	35.9
GAME CREEK	204	4.7	64.6	30.4
GARTINA CREEK	205	4.5	66.3	34.8
SPASSKI CREEK	207	0.0	62.4	18.8
FIRST NO 2	208	0.0	58.4	39.4
SUNTAHEEN CREEK	209	0.0	52.7	36.9
FALSE BAY	210	0.0	83.3	16.6
PT AUGUSTA	211	0.0	54.6	29.4
GYPSUM CREEK	212	1.6	60.6	27.9
IYOUKEEN PENINSULA	213	4.4	42.4	38.2
SEAL CREEK	214	3.3	49.2	35.0
FRESHWATER BAY	215	1.9	57.2	29.1
FRESHWATER CREEK	216	0.0	72.5	18.8
KENNEL CREEK	217	4.7	63.6	16.0
PAVLOF RIVER	218	4.4	73.4	22.4
PT CANNERY	219	6.1	69.1	25.5
TENAKEE SPRINGS	220	2.4	66.7	17.5
WHIP STATION	221	13.0	50.8	26.6
SAND STATION	222	6.7	66.6	21.3
GOOSE VIEW	223	0.0	48.2	49.2
TENAKEE INLET	224	7.1	42.3	61.2
LITTLE GOOSE FLATS	225	0.0	51.4	44.7
GOOSE FLATS	226	0.0	49.2	39.5
HUB STATION	227	0.0	58.4	26.5
BETH STATION	230	2.6	71.2	29.6
SALTERY BAY	231	3.5	61.8	32.3
CRAB BAY	232	5.9	67.0	32.5
SOUTH CRAB BAY	233	0.0	59.7	38.0
INBETWEEN	234	0.0	81.1	12.5
KADASHAN	235	1.1	64.1	24.0
CORNER BAY	236	21.9	66.7	22.2
TRAP BAY	237	2.7	63.0	18.1

Appendix A. Table 1. Continued.

VCU	#	PERCENT CFL ALREADY HARVESTED	PERCENT CFL SCHEDULED FOR HARVEST	PERCENT DEER REMAINING AFTER 100 YEARS
SOUTH PASSAGE	238	0.0	55.0	27.3
KOOK LAKE	239	12.2	39.6	58.7
LITTLE BASKET BAY	240	0.0	43.6	44.5
DO 2 STATION	241	2.8	54.6	36.6
WHITE ROCK	242	19.3	81.0	17.9
SITKOH BAY	243	11.3	70.0	24.8
SITKOH LAKE	244	37.3	79.0	27.8
FALSE ISLAND	245	30.0	76.6	17.0
BROAD ISLAND	246	1.4	52.1	42.4
FINGER MOUNTAIN	247	0.0	53.2	34.3
916 LAKE	248	0.0	45.1	63.7
LISIANSKI RIVER	249	0.0	62.9	35.1
PHONOGRAPH CREEK	250	0.0	57.9	31.9
TARN MOUNTAIN	252	0.0	47.3	49.1
MITE COVE	253	0.0	46.1	49.5
TAKANIS LAKE	256	0.0	29.3	65.3
BOHEMIA BASIN	257	0.0	58.1	38.6
LISIANSKI STRAIGHT	258	0.0	46.2	71.9
APEX-EL NIDO	260	0.0	35.9	56.0
LISIANSKI RIDGE	262	0.0	64.2	37.5
RAPIDS POINT	279	0.0	56.8	30.6
DEEP BAY	280	0.0	48.3	44.1
USHK BAY	281	10.0	60.5	36.3
FICK COVE	282	10.4	73.9	29.2
PATTERSON BAY	283	3.1	55.8	37.1
SOUTH ARM	285	0.0	32.5	55.2
MOSER ISLAND	286	0.0	27.6	66.2
FISH BAY	287	10.7	47.2	55.1
RANGE CREEK	288	0.0	64.1	47.2
NIXON SHOAL	289	0.0	63.6	31.6
COZAIAN REEF	290	10.5	65.4	37.3
PESCHANI POINT	291	22.1	64.6	29.2
RODMAN BAY	292	30.3	61.3	34.6
APPLETON COVE	293	17.6	68.0	32.1
SADOK BAY	294	7.5	61.8	27.1
PORTAGE ARM	296	8.8	53.5	35.7
CATHERINE ISLAND	297	8.1	72.8	26.6
MIDDLE ARM	298	7.1	65.0	29.3
ANNAHOOTZ MOUNTAIN	299	34.1	62.2	45.3
NAKWASINA PASSAGE	300	20.5	44.8	55.9
NAKWASINA SOUND	301	33.3	61.0	40.1
NEVA STRAIT	302	5.0	61.0	34.0
SUKOI STRAIGHT	303	11.2	65.8	29.6
SINITSN BAY	304	0.0	85.5	12.7
SEALION COVE	305	0.0	34.5	49.2
GILMER BAY	306	16.4	56.9	27.0
CURACA COVE	307	34.8	83.7	13.0
MOUNT EDGECUMBE	308	1.6	35.2	59.4
KRESTOF SOUND	309	15.5	71.2	29.9
KATLIAN BAY	312	19.4	48.7	40.2
KATLIAN RIVER	313	31.3	66.3	33.6
GLACIAL RIVER	314	2.6	38.0	52.2
KELP BAY	315	7.1	75.6	14.4
BLUE LAKE	318	0.0	30.0	61.0
SUGARLOAF MOUNTAIN	319	3.7	50.1	27.0

Appendix A. Table 1. Continued.

VCU	#	PERCENT CFL ALREADY HARVESTED	PERCENT CFL SCHEDULED FOR HARVEST	PERCENT DEER REMAINING AFTER 100 YEARS
ALEUTKINA BAY	320	2.3	52.9	38.4
REDOUBT BAY	321	0.0	62.0	24.4
DEEP INLET	322	0.0	45.1	46.3
SALMON LAKE	323	0.0	74.8	15.2
GREEN LAKE	324	0.0	26.3	63.5
YAKUTAT	367	22.6	22.9	77.5
ITALIO RIVER	379	24.9	27.1	96.9
TRIANGLE LAKE	382	0.6	12.9	85.3
USTAY RIVER	387	56.7	58.4	85.9
TANIS MESA	389	27.1	27.8	94.3
KEKU	398	14.1	74.8	39.0
SAGINAW	399	15.4	54.8	38.1
SECURITY	400	13.7	69.8	23.0
WASHINGTON	401	0.9	25.7	67.2
ROWAN	402	8.7	64.1	27.0
MALMSVRY	408	2.9	46.4	40.9
BEAR	409	0.0	42.0	57.2
TABLE	410	5.6	27.7	69.8
KELL	411	3.5	46.8	55.2
MCARTHUR	412	3.5	26.4	77.8
AFFLECK	413	0.0	33.5	77.2
AMELIUS	414	1.1	66.2	33.7
BEAUCLERC	415	1.2	54.4	44.7
ALVIN	416	2.9	70.5	30.3
NO NAME	417	5.1	36.4	31.9
LAGOON	418	2.5	53.3	38.6
THREE MILE	419	4.8	58.0	32.8
CAMDEN	420	0.9	58.5	40.0
KADAKE	421	5.0	68.6	27.6
TURN	422	2.6	31.2	50.3
KAKE	423	23.8	67.0	20.4
BOHEMIA	424	0.6	54.9	55.4
CATHEDRAL	425	30.0	85.0	27.1
HAMILTON	426	0.0	77.0	46.7
IRISH	429	1.2	69.5	54.1
LOVELACE	430	4.4	50.1	67.0
BARRIE	431	26.3	66.1	61.7
TOTEM	432	4.3	54.2	70.9
DOUGLAS	433	24.5	82.0	55.9
KAH SHEETS	434	25.0	81.2	51.1
CASTLE ISLAND	435	1.3	52.7	45.7
CASTLE RIVER	436	0.0	64.6	29.0
MITCHELL	437	2.7	76.1	22.0
INDIAN	438	0.0	66.5	52.4
DUNCAN	439	0.9	65.1	35.1
TOWERS	440	1.1	55.0	56.7
PORTAGE	442	2.7	63.3	30.6
KANE	443	2.8	60.0	24.2
12 MILE	444	1.0	65.0	26.0
SOKOL	446	1.0	54.0	34.1
NARROWS	447	7.6	59.2	35.0
WOEWODSKI	448	4.5	65.8	32.2
FREDERICK	449	0.0	65.3	20.8
MITKOF	450	16.9	74.9	19.5
CRYSTAL	451	12.7	50.9	47.1

Appendix A. Table 1. Continued.

VCU	#	PERCENT CFL ALREADY HARVESTED	PERCENT CFL SCHEDULED FOR HARVEST	PERCENT DEER REMAINING AFTER 100 YEARS
SUMNER	452	13.8	51.3	47.3
IDEAL	453	11.7	62.4	32.9
DRY	454	16.9	68.0	24.4
VANK	455	37.8	78.1	27.7
VANK	455	37.8	78.1	21.6
BAHT	456	22.8	69.9	30.1
ST. JOHN	457	27.3	75.9	33.9
SNOW	458	6.1	75.5	29.5
METER	459	8.5	59.0	42.2
SHRUBBY	460	34.1	82.1	23.4
WORONKOFSKI	461	17.4	49.6	48.7
CHICHIGOF	462	1.9	55.7	32.0
KUNK	463	1.4	64.9	27.9
ANITA	464	1.4	64.8	27.9
QUIET	465	0.0	58.6	35.2
STEAMER	466	10.6	52.8	49.9
MOSMAN	467	3.5	58.0	34.5
BURNETT	468	0.0	41.7	45.5
OLIVE	469	0.0	62.5	29.6
ZIMOVIA	470	1.5	79.9	19.4
EASTERN	476	0.0	54.3	37.2
NEMO	477	15.2	70.7	30.4
VENUS	478	0.0	56.2	40.2
THOMS	479	0.0	70.1	28.5
FOOLS	480	0.0	42.7	50.8
JEFFERSON	483	0.0	35.8	51.9
SPURT	484	9.7	23.0	87.6
SWAN	486	10.2	28.8	72.4
THOMAS	487	26.9	71.0	37.1
MUDDY	489	16.8	47.2	51.2
GARNET	501	0.0	32.1	61.4
VIRGINIA	502	0.9	18.4	75.3
BERG	503	0.0	28.5	59.1
MADAN	504	0.0	48.7	38.2
BIAKE	505	0.7	53.4	45.7
CAMPBELL	510	0.0	17.9	74.7
BRADFIELD	514	12.9	46.4	39.7
CLOUD	515	0.0	35.7	74.3
GLACIER	516	10.9	16.5	91.1
EAST FORK	517	3.5	33.1	50.9
HOYA	520	0.0	24.1	72.3
CANAL	521	0.0	30.5	61.6
FROSTY	524	1.0	38.1	52.3
DEER ISLAND	525	1.0	48.3	37.2
SUNNY	526	1.2	34.1	61.3
PROTECTION	527	0.0	51.7	28.8
MT. CALDER	528	1.2	72.7	14.6
ALDER	529	1.3	78.9	8.8
BUSTER	530	5.2	73.2	16.8
SHAKAN	531	3.6	63.4	23.2
RED BAY	532	14.2	46.7	45.1
RED LAKE	533	0.0	35.9	52.4
SALMON BAY	534	6.6	55.4	34.8
LAVA	535	0.0	80.7	18.3
DRY PASS	536	0.9	50.1	33.3

Appendix A. Table 1. Continued.

VCU	#	PERCENT CFL ALREADY HARVESTED	PERCENT CFL SCHEDULED FOR HARVEST	PERCENT DEER REMAINING AFTER 100 YEARS
EL CAPITAN	537	10.1	72.0	19.1
108 CREEK	538	52.5	93.4	10.1
EXCHANGE	539	1.3	84.1	9.2
RAGGED COVE	540	9.6	86.5	15.4
SHIPLEY	541	0.0	50.1	33.8
DEVIL FISH	542	2.1	42.9	42.4
TROUT CK.	543	23.6	85.0	8.9
CAPE POLE	544	54.9	95.9	5.3
SURVEY CK.	545	69.1	88.5	26.0
EDNA BAY	546	38.4	100.0	6.1
DAVIDSON INLET	547	0.0	68.6	27.0
HOLBROOK MOUNTAIN	548	0.0	50.7	34.4
SARHEEN	549	13.0	67.5	33.0
NECK LAKE	550	37.2	82.4	15.0
WHALE PASS	551	10.2	23.7	77.8
BARNES LAKE	552	9.0	58.0	32.1
MABEL CREEK	553	0.0	89.9	22.4
TOKEEN	555	16.8	84.4	9.6
NEW TOKEEN	556	18.1	75.6	10.7
TUXEKAN NARROWS	557	25.5	89.6	5.5
SEA OTTER	558	27.8	87.1	8.1
TONOWEK	559	20.9	86.5	7.9
KARHEEN	560	19.0	80.5	9.8
WARM CHUCK	561	14.7	81.6	9.7
CONE BAY	562	5.5	87.7	4.6
DERRUMBA	563	2.4	42.4	44.7
NOYES	567	0.0	48.1	37.6
LULU	568	0.0	26.3	75.5
BAKER	569	0.4	36.0	53.6
PORT ALICE	570	70.2	96.7	9.4
NAUKATI BAY	571	9.7	91.1	7.1
COFFMAN COVE	572	26.1	88.4	10.9
SWEETWATER	573	2.0	52.7	32.9
HATCHERY CREEK	574	4.3	70.4	21.4
THORNE LAKE	575	0.8	69.5	23.8
CUTTTHROAT	576	0.0	60.6	33.3
LOG JAM	577	7.4	88.9	10.9
SNAKEY LAKES	578	0.0	92.3	4.7
FALLS CREEK	579	42.9	81.8	24.9
NORTH THORNE	580	1.6	55.6	32.2
LUCK LAKE	581	32.9	75.5	25.4
BAIRD PEAK	582	0.0	52.6	33.3
RATZ	583	25.2	68.4	29.2
LITTLE RATZ	584	28.3	61.5	39.2
NARROW POINT	585	53.2	90.7	18.0
THORNE BAY	586	35.7	68.7	28.8
TUXEKAN PASSAGE	587	19.0	84.0	8.7
STANEY	588	28.4	77.9	18.1
SHAHEEN	589	0.7	64.1	26.6
UPPER STANEY	590	22.8	71.1	24.9
NOSSUK	591	2.0	73.3	18.5
ST. PHILLIP	592	0.0	57.4	43.6
SOMBRERO	593	0.0	31.9	74.4
SHINAKU	594	0.0	66.8	38.8
STEELHEAD	595	1.2	26.3	28.6

Appendix A. Table 1. Continued.

VCU	#	PERCENT CFL ALREADY HARVESTED	PERCENT CFL SCHEDULED FOR HARVEST	PERCENT DEER REMAINING AFTER 100 YEARS
CONTROL	596	0.0	86.2	15.2
GOOSE CREEK	597	10.5	76.1	22.8
SALT CHUCK	598	8.5	78.5	13.2
TOLSTOL	599	9.1	78.4	13.2
WINDFALL HBR	600	7.5	17.6	33.3
KASAAN	601	5.8	40.7	4.8
STREETS ISL.	602	4.3	53.5	44.9
GRINDALL	603	0.0	47.2	66.7
CLIFFS	604	28.6	65.3	62.6
KLAWOCK MTN	609	0.0	15.3	85.7
MAYBESO	610	43.2	53.9	61.5
OUTER POINT	611	12.1	63.8	26.2
KINA	612	24.4	80.4	23.3
OLD FRANK'S	613	6.1	67.3	36.5
SALTERY COVE	614	0.0	76.7	27.9
TROLLERS COVE	615	0.0	78.2	45.1
CLOVER LAKE	616	0.0	63.7	36.0
CLOVER BAY	617	0.0	42.7	69.2
MCKENZIE	618	2.4	38.9	50.8
POLK	619	1.2	66.2	23.2
DOG SALMON	620	6.5	64.4	23.7
12 MILE	621	36.7	84.2	21.1
HARRIS RIVER	622	27.3	72.4	31.5
ST. NICHOLAS	623	2.3	14.1	49.8
FLAT CREEK	624	16.1	31.5	45.7
TROCADERO	625	4.5	20.8	55.9
PALISADE	626	0.0	61.1	61.1
PT. POLOCANO	627	0.0	48.9	67.4
PT. AMAGURA	628	0.0	35.6	73.6
PORT ESTRELLA	630	1.7	32.6	56.4
SHELIKOFF	631	6.5	56.1	53.1
SODA BAY	632	6.0	81.7	26.4
CABRAS	633	0.0	80.3	35.4
SANTA CRUZ	634	1.0	68.0	22.1
PORT REFUGIO	635	0.0	77.6	25.4
ARENA COVE	636	1.8	63.7	29.3
MEARES	637	0.0	29.0	57.5
TLEVAK	638	0.0	46.6	42.9
BOB'S BAY	639	0.0	62.5	30.8
DIVER BAY	640	0.0	59.5	23.4
FOUL BAY	641	0.9	5.0	61.8
MANHATTAN	642	0.0	33.4	56.8
SAKIE	643	2.6	22.6	68.0
FISHERMAN COVE	644	2.3	20.5	69.0
COCO HARBOR	645	1.3	49.1	39.0
DEVIL LAKE	646	0.0	50.9	25.4
WELCOME	647	0.0	46.8	35.8
WATERFALL BAY	648	0.0	57.1	29.2
HIGH POINT	649	0.0	22.3	37.4
ROSE INLET	650	0.0	73.0	21.2
GOLD HARBOR	651	0.0	47.2	34.6
GOOSENECK	653	2.6	58.2	51.1
GRACE HARBOR	654	6.3	93.6	9.6
RITTER POINT	655	12.3	23.2	69.4
PAT BAZAN	656	10.1	59.0	20.3

Appendix A. Table 1. Continued.

VCU	#	PERCENT CFL ALREADY HARVESTED	PERCENT CFL SCHEDULED FOR HARVEST	PERCENT DEER REMAINING AFTER 100 YEARS
ESSOWAH	659	0.0	70.2	27.0
POND BAY	660	0.0	71.6	18.7
SECURITY COVE	661	0.0	46.3	47.2
KAIGANI	662	0.0	62.7	34.8
DATZKOO	663	3.1	59.9	27.6
MCLEAD BAY	666	0.0	36.4	53.3
KOINGLAS	668	5.2	70.5	21.8
JACKSON	670	2.3	22.1	51.1
DUNBAR	671	0.0	58.0	47.3
HYDABURG	672	2.9	67.4	30.9
HETTA	673	2.7	28.6	56.2
WEST ARM	674	3.2	32.7	47.8
SUNNY	675	0.0	41.5	53.0
N CHOMLY	676	0.0	82.7	33.6
DORA BAY	677	2.8	50.9	31.5
SOUTH ARM	678	3.8	67.0	18.7
LANCASTER	679	2.8	66.7	14.3
WINDY POINT	680	0.0	88.6	9.5
DOLOMI	681	4.0	86.8	7.3
NORTH MOIRA	682	0.9	62.6	24.0
MYRTLE	683	0.0	59.3	32.0
NUTKWA	685	3.3	46.5	38.6
NUTKWA CREEK	686	0.8	47.0	37.2
HASSIAH	688	0.0	39.8	49.1
KASSA	689	4.3	30.9	57.8
WEST MOIRA	691	0.0	19.6	72.1
BOKAN	692	0.8	44.0	45.9
EGG	693	2.9	67.4	19.7
INGRAHAM	694	0.0	57.8	31.8
HIDDEN BAY	695	0.0	37.6	43.8
KENDRICK	699	0.0	37.2	58.0
SHORT ARM	700	0.0	44.4	38.4
MCCLEAN	701	0.0	43.3	50.1
STONE ROCK	702	0.0	29.3	68.9
CHACON	703	0.0	7.3	90.0
NICHOLS BAY	704	6.0	40.3	60.6
MEYERS CHUCK	708	8.3	54.5	37.5
UNION BAY	709	0.8	61.5	30.3
CANNERY CREEK	710	0.0	65.3	22.8
NO NAME	711	0.0	78.9	18.2
RAINBOW	712	1.4	61.9	38.0
CAAMAND	713	3.8	41.4	48.5
BOND	714	6.7	58.9	46.6
SMUGGLERS	715	0.0	53.0	41.1
HELM BAY	716	3.7	52.0	41.3
GRANITE CREEK	717	0.0	61.9	36.9
VIXEN LAKE	718	0.0	74.5	29.3
PORT STEWART	719	0.7	58.4	36.1
VIXEN INLET	720	0.0	78.1	26.9
EMERALD	721	0.0	73.9	22.0
SPACIOUS BAY	722	0.6	56.5	43.9
HECKMAN	723	0.0	48.1	40.3
KLU	732	0.0	18.1	76.6
SHRIMP BAY	733	10.8	46.9	45.3
ORCHARD	734	0.7	51.3	41.8

Appendix A. Table 1. Continued.

VCU	#	PERCENT CFL ALREADY HARVESTED	PERCENT CFL SCHEDULED FOR HARVEST	PERCENT DEER REMAINING AFTER 100 YEARS
MASSLER	735	14.9	54.8	38.8
NEETS	736	14.2	62.5	31.3
FIRE COVE	737	25.9	62.1	33.7
MARGARET	738	17.9	58.1	38.9
TRAITORS	739	7.5	43.8	47.3
FRANCIS COVE	740	11.9	55.5	41.8
LORING	741	0.0	40.5	44.2
MOSER	743	1.6	37.6	61.7
CARROLL RIVER	744	8.5	43.0	51.0
SWAN	745	0.9	3.6	95.8
CARROLL INLET	746	7.9	54.8	36.5
SALT LAGOON	747	10.0	47.8	49.5
GEORGE INLET	748	4.6	12.1	62.9
WHIPPLE CREEK	749	1.5	42.4	19.4
GNAT	753	13.9	59.5	39.1
MINX	756	14.5	74.0	19.7
THORNE ARM	757	1.2	51.9	37.9
MOTH BAY	759	0.0	18.7	86.5
HYDER	806	8.4	35.6	74.4
CLOVER PASS	864	0.0	40.9	34.2
GRAND ISLANDS	865	0.0	22.5	63.9