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Research Progress Report

EFFECTS OF FOREST FRAGMENTATION ON DEER IN SOUTHEAST ALASKA

by
Matthew D. Kirchhoff
Project W-23-3
Study 2.10
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Effects of Forest Fragmentation on Deer in Southeast Alaska

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SUMMARY

As logging causes residual stands of old growth to become smaller and more insular, their value to Sitka black-tailed deer (Odocoileus hemionus sitkensis) during the winter is expected to decline. To examine this hypothesis, 103 islands of varying size and remoteness were selected in Sea Otter Sound, near northern Prince of Wales Island. During the springs of 1989 and 1990 measurements of pellet-group densities and browse utilization were made to reflect relative deer density on each island. Detailed data were also collected on the structure and composition of the overstory and understory. Quantitative data on spatial habitat attributes (e.g., island size, shape, and insularity) are still being gathered.

A total of 2,341 pellet-group and vegetation plots were sampled. Pellet-group densities ranged from zero on some islands to over eight per plot on other islands, with considerable year-to-year variation on 30-40% of the islands. Preliminarily, pellet-group densities appear unrelated to island size, overstory characteristics, or understory composition and abundance. Islands with the highest pellet-group densities and the greatest browsing pressure were generally found in the southwest part of the study area, suggesting that deer habitat choices are expressed on a larger scale. Such choices may hinge on finding security from predators as well as availability of a sufficient quantity and quality of food.

Twig dimension-biomass regressions will be developed from samples collected in 1990, and the availability and use of browse will be examined as a complementary index of deer density. In addition, time will be spent in the study area during midwinter to gather information from track counts on deer and wolf use and movements among the various island groups.

Key words: biogeography, black-tailed deer, browse, fragmentation, islands, *Odocoileus hemionus sitkensis*, old growth, pellet-groups, Southeast Alaska.

CONTENTS

INTRODUCTION

Sitka black-tailed deer (<u>Odocoileus hemionus sitkensis</u>) are expected to decline in Southeast Alaska as 4,000 to 8,000 ha (15-30 mi^2) of old-growth forest, much of it important deer winter range, are logged on federal, state, and private lands each year (Wallmo and Schoen 1980, Fagen 1988). On federal lands alone, 200,000 ha (780 mi^2) of old growth have already been logged; an additional 0.7 million ha (2,750 mi^2) are scheduled for eventual harvest. On the average, this level of logging will remove over half of the commercial old growth in all entered drainages and up to 98% of the commercial old growth in the most heavily logged drainages (Schoen et al. 1985).

Much of this logging activity is concentrated along the lower slopes of steep hillsides, potentially restricting elevational movement by deer during the winter (Schoen and Kirchhoff 1985). As residual patches of old growth shrink in size and become more insular, their value to deer is expected to decline. In Southeast Alaska, Samson et al. (1989) pointed out the need for landscape planning and offered examples of cutting patterns to minimize fragmentation and loss of important wildlife habitat. The objective of this research is to determine how habitat attributes such as patch size, shape, and insularity affect the value of landscapes for deer. Data collected in the spring of 1989 (Kirchhoff 1990) have relevance to this work and are also included.

BACKGROUND

Habitat fragmentation has traditionally not been a concern of wildlife managers. Many popular game species, including deer, benefit from increased "edge", and in the past managers have tried to maximize habitat interspersion, juxtaposition, and "fragmentation" to wildlife's advantage (Leopold 1933, Brown 1961). Biologists today, however, find natural ecosystems shrinking rapidly and many wildlife species seriously threatened.

Many long-standing tenets of game management, particularly those promoting the value of early successional forest stages and edge, are being critically reevaluated (Schoen et al. 1981, Kirchhoff et al. 1983, Reese and Ratti 1988).

Recent concerns about habitat fragmentation are based on island biogeographic theory (MacArthur and Wilson 1967), which postulates that the richness of species on an island is controlled by an equilibrium between immigration and emigration. Extensive empirical data show that the number of species typically increases with increasing island area (i.e., the "area effect") and decreases with increasing insularity of islands (i.e., the "distance effect"). By extension, these same principles have been found applicable to habitat fragments or "islands" in a terrestrial setting, such as woodland patches surrounded by agricultural lands (Burgess and Sharpe 1981, Brown and Gibson 1983). These principles hypothetically apply to old-growth reserves surrounded by clear-cuts as well (Harris 1984, Rosenburg and Raphael 1986).

In one of the few published studies of island biogeography and deer, Picton and Mackie (1980) found that mule deer (O. h. hemionus) populations on large montane islands in Montana had lower turnover rates than populations inhabiting small islands. The results suggested that a single large reserve provides higher-quality habitat than several small reserves of the same total area. In Southeast Alaska, biologists have measured higher deer mortality in old-growth retention areas isolated by clear-cuts than in nearby extensive old growth (Schoen et al. 1979, ADF&G files). These observations also suggested that large reserves provide higher-quality habitat. Although neither study measured deer survival or population density directly, the results indicated a likely relationship between habitat quality and patch size, shape, and location.

Identifying specific attributes of high-quality habitat assumes one can objectively and reliably measure habitat quality. Fagen (1988) assumed that habitat quality was positively correlated with deer density, at least during limiting seasons or years. In this study, deer density is determined by measuring both fecal pellet-group densities (Neff 1968) and browse utilization (Shafer 1963, Pitt and Schwab 1988) in various habitat patches. Because both techniques measure persistent indicators of deer presence, not deer themselves, density estimates reflect cumulative use over a relatively long period of time. In Southeast Alaska fecal deer pellets last from 7 to 11 months, depending on rainfall, temperature, and exposure (Fisch 1979, Rose 1982, Kirchhoff 1990). Browsed twigs can persist in a green condition for over 3 years, depending on the plant species, season of browsing, and severity of browsing (ADF&G files).

Despite known limitations, pellet-group counts remain the best method available for assessing relative deer numbers in Southeast Alaska (Kirchhoff and Pitcher 1988; Kirchhoff 1989, 1990). With resident deer, pellet-group counts and browse surveys probably provide a reasonably good indicator of the amount of year-round use (i. e., average deer density) a habitat receives. Using standard pellet-group sampling techniques on a small island with a known-size resident deer population, Kirchhoff (1990) found that the mean density in deer/km^2 is equivalent to the mean pellet-group density (per 20-m^2 plot) times 12; the mean deer density in deer/mi^2 is equivalent to mean pellet-group density times 32.

Inventories of browse production and utilization can provide complementary information on carrying capacity and population density of certain habitats for deer (Anderson et al. 1972, Telfer 1981). Inventory methods range from reconnaissance techniques and weight estimates to clip-and-weigh methods. Reconnaissance estimates are rapid, but they are hindered by observer and statistical bias. Although clip-and-weigh methods (Schwan and Swift 1941) yield highly accurate results, they are costly, tedious, and destructive (Lyon 1970). The twig-count method (Shafer 1963) used in this study has several important advantages. It is as accurate as the clip-and-weigh method and about as fast as the weight estimation method; also because the results are counts and not estimates, data can be analyzed (Shafer 1963).

By use of an average weight per twig for individual species, the twig-count method converts counts of browsed twigs to weight of browse consumed. The relationship is developed by clipping a wide sample of twigs and regressing biomass as a function of basal twig diameter (Shafer 1963, Telfer 1969); however, as Pitt and Schwab (1990) noted, correlations among shrub dimensions, browse production, and use may be highly variable, depending on (1) time of year the twigs are collected (Potvin 1981), (2) geographical location (Basile and Hutchings 1966), (3) site conditions at time of sampling (Peek et al. 1971, (4) portion of crown from which the sample was collected (Lyon 1970), and (5) age of twig (Telfer 1969). Variability with respect to site and stand age has also been demonstrated in Southeast Alaska (Alaback 1986, 1987).

STUDY AREA

The initial phase of the study focuses on biogeographic relationships between deer and habitat on true islands. Sea Otter Sound in southern Southeast Alaska (Fig. 1) contains hundreds of small islands ranging in size from less than 1 ha to more than 1,000 ha. Topographic and vegetative characteristics are similar on most islands, but the size, shape, and remoteness of the islands vary widely. Soils are very productive, particularly on the surrounding large islands (i.e., Kosciusco, N. Prince of Wales, and Heceta). In the 1960's and 1970's extensive clear-cutting occurred on the major islands within the sound (i.e., Tuxekan, Marble, Orr, Hoot, Owl, Eagle, and

Whitecliff). Because the numerous smaller islands (<50 ha) were less productive, they have sustained little logging. Deer, wolves (Canis lupus), and black bears (Ursus americanus) occur throughout the study area. River otters (Lutra canadensis) and mink (Mustela vison) are exceptionally abundant on the small islands, and human population and attendant hunting-trapping pressures are low.

METHODS

From 9 May to 2 June 1989 deer use and selected habitat attributes were measured on 100 islands in Sea Otter Sound. The following spring (24 April-19 May 1990), the 87 original islands and 3 new islands that were sampled were relatively small, ranging from less than 1 to 35 ha in size, and completely forested with old growth. Islands were selected to reflect a range of shapes, sizes, and insularity, but with similar vegetative and topographic attributes. Each island was given a sequential identification number, and it's location was recorded on a 1:40,000-scale nautical chart (ADF&G files). With the assistance of field volunteers and research assistants from the University of Alaska, field work was conducted from a base camp at New Tokeen on El Capitan Island.

On each island 2 to 4 parallel transect lines were established equidistant from one another and oriented to achieve maximum coverage. Starting from the high-tide line and following a strict compass bearing, 1 member of each 2-person field crew pulled a 20-m poly-clad fiberglass surveyor's cable in a straight line across the island. Every 20 m, the 1st crew member would stop and record vegetative data, while the 2nd crew member walked through the plot looking for pellet-groups. A pellet-group was defined as one or more fecal pellets that, on the basis of similar size, shape, color, and position relative to other pellets, were judged to be a discrete "group" or dropping. All pellet-groups, regardless of age, were counted if the estimated center of the group fell within 0.5 m of the cable.

In 1989 estimates of forest age class and volume class were made for each plot, referencing a 20-m x 20-m quadrat (0.1 acre) bisected by the pellet-group cable. Age class categories conformed to definitions used on USFS timber type maps and included young clear-cut (<25 yrs old), pole-timber (26-75 yrs old), young sawtimber (76-150 yrs old), and old growth (>150 years old). Volume class categories also conformed to definitions used on timber type maps, including noncommercial (<8 mbf/acres), class 4 (8-20 mbf/acres), class 5 (20-30 mbf/acres), class 6 (30-50 mbf/acres), and class 7 (>50 mbf/acres) old growth. Field personnel were trained to accurately estimate the net inventory volume through periodic checks with cumulative tally sheets for board feet (USFS 1979).

From the end point of each pellet-group plot, basal areas of Sitka spruce (Picea sitchensis), western hemlock (Tsuga heterophylla), and red cedar (Thuja plicata) were measured using a Relaskop. An optical range finder or hip chain was used to get 60 m from a typical count tree in the plot, and the total height of that tree was read directly from the Relaskop. The average height of all other count trees (by species) was estimated using the known height of the tree for reference.

The percentages of cover of 5 large or widely spaced understory plants (Vaccinium ovalifolium/alaskense, Vaccinium parvifolium, Menzesia ferruginea, Oplopanax horridus, and Lysichiton amnericanum) were estimated in a 0.002-ha (0.005-acre) circular plot (radius = 2.7 m) centered on the end point of the cable. For smaller herb layer plants (Table 1), percentages of cover were estimated for 1-m^2 circular plots (radius = 0.56 m). Cover was recorded in 1 of 8 categories: 0%, 1-5%, 6-10%, 11-25%, 26-50%, 51-75%, 76-95%, and over 95% (Daubenmire 1968). The percentage of cover is convertible to biomass using established regression equations (Alaback 1986, Yarie and Mead 1989).

In 1990 additional habitat and deer use variables were measured on 90 islands; 87 of these had been sampled in 1989. The sampling design was similar to that used in 1989 (Fig. 2); however, transect starting points and routes varied. From the end point of each pellet-group plot, total basal area was measured using a Cruz-all[tm] (Forestry Suppliers Inc., Jackson, MS). Volume class was again estimated with reference to a 20-m x 20-m quadrat bisected by the pellet-group cable. Within that same quadrat, vegetation was keyed to understory plant association (USFS files). At each plot, Vaccinium plants were examined for evidence of browsing. Looking at live stems below 1.5 m (5 ft), the proportion of live twigs that had been browsed was recorded in the following categories: 0-1%, 2-5%, 6-10%, 11-25%, 26-50%, 51-75%, 76-95%, and 96-100%. Following Mankowski and Peek (1989), actual counts of browsed and unbrowsed twigs were not made.

More intensive browse-utilization data were gathered using the twig count method (Shafer 1963). From the end point of the 20-m pellet-group plot, a plumb-bob was thrown backwards over the shoulder to randomly establish a plot center. The number of Vaccinium plants rooted within a 3-m^2 circular plot (radius = 0.98 m) were identified according to species, and the basal diameter measured to 0.25 mm (0.001 inch). The diameter at point of browsing (to 0.25 mm) was measured for all browsed twigs on all Vaccinium plants rooted in the plot. Efforts were made to carefully distinguish between twigs that had actually been browsed versus last year's terminal leaf scars or twigs broken because of insect or freezing damage.

Where the 3-m^2 plot included numerous Vaccinium plants (> 30), one of 2 smaller plot sizes were used to reduce the investment of time. Of the 1,079 plots measured, 1,009 (93.5%) were the full

3-m^2 size; on 31 plots 1-m^2 size was used; and on 39 plots a 0.5-m^2 size was used. Occasionally, a single plant showed such heavy browsing (>300 twigs browsed) it was not practical to measure every twig. In those instances, all browsed twigs were counted, but only 25-50 twig diameters were measured. Of the 2,374 plants sampled, 2,286 (96.2%) had all twigs measured; 88 (3.8%) had a subsample (i.e., 25-50 twigs) measured.

The above sampling methodology provides the mean number of browsed Vaccinium twigs per 3-m^2 area as well as the mean twig diameter at point of browsing. Knowing the relationship between the terminal twig diameter and twig biomass (i.e., distal from point of browsing), one can calculate the total Vaccinium biomass consumed by deer on the island. To develop this twig diameter-biomass relationship, unbrowsed twigs of varying diameters were clipped near each plot. For each species browsed, 3 twigs were clipped from nearby plants of like species and growth form, taking care to encompass the full range of terminal twig diameters browsed. If a plot had no plants or no browsing, no twig samples were collected. The twigs were taped together in groups of 3 (from the same island, plot, and species) and retained so that diameter and weight could be measured later.

At the end of each day, the diameter (at point of clipping) of each individual twig was measured to the nearest 0.01 mm with a digital caliper. Each sample (3 twigs/sample) was weighed to 0.1 g with an electronic scale. At the conclusion of the field season, all twigs were dried in a convection oven (70°C, 24 hrs), individually reweighed (to 0.001 g), and their diameter re-measured. These data permit calculation of the relationship between diameter at point of clipping and twig weight for each of the three Vaccinium species. Since this relationship probably varies from island to island, depending on the intensity of browsing, separate regressions will be generated for individual islands or deer density categories as warranted; they will be used to provide information on the total browse biomass consumed.

The size (ha) and perimeter (km) of each island were measured using a LASICO model 42-P electronic planimeter (Lasico Inc, Los Angeles, CA). Unfortunately, the instrument could not provide sufficient resolution to accurately measure many of the smaller islands at the map scale available (1:40,000). The Forest Service may be able to provide these data from their Geographic Information System (GIS). Otherwise, a more sensitive planimeter will be purchased. Other spatial attributes that will be measured and incorporated into the data include core size (assuming 25- and 100-m beach edge ecotones), shortest distance to extensive old growth (<1,000 contiguous acres), and mean distance to 3 nearest large islands (>100 ha).

Pellet-group and vegetative data were aggregated by island; each year's results (mean and SD for each variable) were written to a separate file. The means for net inventory volume, percentage of cover, and browse utilization were computed using the midpoints of the volume, cover class, and browse use categories, respectively. The age class and plant association reflected the most common classification or association recorded on each island. Data analyses were performed with SPSS/PC software (Norusis 1988).

RESULTS

Most field data, excepting spatial information (island size, shape, insularity, etc.), have been keypunched, edited, and summarized; however analyses of these data have just begun. Preliminary summaries have been completed.

Biogeographic Relations on Islands (Job 4)

A total of 1,262 plots were sampled in 1989 on 100 islands (Nos. 1-103, excepting 7, 11, and 77). In 1990, 1,079 plots were sampled on 90 islands (Nos. 1-90). Specific attributes measured in 1989, 1990, and in both years are listed in Table 1. Deer use, plant association, and overstory attributes sampled on each island are summarized in Table 2.

Deer use ranged from virtually none (zero pellet-groups and traces of browsing) to very high (over 8 pellet-groups per plot and over 90% browse utilization); the overall mean was 2.3 (SD = 2.1) pellet-groups per plot (about 74 deer per mi^2). Browse utilization averaged 36% across all islands. Between 1989 and 1990 pellet-group densities varied significantly on some islands; of the 87 islands sampled in both years, 37% differed by more than 1 pellet-group per plot. The largest differences were between islands that had been moderately used during one year and then very heavily used during the other. Basal area and volume class estimates were highly consistent from year to year, averaging 174 ft^2/acre (SD = 51.1) and 18.4 mbf/acre (SD = 6.6) over the study area.

On islands where two or more plant associations were represented, they were characterized by the most common plant association; the majority (64%) of islands sampled were classified as having an association with western hemlock, red cedar, and blueberry. Of the 1,079 plots sampled, 11.2%, 17.8% and 66.9% were in the hemlock, spruce, and western hemlock-red cedar series, respectively. Mean heights of hemlock, spruce, and red cedar trees across all islands were 42.9 m (SD = 27.8), 26.1 m (SD = 38.5), 31.7 m (SD = 30.6), respectively. Nearly all plots sampled (97.8%) were old growth; 36.6%, 50.4%, 10.2%, and 0.6% were in volume classes 4, 5, 6, and 7, respectively. Beach fringe areas were generally less productive and had a higher proportion of cedar than interior island areas.

The percentages of cover for 22 understory species on each island are summarized in Table 3. The most ubiquitous plant was <u>Vaccinium</u> spp., which occurred on all but 3 islands. Deer heart

(Maiantheumum dilitatum) was abundant, reaching nearly 100% ground cover on several islands. Twayblade (Listera cordata and L. caurina) was also relatively abundant. Two plants notable for their absence were goldthread (Coptis aspleniifolia) and skunk cabbage (Lysichiton americanum), reflecting the lack of wet, organic soils. Other evergreen forbs (e.g., Cornus canadensis, Rubus pedatus, Tiarella spp.) were well represented on most islands, although they were not abundant in areas where deer density was high. Salal (Gaultheria shallon) was locally abundant, but it occurred on only 15 islands.

Browsing on blueberry and rusty menzesia (M. ferruginea) was high on some islands; severe "brooming" and death of individual plants were evident in places. The extent of browsing on each island was quantified by counting and measuring the diameter of all browsed twigs on each plant rooted in the plot (Figure 3). A total of 13,381 twigs were measured on 2,286 plants over 90 islands. The mean basal diameter was 101.6 mm (SD = 66.0). Mean twig diameter (at point of browsing) was 12.7 mm (SD = 7.6).

Unbrowsed twig samples were collected on all plots where browsing of Vaccinium occurred. Of 1,845 twigs collected, mean diameter at point of browsing was 37.5 mm (SD = 14.3). Mean wet weight of each twig was 0.25 g (SD = 0.25). Although data on oven-dry weights and diameters have been collected, they have not yet been analyzed.

DISCUSSION

There are no obvious explanations for the observed pattern of deer use among the islands sampled. Without reference to data, the size of the island does not appear to explain the wide difference in deer density among them. Likewise, deer use is not obviously linked to plant association, understory abundance, or overstory characteristics of individual islands. Some of these attributes may, in combination, be more revealing. Likewise, the variability of certain attributes (e.g., access to a combination of volume classes) may be more important to deer than mean volume. These factors will be examined using more sophisticated analytical techniques in the coming reporting period.

Certain groups or clusters of islands having higher deer densities tended to be located in the southwestern portion of the study area (i.e., more remote portion with smaller islands). Quite possibly, deer are attracted to specific island groups because they provide increased security from wolves and black bears that primarily use the larger islands (Sylvia Geraghty, pers. commun.). The phenomenon of density overcompensation by birds and lizards (e.g., Anolis spp.) on predator-free islands have been described in the biogeographic literature (Brown and Gibson 1983). Such may be the case with deer and wolves here as well.

In the next reporting period (1 July 1990-30 June 1991), twig dimension-biomass regressions will be developed and the availability and use of browse examined as an index of deer density. In addition, time will be spent in the study area during midwinter to gather information (from tracks) on deer and wolf use among the various islands groups. Work will continue on the development of a computerized, annotated bibliography on the effects of fragmentation on wildlife (Job 6).

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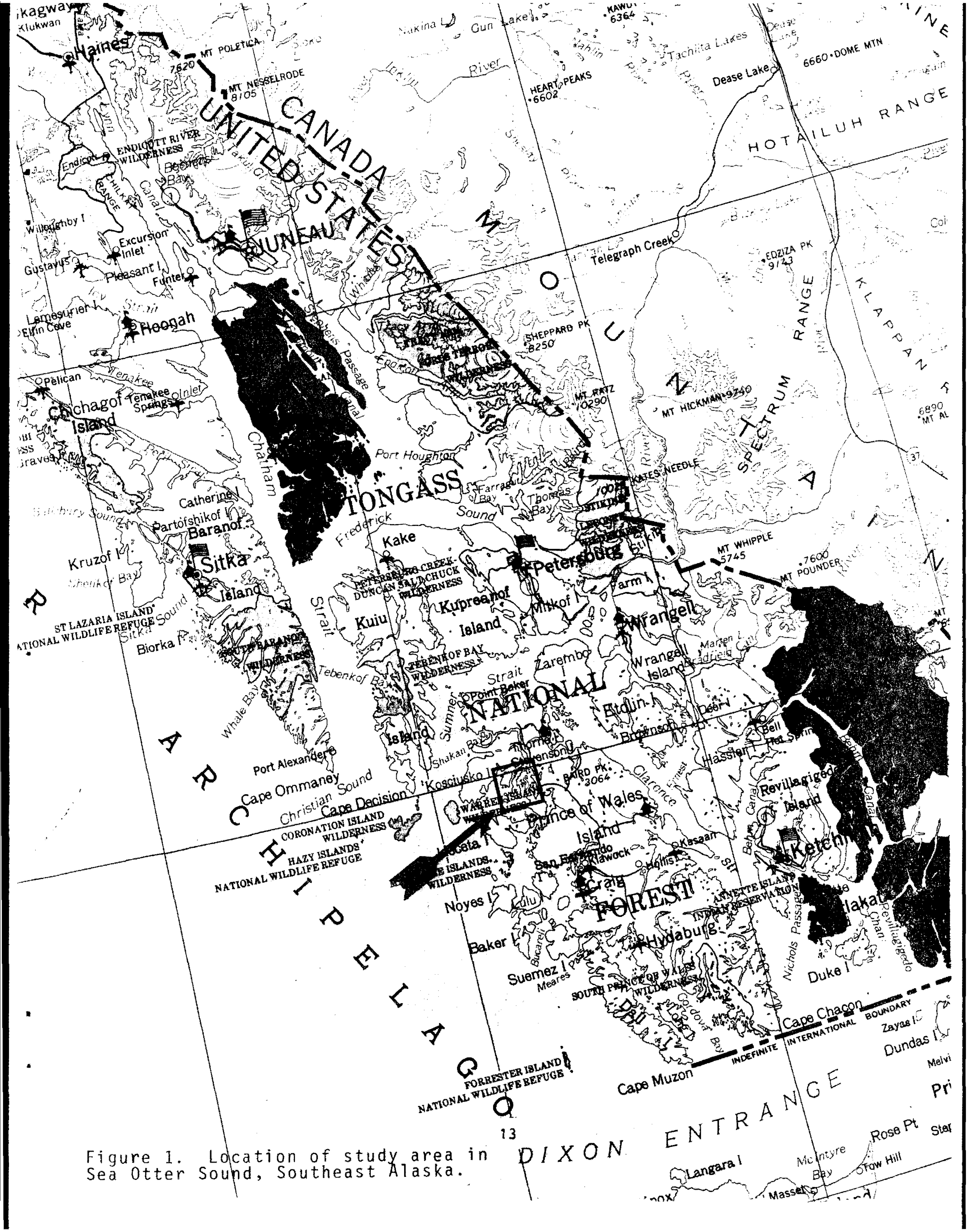

Figure 1. Location of study area in Sea Otter Sound, Southeast Alaska.

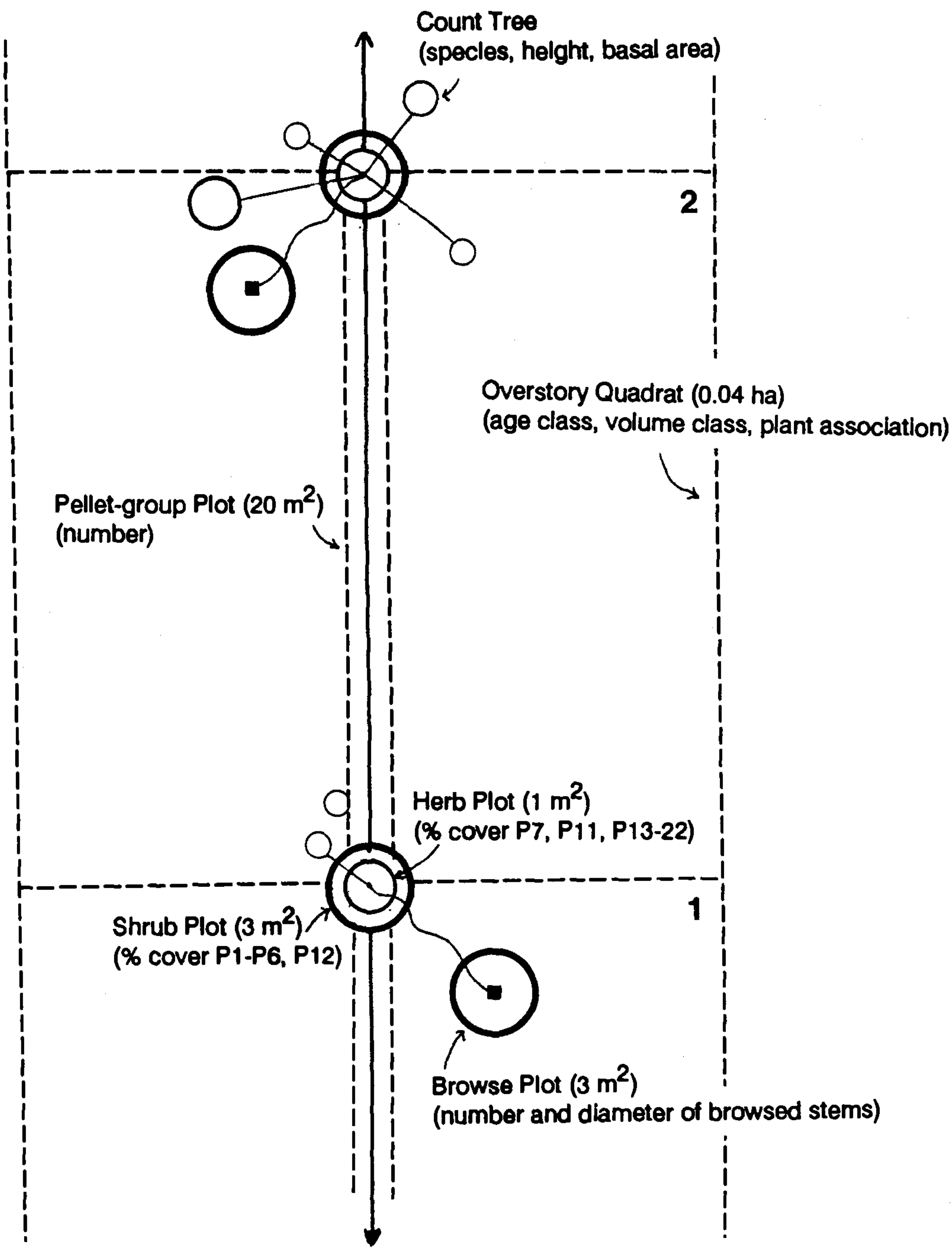

Figure 2. Sampling design used to gather deer use and habitat data, spring 1989 and 1990 (not drawn to scale).

Table 1. Key to deer use and vegetative attributes measured on 103 islands in Sea Otter Sound.

Variable	Year	Name	Units
PG	89,90	Pellet-group Density	per 20 m^2
BU	90	Browse Utilization	%
PA	90	Plant Association	
HEM	89	*Tsuga heterophylla*	%
SPR	89	*Picea sitchensis*	%
CED	89	*Thuja plicata*	%
VOL	89,90	Net Inventory Volume	MBF/acre
BA	89,90	Basal Area	sq. ft./acre
PLOTS	89,90	Number of plots	
ELEV	89	Elevation	m
P1	89	*V. ovalifolium/alaskensis*	%
P2	89	*Vaccinium parvifolium*	%
P3	89	*Menzesia ferruginea*	%
P4	89	*Oplopanax horridus*	%
P5	89	*Rubus spectabilis*	%
P6	89	*Gaultheria shallon*	%
P7	89	*Cornus canadensis*	%
P8	89	*Rubus pedatus*	%
P9	89	*Listera cordata*	%
P10	89	*Tiarella trifoliata*	%
P11	89	*Tiarella unifoliata*	%
P12	89	*Lysichiton americanum*	%
P13	89	*Mianthemum dilitatum*	%
P14	89	*Steptopus spp.*	%
P15	89	*Moneses uniflora*	%
P16	89	*Prenanthes alata*	%
P17	89	*Viola glabella*	%
P18	89	*Fauria crista-galli*	%
P19	89	*Pyrola secunda*	%
P20	89	*Polysticum munitum*	%
P21	89	*Gymnocarpium dryopteris*	%
P22	89	*Dryopteris dilitatum*	%

Table 2. Deer use and habitat attributes of 103 islands in Sea Otter Sound, spring 1989 and 1990.

Island	Plots	Pellet groups	% use browse	Plant assoc.	% hemlock	% spruce	% cedar	Volume mbf/ acre	Basal area
1	10	1.0	35	110	36	13	51	22.0	180
2	16	2.2	16	110	59	9	33	22.5	158
3	5	0.0	1	760	56	11	33	17.9	157
4	1	1.5	63	320	0	60	40	14.0	200
5	14	1.4	42	110	64	7	29	22.4	192
6	11	0.8	40	710	57	30	13	22.0	178
7	7	1.1	1	710	--	--	--	20.3	211
8	14	1.3	1	710	32	3	65	25.3	206
9	10	8.4	92	330	18	83	0	41.0	207
10	9	0.8	1	710	50	10	40	20.9	208
11	8	4.3	13	710	--	--	--	18.7	290
12	4	3.2	15	710	25	25	50	14.0	183
13	7	2.7	10	710	30	2	67	16.8	208
14	14	0.9	1	710	73	17	10	23.0	244
15	4	0.0	1	710	18	45	36	15.4	168
16	6	0.0	1	710	27	27	46	18.8	235
17	8	3.9	70	120	46	12	42	28.8	198
18	7	0.9	63	710	28	13	59	14.0	232
19	8	2.4	6	310	79	4	17	20.2	211
20	5	1.9	22	710	31	6	63	19.5	278
21	4	2.5	16	310	17	0	83	17.3	220
22	17	1.5	30	710	53	13	35	23.3	184
23	16	0.8	23	110	55	43	1	24.3	175
24	5	1.8	7	310	6	94	0	23.6	--
25	13	0.5	1	760	42	0	58	16.9	143
26	18	4.9	44	710	28	25	47	18.2	166
27	13	1.3	13	710	28	24	48	25.0	189
28	6	3.6	13	710	40	13	47	12.3	168
29	32	1.1	23	710	57	9	34	26.0	204
30	17	1.1	11	710	35	6	59	16.6	210
31	8	3.9	23	760	21	0	79	19.0	242
32	5	0.3	2	710	40	20	40	7.0	120
33	40	1.6	15	710	57	14	29	26.3	191
34	14	2.9	15	710	24	5	71	17.5	168
35	7	4.2	27	710	14	0	86	15.0	127
36	16	2.3	61	310	48	26	26	22.9	163
37	4	2.4	54	310	25	50	25	16.2	176
38	3	4.8	86	330	29	71	0	14.0	215
39	8	6.6	83	710	38	29	33	22.3	213
40	43	1.1	18	710	--	--	--	27.6	105

Table 2. (continued)

Island	Plots	Pellet groups	% use browse	Plant assoc.	% hemlock	% spruce	% cedar	Volume mbf/ acre	Basal area
41	5	4.6	44	110	75	25	0	14.0	88
42	10	1.5	11	710	58	26	16	21.7	152
43	5	4.2	44	710	29	43	29	14.0	123
44	18	2.0	51	310	77	11	13	24.0	145
45	6	0.4	23	710	15	0	85	14.0	166
46	15	8.8	86	310	31	31	38	19.4	183
47	31	4.2	67	710	52	23	25	33.0	217
48	8	0.7	--	360	0	100	0	16.5	157
49	3	0.0	--	360	0	100	0	0.0	45
50	5	4.3	36	710	0	50	50	11.7	137
51	11	3.1	80	750	35	38	27	34.5	255
52	11	1.5	51	710	24	33	43	18.3	187
53	11	5.2	66	710	42	25	33	22.4	183
54	5	7.6	31	710	25	19	56	14.0	183
55	55	1.2	17	760	--	--	--	13.7	67
56	6	0.0	8	710	0	0	100	2.6	84
57	14	2.4	49	110	56	18	25	23.3	137
58	8	3.2	70	710	53	17	30	15.8	193
59	31	0.9	33	110	31	5	64	20.0	167
60	3	0.0	33	710	25	25	50	12.3	145
61	10	1.0	25	110	50	17	33	20.4	163
62	32	1.6	39	710	51	10	39	27.3	207
63	9	2.1	64	710	25	9	66	20.4	239
64	30	3.4	25	710	41	6	53	23.1	186
65	2	0.0	1	710	0	0	100	16.0	70
66	9	4.5	67	710	41	9	50	11.2	173
67	32	1.6	74	110	57	24	19	23.7	161
68	8	6.7	94	310	41	47	12	19.2	163
69	14	5.2	89	710	27	25	48	17.8	192
70	3	1.0	4	310	33	67	0	14.0	77
71	3	0.0	3	710	60	20	20	14.0	107
72	12	3.2	89	710	55	15	30	24.5	153
73	15	4.9	41	710	24	9	66	25.0	207
74	10	2.6	63	320	56	9	34	17.3	144
75	4	2.6	44	710	0	47	53	19.5	237
76	4	7.1	84	710	7	36	57	19.5	189
77	5	3.6	89	710	--	--	--	14.0	272
78	16	2.0	87	710	27	8	65	13.1	119
79	4	6.7	30	710	20	20	60	7.0	103
80	6	2.4	11	710	13	13	75	0.0	75

Table 2. (continued).

Island	Plots	Pellet groups	% use browse	Plant assoc.	% hemlock	% spruce	% cedar	Volume mbf/ acre	Basal area
81	13	1.1	6	710	58	20	22	20.8	179
82	35	0.9	1	710	36	7	57	12.4	111
83	13	2.3	93	710	31	8	61	19.5	173
84	9	2.8	76	710	41	2	57	23.5	240
85	3	0.8	3	710	40	40	20	14.0	117
86	3	0.2	17	710	20	15	65	15.8	267
87	35	1.3	21	310	53	16	31	26.3	173
88	3	1.5	4	310	31	0	69	11.7	207
89	4	0.6	18	760	54	0	46	14.0	197
90	26	1.0	33	710	38	3	60	19.0	166
91	25	1.0	--	--	45	13	42	3.4	50
92	36	1.4	--	--	44	24	33	24.3	217
93	5	0.2	--	--	25	34	41	11.2	256
94	43	0.3	--	--	76	6	18	15.3	178
95	27	0.6	--	--	46	14	39	19.6	188
96	3	1.7	--	--	0	31	69	14.0	173
97	1	8.0	--	--	0	100	0	14.0	80
98	8	0.0	--	--	38	14	48	11.9	145
99	10	1.1	--	--	72	5	23	16.2	156
100	7	0.7	--	--	35	19	47	17.1	246
101	14	0.0	--	--	71	6	24	30.4	206
102	17	1.3	--	--	33	2	64	13.0	99
103	27	1.3	--	--	43	8	49	25.0	164

Table 3. Percentage of cover of understory species P1-P11 on small islands in Sea Otter Sound.

Island	Vaov	Vapa	Mefe	Opho	Rusp	Gash	Coca	Rupe	Lico	Titr	Tiun
1	8	44	43	0	0	0	49	29	78	29	0
2	23	28	27	0	0	0	15	5	34	0	0
3	10	10	21	0	0	39	0	0	0	0	0
4	0	0	0	98	0	0	0	0	98	0	0
5	20	23	2	0	0	0	0	0	46	0	0
6	0	32	18	0	0	0	0	0	0	0	0
7	--	--	--	--	--	--	--	--	--	--	--
8	20	27	23	0	0	0	23	0	44	0	0
9	13	31	20	12	0	0	10	0	0	3	0
10	13	21	25	0	0	0	27	0	20	0	0
11	--	--	--	--	--	--	--	--	--	--	--
12	35	11	1	0	0	0	0	0	33	0	0
13	9	6	20	0	0	0	25	0	74	0	12
14	16	24	24	0	0	0	0	0	21	7	0
15	21	38	0	0	0	0	34	33	0	0	0
16	3	7	3	0	1	0	17	16	16	0	0
17	9	7	25	0	0	0	0	1	20	21	0
18	20	20	10	0	0	0	0	0	25	0	0
19	9	8	30	0	0	0	39	0	78	0	0
20	4	16	8	0	0	0	3	0	33	0	0
21	36	8	0	2	0	0	0	0	0	0	0
22	50	17	19	2	1	0	6	0	74	6	6
23	28	26	8	6	5	0	5	13	49	10	0
24	4	25	12	0	0	0	0	0	25	0	0
25	32	17	18	0	0	8	38	26	98	0	0
26	6	8	8	9	0	0	21	0	70	0	21
27	6	33	22	14	0	0	14	14	15	28	0
28	31	31	13	2	0	0	51	25	74	0	0
29	28	22	17	6	0	0	13	10	34	19	10
30	31	8	17	4	0	0	48	4	27	9	4
31	13	29	31	0	0	25	0	0	98	0	0
32	30	6	7	0	0	0	0	0	33	0	0
33	23	20	32	0	0	0	9	6	37	0	0
34	20	45	21	0	0	10	23	0	98	0	0
35	14	4	3	0	0	0	65	0	0	0	0
36	20	18	20	0	1	5	10	0	26	0	0
37	7	5	10	0	1	0	0	0	0	0	0
38	0	4	21	8	0	0	0	0	0	0	49
39	6	11	11	1	0	0	16	12	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0

Table 3. (continued).

Island	Vaov	Vapa	Mefe	Opho	Rusp	Gash	Coca	Rupe	Lico	Titr	Tiun
41	41	16	5	2	0	0	49	25	25	0	0
42	20	40	13	0	0	0	20	0	20	0	0
43	28	21	0	0	0	0	66	0	0	0	0
44	22	29	17	8	0	0	8	0	23	15	0
45	4	43	9	0	0	45	60	20	59	0	0
46	23	47	30	9	0	0	19	9	45	37	0
47	15	25	17	13	4	0	20	0	71	24	4
48	0	0	0	0	0	0	0	0	0	0	0
49	0	0	0	0	0	0	0	0	0	0	0
50	21	36	15	3	0	0	6	0	33	2	0
51	6	23	6	3	17	0	34	18	65	65	16
52	10	9	21	2	3	0	20	0	0	44	0
53	20	41	14	0	0	0	17	34	98	0	0
54	6	29	3	0	0	0	49	0	74	0	0
55	0	0	0	0	0	0	0	0	0	0	0
56	6	25	25	0	0	0	66	0	0	0	0
57	18	31	37	0	0	7	26	20	26	20	0
58	17	14	9	0	0	0	0	0	0	0	0
59	29	15	39	0	0	0	35	44	60	0	10
60	0	18	0	0	0	0	0	0	0	0	0
61	22	15	17	0	0	0	14	14	44	0	0
62	21	25	30	0	3	0	0	0	40	3	0
63	42	32	34	0	0	0	0	0	70	0	0
64	22	19	26	0	0	9	4	0	68	0	0
65	3	8	0	0	0	0	0	0	98	98	0
66	9	10	11	0	0	38	20	0	20	0	0
67	19	17	23	0	0	0	0	0	24	2	0
68	10	8	8	4	21	0	40	0	39	2	20
69	4	12	9	1	0	0	36	18	45	18	0
70	2	0	0	0	0	0	4	0	0	0	0
71	9	5	8	1	0	0	4	0	0	0	0
72	16	7	27	0	0	0	0	0	25	0	6
73	15	9	13	0	0	0	17	5	87	5	0
74	16	19	8	3	2	0	0	0	78	30	0
75	1	68	2	0	0	0	0	0	1	0	0
76	15	38	5	0	0	0	0	0	65	0	0
77	--	--	--	--	--	--	--	--	--	--	--
78	18	56	20	6	0	0	0	0	67	0	12
79	21	35	15	0	0	6	0	0	0	0	0
80	12	2	17	0	0	2	22	0	20	0	0

Table 3. (continued).

Island	Vaov	Vapa	Mefe	Opho	Rusp	Gash	Coca	Rupe	Lico	Titr	Tiun
81	13	11	18	0	0	0	0	0	9	0	0
82	34	27	15	2	0	9	36	31	77	4	4
83	20	7	6	0	0	8	17	25	18	0	0
84	35	33	21	0	0	0	25	12	86	0	0
85	0	51	0	0	0	0	4	0	0	0	0
86	31	4	11	0	0	0	3	0	0	0	0
87	26	30	34	0	0	0	29	13	31	12	2
88	38	6	8	0	0	33	5	0	33	0	0
89	5	11	6	0	0	0	0	0	0	0	0
90	17	25	9	0	0	4	24	0	55	9	0
91	20	5	8	4	16	0	4	0	0	0	12
92	21	25	8	0	0	0	8	20	30	19	0
93	3	38	25	0	0	0	20	0	20	0	0
94	14	36	1	0	3	0	5	2	11	2	0
95	19	29	7	0	0	0	0	0	33	0	4
96	5	9	0	0	0	0	0	0	0	0	33
97	8	0	0	0	0	0	0	0	0	0	0
98	28	18	16	0	0	0	1	12	37	0	0
99	9	20	26	0	0	0	0	20	29	10	0
100	8	15	11	0	0	0	28	0	0	0	0
101	19	35	23	14	0	0	7	0	49	0	0
102	25	11	17	7	6	8	48	65	52	35	23
103	18	28	36	0	4	0	7	4	65	0	0

[a] Abbreviations are first 2 letters of genus and species (<u>see</u> Table 1).

Table 4. Percentage of cover of understory species P12-P22 on small stands in Sea Otter Sound.

Island	Lyam	Midi	Stst	Moun	Pral	Vigl	Facr	Pyse	Pomu	Gydr	Drdi
1	0	29	0	10	0	0	0	0	0	39	0
2	0	0	0	0	0	0	0	0	10	30	10
3	0	33	0	33	0	0	0	0	33	0	0
4	0	3	3	0	0	0	0	0	98	0	0
5	0	0	0	0	0	0	0	0	15	23	8
6	0	34	0	1	0	0	0	16	16	0	0
7	--	--	--	--	--	--	--	--	--	--	--
8	0	42	0	0	0	7	0	0	7	0	0
9	0	8	11	10	14	0	0	0	0	0	21
10	0	40	0	0	0	0	0	0	0	0	0
11	--	--	--	--	--	--	--	--	--	--	--
12	0	0	0	0	33	0	0	0	65	0	0
13	0	62	49	0	12	0	0	0	12	0	0
14	0	0	7	7	0	0	0	0	0	14	28
15	0	51	0	0	0	0	0	0	0	0	0
16	0	48	0	0	6	0	0	0	50	4	1
17	0	20	0	0	20	0	0	0	0	6	20
18	0	0	12	0	37	0	0	0	37	0	0
19	0	37	39	20	0	0	0	0	59	2	20
20	0	0	0	33	36	0	0	0	65	0	0
21	0	0	0	0	0	0	0	0	49	0	0
22	0	6	25	0	0	0	0	0	31	0	31
23	0	6	25	15	0	0	0	0	5	10	10
24	0	80	0	0	25	0	0	0	0	0	49
25	0	61	25	0	0	0	0	0	12	12	12
26	0	19	7	0	42	7	0	0	7	14	0
27	0	42	28	0	28	0	0	0	0	0	0
28	0	2	0	0	25	0	0	0	0	0	0
29	3	21	19	3	0	0	0	0	12	28	0
30	9	13	9	0	0	0	0	0	17	13	9
31	0	0	0	0	0	0	0	0	0	0	0
32	0	1	0	0	0	0	0	0	33	0	0
33	0	29	3	12	0	0	0	0	12	14	29
34	0	23	0	0	8	0	0	0	8	4	8
35	0	0	0	0	33	0	0	0	0	0	0
36	0	32	5	5	5	0	0	0	27	5	15
37	0	14	0	0	0	0	0	0	0	0	0
38	0	43	2	0	98	0	0	0	49	0	0
39	0	18	38	0	38	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0

Table 4. (continued).

Island	Lyam	Midi	Stst	Moun	Pral	Vigl	Facr	Pyse	Pomu	Gydr	Drdi
41	0	98	74	0	25	0	0	0	25	0	0
42	0	0	0	0	0	0	0	0	0	0	10
43	0	65	0	0	98	0	0	0	33	0	0
44	0	30	8	8	0	0	0	0	15	8	53
45	0	20	0	0	0	0	0	0	0	0	0
46	0	63	45	18	36	0	0	9	9	9	20
47	0	23	35	8	20	0	0	4	20	21	27
48	0	46	0	20	0	0	0	0	0	0	0
49	0	98	0	0	0	0	0	0	98	0	0
50	0	6	4	0	35	0	0	0	0	0	34
51	0	7	36	0	66	0	0	0	0	22	2
52	0	24	14	11	36	0	0	0	0	0	13
53	0	16	33	0	16	0	0	0	0	10	0
54	0	25	25	0	25	0	0	0	0	0	0
55	0	0	0	0	0	0	0	0	0	0	0
56	0	33	0	0	0	0	0	0	0	0	0
57	0	26	0	7	20	0	0	0	59	27	26
58	0	0	0	0	0	0	0	0	14	0	0
59	0	29	0	5	5	0	0	0	20	10	5
60	0	8	3	0	0	0	0	0	98	0	0
61	0	1	0	14	0	0	0	0	0	1	29
62	9	0	0	21	0	0	0	9	21	3	15
63	0	14	0	0	42	0	28	0	0	0	0
64	0	0	4	0	0	0	0	0	4	1	4
65	0	0	0	0	0	0	0	0	0	0	0
66	0	39	0	20	20	0	0	0	20	0	0
67	2	0	0	0	0	0	0	2	4	6	8
68	20	30	22	0	59	0	0	0	0	20	21
69	0	34	13	0	63	0	0	0	0	10	9
70	0	18	0	0	2	0	0	0	0	0	0
71	0	68	34	0	34	0	0	0	1	33	0
72	0	24	0	18	18	0	0	6	7	15	13
73	0	11	11	5	11	0	0	0	5	35	0
74	0	20	10	0	10	0	0	0	10	31	20
75	0	35	33	0	66	0	0	0	0	0	0
76	0	0	0	0	0	0	0	0	0	0	0
77	--	--	--	--	--	--	--	--	--	--	--
78	0	25	0	25	0	1	0	0	6	0	37
79	0	33	0	0	33	0	0	0	0	0	0
80	0	59	0	0	20	0	0	0	0	0	0

Table 4. (continued).

Island	Lyam	Midi	Stst	Moun	Pral	Vigl	Facr	Pyse	Pomu	Gydr	Drdi
81	0	18	0	0	0	0	0	0	9	9	0
82	6	6	8	0	0	0	0	0	21	8	2
83	0	33	0	0	25	0	0	0	8	2	1
84	0	12	0	0	25	0	0	0	25	12	12
85	0	63	2	0	8	0	0	0	0	0	0
86	0	0	0	0	0	0	0	0	0	0	0
87	3	17	2	8	0	0	0	4	29	8	35
88	0	0	0	0	0	0	0	0	0	0	0
89	0	66	0	0	34	0	0	0	33	0	0
90	0	0	0	0	0	0	0	0	12	12	0
91	5	4	0	0	8	0	0	4	24	12	8
92	1	40	11	22	25	0	0	0	14	13	25
93	0	82	0	0	26	0	0	0	0	0	0
94	0	0	9	0	0	0	0	0	7	28	25
95	0	7	7	4	0	0	0	0	7	7	7
96	0	1	0	0	0	0	0	0	0	0	0
97	0	98	0	0	0	0	0	0	0	0	0
98	0	27	13	0	37	0	0	25	37	12	13
99	0	20	10	10	20	0	0	0	0	10	29
100	0	14	0	0	0	0	0	0	14	1	0
101	0	0	7	7	0	0	0	0	7	0	0
102	10	12	35	0	0	6	0	0	35	18	24
103	0	11	0	0	4	0	0	0	30	11	11

[a] Abbreviations are first 2 letters of genus and species (<u>see</u> Table 1).

WILDLIFE RESTORATION

Federal Aid Project
funded by your purchase of
hunting equipment