file

ALASKA DEPARTMENT OF FISH AND GAME
JUNEAU, ALASKA

STATE OF ALASKA
William A. Egan, Governor

DEPARTMENT OF FISH AND GAME
James W. Brooks, Commissioner

DIVISION OF GAME
Frank Jones, Director
Donald McKnight, Research Chief

MOOSE RESEARCH CENTER STUDIES

By

Albert W. Franzmann
and
Paul D. Arneson

Volume XV
Project Progress Report
Federal Aid in Wildlife Restoration
Project W-17-6, Jobs 1.1R and 1.7R

(Printed October 1974)

JOB PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperators: Albert W. Franzmann and Paul D. Arneson

Project No.: W-17-6 Project Title: Big Game Investigations

Job No.: 1.1R Job Title: Moose Productivity and Physiology.

Period Covered: July 1, 1973 to June 30, 1974.

SUMMARY

Survival of calves through the relatively mild winter of 1973-74 at the Kenai Moose Research Center (MRC) was 20 percent (2 of 10). Similar poor calf survival (25.4 percent) was recorded in Game Management Subunit 15A, in which the MRC is located. Snow depths during the winter of 1973-74 were considerably less than the previous two winters and did not appear to impede moose movements. Ground forage was more accessible than during the previous two winters. With the progression of plant succession in the 1947 Kenai burn area, browse quality was suspected as a potential factor influencing calf mortality. One aspect of this was indicated by results of moose hair analyses which reflected low values throughout the year for certain elements (mangnesium, copper and manganese). Subsequent analysis of moose browse plants demonstrated low values for manganese and copper. The complexity of micro-nutrient metabolism limits our understanding of the cause and effect relationship; however, the low levels in hair and plants, particularly when occurring in September when mineral uptake should be optimal, were disturbing.

Adult moose mortality was low at the MRC during the winter of 1973-74. Three female moose died; one from old age (19 1/2 years) and two possibly from the influence of introduction into Pen 4. No enclosed moose died from immobilization and handling procedures during this report period.

Of 10 adult female penned moose examined from January through April, 50 percent were pregnant. Fourteen moose examined outside the enclosures had a pregnancy rate of 64 percent. In contrast, during the Copper River moose tagging operation in March, 91.6 percent were pregnant (22 of 24).

Whole body weights from 17 moose and measurements from 315 moose were obtained during this report period. A publication relative to moose morphometric and weight data is in preparation. A new moose weighing device was completed in February.

Whole blood and serum samples were collected from 294 moose during this report period. Results of blood chemistry and electrophoretic

patterns were stored and sorted by computer on the basis of age class, sex, month sampled, reproductive status, location and drug used for immobilizations. Analyses of blood physiologic values will be reported with combined samples upon completion of this job. To date 1,079 moose blood samples have been analyzed.

Serial blood chemistry data from individual moose representing each pen at the MRC demonstrated a general trend to maintain homeostasis; however, some seasonally related influences were detectable. Moose hair element values from the serially sampled moose, although limited in number and distribution, fluctuated seasonally as did values reported for large pooled samples.

Two manuscripts relative to moose hair element analysis were prepared for publication. The abstracts are included in this report.

Twelve moose milk samples were analyzed for 18 elements by atomic absorption spectroscopy.

An annual report by John Oldemeyer, Bureau of Sport Fisheries and Wildlife, relative to moose browse production and utilization studies at the MRC is included in this report.

CONTENTS

BACKGROUND

The basis for investigations of moose (*Alces alces*) productivity and physiology initiated at the Kenai Moose Research Center (MRC) was outlined in preceding progress reports (LeResche 1970, LeResche and Davis 1971, LeResche et al. 1973, and Franzmann and Arneson 1973). These studies were continued during this reporting period and background material will not be repeated. This report will include data collected during this report period but will not involve detailed interpretation since papers are in various stages of preparation regarding these studies.

OBJECTIVES

To measure natality, mortality and general condition of moose at the Kenai Moose Research Center.

To establish baselines by sex, age, season, reproductive status, area, drug used, excitability and condition for the following physiologic parameters in moose, and to evaluate their usefulness as indicators of nutritional and general status in moose:

A. Blood Values for:

1. Calcium
2. Inorganic phosphorus
3. Calcium/phosphorus ratio
4. Glucose
5. Blood urea nitrogen (BUN)
6. Uric acid
7. Cholesterol
8. Total protein
9. Albumin
10. Globulin
11. Albumin/globulin ratio

12. Alpha-1, alpha-2, beta and gamma globulins

13. Bilirubin

14. Alkaline phosphotase

15. Lactic dehydrogenase (LDH)

16. Serum glutamic oxalacetic transaminase (SGOT)

17. Hemoglobin

18. Hematocrit (PCV)

19. White blood cells

20. Differential cell count

B. Hair element values for:

1. Zinc (Zn)
2. Copper (Cu)
3. Magnesium (Mg)
4. Manganese (Mn)
5. Calcium (Ca)
6. Sodium (Na)
7. Potassium (K)
8. Cadmium (Cd)
9. Iron (Fe)
10. Lead (Pb)

C. Heart and respiratory rate

D. Body temperature

To establish excitability stress classifications for moose based upon appropriate and selected physiologic parameters mentioned above.

To estimate browse production and utilization and to quantitatively and qualitatively estimate consumption of all plant materials by moose.

To determine nutritional values and digestibilities of the more common moose forage species.

The overall objective is to obtain more thorough and specific knowledge of how moose affect vegetation and how vegetation affects moose. The application of the indicator species concept to moose by gaining knowledge specific to moose function (physiology) is an integral part of this objective.

PROCEDURES

Kenai Moose Research Center Facilities

LeResche and Davis (1971) provided a thorough description of the facilities. During this reporting period, a second log building was completed providing living quarters for four persons. A gate was installed between Pen 4 and Pen 2 to facilitate movement of equipment.

Productivity and Mortality

Mortality and natality within the pens were assessed by ground observation, periodic aerial observations and trapping. Traps utilized were described by LeResche and Lynch (1973). Rectal examination of females, after January 1, was utilized for pregnancy determination.

Weights and Measurements

Weights, prior to February 1974, were obtained from trapped, immobilized animals using a tripod and chain hoist. This method was time consuming and therefore could not often be used because moose recovered too rapidly from immobilization. After February 1974, we utilized a weighing device consisting of a winch mounted on the front of a pickup truck with a bracket holding two legs of the tripod (Arneson and Franzmann 1974). This winch/tripod device allowed us to weigh a moose in 4 minutes or less and thereby weigh a greater proportion of moose immobilized.

Physiology - Blood, Hair and Milk

Blood and hair samples were obtained from moose trapped within the MRC enclosures, trapped outside the MRC enclosures, immobilized by John Coady for Interior moose studies, immobilized for marking on the Kenai Peninsula (Job 1.4R), immobilized for marking on the Copper River Delta (Job 1.12R) and harvested by hunters during the January 1974 Fort Richardson hunt.

Blood was collected from live animals by jugular vein puncture utilizing sterile evacuated containers. One vial contained heparin to provide a whole blood sample for hemoglobin determination at the MRC utilizing a Hb-Meter (American Optical Corp., Buffalo, N.Y.) and packed cell volume (PCV) values utilizing a micro-hematocrit centrifuge (Readacrit - Clay-Adams Co., Parsippany, N.J.). Three other 15-ml vials were filled with blood and centrifuged at the MRC to separate serum and blood cells. Sera were frozen and one sample was sent to Alaska Medical laboratories, Anchorage, Alaska for blood chemistry analysis (Technicon Autoanalyzer SMA-12) and protein electrophoresis. One of the remaining frozen serum samples was sent to U.S. Seal, Veterans Administration Hospital, Minneapolis, Minnesota for endocrine analysis. The remaining sample was retained for potential future analysis.

Hair samples were obtained by plucking hair from the point of the shoulder (hump) on these moose. These samples were sent to Dr. Arthur

Flynn at Case Western Reserve University, School of Medicine, Cleveland, Ohio, for analysis, utilizing an atomic absorption spectrometer.

Milk samples collected by "milking" immobilized moose were frozen and 1cc of frozen milk was sent to Dr. Arthur Flynn for mineral element analysis and a minimum of 5cc of frozen milk was sent to Dr. D.E. Ullrey, Department of Animal Husbandry, Michigan State University, East Lansing, Michigan for standard milk analysis.

Excitability Evaluation

The initial approach to this problem was to subjectively classify the captured moose on the basis of activity prior to and during handling. The state of excitement was evaluated on a 1 to 5 scale (1 - none, 2 - slight, 3 - moderate, 4 - excited, and 5 - highly excited). Seven ambient temperature classes were established (Table 1). Rectal temperatures of the moose were determined and each animal was assigned a rectal temperature class (Table 2). Blood chemistry values were evaluated for their ability to reflect excitability and all possible useful parameters were tested for correlation.

Condition Evaluation

As an adjunct to better evaluation of the moose processed at the MRC a subjective evaluation of each moose's condition was made and graded (1 to 10) on the basis of the following criteria (adapted to moose from Robinson 1960):

10. A prime, fat moose with thick, firm rump fat by sight. Well fleshed over back and loin. Shoulders are round and full.

9. A choice, fat moose with evidence of rump fat by feel. Fleshed over back and loin. Shoulders are round and full.

8. A good, fat moose with slight evidence of rump fat by feel. Bony structures of back and loin not prominent. Shoulders well fleshed.

7. An "average" moose with no evidence of rump fat, but well fleshed. Bony structures of back and loin evident by feel. Shoulders with some angularity.

6. A moderately fleshed moose beginning to demonstrate one of the following conditions: (A) definition of neck from shoulders; (B) upper fore leg (humerus and musculature) distinct from chest; or (C) rib cage is prominent.

5. A condition in which two of the characteristics listed in Class 6 are evident.

4. A condition in which all three of the characteristics listed in Class 6 are evident.

3. A condition in which the hide fits loosely about neck and shoulders. Head is carried at a lower profile. Walking and running postures appear normal.

Table 1. Ambient Temperature Classes

Class	Centigrade	Fahrenheit
1	Below -20	Below -14
2	-20 to -10	- 4 to 14
3	-10 to 0	14 to 32
4	0 to 10	32 to 50
5	10 to 20	50 to 68
6	20 to 30	68 to 86
7	Above 30	Above 86

Table 2. Rectal Temperature Classes

Class	Centigrade	Fahrenheit
1	Below 38	Below 100.4
2	38 to 39	100.4 to 102.2
3	39 to 40	102.2 to 104.0
4	40 to 41	104.0 to 105.8
5	Above 41	Above 105.8

2. Signs of malnutrition are obvious. The outline of the scapula is evident. Head and neck low and extended. The moose walks normally but trots and paces with difficulty, and cannot canter.

1. A point of no return. A generalized appearance of weakness. The moose walks with difficulty and can no longer trot, pace or canter.

0. A dead moose, from malnutrition and/or accompanying circumstances.

FINDINGS

Productivity and Mortality

Table 3 presents raw tagging, breeding and mortality data for all moose within the enclosures for the period July 1, 1973 through April 30, 1974. The total number of observations and times trapped are also included.

No yearlings were recruited into the population within the MRC enclosures following the winter of 1972-73 (Table 4). Nine calves were born within the pens in spring 1973 raising the population to 42 moose (4.1 moose per square kilometer). From July 10, 1973 to November 29, 1973 seven adult cows and one calf were introduced into Pen 4 to increase the moose density to the desired level. On September 30, 1973 rutting bulls broke the gate between Pens 1 and 2 and three adult cows and two calves escaped into Pen 2. Populations within the enclosures following introductions and escapes are shown in Table 5. Densities at that time were 4.6 moose per square kilometer.

During a relatively mild winter in 1973-74, 80 percent (8 of 10) of the calves died. One calf survived in Pen 1 and one in Pen 3 (Table 6). Also, Rastus the calf of our tame moose Raquel, survived but was supplementally fed. A similar high mortality of calves may have been experienced in the 1947 Kenai Burn surrounding the MRC. Four dead calves were located within 1.6 kilometers of the cabin facilities at the MRC. Spring survival counts in Game Management Subunit 15A flown in May 1974 by Paul LeRoux, Alaska Department of Fish and Game, indicated that 25.4 percent of the fall calf herd survived (74.4 percent calf winter mortality). The immediate area around the MRC (Swanson River and Moose River Flats) had the lowest calf survival in this entire subunit.

Snow depths during the winter of 1973-74 were considerably less than the previous two winters. Depths did not appear to impede moose movements. Maximum depths did not occur until late February (Table 7) and ground vegetation was visible through the snow much later into the winter. Warm weather in March quickly melted the snow and most had disappeared by early April. Ground vegetation was unavailable to cratering moose for a relatively short period in comparison to the two previous winters. Moose in this area have utilized ground vegetation, particularly mountain cranberry (*Vaccinium vitis-idaea*), to supplement their winter diet (LeResche and Davis 1973). In spite of the easier access to and availability of ground forage during the winter of 1973-74, high calf mortality was experienced in the 1947 Kenai Burn area.

Table 3 Histories of individual moose in Kenai Moose Research Center enclosures, July 1, 1973 through April 30, 1974.

PEN I

Moose No.	Sex	Age (Years)	Significant Observations: Date	Significant Observations: Event	Significant Observations: Circumstances	No. Times Observed	No. Times Captured
10	F	6	Sept. 11, 1973	With Calf-Calf tagged #109	Trapped	18	2
			Apr. 18, 1974	With Calf	Observed-Helicopter		
35	M	5	July 9, 1973	Antler spread - 104 cm	Trapped	10	4
			Oct. 2, 1973	Antler spread - 108 cm	Trapped		
43	M	6	Oct. 4, 1973	Antler spread - 125 cm	Trapped	16	2
58	M	3	July 9, 1973	Antler spread - 77 cm	Trapped	10	4
			Oct. 2, 1973	Antler spread - 85 cm	Trapped		
R70-8	F	5	Feb. 6, 1974	Weight 336 kg. Likely with calf, tracks nearby	Trapped	16	2
			Apr. 18, 1974	With no calf	Observed-Helicopter		
69	F	4	July 12, 1973	With no calf	Trapped	8	1
99	M	Calf	Sept. 11, 1973	Recaptured-in good shape	Trapped	4	1
			Dec. 10, 1973	Last observed with mother #R70-8	Observed-Supercub		
109	F	Calf	Sept. 11, 1973	First marked (#10's calf)	Trapped	8	1
			Apr. 18, 1974	In pen with mother	Observed-Helicopter		

Table 3 (continued) Histories of individual moose in Kenai Moose Research Center enclosures, July 1, 1973 through April 30, 1974.

PEN II

Moose No.	Sex	Age (Years)	Significant Observations: Date	Event	Circumstances	No. Times Observed	No. Times Captured
1	F	9	July 11, 1973	Lactating-calf never observed	Trapped	10	3
			Dec. 19, 1973	Last seen	Observed		
3	F	11	July 31, 1973	Weight-374 kg lactating	Trapped (Pen 1)	13	5
			Sept. 5, 1973	With calf-calf tagged#107	Trapped (Pen 1)		
			Sept. 30, 1973	Escaped with calf into Pen 2	Observed in Pen 2		
			Apr. 18, 1974	With no calf	Observed-Helicopter		
R70-4	F	6	Aug. 7, 1973	Weight 317 kg with no calf	Trapped	5	1
670	F	3	Sept. 30, 1973	Escaped into Pen 2 No calf this year	Observed	12	0
36	M	5	Oct. 8-16,1973	Interacting through fence with #7 (Pen 4)	Observed	15	0
40	F	5	July 9, 1973	With calf-marked as #101 Never again seen with calf	Trapped	12	5
			Sept. 30, 1973	Escaped into Pen 2	Observed		
Raquel	F	4	July 13, 1973	Released into Pen 2 with calf	Trapped	Tame	5
			Sept. 24, 1973	Put back into calf pen with calf	Observed		
			Oct. 8, 1973	Released into Pen 2 with calf	Observed		
			Dec. 27, 1973	Weight: 429 kg	Trapped		
			Feb. 13, 1974	Weight: 425 kg	Trapped		
			Apr. 30, 1974	Led back to calf pen	Observed		

Table 3 (continued) Histories of individual moose in Kenai Moose Research Center enclosures, July 1, 1973 through April 30, 1974.

PEN II (cont.)

Moose No.	Sex	Age (Years)	Significant Observations: Date	Event	Circumstances	No. Times Observed	No. Times Captured
Rastus	M	Calf	July 13, 1973	Weight: 44 kg.	Trapped	Tame	4
			Dec. 27, 1973	Weight: 184 kg.	Trapped		
			Feb. 13, 1974	Weight 209 kg.	Trapped		
			Apr. 18, 1974	With mother (Raquel)	Observed-Helicopter		
Wally, Jr.	MN Castrated	2	July 13, 1973	Antler spread: 79 cm (growing!)	Trapped	Tame	4
			July 24, 1973	Released into Pen 2 for first time.	Observed		
			Sept. 6, 1973	Put back into calf pen	Trapped		
			Oct. 8, 1973	Again released into Pen 2	Observed		
61	F	11	Aug. 23, 1973	With no calf this year	Observed	6	3
73	M	4	Sept. 4, 1973	New numbered collar put on	Trapped	8	3
79	F	4	Sept. 6, 1973	With calf, calf marked #108	Trapped	6	2
			Apr. 18, 1974	With no calf	Observed-Helicopter		
101	F	Calf	July 9, 1973	First marked (#40's calf)	Trapped	7	1
			Sept. 30, 1973	Escaped into Pen 2	Observed		
			Oct. 8, 1973	Last seen; assumed dead	Observed		
107	M	Calf	Sept. 5, 1973	First marked (#3's calf)	Trapped	7	3
			Sept. 30, 1973	Escaped into Pen 2 with #3	Observed		
			Dec. 10, 1973	Last seen; likely dead	Observed-Supercub		
108	M	Calf	Sept. 6, 1973	First marked, (#79's calf)	Trapped	4	1
			Feb. 13, 1974	Last seen; likely dead	Observed		

Table 3 (continued) Histories of individual moose in Kenai Moose Research Center enclosures, July 1, 1973 through April 30, 1974.

PEN III

Moose No.	Sex	Age (Years)	Significant Observations: Date	Event	Circumstances	No. Times Observed	No. Times Captured
27	F	6	July 11, 1973	With no calf this year	Trapped	3	1
2870	F	3	Oct. 8, 1973	With no calf this year	Observed	3	0
38	F	19	Jan. 17, 1974	Not pregnant; condition 4	Trapped	3	1
			Apr. 18, 1974	Found dead	Observed-Helicopter		
39	F	8	Dec. 10, 1973	With calf	Observed-Supercub	26	1
			Apr. 18, 1974	With no calf	Observed-Helicopter		
72	F	3	Sept. 13, 1973	Weight: 313 kg.	Trapped	13	3
			Jan. 23, 1974	Pregnant by rectal palpation	Trapped		
			Apr. 18, 1974	With calf	Observed-Helicopter		
75	F	4	Oct. 8, 1973	With no calf this year	Observed	5	1
80	M	4	Dec. 10, 1973	With both antlers present	Observed-Supercub	11	0
98	M	Calf	Apr. 18, 1974	With mother - #72	Observed-Helicopter	7	0
104	M	Calf	Aug. 7, 1973	First marked (#39's Calf)	Trapped	12	1
			Dec. 10, 1973	Last seen; likely dead	Observed-Supercub		

Table 3 (continued) Histories of individual moose in Kenai Moose Research Center enclosures, July 1, 1973 through April 30, 1974.

PEN IV

			Significant Observations				
Moose No.	Sex	Age (Years)	Date	Event	Circumstances	No. Times Observed	No. Times Captured
7	M	4	Nov. 16, 1973 Feb. 14, 1974	Antler spread: 88.5 cm. Weight 363 kg.	Trapped Trapped	15	3
22	F	8	Jan. 26, 1974 Apr. 10, 1974	With calf (never marked) With no calf	Observed Observed	20	0
36	F	10	July 31, 1973 Oct. 4, 1973	With no calf this year Weight 356 kg.	Trapped Trapped	11	3
37	F	4	July 23, 1973	No calf seen this year (Pregnant, March 1973)	Observed	16	0
57	F	3	July 9, 1973	With no calf this year	Observed	14	0
59	M	5	July 9, 1973	Broken antlers growing downward	Observed	19	2
71	F	4	Feb. 7, 1974 Apr. 18, 1974	With one calf (never marked) With no calf	Observed Observed-Helicopter	16	0
81	F	4	July 9, 1973 Oct. 2, 1973 Jan. 24, 1974	With no calf this year Weight 279 kg. Not pregnant (rectal palpation)	Observed Trapped Trapped	12	3
84	F	6	Aug. 28, 1973 Jan. 24, 1974	With no calf this year Likely pregnant (rectal palpation)	Observed Trapped	9	2
100	M	4	Oct. 2, 1973	Antler spread: 85 cm.	Trapped	7	5

Table 3 (continued) Histories of individual moose in Kenai Moose Research Center enclosures, July 1, 1973 through April 30, 1974.

PEN IV (cont.)

Moose No.	Sex	Age (Years)	Significant Observations: Date	Event	Circumstances	No. Times Observed	No. Times Captured
102	F	3	July 10, 1973	Introduced into Pen 4 with no calf	Trapped	7	2
103	F	3	July 13, 1973	Introduced into Pen 4 with no calf	Trapped	4	5
			Jan. 17, 1974	Pregnant (2 fetuses-rectal palpation)	Trapped		
105	F	7	Aug. 9, 1973	Introduced into Pen 4 with no calf	Trapped	6	2
			Feb. 21, 1974	Weight: 324 kg, not pregnant	Trapped		
106	F	9	Aug. 15, 1973	Introduced into Pen 4 with no calf	Trapped	2	2
			Apr. 18, 1974	Found dead	Observed-Helicopter		
110	F	Unk.	Oct. 5, 1973	Introduced into Pen 4 with no calf	Trapped	Uncollared	1
111	F	3	Oct. 9, 1973	Introduced into Pen 4 with no calf	Trapped	13	4
			Feb. 5, 1974	Weight: 400 kg. Pregnant	Trapped		
112	F	9	Nov. 29, 1973	Introduced into Pen 4 with one calf (#113). Never again seen with calf	Trapped	6	3
			Dec. 27, 1973	Pregnant (rectal palpation)	Trapped		
113	F	Calf	Nov. 29, 1973	Introduced into Pen 4 with mother Never again seen with mother	Trapped	2	1
			Apr. 18, 1974	Found dead	Observed-Helicopter		
115	F	10	Oct. 8, 1973	Introduced into Pen 4; no calf	Trapped	11	3
			Feb. 6, 1974	Weight: 391 kg. Not pregnant	Trapped		

Table 4 Populations within Kenai Moose Research Center enclosures as of July 1, 1973.

	Adult FF	Yearling	Calves	Adult MM	Total
Pen 1	6	0	4	3	13
Pen 2	4	0	1	2	7
Pen 3	6	0	2	1	9
Pen 4	8	0	2	3*	13
Total	24	0	9	9	42

* Adult male introduced June 20, 1973.

Table 5 Populations within Kenai Moose Research Center enclosures as of December 10, 1973.

	Adult FF	Yearling	Calves	Adult MM	Total
Pen 1	3	0	2	3	8
Pen 2	7	0	2*	2	11
Pen 3	6	0	2	1	9
Pen 4	14**	0	3	3	20
Total	30	0	9	9	48

* Calf of # 40 not seen
** U/C female not seen

Table 6 Populations within Kenai Moose Research Center enclosures as of April 18, 1974

	Adult FF	Yearling	Calves	Adult MM	Total
Pen 1	3	0	1	3	7
Pen 2	7	0	0	2	9
Pen 3	5	0	1	1	7
Pen 4	13	0	0	3	16
Total	28	0	2	9	39

Not Seen: Pen 1 - Calf of R70-8
Pen 2 - Calves of #'s 3, 40, and 79
Pen 3 - Calf of #39
Pen 4 - Unmarked calf; unmarked adult female

Table 7 Snow depth (cm.) in each of eight habitat types, Kenai Moose Research Center, winter 1973-74.

Habitat Type	1973			1974							
	11/28	12/19	12/28	1/3	1/25	2/8	2/14	2/22	3/1	3/21	4/2
Dense Hardwoods	15*	14*	10*	10	11	19	25	28	32	21	Tr*
Thin Hardwoods	20*	16*	16*	21	23	31	42	42	44	36	Tr*
Sedge	19**	22**	19**	22**	24**	28**	39	37	44	25**	Tr**
Spruce Regrowth	23*	19*	16*	21*	24*	35	45	49	51	40	Tr*
Birch-Spruce Thin	23	19	18*	23*	24*	32	45	47	50	36	Tr*
Birch-Spruce Dense	23	19	18*	21*	23*	34	40	44	44	32	Tr*
Spruce-*Ledum*	23	19	19	22	24	34	44	47	49	35	Tr*
Mature Spruce	13	12	7*	7*	12	17	21	24	28	16	Tr*

* *Vaccinium vitis-idaea* visible
** *Carex* sp. visible

An additional factor potentially influencing high calf mortality may be related to the quality of moose browse in the 1947 Kenai burn. As plant succession procedes, the quality of the browse decreases (Cowan et al. 1950). Based upon moose hair analysis, the level of certain mineral elements (magnesium, copper and manganese) were low throughout most of the year (Franzmann et al. 1974), potentially affecting the nutritional status and viability of calves. Subsequent analysis of moose browse plants demonstrated low values for manganese and copper in September (Table 8) and January (Table 9). This assessment was speculative since there is no established optimal level recognized for plants, particularly those browsed by moose. The complexity of micro-nutrient metabolism limits our understanding of the cause and effect relationships (Underwood 1971). Nevertheless, low levels in hair and plants, particularly occurring in September when vegetation mineral element values should be optimum, were disturbing. An additional complicating observation was made on two calves near the MRC cabin which seemingly ate sufficient quantities of vegetation up until their death. LeResche and Davis (1973) noted that many of the winter-killed calves died with rumens full of woody browse. Negative energy balance must be considered in the moose winter mortalities.

Adult moose mortality was low during winter 1973-74. An adult female (#128) was not seen during this report period and likely died during the winter of 1972-73. Three adult females died during the winter of 1973-74; one from old age (19 1/2 years) and two possibly from the influence of introduction into the high moose density Pen 4 (Table 10). No enclosed moose died from immobilization and handling procedures during this report period.

Population estimates on the Kenai National Moose Range, based on random stratified counts in February 1974, reflected a 14.9 percent decrease from the 1973 counts. The 1973 estimate was 5,700 ± 1,348 moose and the 1974 estimate was 4,850 ± 1,045. Heavy calf mortality in winter 1972-73 with continued hunting, poaching, predator and other mortality forces working on a declining population were probably responsible for this. Most calf mortality for 1973-74 did not occur until late February and March and was not a major factor reflected in this decline.

Displaced moose (those that escaped from Pen 1 into Pen 2 on September 30, 1973) did not behave similarly to those displaced the previous year (Franzmann and Arneson 1973). They did not frequently pace the fence between the two pens; however moose #670 was seen eight times near the border.

From January through April 1974 all adult female moose initially trapped both in and out of the pens were examined for pregnancy by rectal palpation (Table 11). Due to poor winter trapping success only 10 inside moose were examined. Five (50 percent) were pregnant, but one of these (No. 111) may have been bred outside the pens prior to being released into Pen 4. Outside the enclosures 14 moose were examined and 9 (64 percent) were pregnant. Although sample size was too small to warrant difinitive conclusions or comparisons, it was disturbing to note the low pregnancy rates for the past two years (cf: Franzmann and Arneson 1973). Bull numbers (especially within the enclosures) should have been adequate for higher conception rates. During the Copper River

Table 8. Mineral analysis of selected moose browse plants on the Kenai Peninsula, Alaska, September, 1973.

Plants Analyzed	Elements (ppm)										
	Zn	Cu	Mg	Mn	Ca	Na	K	Cd	Fe	Pb	Co
Group 1 inside MRC[1]											
Betula nana	52.5	10.0	1560	7.7	4430	55	4950	All	61	2.5	0.3
Salix commutata	55.0	27.5	2165	ND[2]	10155	70	7740	Values	99	ND	ND
Populus tremuloides	17.5	5.0	2190	ND	9390	75	7005	less	48	1.2	ND
Alnus sinuata	17.5	25.0	2105	ND	6260	70	4890	than	79	0.3	0.1
Betula papyrifera	12.5	5.0	2060	22.7	5215	90	6305	0.5	103	ND	ND
Vaccinium vitis-idaea	12.5	5.0	1450	20.7	4565	65	4550		74	ND	0.2
Salix arbusculoides	22.5	15.0	2020	ND	8410	65	7050		92	ND	0.1
Group 2 outside MRC											
Populus tremuloides	65.0	10.0	2170	ND	9155	70	7640		40	ND	0.3
Alnus sinuata	12.5	15.0	2010	ND	5470	65	6530		81	ND	ND
Betula papyrifera	60.0	7.5	2020	7.7	3840	55	6725		75	ND	ND
Vaccinium vitis-idaea	7.5	2.5	1075	18.4	4705	60	4550		37	ND	ND
Salix arbusculoides	15.0	10.0	2100	ND	8330	60	7295		80	ND	0.2
Group 3 Kenai Mtns.											
Betula nana	37.5	12.5	1900	1.99	3410	55	6150		57	1.0	0.1
Populus tremuloides	67.5	0.5	2080	ND	7270	50	7005		65	ND	0.3
Alnus sinuata	40.0	12.5	1950	ND	6460	65	6320		102	ND	0.1
Betula papyrifera	75.0	10.0	2035	6.4	4770	55	6530		70	ND	0.1
Salix arbusculoides	65.0	10.0	2075	ND	10945	65	7060		84	ND	0.1
Vaccinium vitis-idaea	5.0	10.0	1520	13.6	5540	40	4050		34	ND	0.1

1 - MRC - Kenai Moose Research Center
2 - ND - Not detectable

Table 9 Mineral analysis of selected moose browse plants on the Kenai Peninsula, Alaska, January 1974.

Plants Analyzed	Plot	Elements (ppm)										
		Zw	Cw	Mg	Mn	Ca	Na	K	Cd	Fe	Pb	Co
Alnus sinuata	1	0.3	0.3	5.3	1.5	17.9	21.4	16.9	ND[1]	11.0	0.2	0.1
Betula papyrifera	1	0.9	0.2	4.1	2.0	10.2	21.2	14.1	ND	9.0	ND	ND
Populus tremuloides	1	0.4	0.2	5.8	0.8	16.8	22.5	45.0	ND	6.5	0.1	ND
Salix spp.	1	0.6	0.4	4.8	0.8	27.0	22.8	32.0	ND	5.5	ND	0.05
Vacccinium vitis-idaea	1	0.1	0.2	5.3	1.9	25.0	23.2	25.0	ND	3.5	ND	0.05
Alnus sinuata	2	0.1	0.2	5.7	1.0	23.3	23.2	21.0	ND	4.0	ND	0.05
Betula papyrifera	2	0.5	0.2	4.1	1.4	9.4	22.4	16.4	ND	5.5	ND	ND
Populus tremuloides	2	0.4	0.5	6.0	0.7	16.9	23.9	53.5	ND	7.0	0.1	0.2
Salix spp.	2	0.5	0.2	4.5	0.8	17.4	21.8	25.2	ND	4.5	ND	0.05
Vaccinium vitis-idaea	2	0.9	0.3	4.7	1.8	25.9	22.6	39.0	ND	3.5	ND	ND
Alnus sinuata	3	0.2	0.3	5.0	0.9	20.6	22.6	32.9	ND	5.5	0.1	0.05
Betula papyrifera	3	1.0	0.2	4.9	1.1	11.7	23.0	32.4	ND	5.5	ND	0.1
Populus tremuloides	3	0.5	0.2	6.1	0.6	19.1	24.1	83.8	ND	5.5	0.1	ND
Salix spp.	3	0.3	0.2	3.9	0.6	18.7	23.0	60.0	ND	4.0	ND	0.05
Vaccinium vitis-idaea	3	0.4	0.2	4.1	2.3	27.5	23.0	35.3	ND	1.5	ND	ND
Alnus sinuata	4	0.2	0.2	4.5	0.7	17.6	22.8	27.3	ND	3.0	ND	0.05
Betula papyrifera	4	0.6	0.3	5.1	1.5	11.4	22.1	18.0	ND	3.5	ND	ND
Populus tremuloides	4	0.4	0.3	6.2	0.6	16.1	22.7	49.8	ND	3.5	0.1	ND
Salix spp.	4	1.0	0.5	3.6	1.0	19.1	22.5	32.1	ND	7.0	ND	0.05
Vaccinium vitis-idaea	4	0.2	0.2	4.7	1.5	32.3	23.1	27.1	ND	3.0	ND	0.05
Alnus sinuata	5	0.1	0.3	4.0	0.8	11.8	23.5	24.3	ND	3.0	0.1	ND
Betula papyrifera	5	0.6	0.3	5.1	1.2	12.2	23.8	22.2	ND	4.0	0.1	ND
Populus tremuloides	5	0.6	0.2	5.8	0.6	18.3	23.9	61.1	ND	6.5	0.1	ND
Salix spp.	5	0.6	0.3	4.7	0.7	20.9	23.5	28.3	ND	3.0	ND	0.05
Vaccinium vitis-idaea	5	0.1	0.2	4.3	2.2	22.6	22.2	24.6	ND	3.5	ND	ND

Table 9 (cont.) Mineral analysis of selected moose browse plants on the Kenai Peninsula, Alaska, January 1974.

Plants Analyzed	Plot	Elements (ppm)										
		Zw	Cw	Mg	Mn	Ca	Na	K	Cd	Fe	Pb	Co
Alnus sinuata	6	0.2	0.2	5.2	0.8	23.5	23.5	30.4	ND	7.0	0.2	ND
Betula papyrifera	6	0.7	0.4	4.7	1.4	11.5	23.9	26.5	ND	4.5	0.1	0.05
Populus tremuloides	6	1.1	0.5	5.9	1.1	16.3	22.2	52.0	ND	6.5	ND	ND
Salix spp.	6	0.5	0.3	4.7	0.8	20.3	22.4	32.1	ND	6.5	ND	0.05
Vaccinium vitis-idaea	6	0.1	0.2	4.6	2.1	26.9	22.4	27.7	ND	4.0	ND	0.05

1 - ND - Not Detectable

Table 10 Mortalities within Kenai Moose Research Center enclosures July 1, 1973 - April 30, 1974.

Moose Number	Sex	Age	Pen No.	Date Month	Date Year	Cause
99	M	Calf	1	Not	Found	Assumed Dead
101	F	Calf	2	Not	Found	Assumed dead
107	M	Calf	2	Not	Found	Assumed Dead
108	M	Calf	2	Not	Found	Assumed Dead
38	F	19	3	April	1974	Old Age
104	M	Calf	3	Not	Found	Assumed Dead
106	F	9	4	April	1974	Winter (introduced)
113	F	Calf	4	April	1974	Winter (introduced)
128	F	Unk-Adult	4	Not	Found	Assumed Dead
Unmarked		Calf	4	April	1974	Assumed Dead
Unmarked		Calf	4	Not	Found	Assumed Dead
Unmarked	F	Adult	4	Not	Found	Assumed Dead

Table 11 Reproductive status of moose at Kenai Moose Research Center based on rectal palpation.

	Moose Not Pregnant	% not Pregnant	Moose* Pregnant	Moose With 1 Fetus	Moose With 2 Fetuses	Total Pregnant	% Examined Pregnant	Repro. Status Unknown	Total No. Cows	Total No. Bulls
Pen 1	1	--	--	--	--	--	--	2	3	3
Pen 2	--	--	--	--	--	--	--	7	7	2
Pen 3	1	50	--	1	--	1	50	4	6	1
Pen 4	3	43	2	1	1	4	57	8	15	3
Total MRC	5	50	2	2	1	5	50	21	31	9
Total Outside MRC	5	36	5	4	--	9	64	--	--	--

*During late pregnancy number of fetuses not determined.

tagging operation in March 1974, 24 cows were rectally examined for pregnancy and 22 were pregnant (91.6 percent). The possibility of influence of browse quality on pregnancy rates cannot be ignored.

Weights and Measurements

Table 12 lists 17 whole weights of moose from within the MRC pens and seven whole weights of moose trapped and immobilized outside the pens. No significant serial data were recorded. A publication relative to moose morphometric and weight data collected in Alaska is in preparation.

Blood Values

The sources of 294 moose blood samples collected and analyzed during this report period are listed in Table 13. The data obtained were placed on a Game Biological Input Form (cf: Franzmann and Arneson 1973) and sent to the Computer Services Division of the Alaska Department of Administration where they were stored and programmed for retrieval with moose data previously obtained. Table 14 lists mean blood chemistry and electrophoretic values, based on sex, from samples collected to May 1, 1974. Final evaluation will be made upon termination of this job.

Tables 15 through 23 list serial physiologic data from individual moose representing each pen at the MRC. The general trend was for animals to maintain blood chemistry homeostasis; however, some seasonally related influences were detectable in these samples. Blood urea nitrogen (BUN) values obtained in early spring (April and May) were all below 6 mg/100 ml except for the two tame moose (Tables 22 and 23) which were supplementally fed high protein calf pellets. Their BUN values were not below 15 mg/100 ml for equivalent periods. BUN values have been correlated with protein intake in other ruminants (Preston et al. 1965, Franzmann 1972, LeResche et al. 1974). A general rule regarding BUN values in bighorn sheep (*Ovis canadensis*) was that values above 20 mg/100 ml indicated adequate protein intake, values between 15 and 20 mg/100 ml indicated a potential problem in protein intake, and values below 15 mg/100 ml indicated a low protein intake (Franzmann 1972). This rule may be applicable to moose based upon this small serial sample. Additional testing is needed for verification, however.

Packed cell volume levels in most of the serially sampled moose followed a seasonal pattern peaking during summer and fall and dropping in late winter and early spring. Cholesterol, glucose and total protein, in general, peaked in summer and early fall whereas, SGOT values peaked in late winter (cf: LeResche et al. 1974).

Calcium values were seasonably stable in the serially sampled moose, but the inorganic phosphorus levels varied considerably, although not necessarily on a seasonal basis. This was further represented by calcium:phosphorus ratio fluctuations.

Values were from limited numbers of serially sampled moose and did not represent critical periods for all moose but they did reflect, in general, similar fluctuations to those reported from larger pooled samples (Franzmann and Arneson 1973, LeResche et al. 1974). The supplementally fed tame moose did not reflect seasonal patterns, suggesting that the fluctuations noted were primarily nutritional.

Table 12 Whole weights of moose of known age, sex and reproductive status inside and outside Kenai Moose Research Center pens (July 1, 1973-April 30, 1974).

Moose No.	Date	Pen	Sex	Age (mo.)	Reproductive Status and Remarks	Weight kg	Weight 16 Pounds
					INSIDE		
3	July 31, 1973	1	F	134	With one calf	374	825
7	Feb. 14, 1974	4	M	56	Poor Condition (5)	364	800
36	Oct. 4, 1973	4	F	124	With no calf	357	785
72	Sept. 13, 1973	3	F	39	With one calf	314	690
81	Oct. 2, 1973	4	F	52	With no calf	279	615
105	Feb. 21, 1974	4	F	92	With no calf	325	715
111	Dec. 4, 1973	4	F	42	With no calf	402	885
111	Jan. 4, 1974	4	F	43	Possibly mis-weighed	393	865
111	Feb. 5, 1974	4	F	44	Pregnant	400	880
115	Feb. 6, 1974	4	F	128	With no calf, not pregnant	391	860
R70-4	Aug. 7, 1973	2	F	110	With no calf	317	698
R70-8	Feb. 6, 1974	1	F	68	With one calf, not pregnant	336	740
Raquel	Dec. 27, 1973	CP	F	55	With one calf; Supplemental feeding	429	945
Raquel	Feb. 13, 1974	CP	F	56		426	938
Rastus	July 13, 1973	CP	M	1	Calf born June 11, 1973; Supplemental feeding	45	98
Rastus	Dec. 27, 1973	CP	M	7		184	405
Rastus	Feb. 13, 1974	CP	M	8		209	460
					OUTSIDE		
139	Oct. 9, 1973		F	100	Possibly lost twin calves, Condition 8	420	925
230	Feb. 6, 1974		M	116	Condition 6	473	1040
231	Feb. 7, 1974		F	224	Pregnant! Condition 6	377	830
232	Feb. 12, 1974		M	56		281	618
233	Feb. 12, 1974		F	56	Not pregnant; condition 6	311	685
235	Feb. 14, 1974		F	68	Not pregnant; condition 6	370	815
239	Feb. 21, 1974		F	92	Pregnant; poor condition (5)	336	740

Table 13 Sources of moose blood and hair collected from May 1, 1973 to May 1, 1974.

Source	Number of Specimens		
	Serum	Whole Blood	Hair
Trapping at MRC			
Pen 1	25	25	25
Pen 2	32	32	32
Pen 3	9	9	9
Pen 4	31	31	30
Outside Pens	68	66	65
Total MRC	165	163	162
Tagging - GMU 15 Caribou Hills October 1973	61	61	67
Tagging - GMU 20 Alaska Range (Coady) October 1973	--	--	21
Tagging - GMU 6 Copper River March 1974	44	44	43
Fort Richardson Hunt January 1974	47	47	47
TOTAL	317	315	340

Table 14. Blood values[1] based on sex from moose sampled to May 1, 1974.

	Female			Male		
	Mean	S.D.	N	Mean	S.D.	N
Calcium	10.3	1.3	636	10.0	1.2	244
Phos.	5.0	1.6	636	5.3	1.5	244
Glucose	125	46	636	127	44	244
B.U.N.	13	11	636	16	13	244
Uric Acid	0.4	0.2	636	0.5	0.9	244
Cholesterol	87	18	636	80	21	244
Bilirubin	0.5	0.3	636	0.5	0.3	244
Alk. Phos.	64	67	635	95	94	242
L.D.H.	329	112	634	351	117	244
SGOT	170	61	634	160	54	244
Ca/P Ratio	2.28	0.84	423	2.07	0.57	182
Total Protein	7.1	1.0	630	6.9	1.1	248
Albumin %	54.2	6.1	441	52.6	6.4	190
Globulin %	45.8	6.1	441	47.4	6.4	190
Alpha 1 %	5.6	1.9	441	5.8	1.9	190
Alpha 2 %	8.6	2.1	441	9.3	2.5	190
Beta %	10.5	2.1	441	10.4	2.2	190
Gamma %	21.0	3.8	441	21.8	4.6	190
A/G Ratio	1.27	0.35	630	1.21	0.35	248

1. Values expressed as mg./100 ml., except as designated otherwise and total protein as gm./100 ml.

Table 15 Serial physiologic values from Pen 1 adult male moose 58, Kenai Moose Research Center, Alaska.

		1972						
		July	Aug.	Apr.	June	July	Aug.	Oct.
Blood Values								
Calcium	mg %	10.5	9.6	9.5	8.9	10.2	10.8	10.2
Inor. Phosphorus	mg %	5.1	4.3	2.3	5.3	4.8	4.4	4.7
Calcium/Phosphorus	ratio	2.06	2.23	4.13	1.68	2.13	2.45	2.17
Glucose	mg %	102	90	110	126	114	116	121
Urea Nitrogen	mg %	25	31	4	22	29	29	8
Cholesterol	mg %	92	97	67	65	94	97	87
SGOT	mu/ml	127	160	300	114	140	133	197
Total Protein	gm %	7.1	7.3	6.2	6.5	7.5	7.5	7.8
Albumin	gm %	3.7	3.7	3.6	2.9	4.1	3.8	4.4
Albumin/Globulin	ratio	1.06	1.03	1.33	0.79	1.23	1.03	1.29
Hemoglobin	gm %	13.5	15.1	17.2	16.5	16.4	17.7	19.2
Packed Cell Volume	%	--	--	45	43	40	45	50
Hair Values								
Zinc	ppm	35	51	--	85	64	64	67
Copper	ppm	5	6	--	5	8	12	9
Magnesium	ppm	22	196	--	24	64	240	155
Manganese	ppm	0	0	--	0	0	1	2
Calcium	ppm	161	953	--	152	136	362	140
Sodium	ppm	525	212	--	647	593	933	955
Potassium	ppm	1094	276	--	816	803	1627	1987
Cadmium	ppm	1	0	--	0	0	0	1
Iron	ppm	59	26	--	30	43	58	66
Lead	ppm	12	4	--	1	6	17	10
Evaluation								
Condition	Class	7	6	6	6	7	7	7
Rectal Temp	C	38.8	39.5	39.3	39.2	39.2	38.3	38.9
Weight	Kg	--	--	--	--	--	--	--

Table 16 Serial physiologic values from Pen 1 adult male moose 35, Kenai Moose Research Center, Alaska.

		1972			1973				
		June	July	Nov.	Feb.	Apr.	July	Aug.	Oct.
Blood Values									
Calcium	mg %	10.6	10.9	9.5	9.3	9.8	9.7	9.9	8.5
Inor. Phosphorus	mg %	5.0	4.8	3.4	6.1	4.1	5.7	6.5	6.2
Calcium/Phosphorus	ratio	2.12	2.27	2.79	1.52	2.39	1.70	1.52	1.37
Glucose	mg %	156	122	125	107	112	112	105	101
Urea Nitrogen	mg %	36	29	9	29	3	25	23	16
Cholesterol	mg %	90	101	73	80	72	67	93	56
SGOT	mu/ml	157	168	141	173	200	168	157	200
Total Protein	gm %	7.5	7.7	6.7	6.4	6.6	6.8	7.5	7.5
Albumin	gm %	3.8	4.2	4.3	3.4	3.4	2.6	3.4	3.5
Albumin/Globulin	ratio	1.00	1.17	1.79	1.17	1.06	0.64	0.85	0.88
Hemoglobin	gm %	18.5	15.2	18.2	18.5	15.4	17.2	20.0	20.5
Packed Cell Volume	%	--	--	--	41	37	39	53	54
Hair Values									
Zinc	ppm	42	--	69	110	70	99	74	70
Copper	ppm	2	--	17	2	7	4	18	8
Magnesium	ppm	18	--	74	57	31	13	239	116
Manganese	ppm	0	--	6	2	2	0	1	1
Calcium	ppm	260	--	147	272	243	282	426	149
Sodium	ppm	345	--	1129	890	799	1011	1034	866
Potassium	ppm	650	--	946	180	377	1805	724	1866
Cadmium	ppm	0	--	1	0	1	1	1	2
Iron	ppm	50	--	23	67	50	17	79	68
Lead	ppm	5	--	9	6	8	11	11	7
Evaluation									
Condition	Class	6	8	8	7	6	6	8	7
Rectal Temperature	C.	39.6	--	39.8	--	39.0	39.6	38.7	39.3
Weight	Kg	--	--	--	--	--	--	--	--

Table 17 Serial physiologic values from Pen 2 adult female moose 73, Kenai Moose Research Center, Alaska.

		1972			1973				
		May	June	Oct.	Apr.	June	Aug.	Sept.	Oct.
Blood Values									
Calcium	mg %	9.2	9.3	10.2	10.1	10.3	9.9	9.9	10.7
Inor. Phosphorus	mg %	4.2	5.2	4.7	2.8	5.0	6.2	5.5	3.5
Calcium/Phosphorus	ratio	2.19	1.79	2.17	3.60	2.06	1.60	1.80	3.06
Glucose	mg %	122	67	122	125	128	145	263	175
Urea Nitrogen	mg %	6	34	4	1	28	36	19	19
Cholesterol	mg %	75	73	70	69	88	112	112	111
SGOT	mu/ml	220	180	118	173	130	140	157	155
Total Protein	gm %	5.5	6.4	7.5	5.8	6.6	7.7	7.7	8.2
Albumin	gm %	2.5	4.0	4.5	3.2	2.9	3.6	4.2	4.4
Albumin/Globulin	ratio	1.15	1.60	1.50	1.23	0.78	0.88	1.24	1.16
Hemoglobin	gm %	--	13.0	18.8	15.1	15.6	18.3	18.3	19.0
Packed Cell Volume	%	--	--	--	--	39	49	49	49
Hair Values									
Zinc	ppm	64	61	100	--	61	57	65	54
Copper	ppm	2	2	15	--	9	13	16	11
Magnesium	ppm	36	26	138	--	40	116	155	139
Manganese	ppm	2	5	8	--	0	2	0	0
Calcium	ppm	361	340	251	--	162	259	336	151
Sodium	ppm	562	702	1218	--	660	1340	873	1140
Potassium	ppm	219	275	2380	--	641	1869	2209	1629
Cadmium	ppm	0	0	0	--	0	1	0	2
Iron	ppm	40	36	92	--	27	39	61	69
Lead	ppm	7	4	16	--	1	25	16	11
Evaluation									
Condition	Class	7	5	7	5	6	6	6	6
Rectal Temperature	C.	40.7	39.4	39.3	38.3	39.1	39.1	40.4	39.4
Weight	Kg	--	238	--	--	--	--	--	--

Table 18. Serial physiologic values from Pen 2 adult female moose 3, Kenai Moose Research Center, Alaska.

		1972				1973				
		June	July	Aug.	Nov.	Apr.	July	Sept.	Oct.	Nov.
Blood Values										
Calcium	mg %	9.9	10.8	10.9	10.6	10.3	10.4	10.8	10.9	10.7
Inor. Phosphorus	mg %	4.3	3.8	4.7	4.7	3.2	3.2	4.8	4.8	3.5
Calcium/Phosphorus	ratio	2.30	2.84	2.32	2.26	3.22	3.25	2.25	2.27	3.06
Glucose	mg %	113	120	115	135	97	155	165	131	160
Urea Nitrogen	mg %	20	27	28	9	3	30	28	9	10
Cholesterol	mg %	87	84	97	77	88	93	106	97	82
SGOT	mu/ml	127	145	130	152	167	140	137	136	163
Total Protein	gm %	7.3	8.1	8.5	7.7	6.9	8.3	8.6	8.2	7.3
Albumin	gm %	4.1	4.5	3.9	4.6	3.7	4.2	4.3	4.4	4.2
Albumin/Globulin	ratio	1.28	1.22	.85	1.44	1.16	1.00	1.00	1.16	1.35
Hemoglobin	gm %	14.2	16.2	16.1	16.5	15.6	16.7	17.6	19.0	20.0
Packed Cell Volume	%	--	--	--	--	42	46	49	50	53
Hair Values										
Zinc	ppm	54	--	58	71	101	68	62	57	
Copper	ppm	4	--	2	17	4	11	15	6	
Magnesium	ppm	65	--	114	111	30	171	125	113	
Manganese	ppm	0	--	0	4	1	2	1	1	
Calcium	ppm	492	--	546	203	293	242	192	111	
Sodium	ppm	662	--	334	1489	679	956	1493	1313	
Potassium	ppm	482	--	162	1163	545	2708	993	1504	
Cadmium	ppm	0	--	2	2	1	1	1	2	
Iron	ppm	110	--	24	58	96	67	68	79	
Lead	ppm	12	--	7	20	4	20	35	18	
Evaluation										
Condition	Class	5	6	7	7	6	7	6	7	5
Excitability	C.	39.0	38.1	38.0	38.8	38.8	38.3	38.3	38.1	38.2
Weight	Kg	295	--	--	--	--	375	--	--	--

Table 19. Serial physiologic values from Pen 3 adult female moose 72, Kenai Moose Research Center, Alaska.

		1972				1973				1974
		May	June	Aug.	Sept.	Apr.	June	Sept.	Nov.	Jan.
Blood Values										
Calcium	mg %	10.1	10.1	6.7	9.4	10.3	10.4	12.5	10.4	10.2
Inor. Phosphorus	mg %	2.4	5.6	2.0	4.6	4.8	5.1	4.1	4.9	4.3
Calcium/Phosphorus	ratio	4.21	1.80	3.35	2.04	2.14	2.04	3.05	2.12	2.37
Glucose	mg %	87	135	73	115	98	136	123	135	130
Urea Nitrogen	mg %	5	39	17	24	2	28	27	19	10
Cholesterol	mg %	68	102	69	110	80	79	136	87	75
SGOT	mu/ml	165	128	73	105	143	125	133	175	195
Total Protein	gm %	6.2	7.5	4.9	7.0	6.4	6.4	8.0	6.9	6.7
Albumin	gm %	3.7	3.9	2.7	3.8	3.7	2.8	4.1	3.9	4.0
Albumin/Globulin	ratio	1.48	1.05	1.29	1.23	1.37	0.79	1.03	1.30	1.48
Hemoglobin	gm %	--	--	17.5	14.7	16.3	16.0	20.6	20.0	19.0
Packed Cell Volume	%	--	--	--	--	41	39	57	48	46
Hair Values										
Zinc	ppm	57	44	51	--	--	98	66	--	--
Copper	ppm	2	4	5	--	--	7	9	--	--
Magnesium	ppm	35	19	127	--	--	65	167	--	--
Manganese	ppm	2	0	0	--	--	0	1	--	--
Calcium	ppm	304	198	1029	--	--	244	171	--	--
Sodium	ppm	624	575	240	--	--	735	820	--	--
Potassium	ppm	368	1869	941	--	--	944	1737	--	--
Cadmium	ppm	1	0	1	--	--	1	2	--	--
Iron	ppm	45	59	24	--	--	11	66	--	--
Lead	ppm	6	2	4	--	--	3	9	--	--
Evaluation										
Condition	Class	--	5	5	6	6	6	6	6	5
Rectal Temperature	C.	--	40.1	38.8	38.9	41.1	39.7	38.2	38.8	38.7
Weight	Kg	--	--	--	--	--	--	314	--	--

Table 20. Serial physiologic values from Pen 4 adult male moose 7, Kenai Moose Research Center, Alaska.

		1972	1973				1974
		Nov.	Jan.	Apr.	Sept.	Nov.	Feb.
Blood Values							
Calcium	mg %	8.6	10.0	10.0	11.7	10.6	10.8
Inor. Phosphorus	mg %	4.8	4.4	5.3	5.5	3.2	3.9
Calcium/Phosphorus	ratio	1.79	2.27	1.88	2.13	3.31	2.77
Glucose	mg %	123	105	127	131	130	125
Urea Nitrogen	mg %	20	11	4	29	19	5
Cholesterol	mg %	75	72	83	120	93	94
SGOT	mu/ml	300	215	131	162	160	244
Total Protein	gm %	6.2	6.5	6.0	8.1	6.9	6.8
Albumin	gm %	3.8	3.6	3.7	4.5	3.8	3.4
Albumin/Globulin	ratio	1.65	1.20	1.54	1.25	1.23	1.00
Hemoglobin	gm %	16.4	17.0	12.5	19.7	20.0	18.0
Packed Cell Volume	%	--	38	33	53	51	--
Hair Values							
Zinc	ppm	55	60	--	59	--	--
Copper	ppm	2	2	--	12	--	--
Magnesium	ppm	65	44	--	157	--	--
Manganese	ppm	6	1	--	1	--	--
Calcium	ppm	195	184	--	166	--	--
Sodium	ppm	827	1111	--	1006	--	--
Potassium	ppm	613	278	--	1741	--	--
Cadmium	ppm	1	0	--	0	--	--
Iron	ppm	42	85	--	62	--	--
Lead	ppm	19	6	--	21	--	--
Evaluation							
Conditon	Class	7	7	7	7	6	5
Rectal Temperature	C.	37.8	37.3		38.4	38.3	38.4
Weight	Kg	--	--		--	--	364

Table 21. Serial physiologic values from Pen 4 adult female moose 81, Kenai Moose Research Center, Alaska.

		1972	1973			1974
		July	Apr.	Aug.	Oct.	Jan.
Blood Values						
Calcium	mg %	10.6	9.8	10.5	10.8	10.4
Inor. Phosphorus	mg %	4.6	3.5	5.0	5.1	5.0
Calcium/Phosphorus	ratio	2.30	2.80	2.10	2.12	2.08
Glucose	mg %	142	155	175	117	140
Urea Nitrogen	mg %	26	4	29	18	15
Cholesterol	mg %	105	81	105	115	100
SGOT	mu/ml	140	142	221	160	167
Total Protein	gm %	7.4	6.4	8.0	8.1	7.4
Albumin	gm %	3.4	3.3	3.4	3.8	3.8
Albumin/Globulin	ratio	0.85	1.06	0.76	0.88	1.06
Hemoglobin	gm %	15.0	17.6	18.5	19.0	19.7
Packed Cell Volume	%	--	39	51	49	49
Hair Values						
Zinc	ppm	31	--	61	51	--
Copper	ppm	6	--	11	11	--
Magnesium	ppm	52	--	170	87	--
Manganese	ppm	0	--	2	2	--
Calcium	ppm	184	--	480	92	--
Sodium	ppm	670	--	1296	1402	--
Potassium	ppm	1435	--	1837	1677	--
Cadmium	ppm	1	--	1	2	--
Iron	ppm	71	--	37	75	--
Lead	ppm	13	--	17	16	--
Evaluation						
Condition	Class	6	5	7	6	5
Rectal Temperature	C.	40.0	39.1	42.8	38.3	39.9
Weight	Kg	--	--	--	280	--

Table 22. Serial physiologic values from Pen 2 adult castrated male moose 13800, Kenai Moose Research Center, Alaska.

		1972					1973							
		May	July	Aug.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	July	Aug.	Sept.	Dec.
Blood Values														
Calcium	mg %	10.8	11.8	9.7	10.4	10.5	9.0	10.6	9.5	10.5	10.6	10.9	10.6	10.9
Inor. Phosphorus	mg %	7.0	7.4	6.2	7.2	7.8	6.1	7.4	6.3	6.7	5.4	6.4	3.9	5.6
Calcium/Phosphorus	ratio	1.54	1.50	1.56	1.44	1.35	1.48	1.43	1.51	1.56	1.96	1.70	2.72	1.95
Glucose	mg %	137	110	140	100	90	115	140	140	131	128	178	134	167
Urea Nitrogen	mg %	15	23	29	21	30	29	33	33	20	29	28	33	23
Cholesterol	mg %	90	85	105	55	87	70	101	95	89	100	115	121	79
SGOT	mu/ml	114	98	95	90	90	169	77	95	75	87	109	116	94
Total Protein	gm %	7.2	6.5	7.1	6.9	7.5	7.7	8.4	7.6	7.3	7.4	7.9	7.6	7.7
Albumin	gm %	4.5	4.0	3.6	3.8	4.4	3.5	3.7	4.4	3.4	4.1	3.9	3.9	3.5
Albumin/Globulin	ratio	1.73	1.54	1.06	1.19	1.38	.85	.79	1.33	.89	1.27	0.95	1.03	0.83
Hemoglobin	gm %	--	14.4	10.5	15.7	16.8	14.6	17.0	19.4	17.9	18.7	18.5	19.4	19.2
Packed Cell Volume	%	--	--	--	--	--	39	43	44	43	47	51	41	49
Hair Values														
Zinc	ppm	--	71	55	79	71	74	75	70	52	91	80	78	--
Copper	ppm	--	3	7	21	0	2	6	11	1	9	10	14	--
Magnesium	ppm	--	91	92	73	56	69	63	34	59	17	245	212	--
Manganese	ppm	--	0	2	7	7	1	1	1	0	1	1	1	--
Calcium	ppm	--	646	454	161	248	217	202	247	193	338	407	472	--
Sodium	ppm	--	1074	700	1472	1414	1360	1143	840	992	1000	1061	947	--
Potassium	ppm	--	2036	1511	652	321	390	332	345	396	979	1264	1610	--
Cadmium	ppm	--	0	0	1	0	0	0	0	0	1	1	1	--
Iron	ppm	--	41	42	44	61	71	84	65	61	63	59	58	--
Lead	ppm	--	17	18	22	9	5	7	8	6	9	17	8	--
Evaluation														
Condition	Class	--	8	8	5	7	7	6	7	7	6	7	6	6
Rectal Temperature	C.	--	39.1	39.1	38.7	38.7	38.7	38.9	40.2	39.6	39.1	40.0	38.8	39.8
Weight	Kg	214	--	--	--	298	--	320	--	--	--	--	--	--

Table 23. Serial physiologic values from Pen 2 adult female moose 15, Kenai Moose Research Center, Alaska.

		1972						1973								1974
		June	July	Aug.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	July	Sept.	Oct.	Dec.	Feb.
Blood Values																
Calcium	mg %	10.4	10.2	10.1	10.5	9.3	10.2	10.7	9.8	9.7	10.3	10.5	11.1	9.8	10.3	10.4
Inor. Phosphorus	mg %	7.1	5.2	6.3	6.0	7.2	6.1	8.4	7.1	5.1	6.3	4.6	6.7	5.8	4.9	6.1
Calcium/Phosphorus	ratio	1.48	1.96	1.60	1.75	1.29	1.67	1.27	1.38	1.90	1.62	2.28	1.66	1.69	2.10	1.70
Glucose	mg %	86	93	102	81	107	79	85	135	118	128	136	241	145	129	139
Urea Nitrogen	mg %	24	24	26	19	24	24	23	28	30	27	32	26	24	10	19
Cholesterol	mg %	95	94	101	107	87	82	90	102	95	95	107	122	98	82	82
SGOT	mu/ml	120	69	108	128	85	102	113	128	154	75	107	136	95	90	107
Total Protein	gm %	7.3	7.8	8.1	9.2	8.7	9.2	8.5	8.4	8.6	9.0	8.4	8.2	8.4	7.9	8.3
Albumin	gm %	4.0	4.1	4.3	4.7	4.3	4.3	4.2	4.4	4.4	4.9	4.9	4.4	4.5	3.8	3.3
Albumin/Globulin	ratio	1.25	1.05	1.19	1.04	.96	.88	1.00	1.07	1.02	1.17	1.38	1.16	1.15	0.93	0.66
Hemoglobin	gm %	15.8	15.5	13.2	14.8	15.3	17.0	19.0	18.2	19.2	18.4	19.9	20.0	20.0	20.0	19.7
Packed Cell Volume	%	--	--	--	--	--	--	48	44	48	44	51	55	52	53	54
Hair Values																
Zinc	ppm	41	71	89	84	74	70	74	77	86	85	85	68	63		
Copper	ppm	2	5	8	15	17	0	1	1	8	10	7	12	11		
Magnesium	ppm	32	123	144	100	103	62	74	78	45	65	68	174	117		
Manganese	ppm	0	0	0	3	4	6	2	2	2	4	0	1	11		
Calcium	ppm	195	468	397	301	165	202	190	337	300	240	356	276	87		
Sodium	ppm	385	863	665	810	1186	1279	1204	1079	829	821	743	837	1154		
Potassium	ppm	461	1507	1064	402	2306	418	535	494	616	611	688	2031	1665		
Cadmium	ppm	0	0	0	3	1	0	0	0	0	0	1	2	1		
Iron	ppm	56	44	38	50	51	60	93	91	80	94	58	60	66		
Lead	ppm	4	11	14	14	12	16	7	9	1	2	11	10	17		
Evaluation																
Condition	Class	7	8	8	7	6	7	7	8	8	8	7	8	7	7	7
Rectal Temperature	C.	38.9	39.1	38.7	38.8	38.9	38.4	38.2	38.7	39.2	39.0	38.7	38.7	38.8	38.9	38.3
Weight	Kg	352	--	--	--	373	384	--	--	445	--	--	--	--	430	426

The moose hair element values from the serial sampled moose, although limited in number and distribution (Tables 14 through 22), did seasonally fluctuate as did values reported for large pooled samples (Franzmann et al. 1974). Hair samples were not subject to homeostatic influences and may be more useful as monitors of environmental influences on the moose. Interpretation of the values in this early stage of investigation may, however, be more difficult. Additional discussion of hair analysis appears in the hair values section of this report.

Hair Values

From May 1, 1973 to May 1, 1974, 340 hair samples were collected. Analyses were completed through October 1973 from moose sampled at the MRC and from moose sampled in the Alaska Range by John Coady, Alaska Department of Fish and Game, in the Caribou Hills tagging program and at Fort Richardson.

A paper entitled "Monitoring Moose Mineral Metabolism Via Hair Element Analysis", by Franzmann, Flynn, Arneson and Oldemeyer was presented at the 10th N. A. Moose Workshop. The following abstract of a manuscript entitled "Monitoring Moose Mineral Metabolism Via Hair Element Analysis" by Franzmann, Flynn and Arneson which has been submitted to JWM summarizes these data:

Abstract: Three hundred seventeen Alaskan moose (*Alces alces gigas*) hair samples were analyzed for 10 elements by atomic absorption spectroscopy between May, 1972 and May, 1973. Results demonstrated seasonal variation associated with general moose condition. Peak levels occurred in the fall and low levels occurred during late winter and early spring. Some element levels were lower than domestic animal lower limits of "normal values" over extended periods of time. Moose from different geographical locations demonstrated significant differences with certain elements, suggesting geochemical or range differences. Significant differences in three elements (magnesium, copper and manganese) were noted between winter-killed calves and live moose from the same area. To validate the suggested mineral deficiences, it will be necessary to establish the mineral requirements for moose and to establish base-line moose hair element values. The ease in collecting, handlng, and storing hair and its physiologic stability provide additional reasons to fully investigate its potential to monitor mineral element metabolism in moose.

Milk Values

Twelve moose milk samples were analyzed for 18 elements by atomic absorption spectroscopy. Six elements (As, Co, Cr, Mn, Mo, and Ni) were below the detection limits of the machine. Results of the other 12 elements are listed in Table 24. Cook et al. (1970) reported mineral values from two samples of moose milk but the values were expressed as percent of ash. Our values were calculated as parts per million (ppm) and total ash was not analyzed, therefore results are not comparable. We sent these same samples to another laboratory which hopefully will provide these data, but results have not been received.

Table 24 Moose milk mineral element levels, Kenai Moose Research Center, Alaska.

Sample Number	Elements (ppm)											
	Zn	Cu	Mg	Ca	Na	K	Cd	Fe	Pb	Al	Se	Hg
67319	5.20	4.0	204.0	1209.0	299.5	104.3	1.9	4.9	0.3	1.91	19.13	10.79
67320	12.60	2.5	217.5	1558.5	426.5	1053.0	0.6	1.8	1.3	1.46	19.54	10.33
70841	6.80	4.5	197.5	1582.5	390.0	1093.0	0.8	1.8	1.6	1.52	19.30	10.83
70871	7.50	4.0	220.0	1738.0	463.0	1080.5	0.3	5.1	1.3	1.07	18.31	11.79
71661	7.05	3.5	177.5	1697.5	379.0	935.5	0.4	4.4	2.1	0.93	17.14	8.96
71664	6.75	3.0	186.5	1868.0	332.0	1044.0	0.2	1.5	0.9	1.52	19.41	8.75
71669	5.95	2.5	163.0	1743.5	375.0	1020.0	0.9	2.6	0.8	1.78	18.78	9.70
71704	7.50	1.5	130.5	1124.0	399.5	1037.0	0.4	4.2	1.0	1.51	19.00	11.04
71712	9.85	2.5	179.0	1550.0	457.5	994.5	1.0	3.6	1.1	1.00	20.15	11.13
71715	5.50	2.5	211.5	1771.5	403.5	979.5	0.9	3.1	1.1	0.98	19.17	10.89
71719	5.95	1.5	209.0	1744.5	418.0	1032.0	0.5	2.5	0.7	1.21	19.34	10.54
71736	4.10	2.0	150.0	1192.0	399.5	1050.0	0.4	1.9	0.4	1.30	18.89	12.50
Mean	7.1	2.8	187.2	1564.9	395.3	1038.5	0.7	3.1	1.1	1.35	19.01	10.60
Standard Deviation	2.3	0.6	28.3	253.5	46.7	50.3	0.5	1.3	0.5	0.63	0.74	1.07

It is difficult to evaluate the results without knowing base-line values, but as additional samples are analyzed some comparative evaluations can be made. Dr. Flynn, Cleveland Metropolitan General Hospital, commented on the relatively high mercury and selenium levels in the samples, indicating that 10 ppm is very high for mercury and 20 ppm is high for selenium.

Browse Production and Utilization

John L. Oldemeyer, Bureau of Sport Fisheries and Wildlife, has conducted the browse production and utilization studies at the MRC since May 1971. His most recent Annual Progress Report follows:

ANNUAL PROGRESS REPORT
WILDLIFE RESEARCH WORK UNIT
DENVER WILDLIFE RESEARCH CENTER

January 1972 - July 1973

PROJECT DC-102: Basic Ecology and Life History Studies of Wildlife

WORK UNIT DC-102.1: Ecology, Life History, and Dynamics of Selected Wildlife Species

STUDY PLAN: Production and Utilization of Paper Birch in Four Moose Pens in the 1947 Burn, Kenai National Moose Range, Alaska.

PRINCIPAL INVESTIGATOR: John L. Oldemeyer

ABSTRACT: This annual report presents data collected from October 1971 - May 1973 in pens 3 and 4 at the Kenai Moose Research Center. Two years of clipping and weighing paper birch (*Betula papyrifera*) has resulted in development of reliable regression equations of birch production. Number of twigs produced, crown length, and basal diameter were the most important measurements made for predicting sapling production. Nineteen of 23 site regression equations did not differ between years. Estimated production of birch did not differ between pen 3 and pen 4 but production increased the second year. Utilization was higher in the high moose density pen, and percent of twigs browsed was greater in both pens the second year. A good curvilinear relation (R^2 = 0.82) exists between percent of saplings browsed and percent of twigs browsed. Snowshoe hares (*Lepus americanus*) browsed a high percentage of birches.

INTRODUCTION

The Kenai National Moose Range was established in 1941 primarily for protecting habitat of the Kenai Moose (*Alces alces gigas*). The Moose Range covers 1.7 million acres of the Kenai Peninsula which is located between Prince William Sound and Cook Inlet in Southcentral Alaska. Approximately one million acres of the Moose Range is lowland terrain characteristic of typical moose habitat. The lowland is a broad shelf from 20 to 50 miles wide, 106 miles long, and less than 400 feet above sea level and is bordered on the east by the Kenai Mountains, on the north by Turnagain Arm, and on the west by Cook Inlet. One-third of the lowland is wet areas and lakes. Tustumena and Skilak Lakes occupy glacially scoured and moraine-dammed troughs and are drained by the Kasilof and Kenai Rivers, respectively.

The climate of the Cook Inlet area is intermediate between the dry, cold continental climate of Interior Alaska and the wet and mild maritime climate of the Gulf of Alaska coastal area. The Kenai lowland is much influenced by the Kenai Mountains and has a lower mean annual precipitation than the mountains or the lowland to the west and north. Precipitation increases from south to north and temperatures decrease from south to north.

Summer high temperatures on the Kenai have reached 90F; however, the average July mean temperature is only 54.2F and summer temperatures are mild. Winter low temperatures are recorded as low as -48F, and January mean temperatures are a cold 10.9F. There are generally 90-110 days between freezing dates in the summer. Table 1 summarizes weather from 1970-1973.

The Kenai has a long history of fire (Lutz 1960 and Spencer and Hakala 1964). A 310,000-acre fire in 1947 burned in the center of the Kenai lowlands and was an important influence on today's moose populations. As a result of this fire, and the subsequent regrowth of birch, aspen and willow, moose populations increased drastically.

Concern for the proper management of moose resulted in a cooperative agreement being signed in 1967 between the Bureau of Sport Fisheries and Wildlife and the Alaska Department of Fish and Game. This agreement outlined a unique approach to management-oriented research. Four 640-acre pens were built in such a manner as to minimize disturbance to the habitat, and moose are kept in the pens year round to form an integral part of a large outdoor laboratory. The Alaska Department of Fish and Game provides biologists to study the biology of moose and the Bureau of Sport Fisheries and Wildlife provides a biologist to study moose habitat.

Construction of the pens started in 1966 in the vicinity of Coyote Lake, beyond the termination of the Swan Lake Road. Pens 1 and 2 were enclosed in January 1967 and Pens 3 and 4 in August 1969.

Vegetation in the pens is primarily birch regrowth with islands of mature birch, mature spruce, regrowth spruce, sedge, and spruce-*Ledum*. Results of a soil survey in the pens by Stephens (1967) indicated that the upland soils were fairly uniform Naptowne podzolic soils occupying 85 percent of the area. Tustumena podzols occupy about 5 percent. Both soils have low fertility and are acedic (pH 4.5), but the Naptowne soils are much higher in phosphate, calcium, magnesium and potassium. The Naptowne soils support birch vegetation and the Tustumena soils support spruce vegetation (Stephans, 1967). Wet soils and lakes occupy the other 10 percent.

This annual report concerns data collected at the Moose Research Center from October 1971 through May 1973 and is the result of two years of production and utilization sampling at the Center. The report is divided into three parts: The first is concerned with the development of regressions of birch production; the second with birch production and utilization in pens 3 and 4; and the third with snowshoe hare browsing on birch.

Table 1. Weather Conditions from 1971-1973 as Reported by the Kenai Federal Aviation Administration.

	Mean Temperature				Degree Days			Inches of Precipitation				Inches of Snowfall			Maximum Depth of Snow on Ground		
	10 Yr. Avg.	1971	1972	1973	1971	1972	1973	10 Yr. Avg.	1971	1972	1973	1971	1972	1973	1971	1972	1973
January	7.5	-4.8	3.7	-4.7	2167	1902	2163	0.81	0.06	0.98	1.46	0.1	10.1	14.7	11	22	19
February	17.5	18.0	12.3	8.3	1312	1522	1584	1.20	1.62	0.97	0.29	21.6	10.8	2.6	11	28	22
March	20.2	9.0	9.6	20.4	1732	1714	1377	1.20	0.67	0.47	0.73	6.7	6.4	6.7	17	14	10
April	32.7	31.0	23.5	35.8	1015	1239	890	1.03	1.49	0.60	0.30	12.4	6.6	0.7	15	15	3
May	43.9	41.6	44.5	43.5	717	630	660	1.33	0.98	1.00	0.71	1.9	T	T	1	4	0
June	49.6	49.7	51.1	47.8	452	410	508	1.38	0.93	1.26	0.67	0	0	0	0	0	0
July	54.6	53.2	58.7	52.8	360	193	370	1.78	1.88	0.39	0.54	0	0	0	0	0	0
August	53.9	54.4	57.3		321	233		2.69	4.09	2.19		0	0		0	0	
September	44.0	46.6	54.8		546	489		2.26	1.55	4.63		0	T		0	0	
October	34.2	35.5	36.1		909	893		2.38	2.41	3.94		7.1	0.7		6	1	
November	21.0	18.5	24.5		1392	1210		1.38	0.91	1.68		8.3	11.8		6	8	
December	11.9	14.1	10.7		1573	1678		1.83	2.21	0.50		24.9	4.5		25	7	

PART 1 - ESTIMATING PRODUCTION OF BIRCH SAPLINGS

Paper birch saplings are an important moose forage plant on the Kenai Peninsula. LeResche and Davis (1973) found that paper birch made up over 50 percent of the twigs browsed by moose at the Kenai Moose Research Center. Therefore, estimating paper birch production is important in determining trends in moose habitat conditions.

The utility of measuring some parameter on the shrub to estimate production has been shown by Lyon (1968), Telfer (1969) and Peek (1970). Lyon (1968) and Peek (1970) correlated weight of plant twig production with crown volume and crown area. They found that crown volume was responsible for over 80 percent of the variation in twig production in serviceberry (*Amelanchier alnifolia*), beaked hazel (*Corylus cornuta*), pussy willow (*Salix discodor*) and aspen (*Populus tremuloides*). In addition, Peek (1970) obtained good correlations between weight and canopy area (r = 0.86-0.94), and weight and plant height (r = 0.65-0.84). In almost all cases with Peek's data, the correlation coefficient was increased when both variables were transformed by logarithms. Telfer (1969) correlated leaf weight and total above-ground biomass with the diameter of the stem just above the swelling at the root collar and obtained high correlations on 22 species of woody plants.

Methods

Twenty-four saplings no larger than 5 cm DBH in each of 23 sites were collected after leaves had fallen in 1971 and 1972. The following measurements were made on each sapling: Circumference of stem above any basal swell, crown length (measured vertically from the proximal end of growth on the lowest twig to the terminal bud), maximum height, diameter of the crown and number of twigs. Throughout this report "twigs" refer to current year's growth. The twigs from each sapling were clipped, dried as a unit at 95C for 24 hours and weighed as a unit to the nearest 0.1 gram.

Two regression models were assumed:

(1) $y = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_6x_6$

(2) $\log y = a + b_1\log x_1 + b_2\log x_2 + b_3\log x_3 + b_4\log x_4 + b_5\log x_5 + b_6\log x_6$

where y = oven-dry weight of production,

x1 = crown length,
x2 = total height,
x3 = basal circumference
x4 = crown area, $\left(\frac{\text{Crown diameter}}{2}\right)^2$
x5 = number of twigs, and
x6 = crown volume, (x_1x_4).

Stepwise regression was used to determine which variables contributed most to the regression.

Results and Discussion

After the first year's data were analyzed, diameter of crown was abandoned as a measurement for estimating birch production because it did not contribute uniformly to the correlation and, more importantly, because it could not be accurately measured on all saplings.

The coefficient of determination (R^2) of all the data analyzed together increased from 0.69 for model 1, to 0.81 for model 2. Baskerville (1972) suggested using the logarithmic transformation as a means to meet the assumptions of regression, since in many cases these assumptions are not met with the nontransformed data. I followed suggestions by Draper and Smith (1966) for determining bias in regression and could detect no noticeable tendencies where the data followed a pattern, except that the residuals tended to be positive at the extremes of the stem circumferences and crown length. I suspect this is due to minimum numbers of trees at those extremes. A way to correct this would be to collect more trees at the extremes of size. Logarithmic transformation resulted in a more rectangular distribution than non-transformed and at this point I am satisfied that the logarithmic transformation is proper.

The contribution of each variable to the regression changed from one sample site to another. With 46 regression equations calculated on the 23 sites over two years, the number of twigs contributed most to regression 26 times, crown length 10 times, stem circumference 9 times, and height 1 time. The number of twigs and crown length were the most important first two variables 23 of 46 times, while the next most important combination of any two variables occurred only seven times. A third variable made a significant improvement in the regression 23 times and contributed from 1.0 percent to 6.0 percent to the increase in R^2. There were only 3 times when a fourth variable (height) contributed significantly to the regression.

The resulting equation took the form: log (production) = $a + b_1$ log (crown length) + b_2 log (basal circumference) + b_3 log (number of twigs). A sum of ranks analysis indicated that those three variables contributed most overall to the regression of birch production. The R^2 of the regressions using the above three variables had a range of 0.46 to 0.91. Only 9 of the 46 had an R^2 less than 0.75, and one was less than 0.50. Five of the six roots sampled in our thin mature hardwoods type had an R^2 less than 0.75. For the purposes of estimating production of a sample of birch plants, I considered an $R^2 = 0.75$ as biologically significant. The low R^2 values found in the thin mature hardwood types indicate that we were not totally successful in that type. Density of birch saplings in that type is low and those occurring are heavily browsed and many are sprouts from mature trees. This combination evidently influences the production regression.

I used Rao's (1966:237) test for the equality of regression equations to test the hypothesis of no difference between the two regression equations calculated at each collection site. The test failed to reject (Atd = 0.10) that hypothesis for 19 of the 23 sites. This is an indication then that a regression equation of the two year's data could be satisfactorily used for estimation purposes.

In general, the R^2's calculated from birch are not as uniformly high as those Lyon (1968), Telfer (1969), or Peek (1970) calculated for other shrub species. Our plants were collected from areas of high moose density (greater than 7 moose/sq. mile on a year-around basis) and varying intensities of browsing the years before collection. One of the purposes of using crown length was to compensate for browsing. In fact, whenever crown length was the second most important variable in the regression it contributed an average of 7.3 percent to the increase in R^2.

PART II - PRODUCTION AND UTILIZATION OF BIRCH IN PENS 3 AND 4

Pens 3 and 4 were enclosed in August 1969. Pen 3 was to contain populations similar to outside the Moose Research Center while pen 4 was to contain populations dense enough to severely overbrowse the range. In June 1970, they contained 13 and 18 moose, respectively, and in June 1971, they contained 12 and 21 moose, respectively. In September 1971, moose were introduced into pen 4 from outside the pens until there were 44 moose. Pen 3 was left at about 12 animals. The population in pen 4 was reduced by natural mortality to 13 by May 1972, while pen 3 dropped to 8. In September 1972, the population in pen 4 was again raised to "only" 28 moose, and pen 3 was again left unaltered at 8 moose. By May 1973, the pens were down to 7 and 16, respectively.

LeResche (1970) and LeResche and Davis (1971) reported the results of Assistant Refuge Manager Bob Seemel's browse surveys. These have shown that birch make up almost 90 percent of the browse diet of moose in the Moose Research Center while willow, the next most important shrub, makes up only about 5 percent of the diet. LeResche and Davis (1973) reported similar results from tame moose food habits studies but in addition, reported that lowbush cranberry made up 21 percent of the total "bites" taken. Franzmann and Arneson (1973) and Johnson et al. (1973) have also reported the importance of lowbush cranberry at the Moose Research Center. The results of these studies combined with density surveys reported by Oldemeyer (1972) show that the Moose Research Center is primarily a single shrub species system complemented by an important ground cover species. Bergerud and Manuel (1968) reported stable and high moose populations in Central Newfoundland with two major forage species, paper birch and balsam fir (*Abies balsamea*).

Methods

The methods used in this project are described fully in Oldemeyer (1972). Briefly, they are as follows: Twenty transects were located in a stratified design in each pen, and 24 birch saplings were randomly located along each transect and tagged with metal tags. After leaf fall each plant was measured for basal circumference, total height and crown length; and the number of current annual growth twigs were counted. The following spring the plants were measured for total height, the diameters of browsed and unbrowsed twigs were measured and counted and a record was made of the browsing species, if any.

Mean twig weight was determined from the clipping data reported in Part I of this report and is the total sapling production divided by the number of twigs. The site mean is weighed. Birch density is from Oldemeyer (1972).

Results

Birch production and utilization are summarized in Tables 2 through 5. There was not a significant difference ($p > 0.5$) in twigs produced per sapling between the two pens either year; however, the number of twigs produced in 1971 was greater than in 1972 ($p < 0.01$).

In pen 4, the average twig weight in 1971 was less ($p < 0.01$) than the average twig weight in 1972, and by multiplying average twig weight by average number of twigs per sapling an estimation of production can be made. This estimate averaged 0.5 gms higher per plant in 1972 than in 1971. Thus, even though the mean number of twigs was less in 1972, their weight was greater, resulting in a slightly higher production per plant. My 1973 data indicated no difference in twig weights between pens 3 and 4 and I used pen 4's 1971 and 1972 twig weights to estimate sapling production in pen 3. They follow the same trend as pen 4 except that pen 3 did not experience as great a decrease in number of twigs produced as pen 4 and the overall production per sapling in 1972 was markedly greater.

We went so far as to calculate an estimated dry weight birch production by pen from the habitat types sampled. In 1971, total production in pen 3 was 11.0 gm/m^2 (sy = 2.960) which expanded to 14,842 kg. and in pen 4 was 7.9 gm/m^2 ($s_{\bar{y}}$ = 1.950) producing 13,554 kg. of birch twigs. In 1972, production was up by 4.1 gm/m^2 in pen 3 resulting in 20,409 kg. of birch twigs and up 1.9 gm/m^2 in pen 4 producing 16,753 kg.

Percent of twigs browsed was significantly greater ($p < 0.01$) in pen 4 both years, and was greater ($p < 0.01$) in both pens in the spring of 1973. This increase in 1973 was probably due to the decrease in numbers of twigs produced that previous growing season. The greater use in pen 4 than pen 3 was a reflection of our moose densities.

A graph of the percent of plants browsed compared to percent of twigs browsed is shown in Figs. 1 and 2. Removal of the (0,0) point in spring 1972 results in a correlation coefficient of 0.91; however, the regression coefficients are little affected by that point. In both years the plot of the logarithm curve seems to better fit the data than a straight line curve. Correlation coefficients differ little between the straight line correlation and correlation of the data using a logarithmic transformation of the percent of plants browsed. Similar regressions will be calculated when percent of weight removed has been calculated. If similar correlation coefficients result, the estimation of utilization will be greatly simplified.

Discussion

Bergerud and Manuel (1968) determined that between 59 and 81 percent of the live birch stems were browsed in 15 cutovers in Central Newfoundland. These cutovers had considerably lower birch density than those at the Moose Research Center (619-3183 stems/acre on their good sites compared to 3,900-23,600 stems/acre on Moose Research Center regrowth sites). Winter moose populations during their study were greater than

Table 2. 1971 Production and utilization of Paper Birch in Pen 3, Kenai Moose Research Center.

		1971				
Site	Density (Birch/ m^2)	Mean Twig Weight (gms)	No. Twigs Produced/ Sapling	Estimated Production /Sapling (gms)	Mean Percent Twigs Browsed /Sapling (%)	Mean Percent Sapling Browsed (%)
Dense Birch Regrowth						
01	3.3	0.27	11.1 (10.27)	3.0	20.3 (35.10)	41.6
02	4.7		11.6 (7.90)	3.1	48.8 (37.67)	75.0
03	6.4		21.9 (27.15)	5.9	66.2 (40.44)	91.7
04	3.9		16.8 (14.27)	4.5	47.4 (32.27)	87.5
10	4.0		16.9 (25.23)	4.6	15.8 (26.00)	29.2
12	7.6		15.2 (19.62)	4.1	74.3 (34.70)	91.7
16	5.0		21.7 (20.44)	5.9	47.5 (41.33)	66.7
19	5.9		14.1 (12.73)	3.8	24.7 (26.72)	62.5
Medium Birch Regrowth						
05	3.8	0.19	18.4 (22.16)	3.5	37.5 (40.35)	54.2
06	3.2		10.2 (11.44)	1.9	11.3 (28.10)	20.8
08	5.0		17.5 (16.50)	3.3	3.3 (10.38)	20.8
17	3.5		11.9 (8.16)	2.3	31.2 (34.07)	58.4
20	1.7		37.5 (36.43)	7.1	31.5 (36.48)	50.0
Thin Birch Regrowth						
07	2.2	0.19	23.0 (30.82)	4.4	19.8 (30.79)	37.5
11	0.8		40.2 (31.54)	7.6	17.5 (32.08)	37.5
13	1.6		18.2 (20.51)	3.5	0	0
23	2.2		41.0 (41.00)	7.8	25.4 (27.12)	66.7
Thin Mature Hardwoods						
15	0.5	0.15	16.5 (20.20)	2.5	35.5 (33.19)	66.7
18	0.7		7.6 (6.65)	1.1	38.9 (42.78)	50.0
24	1.1		11.1 (8.66)	1.7	36.9 (34.36)	62.5

Table 3. 1972 Production and Utilization of Paper Birch in Pen 3, Kenai Moose Research Center.

		1972				
Site	Density (Birch/ m^2)	Mean Twig Weight (gms)	No. Twigs Produced/ Sapling	Estimated Production /Sapling (gms)	Mean Percent Twigs Browsed /Sapling (%)	Mean Percent Sapling Browsed (%)
Dense Birch Regrowth						
01	3.3	0.44	10.5 (12.31)	4.6	69.1 (42.41)	75.0
02	4.7		12.7 (15.50)	5.6	75.3 (39.26)	83.3
03	6.4		17.8 (19.61)	7.8	71.1 (35.89)	87.5
04	3.9		17.0 (17.82)	7.5	81.8 (24.86)	95.8
10	4.0		14.6 (23.18)	6.4	45.5 (44.47)	66.7
12	7.6		16.6 (26.34)	7.3	78.7 (28.15)	91.7
16	5.0		18.5 (16.58)	8.1	69.6 (38.11)	79.2
19	5.9		13.0 (15.30)	5.7	76.7 (34.77)	87.2
Medium Birch Regrowth						
05	3.8	0.35	13.6 (18.94)	4.6	60.6 (37.64)	83.3
06	3.2		8.0 (7.59)	2.7	32.2 (39.26)	50.0
08	5.0		16.5 (20.62)	5.6	29.8 (37.81)	50.0
17	3.5		10.6 (7.78)	3.6	55.0 (33.67)	87.5
20	1.7		24.7 (22.20)	8.4	41.9 (38.47)	62.5
Thin Birch Regrowth						
07	2.2	0.24	19.4 (25.69)	4.6	48.8 (43.27)	62.5
11	0.8		26.2 (22.73)	6.3	52.9 (43.76)	75.0
13	1.6		14.5 (13.05)	3.5	59.1 (38.23)	75.0
23	2.2		31.9 (38.41)	7.6	42.9 (38.29)	70.9
Thin Mature Hardwoods						
15	0.5	0.19	14.0 (18.67)	2.7	80.7 (24.24)	100.0
18	0.7		8.7 (7.83)	1.7	66.4 (40.70)	83.3
24	1.1		8.0 (7.16)	1.5	44.6 (40.18)	62.5

Table 4. 1971 Production and Utilization of Paper Birch in Pen 4, Kenai Moose Research Center (Std. Dev. in parenthesis).

		1971				
Site	Density (Birch/ m^2)	Mean Twig Wt. (gms)	No. Twigs Produced/ Sapling (S.D.)	Estimated Production /Sapling (gms)	Mean Percent Twigs Browsed /Sapling (%)	Mean Percent Saplings Browsed (%)
Dense Birch Regrowth						
02	4.1	0.31 (0.0094)	17.2 (16.23)	5.3	89.7 (21.83)	100.0
22	5.8	0.25 (0.0087)	29.4 (25.45)	7.4	75.0 (24.57)	100.0
37	4.2	0.25 (0.0191)	19.1 (17.07)	4.8	80.1 (21.60)	100.0
Medium Birch Regrowth						
20	3.3	0.11 (0.0020)	14.5 (11.74)	1.6	63.2 (29.78)	91.7
26	4.7	0.18 (0.0121)	16.1 (13.32)	2.9	87.2 (17.18)	100.0
27	3.9	0.23 (0.0074)	19.0 (25.05)	4.4	65.2 (31.71)	91.7
28	2.9	0.27 (0.0178)	20.2 (24.53)	5.5	90.0 (20.98)	95.9
29	3.5	0.16 (0.0078)	17.3 (15.09)	2.8	88.7 (17.33)	100.0
38	3.5	0.20 (0.0090)	25.6 (23.51)	5.1	69.7 (31.68)	91.7
Thin Birch Regrowth						
17	1.0	0.17 (0.0045)	22.7 (21.85)	3.9	31.4 (28.79)	66.7
30	3.8	0.16 (0.0060)	13.2 (9.75)	2.1	31.6 (36.28)	58.4
31	3.1	0.14 (0.0065)	20.2 (13.62)	2.8	42.6 (26.94)	91.7
33	3.9	0.21 (0.0041)	23.0 (30.05)	4.8	66.6 (27.75)	100.0
35	2.0	0.26 (0.0960)	22.9 (25.08)	6.0	65.6 (28.17)	100.0
Spruce Birch Regrowth						
01	2.0	0.32 (0.0322)	29.3 (23.56)	9.4	81.1 (24.35)	95.9
04	1.0	0.16 (0.0054)	67.7 (77.06)	10.8	50.1 (38.95)	87.5
34	2.8	0.14 (0.0046)	18.6 (16.82)	2.6	69.9 (29.63)	95.9
39	0.7	0.14 (0.0048)	23.3 (20.84)	3.3	38.7 (31.38)	75.0
Thin Mature Hardwoods						
19	0.1	0.14 (0.0095)	5.2 (4.26)	0.7	23.2 (34.67)	45.8
32	0.3	0.14 (0.0067)	6.3 (3.93)	0.9	51.5 (41.86)	66.7
36	0.8	0.16 (0.0050)	10.3 (9.09)	1.6	55.9 (33.22)	83.3

Table 5. 1972 Production and Utilization of Paper Birch in Pen 4, Kenai Moose Research Center (Std. Dev. in parenthesis).

Site	Density (Birch/ m²)	1972 Mean Twig Weight (gms)	No. Twigs Produced/ Sapling (S.D.)	Estimated Production /Sapling (gms)	Mean Percent Twigs Browsed /Sapling (%)	Mean Percent Saplings Browsed (%)
Dense Birch Regrowth						
02	4.1	0.37 (0.0156)	12.6 (14.22)	4.7	95.2 (10.74)	100.0
22	5.8	0.56 (0.0956)	26.7 (28.89)	15.0	86.2 (20.77)	100.0
37	4.2	0.40 (0.0297)	11.1 (9.29)	4.4	89.2 (18.34)	95.9
Medium Birch Regrowth						
20	3.3	0.24 (0.0051)	8.2 (6.50)	2.0	74.2 (26.67)	100.0
26	4.7	0.39 (0.0256)	14.2 (10.68)	5.5	95.5 (7.74)	100.0
27	3.9	0.29 (0.0214)	9.3 (10.40)	2.7	91.2 (22.19)	95.9
28	2.9	0.40 (0.0192)	11.3 (11.87)	4.5	89.2 (21.58)	95.9
29	3.5	0.37 (0.0153)	14.0 (17.18)	5.2	92.1 (22.356)	95.9
38	3.5	0.42 (0.0422)	12.8 (9.33)	5.4	91.1 (15.41)	100.0
Thin Birch Regrowth						
17	1.0	0.16 (0.0040)	17.3 (14.73)	2.8	69.6 (29.70)	95.9
30	3.8	0.22 (0.0052)	11.9 (13.39)	2.6	65.4 (33.49)	87.5
31	3.1	0.20 (0.0058)	13.3 (8.89)	2.7	62.5 (32.94)	91.5
33	3.9	0.29 (0.0134)	23.4 (35.98)	6.8	82.2 (28.90)	91.5
35	2.0	0.32 (0.0164)	17.6 (18.28)	5.3	89.2 (18.33)	100.0
Spruce Birch Regrowth						
01	2.0	0.50 (0.0613)	20.5 (18.44)	10.3	81.0 (28.98)	95.9
04	1.0	0.29 (0.0643)	39.0 (41.71)	11.2	40.3 (44.16)	62.5
34	2.8	0.14 (0.0046)	13.0 (10.87)	1.8	87.9 (15.22)	100.0
39	0.7	0.16 (0.0044)	14.0 (10.52)	2.2	77.4 (28.22)	95.9
Thin Mature Hardwoods						
19	0.1	0.14 (0.0083)	6.1 (5.64)	0.9	54.1 (38.11)	87.5
32	0.3	0.20 (0.0120)	5.5 (3.35)	1.1	61.8 (38.38)	79.2
36	0.8	0.24 (0.0139)	6.1 (5.00)	1.5	79.6 (34.42)	87.2

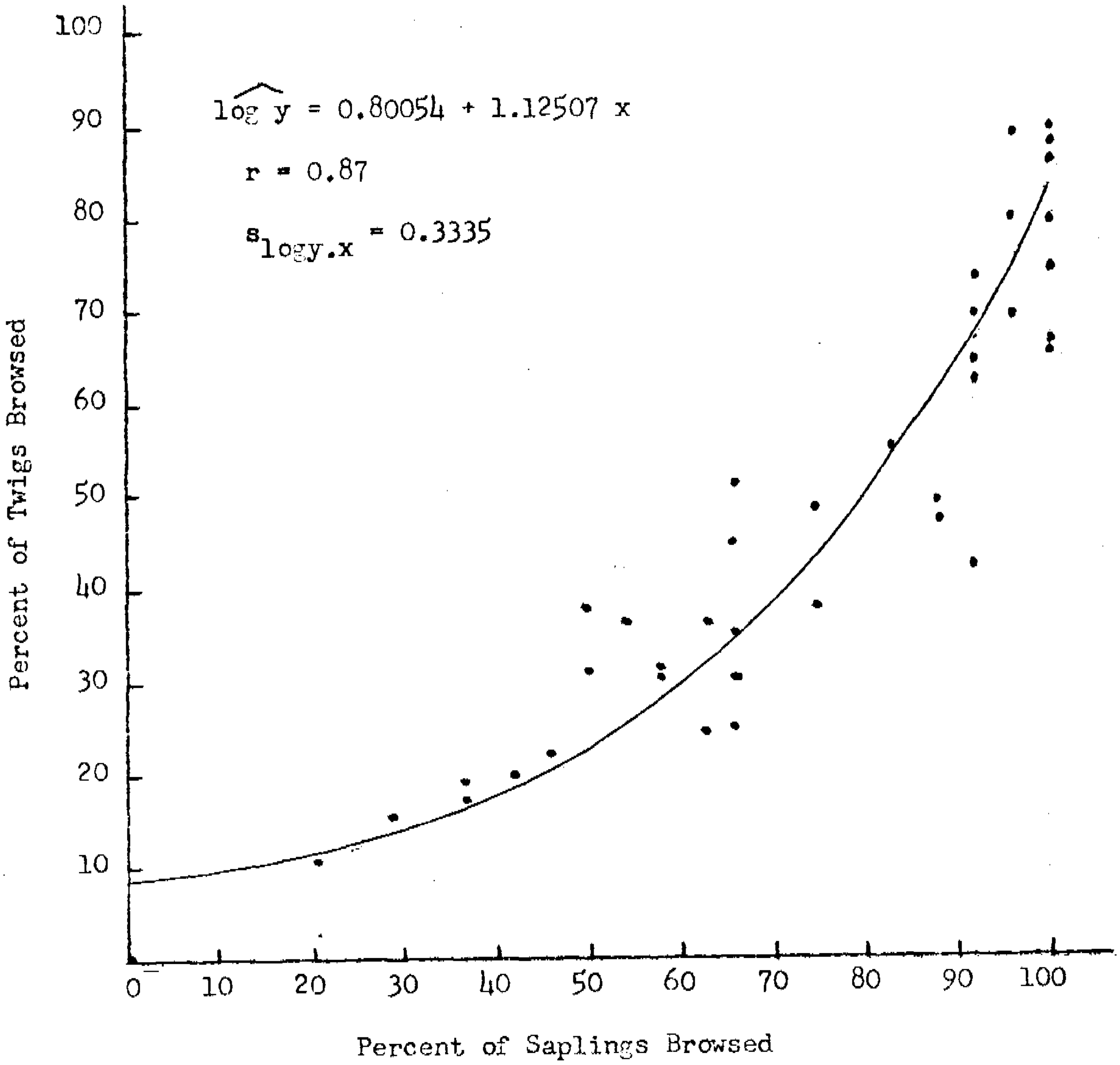


Figure 1. Graph of percent of birch saplings browsed and percent of twigs browsed, Spring 1972.

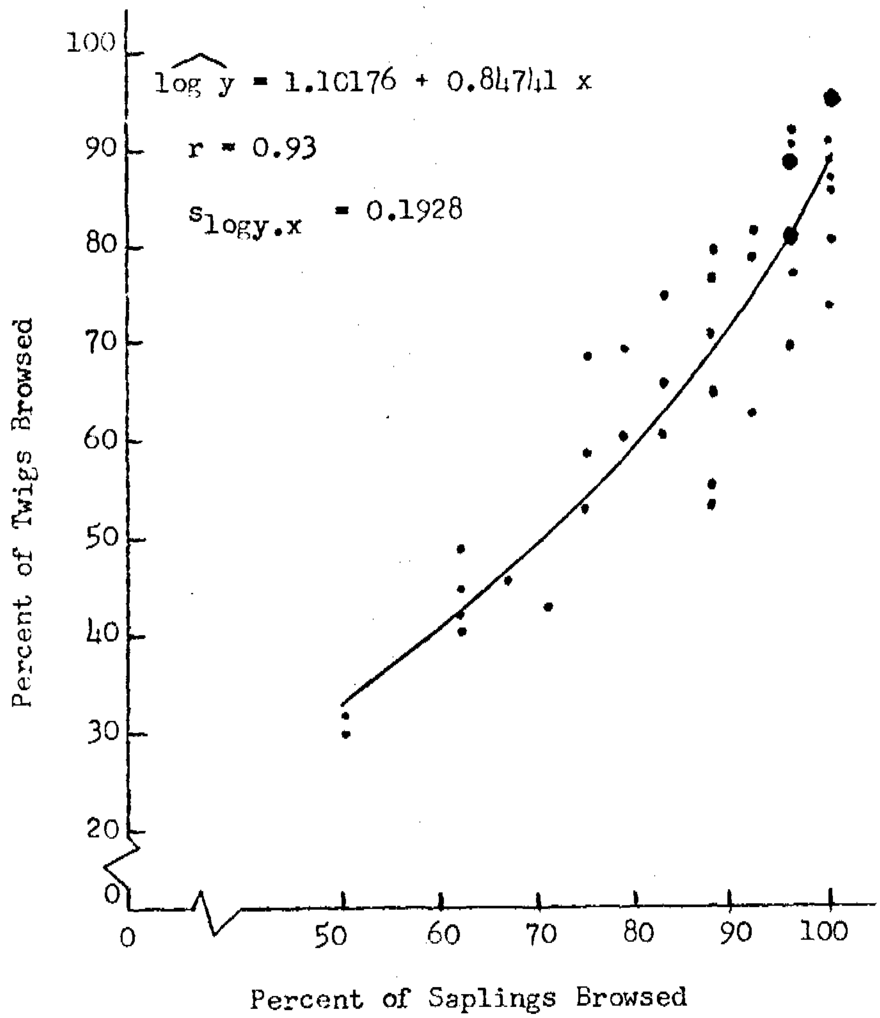


Figure 2. Graph of percent of birch saplings browsed and percent of twigs browsed, Spring 1973.

12 moose per square mile, which was similar to the population in pen 3. Percent of saplings browsed in pen 3 was 45 the winter of 1971-72 and 64 in 1972-73. Neither of these percentages seems unusually high in view of the moose density in that pen, and overall plant condition is probably little affected.

Peek (1972) reported that an average of 36 percent of birch current annual growth twigs browsed in northern Minnesota was the highest browsing he observed on birch. He considered this to be of little importance to continued good vigor. Aldous (1952) reported that paper birch could withstand experimental clipping of 50 percent of the current year's growth over a six-year period without lowering production.

Birch use in pen 4 the winters of 1971-72 and 1972-73 was probably too high to sustain vigorous plant growth. The combination of greater twig weight but fewer twigs produced makes it difficult to fully evaluate the effect of the browsing. Fuller analysis of the data should help clarify this. However, Cole (1958), suggested that no more than 75 percent of the growth of a browse plant should be removed during a severe winter. Considering that birch is the primary forage plant for moose at the Moose Research Center, utilization this high for several years probably would result in poorer birch production and eventually declining moose populations.

Weather appeared to play an important role in annual browse production. The summer of 1972 was warmer as shown by the average July and August temperatures and by the degree days, and it was slightly dryer. Average twig weights were over 50 percent greater than 1971. The 10-year average July and August temperatures were more like those of 1971 and twigs weights that year probably more nearly reflect the overall average. LeResche (1970) reported opposite findings when he compared twig weights produced in the cool summer of 1968 with those produced in the warmer summer of 1969. However, he was considering twigs as several years growth rather than annual growth as this work does. Perhaps the difference is in that point.

Stickney (1966) found that percent of twigs browsed was well correlated to percent of linear twig growth utilization. Our procedure involves the assumption that percent of twigs browsed or percent of plants browsed is correlated to percent of production by weight utilized. The high correlations we obtained between percent of plants browsed and percent of twigs browsed indicates this may be true; however, our data analysis has not progressed to this point. If our assumption holds, the burden of sampling for estimating birch utilization will be greatly reduced.

PART III - SNOWSHOE HARE BROWSING ON PAPER BIRCH

High snowshoe hare populations in the region of the Moose Research Center have resulted in considerable browsing on birch. Dodds (1960) noted that birch was the most important tree species food source for hares in Newfoundland. Trapp (1963) reported heavy use of birch twigs and bark in Interior Alaska and reported that stands of small birch and poplars were conspicuously barked and girdled.

Telfer (1972) reported that evergreens made up over 66 percent of the hare's diet in Nova Scotia and New Brunswick. Spruce (*Picea* sp.) made up 15.4 percent of the weight browsed in a sugar maple - yellow birch - fir zone in New Brunswick and over 56 percent of the weight of food browsed in a red spruce - hemlock - pine zone of Nova Scotia. Other species that he reported as being important were huckleberry (*Gaylussaccia baccata*), red maple (*Acer rubrum*), white cedar (*Thuja occidentalis*) and beech (*Fagus grandifolis*). Pulliainen (1972) reported that *Betula* sp., *Salix* sp., and *Juniperus communis* were important food items of Arctic hares (*Lepus timidus*) in northeastern Lapland.

Methods

In the normal course of measuring marked birch saplings for browsing, the animal species (hare or moose) browsing the plant was recorded and, in 1973, the maximum height browsed by hares on each plant was measured.

Results

A summary of hare browsing is shown in Table 6. The percent of plants browsed during the winter of 1971-72 was relatively low. Individual analysis of the sites indicated that there was little hare use in the thin mature hardwood and thin birch regrowth types. This was not as evident during the winter of 1972-73, probably because of the overall heavy use of birch that year.

There was little difference in the average maximum height browsed by hares among the three pens. Average birch height and snow depth influence the maximum height of hare browsing but this facet has not yet been explored in depth. Maximum snow depth at the Moose Research Center during the winter of 1972-73 was 60 cm.

Although hares browse a high percentage of plants, there is little evidence that they are serious competitors with the moose for forage. Moose are capable of browsing plants to over 3 meters in height and the browse produced in the stratum above which hares can browse probably makes up over 75 percent of the forage produced. Telfer (1972) found that during high populations of deer and hares, there was localized competition for forage. He found that hares utilized more browse per hectare than did deer.

Of more affect on plant density is the girdling of saplings and browsing to such a great degree that no living buds remain after the dormant period. In the winter of 1972-73, about nine percent of the stems examined were in such condition. While this type of damage results in lower birch density, in sites of dense birch regrowth the removal of competition may help the stand.

ACKNOWLEDGEMENTS

Many individuals from the Alaska Department of Fish and Game and the U.S. Fish and Wildlife Service were involved in projects at the Kenai Moose Research Center (MRC).

Table 6. Summary of Snowshoe Hare Browsing on Paper Birch

Pen		Percent of Plants Browsed 1972	Percent of Plants Browsed 1973	Ave. Maximum Ht. Browsed 1973
2	$\bar{x}$	-	68.7	82.6
	S.D.	-	23.43	15.8
3	$\bar{x}$	16.4	59.0	75.8
	S.D.	24.18	19.51	10.89
4	$\bar{x}$	33.7	73.4	69.1
	S.D.	33.63	32.07	16.69

K. Schneider provided the leadership and guidance at the Regional level to allow MRC personnel freedom to function. The basic goals and outlines for the MRC as initiated by R. Rausch serve us well and are still in force.

Laboratory personnel in Anchorage and Fairbanks, including C. Lucier, K. Neiland, D. Calkins, R. Modaferri, T. Spraker and C. Nielsen, provided laboratory support necessary to accomplish the MRC objectives.

P. LeRoux and J. Davis were involved and assisted in many aspects of MRC projects.

All personnel assigned to the Kenai National Moose Range provided support in their particular realm of activity to facilitate the MRC operation.

J. Seal, Alaska Department of Administration, Computer Services Division, was most helpful with computer programming and interpretation.

A. Flynn, Case Western Reserve School of Medicine, provided hair analyses and invaluable assistance in interpretation of values and preparation and review of manuscripts.

R. LeResche was most helpful in reviewing manuscripts. His initial work at MRC provides the basis of ongoing projects.

J. Oldemeyer assisted us in many ways above and beyond that of being a cooperator implies.

Our sincere thanks to every group and individual above and to all the unmentioned who were involved in MRC projects.

LITERATURE CITED

Aldous, S.D. 1952. Deer browse clipping study in the Lake States Region. J. Wildl. Manage. 16(4):401-409.

Arneson, P. D. and A.W. Franzmann 1974. A winch/tripod device for weighing moose (submitted for publication).

Baskerville, G.L. 1972. Use of logarithmic regression in the estimation of plant biomass. Canadian J. For. Research 2:49-53.

Bergerud, A.T. and F. Manuel. 1968. Moose damage to balsam fir-white birch forests in Central Newfoundland. J. Wildl. Manage 32(4):729-746.

Cole, G.F. 1958. Range survey guide. Montana Dept. of Fish and Game Helena. 18pp.

Cook, H.W., R.A. Rausch, and B.E. Baker. 1970. Moose (*Alces alces*) milk. Gross composition, fatty acid, and mineral constitution. Can. J. Zool. 48(2):213-215.

Cowan, I. MCT., W.S. Hoar, and J. Hatter. 1950. The effect of forest succession upon the quantity and upon the nutritive values of woody browse plants used as food by moose. Can. J. Res. 28(5):249-271.

Dodds, D.G. 1960. Food competition and range relationships of moose and snowshoe hare in Newfoundland. J. Wildl. Manage. 24(1):52-60.

Draper, N.R. and H. Smith. 1966. Applied regression analysis J. Wiley & Sons, Inc. New York. 407pp.

Franzmann A.W. 1972. Environmental sources of variation of big-horn sheep physiologic values. J. Wildl. Manage. 36(3): 942-932.

______________. and P.D. Arneson. 1973. Moose Research Center Studies. Alaska Dept. Fish and Game, P-R Proj. Rep. W-17-S. 117pp. Multilith.

______________., A. Flynn, and P.D. Arneson. 1974. Hair mineral element levels of the Alaskan moose (in review).

Johnson, D.R., P.D. Arneson, and A.W. Franzmann 1973. Behavior and survival in orphaned moose calves. Dept. of Fish and Game. Final Report Project W-17-4, Job 19.9R and Project W-17-5, Job 1.10R. 32pp.

LeResche, R.E. 1970. Moose Report. Alaska Dept. Fish and Game, P-R Proj. Rep., W-17-2. 64pp. Multilith.

______________ and J.L. Davis. 1971. Moose Report. Alaska Dept. Fish and Game, P-R Proj. Rep., W-17-3. 87pp. Multilith.

______________ and J.L. Davis. 1973. Importance of nonbrowse foods to moose on the Kenai Peninsula, Alaska J. Wildl. Manage. 37(3) 279-287.

______________ and G.M. Lynch. 1973. a trap for free-ranging moose. J. Wildl. Manage. 37(1):87-89.

______________ ,A.W. Franzmann and P.D. Arneson. 1973. Moose Research Center Report. Alaska Dept. Fish and Game, P-R Proj. Rep., W-17-4. 117pp. Multilith.

______________, U.S. Seal, P.D. Karns, and A.W. Franzmann. 1974. Blood chemistry and nutrition of moose: a review. LeNaturaliste Canadien (in press).

Lutz, H.J. 1960. History and early occurrence of moose on the Kenai Peninsual and other sections of Alaska. Misc, Publ. No. 1. U.S. Forest Service, Juneau, Alaska. 25pp.

Lyon, L.J. 1968. Estimating twig production of serviceberry from crown volumes. J. Wildl. Manage. 32(1);115-119.

Oldemeyer, J.L. 1972. Production and utilization of paper birch in four moose pens in the 1947 Burn, Kenai National Moose Range, Alaska. U.S. Bur. Sprot Fish. & Wildl., Denver Wildlife Research Center. Ann. Report. Work Unit DC-102.1. Mimeo. 29pp.

Peek, J.M. 1970. Relation of canopy area and volume to production of three woody species. Ecology 51(6):1098-1101.

_______________ 1972. Moose habitat selection and relationships to forest management in northeastern Minnesota. Ph.D Dissertation. Univ. of Minnesota, St. Paul. 225pp.

Preston, R.L., D.D. Schnakenberg, and W.H. Pfander. 1965. Protein utilization in ruminants. I. Blood urea nitrogen as affected by protein intake. J. Nutrition 86*3):281-288.

Pulliainen, E. 1972. Nutrition of the Arctic hare (*Lepus timidus*) in northeastern Lapland. Ann. Zool. Fennici 9:17-22.

Rao, C.R. 1966. Linear statistical inference and its applications J. Wiley & Sons. New York. 522pp.

Robinson, W.L. 1960. Test of shelter requirements of penned white-tailed deer. J. Wildl. Manage 24(4):364-371.

Spencer, D.L. and J.B. Hakala. 1964. Moose and fire on the Kenai. Tall Timbers Fire Ecol. Conf. Proc. 3:11-33.

Stephens, F.R. 1967. Soils of the Kenai Moose Range Enclosure Study Area. U.S.F.S. Mimeo. Report. 10pp.

Stickney, P.F. 1966. Browse utilization based on percentage of twig numbers browsed. J. Wildl. Manage. 30(1):204-206.

Telfer, E.S. 1969. Twig weight-diameter relationships for browse species. J. Wildl. Manage. 33(4):914-921.

_______________. 1972. Forage yield and browse utilization on logged areas in New Brunswick. Canadian Jour. of Forest Research 2(3):346-350.

Trapp, G.E. 1963. Snowshoe hares in Alaska. II Home range and ecology during an early population increase. M.S. Thesis. Univ. of Alaska. 137pp.

Underwood, E.J. 1971. Trace elements in human and animal nutrition. 3rd ed. Academic Press, New York and London. 543pp.

PREPARED BY:

Albert W. Franzmann and Paul D. Arneson
Game Biologists

SUBMITTED BY:

Karl B. Schneider
Regional Research Coordinator

APPROVED BY:

Frank Jones
Director, Division of Game

Donald E. McKnight
Research Chief, Division of Game

JOB PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperators: James L. Davis, Paul D. Arneson, Paul A. LeRoux, and Albert W. Franzmann.

Project No.: W-17-6 Project Title: Big Game Investigations

Job No.: 1.7R Job Title: Kenai Peninsula Moose Population Identity Study.

Period Covered: July 1, 1973 through June 30, 1974

SUMMARY

One hundred and seventeen moose were tagged with individually identifiable collars during the reporting period: 51 outside the enclosures at the Kenai Moose Research Center, 55 in the Caribou Hills and 11 southwest of the Caribou Hills.

A total of 1,385 recoveries and resightings of tagged moose have been recorded since the inception of this project. Four hundred observations of collared moose were made during the reporting period.

Eighty percent (44/55) of the moose tagged in the Caribou Hills have been resighted and 55 percent (6/11) of those tagged southwest of the Caribou Hills have been relocated.

The majority of post-rut observations of both groups were made in the respective tagging areas. Most winter resightings of moose tagged in the Caribou Hills were in Game Management Subunit 15B (west). Most moose moved northwesterly, but some moved easterly, southerly and westerly from the tagging areas for the winter, while others remained in the tagging areas.

New collar design enhanced the number of individually identifiable moose observations reported by the public and facilitated proper identification by experienced observers.

CONTENTS

BACKGROUND

Population identity studies of moose (*Alces alces*) in Game Management Subunits (GMSU) 15A and 15B have yielded important information on movements of various subpopulations of the Kenai Peninsula moose herd (cf. LeResche and Davis 1971, LeResche 1972, Franzmann and Arneson 1973 and LeResche 1974). Knowledge of seasonal moose movements is essential for proper management, especially with the formalization of management plans for all species, including moose, that is underway in Alaska at present. Understanding these movements makes it possible to identify and delineate critical wintering, calving and rutting areas so these habitats may be preserved. GMSU 15C contains a substantial moose herd including a trophy bull segment, but these animals' movements are just now becoming understood.

Vegetation in GMSU 15C is characterized by climax willow (*Salix* spp.) stands above 2,000 feet elevation in the Caribou Hills and above 1,800 feet on various other smaller hills southwest of the Caribou Hills. Large expanses of mature spruce (*Picea* spp.) interspersed with riparian willow, alder (*Alnus* spp.) and muskeg typify areas at lower elevations. Moose concentrate in climax willow stands during the rut and post-rut but many subsequently disperse to wintering and calving areas elsewhere.

The Kenai National Moose Range (KNMR) encompasses a large portion of the Caribou Hills. Hunter access has been limited in this area through restrictions on aircraft and off-road vehicle use. This area has a higher bull-cow ratio (28 bulls/100 cows in 1973) than the remainder of GMSU 15C (11 bulls/100 cows in 1973), where heavier hunting pressure has occurred since the early 1960's through the use of off-road vehicles. There is increasing hunting pressure on the KNMR portion of the subunit from hunters using horses, however.

The number of large bulls outside the KNMR in GMSU 15C has been low since the mid-1960's, ranging between 9.8 and 26.0 bulls per 100 cows during the past eight years. Consequently, there is not a very large standing crop of harvestable bulls. During a severe winter, such as that of 1971-72, yearling recruitment is practically non-existent and any harvest of the older bulls further lowers the bull/cow ratio.

OBJECTIVES

To identify populations and key habitat areas and to learn seasonal movement patterns of moose on the Kenai Peninsula.

PROCEDURES

Moose were tagged using helicopters (Neilson and Shaw 1967) or fenceline traps (LeResche and Lynch 1973) and succinylcholine chloride[1] in projected syringes. The enzyme, hyaluronidase,[2] was added to the drug to shorten induction time. Between May 1, 1973 and April 30, 1974, 55 moose were tagged in the Caribou Hills, 11 in hills southwest of Caribou Hills and 51 outside the enclosures at the Kenai Moose Research Center (MRC) (Table 1). Fig. 1 shows the tagging areas in GMSU 15C. All animals, except calves at the MRC which were ear-tagged only, were marked to be distinguishable from afar as individuals. Adults were marked with numbered, color-coded, canvas-web neck collars (Fig. 2) obtained from Denver Tent and Awning Co., Denver, CO. Calves at the MRC were fitted with metal ear-tags (Salt Lake Stamp Co., Salt Lake City, UT) and silver Saflag (Safety Flag Co. of America, Pawtuket RI) material in the right ear of females and the left ear of males. Animals in the Caribou Hills were ear-marked with Saflag material and/or Goliath Rototags (Dalton Supplies Ltd., Henley-on-Thames, Nettlebed, England). Those tagged southwest of Caribou Hills were ear-marked with Goliath Rototags or metal ear-tags and Saflag material.

Weekly flights were attempted by Alaska Department of Fish and Game personnel to monitor movements of the 436 moose tagged prior to June 30, 1973 and the 117 marked since then (Table 2). Additional sightings were made by U.S. Bureau of Sport Fisheries and Wildlife and Alaska Department of Fish and Game personnel during cooperative sex and age composition surveys and a random stratified population estimate survey. Personnel of both agencies also contributed miscellaneous observations of collared moose. Resightings and locations of collared moose were also reported by the public, especially in GMSU 15C.

FINDINGS

A total of 1,385 recoveries and resightings of tagged moose have been recorded through April 30, 1974 (Table 3). Based on 413 recoveries and observations of tagged moose accrued through June 15, 1971, LeResche and Davis (1971) presented a thorough discussion of population identities, movements and concentrating areas for groups tagged at Mystery Creek, Bottenintnin Lake, MRC and Moose River Flats. This 1971 discussion was based on an analysis of resightings by season, location and (tagging) groups without benefit of resightings of identifiable individuals. Franzmann and Arneson (1973) discussed population identities, movements and concentrating areas for Big Indian, Lower Funny River Strip and

1. Anectine - Burroughs Wellcome & Co., Inc., Research Triangle Park, NC
2. Wydase - Wyeth Laboratories, Philadelphia, PA

Table 1. Moose tagged in Game Management Units 15 and 7, Kenai Peninsula, October 1968 - April 1973.

Tagging Location	Males	Females	Number Tagged Sex?	Calves	Total
Mystery-Dike Creek (highlands) October 1968	10	18	0	0	28
Bottenintnin Lake (lowlands) March 1970	16	52	1	0	69
Moose River Flats (lowlands) June 1970	26	43	2	0	71
Moose Research Center (lowlands) continuous	18	136	0	27	181
Moose River Flats May 1971	10	51	0	0	61
Skilak-Tustumena Bench April 1971	2	2	0	0	4
Big Indian Creek October 1972	2	10	0	0	12
Tustumena Benchland October 1972	19	8	0	0	27
Lower Funny River Airstrip October 1972	12	21	0	0	33
Caribou Hills October 1973	32	34	0	0	66
TOTAL	147	376	3	27	553

Identification Code

Area	Male Collar	Male Ear	Female Collar	Female Ear	Pendant
Mystery Creek	Yellow	Left orange	Red	Right orange	None
Bottenintnin Lake	Blue	Left orange	White	Right orange	None
Moose River Flats (1970)	Blue	Left green	White	Right green	Red A1-A100
MRC (prior to March 1972)	Blue	Left silver	White	Right silver	White 51-100
Moose R. Flats (1971)	Yellow/orange*	Left yellow	Pink/red*	Right yellow	Red C1-C100
Skilak-Tustumena Benchland (1971)	Yellow/orange*	Left yellow	Radio	Right yellow	Red: "C" series
MRC (Post March 1972)	YBWRP**	Left silver	**	Right silver	None
Big Indian Creek (1972)	YBWRP**	White "Roto"	**	White "Roto"	None
Tustumena Benchland (1972)	YBWRP**	White "Roto"	**	White "Roto"	None
MRC(Post July 1973)	White with blue no.	Left silver	White with blue no.	Right silver	None
Caribou Hills (1973)	Blue with yel. no.	Yellow "Roto" w/gr. flag	Blue with yel no.	Yellow "Roto" w/gr. flag	None
Southwest of Caribou Hills (1973)	Blue with yel. no.	Yellow "Roto" and/or or. flag	Blue with yel. no.	Yellow "Roto" and/or or. flag	None

* Colored stripes on both sides or top of collar make the moose identifiable as individuals.
** Collars comprised of 4 quarters (left front; right front; left rear; right rear) consisting of some combination of from 2 to 4 of the following colors make these moose individually identifiable: yellow, blue, white, red, pink.

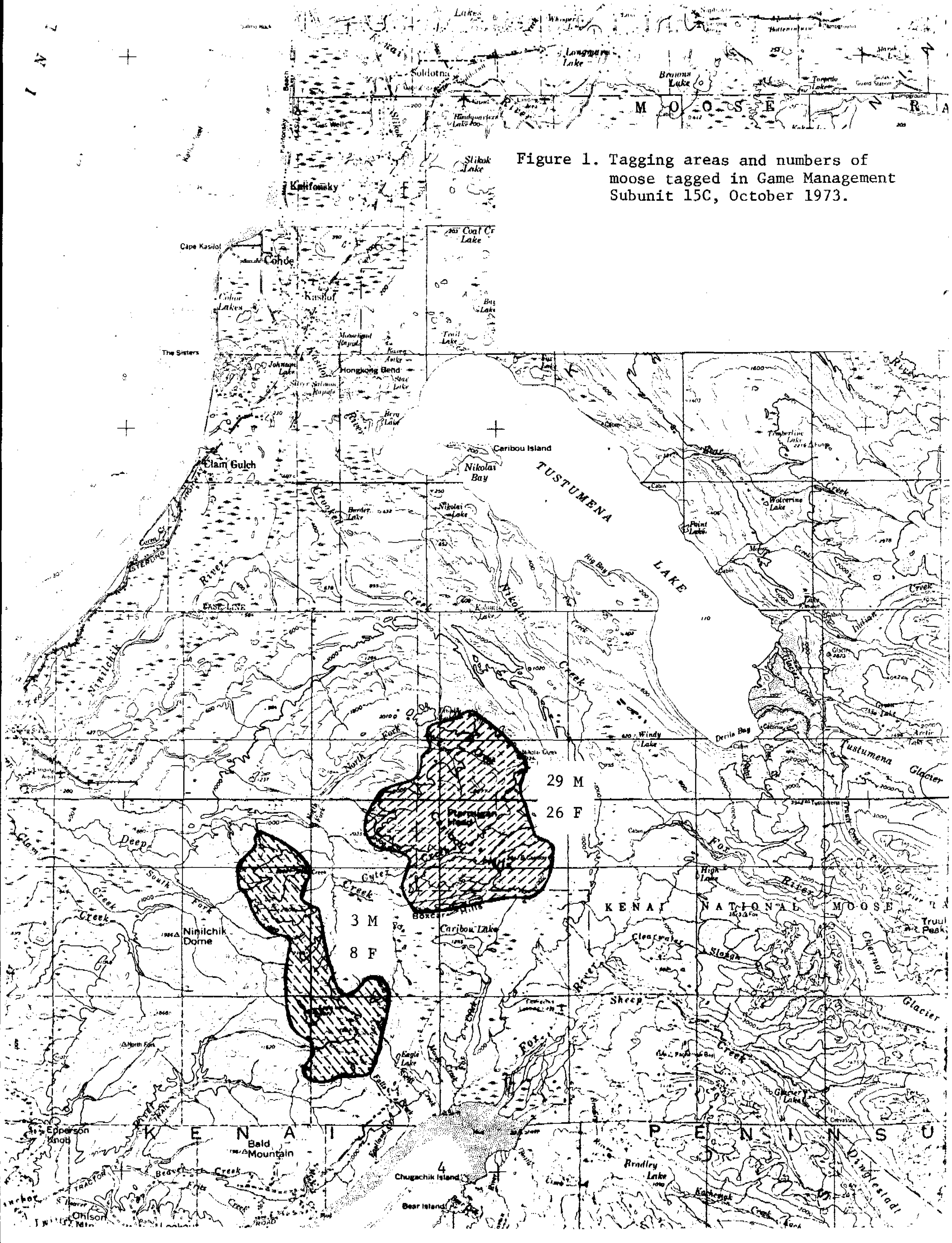
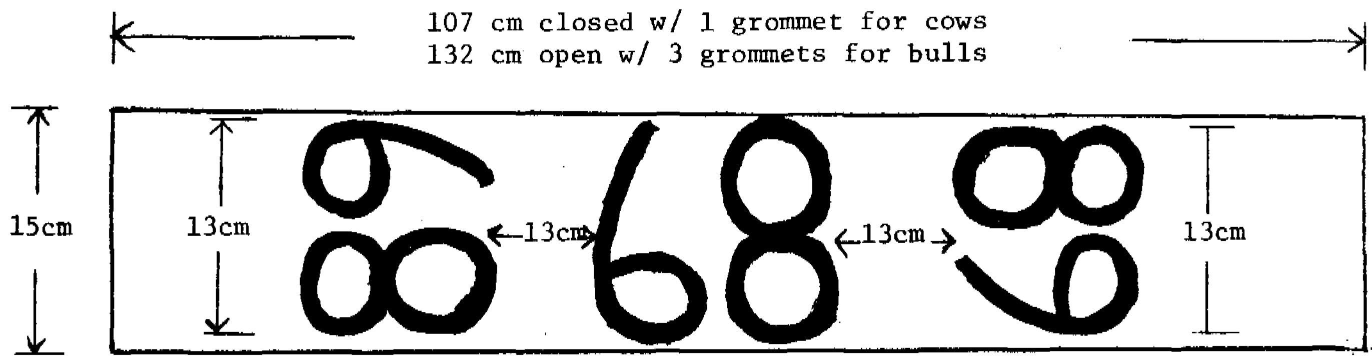


Figure 1. Tagging areas and numbers of moose tagged in Game Management Subunit 15C, October 1973.

Figure 2. Design of canvas web neck collares used to identify tagged moose as individuals.



Background and number color varies with tagging site.

Table 2. Reconnaissance flights by Alaska Department of Fish and Game for collared moose

Date	Area	Collared Moose Located*
3 July 73	Lower Funny River Strip and Benchland	5LFRS, 5BEN, 1BL, 1Unk.
11 July 73	Kenai Mts. N. of Sterling Highway	3MRF, 1MRC
17 July 73	Kenai Mts. N. of Sterling Highway, LFRS	1BEN, 2LFRS, 2Unk.
21 July 73	Unit 7-Kenai Mts.	1MRF
26 July 73	LFRS and Benchland	7BEN, 2LFRS, 1MRF
July 73	Misc. sighting by public	1MC
3 Aug. 73	1947 Burn - MRF	1MRC, 1MRF, 2Unk.
13 Aug. 73	LFRS to Benchland	6LFRS, 1BL
28 Aug. 73	Kenai Mts. N. of Sterling Highway	5BI, 10MRF, 1MRC, 4Unk.
29 Aug. 73	Benchland	1BEN, 1Unk.
August 73	Misc. sightings by public	1BI
3 Sept. 73	Benchland and LFRS	2LFRS
6 Sept. 73	Unit 7, Big Indian, Resurrection	3BI
14 Sept. 73	LFRS, Benchland	4LFRS,3BEN, 1BL
20 Sept. 73	LFRS	5LFRS, 1BEN, 1Unk.
3 Oct. 73	LFRS, Benchland, Caribou Hills	6BEN, 5LFRS, 1BL
11 Oct. 73	LFRS, Benchland	3LFRS, 2BEN, 1BL, 1Unk.
16 Oct. 73	Caribou Hills	0
19 Oct. 73	Kenai Mts. N. of Sterling Highway	1BI, 1Unk.
1 Nov. 73	Kenai Mts. N. of Sterling Highway	1BI, 4MRF, 1MC, 2Unk.
12 Nov. 73	LFRS, Benchland	6BEN, 3LFRS, 2BL, 2Unk.
19 Nov.-1 Dec 73	Sex and age composition counts	51CH, 17MRC, 8BEN, 8LFRS, 6MRF, 1BI, 1BL 14Unk.
November 73	Misc. sightings by public	2CH, 3Unk.
11 Dec. 73	LFRS, Benchland, Slikok	4BEN, 4LFRS, 1BL
15 Dec. 73	Caribou Hills	7CH
21 Dec. 73	Caribou Hills	18CH
December 73	Misc. sightings by public	2CH
2 Jan. 74	Caribou Hills	4CH
6 Jan. 74	Kenai Mts. N. of Sterling Highway	1MRC
14 Jan. 74	LFRS, Benchland	3BEN, 3LFRS
17 Jan. 74	1947 Burn, 1969 Burn	8MRC, 1Unk
21 Jan. 74	1947 Burn, lowlands	9MRC, 3MRF, 1Unk.
24 Jan. 74	Caribou Hills	2CH
31 Jan. 74	Kenai Mts. N. of Sterling Highway	1MRF
January 74	Misc. sightings by public	8CH, 2Unk.
11 Feb. 74	LFRS, Benchland, Caribou Hills	6CH, 1LFRS, 1Unk.
18 Feb. 74	Moose River Flats, Sterling to Kenai	2MRC, 1BEN, 1LFRS, 1Unk.
19 Feb. 74	Lowlands near Sterling	0
25-28 Feb. 74	Random Stratified counts	8BEN, 4LFRS, 1BI, 1BL, 1MRC, 1Unk.
February 74	Misc. sightings by public	5CH, 1BEN, 1MRC, 1Unk.
11 Mar. 74	Kenai Mts. N. of Sterling Highway	1MRF
15 Mar. 74	LFRS, Benchland, Caribou Hills	3BEN
21 Mar. 74	Caribou Hills	2CH
March 74	Misc. sightings by public	4CH, 1MRF, 1LFRS
5 Apr. 74	MRF, LFRS, Benchland	8MRC, 1MRF, 1MC 2Unk.
12 Apr. 74	Caribou Hills, Fox River Flats	2CH
April 74	Misc. sightings by public	2MRC, 2Unk.

* Code:
- MC Tagged at Mystery Creek 1968
- BL Tagged at Bottenintnin Lake 1970
- MRF Tagged at Moose River Flats 1970, 1971
- MRC Tagged at Moose Research Center 1968 to date
- BEN Tagged at Tustumena-Skilak Benchland 1971, 1972
- LFRS Tagged at Lower Funny River Strip 1972
- BI Tagged at Big Indian and American Pass 1972
- CH Tagged at Caribou Hills 1973
- Unk Tagging site unknown (misidentified or not all markings present)

Table 3. Recoveries and resightings of collared moose, Kenai Peninsula, through April 1974.

Tagging Site	July 1973 - April 1974 Recoveries and Sightings	Total Number of Recoveries and Sightings
Mystery Creek	3	155
Bottenintnin Lake	11	164
Moose Research Center	53	148
Moose River Flats	34	364
Tustumena Benchland 1971	4	8
Big Indian	18	33
Lower Funny River Strip	59	94
Tustumena Benchland 1972	56	86
Caribou Hills	113	113
Unknown or improperly identified	49	220
TOTAL	400	1385

upper Tustumena Benchland taggings based on resighting of identifiable individuals. Many resightings have subsequently been made of identifiable individuals from 1970 and 1971 Moose River Flats and MRC, and 1972 Big Indian, Lower Funny River Strip and upper Tustumena Benchland taggings. At present these resightings warrant little elaboration on population identity and concentrating areas of these groups. A final report after fiscal year 1975 will summarize these findings for GMSU 15A and 15B.

Game Management Subunit 15C Population

Fifty of 66 moose tagged in the Caribou Hills vicinity had been relocated through April, 1974 (Table 4). From these resightings 1973-74 post-rut and wintering areas were delineated. Resightings of moose tagged in the Caribou Hills suggest a post-rut area almost exclusively within the tagging area. In late December and January, some of the collared moose moved to other wintering areas while the remainder stayed in the tagging area all winter. A large portion of these moose moved northwest into GMSU 15B (Fig. 3). Four moose moved easterly to winter in the Fox River flats area, two moved westerly and two southerly, mixing with moose tagged southwest of the Caribou Hills.

Based upon the six individuals resighted from the group tagged southwest of the Caribou Hills, it appeared that these moose spent the post-rut period either in the tagging area or moved north to the Caribou Hills. Resightings during the winter for these moose were few, but individuals moved north, northwest and south (Fig. 4).

Due to the vast areas of mature timber and to possible radiating movement of moose in many directions to winter in riparian habitat, it was suspected from the start that some reliance would have to be placed on the public to report sightings of collared moose in GMSU 15C. To a certain extent, this has occurred particularly along the road systems. The new collar design was an aid to the public in identifying individual moose; however, many reports were incomplete or inaccurate. This collar design speeded observation time and improved accuracy of identifying individual moose by experienced observers in a Piper "Supercub".

The quadra-color collar design (Franzmann and Arneson 1973) proved unsatisfactory for identifying individual moose because yellow-pink color combinations were often misidentified from the air.

RECOMMENDATIONS

Reconnaissance flights throughout GMSU 15A, 15B and 15C should be continued at a minimum of once per week to derive maximum information from individually identifiable tagged animals. Priorities should be 15C, 15B and 15A, respectively.

The tagging program should be extended for one more year in Subunit 15C to include more moose outside the Caribou Hills.

Accrued results of the tagging program should be considered in formulation of forthcoming species management plans and other management decisions.

Table 4. Resightings of individually identifiable moose tagged in Game Management Subunit 15C, October 1973.

Tagging Area	Sex	Observer	Number of Times Individual Relocated 1	2	3	4	5	Number Tagged	Number of Individuals Relocated	Percent of Individuals Relocated
Caribou Hills	M	ADFG/FWS	5	9	7*	2	0	29	23***	79
		Public	3	0	2**	0	0			
Caribou Hills	F	ADFG/FWS	9	7	1	2	0	26	21	81
		Public	2	1	1	0	1			
Southwest of Caribou Hills	M	ADFG/FWS	1	0	0	0	0	3	2	67
		Public	1	0	0	0	0			
Southwest of Caribou Hills	F	ADFG/FWS	3	0	1	0	0	8	4	50
		Public	1	0	0	0	0			
TOTAL		ADFG/FWS	18	16	9	4	0	66	50	76
		Public	7	1	3	0	1			

* This means the ADFG and/or USFWS resighted 7 identifiable individuals 3 times each.

** This means the public resighted 2 identifiable individuals 3 times each.

*** This total may not equal the summation of resightings of the ADFG/FWS and public because both groups may have resighted the same individual.

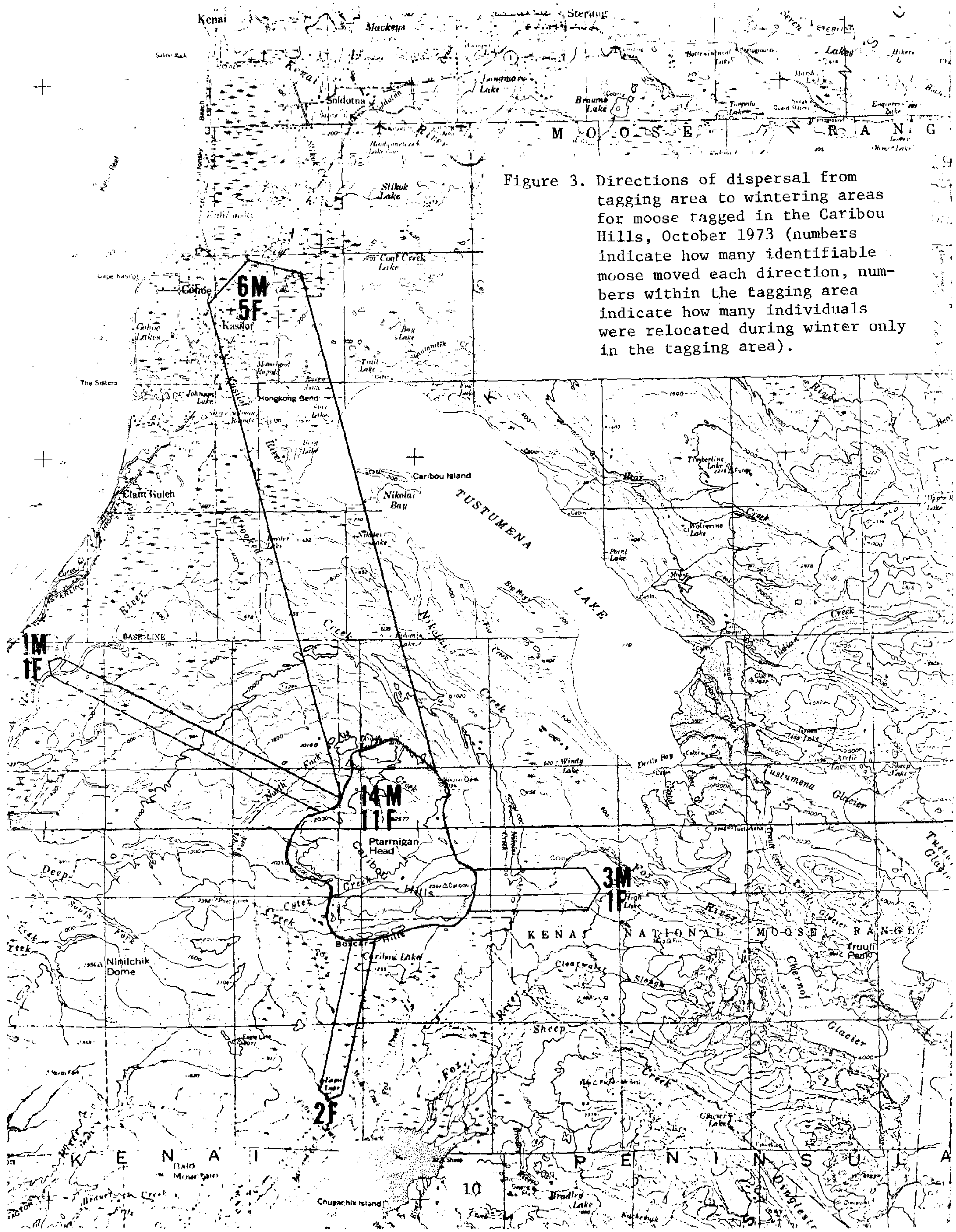


Figure 3. Directions of dispersal from tagging area to wintering areas for moose tagged in the Caribou Hills, October 1973 (numbers indicate how many identifiable moose moved each direction, numbers within the tagging area indicate how many individuals were relocated during winter only in the tagging area).

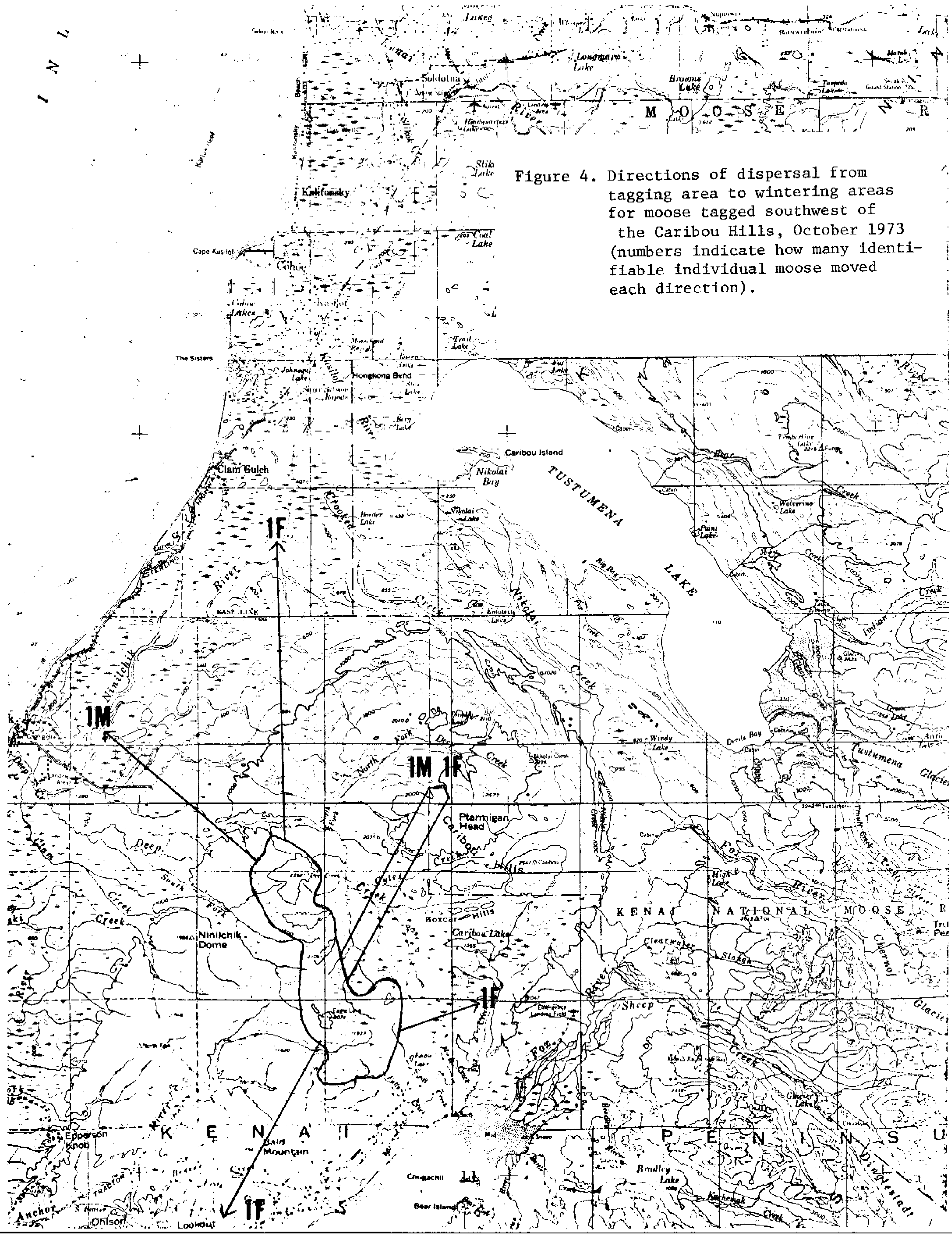


Figure 4. Directions of dispersal from tagging area to wintering areas for moose tagged southwest of the Caribou Hills, October 1973 (numbers indicate how many identifiable individual moose moved each direction).

LITERATURE CITED

Franzmann, A.W. and P.D. Arneson. 1973. Moose Research Center Studies. Alaska Dept. Fish and Game, P-R Proj. Rep. W-17-5 117 pp. Multilith.

LeResche R.E. 1972. Migrations and population mixing of moose on the Kenai Peninsula (Alaska). 8th N. Am. Moose Conf. Thunder Bay, Ontario 8:185-207.

______________. 1974. Moose migrations in North America. LeNaturaliste Canadien 101(1).

______________. and J.L. Davis. 1971. Moose Research Report. Alaska Dept Fish and Game, P-R Proj. Rep. W-17-3 87pp. Multilith.

______________. and G.M. Lynch. 1973. A trap for free ranging moose. J. Wildl. Manage. 37(1):87-89.

Nielson, A.E. and W.M. Shaw. 1967. A helicopter-dart gun technique for capturing moose. Proc. Western Assoc. Game and Fish Comm. 47:183-199.

PREPARED BY:

James L. Davis, Paul D. Arneson,
Paul A. LeRoux and Albert W. Franzmann
Game Biologists

SUBMITTED BY:

Karl B. Schneider
Regional Research Coordinator

APPROVED BY:

Frank R. Jones
Director, Division of Game

Donald E. McKnight
Research Chief, Division of Game