ECOLOGICAL AND PHYSIOLOGICAL ASPECTS OF A MOOSE POPULATION IN THOMAS BAY, SOUTHEAST ALASKA

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Abstract: Ecological studies of moose (*Alces alces andersoni*) inhabiting the moist temperate *Picea sitchensis* - *Tsuga heterophylla* biome of southeast Alaska are lacking. This study reports on field investigations from March, 1978 to January, 1980 of a small moose population in an intensively logged mainland area near Petersburg, Alaska. Five telemetered female moose were nonmigratory. Summer and winter home ranges averaged 14.1 km^2 (range 2.2 to 29.6 km^2, n = 8) and 11.4 km^2 (range 3.2 to 30.3 km^2, n = 5), respectively. The maximum observed distance moose moved in a 22 month period averaged 9.3 km (range 4.8 to 18.4 km, n = 5). *Vaccinium ovalifolium*, *Alnus crispa sinuata*, *Ribes laxiflorum*, *Salix sitchensis*, *Populus balsamifera trichocarpa*, *Cornus canadensis*, *Dryopteris dilatata*, and *Athyrium filix-femina* were major fall and winter food species as determined from rumen content analysis and browse utilization transects. Moose preferred habitats within 1.6 km of rivers, at elevations under 80 m, and with slopes of less than 30%. Twenty percent of all telemetry locations were in noncommercial riparian vegetation, 1% were in muskegs, and 13% were in muskeg-scrub timber or mixed muskeg-coniferous forest. The remainder of the locations were divided equally between commercial old-growth and 6-to-26-year-old clearcuts. Seasonal habitat preferences are presented. Moose densities were estimated at 1.6 to 2.3/km^2. Herd quality appeared poor based on blood chemistry data, a low incidence of twinning, and poor winter calf suvival. Low availability of high quality browse during winter is believed to be the major regulating factor on the herd. Some habitat management concerns are described.

Moose (*Alces alces*) are widely distributed in Alaska (LeResche et al. 1974) and are popular for meeting human subsistence, sport and esthetic needs. Isolated populations of moose occur in southeast Alaska (Klein 1965b, LeResche et al. 1974) and are important locally. Many studies have been completed on moose ecology and physiology in Alaska, but there is little information on the species' ecology and physiology in the moist temperate biome of southeast Alaska.

LeResche et al. (1974) noted a small population of moose existing at Thompson Bay (sic) was probably dependent on secondary succession following logging. Nearby moose populations exist at the Stikine River and Farragut Bay, which like Thomas Bay are characterized by mainland streams draining the Coast Range between Alaska and British Columbia (Figure 1). Other populations in southeast Alaska occur in similar drainages, including introduced populations at Berners Bay and the Chickamin River (Burris and McKnight 1973).

The Thomas Bay area was logged utilizing clear-cutting from 1950 through 1976 and over 2,500 ha of the area were harvested. Timber access roads were constructed which sparked interest in moose hunting. The area is within the boundaries of the Tongass National Forest and includes State and private holdings. To ensure consideration of moose in future timber harvest plans, the U.S.D.A. Forest Service and the Alaska Department of Fish and Game jointly began a project in 1978 to collect basic information on habitat quality and use, herd condition, population dynamics, and movement of the Thomas Bay moose herd. This paper summarizes initial work at Thomas Bay from March, 1978 through January, 1980.

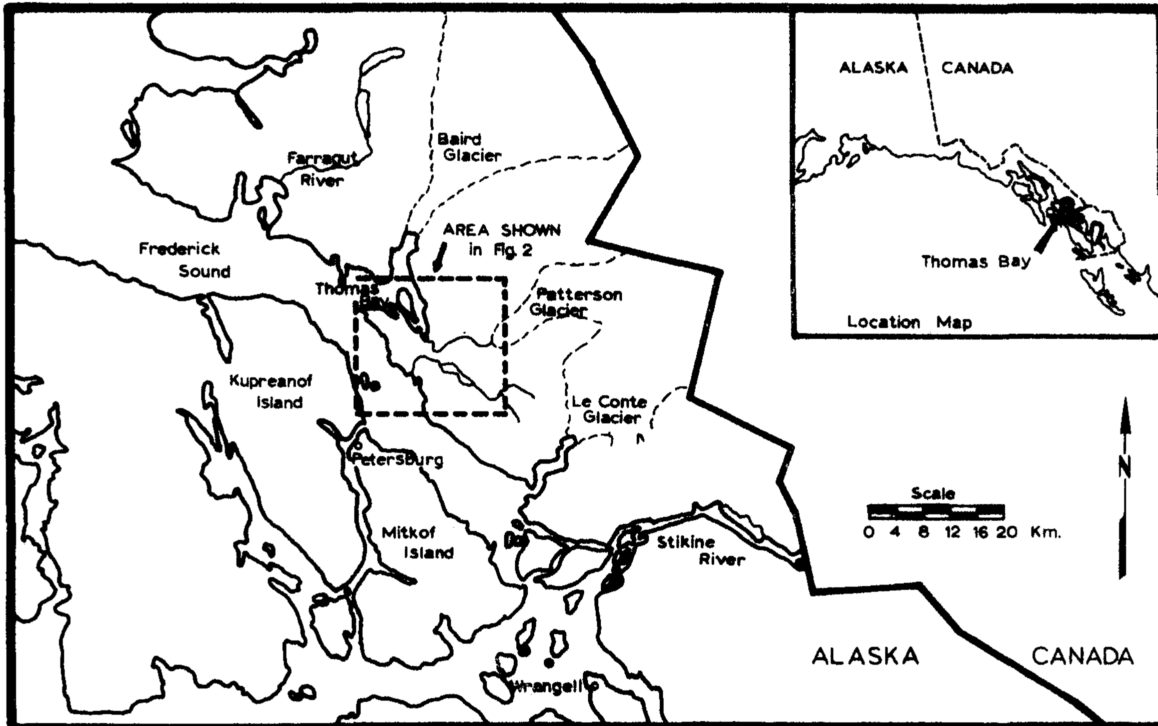

Figure 1. Thomas Bay and surrounding area.

METHODS

During March, 1978, 16 moose were immobilized from a Hiller 12J-3 helicopter utilizing a Cap-Chur gun and a combination of etorphine (M-99, D-M Pharmaceuticals Inc., Rockville, MD) and xylazine hydrochloride (Rompun, Chemagro, Kansas City, MO). After handling, diprenorphine (M50-50, D-M Pharmaceuticals, Inc., Rockville, MD) was administered as an antagonist. Six adult cows and 3 adult bulls were marked with numbered collars, and 7 adult cows were fitted with radio transmitters (Wildlife Materials, Inc., Carbondale, IL) and numbered collars. Blood samples were collected and analyzed (Franzmann et al. 1976, Franzmann and LeResche 1978).

From March, 1978 through January, 1980, aerial searches were made approximately twice a month utilizing a Cessna 180 with wing-mounted Yagi antennae. Locations were recorded on a map and described. No flights were made during the moose hunting season (October) to avoid disturbing hunters. Additional location data were obtained from helicopter flights and ground surveys utilizing a radio receiver and hand-held antenna. Hunters and local workers provided sightings as well.

Locations of telemetered moose were visually confirmed during 14% of 129 locations made by radio. The suspected location was always circled repeatedly to pinpoint the animal, but overstory density frequently made confirmation impossible. If visual contact was not made and if the suspected location overlapped on 2 or more habitat types, locations were recorded as "inexact."

A further indication of the difficulty in sighting moose was that only 17 sightings of marked moose without transmitters were recorded in the 22 month study period. One of these moose had been fitted with a radio that failed in October, 1978, and it accounted for 13 of the sightings after radio failure.

All moose sighted during aerial flights and ground field work were classified to age and sex if possible. Collared moose and their calves were counted only once when summing composition data over a given time interval. Because of extremely poor sightability conditions and a number of other factors, it is possible that the observed composition data were not representative of the entire population. Certain trends in the data, such as a low incidence of twinning, a large fall calf crop in 1979, and a low adult male/female sex ratio, were supported by observations of others in the field and by the age structure of the adult bull harvest (H. Merriam pers. comm.). Lacking other data, herd composition data are cited in this report, recognizing potential bias of these observations.

Home range was determined by connecting all outside locations that resulted in the largest polygon. Seasonal home range similarity coefficients (S) were derived from the following equation:

$$S = ((A_{12}/A_1) + (A_{12}/A_2)) \times 0.5,$$

where A_{12} is the area of overlap between the 2 seasonal home ranges and A_1 and A_2 are the areas of the 2 respective seasonal home ranges.

Browse utilization measurements and pellet group counts were made in fall, 1978 and spring, 1979 along 300-pace (250m) transects established in 10 distinct vegetation types and clearcuts of varying ages. Moose and black-tailed deer (Odocoileus hemionus sitkensis) pellet groups were recorded in .004 hectare circular plots at 10 points equally spaced along the transect. At 3-pace intervals, the nearest shrub within a 180° arc in front of the observer's right foot was selected. Species, growth form (young, mature, decadent or dead), availability (portions of plant over 3.1 m from the ground were classed "unavailable"), and use (none, light, moderate or heavy) were recorded. Ten twigs at least 3 cm in length were examined to determine browsing on the current year's growth. To insure data collection on browse species most favored by moose, "preferred" species were determined. After the first half of the transect had been sampled, those species receiving use were listed. On the last half of the transect, if selected plants were not on the preferred list, the nearest preferred plant was also measured.

Rumen samples were collected by Alaska Department of Fish and Game personnel during October hunting seasons. Samples of ca. 0.75 liters were washed and strained through a 4.25 mm mesh sieve. Food items were separated, towel-dried and measured by volume displacement. Average values were calculated using the aggregate percent method (Swanson et al. 1974).

Plant identification and classification throughout this study follows Hulten (1968). Statistical comparisons were performed using standard Chi-square tests and contingency tables with Yates correction factor for small sample size.

STUDY AREA

The study area was located between the LeConte and the Baird Glacier and included the drainages of the Muddy and Patterson Rivers (Figure 2). Coniferous forests are common from the beach to 1000 m elevation. Glaciers, ice fields, vertical rock cliffs, talus slopes, alpine tundra, krummholz, floodplain and muskeg are typical of the area. Approximately 3780 ha of the remaining Sitka spruce - western hemlock (Picea sitkensis - Tsuga heterophylla) "old-growth" forest have timber which can be commercially harvested. Most old-growth forests are uneven age and canopy cover varies. Understory vegetation consists of early blueberry (Vaccinium ovalifolium) and Alaska blueberry (V. alaskensis), which are known to hybridize (Viereck and Little 1972) and referred to herein as early blueberry. Hybrids of Swedish dwarf cornel (Cornus suecica) and bunchberry (C. canadensis) are common in the area and all are referred to as bunchberry. Thomas Bay receives an annual precipitation of 254 cm which includes roughly 254 cm of snow falling from November through April. Klein (1965a) describes in detail the vegetation and climate of southeast Alaska. Habitat classification followed ecosystem classification developed by Stephens et al. (1968) for soils and vegetation inventory. "RW" refers to riverwash, "F" to spruce-hemlock forests and "M" to muskeg. Capital letters refer to vegetative types at or near climax, while lower case letters identify younger stages. Numerals following the F category refer to the vegetation characteristics and site index used by foresters in productivity classifications. Forest site productivity is measured in terms of total height that

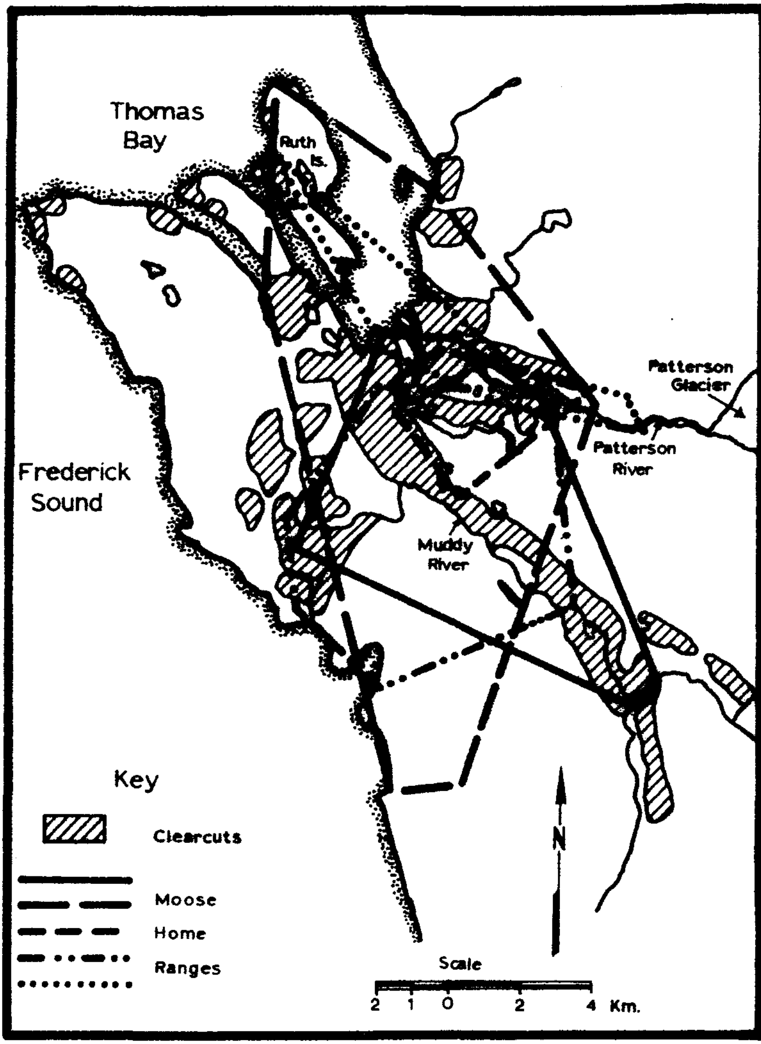

Figure 2. Location of clearcuts and total home ranges of telemetered moose.

the average dominant and condominant hemlock and spruce will attain at 100 years of age (Harris and Farr 1979). Site indices of Sitka spruce are as follows: F1 and F2 - 150, F3 - 130, F4 - 120 and F5 - 80. Lower case letters t, b, d, and r following F refer to river terrace, beach, deep (greater than 1.67 m), and rock soil types, respectively. MF5 identifies muskeg-scrub timber. Fxy types are forest soils of mixed Sitka spruce productivity.

Two plant communities were sampled in riverwash land forms. Early riparian communities were composed of bare, mineral soils interspersed with young stands of Sitka alder (*Alnus crispa sinuata*), Sitka willow (*Salix sitchensis*), black cottonwood (*Populus balsamifera trichocarpa*) and small conifers, predominantly less than 3 m in height. Mature alder communities were stands of approximately 90% canopy cover dominated by mature Sitka alder, often over 10 m in height.

RESULTS

Home Range and Movements

Observed distance of maximum separation between locations for 5 telemetered cow moose during the period March, 1978 to October, 1979 (Table 1) averaged 11.1 km. Distances of maximum separation between locations during the periods March - September, 1978 and April - September, 1979, averaged 7.5 km, while distances of maximum separation observed during the period November, 1978 - March, 1979 averaged 6.2 km.

Table 1: Straight-line distances of maximum separation between locations of telemetered moose at Thomas Bay, Alaska, March 1978 - October 1979.

Moose	Distance of Maximum Separation (km)				Months of Greatest Separation	
	S78[1]	W78-79	S79	Total 78-79	S78:W78-79	W78-79:S79
Cow 1	4.2 (12)[2]	3.7 (5)	____	4.8 (17)	3-3[3]	____
Cow 2	10.9 (13)	4.3 (10)	10.9 (14)	10.9 (23)	3-7	5-(6-9)
Cow 3[4]	8.6 (12)	12.8 (9)	6.6 (14)	18.4 (21)	3-6	3-4
Cow 4	8.3 (11)	5.8 (10)	8.2 (15)	9.0 (21)	2-8	5-6
Cow 5[4]	8.5 (6)	4.5 (6)	1.6 (3)	12.6 (12)	2-6	____
Cow 6	9.0 (3)	____	____	____	____	____

1/ S78 = March '78 - Sept. '78, W78-79 = Nov. '78 - March '79, S79 = April '79 - Sept. '79

2/ Number of locations in parenthesis

3/ 1 = January, 12 = December

4/ Cows with calves both years. Others were never observed with calves.

Three marked adult bull moose were each relocated only once during this study 2.2, 6.1 and 7.5 km from their respective capture locations.

Movement patterns were highly variable among the telemetered moose. Home range sizes for the summer months, winter months and throughout the year averaged 14.1, 11.4 and 28.4 km^2, respectively (Table 2). A migratory population is considered to be one with "two or more seasonally and spatially distinct ranges" (Mould 1979:6, LeResche 1974). Home range similarity coefficients (Table 3) suggest that the Thomas Bay population is primarily nonmigratory. Only Cow 5 had observed winter locations that did not overlap with its summer locations (Table 3). In this case, the observed winter home range bordered the observed summer home range, and the centers of the 2 respective home ranges were 5.4 km apart. The winter range of Cow 5 was based on six visual sightings because the radio transmitter failed in the fall of 1978. Telemetry may have revealed some overlap in seasonal home ranges of Cow 5.

No tendency to move farther inland or to higher elevations during the summer months predominated, as has been widely reported for black-tailed deer in southeast Alaska (Klein 1965a, Regelin 1979).

Forage Preference and Food Habits

Utilization of browse species, as measured from spring transects, is presented in Table 4. Willow and cottonwood were highly preferred species in riverwash and in disturbed roadsides. In all

Table 2: Observed home range sizes of telemetered moose at Thomas Bay, Alaska.

	Home Range (Hectares)			
Moose	S78	W78-79	S79	Total 78-79
Cow 1	220	550	---	900
Cow 2	2960	660	1190	3300
Cow 3 1/	1680	3030	1310	5140
Cow 4	2620	1140	580	3170
Cow 5 1/	750	320	---	1700
Average	1650	1140	1030	2840

1/ Cows with calves both years.

Table 3: Observed similarity coefficients for summer and winter home ranges of telemetered moose at Thomas Bay, Alaska.

	Similarity Coefficients		
Moose	S78:W78-79	S78:S79	W78-79:S79
Cow 1	.40	---	---
Cow 2	.56	.66	.37
Cow 3	.20	.20	.14
Cow 4	.51	.50	.58
Cow 5	.00	---	---

Table 4: Summary of Spring 1979 Browse Transects at Thomas Bay, Alaska.

Species	Soil-Vegetation Type	% Browsed	n1/
Salix sitchensis	F3 clearcut roadway	43.6	250
	RW early riparian	32.7	1230
	RW mature alder	5.9 2/	120
Populus balsamifera trichocarpa			
	F3 clearcut roadway	42.0	250
	RW early riparian	20.4	730
	RW mature alder	5.0 2/	280
Alnus crispa sinuata	All F Sites (logged and unlogged), except roadways	17.8	360
	F3 clearcut roadway	10.8	250
	RW early riparian	5.0	810
	RW mature alder	1.3 2/	640
Malus fusca	All F Sites (logged and unlogged), except roadways	73.3	30
Viburnum edule	All F Sites (logged and unlogged), except roadways	57.2	360
Sambucus racemosa	All F Sites (logged and unlogged), except roadways	36.7	30
Ribes laxiflorum	All F Sites (logged and unlogged), except roadways	15.1	490
Alnus oregona	All F Sites (logged and unlogged), except roadways	2.2	90 3/
Rubus spectabilis	All F Sites (logged and unlogged), except roadways	1.7	420 3/
Vaccinium ovalifolium	F3 (9 year regrowth)	25.0	250
	F3 old-growth (Site 1) 4/	12.0 2/	800
	flt old-growth	6.6	860
	F3 old-growth (Site 3) 4/	2.4 2/	840
	flt (two 11 to 13 year regrowth sites)	1.4	760
	F1 (22 year regrowth)	1.0	640
	F3 19-year-old clearcut (Site 2) 4/	1.2	640
Picea sitchensis	All sites	0.2	1690 3/
Tsuga heterophylla	All sites	0.1	1590 3/
Menziesia ferruginea	All sites	0	400 3/
Echinopanax horridum	All sites	0	550 3/

1/ Number of twigs measured.

2/ Sites with substantial deer use relative to use by moose as determined from pellet group counts (Table 9) and other field observations. Other sites had little or no use by deer.

3/ Includes plants measured during fall 1978 transects.

4/ Site 1 was located in a 140 meter-wide leave strip surrounded by two 19-year-old regrowth stands. Site 2 was 200 meters from Site 1 and was thinned with an 8 x 8 spacing at 17 years of age, leaving dominant regrowth conifers. Site 3 was located adjacent to a 19-year-old clearcut 2.3 Km from Site 1. All sites were under 30 meters elevation.

transects in forest soils, highbush cranberry (Viburnum edule), Oregon crabapple (Malus fusca), elderberry (Sambucus racemosa), trailing black currant (Ribes laxiflorum), and Sitka alder were utilized 15% or more. Utilization of early blueberry ranged from less than 1% to 25%. Other browse species showed little or no use.

Form class estimates (Table 5 and 6) also indicated that willows and cottonwoods were heavily used along roadsides and in early riparian riverwash. Decreased use of these species was found in mature alder stands. Sitka alder was more heavily browsed in logged and unlogged coniferous forest sites, where it was less abundant, than in riverwash stands, where it was the dominant shrub species. Early blueberry was most heavily browsed in a 9-year-old F3 clearcut, and second most heavily used in an flt and an F3 old-growth site. Two clearcuts older than 18 years, and 2 flt clearcuts revealed low moose use of blueberry twigs.

Analysis of rumen samples (Table 7) suggest that trailing black currant, shield fern (Dryopteris dilatata), lady fern (Athyrium filix-femina), bunchberry and early blueberry comprise approximately 60% of the October diet. These 5 species are most abundant in F sites and are generally much more abundant in 8-to-23-year-old clearcuts than similar old-growth sites at Thomas Bay. Browse species comprised 53% of the rumen samples; however, willow and cottonwood, highly preferred riparian species, made up only 6% of the total. Monocots and forbs comprised 13 and 32%, respectively, of the samples. Trailing black currant appears to be the single most important species in the fall diet.

Table 5: Form class of browsing on selected forage plants.

	Proportion with: Little or No Use	Moderate and Heavy	Average Rating[1/]	n[2/]
Riverwash:				
young riparian:				
Salix sitchensis	25	75	3.1	114
Populus balsamifera	30	70	3.0	71
Alnus crispa sinuata	86	14	1.6	83
mature alder:				
Salix sitchensis	89	11	1.6	9
Populus balsamifera	73	27	1.9	22
Alnus crispa sinuata	95	5	1.3	39
Roadway (F3 clearcut):				
Salix sitchensis	8	92	3.6	25
Populus balsamifera	4	96	3.8	25
Alnus crispa sinuata	64	36	2.2	25

1/ 1 = No use, 2 = Light use or hedging, 3 = Moderate hedging, 4 = Heavy hedging

2/ Number of plants measured.

Table 6: Form class of browsing on *Vaccinium ovalifolium* by habitat types.

	Percentage with:[1/] Little or No Use	Moderate and Heavy	Average Rating	n
F3 (9 year regrowth)	48[a]	52	2.4	25
F3 old-growth (Site 1)	74[b]	26	1.9	77
flt old-growth	85[b,c]	15	1.5	81
F3 old-growth (Site 3)	93[c,d]	7	1.5	73
F1 (22 year regrowth)	92[c,d]	8	1.2	62
flt (11 to 13 year regrowth)	96[d]	4	1.2	73
F3 clearcut (Site 2)	96[d]	4	1.2	57

1/ Percentages with same letter are not significantly different ($P < 0.05$).

Table 7: Food contents of rumen samples from 19 hunter-killed moose (October 1978 and 1979) from Thomas Bay, Alaska.

Species	Average % Volume	Freq.1/
Ribes laxiflorum	19	.42
Ferns2/	17	.58
Cornus canadensis	12	.89
Vaccinium ovalifolium	12	.63
Gramineae and Cyperaceae:		
Scirpus sp.	5	.05
Others	8	.32
Alnus crispa sinuata	7	.47
Populus balsamifera trichocarpa	4	.26
Salix sitchensis	2	.32
Lysichiton americanum	2	.26
Menziesia ferruginea	2	.21
Tsuga heterophylla	1	.11
Pinus contorta contorta	1	.05
Caltha sp.	1	.05
Sphagnum moss	trace	.05
Chamaecyparis nootkatensis	trace	.05
Vaccinium vitis-idaea	trace	.05
Unidentified Woody Twigs	5	---
Bark, Wood, Rocks, Litter	2	---

1/ Frequency recorded if the item composed 1% or more of the total volume of the sample.

2/ Dryopteris dilatata and Athyrium filix-femina.

Habitat Selection

Table 8 summarizes locations of telemetered moose by habitat types. Riverwash, representing less than 5% of the study area, and comprising 17 to 23% of all locations, was the preferred habitat type. Five percent of all locations were in muskeg-scrub timber and 1% were in sedge muskegs; 8% of all locations were in either muskegs, muskeg-scrub timber, or adjacent forest types.

Spruce-hemlock forest types comprised the majority of all locations. These locations were distributed through old-growth and clearcuts. F1, F1t, f1t, and F3 habitat types comprised 85% of all locations in spruce-hemlock forests. Moose were never located in alpine, estuarine, or krummholz habitats.

Moose appeared to prefer areas with little slope in low elevation areas during all seasons. Only 5% of all locations of radio-marked moose were on or near slopes greater than 30%. Of 169 locations of telemetered moose from March, 1978 through January, 1980, 67% were from sea level to 33 m elevation, while only 4% were above 81 m elevation. Locations above 81 m elevation occurred in August (1 location), January (4 locations) and February (2 locations), and were primarily associated with F5 and MF5 habitats. In January and early February 1979, both Cow 3 and Cow 4 used elevations of 276 m and 114 m, respectively, although snow depths were approximately 100 cm greater there than at lower elevations. In mid-February, when over 100 cm of snow fell in a one-week period, Cows 3 and 4 moved 2 km to old-growth timber at sea level. Both moose remained near the beach until late March when Cow 4 moved 2.4 km inland and

Table 8: Summary of locations of telemetered Thomas Bay moose, April 1978 - Jan. 1980 by soil-vegetation type.

Soil-Vegetation Type	No. Locations	Percent
Riverwash (RW)	26	17
Spruce-Hemlock (F types)	92	62
Muskeg-Scrub (MF5)	8	5
Muskeg	2	1
RW-F Mixture1/	9	6
M-F or MF-F Mixture1/	12	8
	149	
F Types (62% of total)		
Old-growth	30	20
Clearcuts (3 to 26 years)	41	28
Uncertain1/	21	14
RW-F and M-F Mixture (14% of total)1/		
Old-growth2/	13	9
Clearcuts2/	2	1
Uncertain	6	4
F Types (exact location)		
F1, F1b, F1d	25	33
F1t, f1t	21	28
F12	3	4
F14	2	3
F2	1	1
F3	18	24
F4	3	4
F45	1	1
F5	2	3
	76	100

1/ Exact location could not be determined.

2/ F type which could have contained the moose.

Cow 3 moved a straight line distance of 14.7 km to another site at sea level, where it remained until late April - early May. These movements by Cow 3 were the most erratic movements observed of telemetered moose.

Ninety-two percent of all locations (N = 149) were within 1.6 km of either the Muddy or the Patterson Rivers. All but one of the remaining 13 locations were within 0.8 km of saltwater.

The percent of locations of radio-marked moose in clearcuts, excluding all inexact locations, during April - May (54%) was not significantly different than during November - January (47%). The percent of locations in clearcuts during April - May and during November - January was significantly higher ($P < .025$) than both the period from February - March (0%) and the period from June - September (20%). The February - March locations were made only in 1979 during a period of exceptionally deep snow. During a winter with less snowfall, use of clearcuts during late winter may be higher than we observed.

A significantly greater percent ($P < .005$) of the locations of radio-marked moose were observed in muskegs and muskeg-scrub timber during January - February (28%) compared to the remaining months of the year (2%). Use of riverwash (RW) habitats was significantly less during March - May compared to the rest of the year, based on the proportion of telemetered moose located in RW during those time periods (3 vs. 23%, $P < .025$).

A young river terrace (flt) stand with approximately 65% canopy cover, a 9-year-old F3 clearcut with less than 25% understory (less than 9.2 m high) conifer cover, early riparian riverwash communities, and two 11-to 13-year-old flt clearcuts had comparatively high moose use based on spring pellet group counts (Table 9). A mature alder RW site had only 7% as many moose pellet groups as nearby early riparian RW sites. No moose pellets were found in 2 transects in clearcuts older than 18 years. One F3 old-growth site was heavily used by moose and deer, while another F3 old-growth site was not. Browse utilization measurements (Tables 4-6) lend support to the habitat use assessments from the pellet-group counts.

Clearcuts of ages 3-6, 7-12, 13-19, and 20+ comprised 8, 34, 43, and 15 percent, respectively, of all clearcuts. Moose locations in these respective age categories were 1, 39, 51, and 9 percent of all locations in clearcuts. The proportion of telemetered moose located in each age category is significantly different ($P < .005$) than would be expected based on the proportion of these categories in the study area. These comparisons suggest moose avoid clearcuts less than 8 years of age and prefer clearcuts 8-to-19 years of age among clearcuts from 3-to-28 years of age. Assessment of the effect of the age of the clearcut on moose use is somewhat equivocal because of the pattern of logging at Thomas Bay and the other factors which influence habitat selection. For example, higher elevation, steeper slopes, and less productive sites were logged later than forests adjacent to riparian habitats in lower elevations.

Population Size, Composition and Sport Harvest

No precise population estimates were obtained because of poor sightability conditions. In the fall of 1978, we extrapolated a

Table 9: Pellet group counts by soil-vegetation types, Thomas Bay, Spring 1979.

Soil-Vegetation Type	n[1]	Moose Pellet Groups/Hectare	Black-tailed Deer Pellet Groups/Hectare	$Moose/km^2$ [2]
Riverwash:				
early riparian	30	342	17	5.4
mature alder	10	25	75	0.8
Spruce-Hemlock				
flt old-growth	10	250	0	8.1
Flt old-growth	10	75	125	2.4
flt 11-to-13-year regrowth	20	139	12	4.4
F1 22-year regrowth	10	0	0	0
F3 9-year regrowth	20	212	0	6.9
F3 19-year regrowth (Site 2)	10	0	0	0
F3 old-growth (Site 1)	10	175	550	5.6
F3 old-growth (Site 3)	10	25	0	0.8
Clearcut Road (F3)	15	150	0	2.4

1/ Number of .004 hectare plots.

2/ Estimated assuming a 360-day accumulation period for moose pellet groups in early riparian riverwash and roads, a 180-day accumulation period in all other sites, and a defecation rate of 17 pellet-groups/day.

population of 180 moose in a 51 km^2 area from the proportion of marked to unmarked moose seen during 2 aerial surveys. The highest moose density we actually observed over a large area was 30 moose in a 13 km^2 area along the Patterson River in November, 1978.

Moose densities estimated from pellet group counts (Table 9) averaged 3.4/km^2 for all sites sampled. While this estimate is subject to considerable error, it does suggest a relatively high moose density adjacent to and within the logged portion of Thomas Bay. A low ratio also of marked/unmarked moose has been reported by hunters (H. Merriam pers. comm.).

The average annual harvest from 1973 through 1975 was 5 bulls, and the harvest from 1976 through 1978 averaged 14 bulls (McKnight 1975, 1976, H. Merriam pers. comm.). In 1979, 18 bulls were killed, the largest harvest to date (H. Merriam pers. comm.). A fall population of 200 to 300 moose appears to be capable of producing the number of bulls killed by hunters in recent years, given the observed herd composition data (Table 10), and is considered the most likely population estimate for 1978-79. Estimated hunting mortality of adult bulls was ca. 26% in 1978 and ca. 67% in 1979. A decline in the post-harvest bull/cow ratio was observed between 1978 and 1979.

Herd Condition and Productivity

Packed cell volume, hemoglobin, calcium, total protein, and albumin (condition related parameter) concentrations in blood were all significantly lower ($P < .001$) in Thomas Bay moose than in Alaskan moose in average-good condition as reported by Franzmann and LeResche (1978) (Table 11). Packed cell volume, hemoglobin, total

Table 10: Thomas Bay moose composition data.

Period	No. Observed	% Calves	% Cows	% Bulls	Calf/Cow	Bull/Cow
Nov. - Dec. 1978	88	18	69	13	.26	.18
Jan. - April 1979	40	5	-----95-----		.06 1/	---
Oct. - Dec. 1979	34	35	59	6	.60	.10
Jan. 1980	29	32	-----68-----		.35 2/	---

1/ Telemetered cow moose and their calves were only counted once if seen repeatedly during the time period.

2/ Assuming 18 Bulls/100 Cows.

3/ Assuming 10 Bulls/100 Cows.

Table 11: March 1978 blood parameters of the Thomas Bay moose with comparisons to values for Alaskan moose in average-good condition.

Blood Parameter	Average Thomas Bay3/	Average or Good Condition1/
Packed Cell Volume (%)2/	36.2 ± 5.9 (16)4/	50
Hemoglobin (gms/dL)2/	14.1 ± 2.2 (16)4/	18.6
Calcium (mg/dL)2	9.9 ± 0.5 (15)4/	10.4
Phosphorus (mg/dL)2/	5.0 ± 0.9 (15)	5.2
Total Protein (gms/dL)2/	6.4 ± 0.4 (15)4/	7.5
Albumin (gms/dL)	3.6 ± 0.2 (15)4/	4.5
Glucose (gms/dL)	139 ± 65 (13)	140
Globulin (g/dL)	2.9 ± 0.3 (15)	---
Cholesterol (g/dL)	55.1 ± 5.9 (15)	---
Triglycerides (mg/dL)	30.0 ± 24.8 (15)	---
LDH (u/l)	269.6 ± 40.1 (15)	---
SGOT (u/l)	81.4 ± 13.2 (15)	---
Alkaline Phosphotase (u/l)	82.1 ± 85.7 (15)	---
Sodium (meg/l)	140.5 ± 1.6 (15)	---
Potassium (meg/l)	5.8 ± 0.6 (15)	---
Chloride (meg/l)	98.1 ± 3.1 (15)	---
Carbon Dioxide (meg/l)	18.9 ± 6.6 (15)	---
Blood Urea Nitrogen (mg/dL)	8.3 ± 3.1 (15)	---
Creatanine (mg/dL)	1.93 ± 0.2 (15)	---
Total Bilirubin (mg/dL)	0.15 ± 0.06 (15)	---
Thyroxine (mg/dL)	4.11 ± 0.5 (14)	---

1/ From Franzmann and LeResche (1978).
2/ Considered best indicators of late winter condition (Franzmann and LeResche (1978)).
3/ ± standard deviation, sample size in parentheses.
4/ Means different than moose in average-good condition ($P < 0.001$).

protein, and albumin concentrations of Thomas Bay were among the lowest values reported for Alaskan moose. These data strongly suggest poor physical condition of the moose. Condition of Thomas Bay moose was not related to severe winter, since the winter prior to sampling (1977-78) had relatively low snowfall and accumulation for the Petersburg area.

Of 41 cows with calves observed in fall in 1978 and 1979, only 1 cow had twin calves. This proportion is considerably lower than the fall percentage of cows with twins among moose with calves reported by McKnight (1975, 1976) for the Stikine River (18-25%), Taku River (14-23%), Berners Bay (5-29%) and the Chilkat River (8-22%). Twinning rates have been shown to be accurate indicators of range and herd conditions in other moose populations (Pimlott 1959, Markgren 1969, Simkin 1974).

During the 1979 October season, only one of 18 bulls killed by hunters at Thomas Bay was a yearling (H. Merriam pers. comm.), while yearlings comprised approximately two-thirds of the harvest on the nearby Stikine River (R. Wood pers. comm.). The observed 1979 calf/cow ratio from January to April was only 5/100 (Table 10). These data suggest extremely high overwinter mortality of calves during the 1978-79 winter when snow depths temporarily exceeded 150 cm in exposed lowland areas. High calf mortality during winters of severe snowfall is a common phenomenon (Coady 1974, Franzmann and Arneson 1976, Sigman 1977). Reduced calf production in the year following severe winters has been reported for moose and other ungulates (Peterson 1977). In this study, however, the calf/cow ratio (60/100) in the fall of 1979 was exceptionally high, indicating that adult females had not been severely stressed. The harvest of 2+ bulls that fall was the highest ever, indicating a low overwinter bull mortality. These observations suggest most adult females and males can survive periods of excessive snow depth, while calves suffer severe losses.

DISCUSSION

The distance moose move during a year is highly variable among individuals and among various populations in North America (Van Ballenberghe and Peek 1971, Van Ballenberghe 1977, LeResche 1974, Bailey et al. 1978, Mould 1979, Ritchie 1978, Lynch 1976). The distances of maximum separation found in this study are among the shortest reported and probably reflect topographical constraints (steep mountains, saltwater) surrounding the study area.

LeResche (1974), reviewed studies on movement patterns of moose throughout North America, and concluded that seasonal home ranges seldom exceed 5 to 10 km^2. The average seasonal home range of Thomas Bay moose was 13 km^2. Bailey et al.(1978), Ritchie (1978) and Lynch (1976) also found seasonal home ranges of moose larger than those suggested by LeResche (op. cit.).

Overall population densities at Thomas Bay were estimated at 1.6 to 2.3 moose per km^2, although densities in preferred habitats are often much higher. A carrying capacity of $2.3/km^2$ has been suggested for the best moose range in Newfoundland (Mercer and Kitchen 1968, Bergerud and Manuel 1968) and the Kenai Peninsula (Spencer and Chatelain 1953). Densities greater than this resulted in severe over-utilization of preferred browse species in Newfoundland, and liberal hunting seasons were enacted to reduce the population (Bergerud and Manuel 1968, Bergerud et al. 1968). Jordan et al. (1971) reported moose densities of $2.3/km^2$ on Isle Royale during a period of high abundance. When summer densities approached $4.7/km^2$ on Isle Royale, preferred forage species were overbrowsed (Belovsky et al. 1973, Janke 1976). LeResche and Davis (1973) observed moose densities as high as $7.6/km^2$ in favorable habitats on the Kenai Peninsula and concluded that such densities were only found on moose ranges in Alaska characterized by relatively short periods of total snow accumulation. Available understory forage species were believed to be an important factor supporting the high moose densities found on the Kenai (LeResche and Davis op. cit.).

Thomas Bay has longer snow-free periods compared to more northern moose ranges in Alaska. During mild winters, evergreen forbs may be unavailable in exposed locations for less than 100 days, and available in old-growth stands for most of the winter. These forbs are higher in protein and digestibility than most winter browse (LeResche and Davis 1973, Oldemeyer et al. 1977, Schoen and Wallmo 1979). Total winter browse is abundant throughout Thomas Bay, except when deep snow covers browse in clearcuts and other exposed sites. Preferred browse species are low in overall abundance and utilized to various degrees throughout the range. Summer forage is very abundant, as evidenced by the lush, dense understory. Moose condition appears poor, even in mild winters and heavy calf mortality occurred during the severe winter of 1978-79.

Adults appear to exhibit a considerably greater ability to survive these severe winters, a phenomenon observed elsewhere (Bishop and Rausch 1974). Food habits data were limited, but rumen analysis suggests that browse species of low preference make up a substantial portion of the diet. The use of forbs and monocots in the fall is higher than reported in food habit studies elsewhere (Knowlton 1960, Peek 1974, Peek et al. 1976, Cushwa and Coady 1976).

The poor physical condition of Thomas Bay moose that utilize high quality forbs and under-utilize abundant browse suggests that this diet combination does not support healthy populations. These observations are supported by studies on the Kenai National Moose Range. Following a large fire in 1947, great quantities of palatable browse were produced. Analysis of 96 moose rumens in the early 1960's suggested that 65% of the winter diet was composed of willow, cottonwood and aspen (Populus tremuloides) (Spencer and Chatelain 1953). From 1950 to 1958, the moose population tripled (Bishop and Rausch 1974). By the early 1970's the range was dominated largely by birch, a low quality browse plant (Oldemeyer et al. 1977). Decreased use of high quality browse and increased use of ericaceous, herbaceous and low quality browse was evident (LeResche and Davis 1973, Cushwa and Coady 1976). The moose population has subsequently declined (Bailey 1978) and exhibited low quality blood parameters (Franzmann and LeResche 1978) and heavy winter calf losses in severe winters (Bishop and Rausch 1974, Franzmann and Arneson 1976, Sigman 1977). Utilization of birch by moose has been reported at 20% (LeResche and Davis 1973) and 25% (calculated from

Oldemeyer 1975) in areas of high moose densities.

We conclude from these observations that high use of non-browse species in the fall and winter reflect poor range conditions. The Thomas Bay moose select forage in this pattern and we thereby conclude that the population is on poor quality range and is not regulated by quantity of low quality browse.

Glacial riverwash, river terrace soils, and F soil types with the most productive Sitka spruce site indexes were the most preferred soil types based on telemetry locations. Riparian habitats are the only sites at Thomas Bay with substantial quantities of willows and cottonwoods. Use of riparian habitat and adjacent areas by moose is widespread in North America (Peterson 1955, Denniston 1956, Knowlton 1960, Houston 1968, Krefting 1974, LeResche et al. 1974, Joyal and Scherrer 1978, Mould 1979).

Logging has been shown to benefit moose habitat and populations in other studies in North America and Scandinavia (Bergerud and Manuel 1968, Markgren 1974, Ahlen 1975, Peek et al. 1976). In Thomas Bay, use of some clearcuts was substantial, especially in spring and fall - early winter. Moose avoided clearcuts during high snow depths, utilizing old-growth timber and riparian areas. Use of clearcuts under 6 years of age also appeared light. Moose pellet group densities were generally higher in old-growth stands than adjacent clearcuts. Thus our study suggests that old-growth forests are important components of moose habitat in southeast Alaska. Data from a similar study on the nearby Stikine River (U.S.F.S. unp. data) support this conclusion. Peek et al. (1976)

found the same seasonal pattern of clearcut - mature timber use in Minnesota. Eastman (1974) found little use of recent clearcuts with peak use between 10 to 25 years of age in sub-boreal forests in British Columbia. Parker and Morton (1978) found 8-to-10-year-old clearcuts in Newfoundland were preferred by moose. Ritchie (1978) found greater winter moose use in mature forest than in 10-to-15-year-old clearcuts in Idaho. Others have reported the importance of mature timber as winter habitat (Knowlton 1960, Van Ballenberghe and Peek 1971, Peterson 1977).

It is likely that moose populations have increased at Thomas Bay as a result of logging. Harris and Farr (1979), Alaback (1978), and Schoen and Wallmo (1979) have all shown that understory browse and forbs dramatically decline as regrowth conifers become dominant. The even-age stand that persists for the rest of the rotational logging period (ca. 100 years) is nearly void of available browse. This successional pattern will undoubtedly have severe effects on the condition and productivity of the herd. Under current forestry practies, many of the regrowth stands at Thomas Bay are precommercially thinned at ca. 15 years of age leaving dominant conifers. Limited observations suggest that such thinning practices may temporarily benefit moose. We feel that the understory density of conifers in clearcuts older than 7 years of age is inversely related to the value of that clearcut for moose, other factors being equal. Peek et al. (1976) also noted that dense conifer regrowth was detrimental to moose use of clearcuts in Minnesota. The spacing of precommercial thinning at Thomas Bay has been increased to as wide as 4.3 x 4.3m and willow, cottonwood, highbush cranberry and red osier dogwood (Cornus stolonifera) browse is not cut. Developing economical methods of establishing greater quantities of willows and other high quality browse in recently logged sites would benefit moose. Forestry practices, such as pulp sales and shortening the rotational age of the clearcut, would produce greater quantities of browse over a long-term period. Creating permanent openings up to 5 hectares in size in regrowth stands would provide some moose forage in clearcuts during even-age successional stages. Such openings could be maintained by selective cutting of regrowth conifers beginning 20 to 30 years after the initial clearcut and continuing every 10 to 20 years for the rest of the rotational period.

It is hoped that the data presented here will aid in identifying moose habitat throughout southeast Alaska and will aid in coordinating timber harvesting operations with moose management objectives where overlap occurs.

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