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MOOSE RESEARCH CENTER STUDIES

by
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and
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Volume XIV
Project Progress Report
Federal Aid in Wildlife Restoration
Project W-17-5, Jobs 1.1R, 1.2R, 1.6R and 1.7R

(Printed December, 1973)

ACKNOWLEDGEMENTS

Many individuals from the Alaska Department of Fish and Game and the United States Fish and Wildlife Service were involved in projects at the Kenai Moose Research Center.

R. Rausch, K. Schneider and R. LeResche provided leadership assistance and were instrumental in accomplishing a smooth transition during personnel changes.

Laboratory personnel in Anchorage and Fairbanks, including C. Lucier, K. Neiland, D. Harkness, D. Calkins and C. Nielsen, provided laboratory support necessary to accomplish the 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 special thanks to J. Oldenmeyer who was always willing to assist us both physically and mentally.

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

JOB PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperators: Albert W. Franzmann and Paul D. Arneson

Project No.: W-17-5 Project Title: Moose Investigations

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

Period Covered: July 1, 1972 through June 30, 1973

SUMMARY

Productivity of moose was determined for populations in four one-square-mile pens at the Kenai Moose Research Center (MRC). Natality for this report period (calves born in spring, 1973) was equivalent to 41.7 calves per 100 cows. In the spring of 1972 an equivalent of 34.4 calves per 100 cows was produced. There was no yearling recruitment in 1972 or 1973 due to total loss of calf crops in each preceding winter. The adult population declined by 8.9 percent, not considering experimental manipulation. The overall decline in the total population within the pens was the result of mortality in all segments of the population (calves, yearlings, and adults). Calf mortality was attributed primarily to time of occurrence and depth of snow with corresponding lowered availability of food. All calves appeared to have ultimately died from malnutrition. Causes of adult mortalities were variable and complex in nature.

Of 21 adult female penned moose examined from January through April, 62 percent were pregnant. Thirty-four moose examined outside the enclosures had a pregnancy rate of 76.5 percent.

Whole body weights from 34 moose and measurements from 356 moose were obtained during this report period. The data will be combined with previously obtained data and statistically analyzed. Weight losses of moose during the winter within the pens appeared greater than those of moose outside the pens (8 to 15 percent versus 3 percent). The mean weight of eight enclosed adult female moose weighed from January through April was 316 kg. (697 pounds) and of 13 outside moose during this same period was 381 kg. (838 pounds).

Whole blood and serum samples were collected from 356 moose during this report period. Results of the blood chemistry and electrophoretic patterns were stored and sorted by computer on the bases of age class, sex, month sampled, reproductive status, location and drug used for immobilizations. These classifications diluted the sample size and only age and sex classifications provided adequate sample sizes. Analyses of blood physiologic values will be reported with combined samples at a later date.

Rectal temperature proved to be the most useful indicator of excitability in moose. Five rectal temperature classes were established so that samples of moose could be equitably compared without the influence of variable degrees of excitability of the animal at the time the samples were drawn. Excitability classes, based on subjective evaluation of the moose at time of handling, were significantly correlated ($r = .796$) with rectal temperature, indicating the usefulness of this evaluation.

The base line rectal temperature taken from 109 Class 1 (not excited) and Class 2 (slightly excited) moose was 38.7 C (S.D. =0.42). The mean heart rate from 218 moose from all excitability classes was 85.4 beats per minute (SD = 23.53) and the mean respiratory rate from 217 moose from all excitability classes was 31.6 breaths per minute (SD = 19.11).

There was no significant correlation between the subjective condition classification of 200 moose and selected blood physiologic values. The basis for this could be either an invalid condition classification or the inability of blood values to reflect condition. Until one or more physiologic parameters can be found that consistently reflect condition changes, no conclusion can be made.

Hair samples from 316 moose were analyzed by atomic absorption for four macro elements (calcium, magnesium, potassium and sodium) and six trace elements (cadmium, copper, iron, lead, manganese and zinc). Seasonal fluctuations with peaks in the fall were noted for all elements except iron. Some deficiencies were noted when comparing levels to other domestic animal "normals". Hair values fluctuated in general with seasonal condition changes in the moose. Hair and blood values showed no significant correlation.

Bone marrow fat values obtained from moose collected on the Kenai Peninsula and at the Moose Research Center varied with the source and time of collection. There was a marked difference between road-killed and winter-killed calves. Adult moose from the Moose Research Center had lower marrow fat percentages than moose from outside the pens and on other parts of the Kenai Peninsula. Marrow fat values of winter-killed moose were generally below 10 percent.

CONTENTS

BACKGROUND

The basis for investigations of moose *(Alces alces)* productivity and physiology initiated at the Kenai Moose Research Center (MRC) was discussed by LeResche (1970) and LeResche and Davis (1971). These studies were continued during the past reporting period with some change in emphasis based upon the need to further standardize procedures to more efficiently utilize the moose as the most effective indicator of conditions in its dynamic environment. Background material contained in previous reports will not be repeated. The following background information provides additional information relative to active projects and changes in emphasis.

The ultimate response of a population to its environment is its reproductive success or failure. This is the population's response to all forces acting upon it. Many factors (primarily density-dependent) have been theorized as principle population regulating mechanisms. Some of these are: inter-specific and intra-specific competition (Elton, 1949), intra-specific competition (Nicholson, 1954), climate (Andrewartha and Birch, 1954), crowding (Errington, 1946), predation (Mech, 1966), disease (Anderson, 1972), genetics (Chitty, 1960), behavior-physiology (Christian and Davis, 1964), behavior (Wynne-Edwards, 1965), territoriality (Brown, 1969), and food (Lack, 1954). Under the conditions studied, each of these theories applies. The lesson from the diversity of thought on this problem exemplifies the potential of sampling from the ultimate benefactor or victim of these forces (the animal itself - the indicator).

Since physiology is the study of function of an animal, it was essential that physiologic parameters of the moose be established. Past studies at the MRC have provided physiologic parameters from 520 moose. LeResche et al. (1973) reviewed the blood chemistry of moose relative to the problems, challenges and status of present knowledge.

Emphasis on present physiologic studies at the MRC is directed to blood value interpretive problems that are often confounded by excitability and stress at capture and during handling (Franzmann, 1972; Franzmann and Thorne, 1970; LeResche and Davis, 1971; LeResche et al., 1973; Seal et al., 1973; Gartner et al., 1969; and Gartner et al., 1965). Some physiologic parameters may be altered by handling, while others may not be. It is imperative to recognize these (Geraci and Medway, 1973). To minimize these effects in interpreting blood chemistry values and facilitate excitability classification for a species it is necessary to establish rectal temperature classes at the time of handling (Franzmann and Herbert, 1971). Heart rate (Smith and Hamlin, 1970) and respiratory rate (Tenney, 1970) are affected by excitability states and should be evaluated to facilitate excitability classification. A subjective classification of activity, prior to immobilization and handling, should be used to establish excitability classes (Franzmann, 1972).

The evaluation and classification of excitability stress in animals may be approached through analysis of intra-cellular enzymes, such as serum glutamic oxalacetic transaminase (S G O T) and serum creatanine phosphokinase (S C P K), whose presence in the circulatory system indicates tissue destruction of various degrees (Cardinet, 1971). Tissue breakdown and subsequent release of these enzymes have been examined in pathologic conditions in domestic animals (Blinko and Dye, 1958; Whanger et al., 1969). The influence of excitability on S.G.O.T. values from handling bighorn sheep (*Ovis canadensis*) was demonstrated, but no correlation with degrees of excitability was noted (Franzmann and Thorne, 1970).

Blood chemistry values respond to many influences (Coles, 1967), and to utilize them to monitor animal populations these influences must be evaluated and standardized. In search for more stable material to utilize as a physiologic monitor, researchers in human medicine are investigating hair sampling from several aspects. Some are monitoring protein metabolism (Bradfield, 1968; Bradfield et al., 1967; Bradfield and Jelliffe, 1970; Crounse et al., 1970; Godwin, 1959; Lowry et al., 1951; Sims, 1968) while others are monitoring mineral metabolism (Hammer et al.,1971; Klevay, 1970a; Klevay, 1970b; Kopito et al., 1967; Schroeder and Nason, 1969; Strain et al., 1972; Strain et al., 1966). The importance of protein metabolism related to wool growth has been determined (Drummond and Basset, 1952; Marston, 1955; Ryder, 1958; Slen and Whiting, 1952). Mineral metabolism malfunction has been related to skin and hair pathology in swine (Lewis et al., 1957).

The search for physiologic parameters to assist in evaluating condition in moose is aided by applying known criteria such as femur marrow values. The percent fat of femur marrow, as an indicator af an animal's condition, has been reported by several authors (Cheatum, 1949; Bischoff, 1954, Greer, 1968 and Neiland, 1970). Greer (1969) stated that the marrow of elk (*Cervus canadensis*) in poor condition contained less than 10 percent fat. Some elk collected in the spring and winter-killed elk contained less than one percent marrow fat (Greer, 1968). Neiland (1970), subjectively classifying caribou (*Rangifer tarandus granti*) as in poor condition by visual estimation, found their marrow to contain 3-34 percent fat.

Subjective classifications of condition when accomplished by experienced individuals can provide another guideline in the total condition evaluation of an animal (Robinson, 1960; and Franzmann, 1972).

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 dehydorgenase (LHD)
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. Cadium(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 Facility

LeResche and Davis (1971) provided a thorough description of the facilities. During this report period, an additional trap was constructed in the northwest corner of Pen 4 and another is under construction in the northeast corner of Pen 4. A log building which will replace the trailer living facilities for personnel assigned to the Kenai Moose Research Center was started and nears completion. Two additional gates were purchased and will be installed to facilitate movement of equipment in the enclosures.

Productivity and Mortality

Mortality and natality within the pens were assessed by ground observations, periodic aerial observations (including intensive spring and fall helicopter surveys), trapping and radio-telemetry. Rectal examination of females after January 1 was utilized for pregnancy determination.

Weights and Measurements

Weights were obtained from trapped, immobilized animals utilizing a 4 x 4 truck with a long boom and winch when weather conditions permitted. A tripod was utilized when it was not possible to utilize the boom truck (snow and mud conditions). A heavy duty spring-scale was used.

Physiology - Blood and Hair

Blood samples were obtained from moose trapped within Moose Research Center enclosures, trapped outside of enclosures, killed during the January, 1973 Fort Richardson hunt, and immobilized for marking on the Kenai Peninsula (Job 1.4R).

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. The remaining two frozen serum samples have been retained for future analysis .

Hair samples were obtained by plucking hair from the point of the shoulder (hump) on these moose. The samples were sent to Dr. Arthur Flynn at Case Western Reserve University, School of Medicine, Cleveland, Ohio, for analysis, utilizing an atomic absorption spectrometer.

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 classified into five classes (Table 2). Respiratory rate and heart rate were determined for each animal handled and sampled. 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 Moose Research Center, 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.

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

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

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.

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.

In addition to this subjective evaluation, physiologic parameters, as their usefulness was being assessed, were utilized to evaluate condition. Marrow fat analysis and an evaluation of visceral fat deposits were made on moose that died in the pens in conjunction with post-mortem clinical evaluations.

During the winter months, many adult and calf femurs were collected from road kills, winter kills and miscellaneous mortalities both at the MRC and from many other points on the Kenai Peninsula by biologists from the Soldotna Office, Alaska Department of Fish and Game. With these samples, comparisons between the areas were made and the general condition of the Kenai moose herd can be assessed. In all cases, femurs were frozen and processed in the Anchorage Department of Fish and Game laboratory by the technique described by Neiland (1970). Times from death of the moose to femur collection and from femur collection to processing varied considerably. Femurs were collected as soon after the death of the moose as possible, but some may have remained frozen for up to 60 days before processing. This may have affected the results (Greer, 1968).

FINDINGS

Productivity and Mortality

Table 3 presents raw tagging, breeding and mortality data for all moose within the enclosures from July 1, 1972 through June 1973. The total number of observations and times trapped are also included. Due

Table 3. Histories of individual moose in Kenai Moose Research Center enclosures, July 1, 1972 through June 30, 1973.

			PEN 1 Significant Observations				
Moose No.	Sex	Age (years)	Date	Event	Circumstances	No. Times Observed	No. Times Captured
3	F	10	July 14, 1972	With no calf	Observed	23	4
			Apr. 15, 1973	Pregnant	Helicopter capture		
			June 18, 1973	With 1 calf	Observed		
670	F	2	July 6, 1972	With no calf	Trapped	12	2
			June 18, 1973	With no calf	Observed - helicopter		
10	F	5	August 5, 1972	With 1 calf	Observed	14	1
			Jan. 3, 1973	With no calf	Observed		
			June 18, 1973	With 1 calf	Observed - helicopter		
35	M	4	Nov. 14, 1972	Antler spread - 88 cm	Trapped	23	9
			June 5, 1973	Antler spread - 71 cm	Trapped		
40	F	4	July 24, 1972	With no calf	Observed	23	3
			Oct. 12, 1972	Escaped into Pen 2	Observed		
			Dec. 1, 1972	Driven back into Pen 1	Observed		
			June 18, 1973	With 1 calf	Observed - helicopter		
43	M	5	July 16, 1972	Antler spread - 102 cm	Trapped	42	2
			Sept. 15, 1972	Escaped into Pen 2	Observed		
			Jan. 4, 1973	Weight - 398 kg.	Trapped		
			Feb. 7, 1973	Driven back into Pen 1	Observed		
58			Aug. 8, 1972	Antler spread - 75 cm	Trapped	16	5
			June 22, 1973	Antler spread - 65 cm	Trapped		
R70-8	F	4	July 7, 1972	With no calf	Trapped	18	4
			June 7, 1973	With 1 calf	Trapped		
64	M	3	July 21, 1972	Antler spread - 69 cm.	Trapped	9	4
			June 6, 1973	Died. Weight - 284 kg. Antler spread - 45 cm	Trapped		

Table 3. (Continued) Histories of individual moose in Kenai Moose Research Center enclosures, July 1, 1972 through June 30, 1973.

PEN 1

Moose No.	Sex	Age (years)	Significant Observations: Date	Event	Circumstances	No. Times Observed	No. Times Captured
65	M	2	July 11, 1972	Antler spread - 545 cm	Trapped	25	8
			Oct. 4, 1973	Weight: 330 kg.	Trapped		
			Dec. 1, 1973	Driven into Pen 1 with #40 from Pen 2	Observed		
			Dec. 5, 1973	Weight: 339 kg.	Trapped		
			Jan. 3, 1973	Weight: 318 kg.	Trapped		
			Feb. 5, 1973	Died: weight - 286 kg.	Trapped		
69	F	3	June 18, 1973	With no calf	Observed - helicopter	11	0
76	F	9	Sept. 6, 1972	With 1 calf	Observed	22	3
			Oct. 26, 1972	Weight: 366 kg.	Trapped		
			Jan. 29, 1973	With no calf	Observed		
			Apr. 6, 1973	Pregnant	Trapped		
			June 18, 1973	Found dead	Observed - helicopter		
93	M	3	Oct. 11, 1973	Escaped from Pen 2 from Pen 1	Trapped	0	2
			Nov. 14, 1973	Died. Weight 350 kg. Antler spread - 81 cm	Trapped		
96	M	Calf	Dec. 22, 1972	Released into Pen 1 - Orphan, weight: 145 kg	Trapped	2	1
			Jan. 23, 1973	Found dead	Observed		

Table 3. (Continued) Histories of individual moose in Kenai Moose Research Center enclosures, July 1, 1972 through June 30, 1973.

Moose No.	Sex	Age (years)	PEN 2 Significant Observations Date	Event	Circumstances	No. Times Observed	No. Times Captured
1	F	8	July 6, 1972	With no calf	Observed	29	4
			Oct. 6, 1972	Weight: 411 kg.	Trapped		
			June 18, 1973	With no calf	Observed - helicopter		
R70-4	F	5	July 7, 1972	With no calf	Trapped	15	2
			June 18, 1973	With no calf	Observed - helicopter		
36	M		June 7, 1973	Antler spread - 72 cm	Trapped	27	4
Raquel	F	3	Oct. 2, 1972	Released into Pen 2 for breeding	Trapped	Tame	11
			Nov. 13, 1972	Weight: 373 kg.	Trapped		
			Dec. 18, 1972	Weight: 384 kg.	Trapped		
			Mar. 27, 1973	Weight: 445 kg.	Trapped		
			June 11, 1973	With 1 calf	Observed		
Wally, Jr.	M	1	Nov. 13, 1972	Antler spread: 73-1/2 kg	Trapped	Tame	10
			Dec. 18, 1972	Weight: 298 kg.	Trapped		
			Feb. 26, 1973	Weight: 320 kg. Antlers present	Trapped		
			June 4, 1973	Freeze branded	Trapped		
45	M	5	Aug. 1, 1972	Weight: 384 kg.	Trapped	11	8
			Oct. 4, 1972	Weight: 386 kg.	Trapped		
			Dec. 20, 1972	Weight: 393 kg.	Trapped		
			Feb. 8, 1973	Died: weight: 357 kg.	Trapped		
52	F	4	Sept. 6, 1972	With 1 calf	Observed	18	3
			Feb. 20, 1973	With no calf	Observed		
			Apr. 26, 1973	Pregnant	Trapped		
			May 10, 1973	Found dead	Observed		
61	F	10	July 14, 1972	With no calf	Observed	37	3
			Sept. 15, 1972	Escaped into Pen 2	Observed		
			Feb. 13, 1973	Weight: 320 kg.	Trapped		
			June 18, 1973	With no calf	Observed - helicopter		

Table 3. (Continued) Histories of individual moose in Kenai Moose Research Center Enclosures, July 1, 1972 through June 30, 1973.

PEN 2

			Significant Observations				
Moose No.	Sex	Age (years)	Date	Event	Circumstances	No. Times Observed	No. Times Captured
73	M	3	June 12, 1973	Antler spread - 55 cm right antler broken	Trapped	12	4
77	F	6	Aug. 23, 1972	With no calf	Observed	22	2
			Dec. 5, 1972	Weight: 402 kg.	Trapped		
			Apr. 26, 1973	Died: pregnant - 1 fetus	Trapped		
78	M	4	Aug. 3, 1972	Found dead	Observed	2	0
79	F	3	July 1, 1972	With 1 calf	Observed		
82	F	Calf	Aug. 10, 1973	First marked	Trapped	18	1
			Feb. 20, 1973	Found dead	Observed		
83	M	Calf	Sept. 6, 1972	First marked	Trapped	12	1
			Feb. 15, 1973	Last seen; assumed dead	Observed		
97	M	Calf	Jan. 24, 1973	Released into Pen 1 orphan	Trapped	0	1
R-70-7	F	8	July 10, 1972	With 1 calf	Trapped	36	3
			Mar. 11, 1973	With no calf	Observed		
			Apr. 26, 1973	Not pregnant, condition 3	Darted from helicopter		
			June 18, 1973	Found dead	Observed - helicopter		

Table 3. (Continued) Histories of individual moose in Kenai Moose Research Center Enclosures, July 1, 1972 through June 30, 1973.

			PEN 3 Significant Observations				
Moose No.	Sex	Age (years)	Date	Event	Circumstances	No. Times Observed	No. Times Captured
27	F	5	July 12, 1972	With no calf	Trapped	8	4
			Apr. 4, 1973	Pregnant	Helicopter capture		
			June 21, 1973	With no calf	Trapped		
2870	F	2	Dec. 5, 1972	Weight: 303 kg.	Trapped	15	4
			Apr. 25, 1973	Not pregnant	Trapped		
38	F	18	July 11, 1972	With no calf	Trapped	6	2
			June 18, 1973	With no calf	Observed - helicopter		
39	F	7	July 7, 1972	With no calf	Observed	23	4
			Sept. 18, 1972	Weight: 305 kg.	Trapped		
			June 18, 1973	With 1 calf	Observed - helicopter		
72	F	2	June 6, 1973	With 1 calf (no calf 1972)	Trapped	17	5
75	F	3	July 6, 1972	With no calf	Trapped	12	2
			June 18, 1973	With no calf	Observed		
80	M	3	July 14, 1972	Antler spread: 60 cm	Trapped	11	1

Table 3. (Continued) Histories of individual moose in Kenai Moose Research Center Enclosures, July 1, 1972 through June 30, 1973.

Moose No.	Sex	Age (years)	PEN 4 Significant Observations: Date	Event	Circumstances	No. Times Observed	No. Times Captured
7	M	3	Oct. 11, 1972	Rutting	Observed	31	4
			July 9, 1972	With no calf	Observed		
22	F	7	June 18, 1973	With 1 calf	Observed - helicopter	27	1
			July 9, 1972	With no calf	Observed		
36	F	9	July 9, 1972	With no calf	Observed	23	1
			June 21, 1973	With no calf	Trapped		
37	F	3	July 13, 1972	With no calf	Observed	21	4
			Mar. 14, 1973	Pregnant	Trapped		
			June 24, 1973	With no calf	Observed		
53	M	2	July 20, 1973	Antler spread: 62 cm	Trapped	33	7
			Oct. 12, 1972	Escaped into Pen 2 from Pen 1	Observed		
			Nov. 15, 1973	Antler spread 73.5 cm, released into Pen 4	Trapped		
			Mar. 2, 1973	Condition 4	Trapped		
			May 10, 1973	Found dead	Observed		
57	F	2	July 9, 1972	With no calf	Observed	22	1
			June 24, 1973	With no calf	Observed		
59	M	4	Nov. 21, 1972	Both antlers double spikes	Observed	22	1
			June 12, 1973	Antler spread 45 cm, broken	Trapped		
71	F	3	July 6, 1972	With no calf	Observed	30	1
			June 18, 1973	With 1 calf	Observed		
81	F	3	July 19, 1972	With no calf	Observed	19	3
			June 24, 1973	With no calf	Observed		

Table 3. (Continued) Histories of individual moose in Kenai Moose Research Center Enclosures, July 1, 1972 through June 30, 1973.

PEN 4

Moose No.	Sex	Age (years)	Significant Observations: Date	Event	Circumstances	No. Times Observed	No. Times Captured
84	F	5	Sept. 8, 1972	First processed, no calf	Trapped	21	3
			June 24, 1973	With no calf	Observed		
85	F	11	Sept. 18, 1972	Released into Pen 4 with calf, condition 9	Trapped	27	3
			Jan. 20, 1973	With no calf	Observed		
			Jan. 23, 1973	Weight: 385 kg condition 5, twin fetuses	Trapped		
			June 19, 1973	Found dead	Observed		
86	M	Calf	Sept. 18, 1972	Released with mother into Pen 4	Trapped	13	1
			Mar. 4, 1973	Found dead	Observed		
87	F	11	Oct. 26, 1972	Released with calf into Pen 4, weight: 384 kg	Trapped	28	5
			Jan. 15, 1973	With no calf			
			Feb. 5, 1973	Pregnant: one fetus condition 4	Trapped		
			Mar. 19, 1973	Found dead	Radio-located		
88	M	Calf	Oct. 26, 1972	Released into Pen 4 with mother	Trapped	20	1
			Feb. 13, 1973	Found dead	Observed		
89	F	13	Nov. 2, 1972	Released with calf into Pen 4, weight: 407 kg	Trapped	16	3
			Jan. 24, 1973	With no calf	Observed		
			Feb. 13, 1973	Not pregnant	Trapped		
			Mar. 16, 1973	Weight: 355 kg	Trapped		
			June 18, 1973	Found dead	Observed - helicopter		
90	F	Calf	Nov. 2, 1972	Released with mother into Pen 4	Trapped	4	1
			Jan. 26, 1973	Found dead	Observed		

Table 3. (Continued) Histories of individual moose in Kenai Moose Research Center Enclosures, July 1, 1972 through June 30, 1973.

PEN 4

Moose No.	Sex	Age (years)	Significant Observations Date	Event	Circumstances	No. Times Observed	No. Times Captured
91	F	10	Nov. 11, 1972	Released into Pen 4 with calf, weight: 414 kg	Trapped	33	6
			Jan. 5, 1973	With no calf	Observed		
			June 18, 1973	Found dead	Observed - helicopter		
92	F	Calf	Nov. 11, 1972	Released into Pen 4 with mother, weight: 166 kg	Trapped	18	1
			Jan. 31, 1973	Found dead	Observed		
94	F	Calf	Dec. 6, 1972	Released into Pen 4 orphaned, weight: 149 kg	Trapped	6	1
			May 9, 1973	Found dead	Observed		
95	F	Calf	Dec. 6, 1972	Released into Pen 4, orphaned, weight: 166 kg	Trapped	5	1
			Jan. 31, 1973	Found dead	Observed		
100	M	Not yet rec'd.	June 20, 1973	First processed, released into Pen 4	Trapped	0	1
118	F	2	July 21, 1972	With no calf	Observed	13	2
			Apr. 13, 1973	Collected for VFA Study weight: 273 kg, not pregnant	Shot		
123	F	4	July 9, 1972	With 1 calf	Observed	24	8
			Dec. 4, 1972	With no calf	Observed		
			Apr. 13, 1973	Collected for VFA Study weight: 261 kg, not pregnant	Shot		
128	F	Unk.	July 9, 1972	With no calf	Observed	30	3
			Nov. 22, 1972	Weight: 366 kg.	Trapped		
			Jan. 24, 1973	Weight: 330 kg.	Trapped		
			Apr. 5, 1973	Last seen	Observed		
R-70-3	F	5	July 11, 1973	With no calf	Observed	23	1
			Apr. 26, 1973	Died, not pregnant	Darted from helicopter		

to total loss of calves and yearlings within the enclosures in the winter of 1971-72 and the total loss of calves in the winter of 1972-73, there was no natural recruitment into the population during this report period. The population within the enclosures on June 20, 1972, totaled 51 moose (12.75 per square mile). Components of the population as of July 1, 1972 are tabulated in Table 4. The population within the enclosures on November 13, 1972 totaled 62 moose (15.5 per square mile). Components of the population are tabulated in Table 5. Table 6 provides population composition information for April 1, 1973. The population within the enclosures on June 19, 1973 totaled 47 moose (10.5 per square mile). Components of the population are tabulated in Table 7. Tables 4, 5, 6 and 7 do not reflect natural population changes as additions were periodically made during the year, two escapements between Pens 1 and 2 were experienced, moose mortalities occurred during immobilization and handling, and moose were sacrificed for certain studies. These changes and mortalities are outlined in Tables 3 and 8.

In November, 1972, pen-born and and introduced calves comprised 19.4 percent of the population (Table 5) and in April, 1973, 0.0 percent (Table 6). This high calf mortality experienced within the MRC enclosures during the winter of 1972-73 was outlined and discussed by Johnson et al. (1973). Some of the following discussion is taken from that report. Aerial survival counts in the area immediately outside the pens, which is in Game Management Subunit 15(A), were conducted on February 26 and 27, 1973 for comparison with the 100 percent mortality which occurred in the pens. The results of these two counts and those reported by Paul LeRoux and James Davis, Alaska Department of Fish and Game, Soldotna, for Units 7 and 15 are listed in Table 9.

Survival percentages were lower in the area immediately around the pens (5.4 and 5.2 percent) than in the remainder of Subunit 15(A) (7.9, 6.5 and 10.1 percent). Subunits 15(B) and 15(C) had higher survival percentages (16.1 to 16.3 percent) than Subunit 15(A), while the Unit 7 survival percent (7.1 percent) was similar to those reported for Subunit 15(A). Many factors may influence these disparities, including small sample size and distribution bias, but to relate to the poor survival within the enclosures and in the area immediately surrounding the pens, several other factors should be considered.

Snow depth at the MRC in March, 1973 was 60 cm. This was nearly as deep as experienced during the winter of 1971-72, when high calf mortality (90 percent +) occurred on the Kenai Peninsula. In the winter of 1972-73, snow depths varied considerably on the Kenai Peninsula. They decreased to the west and south of the MRC in the direction of movement of moose through this area. At the time of our survival counts in the MRC area, the majority of the moose had drifted to the west and south into areas where survival appeared higher. In the area around the MRC we may have been observing stragglers from this drift which contributed to lower survival counts. The greater snow depths in the area of the MRC during the winter of 1972-73, could have influenced the drift as well as the poor survival, particularly when the moose are somewhat dependent upon ground forage for winter survival (LeResche and Davis, 1973). This same reasoning could explain the total calf mortality within the MRC pens where the moose were retained in the greater snow-depth area and where decreased availability of ground forage and considerable cratering activity were evident.

The differences between Units and Subunits in percent survival cannot be completely explained on the basis of snow depth, but the influence of depth cannot be rejected. More intensive survival counts, to eliminate

Table 4. Populations within Kenai Moose Research Center enclosures as of July 1, 1972

	Adult FF	Yearling	Calves	Adult MM	Total
Pen 1	7	0	1	5	13
Pen 2	7	0	4	5	16
Pen 3	7	0	0	1	8
Pen 4	11	0	1	2	14
Total (All Pens)	32	0	6	13	51

Table 5. Populations within Kenai Moose Research Center enclosures as of November 13, 1972

	Adult FF	Yearling	Calves	Adult MM	Total
Pen 1	7	0	2	4	13
Pen 2	8	0	3	6	17
Pen 3	6	0	0	1	7
Pen 4	15	0	7	3	25
Total (All Pens)	36	0	12	14	62

Table 6. Populations within Kenai Moose Research Center enclosures as of April 1, 1973

	Adult FF	Yearling	Calves	Adult MM	Total
Pen 1	7	0	0	4	11
Pen 2	6	0	0	2	8
Pen 3	6	0	0	1	7
Pen 4	14	0	0	2	16
Total (All Pens)	33	0	0	9	42

Table 7. Populations within Kenai Moose Research Center enclosures as of June 18, 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	2	12
Total (All Pens)	24	0	9	8	41

Table 8. Mortalities within Kenai Moose Research Center enclosures (July 1, 1972-June 30, 1973)

Moose #	Sex	Age	Pen #	Month	Year	Cause
65	M	2+	1	Feb.	1973	Immobilization in poor condition.
93	M	3+	1	Nov.	1972	Hyperthemia during trapping.
96	M	Calf	1	Jan.	1973	Winter (introduced orphan).
45	M	5+	2	Feb.	1973	Immobilization in poor condition.
52	F	6	2	May	1973	Unknown (followed immobilization).
77	F	7	2	Apr.	1973	Immobilization in poor condition.
78	M	4+	2	Aug.	1972	Peritonitis from trocar experiment.
82	F	Calf	2	Feb.	1973	Winter (born in Pen).
97	M	Calf	2	Feb.	1973	Winter (introduced orphan).
53	M	3	4	May	1973	Winter (introduced into Pen 4).
86	M	Calf	4	Mar.	1973	Winter (introduced with mother).
87	F	Adult	4	Mar.	1973	Winter (introduced).
88	M	Calf	4	Feb.	1973	Winter (introduced with mother).
90	F	Calf	4	Jan.	1973	Winter (introduced with mother).
92	F	Calf	4	Jan.	1973	Winter (introduced with mother).
94	F	Calf	4	May	1973	Winter (introduced orphan).
95	F	Calf	4	Jan.	1973	Winter (introduced orphan).
118	F	3	4	Apr.	1973	Collected for VFA study.
123	F	Adult	4	Apr.	1973	Collected for VFA study.
R70-3	F	6	4	Apr.	1973	Immobilization in poor condition.
64	M	4	1	June	1973	Immobilization in poor condition.
76	F	10	1	May	1973	Unknown
R70-7	F	9	2	April	1973	Winter (poor condition).
85	F	12	4	April	1973	Winter (introduced).
89	F	14	4	April	1973	Winter (introduced).
91	F	11	4	March	1973	Winter (introduced).
Unmarked		Calf	1	Not found		Assumed dead.
Unmarked		Calf	1	Not found		Assumed dead.
Unmarked		Calf	2	Not found		Assumed dead.
Unmarked		Calf	4	Not found		Assumed dead.

Table 9. Survival counts from Game Management Units on the Kenai Peninsula, 1973.

Unit or Subunit	Date	Sample Size	Calf %[1] in Herd
15A[2]	Feb. 26	202	5.4
15A[2]	Feb. 27	77	5.2
15A	Apr. 24	304	7.9
15A	May 10	142	6.5
15A	May 16	149	10.1
15B	May 11	92	16.3
15C	Feb. 22	289	16.3
15C	Mar. 30	37	16.2
15C	May 11	149	16.1
7	May 8	56	7.1

1. Bulls were not distinguished in survival counts.

2. Counts made in the immediate area of MRC.

the distributional bias in areas of intensive management, should be conducted and the resulting data should be related to moose density.

Adult moose populations in the enclosures experienced high mortalities during this report period (Table 8). Seven mortalities were attributed to handling and immobilization procedures. Five of these moose died from respiratory paralysis following immobilization, due to overestimation of their condition. All died in late winter or early spring when immobilizing doses are very critical. A total of 175 moose within the MRC pens were immobilized with an immobilization mortality rate of 2.9 percent during this report period. Sixty-three moose were immobilized in traps outside of the pens with one mortality for an immobilization mortality rate of 1.6 percent. The combined immobilization mortality was 2.5 percent for all moose trapped at the MRC.

One moose died from hyperthermia (overheating) during trapping and one moose died from possible complications associated with a rumen trocar experiment (Job 1.6R). Two moose were collected for a volatile fatty acid (VFA) study in April. Both were in extremely poor condition. The remainder of the adult mortalities were from winter kill or unknown causes. Considering the poor condition of some of the moose that died of man-influenced causes, it is possible that some accidental or intentional mortalities may have preceded natural mortality. Not considering this possibility and excluding experimental alterations, there was an adult population change of minus 8.9 percent. LeResche and Davis (1971) reported overall adult population changes of plus 3 percent from 1968 to 1971 excluding experimental alterations.

In comparison, estimates of moose numbers outside the pens based on random mile-square quadrant counts on the Kenai National Moose Range (Monie, 1973) reflected a 28 percent drop in population from 1971 to 1973. The 1971 estimate was 7900 $\pm$ 1460 and the 1973 estimate was 5700 $\pm$ 1348 moose. These figures reflect two successive heavy calf mortality winters (1970-72) on the Kenai Peninsula as does the calf mortality experienced at the MRC.

Resident moose at the MRC that were accidentally or intentionally transplanted into another pen displayed behavioral patterns which may have contributed to the weakening of the animals through the winter period. These moose, with one exception, frequently paced the border nearest the pen from which they came.

On September 15, 1972 rutting bulls broke open the gate between Pens 1 and 2, allowing male number 43 and female number 61 to escape into Pen 2 from Pen 1. Until number 43 was released back into Pen 1 on February 7, he was observed 19 times near the border between Pens 1 and 2. On March 11, 1973 number 61 was last seen at the border of these two pens, but she had been observed 26 times in that area in a three and one-half month period starting November 29.

The gate was again broken open on October 12. At that time female number 40 and male number 53 went from Pen 1 into Pen 2 while female number 76 and her calf went the opposite direction.

Between November 28 and December 1, 1972 number 40 was observed four times along the fence at Pen 1. On the latter date, she was driven, along with male number 65, back into Pen 1. Number 53 was soon (November 15) released into Pen 4. He was observed 15 times in the northwest corner of Pen 4 which was the closest point to his original home in Pen 1. He was also trapped four times in that area before being found dead on May 10, 1973. Number 76 (not classified a resident moose since she broke into Pen 2 from the outside the previous winter) did not pace the fenceline nearest Pen 2 as the other moose were doing. She was trapped along the Pens 1 and 2 border on April 6, 1973 in poor condition and was found dead on June 18, 1973.

Number 65, who accidentally got into Pen 1, paced the border constantly (he was never observed anywhere else). He was observed 10 times and trapped 5 times along the border and died on February 5, 1973 from overdose of an immobilizing drug due to his extremely poor condition.

There apparently was territory preference by resident moose, as noted by LeResche and Davis (1971). The established moose in a pen preferred to be back in their original pen when displaced, as demonstrated by their pacing behavior. This pacing behavior appeared to interfere with feeding and resting activity as well as utilizing additional calories which contributed to the poor condition of these animals.

Based on a helicopter survey flown on June 19, 1973, the 22 cows in the enclosures produced nine calves. One cow was known to not be pregnant and one previously pregnant cow could not be accounted for. This equates to a ratio of 40.9 calves/100 cows or assuming that the one pregnant cow produced, the ratio would be 41.7 calves/100 cows. Spring calf productivity counts are not frequently reported in the literature. LeResche (1968) reported 84.3 calves/100 cows in the Palmer, Alaska area. There are more reports of cow/calf ratios in the fall, most of which show higher calf ratios than we found in the spring (Rausch and Bishop, 1968; Houston, 1968; Peek, 1962; and Stevens, 1970). Considering possible spring to fall mortality as reported by LeResche (1968), comparative productivity was extremely low this spring at the MRC. The first consideration would be that all the calves were not seen, but this particular helicopter survey was directed toward locating calves and an intensive search was made near each female to find the calf. Nearly one hour of helicopter time was devoted to each square-mile pen. A good part of this time was devoted to searching for calves (see Job 1.6R this report). Continued observations and trapping will provide a check on our observations. A similar survey conducted on June 20, 1972 and subsequent ground observations revealed a productivity ratio of 34.4 calves/100 cows, a lower proportion than this year. Subsequent observations and trapping indicated that one calf was not observed during the helicopter survey.

The cow/calf ratio as of June 14, 1971 was 75.9 calves/100 cows (LeResche and Davis, 1971). The two successive years of low calf productivity do not necessarily relate to severe winters, as the winter of 1970-71 was a comparatively severe winter. The possibility of a delayed poor reproductive response to severe winters and its effect on the mooses' ability to recover should not be overlooked. A decrease in browse availability, production, composition and quality may be indicated by poorer reproductive success. Vegatative aspects of this study being conducted by John Oldemeyer, U.S. Bureau of Sport Fisheries and Wildlife, are not complete and will be reported at a later date.

The decrease in the adult population, excluding manipulation, of 8.9 percent may be a further indication of the MRC population's response to vegetative changes as well as to the effects of successive relatively severe winters. A cause and effect relationship cannot be established, as the many variables influencing a population are inherently ecologically related; however, the signs are evident that the MRC population as a whole has negatively responded and it can be assumed that the population was above carrying capacity for this period.

From January through April, 1973 all adult female moose trapped and processed both in and out of the pens were examined for pregnancy by rectal palpation (Table 10). Of a total of 21 moose examined within the enclosures, 62 percent were pregnant as compared to 76.5 percent of 34 moose examined outside the enclosures. These pregnancy rates are lower than those found by most observers (Rausch, 1959; and Rausch and Bratlie, 1965; Markgren, 1969; Houston, 1968; and Simkin, 1965), were similar to those reported by Pimlott (1959), and were higher than those reported by Edwards and Ritcey (1958). The small sample size of examined females during this report period precludes any conclusions or discussion of comparisons at this time. Due to the ease of palpating fetuses in January, we concluded that palpation for pregnancy should begin sooner, and earlier efforts will be made in the future.

The pregnancy rates do not directly relate to productivity within the pens, as some of the cows examined died prior to parturition. Twelve cows that were previously determined to be pregnant were seen on the June 19, 1973 helicopter survey. Two of these had no calves by their side as of June 19, 1973. They were not likely to calve after that date and it can be assumed that their calves suffered late in-utero death or early post-partum mortality. One of these cows was a resident of Pen 4 where a wolf *(Canis lupus)* was known to reside from June 7 to June 14, 1973. It is possible her calf was taken by the wolf. No cows examined for pregnancy and found not-pregnant had calves by side.

Weights and Measurements

Table 11 lists 34 whole weights of moose from within the MRC pens and Table 12 lists 25 whole weights of moose trapped and immobilized outside the pens. Several "inside" moose were serially weighed and provide some evidence of seasonal weight fluctuation as represented in Fig. 1. One adult female moose gained 0.9 kg./day (1.9 pounds) from June to October and another adult female gained 0.8 kg/day (1.8 pounds) from June to September. Two cows and two bulls showed weight losses during the winter. Cow number 128 lost 0.7 kg./day (1.5 pounds) from November through January. Cow number 89 lost 0.5 kg./day (1.1 pounds) from November to March. Bull number 65 lost 0.9 kg./day (1.9 pounds) from December to February. Bull number 45 was weighed every 60 days from August to February. It is interesting to note that he maintained his pre-rut body weight through the rut and did not begin losing weight until after December (Table 11).

Table 12 does not contain serial weights on any one individual. The weights of adult female moose outside the pens did not fluctuate as much from December through April as did the moose within the pens. Without serial sampling and with the small sample size the data are not statistically comparable, but they do suggest a possible added stress this past year on the enclosed moose. The mean weight of seven adult female enclosed moose from September through December was 352 kg.

Table 10. Reproductive status of moose at 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 Number Cows	Total Number Bulls
Pen 1	-	-	4	-	-	4	100	3	7	3
Pen 2	2	40	1	2***	-	3	60	3	8	6
Pen 3	1	25	3	-	-	3	75	2	6	1
Pen 4	6	55	1	2	2	5	45	4	15	2
Total Moose Research Center	8	38	9	3	1	13	62	12	33	12
Total Outside Moose Research Center	8	23.5	10	12	4	26	76.5	-	-	-

* Data based on animal numbers and location during 1972 rut.
** During late pregnancy number of fetuses not determined.
*** Raquel (tame moose) included.

Figure 1. Whole body weights by month from adult MRC moose. (Dotted lines connect sequential weights of individuals)

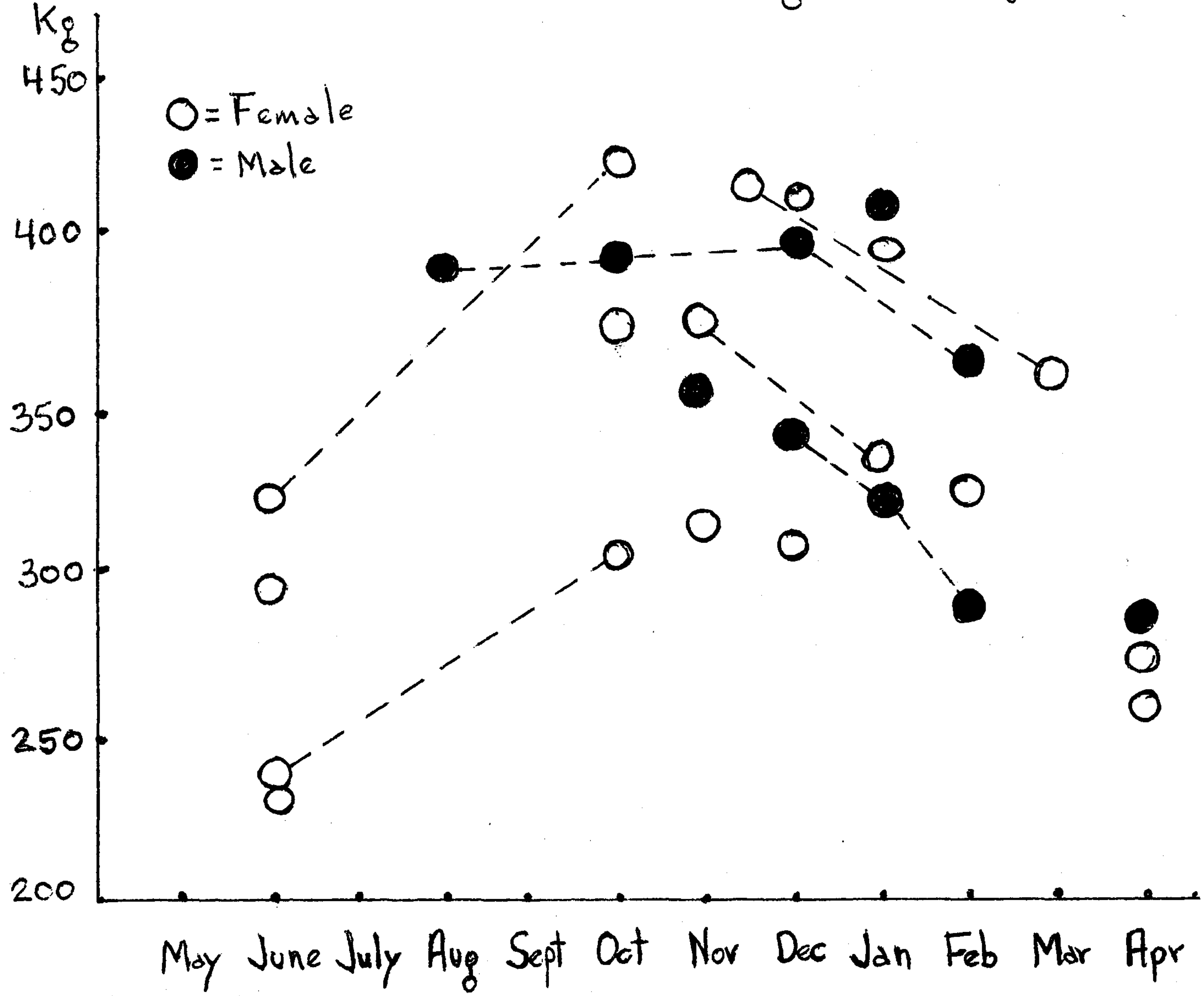

Table 11. Whole weights of moose of known age, sex and reproductive status inside Moose Research Center pens (June 1, 1972 - June 30, 1973).

Moose	Date	Pen	Sex	Age (mo.)	Reproductive Status and Remarks	Weight Kg.	Weight Pounds
73	6/5/72	2	M	36	In poor condition (5)	239	525
1	6/22/72	2	F	96	With no calf	318	700
1	10/6/72	2	F	100	Gained .9 kg/day from June to Oct.	411	905
39	6/23/72	3	F	85	With no calf. Poor condition.	243	535
39	9/18/72	3	F	87	Gained .8 kg/day from June to Sept.	305	670
3	6/24/72	1	F	120	With no calf. Poor condition (5)	295	650
Wally	6/24/72	CP	N	13	Castrated male - semi-tame	234	515
Wally	12/18/72	CP	N	19	Supplemental feeding	298	655
Wally	2/26/73	CP	N	22		320	705
Raquel	6/24/72	CP	F	37	With no calf - tame	352	775
Raquel	11/13/72	CP	F	41	Gained weight through winter on supplemental feeding.	373	820
Raquel	12/18/72	CP	F	42		384	845
Raquel	3/27/73	CP	F	46		445	980
45	8/1/72	2	M	61	Maintained weight through rut, but lost 36 kg. in 50 days.	384	845
45	10/4/72	2	M	63		386	850
45	12/20/72	2	M	65		393	865
45	2/8/73	2	M	67		357	785
76	10/26/72	1	F	113	With one calf	366	805
79	11/10/72	2	F	41	With no calf - pregnant	311	685
128	11/22/72	4	F	Unk.	With no calf - pregnant	366	805
128	1/24/72	4	F	Unk.	Lost 36 kg. in 52 days. Nov. to Jan.	330	725
93	11/14/72	1	M	41		350	770
65	12/5/72	1	M	30	Lost 52 kg. in 60 days, Dec. to Feb.	338	745
65	1/3/73	1	M	31		318	700
65	2/5/73	1	M	32		286	630
2870	12/5/72	3	F	30	No calf - not pregnant	302	665
77	12/5/72	2	F	78	Pregnant	402	885
43	1/4/73	1	M	67		398	875
85	1/23/73	4	F	140	Pregnant	385	848
61	2/13/73	2	F	128	Not pregnant	320	705
89	11/2/72	4	F	161	Trapped outside, put into Pen 4	407	895
89	3/16/73	4	F	164	Lost 52 kg. in 133 days, Nov. to Mar.	355	780
118	4/13/73	4	F	34	Not pregnant - poor condition (4)	273	600
123	4/13/73	4	F	54	Not pregnant - poor condition (4)	261	575
64	6/6/73	1	M	48		284	625

Table 12. Whole weights of moose trapped outside Moose Research Center pens (June 1, 1972 - June 30, 1973).

Moose	Date	Sex	Age (yrs)	Reproductive status and remarks	Weight Kg.	Weight Pounds
87	10/26/72	F	11	With calf - introduced into Pen 4	384	845
89	11/2/72	F	13	With calf - introduced into Pen 4	407	895
91	11/11/72	F	12	With calf - introduced into Pen 4	414	910
92	11/11/72	F	Calf	Calf of #91 - introduced into Pen 4	164	360
94	12/6/72	F	Calf	Introduced into Pen 4	149	328
95	12/6/72	F	Calf	Introduced into Pen 4	166	365
96	12/22/72	M	Calf	Introduced into Pen 1	145	320
148	12/6/72	F	2	No calf seen	311	685
149	12/6/72	F	10	With one calf	380	835
153	12/7/72	F	10	No calf seen	384	845
160	2/15/73	F	13	Not pregnant	389	855
161	2/15/73	F	4	Pregnant	348	765
164	2/26/73	F	7	Pregnant	389	855
167	2/28/73	F	6	Pregnant	386	850
171	3/5/73	F	11	Pregnant	434	955
173	3/6/73	F	15	Pregnant	366	805
174	3/7/73	F	11	Pregnant	393	865
175	3/12/73	F	9	Pregnant	334	735
179	4/3/73	F	17	Pregnant	398	875
180	4/11/73	F	10	Pregnant	357	785
181	4/12/73	F	3	Pregnant, collected for VFA study	380	835
182	4/12/73	F	2?	Pregnant, collected for VFA study	391	860
183	4/12/73	F	5	Pregnant, collected for VFA study	382	840
184	4/13/73	F	7	Not pregnant, collected for VFA study	398	875
188	6/6/73	M	Unk.		275	605

(774 pounds) and for five outside moose during the same period it was 403 kg. (866) pounds. The mean weight of eight adult female enclosed moose from January through April was 316 kg. (697 pounds) and of 13 outside moose during the same period it was 381 kg. (838 pounds). Again the sample size is small and not statistically comparable. Another factor confounding comparisons between inside and outside moose is that five of eight inside moose weighed in the January through April period were from Pen 4 where we purposely maintain high densities of moose (25/square mile in fall of 1972). This does indicate one of the possible effects of these high densities.

Eleven weights from female moose over three years of age taken in February and March at Fort Richardson, Alaska by Bader (1968) averaged 372 kg. (818 pounds). This is similar to the mean of 381 kg. (838 pounds) for 13 adult female moose weighed outside the Moose Research Center enclosures from January through April, 1973.

Of the six moose from inside the pens for which serial weights are available, two adult cows showed 25 and 29 percent weight gains from summer to fall. Two adult bulls showed 8 and 15 percent losses, and two cows showed 15 and 24 percent losses in winter (Table 11 and Fig. 1). These weight fluctuations are similar to the 15 to 24 percent reported by Verme (1970) on captive moose. No serial weights from moose outside of the pens are available. Therefore estimates of seasonal weight changes can be misleading, but the mean weights of outside moose went from 403 kg. (866 pounds) for the period from September through December to 381 kg. (838 pounds) for the January through April period, a decrease of only 3 percent.

Morphometric measurements (total length, hind foot length, girth, height standing and ear length) were taken from nearly all moose handled. Antler measurements were made when applicable. These data will be analyzed in combination with previously obtained morphometric measurements and weight values when the computer program is completed.

Blood Values

The sources of 356 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 (Fig. 1A) 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. Findings in this report are based only on data collected during this report period.

A potential of 72 parameters could be listed for each individual sampled. These were sorted by the computer based upon age class, sex and month sampled. Table 14 lists mean blood chemistry and electrophoretic values based on sex only and Table 15 lists these same values based upon sex and age class. Tables 16, 17, 18, 19, 20 and 21 further classify the blood values on the basis of month sampled. The standard deviation and sample size are listed in each of the tables. The problem of dilution of sample size with additional classification of samples is evident in Tables 16 through 21. Unfortunately even additional classification is necessary to effectively evaluate the applicability of these values to moose management.

Table 13. Sources of moose blood and hair analyzed from May 1, 1972 to July 1, 1973.

Source	Number of Specimens Serum	Whole Blood	Hair
Trapping at MRC			
Pen 1	36	36	30
Pen 2	39	39	34
Pen 3	17	17	14
Pen 4	31	31	30
Calf Pen	24	24	19
Outside Pens	74	74	59
Helicopter Immobilizing at MRC			
Pen 1	6	6	7
Pen 2	8	8	8
Pen 3	6	6	6
Pen 4	7	7	7
Total Kenai Moose Research Center	248	248	214
Tagging - GMU 15 Benchland (1972)	60	60	54
Fort Richardson Hunt (1973)	44	44	44
Collected in GMU 15	4	4	4
Total	356	356	316

31-11A-0190 STATE OF ALASKA DEPARTMENT OF FISH AND GAME GAME BIOLOGICAL INPUT FORM

SYSTEM NUMBER	SPECIE	TAG NUMBER	DATE MO DA YR	UPDATE CODE
11A				☐ 1 DELETE ☐ 2 ADD ☐ 3 REVISION

1 16 17

CRD NO.	SEX	DRUG	DOSE	DOWN TIME	LOCATION	RECAPTURE	AGE (MONTHS)	TOTAL LENGTH (CM)	HIND FOOT (CM)	SHOULDER HEIGHT (CM)	HEART GIRTH (CM)	EAR LENGTH (CM)	TAIL LENGTH (CM)	ANTLER SPREAD (CM)	ANTLER BASE (CM)	WEIGHT (LBS.)
1																

18 57

CRD NO.	CALCIUM	INORG. PHOS.	GLUCOSE	B.U.N.	URIC ACID	CHOLES-TEROL	TOTAL PROTEIN	ALBUMIN	BILIRUBIN	ALKALINE PHOS.	LDH	SGOT	CPK	CA/P RATIO
2														

18 59

CRD NO.	TOTAL PROTEIN (GM)	ALBUMIN (GM)	GLOBULIN (GM)	ALPHA-1 (GM)	ALPHA-2 (GM)	BETA (GM)	GAMMA (GM)	ALB/GLOB RATIO	ALBUMIN %	GLOBULIN %	ALPHA-1 %	ALPHA-2 %	BETA %	GAMMA %
3														

18 60

CRD NO.	WBC	SEGMENT NEUTRAL	LYMPHO-CYTE	DIFF.	HEMOGLOBIN (GM)	HEMATOCRIT VOLUME	MCV	MCHC %	MARROW % FAT	EXCIT.	COND.	HEART RATE	RESP. RATE	RECTAL TEMP.	CLASS	AMBIENT TEMP. C	CLASS
4																	

18 56

CRD NO.	ZN	CV	MG	MN	CA	NA	K	CO	FE	PB
5										

18 51

-30-

Figure 1A. Game biological input form.

Table 14. Blood values[1] based on sex from moose sampled May 1, 1972 to June 1, 1973.

	Female			Male		
	Mean	S.D.	N	Mean	S.D.	N
Calcium	9.9	1.6	231	9.6	1.3	98
Phos.	4.6	1.7	231	5.0	1.5	98
Glucose	122	40	231	118	41	98
B.U.N.	13	10	231	16	11	98
Uric Acid	0.4	0.2	231	0.4	0.2	98
Cholesterol	83	18	231	76	16	98
Bilirubin	0.4	0.2	231	0.4	0.3	98
Alk. Phos.	56	61	230	89	99	96
L.D.H.	321	96	231	338	110	96
SGOT	175	58	231	171	58	98
Ca/P Ratio	7.0	1.3	231	6.7	1.3	99
Total Protein	7.0	1.3	231	6.7	1.3	99
Albumin %	56.7	5.4	231	55.1	6.1	99
Globulin %	43.3	5.4	231	44.9	6.1	99
Alpha 1 %	5.0	1.6	231	4.9	1.6	99
Alpha 2 %	7.8	1.6	231	8.8	2.9	99
Beta %	10.1	2.1	231	10.1	2.4	99
Gamma %	20.4	3.9	231	21.0	4.8	99
A/G Ratio	1.34	0.3	231	1.27	0.31	99

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

Table 15. Blood values[1] based on sex and age from moose sampled, May 1, 1973 to June 1, 1973.

	Age Class (Months)																							
	0 to 12				13 to 24				25 to 36				37 to 96				97 to 144				144 +			
	Female N = 11		Male N = 11		Female N = 11		Male N = 14		Female N = 31		Male N = 26		Female N = 93		Male N = 39		Female N = 60		Male N = 7		Female N = 25		Male N = 1	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Calcium	8.7	3.1	8.9	1.6	9.6	0.7	9.4	1.7	9.6	2.2	9.2	1.4	9.9	1.6	10.1	.6	10.1	1.3	9.9	.3	10.4	.8	6.8	-
Phosphorus	6.3	3.4	5.3	2.1	3.4	1.4	5.9	1.5	4.9	1.7	5.0	1.8	4.9	1.8	4.7	1.1	4.1	1.2	4.9	1.0	4.3	1.0	4.1	-
Glucose	112	74	105	51	145	38	121	41	121	45	103	39	116	36	132	39	129	41	124	22	126	24	67	-
B.U.N.	5.5	3.8	11.5	9.3	10.4	5.6	20.0	10.0	11.4	9.7	17.0	12.3	14.9	11.1	16.4	12.0	14.5	8.8	11.9	5.5	10.8	5.4	3	-
Uric Acid	0.4	0.2	0.4	0.2	0.4	0.2	0.4	0.3	0.4	0.2	0.5	0.2	0.4	0.2	0.5	0.2	0.4	0.2	0.4	0.1	0.4	0.2	0.3	-
Cholesterol	75	27	73	23	71	7	77	20	80	20	76	16	85	18	78	13	87	15	77	7	89	16	49	-
Bilirubin	0.3	0.2	0.4	0.2	0.5	0.3	0.3	0.2	0.4	0.2	0.4	0.2	0.4	0.2	0.5	0.4	0.5	0.3	0.4	0.2	0.5	0.4	0.1	-
Alka. Phos.	70	47	167	144	86	93	52	26	70	55	58	58	48	34	114	112	64	93	22	7	34	19	30	
LDH	368	165	375	196	335	93	291	95	334	99	355	103	315	98	338	90	323	88	333	50	295	53	179	
SGOT	198	67	211	82	207	56	124	50	163	46	191	55	165	57	166	45	192	63	161	42	164	40	92	
Ca/P ratio	1.61	0.61	1.83	.57	3.42	1.70	1.66	.40	2.19	0.66	2.07	.73	2.29	1.03	2.29	.66	2.68	.93	2.23	.60	2.53	.63	1.66	
Total Protein	5.0	1.9	5.3	1.8	6.5	0.6	6.6	1.4	6.6	1.2	6.4	1.2	7.1	1.3	7.2	.6	7.2	1.0	7.9	.5	7.3	.8	4.7	
Albumin %	58.0	4.8	55.6	8.1	60.5	5.8	54.9	6.1	57.9	4.2	56.5	4.7	55.2	5.6	55.1	5.5	57.3	5.3	47.9	6.9	57.2	5.3	62.0	
Globulin %	42.0	4.8	44.4	8.1	39.5	5.8	45.1	6.1	42.1	4.2	43.5	4.7	44.8	5.6	44.9	5.5	42.7	5.3	52.1	6.9	42.8	5.3	38.0	
Alpha 1 %	5.3	1.6	5.1	1.4	5.3	1.6	5.6	1.0	5.1	1.7	5.2	1.6	5.1	1.6	4.7	1.6	4.6	1.8	3.6	2.1	5.0	1.4	4.0	
Alpha 2 %	8.0	2.6	10.7	6.1	7.3	1.3	8.5	1.4	7.7	1.5	8.3	2.1	8.1	1.6	8.6	2.3	7.6	1.6	10.1	2.7	7.5	1.4	6.0	
Beta %	12.0	6.0	10.9	2.5	9.5	2.4	10.3	1.5	10.2	1.6	9.8	1.6	10.1	1.8	10.1	3.1	9.6	1.5	10.0	5.8	10.2	1.6	10.0	
Gamma %	16.8	2.9	17.6	4.1	17.4	3.9	20.7	5.1	19.2	3.0	19.9	3.1	21.5	3.9	21.5	4.2	20.8	3.6	28.4	5.7	20.2	3.7	18.0	
A/G ratio	1.38	0.3	1.31	.35	1.58	0.33	1.24	.28	1.38	.27	1.31	.27	1.27	.31	1.28	.32	1.37	.29	.95	.23	1.37	.32	1.61	

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

Table 16. Mean blood values[1] by month sampled from moose 0 - 12 months old. (May 1, 1972 to June 1, 1973).

	JAN.		FEB.		MAR.		APR.		MAY		JUNE		JULY		AUG.		SEPT.		OCT.		NOV.		DEC.	
	F(7)*	M(6)	F	M	F	M(1)	F	M(1)	F	M	F	M	F	M	F	M	F(1)	M(2)	F	M	F(1)	M	F(2)	M(1)
Calcium	7.8	7.9				8.5		10.8									11.2	10.9			10.6		9.6	9.0
Phosphorus	6.7	5.1				3.6		7.0									8.1	7.2			4.3		4.9	3.1
Glucose	88	80				63		137									170	189			135		157	98
B.U.N.	3	6				19		15									10	17			10		8	25
Uric Acid	.3	.4				.5		.5									.4	.5			.4		.4	.5
Cholesterol	65	59				60		90									120	106			90		78	87
Bilirubin	.2	.4				.4		.5									.4	.7			.4		.5	.5
Ak. Phos.	49	138				300		77									164	296			140		59	45
LDH	337	278				236		300									700	675			277		355	570
SGOT	215	216				300		114									139	158			155		189	300
Ca/P ratio	1.42	1.72				2.36		1.54									1.38	1.53			2.47		1.97	2.90
Total Protein	4.2	4.1				5.6		7.2									7.2	7.1			6.9		6.2	6.4
Albumin %	55.9	51.5				59.0		63.0									56.0	61.0			66.0		62.5	59.0
Globulin %	44.1	48.5				41.0		37.0									44.0	39.0			34.0		37.5	41.0
Alpha 1 %	5.6	5.7				6.0		3.0									6.0	4.5			3.0		5.0	4.0
Alpha 2 %	8.1	12.0				9.0		11.0									9.0	8.5			7.0		7.5	9.0
Beta %	13.4	11.5				9.0		8.0									11.0	12.0			9.0		9.0	10.0
Gamma %	17.0	19.3				18.0		14.0									19.0	14.0			15.0		16.0	18.0
A/G ratio	1.22	1.13				1.43		1.73									1.21	1.59			2.0		1.69	1.37

* Sample size

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

Table 17. Mean blood values[1] by month sampled from moose 13 - 24 months old. (May 1, 1972 to June 1, 1973).

	MONTH																							
	JAN.		FEB.		MAR.		APR.		MAY		JUNE		JULY		AUG.		SEPT.		OCT.		NOV.		DEC.	
	F(1)*	M(3)	F(2)	M(1)	F(3)	M(1)	F(2)	M(3)	F(3)	M	F	M(1)	F	M(1)	F	M(1)	F	M	F	M	F	M(1)	F	M(2)
Calcium	10.3	6.9	9.7	10.6	9.3	9.5	10.0	9.6	9.6			10.2		11.1		9.7						10.4		10.0
Phosphorus	3.1	4.8	3.5	7.4	2.6	6.3	3.9	4.7	4.0			6.2		7.4		6.2						7.2		6.8
Glucose	118	79	152	140	150	140	173	153	126			102		110		140						100		133
B.U.N.	14	12	17	33	13	33	8	12	4			20		23		29						21		24
Uric Acid	.5	.2	.3	1.4	.2	.1	.4	.2	.5			.5		.4		.5						.5		.5
Cholesterol	85	54	73	101	67	95	73	73	66			83		85		105						55		87
Bilirubin	1.1	.2	.7	.2	.4	.3	.5	.4	.2			.3		.2		.2						.4		.7
Alk. Phos.	23	37	179	57	25	42	114	41	86			126		-		78						40		47
LDH	300	188	332	250	395	295	348	305	277			335		310		375						260		384
SGOT	156	142	260	77	234	95	214	148	157			90		98		95						90		158
Ca/P ratio	3.32	1.49	2.86	1.43	4.48	1.51	3.52	2.21	2.70			1.65		1.50		1.56						1.44		1.51
Total Protein	7.1	4.9	6.9	8.4	6.8	7.6	6.6	6.8	5.9			6.0		6.5		7.1						7.0		7.2
Albumin %	64.0	53.0	64.5	43.0	54.3	57.0	62.5	55.0	61.7			61.0		61.0		51.0						53.0		60.5
Globulin %	36.0	47.0	35.5	57.0	45.7	43.0	37.5	45.0	38.3			39.0		39.0		49.0						47.0		39.5
Alpha 1 %	5.0	5.3	4.5	5.0	5.3	5.0	5.0	6.7	6.0			4.0		6.0		7.0						5.0		5.0
Alpha 2 %	8.0	8.3	6.5	11.0	9.0	8.0	6.5	8.0	6.3			7.0		8.0		8.0						10.0		8.0
Beta %	7.0	10.0	8.0	10.0	11.3	10.0	9.5	11.3	9.3			12.0		9.0		10.0						10.5		9.0
Gamma %	16.0	23.3	16.0	30.0	20.0	20.0	16.0	18.6	17.0			15.0		17.0		23.0						22.0		12.5
A/G ratio	1.73	1.17	1.87	.79	1.24	1.33	1.70	1.19	1.62			1.68		1.54		1.06						1.13		1.48

* Sample size.

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

Table 18. Mean blood values[1] by month sampled from moose 25 - 36 months old. (May 1, 1972 to June 1, 1973).

	MONTH																							
	JAN.		FEB.		MAR.		APR.		MAY		JUNE		JULY		AUG.		SEPT.		OCT.		NOV.		DEC.	
	F(4)*	M(6)	F(1)	M(1)	F(2)	M(2)	F(5)	M(2)	F(3)	M(1)	F(2)	M(4)	F(2)	M(3)	F(3)	M(1)	F(3)	M	F(4)	M(4)	F	M(1)	F(2)	M(1)
Calcium	6.9	7.4	10.0	9.1	10.0	9.0	11.0	9.8	7.1	9.2	10.1	9.9	10.1	10.1	9.2	9.6	10.7		10.5	10.0		9.6	10.3	9.8
Phosphorus	6.4	6.3	4.5	4.8	3.2	4.0	4.5	3.2	4.4	4.2	5.5	5.2	5.0	4.7	3.8	4.3	5.6		5.2	4.9		5.5	5.3	4.3
Glucose	66	75	176	86	124	91	104	115	118	122	138	91	72	102	111	90	182		169	155		135	113	97
B.U.N.	4	8	15	29	10	30	4	12	4	6	31	32	20	23	22	31	21		7	8		8	6	9
Uric Acid	.3	.3	.3	.6	.4	.6	.4	.5	.6	.6	.5	.6	.6	.6	.5	.6	.5		.5	.7		.3	.4	.5
Cholesterol	49	59	65	87	63	73	78	63	72	75	91	82	97	100	94	97	109		92	79		80	74	72
Bilirubin	.2	.4	.6	.3	.3	.3	.3	.3	.2	.2	.7	.4	.6	.3	.5	.8	.5		.3	.4		.5	.7	.5
Alk. Phos.	57	28	50	32	42	36	66	49	45	20	95	63	113	183	171	142	66		37	27		35	35	35
LDH	280	310	315	375	319	403	257	345	269	355	378	430	430	308	380	465	489		368	384		252	246	250
SGOT	175	188	204	243	197	259	168	274	168	220	177	185	156	137	106	160	166		133	173		160	202	163
Ca/P ratio	1.36	1.47	2.22	1.90	3.12	2.39	2.50	3.29	2.38	2.19	1.59	1.99	2.05	2.21	2.58	2.23	1.93		2.45	2.19		1.75	1.94	2.28
Total Protein	4.2	4.7	6.4	6.2	6.4	6.1	6.5	6.3	6.3	5.5	6.8	7.0	7.3	7.3	6.9	7.3	7.7		7.8	7.5		6.6	7.1	6.8
Albumin %	55.5	54.3	67.0	57.0	65.0	61.5	59.8	60.5	60.3	55.0	53.5	58.0	57.0	54.3	54.3	50.0	58.0		54.3	55.7		61.0	60.5	57.0
Globulin %	44.5	45.7	33.0	43.0	35.0	38.5	40.2	39.5	39.7	45.0	46.5	42.0	43.0	45.7	45.7	50.0	42.0		45.7	44.3		39.0	39.5	43.0
Alpha 1 %	5.5	5.7	3.0	9.0	5.5	5.0	5.6	5.5	5.3	7.0	6.0	6.0	5.5	5.0	5.0	4.0	5.0		4.3	3.5		4.0	4.0	4.0
Alpha 2 %	9.0	8.5	7.0	7.0	6.0	7.0	7.8	7.0	5.6	10.0	8.0	7.2	9.0	8.0	7.6	10.0	8.0		8.5	10.2		8.0	7.0	7.0
Beta %	10.5	10.1	7.0	9.0	9.0	8.5	9.6	8.0	9.0	10.0	11.5	8.8	10.0	10.6	11.3	14.0	11.3		10.5	9.5		9.0	10.5	9.0
Gamma %	19.3	21.3	16.0	18.0	14.5	17.5	17.0	18.5	19.3	19.0	22.0	19.0	19.0	22.3	22.0	22.0	18.0		22.8	18.5		18.0	18.0	23.0
A/G ratio	1.23	1.20	2.15	1.30	1.86	1.62	1.42	1.58	1.54	1.15	1.16	1.40	1.20	1.17	1.20	1.03	1.35		1.21	1.29		1.55	1.59	1.30

* Sample size

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

Table 19. Mean blood values[1] by month sampled from moose 37 - 96 months old. (May 1, 1972 to June 1, 1973).

	MONTH																							
	JAN.		FEB.		MAR.		APR.		MAY		JUNE		JULY		AUG.		SEPT.		OCT.		NOV.		DEC.	
	F(16)*	M(4)	F(3)	M(2)	F(6)	M	F(16)	M(4)	F(3)	M	F(8)	M(4)	F(7)	M(5)	F(7)	M(1)	F(4)	M	F(15)	M(13)	F(4)	M(5)	F(4)	M(1)
Calcium	7.7	9.9	9.6	9.4	10.0		10.5	10.0	9.2		10.3	10.5	10.5	10.4	10.1	10.0	10.1		10.9	10.3	9.8	9.4	9.9	10.3
Phosphorus	5.9	4.1	4.8	5.6	3.7		4.5	4.2	3.2		5.4	4.3	5.2	5.4	4.5	5.3	4.3		5.4	5.1	5.3	3.5	3.9	5.1
Glucose	71	107	143	110	132		113	124	126		124	169	114	120	115	75	145		146	137	110	150	115	115
B.U.N.	6	13	19	25	16		7	4	7		31	39	30	30	26	10	25		10	10	16	11	16	13
Uric Acid	.3	.4	.6	.6	.4		.2	.3	.5		.6	.8	.5	.5	.6	.4	.4		.5	.6	.4	.3	.5	.5
Cholesterol	62	72	91	80	86		76	71	84		89	86	100	95	101	95	102		94	72	88	77	80	76
Bilirubin	.3	.5	.5	.5	.5		.4	.3	.4		.6	.7	.5	.5	.5	.2	.5		.3	.4	.6	.9	.5	.7
Alk. Phos.	46	83	39	284	49		40	85	33		90	196	69	275	61	275	37		44	31	20	68	26	200
LDH	300	322	261	306	303		270	260	310		380	408	341	411	446	342	360		347	331	268	342	284	218
SGOT	184	201	194	199	226		172	186	207		147	161	126	156	134	123	161		134	139	164	201	194	158
Ca/P ratio	1.62	2.68	2.17	1.70	3.05		2.79	2.55	3.25		1.98	2.56	2.08	1.96	2.40	1.89	2.38		2.12	2.07	1.93	2.85	2.80	2.02
Total Protein	5.5	6.7	7.4	6.7	7.1		6.7	6.2	6.0		7.5	7.6	7.6	7.8	7.9	7.4	8.3		7.9	7.4	8.3	6.9	7.6	7.6
Albumin %	55.6	55.2	52.6	56.5	60.3		56.5	58.5	57.6		53.6	53.5	51.3	54.0	50.9	61.0	53.8		55.9	52.9	55.0	58.4	57.0	57.0
Globulin %	44.4	44.8	47.3	43.5	39.7		43.5	41.5	42.3		46.3	46.5	48.7	46.0	49.1	39.0	46.2		44.1	47.1	45.0	41.6	43.0	43.0
Alpha 1 %	5.3	6.0	7.3	6.0	5.0		6.1	7.0	5.0		5.3	5.3	5.9	4.8	5.1	4.0	4.8		3.6	3.7	4.3	3.4	5.3	5.0
Alpha 2 %	7.9	8.0	8.0	7.5	7.1		7.4	7.2	8.0		7.3	8.0	9.3	8.4	8.7	7.0	8.8		8.6	10.0	8.3	7.6	7.5	8.0
Beta %	9.9	8.5	9.0	7.5	9.1		9.2	9.2	12.3		10.4	10.7	10.4	11.0	10.3	10.0	11.3		11.3	10.0	8.5	12.6	9.0	7.0
Gamma %	21.2	22.5	23.0	22.5	18.3		20.9	18.3	17.3		23.1	22.5	23.1	21.6	24.9	18.0	21.0		20.6	23.3	24.0	18.0	21.3	23.0
A/G ratio	1.27	1.21	1.11	1.29	1.55		1.34	1.50	1.46		1.18	1.16	1.06	1.33	1.04	1.61	1.19		1.31	1.17	1.34	1.45	1.35	1.30

* Sample size

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

Table 20. Mean blood values[1] by month sampled from moose 97 to 144 months old. (May 1, 1972 to June 1, 1973).

	MONTH																							
	JAN.		FEB.		MAR.		APR.		MAY		JUNE		JULY		AUG.		SEPT.		OCT.		NOV.		DEC.	
	F(8)*	M	F(5)	M	F(5)	M	F(6)	M	F(2)	M	F(2)	M	F(4)	M	F(1)	M	F(4)	M	F(17)	M(7)	F(4)	M	F(2)	M
Calcium	8.4		9.9		10.1		10.1		9.9		9.9		11.1		10.9		10.3		10.6	9.9	10.1		10.4	
Phosphorus	4.1		4.4		4.1		2.7		3.1		4.5		4.7		4.7		4.0		4.8	4.9	3.1		4.1	
Glucose	83		127		104		127		120		110		119		115		163		150	123	158		130	
B.U.N.	10		19		18		11		4		22		29		28		29		9	12	12		12	
Uric Acid	.3		.5		.4		.3		.7		.7		.5		.5		.4		.5	.4	.6		.2	
Cholesterol	65		78		85		80		100		90		88		97		108		93	77	86		90	
Bilirubin	.4		.6		.6		.3		.4		.5		.5		.3		.6		.4	.4	.8		.7	
Ak. Phos.	25		110		40		37		38		208		57		56		219		44	22	28		90	
LDH	324		321		277		320		222		342		305		400		400		344	333	277		347	
SGOT	204		254		232		348		138		121		138		130		171		179	161	177		179	
Ca/P ratio	2.14		2.48		2.50		3.99		3.34		2.23		2.42		2.32		2.77		2.40	2.23	3.67		2.56	
Total Protein	5.6		6.8		7.2		6.8		7.0		7.3		7.9		8.5		8.2		7.7	7.9	7.6		7.0	
Albumin %	55.0		58.6		59.2		56.2		60.5		53.5		53.7		46.0		59.8		57.5	47.0	59.0		64.5	
Globulin %	45.0		41.4		40.8		43.8		39.5		46.5		46.3		54.0		40.2		42.5	52.1	41.0		35.5	
Alpha 1 %	5.8		6.6		4.2		5.3		6.0		4.0		5.8		5.0		3.3		3.5	3.6	4.5		3.5	
Alpha 2 %	7.0		7.2		6.0		8.3		7.0		9.0		7.0		8.0		7.0		8.5	10.1	7.8		7.0	
Beta %	9.5		8.2		8.8		8.7		8.5		9.5		10.7		12.0		11.2		10.4	10.0	9.0		8.0	
Gamma %	22.8		19.4		21.6		21.5		18.0		24.5		23.0		29.0		18.5		20.1	28.4	19.8		12.0	
A/G ratio	1.26		1.36		1.48		1.29		1.53		1.17		1.18		.85		1.51		1.39	.95	1.49		1.88	

* Sample size

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

Table 21. Mean blood values[1] by month sampled from moose over 144 months old. (May 1, 1972 to June 1, 1973).

	JAN. F(6)	JAN. M(1)	FEB. F(2)	FEB. M	MAR. F(4)	MAR. M	APR. F(1)	APR. M	MAY F	MAY M	JUNE F	JUNE M	JULY F(1)	JULY M	AUG. F	AUG. M	SEPT. F(1)	SEPT. M	OCT. F(7)	OCT. M	NOV. F(1)	NOV. M	DEC. F(2)	DEC. M
Calcium	10.2	6.8	10.1		10.0		9.6						10.7				11.7		10.7		10.3		10.2	
Phosphorus	4.8	4.1	4.7		3.9		2.3						4.5				5.2		4.7		2.9		3.3	
Glucose	112	67	126		122		142						92				107		136		110		166	
BUN	11	3	16		13		2						19				15		8		4		11	
Uric Acid	.3	.3	.5		.4		.1						.5				.5		.5		.4		.3	
Cholesterol	82	49	78		77		77						100				105		104		83		83	
Bilirubin	.6	.1	.8		.5		.7						.2				.4		.2		.6		1.2	
Alk. Phos.	30	30	79		34		42						44				25		32		17		18	
LDH	270	179	332		276		282						323				255		330		240		294	
SGOT	172	92	214		196		161						102				110		132		152		202	
Ca/P ratio	2.22	1.66	2.16		2.60		4.18						2.38				2.25		2.34		3.55		3.24	
Total Protein	6.7	4.7	6.7		6.9		7.0						7.9				8.3		7.8		7.3		7.6	
Albumin %	57.7	62.0	60.5		60.5		58.0						51.0				54.0		52.7		58.0		65.5	
Globulin %	42.3	38.0	39.5		39.5		42.0						49.0				46.0		47.3		42.0		34.5	
Alpha 1 %	5.5	4.0	4.5		5.3		6.0						6.0				5.0		4.6		5.0		3.5	
Alpha 2 %	6.8	6.0	6.5		6.5		6.0						9.0				9.0		8.9		8.0		7.0	
Beta %	9.8	10.0	8.0		9.8		10.0						11.0				14.0		11.4		8.0		9.0	
Gamma %	20.2	18.0	20.5		39.5		20.0						23.0				19.0		22.6		21.0		15.0	
A/G ratio	1.39	1.61	1.54		1.57		1.41						1.03				1.13		1.12		1.35		1.94	

* Sample size

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

The blood values listed in Tables 14 through 21 are from this report period. Statistical analysis will not be done until all samples, previously collected, and those to be collected under this job are compiled. The compilation should provide adequate sample sizes for additional classification by reproductive status, location, rectal temperature class, condition class and drug used.

Listing the values on the basis of month sampled (Tables 16 through 21) indicates periods of small sample sizes and provides a guide to assist in efforts to obtain certain classes of animals at certain periods of time to improve the distribution of sampling.

Excitability Stress, Body Temperature and Blood Values

Of the parameters used to reflect the influence of excitability related to trapping, capture, immobilization and handling of moose rectal temperature was most efficiently monitored. The utilization of body temperature for this purpose was known to be effective; however, other parameters such as heart rate, respiratory rate, and some blood physiologic parameters were investigated and correlations were made utilizing body temperature as the standard (Table 22).

The lack of significant correlations between rectal temperature or rectal temperature classes and heart rate, respiratory rate, L D H, S G O T and blood glucose indicates that continued utilization of rectal temperature was our most reliable indicator of excitability stress in moose. The classification and use of rectal temperature classes (Table 2) should be a major criteria in classifying moose physiologic values.

Each moose handled was subjectively classified into an excitability class from one to five. To assist in determining how accurately we were judging these individuals, excitability classes were correlated with rectal temperatures. There was a significant correlation (r = .796), indicating that our subjective evaluation was adequate, but could be improved.

To obtain a base line value for the rectal temperature of the moose, only excitability class was used. Class 1 (not excited) and Class 2 (slightly excited) moose were sorted from the data. The resulting mean rectal temperature was 38.7 C (SD = 0.42), based upon a sample of 109. The mean rectal temperature of 234 moose sampled, representing all excitability classes, was 39.2 C (SD = 1.05). The "normal" rectal temperature for moose, based on animals in excitability Classes 1 and 2, ranges between 38.3 and 39.1 C.

Base Line Heart Rate and Respiratory Rate

The attempt to utilize heart rate and respiratory rates as possible excitability classification criteria, made it possible to establish base line values for moose under a variety of conditions. The mean heart rate of 218 moose was 85.4 beats per minute (S.D. = 23.53) and the mean respiratory rate of 217 moose was 31.6 breaths per minute (SD = 1911). Due to the lack of significant correlation of heart rate and respiratory rate with rectal temperature and excitability class, no further classification was attempted. The high standard deviation

Table 22. Correlations of body temperature and body temperature classes[1] with selected physiologic parameters.

Independent Variable (x)	Dependent Variable (y)	Sample Size	Correlation Coefficient
Rectal Temperature	Heart Rate	135	0.384
Rectal Temperature	Respiratory Rate	133	0.487
Heart Rate	Respiratory Rate	124	0.289
Rectal Temperature Class	L.D.H.[2]	153	0.260
Rectal Temperature Class	S.G.O.T.[3]	154	0.089
Rectal Temperature Class	Blood Glucose	154	0.183

1. Based upon Table 2 in this report.
2. L.D.H. = Lactic Dehydrogenase.
3. S.G.O.T. = Serum Glutamic Oxalacetic Transaminase.

indicates considerable variability in both heart rate and respiratory rate. A subjective evaluation of the variability indicates that both are responsive to excitability and stress, but not in the same time relationship, and therefore are not directly correlated with each other or with body temperature. Both heart rate and respiratory rate are more responsive to external stimuli than body temperature and therefore are less usable as monitoring parameters for classifying excitability. The responsiveness of heart rate to environmental stresses would make it a useful criterion to monitor more discrete responses via radio telemetry. The utilization of heart rate and respiratory rate radio-telemetry would provide more useful base line values for each, as conditions at time of monitoring could be more critically evaluated.

Hair

From May 1972 to May 1973, 316 hair samples from moose were collected and analyzed. The sources of these samples are listed in Table 13. Table 23 lists the results of these analyses by month collected, by location (MRC, outside MRC, and other), and by sex. This order of classification was selected, as it appeared that month sampled was the most influential source of variation. The small sample size, resulting from further classifying samples by location and sex, negated the possibility of statistically testing the resulting values for significant differences; however, it was possible to observe trends.

The effect of seasons on the selected values is apparent and has been reported on a preliminary basis from this study (Flynn and Franzmann, 1973). Most of the values (Zn, Cu, Mn, Na, K, and Cd) peak in October (Figs. 2, 3, 5, 7, 8 and 9). Calcium peaks in August (Fig. 6), and magnesium in September (Fig. 4). Iron levels were highest in April (Fig. 10), and lead peaked in November (Fig. 11). Most of the values reflected the peak of condition of moose in the fall in a general way. It should be noted that the calcium peak in August was followed by a rapid decline when other values were high. Since antler development, with its high calcium requirements, is culminating in August, it was suspected that this was influencing the August peak; however, from Table 23 it is evident that the females also attained their highest hair calcium values in August. Magnesium levels followed a similar pattern to calcium with a peak in September. The pattern of iron values does not correspond to the other values and the significance of this is not known. Lead, being an environmental contaminant with no known physiologic function, has a seasonal peak corresponding to improved condition of moose, but on a delayed basis being in November.

The mean values of all elements, except iron, dropped during the winter and early spring, with some variation in time along with monthly fluctuations. The low values did not occur during a particular month, as was experienced with the high values in October. If these values reflect condition of the animal, it would be expected that the low period would not be as consistent as the high period since moose would in general respond to good foraging, as the seasons provide, more uniformly than to the periods of poor foraging which introduces many more variables.

Hair samples were collected nearly every month from our two tame moose (Raquel and Wally) who were receiving supplemental feed in the form of commercial calf pellets (18 percent protein). Table 24 lists the results

Figure 2. Moose hair Zn values by month sampled.

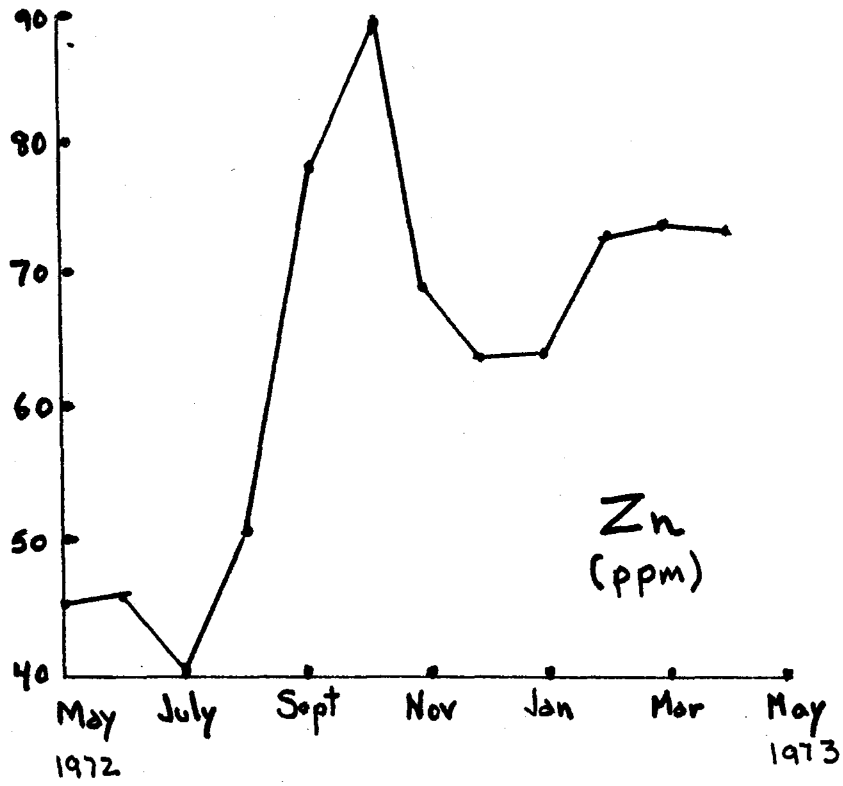

Figure 3. Moose hair Cu values by month sampled.

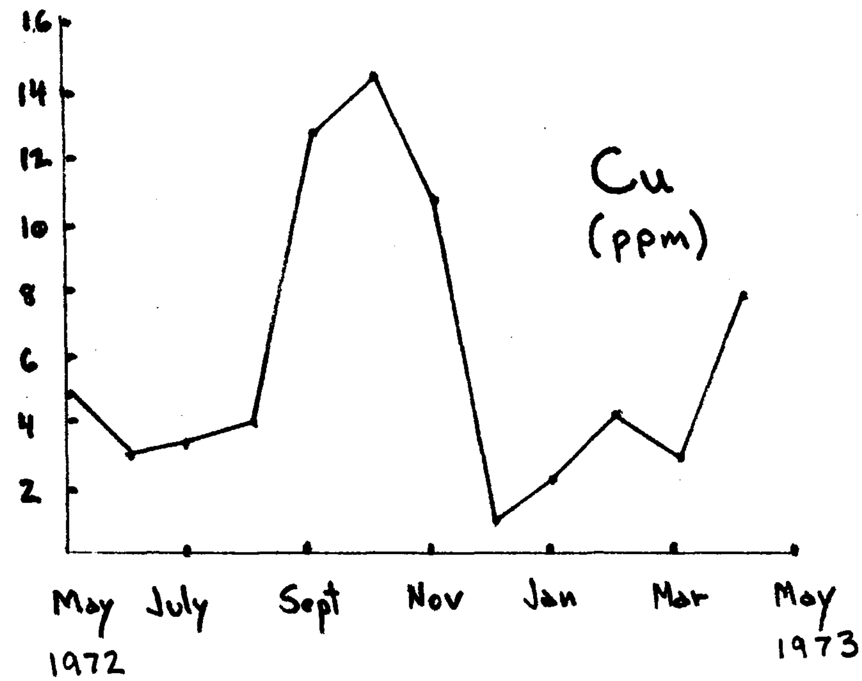

Figure 4. Moose hair Mg values by month sampled.

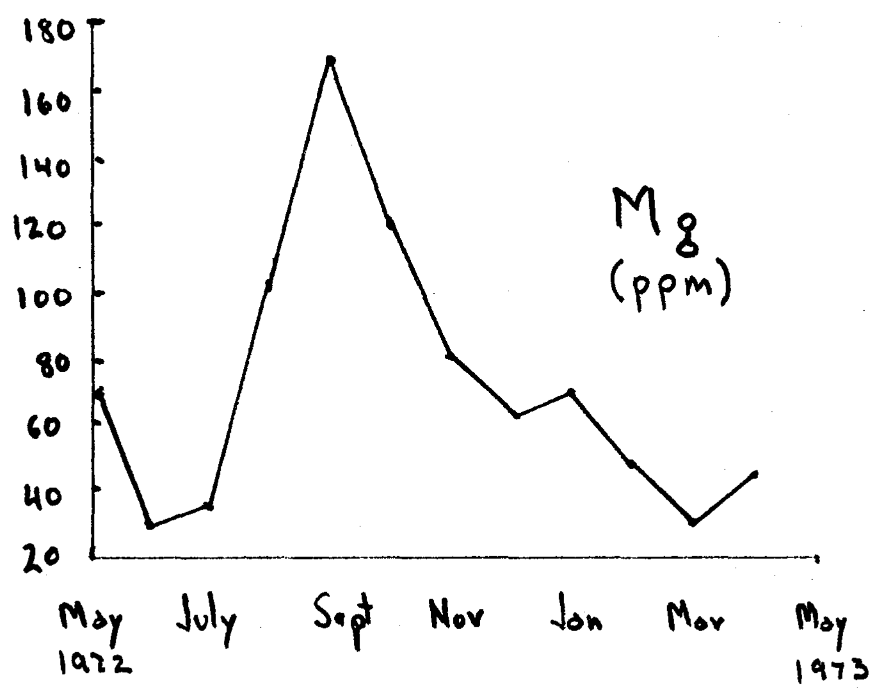

Figure 5. Moose hair Mn values by month sampled.

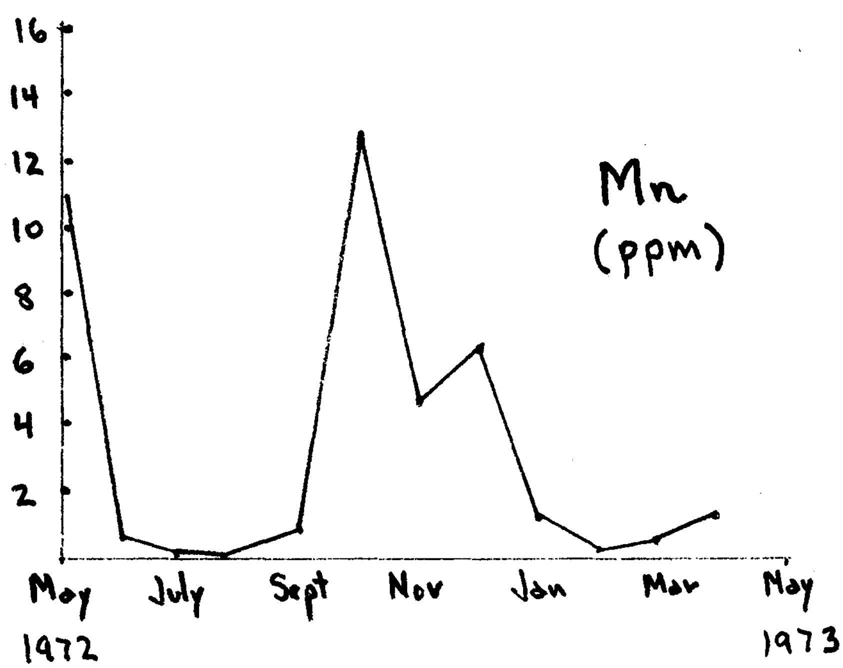

Figure 6. Moose hair Ca values by month sampled.

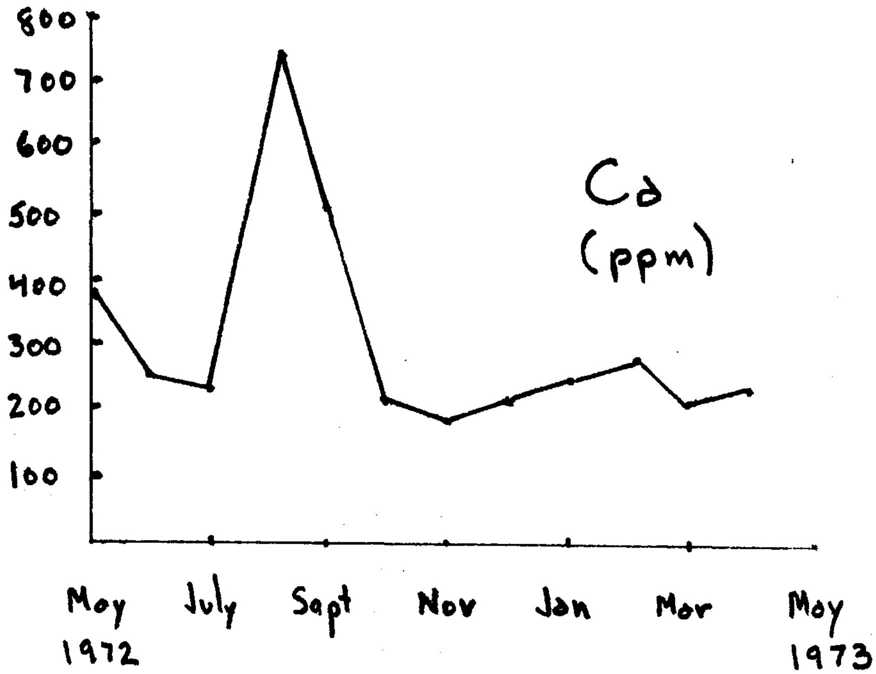

Figure 7. Moose hair Na values by month sampled.

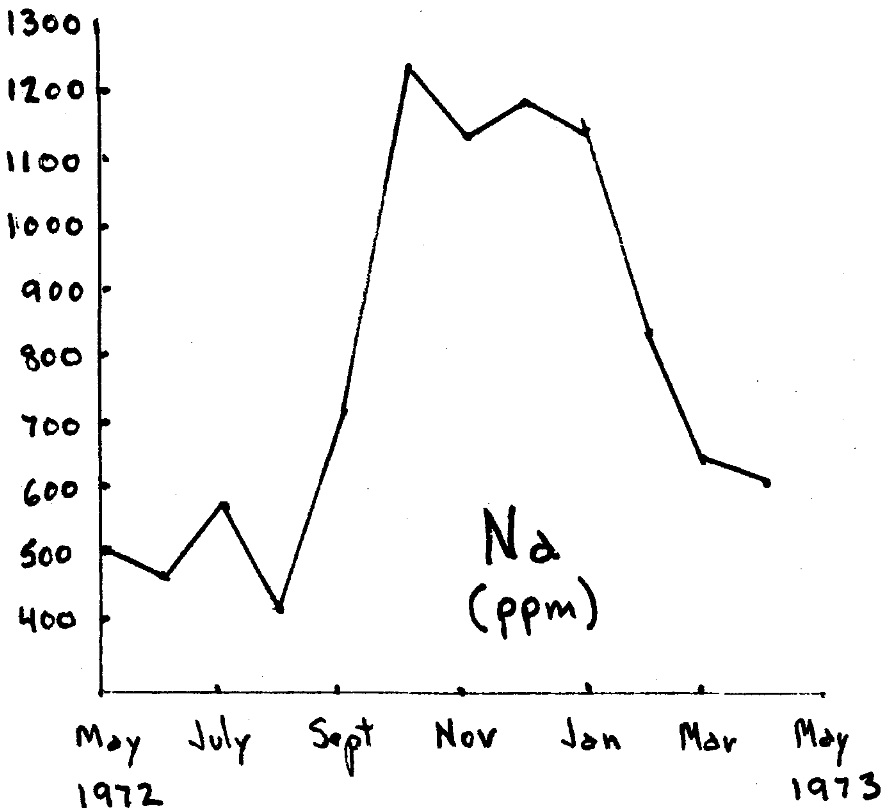

Figure 8. Moose hair K values by month sampled.

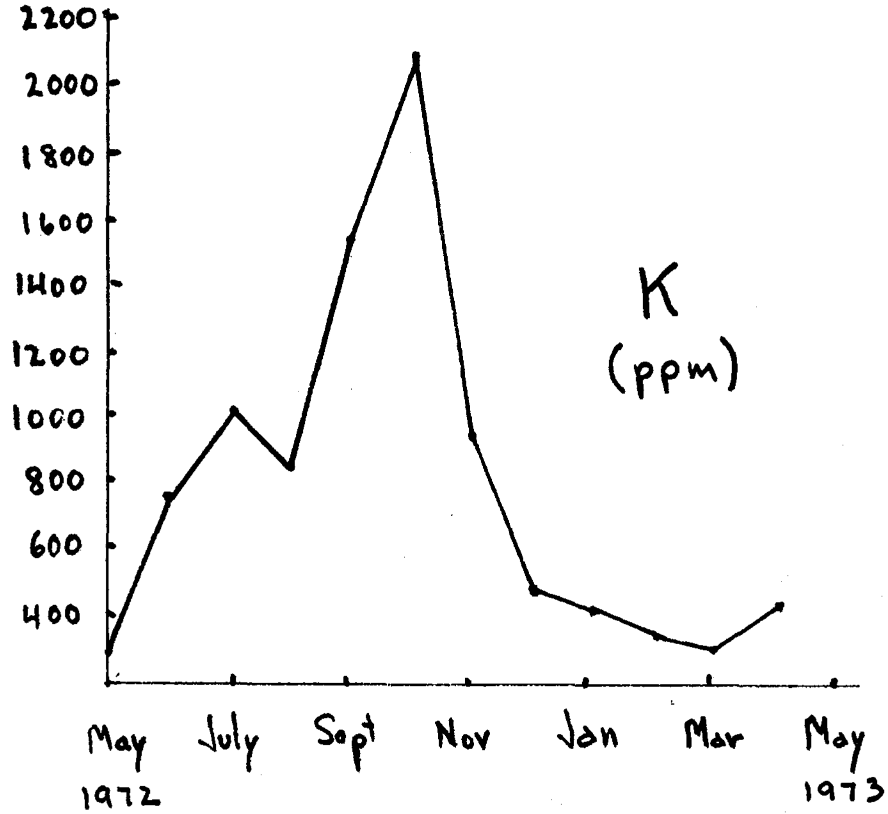

Figure 9. Moose hair Cd values by month sampled.

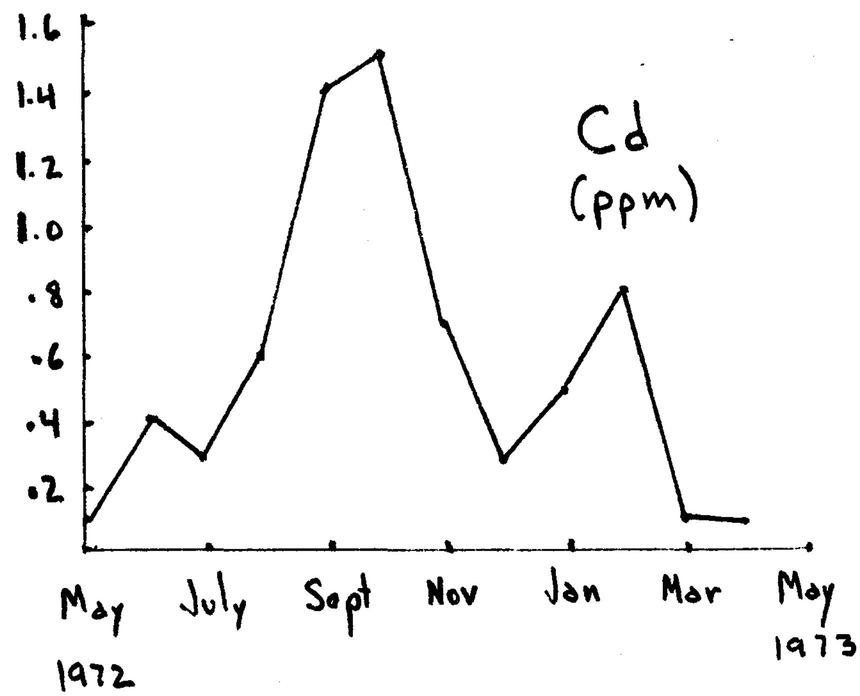

Figure 10. Moose hair Fe values by month sampled.

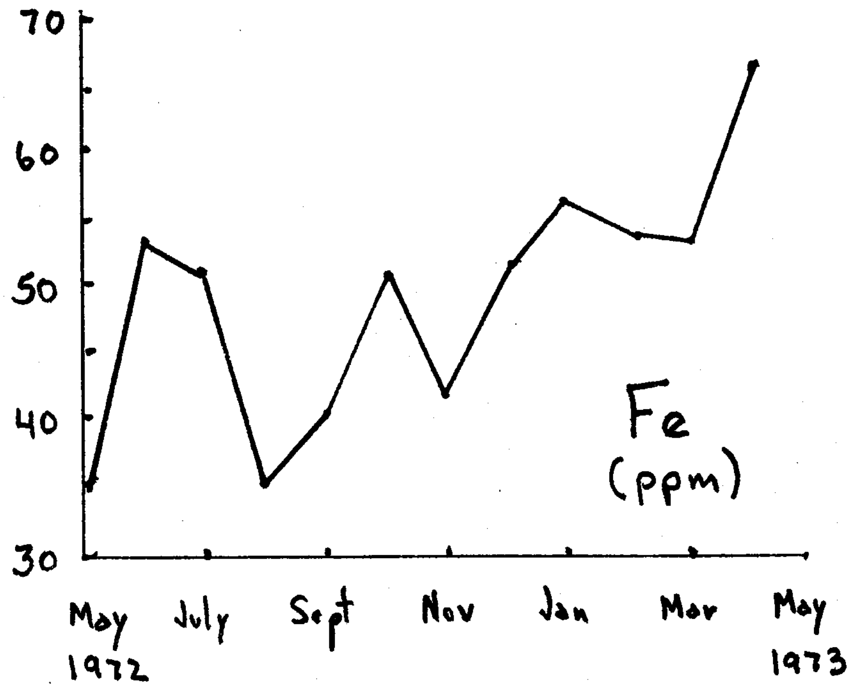

Figure 11. Moose hair Pb values by month sampled.

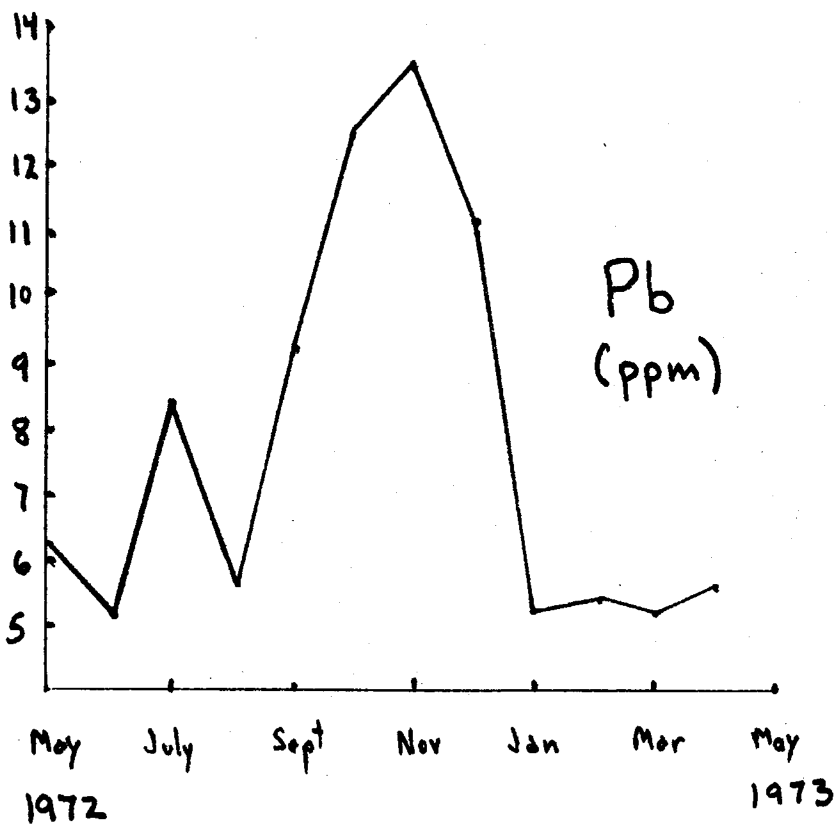

Table 23. Mean monthly hair element values from moose at MRC and outside MRC. May, 1972 to May, 1973.

Month	Location	Sex	Sample Size	Parts per million (PPM)									
				Zn	Cu	Mg	Mn	Ca	Na	K	Cd	Fa	Pb
May	MRC	F	10	65.6	3.5	38.9	3.8	332.4	638.5	261.3	0.3	32.9	5.5
	MRC	M	1	63.9	1.9	35.7	1.9	360.9	562.0	219.0	0.1	39.5	7.1
	Outside	M & F	0										
	Total		11	61.0	3.4	38.3	3.6	335.0	633.5	257.5	.3	33.5	5.6
	Winter kill calves (Kenai Peninsula)		17	34.6	5.6	89.2	15.7	429.5	407.1	336.3	0.7	40.0	7.8
June	MRC	F	10	44.2	3.5	28.4	0.6	255.0	475.9	873.8	0.4	59.0	4.9
	MRC	M	6	47.9	3.1	27.0	1.1	253.2	473.6	633.4	0.2	44.2	5.3
	Outside	F	0										
	Outside	M	1	57.4	2.9	29.4	2.9	279.4	287.5	229.4	0.9	36.7	4.7
	Total		17	45.6	3.2	27.9	0.8	269.6	475.0	783.7	0.4	53.5	5.1
July	MRC	F	11	38.6	3.0	25.3	0.1	216.4	595.6	911.4	0.3	50.5	8.0
	MRC	M	6	32.2	4.5	17.5	0.0	319.2	542.1	1084.1	0.2	53.2	8.9
	Outside	F & M	0										
	Total		17	37.8	3.5	22.5	.06	252.7	576.7	972.4	0.3	51.5	8.3
August	MRC	F	9	50.0	3.8	97.8	.06	763.1	382.3	794.0	0.7	32.9	5.5
	MRC	M	2	60.0	6.6	140.9	.1	688.5	459.9	1098.7	0.3	39.4	7.7
	Outside	F & M	0										
	Total		11	51.8	4.3	105.7	0.06	744.6	408.6	894.4	0.6	34.1	5.6

Table 23. (continued) Mean monthly hair element values from moose at MRC and outside MRC. May, 1972 to May, 1973.

Month	Location	Sex	Sample Size	Parts per million (PPM)									
				Zn	Cu	Mg	Mn	Ca	Na	K	Cd	Fa	Pb
Sept.	MRC	F	11	80.4	13.5	147.5	1.5	515.0	691.4	1683.9	1.2	41.6	9.2
	MRC	M	0										
	Outside	F	1	66.1	11.7	171.2	0.0	521.4	964.9	426.1	3.5	44.4	8.0
	Outside	M	0										
	Total		12	78.4	13.3	174.5	1.4	515.5	714.2	1579.1	1.4	41.9	9.1
Oct.	MRC	M	3	74.6	15.0	86.2	6.9	192.8	1149.0	2251.8	1.5	48.7	7.2
	MRC	M	3	107.3	12.3	104.5	4.3	260.5	893.7	1708.5	0.4	56.0	11.8
	Outside	F	3	78.1	14.4	82.5	4.9	205.6	1267.5	2384.6	3.0	38.4	17.4
	Outside	M											
	Tagging	F	34	92.7	14.4	134.1	13.6	226.9	1295.4	2351.7	1.3	47.7	12.8
	(Benchland)	M	24	77.3	15.0	113.0	11.6	225.0	1217.9	1848.9	1.6	54.3	11.5
	Total		67	89.1	14.7	120.5	12.6	225.4	1235.4	2090.4	1.5	51.4	12.3
Nov.	MRC	F	8	73.2	15.1	88.4	5.6	210.8	1295.8	1095.7	0.8	39.8	16.8
	MRC	M	6	68.8	8.9	68.2	4.5	188.4	1006.8	798.4	0.6	43.5	8.7
	Outside	F & M	0										
	Total		14	71.4	11.3	79.7	5.1	201.1	1172.0	968.3	0.7	41.4	13.3
Dec.	MRC	F	5	61.2	1.8	65.4	7.5	212.1	1295.3	440.7	0.4	44.6	9.5
	MRC	M	3	64.3	2.4	56.5	6.2	237.3	1230.3	349.1	0.2	67.0	4.3
	Outside	F	6	61.3	1.5	70.9	4.5	218.6	1308.4	602.8	0.4	49.8	13.5
	Outside	M	1	65.4	1.1	51.4	13.6	222.0	999.9	345.8	0.7	38.8	15.4
	Total		15	64.5	1.4	62.3	6.5	220.6	1202.6	468.1	0.3	52.6	11.0
Jan.	MRC	F	7	66.0	4.1	51.3	1.7	187.3	1319.0	332.9	0.0	62.8	5.0
	MRC	M	6	63.5	2.7	53.5	2.0	245.8	976.8	296.6	0.0	52.9	3.7
	Outside	F	4	67.2	2.8	54.8	0.8	188.9	1228.1	388.5	0.0	49.1	2.8
	Outside	M	2	71.2	3.5	60.9	2.5	195.8	1051.4	338.2	0.0	61.1	1.8
	Total		19	61.6	2.5	52.8	1.6	205.5	1080.4	315.6	0.0	55.2	4.0
	Ft. Richardson Hunt Total F & M		44	65.2	7.1	76.1	1.6	280.4	1164.3	406.2	0.5	56.1	5.1

Table 23. (continued) Mean monthly hair element values from moose at MRC and outside MRC. May, 1972 to May, 1973.

Month	Location	Sex	Sample Size	Zn	Cu	Mg	Mn	Ca	Na	K	Cd	Fa	Pb
				Parts per million (PPM)									
Feb.	MRC	F	6	79.3	4.5	45.7	1.3	290.3	864.4	374.8	1.8	56.9	4.2
	MRC	M	6	81.9	4.5	53.0	0.5	305.8	776.4	401.0	1.6	52.9	6.2
	Outside	F	9	82.8	5.4	49.0	0.4	298.2	864.8	319.3	0.0	52.7	5.3
	Outside	M	0										
	Total		21	74.1	4.4	48.4	0.6	297.9	849.2	366.6	0.8	54.0	5.2
March	MRC	F	5	87.5	6.2	53.3	2.0	253.9	726.6	477.8	0.2	60.6	4.5
	MRC	M	2	55.6	7.5	54.3	1.0	244.2	818.5	263.0	0.0	55.7	7.0
	Outside	F	13	82.1	8.3	48.3	1.9	238.2	820.4	427.0	0.2	66.3	5.7
	Outside	M	0										
	Total		20	76.4	7.8	49.8	1.9	240.1	802.6	428.2	0.2	64.5	5.5
	Winter Kill Calves		4	70.5	3.3	34.6	0.9	224.5	666.7	305.1	0.1	54.1	5.1
April	MRC	F	16	79.4	7.8	47.6	1.9	283.4	628.7	440.3	0.1	70.6	5.9
	MRC	M	3	72.3	5.3	23.1	1.4	242.6	678.1	400.6	0.5	59.6	7.0
	Outside	F	7	66.8	9.9	45.0	1.4	223.6	606.2	420.2	0.1	66.7	4.2
	Outside	M	1	52.2	9.3	50.4	1.7	292.2	538.2	414.2	0.3	30.7	0.0
	Total		27	74.2	8.1	44.8	1.8	252.4	639.1	433.0	0.1	66.8	5.6

Table 24. Mean monthly hair element values from tame moose at MRC. June, 1972 to May, 1973.

Month	Moose	Parts per million (PPM)									
		Zn	Cu	Mg	Mn	Ca	Na	K	Cd	Fe	Pb
June	Wally	60.7	4.9	51.0	0.0	609.2	474.5	1135.9	0.1	58.3	7.3
	Raquel	41.3	2.0	31.5	0.2	194.9	384.8	460.6	0.1	55.5	3.5
July	Wally	71.4	2.7	90.7	0.0	645.6	1074.2	2035.7	0.1	40.7	16.5
	Raquel	70.5	4.5	122.7	0.0	468.2	862.5	1506.8	0.0	43.6	10.5
August	Wally	54.5	6.5	91.5	1.5	453.6	700.4	1510.9	0.0	42.2	18.3
	Raquel	89.3	8.0	144.0	0.4	397.3	665.3	1064.0	0.0	38.4	14.4
October	Raquel	83.7	14.6	99.9	2.9	301.3	809.6	401.7	2.5	49.8	14.2
November	Wally	72.9	20.8	72.9	6.9	161.1	1472.2	652.8	1.4	43.8	21.5
	Raquel	73.8	16.9	103.4	4.2	164.6	1185.7	2305.9	0.8	51.1	12.2
December	Wally	70.7	0.0	55.6	7.1	247.5	1414.1	320.7	0.0	60.6	9.1
	Raquel	69.7	0.0	62.2	6.3	201.5	1278.6	417.9	0.0	59.7	16.4
January	Wally	73.7	2.3	69.1	0.9	216.6	1359.7	300.0	0.0	70.5	5.1
	Raquel	73.5	1.0	73.5	2.0	189.8	1204.1	534.7	0.0	93.1	6.9
February	Wally	75.0	6.4	63.4	1.0	201.7	1142.6	331.7	0.0	83.5	6.9
	Raquel	76.7	0.8	78.3	1.8	336.6	1079.3	494.0	0.0	91.4	9.2
March	Wally	70.4	10.7	33.5	0.9	247.0	839.9	344.8	0.0	65.3	8.4
	Raquel	85.6	7.5	45.0	1.6	300.0	828.8	615.6	0.0	80.0	1.1
April	Wally	52.3	0.9	58.9	0.2	192.5	992.4	396.4	0.0	60.9	5.5
	Raquel	84.9	9.6	65.7	4.2	234.6	820.5	610.6	0.0	94.3	2.0

of these hair analyses. It is evident that seasonal patterns are present, but not as dramatic as in our composite sample. There are some unexplained fluctuations, but this would be expected from single samples. The supplemental feed apparently either did not contain sufficient quantities of the elements to obviate seasonal patterns or the patterns develop in spite of intake. Analysis of the feed for these elements and the forage consumed should provide insight into the source of the elements.

The demonstration of definite seasonal variations in hair element values indicates the possibility of utilizing hair samples to monitor nutritional status of moose populations. The realization of this possibility depends upon additional research. There are no other data from moose, nor are we aware of data from other ungulates, to utilize for establishing base line values. Information on moose hair growth rates is not available, nor do we know the proportion and pattern of anagen (growing) hair follicles and telogen (quiescent) hair follicles. Knowledge of the source and availability of the various elements in moose forage and consequently in soils would benefit this research approach. The obstacles are many but the advantages of hair sampling from populations versus other physiologic sampling warrant continued research into this approach.

Correlation of Hair and Blood Values

Ten hair element values (Zn, Cu, Mg, Mn, Ca, Na, K, Cd, Fe and Pb) and ten blood chemistry values (Ca, P, Glucose, Cholesteral, Alkaline Phosphotase, LDH, SGOT, Total Protein, Albumin and Globulin) of 221 moose were tested for single and multiple correlation, ignoring other classifications. The highest single correlation was hair potassium with total protein ($r = .42$) and the highest multiple correlation was hair potassium with all blood chemistry values ($r = .53$). It should be noted that hair calcium values and blood calcium values showed no correlation ($r = .08$). It should also be noted that conclusions drawn from this are generally meaningless without further classification of samples on the basis of season, sex, age, location, reproductive status and excitability. The values were tested to determine if there was a possible high correlation disregarding any classification. The results indicate there was none.

Condition Class

Subjective condition classifications were made for 200 moose during this report period. These were correlated with blood physiologic values (Table 25). As readily discernable, with no single correlation coefficients higher than 0.376 and a multiple correlation of 0.485, none of the selected values appear to be useful to evaluate condition, given the premise that the subjective evaluation is correct. The assumption that the condition evaluation is correct is most likely the fallacy in the preceding statement and, until physiologic parameters that will consistently reflect condition can be established, no conclusion can be drawn. Several values not tested may prove more useful (packed cell volume and hemoglobin) but adequate samples were not available during this report period. Other nonhematologic physiologic parameters such as weight and body measurements may be better condition monitors in moose. Hair sampling, with its much more delayed response, may also prove to be useful for this purpose.

The usefulness of the physiologic values, selected in monitoring moose, is not negated by the lack of correlation with condition, for reasons other

Table 25. Correlations of condition classes with selected blood physiologic values.

Blood Physiologic Parameter	Correlation Coefficient with Condition Class
Calcium	0.012
Inorganic Phosphorus	0.020
Glucose	0.376
Blood Urea Nitrogen	0.074
Cholesterol	0.195
Alkaline Phosphotase	0.098
LDH	0.252
SGOT	0.040
Total Protein	0.028
Albumin	0.017
Globulin	0.038
Multiple Correlation	0.485

than the possiblity that the condition evaluation is not valid. Samples were taken in total with no additional classifications. It is possible that, without considering other classifications, we have overlooked one or more significant sources of variation. Again the indication is that we must obtain sufficient samples with adequate distribution throughout the influential classifications we assign to the values.

Bone Marrow

Although sample sizes were small, there was a difference in percent dry-weight between marrows collected from nonwinter-killed adult moose inside the pens and those collected from similar moose outside the pens and in other parts of the Kenai Peninsula (Table 26). Since few adult moose were winter-killed, a comparison of marrows of these animals is not possible. Among calves there was a marked difference between road kills and winter kills. Marrow fat in winter-killed calves from the three areas did not greatly differ. Marrows from road-killed calves in the winter of 1972-73, had higher percent dry weight than those from the previous winter. The winter of 1971-72 was much more severe on much of the Peninsula, so weakened calves were more apt to stay on plowed roads and be killed. No attempt was made to correlate percent fat chronologically through the winter because sample sizes were too small. It is not known how low the percent fat can be in mal-nourished moose and still have the moose recover. Of the marrow examined from winter-killed moose, one of seven adults and two of 67 calves had values of 10 percent or greater dry weight. It would appear that between 10-20 percent is the point of no return and when it drops below 10 percent, the animal succumbs.

Disease and Parasites

No specific disease syndromes were noted at the MRC during this report period other than those relative to malnutrition, anomalies and injuries. An anomaly that occasionally was observed on moose captured outside the enclosures was the long-hoof syndrome. A comparable occurrence of this was noted by Dr. Harold Davis, University of Florida (personal communication) in deer in Florida in areas of known copper deficiency. Other mineral deficiencies may be involved, but with the low copper hair values found during certain periods of the year (this report), this possibility cannot be eliminated. Further sampling of forage and soils in the area with selected hair and blood sampling of these individuals would substantiate or disprove this possibility.

Fifteen moose pellet samples from the Moose Research Center were sent to the Alaska Department of Fish and Game Laboratory in Fairbanks and examined by Carol Nielsen (Table 27). Mrs. Nielsen's interpretation of findings was as follows: all eggs observed were similar in size (246 - 264 x 103 - 129 microns) and shape (oval), and contained less than 50 cells. They were clearly of the subfamily Nematodirinae (Nematoda: Trichostrongylidae), and we suspect they are the eggs of *Nematodirella longispiculata*. These are only general approximations of egg numbers because various factors (water content of feces, diet, daily and hourly variations in egg and fecal production) influence the count. While the egg content of fecal pellets gives some indication of the total worm burden, there is a more direct relationship to the number of female

Table 26. Mean percent dry weight of moose femur marrow at the Kenai Moose Research Center and other parts of the Kenai Peninsula, winters 1971-72, 1972-73. (Sample sizes in parenthesis; NS = no sample).

		Road Kills or Miscellaneous Death			Winter Kills		
	Winter	Kenai Peninsula	Outside MRC	Inside MRC	Kenai Peninsula	Outside MRC	Inside MRC
Adults	1971-72	73.9 (14)	86.7 (4)	23.4 (2)	NS	5.5 (1)	10.5 (5)
	1972-73	85.1 (3)	84.0 (5)	51.5 (4)	NS	NS	4.9 (1)
Calves	1971-72	18.3 (16)	NS	NS	6.9 (45)	7.1 (2)	8.1 (8)
	1972-73	51.4 (4)	NS	NS	7.3 (1)	7.6 (2)	7.3 (9)

Table 27 Results of fecal egg count determination by the McMaster's technique for 15 moose pellet samples from Kenai Moose Research Center.

Label in Sample Bag No.	Sex	1973 Date	1973 Date Examined	Results, Chamber 1	2	Estimated Egg Content of Pellet Samples
45 MRC	M	8/2	22/2	1 nmtr.*	1 nmtr.	100 nematodirids
45 MRC	M	8/2	22/2	1 nmtr.	2 nmtr.	150 nematodirids
47 MRC	M	24/1	23/2	neg.	neg.	negative
53 MRC	M	8/2	22/2	neg.	neg.	negative
53 MRC	M	8/2	22/2	neg.	neg.	negative
85 MRC	F	23/1	22/2	neg.	neg.	negative
85 MRC	F	23/1	22/2	neg.	1 nmtr.	50 nematodirids
91 MRC	F	8/1	21/2	neg.	1 nmtr.	50 nemadodirids
97 calf MRC	M	24/1	23/2	1 nmtr.	neg.	50 nemadodirids
128 MRC	F	24/1	21/2	neg.	neg.	negative
141 MRC	F	25/1	22/2	neg.	neg.	negative
157 MRC	F	26/1	21/2	2 nmtr.	neg.	100 nematodirids
188 MRC	F	26/1	22/2	neg.	neg.	negative
159 MRC	F	7/2	23/2	neg.	neg.	negative
396 (152 out) MRC	F	24/1	22/2	neg.	neg.	negative

Kind of egg found: nematodirid
Number of positive samples: 6 out of 15
(numbers 45, #45, #85, #91, #97, #157)
Estimated egg count range: 0-150 eggs per gram, i.e, very light to light-moderate infections.

*nmtr. = nematodirid egg

worms present. However, degree of host immunity, nutrition, and the age of the helminth infection also contribute to count variations.

RECOMMENDATIONS

1. More intensive survival counts in the spring should be made in areas of intensive moose management to minimize distributional bias.

2. Pregnancy examination of moose by rectal palpation should begin around the first of December, as the fetus is of adequate size at that time.

3. Dilution of sample size when classifying moose to evaluate blood physiologic values necessitates extremely large samples. Continued sampling is necessary to achieve this goal.

4. A subjective condition evaluation, based on a 1 to 10 scale, should be utilized and recorded with all samples obtained from moose.

5. The rectal temperature should be recorded from all live moose sampled for blood physiologic values to classify and subsequently compare values in the same excitability or rectal temperature class.

6. The preliminary demonstration of seasonal fluctuations of hair element values indicates the need for continued investigation. Base-line values and deficiency levels for moose should be established. Research is needed to determine hair growth rate and patterns of growth.

7. Sampling of forage and soil for selected mineral levels and possible deficiencies should be investigated in areas relegated to intensive moose management.

LITERATURE CITED

Anderson, R. C. 1972. The ecological relationships of meningeal worm and native cervids in North America. J. Wildl. Dis. 8(4):304-310.

Andrewartha, H. G. and L. C. Birch. 1954. The distribution and abundance of animals. Univ. of Chicago Press. 782 p.

Bader, D. 1968. Moose tagging program. A report on fish and wildlife conservation activities, Fort Richardson, Alaska, 1968. Compiled and prepared by Post Engineer, Fort Richardson, Alaska.

Bishoff, A.I. 1954. Limitations of the bone marrow technique in determining malnutrition in deer. Proc. Western Assoc. State Game and Fish Comm., Las Vegas, Nevada 34:205-210.

Blinko, C. and W. B. Dye. 1958. Serum transaminase in white-muscle disease. J. An. Sci. 17:224.

Bradfield, R. B. 1968. Changes in hair associated with protein-calorie nutrition. In Calorie Deficiencies, ed. by R. A. McCance and E. M. Widdowson, p. 213. Little, Brown and Co., Boston.

___________., M. A. Bailey, and S. Margen. 1967. Morphologic changes in human scalp hair roots during deprivation of protein. Science, 157:438.

___________. and E. F. P. Jelliffe. 1970. Early assessment of malnutrition. Nature, 225:283.

Brown, J. L. 1969. Territorial behavior and population regulation in birds. Wilson Bull. 81(3):293-329.

Cardinet, G. H. III. 1971. Skeletal muscle In J. J. Kaneko and C. E. Cornelius (Eds.) Clinical biochemistry of domestic animals, Vol. 2, Academic Press, New York and London. 155-177.

Cheatum, E.L. 1949. Bone marrow as an index of malnutrition in deer. New York Conservationist 3:19-22.

Chitty, D. 1960. Population processes in the vole and their relevance to general theory. Can. J. Zool. 38(1):99-113.

Christian, J. J. and D. E. Davis. 1964. Endocrines, behavior, and population. Science. 146(3651):1550-1560.

Coles, E. H. 1967. Veterinary clinical pathology. W. B. Saunders Co., Philadelphia and London. 455 pp.

Crounse, R. G., A. J. Bollet, and S. Owens. 1970. Tissue assay of human protein malnutrition using scalp hair roots. Trans. Assn. Am. Physicians. 83:185-195.

Drummond, J. and J. W. Basset. 1952. Effect of protein supplement upon wool production. Montana Wool Grower 26:42.

Edwards, R.Y. and R.W. Ritcey. 1958. Reproduction in a moose population. J. Wildl. Manage. 22(3):261-268.

Elton, C. 1949. Population interspersion: An essay on animal community patterns. J. Ecol. 37:1-23.

Errington, P. L. 1946. Predation and vertebrate populations. Quart. Rev. Biol. 21:141-177 and 221-245.

Flynn, A. and A.W. Franzmann. 1973. Seasonal variations in hair mineral levels of the Alaskan moose. Proc. Int. Symp. Trace Element Metabolism (TEMA 2), Madison, Wisconsin.

Franzmann, A. W. 1972. Environmental sources of variation of bighorn sheep physiologic values. J. Wildl. Manage. 36(3):924-932.

___________. and D. M. Hebert. 1971. Variation of rectal temperature in bighorn sheep. J. Wildl. Manage. 35(3):488-494.

___________. and E. T. Thorne. 1970. Physiologic values in bighorn sheep *(Ovis canadensis canadensis)* at capture, after handling and after captivity. J. Am. Vet. Med. Assn. 157(5):647-650.

Gartner, R. J. W., L. L. Callow, C. K. Grazien and P. Pepper. 1969. Variations in the concentration of blood constituents in relation to handling of cattle. Res. Vet. Sci. 10:7-12.

___________, J. W. Ryley and A. W. Beattie. 1965. The influence of degree of excitation on certain blood constituents in beef cattle. Austral. J. Exptl. Biol. Med. Sci. 43:713-724.

Geraci, J.R. and W. Medway. 1973. Simulated field blood studies in the bottle-nosed dolphin *(Tursiops truncatus)*. 2. Effects of stress on some hematologic and plasma chemical parameters. J. Wildl. Dis. 9(1):29-33.

Godwin, K. O. 1959. Skin, hair and nail in protein malnutrition. World Rev. Nutr. Diet. 3:107.

Greer, K.R. 1968. A compression method indicates fat content of elk (wapiti) femur marrows. J. Wildl. Manage. 32(4):747-751.

___________. 1969. Femur marrow reveals the condition of game animals. A contribution from Fed. Aid in Wildl. Rest. Montana Proj. W-83-R. Bozeman, Montana. January, 1969. 10 pp.

Hammer, D. J., J. Finklea, R. Hendricks, C. Shy, and R. Horton. 1971. Hair trace metal levels and environmental exposure. Am. J. Epidemiology 93:84.

Houston, D.B. 1968. The Shiras moose in Jackson Hole, Wyoming. Grand Teton Natur. History Assoc. Tech. Bull. 1. 110 p.

Johnson, D.C., P.D. Arneson and A.W. Franzmann. 1973. Behavior and survival in orphaned and nonorphaned moose calves. Final Rep. Job 1A-1.1. Fed. Aid in Wildl. Restoration. Alaska Dept. of Fish and Game.

Klevay, L. 1970a. Hair as a biopsy material, I. Assessment of zinc nutriture. Am. J. Clinical Nutr. 23:284.

___________. 1970b. Hair as a biopsy material II. Assessment of copper nutriture. Am. J. Clinical Nutr. 23:1194.

Kopito, L., R. Byers, and H. Shwachman. 1967. Lead in hair of children with chronic lead poisoning. New England J. Med. 276:949.

Lack, D. 1954. The natural regulation of animal numbers. Oxford Univ. Press. 343 p.

LeResche, R.E. 1968. Spring-fall calf mortality in an Alaskan moose population. J. Wildl. Manage. 32(4):953-966.

___________. 1970. Moose report: Annual Progress Rep. Fed. Aid in Wildl. Restoration. Alaska Dept. of Fish and Game.

___________. and J. L. Davis. 1971. Moose report. Annual Proj. Progress Rep. Fed. Aid in Wildl. Restoration. Alaska Dept. of Fish and Game.

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

__________, U. S. Seal, P. D. Karns and A. W. Franzmann. 1973. Blood chemistry and nutrition of moose. Proc. Int. Symp. Moose Ecology, Quebec.

Lewis, P., W. Hoekstra, and R. Grummer. 1957. Restricted calcium feeding versus zinc supplementation for the control of parakeratosis in swine. J. An. Sci. 16:578.

Lowry, O. H., N. J. Rosenbrough, A. L. Farr, and R. F. Randall. 1951. Protein measurement with the folin phenol reagent. J. Biol. Chem. 233:182.

Markgren, G. 1969. Reproduction of moose in Sweden. Swedish Wildl. (Viltrevy) 6(3):127-299.

Marston, H. R. 1955. Wool growth. *In* Progress in the physiology of farm animals, Vol. 2, p. 543, Butterworths, London.

Mech, L. D. 1966. The wolves of Isle Royale. Fauna Series 7. U.S. Dept. Interior. 210 pp.

Monie, J.B. 1973. Population estimates by quadrat sampling method. Proc. Interagency Moose Meeting, Kenai, Alaska.

Neiland, K.A. 1970. Weight of dried marrow as indicator of fat in caribou femurs. J. Wildl. Manage. 34(4):904-907.

Nicholson, A. J. 1954. An outline of the dynamics of animal populations. Aust. J. Zool. 2:9-65.

Peek, J.M. 1962. Studies of moose in the Gravelly and Snowcrest Mountains, Montana. J. Wildl. Manage. 26(4):360-365.

Pimlott, D.H. 1959. Reproduction and productivity of Newfoundland moose. J. Wildl. Manage. 23(4):381-401.

Rausch, R.A. 1959. Some aspects of the population dynamics of the rainbelt moose population, Alaska. M.S. Thesis, Univ. of Alaska. 71 pp.

__________, and A.E. Bratlie. 1965. Assessments of moose calf production and mortality in southcentral Alaska. An. Conf. W. Assoc. State Game and Fish Commissioners. 45:11.

__________, and R.H. Bishop. 1968. Report on 1966-67 moose studies. Annual Proj. Segment Rep. Fed. Aid in Wildl. Restoration. Vol. VIII and IX. Alaska Dep. Fish and Game. 263 pp.

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

Ryder, M. L. 1958. Nutritional factors influencing hair and wool growth. *In* The biology of hair growth, ed. Montagna, W. and R. A. Ellis, Academic press, N. Y. 305 pp.

Schroeder, H. and A. Nason. 1969. Trace elements in human hair. J. Investigative Dermatology. 53:71.

Seal, U. S., J. J. Ozoga, A. W. Erickson, and L. J. Verme. 1973. Effects of immobilization on blood analysis of white-tailed deer. J. Wildl. Manage. 36:(4):1034-1040.

Simkin, D.W. 1965. Reproduction and productivity of moose in northwestern Ontario. J. Wildl. Manage. 29(4):740-750.

Sims, R. T. 1968. The measurement of hair growth as an index of protein synthesis in malnutrition. Brit. J. Nutr. 22:229.

Slen, S. B. and F. Whiting. 1952. Wool production as affected by the level of protein in the ration of the mature ewe. J. An. Sci. 11:156.

Smith, C. R. and R. L. Hamlin. 1970. Regulation of the heart and blood vessels. Pages 169-195 In M. J. Swenson, ed. Dukes' physiology of domestic animals. Cornell Univ. Press, Ithaca and London.

Stevens, D.R. 1970. Winter ecology of moose in the Gallatin Mountains, Montana. J. Wildl. Manage. 34(1):37-46.

Strain, W., L. Steadman, C. Lankar, W. Berliner, and W. Pories. 1966. Analysis of zinc levels in hair for the diagonsis of zinc deficiency in man. J. Lab. Clinical Med. 68:244.

____________. and W.J. Pories, A. Flynn, and O. A. Hill, Jr. 1972. Trace element nutriture and metabolism through head hair analysis. *In* Trace substances in environmental health-V. Ed. by D. D. Hemphill, U. of Missouri, Columbia.

Tenney, S. M. 1970. Respiration in mammals. Pages 293-339 In M. J. Swenson, ed. Dukes' physiology of domestic animals. Cornell Univ. Press, Ithaca and London.

Verme, L.J. 1970. Some characteristics of captive Michigan moose. J. Mammal. 51(2):403-405.

Whanger, P. O., P. H. Weswig, O. H. Muth, and J. E. Oldfield. 1969. Tissue lactic dehydrogenase, glutamic-oxalacetic transaminase, and peroxidase changes of selenium defecient myopathic lambs. J. Nutr. 99:331-337.

Wynne-Edwards, V. C. 1965. Self-regulating systems in populations of animals. Science. 147(3665):1543-1548.

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JOB PROGRESS REPORT (RESEARCH)

State: Alaska

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

Project No: W-17-5 Project Title: Big Game Investigations

Job Number: 1.7R Job Title: Kenai Peninsula Moose Population Identity Study

Period Covered: July 1, 1972 through June 30, 1973

SUMMARY

One hundred and sixteen moose were tagged with individually identifiable collars during the reporting period: 43 outside the enclosures at the Kenai Moose Research Center, 12 in the Big Indian Creek drainage, 60 in the Tustumena Benchland-Lower Funny River Airstrip area and one miscellaneous tagging.

Nine hundred and eighty-three recoveries and resightings of tagged moose have been recorded since the inception of this project. Two hundred and seventy-nine observations of collared moose were made during the reporting period.

Most of the moose tagged during the rut in the Big Indian Creek area wintered above timberline in the same area but possibly moved to lower elevations to calve.

Moose rutting in the Lower Funny River Airstrip area and above timberline in the Tustumena Benchland area appear to be from separate populations. Resightings of tagged moose from the Lower Funny River group indicated that they wintered north of, or in the tagging area. Calving areas for the group have not been determined.

Eighty percent of resightings of the Tustumena Benchland group occurred above timberline indicating that most of the moose winter in the original tagging area. These moose migrated to lower elevations in April and May, but calving areas were not determined.

CONTENTS

BACKGROUND

The effects of snow on wild ungulate behavior were first studied by Formozov (1946) and Nasimovich (1955). Until now, most research has been concerned with how the physical properties of snow affect ungulate movements (Des Meules, 1964; Kelsall, 1969; Kelsall and Prescott, 1971; and Coady, 1973).

Snow depth is considered the most important factor for moose *(Alces alces)* (Coady, 1973), because migration from summer range to winter range is influenced, activity may be reduced, and food becomes less accessible as snow depth increases. Little mention has been made of moose pawing through the snow for food, as do elk *(Cervus canadensis)* (Murie, 1951), muskoxen *(Ovibos moschatus)* (Lent and Knutson, 1971 and Tener, 1965) and caribou *(Rangifer tarandus)* (Pruitt, 1959 and Henshaw, 1968). Des Meules (1964) stated, "Moose do not appear to have learned to use their feet to dig for food beneath or within the layer of snow.... On two instances only, we have seen evidence of moose nuzzling through 8 or 10 inches of soft snow to reach underlying browse."

The fact that moose are commonly observed cratering in one area and not in another is probably due to habitat and feeding habit differences between moose heards. Moose frequently crater or paw for food through the snow on the Kenai Peninsula. These moose often crater above timberline for dwarf willows *(Salix sp.)* in sedge meadows for *Carex* and in scattered mature hardwood stands in the 1947 Kenai Burn for lowbush cranberry *(Vaccinium vitis-ideae)*. LeReshe and Davis (1973) have stressed the importance of the nonbrowse lowbush cranberry in the winter diet of moose on the Kenai Peninsula. To our knowledge, nothing has been reported on the energy expended by moose digging craters versus the energy derived from the vegetation obtained.

OBJECTIVE

To evaluate the effects of snow conditions on moose feeding patterns and the related snow cratering activity of moose.

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 the objective.

PROCEDURES

Snow Monitoring and Cratering

Eight snow plots in Pens 1 and 2 were utilized. A plot is located in each of the following habitat types: dense hardwoods, thin hardwoods, sedge meadow, mature spruce, spruce regrowth, birch-spruce regrowth (thin), birch-spruce (dense) and spruce-ledum. At weekly intervals a trench was dug in each plot and the total depth, thickness and consistency of each snow layer was recorded. Depth of "sink" in snow of mans' foot was also measured. Presence of lowbush cranberry and other ground vegetation was recorded.

Cratering activity by moose was studied and evaluated by observing both adults and calves, inside and outside the Moose Research Center enclosures. Observations noted were; number of paws per crater, time spent pawing per crater, time spent feeding per crater, total time per crater, number of craters for a period of time and forage utilized in each crater.

FINDINGS

Snow Monitoring and Cratering

The first snowfall of winter 1972-73 occurred on November 25 with a depth of 18 cm. Subsequent major snowfalls occurred on December 30, (18 cm), January 27-30 (18 cm) and March 12-15 (10 cm). Maximum depth was 60 cm in mid-March but it decreased rapidly after that (Table 1). Ground vegetation was visible until the second major snowfall and became visible again in late March and early April. Snow cover was present for approximately 135 days.

Moose did not begin cratering until the second major snowfall. Until that time they nuzzled through the 15-18 cm of snow for ground vegetation. Cratering continued throughout the winter until nonbrowse plants again became visible; however, there appeared to be less activity toward the end of winter.

Emphasis on cratering activity studies this past winter was placed on effort and time expended cratering versus time spent at other activities. Tables 2 and 3 list the cratering activities of calves and adult cows, observed during daylight hours outside and inside the enclosures at the MRC. Much variation was noted in cratering efforts by both calves and adults. An enclosed adult cow and her calf dug 85 consecutive craters before browsing again in a maximum of 15 hours. The following day the same cow dug 12 craters in 40 minutes while her calf dug 35 craters in one hour and 45 minutes. Another cow dug 32 consecutive craters before browsing while her calf dug 20 craters. This is a greater cratering effort than the outside cow and calf near the cabin expended (Table 29). They were observed digging 7 and 25 craters, respectively, over an extended period. While observing several calves, Johnson et al. (1973) noted that 40 percent of their foraging time was spent cratering (20.5 hours cratering and 30.8 hours browsing), while the calf observed near

Table 1. Snow depth (cm) in each of eight habitat types, Kenai Moose Research Center, winter 1972-73.

	1972					1973														
Habitat type	11/30	12/7	12/13	12/20	12/28	1/3	1/10	1/17	1/26	1/31	2/7	2/14	2/21	2/28	3/7	3/15	3/21	3/28	4/4	4/11
Dense Hardwoods	13	11	11.5	12.5	12	27	25	23	24	36	34	35	32	34	33	40	36	25	19*	0
Thin Hardwoods	16.5*	15*	15*	16*	16*	33	34	28	29	46	44	48	48	47	47	53	49	38	24*	12*
Sedge	17**	16**	16**	18**	18**	34	34	32	36	48	46	47	45	43	45	53	50	36	22**	Tr**
Spruce Regrowth	16*	15*	15*	19*	18*	35	34	32	35	52	51	49	48	45	48	53	44	39*	26*	Tr*
Birch-Spruce Thin	17*	15*	16*	16*	16*	37	35	32	36	49	46	45	45	45	47	50	52	38*	30*	Tr*
Birch-Spruce Dense	14.5*	13*	15*	17*	16*	31	34	30	34	46	49	48	47	47	47	55	48	35*	24*	0
Spruce-*Ledum*	16***	16***	15***	16.5***	17***	34	34	31	34	51	50	50	49	50	51	60	57	40	23*	Tr*
Mature Spruce	10.5	10	12	10	10	26	24	20	23	32	32	32	24	23	26	31	27	23	17*	0

* *Vaccinium vitis-ideae* visible.
***Carex* sp. visible.
****Ledum* sp. visible.

Table 2. Winter activities of an outside calf and adult cow moose, Kenai Moose Research Center, 1973.

Date	Sex/Age	Total Time Observed Hrs. Mins.	% of Time Spent Cratering	No. of New Craters Dug	No. of Old Craters Reused	% of Time Spent Browsing	% of Time Spent Resting	% of Time Spent Misc.*
Feb. 14, 1973	Male calf**	4:00	15.4	3	0	29.2	54.6	0.8
Feb. 15, 1973	Male calf	4:05	11.1	3	0	19.6	69.4	0
Feb. 16, 1973	Male calf	8:15	10.7	5	1	32.6	53.1	3.7
Feb. 20, 1973	Male calf	2:26	24.6	2	0	31.5	43.1	0.7
Feb. 21, 1973	Male calf	9:48	20.4	9	14	27.6	42.9	9.2
Feb. 22, 1973	Male calf	9:40	2.2	1	1	44.4	48.1	5.3
Feb. 23, 1973	Male calf	7:15	6.0	2	0	12.6	70.4	11.0
Total/Mean	Male calf	45:59	11.4	25	16	29.3	53.7	5.7
Feb. 15, 1973	Female adult	4:05	14.6	5	0	8.2	69.0	8.2
Feb. 23, 1973	Female adult	7:49	9.6	2	0	21.1	66.6	2.8
Total/Mean	Female adult	11:54	11.3	7	0	16.7	67.4	4.6

* Walking, staring, listening, urinating, defecating, etc.

** Calf died February 27, 1973.

Table 3. Cratering effort by adult and calf moose at Kenai Moose Research Center, winter, 1973.

Sex/Age	No. of Craters Dug	Paws per Crater Mean	Paws per Crater Range	Time in Crater (min.) Mean	Time in Crater (min.) Range
Male calf	18	82	5-208	11.5	1-31
Female calf	7	-	-	6.6	2-14
Female adult	3	31	10-55	19.7	14-24
Female adult (R70-7)	6	-	-	8.8	1-19

the cabin spent 38 percent of its foraging time cratering. Despite the individual variation in effort, cratering for nonbrowse vegetation is an important aspect of winter foraging by moose in the 1947 Kenai Burn.

During the "severe" winter of 1971-72, there was a 100 percent calf loss at the MRC plus several adult winter mortalities. The maximum snow depth that winter was 67 cm, but depths of 60 cm or less were present during most of the winter (LeResche et al., 1973).

Movements of moose are not greatly impeded by 60 cm of snow (Nasimovich, 1955 and Kelsall, 1969), but depths at which cratering for ground vegetation is impeded is not known. Depths this past winter (1972-73) at the MRC reached a maximum of 60 cm, but persisted from 45-55 cm throughout the middle of winter. There was also a 100 percent calf mortality this past winter within the pens and apparently a comparable mortality in the vicinity of the enclosures. Flights were made in late February in the 1947 Kenai Burn near the MRC and several dead or weak calves were found. Assuming snow hardness to be relatively similar for the past two winters (hardness was not measured), it appeared that 50-60 cm of snow was detrimental to calves foraging for nonbrowse ground vegetation and 60 cm or more was detrimental to adults. Pawing through depths of these magnitudes possibly took more energy than that obtained from the vegetation. With this energy loss, the animals weakened or died if adequate vegetation was not reached either by migration or as a result of weather change which decreased snow depths.

The male calf, observed near the MRC headquarters outside the enclosures, died of malnutrition/starvation two weeks after observations began. During that period he spent over 40 percent of the daytime observation time foraging (11.4 percent cratering). He appeared to be getting sufficient quantities of food until the last two days. Whether the cause of death was a negative energy relationship or poor quality vegetation or both is not known.

Density and hardness of the snow did not appear to be critical factors during either of the past two winters. Man was able to penetrate all but a few centimeters of snow both winters at all snow plot sites by placing his weight on one foot and placing it on undisturbed snow. Moose, with foot loads much greater than man, penetrated the snow easily and were not hindered by hard crusts when cratering. The granular layer of snow nearest the ground surface increased in thickness as winter progressed and may have caused more caving in of the craters, requiring more effort by the moose to get at the ground vegetation. Extreme efforts of 208 paws per crater (Table 3) may be a result of this type of snow condition. In several craters no vegetation was reached either due to a lack of plant availability beneath the snow or so much caving in that the moose stopped pawing. Some moose frequently "nosed" the snow before starting to crater, possibly detecting the presence of suitable vegetation by olfaction.

RECOMMENDATIONS

1. Additional observations of moose cratering activity are required to substantiate the preliminary conclusion of a negetive energy balance situation.

2. Continual monitoring of snow conditions at MRC is required to support current productiviey and behavioral studies.

LITERATURE CITED

Coady, J. W. 1973. Influence of snow on behavior of moose. Proc. Int. Symp. Moose Ecology. Quebec. (In press).

Des Meules, P. 1964. The influence of snow on the behaviour of moose. Ministere du Tourisma, de la chasse et de la peche, Quebec. Papport No. 3:51-73.

Formozov, A. N. 1946. Snow cover as an integral factor of the environment and its importance in the ecology of mammals and birds. Moscow. Boreal Institute, Univ. Alberta, Edmonton, Occ. Publ. No. 1. 176 pp.

Henshaw, J. 1968. The activities of wintering caribou in northwestern Alaska in relation to weather and snow conditions. Int. J. Biometeor. 12(1):21-27.

Johnson, D. C., P. D. Arneson, and A. W. Franzmann. 1973. Behavior and survival in orphaned and nonorphaned moose calves. Final Rep. Job 1A 1.1. Fed. Aid in Wildl. Restoration. Alaska Dept. of Fish and Game.

Kelsall, J. P. 1969. Structural adaptations of moose and deer for snow. J. Mammal. 50(2):302-310.

________. and W. Prescott. 1971. Moose and deer behaviour in snow in Fundy National Park, New Brunswick. Can. Wildl. Ser. Rep. Series 15. 25 pp.

Lent, P. C. and D. Knutson. 1971. Muskox and snow cover on Nunivak Island, Alaska. Proc. Snow and Fire in Relation to Wildlife and Recreation Symposium. Iowa State Univ., Ames. p. 50-62.

LeResche, R.E., Franzmann, A.W. and P.D. Arneson. 1973. Moose Research Center Report. Annual Proj. Progress. Rep. Fed. Aid in Wildl. Restoration. Alaska Dept. Fish and Game.

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

Murie, O. J. 1951. The elk of North America. Wildlife Management Institute, Washington, D.C. 376 pp.

Nasimovich, A. A. 1955. The role of the regime of snow cover in the life of ungulates on the USSR. Moskva, Akad. Nauk SSSR. 103 pp. Translated from Russian by Can. Wildl. Serv., Ottawa.

Pruitt, W. O. Jr. 1959. Snow as a factor in the winter ecology of the barren ground caribou *(Rangifer arcticus)*. Arctic 12(3):159-179.

Tener, J. S. 1965. Muskoxen in Canada, a biological and taxonomic review. Queen's Printer, Ottawa. 166 pp.

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JOB PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperators: Albert W. Franzmann and Paul D. Arneson

Project No.: W-17-5 Project Title: Big Game Investigations

Job No.: 1.6R Job Title: Evaluation and Testing of Techniques to Moose Management

Period Covered: July 1, 1972 through June 30, 1973

SUMMARY

Telemetric tracking utilizing radio-transmitters in the 30 megahertz (mhz) range was used to locate individual moose with good success. All transmitters operated but some produced better signals than others. Biotelemetry procedures were investigated and components were purchased to construct equipment for this purpose.

Immobilizing drugs (Rompun and CI-774) were investigated but their usefulness to obtain physiologic data was limited due to the prolonged recovery time associated with use of these drugs. Succinylcholine chloride (Anectine) continued to be the drug utilized for free-ranging moose and M-99 (Etorphine) was preferred for captive moose. The dosages of each varied with season of use and condition of moose.

Pellet-group counting of 160 plots in Pen 1 with known numbers of moose over a two-year period provided data to indicate that during the winter of 1972-73 moose deposited 26.6 pellet groups/day, and in the winter of 1971-72, 28.4 pellet groups/day. This appears to be high and may reflect inadequate pellet group sampling procedures. The similarity of pellet groups per day for the two winters when pellet groups were aged at sampling indicates that the aging technique for winter moose pellets from one year to the next may be valid. An attempt to age summer group pellets was not valid.

Habitat selection by moose based upon pellet groups per habitat type demonstrated an affinity of moose for birch regrowth areas (65.8 percent of groups in 1971-72 and 66.3 percent of groups in 1972-73 were in birch regrowth areas). Spruce regrowth areas for the winters of 1971-72 and 1972-73 contained 14.8 and 9.6 percent of the pellet groups, respectively.

Rumen sampling with a stomach pump was more desirable than by the rumen trocar technique for recumbent immobilized moose.

A freeze branding technique utilizing Freon gas in pressurized cans was tested with variable success. Full evaluation of a resulting brand was not possible due to timing of this report.

In June, 1972, 81 percent of known moose within the enclosures were observed by helicopter census with 196 minutes of observation time. In June, 1973, 95 percent of moose were observed with 238 minutes of helicopter time.

Little difference in overall trapping success was noted between outside and inside traps, although there was much variability between traps. Differences in trapping success between pens are likely a function of density. When seasonal variations were considered trapping success differences between outside and inside traps was noticeable. Trapping success outside was highest during December and January and success inside was highest during the summer and early fall. Salting of traps to attract moose was effective in late spring and early summer for inside moose.

An orphaned moose calf hand-raised in 1972 began to gain weight and overcame her digestive problems once she was free to browse. Her weight at over one month of age was equivalent to the one-week weight (23.6 kg) of a nonorphaned calf nursing the cow.

CONTENTS

BACKGROUND

The Kenai Moose Research Center (MRC), with known numbers and composition of moose *(Alces alces)* and several tame moose for research, is an ideal facility for developing and testing techniques. Developments in many fields that produce drugs, equipment and procedures potentially applicable to moose management determine the thrust of activity under this job objective. Outlined techniques to be tested were; telemetric tracking, telemetric monitoring of physiologic parameters, use of immobilizing drugs, pellet group counting, rumen trocar, marking, and evaluation of aerial censusing. LeResche and Davis (1971) reported preliminary investigations in these areas and this report provides an appraisal of continuing studies.

Telemetric tracking has many potential applications as demonstrated in Will and Patric'c (1972) bibliography on wildlife telemetry which lists over 450 references and 184 active projects utilizing telemetry. The use of telemetry in moose studies has been utilized at the MRC as outlined by LeResche and Davis (1971). Other moose studies utilizing telemetry include those published by Van Ballenberghe and Peek (1971) and Berg and Phillips (1972) and current studies in interior Alaska by John Coady (ADF&G).

The potential of utilizing telemetric monitoring of physiologic parameters (biotelemetry), such as body temperature and heart rate to study estrus in female moose and excitability and stress from diverse activities, is unlimited as demonstrated by the space program. Unfortunately the gap between expertise available for the space program and wildlife physiologic monitoring is large and primarily economically based. The expertise and equipment are available that will provide the information, and much research in wildlife biotelemetry has been accomplished (Boyd et al., 1967; Slater, 1963; Downhower and Pauley, 1970; Folk, 1968; Houseknecht, 1970; Ko and Neuman, 1967; Lonsdale etal., 1971; Lord et al., 1962; MacKay, 1968; McGinnis and Southworth, 1967; McGinnis et al., 1970; Ostbye, 1970; and Riley, 1971). We are not aware of any biotelemetry studies of moose accomplished or underway at this time.

LeResche and Davis (1971) outlined the qualities of an ideal immobilizing drug and as new drugs are developed, their application to moose should be be tested. Other techniques that may prove applicable to moose such as the pellet-count census, rumen sampling, marking, and aerial censusing should also be tested.

A review of pellet-group techniques is provided by Neff (1968).

Rumen sampling from elk *(Cervus canadensis)* and deer *(Odocoileus sp.)* utilizing a rumen trocar technique was reported by Follis and Spillett (1972). Rumen sampling utilizing a stomach tube and pump is a procedure regularly utilized in the practice of veterinary medicine. A method to obtain rumen liquor for *in-vitro* digestion trials in an efficient and effective manner without sacrifice of the individual was required.

Aerial censusing techniques were successfully tested at the MRC (LeResche and Rausch, in press) as a result of having known numbers of moose at the Center. With known sex and age composition at the MRC it is also an ideal situation to test observers' abilities at aerial composition counts. Rausch and Bratlie (1965) outlined procedures to assess the dynamics of moose populations, and sex and age composition counts are an integral part of the procedure. Most agencies involved in moose management depend upon sex and age composition counts to evaluate the status of moose populations, and several studies have incorporated composition counts (Edwards and Ritcey, 1958; Simkin, 1965; Pimlott, 1959; Houston, 1968; Peek, 1962; and Stevens, 1970. The testing of observers' accuracy in composition counts has not been tested and efforts to accomplish this have been initiated at the MRC.

OBJECTIVES

To test and evaluate techniques that are potentially useful for determinining population status, movements and other factors necessary for management of moose.

PROCEDURES

Telemetric Tracking

The radio-transmitters in the 30 megahertz (mhz) range that were utilized by LeResche and Davis (1971) were used to facilitate behavioral studies of cow/calf relationships (Johnson et al., 1973). These transmitters were equipped with new batteries and incorporated into 13 new collars coded by color. Six of the collars were designed to fit calves and 7 were made for cows.

Biotelemetry

Investigations into equipment, procedure and application of biotelemetry equipment were accomplished with the assistance of Charles Irvine, Alaska Department of Fish and Game. Components and equipment necessary to initiate biotelemetry studies were purchased.

Immobilizing Drugs

New drugs tested at the MRC this period were a commercially available drug Rompun (Chamagva) and an experimental drug CI-774 (Parke-Davis). Succinycholine choride (Anectine, Burroughs Wellcome and Co.), an immobilizer extensively used in moose (Bergerud et al., 1964; LeResche, 1970; LeResche and Davis, 1971; and Houston, 1969), was the principle immobilizer used and tested during this report period (274 moose were immobilized with Anectine). M-99 Etorphine (American Cyanamid) was tested on 33 moose within the enclosures.

Pellet-Count Census

Pellet-count census technique testing intitiated by LeResche and Davis (1971) was continued. One hundred and sixty plots in Pen 1 were counted and cleared in May 1973. Total moose days were established for Pen 1 and the area represented by the sample was established.

Rumen Sampling

Rumen sampling to obtain rumen liquor for *in-vitro* digestion trials was done by the rumen trocar and stomach pump methods.

Marking Techniques

Marking moose for identification is a continuing area of investigation. Color-coded collars, described by LeResche and Davis (1971), were utilized on moose outside the MRC enclosures for the Kenai moose population identity study. New collars designed by Jim Davis, Alaska Department of Fish and Game, were ordered as the supply of color-coded collars was depleted. The new collars are a color-code and number combination. Marking by freeze-branding was attempted using a new technique employing pressurized Freon gas.

FINDINGS

Telemetric Tracking

The 30 mhz radio-transmitters utilized from November through April functioned with no major failures; however, some radios worked better than others. Two multi-frequency receivers were utilized with the major problem being related to antenna wire connections. For this particular study the telemetric tracking equipment performed satisfactorily and the equipment will be utilized for further studies requiring the location of specific animals.

New lithium batteries were purchased to test claims of longevity with smaller size. A transmitter powered by lithium batteries was placed on our semi-tame moose, Wally, Jr., but a failure of yet an undetermined nature necessitated removing the transmitter. Further testing of lithium batteries will be continued.

Biotelemetry

It was determined that long range biotelemetry could be accomplished by utilizing a receiver-transmitter attached to a collar that could relay the impulses from a miniature implanted receiver. This procedure could provide the temperature data required to monitor estrus, excitability and stress.

No biotelemetric application has been installed or tested to date.

Immobilizing Drugs

Investigations of drugs utilized daily to immobilize moose continued and new drugs were tested and evaluated as they became available.

CI-744 (Parke-Davis): This unnamed, experimental, multispecies, parenteral, anesthetic agent was used to immobilize 14 Alaskan moose with variable results (Table 1). CI-744 is a 1:1 combination of two ingredients: tiletamine hydrochloride (CI-634), a central nervous system (CNS) depressant which produces profound analgesia and cataleptoid anethesia, and a diazepionone (CI-716) which is a non-phenothiazine derivative tranquilizer.

The uncertainty associated with establishing dosages for the Alaskan moose may be responsible for much of the variability. Initially dosages on the conservative side of those recommended for the bovine were used. The problems encountered with this low dosage were confounded by the extremely poor condition of the animals. As the condition of the animals improved, dosages were increased and somewhat better response was noted in the animals that went down. A high proportion of animals did not go down. Some of these may not have received the full dose from the 10 cc "Cap-Chur" syringe. The three animals which did not respond in July were not given supplemental doses since they were "heating up" due to high ambient temperature, and stress from trapping and our presence.

There were several problems which necessitated terminating use of this drug. The first was the long period of ataxia experienced by animals during recovery, which required spending much time with the animal through the recovery phase. We also had problems concentrating the drugs sufficiently to incorporate an immobilizing dose in a 10 cc "Cap-Chur" syringe. A renewed attempt to evaluate this drug will be made when the moose are in prime condition and when the volume of drug required can be reduced.

Rompun (Chemagro): This product, available for some time on an experimental basis, is now marketed in the United States by Chemagro, Division of Baychem Corporation, Kansas City, Missouri. Rompun is an analgesic,

Table 1. Results of Immobilization of Alaskan Moose at MRC With CI-744.

Animal No.	Month	Total Dose Mg	Weight Kg	Dose per Mg	Number of Injections	Induction Time Min.	Time Immobilized Min.	Return to Normal Min.
134	March	500	164	3.1	1	1	49	99
63	March	1300	443*	2.9	3	35	18	68
64	April	1000	282	3.5	1	0.5	91	219
65	April	1100	296*	3.7	4	42	87	342
66	April	800	327	2.4	1	4	Animal died from injury	
67	April	1450	300*	4.8	2	20	103	328
43	April	2400	409*	2.9	2	Did not go down		
Wally	April	1130	214	5.3	3	26	15	89
78	June	1200	387*	3.1	2	2	22	104
75	July	1000	296*	3.4	1	Did not go down		
670	July	1000	273*	3.6	1	Did not go down		
12	July	1100	319*	3.4	1	Did not go down		
35	July	2200	443*	4.9	3	35	Had to hold down	
Raquel	August	1600	395	4.0	1	7	46	99

* Estimated weight

central nervous system depressant and a muscle relaxant. The drug has proven to be effective and reliable in the Bovidae and larger Camilidae (Hime and Jones, 1970).

Sedation and analgesia were produced in moose using dosages of 2.2 mg/kg body weight. The usefulness of this drug is limited for most moose processing applications at the MRC due to the prolonged period of ataxia experienced during recovery (up to 2 hours). Additional use will be made of the drug to further test its applicability.

M-99 (Etorphine) and M 50-50 (Diprenorphine): As outlined by LeResche (1970), M-99 incorporates most of the desirable qualities of an immobilizing drug for moose. It has the added benefit of an available and effective antagonist (M 50-50).

The dosage used by Houston (1970) on Shiras moose *(Alces alces shirasii)* was 3 to 5 mg. (0.4 + 0.7 mg/100 pounds) for adults, 3 to 4 mg. (0.6 to 0.8 mg./100 pounds) for yearlings and 1 to 2 mg. (0.4 to 0.7 mg./100 pounds) for calves. LeResche (1970) noted that the dosage varied by season and LeResche and Davis (1971) established ranges of doses from 4 to 5 mg. for 700 to 800 pound cows in the spring (0.6 mg./100 pounds) to 6 to 9 mg. for 900 to 980 pound cows in the fall (0.8 mg./100 pounds).

During this report period, 33 moose were immobilized using M-99 with M 50-50 as the antagonist. The dosages were higher on a weight basis than those reported by Houston (1970), and the doses for cows on a weight basis were similar to those reported by LeResche and Davis (1971). Results are summarized in Tables 2, 3 and 4.

Doses of M-99 for both adult and yearling moose were similar (0.72 mg./100 pounds) while moose calf doses were higher by unit of weight (0.9 mg./100 pounds).

Succinylcholine chloride (Anectine - Burroughs Wellcome and Co., Inc.): This drug continues to be the most used for the reasons enumerated by LeResche and Davis (1971). Tables 5, 6 and 7 list the dosages used in concentrations of 10 mg/cc with and without the enzyme hyaluronidase (Wydase - Wyeth Laboratories, Inc.). Nine N.F. units of Wydase were used per milligram of Anectine. During the period January 1, 1972 to June 30, 1973 a total of 194 moose were immobilized with Anectine at the MRC. In October, 1972, 80 free-ranging moose were immobilized via helicopter on the Kenai Peninsula. Four moose (2 percent) died at the MRC and eight moose (10 percent) died during helicopter tagging, all when Wydase was used.

Induction times were over a minute greater for moose trapped outside the MRC than those inside. Possible reasons for this are that outside moose were in better condition and unaccustomed to trapping, thereby more excited. Immobilization times were about the same for inside and outside moose with means varying from 21 to 32 minutes. The percent of moose immobilized was somewhat higher for outside moose than for inside, possibly due to higher dosages normally used on the outside, yet no outside

Table 2. Results of immobilization of adult moose at MRC with M-99 and M 50-50

Animal No.	Sex	Month	Total Dose mg	Weight Pounds	Dose mg /100#	Induction Time Minutes	Time Immobilized Minutes	Reversal Time (min) M 50-50
Raquel	F	Nov.	5	820	.60	14	36	0.5
5370	M	Nov.	5	750*	.66	19	44	1
Raquel	F	Nov.	5	820	.60	6	32	1
Raquel	F	Dec.	7	845	.82	7	32	2
45	M	Dec.	7	865	.80	5	31	1
Raquel	F	Jan.	7	850*	.81	7	26	2
**65	M	Feb.	7	630	1.10	1	91	10
87	F	Feb.	6	800*	.75	5	40	1
***53	M	Feb.	6.5 + 3.0	725*	1.30	34	63	1
91	F	Feb.	6.5	800*	.81	20	58	1
Raquel	F	Feb.	7	850*	.82	17	49	1
53	M	Mar.	7	700	.71	8	33	2
91	F	Mar.	7	750*	.93	9	29	1.5
84	F	Mar.	7	725*	.96	5	20	1
176	F	Mar.	7	800*	.87	13	94	4
177	F	Mar.	7	750*	.93	9	50	2
Raquel	F	Mar.	7	980	.72	8	35	10
Raquel	F	Apr.	7	980*	.72	8	28	2
52	F	Apr.	7	850*	.82	13	14	Got up without M 50-50
72	F	June	7	750*	.93	9	33	1
37	F	June	7	800*	.87	10	19	1
10	F	June	7	750*	.93	6	25	6
36	M	June	8	825*	.96	13	22	2
27	F	June	7	750*	.93	8	37	1
Mean			7	810	.82	10	35.8	2.1

* Estimated weight
** Animal died about 2 hours later (was in extremely poor condition)
*** Supplemental dose given. Assume first dose not complete
Neither ** or *** are calculated into range or mean values

Table 3. Results of immobilization of a yearling male moose at MRC with M-99 and M 50-50

Animal No.	Month	Total Dose mg	Weight Pounds	Dose mg/100#	Induction Time Minutes	Time Immobilized Minutes	Reversal Time (min) M 50-50
Wally	Nov.	5	600	.83	14	36	0.5
Wally	Nov.	5	600	.83	6	24	1
Wally	Dec	5	655	.76	5	47	1.5
Wally	Feb.	6	705	.85	6	44	2.0
Wally	Mar.	6	750*	.80	6	34	0.5
Wally	Apr.	6	750*	.80	6	20	0.5
Mean			676.7	.82	7.2	34.2	1.0

* Estimated weight

Table 4. Results of immobilization of moose calves at MRC with M-99 and M 50-50

Animal No.	Sex	Month	Total Dose mg	Weight Pounds	Dose mg/100#	Induction Time Minutes	Time Immobilized Minutes	Reversal Time (min) M 50-50
92	F	Nov.	3	365	.82	8	39	1.5
96	M	Dec.	3	320	.93	10	31	1.0
97	M	Jan.	3	325*	.92	7	18	1.0
Mean				336.7	.89	11.7	29.3	1.2

* Estimated weight

Table 5. Effects of Succinylcholine Chloride (Anectine) and Hyaluronidase (Wydase) administered to trapped moose within the Kenai Moose Research Center enclosures. January 1, 1972 to June 30, 1973. (Sample size in parenthesis.)

	Mean Induction Time (minutes)				Mean Time Immobilized (minutes)			
	Anectine		Anectine & Wydase		Anectine		Anectine & Wydase	
Dose Milligrams	Male	Female	Male	Female	Male	Female	Male	Female
13	0	8(1)	0	6(1)	0	10(1)	0	14(1)
13.5	7.5(3)	10.6(23)	2.5(1)	8.3(13)	41.5(3)	20.4(23)	22(1)	34.4(12)
14	9.1(7)	8.9(9)	4.5(1)	5.2(5)	9.1(7)	18.6(9)	14(1)	20(5)
15	9.7(3)	9(1)	0	6(1)	15.7(3)	25(1)	0	17(1)
15.5	0	10.5(2)	8(1)	0	0	16.5(2)	27(1)	0
16	9(2)	0	6(1)	0	26(2)	0	21(1)	0
17	6.3(3)	0	0	0	19.3(3)	0	0	0
17.5	0	0	0	9(1)	0	0	0	21(1)
18	7(1)	7.8(2)	5.4(4)	9.4(7)	?	21.5(2)	79(1)	31.5(4)
18.5	0	0	8(1)	0	0	0	39(1)	0
19	6.5(2)	7.2(6)	6.5(2)	8.1(8)	38.5(2)	30.3(6)	15(1)	40.5(4)
20	7(1)	11.3(4)	3.8(3)	4.3(4)	30(1)	22.9(4)	32.3(2)	34(4)
21	0	0	7.0(3)	6.5(3)	0	0	28(2)	26(3)
21.5	0	0	4(1)	0	0	0	44(1)	0
Total Mean	8.2(22)	8.2(48)	4.8(18)	7.5(43)	25.1(21)	20.9(48)	31.0(12)	28.4(35)

Table 6. Effects of Succinylcholine Chloride (Anectine) and Hyaluronidase (Wydase) administered to trapped moose outside the Kenai Moose Research Center enclosures. January 1, 1972 to June 30, 1973. (Sample sizes in parenthesis.)

Dose Milligrams of Anectine	Mean Induction Time (minutes)				Mean Immobilized Time (minutes)			
	Anectine		Anectine & Wydase		Anectine		Anectine & Wydase	
	Male	Female	Male	Female	Male	Female	Male	Female
12.5	0	12(1)	0	0	0	34(1)	0	0
13	0	12.8(5)	0	0	0	22.4(5)	0	0
13.5	10(1)	13.3(3)	0	15(1)	37(1)	12.3(3)	0	23(1)
14	19(1)	11.5(2)	0	3(1)	25(1)	27(2)	0	12(1)
15.5	0	0	0	9(2)	0	0	0	14.5(2)
16	0	11(1)	0	0	0	14(1)	0	0
18	5(1)	6(4)	3(1)	6.9(9)	32(1)	21.8(3)	30(1)	30.1(9)
19	6(1)	0	6(1)	6.0(14)	35(1)	0	27(1)	31.6(13)
20	0	8.5(2)	8(1)	6.1(11)	0	30.5(2)	9(1)	25.8(11)
Total Mean	7.5(4)	9.7(18)	5.7(3)	6.4(38)	32.3(4)	26.1(17)	22(3)	24.7(37)

Table 7. Effects of Succinylcholine Chloride (Anectine) and Hyaluronidase (Wydase) administered to free-ranging moose on the Kenai Peninsula October, 1972. (Sample sizes in parenthesis.)

Anectine with Wydase (mg of Anectine)	Mean Induction Time (Min.)		Mean Time Immobilized (min.)	
	Male	Female	Male	Female
20	9.2(22)	8.9(18)	24.8(6)	26.5(2)
21	9.3(4)	8.7(20)	43.5(2)	18.5(4)
22.5	13.5(2)	5.7(3)	23(2)	Unk.
Total Mean	9.5(28)	8.6(41)	28.2(10)	21.1(6)

mortalities were experienced.

Causes for moose not becoming immobilized varied. Seasonal differences were obvious in that late winter and spring moose in poorer condition went down easily. Of the four moose mortalities experienced with Anectine immobilization, one died in February, two in April and one the first part of June. Bulls appeared more susceptible to problems with the drug in the spring, and smaller doses were given to them than to cows. After mid-June, doses were gradually increased again. Fall moose in prime condition were more difficult to immobilize. Layers of fat in the rump region may have prevented the drug from getting into the bloodstream as readily, consequently the animal would not respond. There did not appear to be serious problems when drugging rutting bulls as reported by LeResche and Davis (1971). All the free-ranging moose (see Tables 7 and 8) were darted in October and bulls were immobilized more easily and experienced lower mortality than cows.

The site of injection also played a role in whether the moose became immobilized. Attempts were made to hit the moose in the rump region, but when bad hits (abdomen, thoracic cavity, low on leg) occurred moose usually did not go down. Darts bouncing off and substantial bleeding from the dart would also reduce chances of immobilization. Individual moose variation in susceptability to the drug must also be considered. It appeared that some moose responded well to the drug each time they were darted and others under like conditions did not respond at all.

Wydase decreased induction time 9 to 41 percent and increased the percent of moose immobilized, but immobilization times were not altered significantly. Although mortality rates are higher with Wydase, it is useful when time must be saved as in helicopter tagging.

Manual artificial respiration was administered to eight moose at the MRC. Four of these later died. A mobile artificial resuscitator may help reduce these mortalities.

<u>Pellet-count Census</u>

Table 9 summarizes counts of pellet groups deposited in 160, 17.9 m^2 plots (192 square feet) in Pen 1. These were counted on May 10, 11, 14 and 18, 1973.

The plots were cleared in June, 1971 (LeResche and Davis, 1971) and all groups were deposited between June, 1971 and May, 1973. The plots were not read in 1972. Separation of past year from present year groups was attempted on the basis of leaf and duff cover over pellet-groups, deterioration of pellet-groups and color and texture of these groups. Summer and winter groups were separated on basis of form. A fecal group made up of distinguishable pellets was classified winter and a soft or non-pelleted fecal deposit was classified as summer.

Moose days were calculated for the winters of 1971-72 and 1972-73 based upon a 210-day (November 1 to June 1) winter period and known numbers of moose present (Table 10). The sample plots constitute 0.145 percent of the area utilized. Spruce-*ledum*, grass, sedge and water areas were discounted for winter pellet groups as they are primarily summer

Table 8. Effects of Succinylcholine Chloride (Anectine) and Hyaluronidase (Wydase) on moose.

	Percentage Immobilized Moose Darted				Percentage Killed of Moose Immobilized			
	Anectine		Anectine & Wydase		Anectine		Anectine & Wydase	
	Male	Female	Male	Female	Male	Female	Male	Female
Trapped Inside MRC	63 (22 of 35)	68 (48 of 71)	67 (18 of 27)	74 (43 of 58)	0 (0 of 22)	0 (0 of 48)	11 (2 of 18)	5 (2 of 43)
Trapped Outside MRC	80 (4 of 5)	67 (18 of 27)	75 (3 of 4)	81 (38 of 47)	0 (0 of 4)	0 (0 of 18)	0 (0 of 3)	0 (0 of 38)
Free-ranging - Kenai Peninsula	-	-	65 (35 of 54)	55 (45 of 82)	-	-	6 (2 of 35)	13 (6 of 45)

Table 9. Pellet groups deposited from June, 1971 to May, 1973 on 160 plots by habitat type in Pen 1, Kenai Moose Research Center.

Habitat Type	Number of Plots	1971-72 Winter Pellet Groups/Plot							1971 Summer Groups/Type		1972-73 Winter Pellet Groups/Plot							1972 Summer Groups/Type	
		0	1	2	3	4	Tot	% of Tot	Tot	% of Tot	0	1	2	3	4	Tot	% of Tot	Tot	% of Tot
Dense birch-spruce regrowth	25	7	9	6	3	0	30	27.8	3	27.3	8	14	1	1	1	23	27.7	6	27.3
Medium birch-spruce regrowth	26	9	11	6	0	0	23	21.3	1	9.1	13	7	5	0	0	20	24.1	3	13.6
Thin birch-spruce regrowth	25	11	10	4	0	0	18	16.7	2	18.1	14	10	1	0	0	12	14.5	5	22.7
Spruce birch regrowth	24	14	8	2	0	0	12	11.1	3	27.3	20	4	0	0	0	4	4.8	3	13.6
Spruce regrowth	20	17	2	1	0	0	4	3.7	1	9.1	17	2	1	0	0	4	4.8	4	18.2
Dense mature hardwood	20	14	6	0	0	0	6	5.6	1	9.1	14	6	0	0	0	6	7.2	1	4.6
Thin mature hardwood	20	12	3	3	2	0	15	13.8	0	0.0	11	6	2	0	1	14	16.9	0	0.0
Total	160	85	49	22	5	0	108	100.0	11	100.0	96	49	10	2	22	83	100.0	22	100.0

Table 11. Area measure of habitat types in Pen 1 at Kenai Moose Research Center.

Vegetation Type	Acreage	Hectares
Dense birch-spruce regrowth	113	45.7
Medium birch-spruce regrowth	95	38.4
Thin birch-spruce regrowth	69	27.9
Spruce-birch regrowth	89	36.0
Dense mature hardwood	54	21.9
Thin mature hardwood	46	18.6
Spruce-Ledum	35	14.2
Grass	9	2.0
Sedge	28	11.3
Water	35	14.2
Total	594	240.4

use areas. Table 11 provides area measurements of habitat types in Pen 1 from which area utilized was extracted.

From known total winter pellet-groups deposited for each winter (Table 9), total moose days (Table 10) and area represented by sample (Table 11), it was calculated that moose during the winter of 1972-73 deposited 26.6 pellet groups/day and in the winter of 1971-72 28.4 pellet groups/day. LeResche and Davis (1971) calculated deposition of 32.2 groups/day on plots in Pen 1 cleared the previous year. LeResche (1970) reported 10.3 groups/moose/day based upon pellet-count census and known numbers of moose. Several investigators have reported pellet groups/day for deer; Smith (1964) reported 13.2 groups/day, Rogers et al. (1958) reported 15.2 groups/day, Rasmussen and Doman (1943) found 12.7 groups/day and Eberhardt and VanEtten (1956) reported 12.7 groups/day. Neff et al. (1965) reported 12.5 pellet groups/day for elk. It appears that moose defecation rates from 26.6 to 32.2 groups/day are higher than those reported for other ungulates. This may indicate an inadequate pellet group sampling procedure. With established defecation rates per day for moose based on definitive observations, it would be possible to more accurately evaluate pellet-group census techniques for moose.

The defecation rates of 26.6 and 28.4 per day based upon a two-year interval in reading plots substantiates the observers' ability to age winter pellet groups in this study. Aging of summer fecal deposits is apparently not valid, with a total of 11 summer deposits in 1971 and 22 in 1972.

Habitat selection by moose, as indicated by pellet groups per habitat type (Table 9), demonstrates an affinity for birch *(Betula glandulosa)* regrowth (combined dense, medium and thin birch-spruce *(Picea sp.)* regrowth) areas. During the winter of 1971-72, 65.8 percent of pellet groups were in birch regrowth and correspondingly, 66.3 percent in 1972-73. Summer deposits also indicate a preference for birch regrowth areas with 54.5 percent of the deposits counted in these areas during the summer of 1971 and 63.6 percent in the summer of 1972. This does not necessarily imply that summer preference is birch regrowth since spruce-*Ledum*, grass, and sedge areas, which are observed to receive substantial summer use, were not sampled.

Spruce regrowth areas (combined spruce-birch regrowth and spruce regrowth) for the winters of 1971-72 and 1972-73 contained 14.8 and 9.6 percent of the pellet groups, respectively, indicating lower selectivity as would be expected.

Mature hardwood areas (combined dense and thin mature hardwoods) contained 19.4 and 24.1 percent of the pellet groups for the winters of 1971-72 and 1972-73, respectively. Hardwood areas contain the greatest proportion of ground cover low-bush cranberry *(Vaccinium vitis-ideae)*. The relatively substantial use of hardwood areas, reflected by pellet group distribution, may further substantiate the importance of nonbrowse vegetation in moose diets in the area as reported by LeResche and Davis (1973). The use of hardwoods by moose in winter for protection, resting and relief from snow, may, however, be the reason for pellet group distribution in those areas. LeResche (1970), utilizing habitat-use indices derived from pellet-count data, demonstrated similar habitat use trends with some differences in rank of use between habitat types.

Table 10. Moose days in Pen 1 for winters of 1971-72 and 1972-73*.

Moose Number	Winter 1971-72	Winter 1972-73
3	210	210
670	210	210
10	210	210
Calf of 10	45	15
35	210	210
40	210	180
Calf of 40	45	-
43	210	111
58	210	210
R-70-8	210	210
Calf of R-70-8	45	-
69	210	210
64	210	210
65	-	180
76	210	
Calf of 76	-	45
93	-	14
96	-	22
6	135	-
Calf of 6	45	-
Total	2625	2157

* Based on 210-day winter period (November 1 to June 1)

Rumen Sampling Via Trocar

A procedure to obtain rumen contents from elk and deer using a trocar is outlined by Follis and Spillett (1972). This procedure was used on a four-year-old male moose at the MRC on June 30, 1972. The technique is easily accomplished and, with the moist rumen contents in June, it was easy to obtain a sample without the mechanical fingers. This particular animal experienced difficulties while immobilized and rolled on his side after being trocared and some leakage of rumen contents into the abdominal cavity was noted. The animal recovered from immobilization and was released back into Pen 2. The moose was seen on July 18, but was found dead on August 3. The condition of the carcass did not permit an autopsy to determine cause of death, but it is possible that the moose developed peritonitis from rumen contents spilled into the abdominal cavity.

It is important, particularly in summer when rumen contents are more fluid, to retain the animal in sternal recumbancy or preferably standing position for the trocar procedure. The rumen trocar can be utilized when necessary to obtain rumen samples, but the use of a stomach tube and pump is preferred, particularly during the summer.

Rumen Sampling Via Stomach Tube and Pump

To obtain rumen liquor for *in-vitro* digestion trials a 9 foot by 1/2 inch (inside diameter) plastic stomach tube and a standard two-way veterinary stomach pump were used. With the dry compacted rumen contents during winter, it was necessary to pump water into the rumen and allow it to mix with the rumen contents for about 5 minutes prior to pumping the mixture back out.

This method is preferred over the trocar method for our purposes as we have the moose immobilized and can devote the extra time involved with the stomach pump. Moose immobilized with M-99 for this procedure should also be given a tranquilizer (Acepromazine, Ayerst Laboratories, New York, N.Y.) due to the potential time involved.

Marking Techniques

The color-coded collars described by LeResche and Davis (1971) were utilized during this report period for marking outside moose trapped at the MRC and those immobilized via helicopter for movement study (Job 1.7R). New collars which combine color and numbers for individual identification were ordered to replace the depleted supply. The collars are made of canvas-webbing 15 cm wide with three 13 cm high numbers from 1 to 99 on each collar. Various color combinations of numbers and collar background will permit several series of numbers. A collar was placed on Raquel, our tame moose, and the colors and number were easily recognized from the air in a Supercub by Jim Davis, Alaska Department of Fish and Game.

Freeze-branding with a spray-on refrigerant (Cryokwik, International Equipment Company) was attempted on March 27, 1973. One area on the left flank of Wally, Jr., our semi-tame moose, was clipped and sprayed for 20 seconds. The right flank was sprayed for 20 seconds without clipping the hair, and an area on the rump was sprayed for 20 seconds after parting the hair. No adverse effects were noted, however, no brand resulted.

A modified freeze-branding technique, as outlined by R.K. Farrell, Endoparasite Vector Pioneering Research Laboratory, Pullman, Washington (personal communication), was also attempted on Wally, Jr. The procedure utilized Freon 12 and Freon 22 gas in pressurized cans and stainless steel "cookie cutter" devices, one rectangular and one "L" shaped. The area to be branded was clipped and the "cookie cutters" were held against the skin on a horizontal area to produce a pool when sprayed with the Freon. The area was sprayed for a period of time and then quickly thawed with warm water. The procedure used is outlined in Table 12.

Due to the timing of this report, no final determination on this trial was made, but preliminary observations indicate that Freon 22 for 30 seconds with a quick thaw and Freon 22 for five and ten seconds with no thaw (areas 4, 5 and 6) provided the best brand. Areas 1, 2 and 3 produced excessive scarring.

Aerial Census

Testing of observer success in aerial composition counts was planned for this report period; but, due to total calf and yearling loss in the winter of 1971-72 and total calf loss in the winter of 1972-73 at the MRC, there were no calf, yearling or 2-year-old moose to classify.

Helicopter surveys made of the pens on June 20, 1972 and June 18, 1973 to determine spring survival and production in known populations of moose are summarized in Table 13. The percent of moose observed in 1972 was 81 compared to 95 percent observed in 1973. The increase in percent of observed moose in 1973 can be attributed to increase in survey time (42 minutes) and increase in the observers' experience, as conditions otherwise were similar. One calf, not observed on the helicopter survey of 1972, was accounted for by subsequent ground observations. Five of six calves were observed from the air. The survey of 1973 revealed nine calves and one additional calf has subsequently been observed. This calf was believed to have been born after the survey.

Trapping Success

The layout of traps at the MRC was diagrammed by LeResche and Davis (1971). A new trap was built in the northwest corner of Pen 4 and put into operation in January, 1973. Design for the traps was described by LeResche and Lynch (1973). Nine outside and 11 inside traps are now being used. Their relative success is shown in Tables 14 and 15.

A processed moose was one that was immobilized and marked or had the standard physiologic procedures performed. Moose were released when they had been processed within the previous three to four weeks. Others were released

Table 12. Freeze-branding trial utilizing bottled Freon gas on June 4, 1973.

Area	Type of Gas	Time (Sec.)	Type of Thaw
1	Freon 12	30	Delayed
2	Freon 12	45	Quick
3	Freon 22	15	Quick
4	Freon 22	30	Quick
5	Freon 22	5	None
6	Freon 22	10	None

Table 13. Helicopter surveys of known populations of moose at Kenai Moose Research Center.

June 20, 1972					June 18, 1973				
Pen No.	Helicopter Time (Min.)*	Moose Present	Moose Observed	Percent Observed	Pen No.	Helicopter Time (Min.)*	Moose Present	Moose Observed	Percent Observed
1	49	12	9	75	1	43	10	10	100
2	49	14	11	79	2	51	7	7	100
3	49	8	7	88	3	30	7	6	86
4	49	13	11	85	4	114	13	12	92
Total	196	47	38	81	Total	238	37	35	95

* Total time only available - divided equally for each pen.

Table 14. Trap effectiveness by individual trap and pen within the enclosures at the Kenai Moose Research Center, April, 1972 to June, 1973.

Trap No.	No. Trap Nights	No. Moose Processed	No. Moose Released	No. Moose Escaped	No. Malfunctions (moose)	No. Malfunctions (other)	No. Moose Driven into Trap	Trap Success
1E	135	16	11	1	2	2	2	.21
1W	99	7	3	-	2	-	1	.10
1N	123	12	3	-	-	2	-	.12
2S	131	14	6	-	7	1	-	.15
2E	127	12	5	-	6	2	-	.13
CP-2	87	11	3	2	-	2	1	.18
3N	68	6	1	-	-	1	-	.10
3S	108	14	3	-	2	1	-	.16
4SE	90	10	4	-	3	1	-	.16
4S	96	5	3	1	1	1	1	.09
4NW	51	14	9	-	5	2	1	.45
Pen 1	357	35	17	1	4	4	3	.15
Pen 2	345	37	14	2	13	5	1	.15
Pen 3	176	20	4	-	2	2	-	.13
Pen 4	237	29	16	1	9	4	2	.19
All Pens	1115	121	51	4	28	15	6	.16

Table 15. Trap effectiveness by individual trap outside the enclosures at the Kenai Moose Research Center, April, 1972 to June, 1973.

Trap No.	No. Trap Nights	No. Moose Processed	No. Moose Released	No. Moose Escaped	No. Malfunctions (moose)	No. Malfunctions (other)	No. Moose Driven into Trap	Trap Success
10E	108	9	5	2	4	-	-	.15
10S	91	16	6	-	-	3	-	.24
10W	71	6	-	-	-	2	-	.08
10N	72	7	2	2	1	-	-	.15
20N	72	3	-	1	-	-	2	.06
30N	65	6	4	3	-	1	-	.20
40S	89	8	-	2	1	1	-	.11
40E	91	13	3	4	-	1	-	.22
40W	107	6	5	-	1	3	-	.10
All Traps	766	74	25	14	7	11	2	.15

when they didn't respond to the drug, became overheated or were calves and processing was not desired. If more than one moose was caught per trap, one was released. Moose that escaped generally went over the top of the fence after it had been smashed down or between the gate and fence. When this happened the fence was reinforced or the gate readjusted to reduce loss. Escape was greatest during the winter on the outside when moose, not accustomed to entrapment, stood on approximately one-half meter of hard-packed snow. The fence barrier apparently was not as much of a deterrent at this time. A common source of malfunction was the trigger string. Monofilament line was tried because of its transparency, but proved too elastic and normally only triggered one gate before breaking. Malfunctions, other than those caused when moose were present, were largely caused by wind knocking the trigger loose on one gate. On separate occasions a brown *(Ursus arctos)* and a black bear *(Ursus americanus)* triggered traps. Malfunctions that occurred during the day and went unnoticed, took away the subsequent trap night, since moose were normally trapped during their period of greatest activity near dawn (LeResche and Lynch, 1973). We were able to drive some moose standing near a trap along the fence into the trap by snowmachine, truck or walking. The trap success was calculated by dividing the total number of moose caught by the number of trap nights.

Little difference in overall trapping success was noted for outside and inside traps, although there was much variability between individual traps. Differences between pens are likely a function of density. Throughout this reporting period Pens 1 and 2 had 11-12 moose, Pen 3 had seven moose and Pen 4 had 20-25 moose.

When seasonal variations were considered (Tables 16 and 17) trapping success differences between outside and inside traps were more noticeable. Trapping success was highest during December and January for outside traps but quite low for inside traps during the same months. A likely cause was that moose are migrating to winter areas at this time and are more susceptible to being trapped. During summer and early fall trapping was best inside the pens but outside there was little success. Effort was reduced outside at that time because of the lack of activity. There was little or no trapping effort in May both years because of breakup. Trapping success during this reporting period was lower than that reported by LeResche (1970) and LeResche and Lynch (1973). This may partially be due to moose inside the pens becoming accustomed to the locations of traps and avoiding those areas. They may also have learned to avoid triggering the trap. On 18 occasions moose inside the pens walked to the trigger string and either turned away or jumped over it. This could be told by tracks in soft ground or snow. Another possible cause of lower trap success was that effort was greatly increased in all months of the year to get a desired sample of moose both on the inside and outside (Job 1.1R, this report).

An attempt was made to increase trap success during the spring and summer of 1972 by using salt blocks. Salt was placed under the trigger string in most traps and was quite successful in attracting bulls in early summer. One particular bull (#36, Pen 2) defended a salt block

Table 16. Trap effectiveness by month for traps inside the enclosures at the Kenai Moose Research Center.

Month	No. Trap Nights	No. Moose Processed	No. Moose Released	No. Moose Escaped	No. Malfunctions (moose)	No. Malfunctions (other)	No. Moose Driven into Trap	Trap Success
1972 April	170	4	-	1	-	2	1	.03
May	5	1	-	-	-	-	-	.20
June	80	18	4	-	5	3	-	.28
July	100	21	17	1	5	3	-	.39
Aug.	61	12	8	1	3	1	-	.34
Sept.	35	11	2	-	1	-	-	.37
Oct.	47	5	1	1	4	1	-	.15
Nov.	82	11	-	-	1	-	-	.13
Dec.	68	4	1	-	1	-	2	.07
1973 Jan.	78	6	4	-	2	-	3	.13
Feb.	81	8	6	-	2	-	-	.17
Mar.	137	5	1	-	2	3	-	.04
Apr.	65	2	1	-	-	-	-	.05
May	0	-	-	-	-	-	-	-
June	106	13	6	-	2	2	-	.18
	1115	121	51	4	28	15	6	.16

Table 17. Trap effectiveness by month for traps outside the enclosures at the Kenai Moose Research Center.

Month	No. Trap Nights	No. Moose Processed	No. Moose Released	No. Moose Escaped	No. Malfunctions (moose)	No. Malfunctions (other)	No. Moose Driven into Trap	Trap Success
1972, April	75	5	-	-	-	2	-	.07
May	3	-	-	-	-	-	-	.00
June	31	2	1	-	1	-	-	.10
July	1	1	-	-	-	-	-	1.00
Aug.	2	-	-	-	-	-	-	.00
Sept.	38	5	-	-	-	3	-	.13
Oct.	137	7	10	3	-	1	-	.15
Nov.	50	4	-	-	-	-	-	.08
Dec.	57	10	1	2	1	-	-	.23
1973, Jan.	71	7	3	5	1	-	-	.21
Feb.	89	11	2	4	1	1	-	.19
Mar.	76	10	-	-	1	4	1	.13
Apr.	49	3	1	-	-	-	1	.08
May	0	-	-	-	-	-	1	-
June	87	9	7	-	2	-	-	.18
	766	74	25	14	7	11	2	.15

and displayed aggressively toward us and our vehicle when approached. Two cows and one calf also came to the salt frequently. As the summer progresssed, less use was made of the salt blocks. The blocks were removed to reduce influences on physiologic studies but enough had leached into the soil that some moose still licked the ground in the spring of 1973. No natural salt licks have been located in the vicinity outside the enclosures; however, outside moose were not attracted to salt blocks placed in outside traps.

Raising Orphaned Moose Calf

On June 21, 1972 an orphaned moose calf was brought to the MRC and held in the trap behind the cabin which was converted temporarily to a moose calf pen. The female calf weighed 15.5 kg. (34 pounds) and was estimated to be less than one week old. She was raised to supplement tame moose studies. Chronology of events related to raising the calf is presented in Table 18 and a popularized version of the events has been published (Franzmann, 1973).

The calf was allowed to browse freely outside the enclosures and feeding observations were made. The browse in order of preference was: willow *(Salix Sp.)*, fireweed blossoms *(Epilobium angustifolium)*, bunchberry *(Cornus canadensis)* and birch.

Once the calf was free to browse (after July 1) she began to gain weight and overcame her digestive problems demonstrated by clinical diarrhea. Allowing her freedom to browse also permitted her to wander off. The calf was gone and on her own from August 19 to October 19, 1972. When she reappeared she was quite thin, but appeared healthy. At that time, she was placed into Pen 1, but she has not been seen since, in spite of intensive searches. We assume that she died, but are unaware of the circumstances.

A male calf born to our tame moose (Raquel) weighed 14.5 kg. (32 pounds) at birth and at one week of age weighed 23.6 kg. (52 pounds), gaining 1.3 kg. (2.86 pounds) per day during his first week. The orphaned moose in contrast was over one month old before she attained the one-week-old weight of Raquel's calf.

RECOMMENDATIONS

1. Biotelemetry investigations should be pursued based upon work in other fields and the availability of equipment and expertise.

2. Research to more definitively establish the number of pellet-groups deposited per day for moose and the timing of change to and from pellet and summer deposits should be accomplished.

3. Testing of observer success in aerial composition counts should be done at the Moose Research Center when the moose composition within the pens warrants it.

Table 18. Chronology of Events in Raising a Moose Calf.

Date	Milk Replacer[1] Consumed (liter)	Body Weight (kg)	Event
June 21	.15	15.5	
June 22	.47		Placed on 4 hr. schedule. Began browsing.
June 23	2.07		Drinking from pan.
June 24	1.33		Placed on 6 hr. schedule.
June 25	1.66		Began eating calf pellets[2]
June 26	2.46		
June 27	3.32	16.4	
June 28	4.98		
June 29	4.74		Calf scouring - given 1 cc vitamin injection[3] daily for 1 week.
June 30	2.84		Reduced consumption
July 1	3.79		3.79 liters (1 gallon) milk replacer given daily hereafter (8 hr. schedule). Calf browses daily, eats pellets.
July 12		19.1	Broke to lead with halter.
July 26		24.6	Began turning out daily to browse.
Aug. 3		27.3	
Aug. 10		35.0	
Aug. 17		39.5	
Aug. 19			Wandered away - missing for 2 months.
Oct. 19			Returned to area, put into Pen 1.

1. Suckle, Albers Milling Co.
2. Don's Calf Starter Pellets, Alaska Mill and Feed, Anchorage.
3. Betalin Complex F.C., Eli Lilly Co., Indianapolis, Ind.

LITERATURE CITED

Berg, W.E. and R.L. Phillips. 1972. Winter spacing of moose in northwestern Minnesota. Trans. 8th N. Am. Moose Conf. and Workshop, Thunder Bay, Ont.:166-176.

Bergerud, A.T., A. Butt, H.L. Russell and H. Whalen. 1964. Immobilization of Newfoundland caribou and moose with succinylcholine chloride and Cap-Chur equipment. J. Wildl. Manage. 28(1):49-53.

Boyd, J.C., W.J.L. Sladen, H.A. Baldwin. 1967. Biotelemetry of penguin body temperature. 1966-67. Anarctic U.S. 2(4):97-99.

Downhower, J.F. and J.D. Pauley. 1970. Automated recordings of body temperature from free ranging yellow-bellied marmots. J. Wildl. Manage. 34(3):639-641.

Eberhardt, L. and R.C. VanEtten. 1956. Evaluation of the pellet group count as a deer census method. J. Wildl. Manage. 20(1):70-74.

Edwards, R.Y. and R.W. Ritcey. 1958. Reproduction in a moose population. J. Wildl. Manage. 22(3):261-268.

Folk, G.E. 1968. Telemetry of physiological function of large carnivores. Proc. Workshop. Biol. Bears., Proc. AAAS (Alaska Branch) 19:52-63.

Follis, T.B. and J.J. Spillett. 1972. A new method for rumen sampling. J. Wildl. Manage. 36(4):1336-1340.

Franzmann, L. 1973. My summer with Tillie - a moose. Alaska Magazine 39(7):8,76-77.

Hime, J.M. and D.M. Jones. 1970. The use of xylazine in captive wild animals. Proc. 11th International Symposium on Diseases of Zoo Animals, Budapast, Hungary.

Houseknecht, C.R. 1970. Biotelemetry as a technique in disease ecology studies. J. Wildl. Dis. 6(4):414-417.

Houston, D.B. 1968. The Shiras moose in Jackson Hole, Wyoming. Grand Teton Natur. History Assn. Tech. Bull. 1. 110 pp.

____________. 1969. Immobilization of the Shiras moose. J. Wildl. Manage. 33(3):534-537.

____________. 1970. Immobilization of moose with M-99 etorphine. J. Mammal. 51(2):396-399.

Johnson, D.C., P.D. Arneson and A.W. Franzmann. 1973. Behavior and survival in orphaned and nonorphaned moose calves. Final Rep. Job 1A-1.1 Fed. Aid in Wildl. Restoration. Alaska Dept. Fish and Game.

Ko, W.H. and M.R. Neuman. 1967. Implant biotelemetry and micro electronics. Science 156:351-360.

LeResche, R.E. 1970. Moose report. Annual Proj. Progress Rep. Fed. Aid in Wildl. Restoration. Alaska Dept. of Fish and Game.

____________ and J.L. Davis. 1971. Moose report. Annual Proj. Progress Rep. Fed. Aid in Wildl. Restoration. Alaska Dept. of Fish and Game.

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

____________ and R.A. Rausch. In press. Accuracy and precision of aerial moose censusing. J. Wildl. Manage.

Lonsdale, E.M., B. Bradach and E.T. Thorne. 1971. A telemetry system to determine body temperature in pronghorn antelope. J. Wildl. Manage. 35(4):747-751.

Lord, R.D., Jr., F.C. Bellrose, and W.W. Cochran. 1962. Radiotelemetry of the respiration of a flying duck. Science 137:39-40.

MacKay, R.S. 1968. Biomedical telemetry: sensing and transmitting biological information from animals to man. John Wiley and Sons, Inc., N.Y. 388 pp.

McGinnis, S.M., V.A. Finch, and A.M. Harthoorn. 1970. A radio telemetry technique for monitoring temperatures from unrestrained ungulates. J. Wildl. Manage. 34(4):921-925.

____________ and T.P. Southworth. 1967. Body temperature fluctuations in the northern elephant seal. J. Mammal. 48(3):484-485.

Neff, D.J. 1968. The pellet-group technique for big game trend, census and distribution: a review. J. Wildl. Manage. 32(3):597-614.

__________, O.C. Wallmo and D.C. Morrison. 1965. A determination of defecation rate for elk. J. Wildl. Manage. 29(2):406-407.

Ostbye, E. 1970. A new temperature gradient apparatus for use on terrestrial arthropods and small vertebrates. Norwegian J. Zool. 18(1):75-79.

Peek, J.M. 1962. Studies of moose in the Gravelly and Snowcrest Mountains, Montana. J. Wildl. Manage. 34(1):37-46.

Pimlott, D.H. 1959. Reproduction and productivity of Newfoundland moose. J. Wildl. Manage. 23(4):381-401.

Rasmussen, D.I. and E.R. Doman. 1943. Census methods and their application in the management of mule deer. Trans. N. Am. Wildl. Conf. 8:369-380.

Rausch, R.A. and A. and A. Bratlie. 1965. Annual assessments of moose calf production and mortality in southcentral Alaska. Ann. Conf. W. Assn. State Fish and Game Commissioners 45:140-146.

Riley, J.L. 1971. Frequency-to-voltage converter for recording animal temperature by radiotelemetry. J. Applied Physiol. 30(6): 890-892.

Rogers, G., O. Julander and W.L. Robinette. 1958. Pellet-group counts for deer census and range-use-index. J. Wildl. Manage. 22(2): 193-199.

Simkin, D.W. 1965. Reproduction and productivity of moose in northwestern Ontario. J. Wildl. Manage. 29(4):740-750.

Slater, L.E. 1963. Bio-telemetry. The use of telemetry in behavior and physiology in relation to ecological problems. Proc. Interdisciplinary Conf. N.Y. Pergamon Press, N.Y. 373 pp.

Smith, A.D. 1964. Defecation rates of mule deer. J. Wildl. Manage. 28(3):435-444.

Stevens, D.R. 1970. Winter ecology of moose in the Gallatin Mountains, Montana. J. Wildl. Manage. 34(1):37-46.

Van Ballenberghe, V. and J.M. Peek. 1971. Radiotelemetry studies of moose in northeastern Minnesota. J. Wildl. Manage. 35(1):63-71.

Will, G.B. and E.F. Patric. 1972. A contribution toward a bibliography on wildlife telemetry and radio tracking. A joint contribution of New York Fed. Aid and Wildl. Restoration Proj. W-123-R and Rhode Island Agr. Exper. Station, Contribution 1439.

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JOB PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperators: Albert W. Franzmann and Paul D. Arneson

Project No: W-17-5 Project Title: Big Game Investigations

Job No: 1.2R Job Title: Moose Behavior

Period Covered: July 1, 1972 through June 30, 1973

SUMMARY

Cratering activity was monitored in relation to snow depth, time spent cratering, time spent browsing, paws per crater and number of craters. The importance of nonbrowse food obtained through cratering activity was substantiated. The possibility of a negative energy balance situation resulting from cratering activities for forage with certain snow conditions was suggested.

CONTENTS

BACKGROUND

Moose *(Alces alces)* in the lowland areas of the Kenai Peninsula have received considerable hunting pressure for many years. In late fall, moose herds in these areas are characterized by a relatively low bull-cow ratio (less than 20 bulls:100 cows) and a higher calf-cow ratio than highland populations. Few large bulls are observed during fall in the lowlands prior to November when many highland bulls move downward. Calf-cow ratios recorded in November have ranged from 33 calves:100 cows in 1970 to 41:100 in 1972. A sizable portion of the northern lowland area is seral birch *(Betula glandulosa)* range--a product of the 1947 Sterling Burn. Although browse (primarily birch) is abundant throughout the area, substantial numbers of moose have died during severe winters. From November, 1971 to May, 1972, over 80 percent of the calves died in Game Management Subunit 15A and over 65 percent of the calves died during the same period in 1972-73. After two successive winters of heavy mortality, population estimates by personnel of the Kenai National Moose Range have dropped from 7,900 ± 1,400 (90% confidence level) minimum north of the Kasilof River in early 1971 to 5,692 ± 1,348 (90% confidence level) minimum in early 1973. Although there is overlap in these population ranges, the change in means probably reflects a true population reduction.

The moose traditionally using climax willow ranges in the highland areas, but wintering on the lowland areas, received little hunting pressure in the past. However, they have been gradually receiving more pressure as evidenced by declining bull-cow ratios. In Subunit 15B the ratio dropped from 44 bulls:100 cows in 1964 to 31 bulls:100 cows in 1972; in the Unit 7 highlands from 47 bulls:100 cows in 1961 to 17 bulls: 100 cows in 1972. Calf proportions have remained low in these groups.

Increasing pressure on Kenai Peninsula moose and their habitat necessitated greater understanding of the moose resource. Data needs and their possible management application were summarized by LeResche and Davis (1971) as follows:

> With the formalization of moose management plans for the Kenai and the designation of certain areas as trophy, foothunting

and maximum sustained yield hunting areas, delineation of these various groups, their interactions, their seasonal movements, and their calving and breeding sites, has become imperative. Further, the proposed classification of more than one million acres of the area as wilderness, as well as the possibility of a limited access road bisecting part of the area, requires specific knowledge of the migrations of these moose. Descriptions of populations and their movements would, 1) allow harvesting of desired portions of specified moose herds and prevent harvesting of trophy-class bulls while they are away from trophy-management areas (and often antlerless), 2) prevent unnecessary restriction of activities (eg: by wilderness designation) in areas of key winter range, where habitat manipulation might someday become necessary, 3) contraindicate development of small areas seasonally crucial to large numbers of moose (eg: during calving, rutting, or wintering) and 4) provide valid data relative to possible obstructions presented by future proposed highways and other projects.

The literature contains few major studies of moose migrations and/or movements in North America. LeResche (1973) made a comprehensive review of existing literature and summarized moose movements as follows:

Seasonal home ranges are typically small (5-10 km^2), and the same ranges are occupied annually by individual moose. Yearlings and rutting bulls in some areas have larger and less fixed home ranges. Movements between seasonal home ranges (migrations) may be classified along a continuum including Type A (short distance movements between two seasonal ranges with little change in elevation), Type B (medium to long distance movements between only two seasonal ranges with significant differences in elevation between higher summer-fall ranges and lower winter ranges), and Type C (medium to long distance movements between three distinct seasonal ranges with significant changes in elevation). Several types of movements may occur in one area, resulting in aggregations and segregations of population segments. Movements follow traditional routes, although timing may vary annually. Snow, forage and internal stimuli mediate seasonal movements. Physical and environmental distances between seasonal ranges vary, but generally the shortest migrations occur in flat habitat with little environmental gradient. Regular migrations of from 1 km to 170 km are reported from North America. Moose do disperse into new habitat, but the traditionality of home ranges and movement patterns impedes this dispersal. Many "dispersals" reported may in fact have been local population increases. Moose migrations provide optimal physical, biotic and social environments on a seasonal basis.

LeResche suggested that the most definitive movement studies were those reported by Edwards and Ritcey (1956) in British Columbia, Knowlton (1960) in Montana, Berg (1971) and Van Ballenberghe and Peek (1971) in Minnesota, Houston (1968) in Wyoming, Goddard (1970) in Ontario, and LeResche (1972) in Alaska.

OBJECTIVES

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

PROCEDURES

Moose were tagged using helicopters (Nielson and Shaw, no date) or fenceline traps (LeResche and Lynch, 1973) and succinylcholine chloride in projected syringes. The enzyme, hyaluronidase, was added to the drug. Between July 1, 1972 and June 30, 1973, 12 moose were tagged in Big Indian Creek, 60 were tagged in the Tustumena Benchland-Lower Funny River Airstrip area, 43 were tagged outside the enclosures at the Kenai Moosee Research Center (MRC) and one was tagged after being rescued from being mired in mud (Table 1). Figs. 1 and 2 show tagging areas for all animals collared to date. All of the above-mentioned animals were tagged to be distinguishable from afar as individuals (an exception was several calves tagged at the MRC that were ear tagged only). They were made identifiable by color-coded canvas web (Table 1 and Fig. 3) neck collars obtained from Denver Tent and Awning Co., Denver, Colorado. The MRC tagged animals were marked with metal ear-tags (Salt Lake Stamp Co., Salt Lake City, Utah) and silver Saflag (Safety Flag Co. of America, Pawtuket, R.I.) material in the right ear of females and the left ear of males. All other tagged animals were ear marked with Goliath Rototags (Dalton Supplies Ltd., Henley-on-Thames, Nettlebed, England).

Weekly reconnaissance or counting flights were attempted by Alaska Department of Fish and Game personnel to monitor movements of the 320 moose tagged prior to June 30, 1972 and the 116 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 count. Personnel of both agencies also contributed miscellaneous observations of collared moose. Resightings and locations of hunter-killed collared moose were reported by the public.

FINDINGS

Nine hundred and eighty-three recoveries and resightings of tagged moose have been recorded through June 30, 1973 (Table 3). Based on the 413 recoveries and sightings of tagged moose accrued through June 15, 1971, LeResche and Davis (1971) presented a thorough discussion of inferences of population identities, movements, and concentrating areas for groups tagged at Mystery Creek, Bottenintnin Lake, Kenai Moose Research Center and Moose River Flats. This 1971 discussion was based on an analysis of resightings by season, location and (tagging) group without benefit of resightings of identifiable individuals (except for resightings of four presumed identifiable individuals). Many resightings of identifiable individuals from the 1970 and 1971 Moose River Flats tagging and the MRC taggings have subsequently been made (Table 4). At present the resightings warrant little elaboration on population identity and concentrating areas of these groups. Resightings of individuals from the Big Indian Creek, Lower Funny River Strip and upper Benchland taggings have suggested rutting, wintering and spring-calving use areas for these populations. Since these were all rutting groups they are considered true populations (i.e.: randomly interbreeding groups).

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

Tagging Location	Number Tagged: Males	Females	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)	12	106	0	12	130
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	12	21	0	0	33
Totals	109	312	3	12	436

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

* Colored stripes on both sides 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.

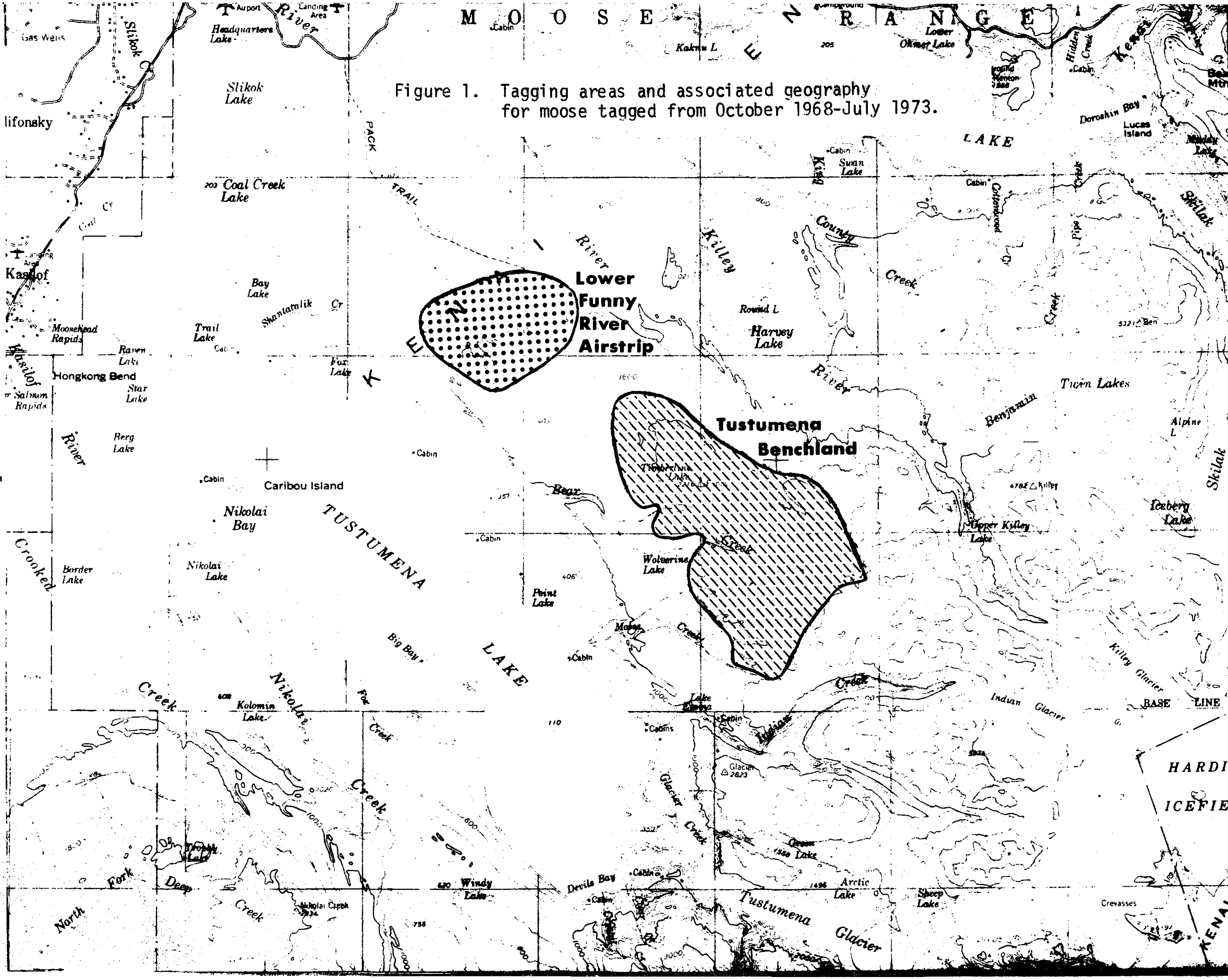


Figure 1. Tagging areas and associated geography for moose tagged from October 1968-July 1973.

Figure 2. Tagging areas and associated geography for moose tagged from October 1968-July 1973.

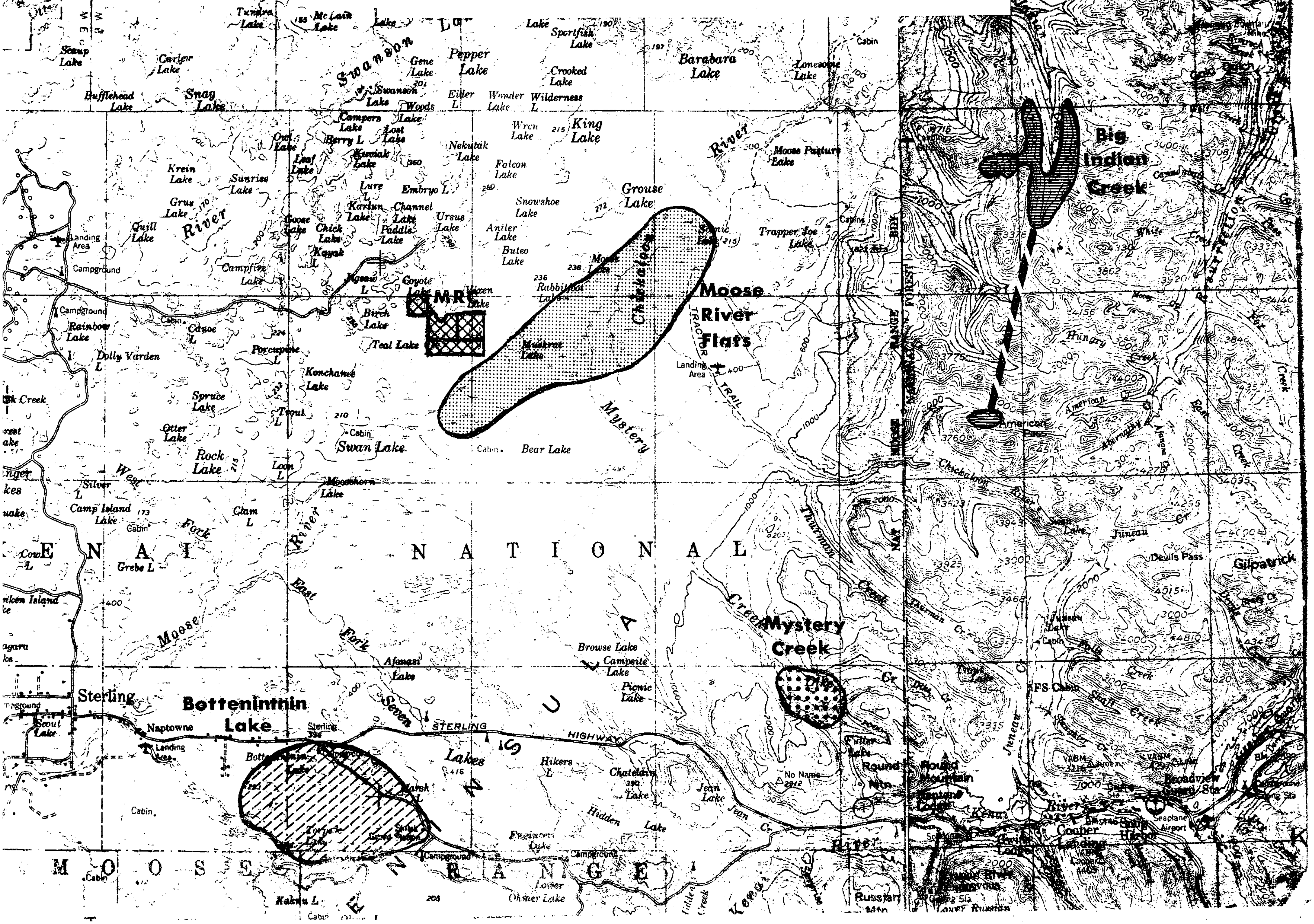


Figure 3. Design of canvas web neck collars used to identify tagged moose as individuals.

42" for cows
52" for bulls

Panel 1	Panel 2
Panel 3	Panel 4

Panels consist of any combination of the following colors: red, yellow, blue, white, pink.

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

Date	Area	Collared Moose
13 July '72	Tust.-Skilak Benchland	0
25 July '72	69 & 47 Burn, Tust.-Skilak Lowlands	4 FF
1 Aug. '72	47 Burn & Kenai Mts.	0
21 Sept. '72	Kenai Mts.	4 FF, 1 MM
3 Oct. '72	Kenai Mts.	12 FF, 1 MM
17 Oct. '72	Tust. Benchland	0
27 Oct. '72	Kenai Mts.	6 FF, 2 MM
14 Nov. '72	Lowlands Burns	2 FF
21 Nov. '72	Lowlands	3 FF
27 Nov.-2 Dec. '72	Misc. - Sex & age composition counts	46 FF, 15 MM
21 Dec. '72	Kenai Mts.	2 FF, 1 MM
27 Dec. '72	Kenai Mts. & Lowlands	7 FF, 2 MM
17 Jan. '73	Benchland & Lowlands	3 FF, 3 MM
31 Jan. '73	Benchland	3 FF, 2 MM
1 Feb. '73	Lowlands	8 FF
3 Feb. '73	Kenai Mts.	10 FF, 2 MM
9 Feb. '73	Lowlands	4 FF
12-15 Feb. '73	Random strat. counts	13 FF, 4 MM
20 Feb. '73	47 Burn	11 FF
22 Feb. '73	Benchland	6 FF
26 Feb. '73	47 Burn	15 FF
27 Feb. '73	47 Burn	1 FF
9 Mar. '73	Kenai Mts.	5 FF
16 Mar. '73	Benchland	4 FF, 4 MM
21 Mar. '73	Lowlands	0
3 Apr. '73	Lowlands & Kenai Mts.	0
16 Apr. '73	Benchland	16 FF
8 May '73	Lowlands	3 FF
10 May '73	MRF - Lowlands	11 FF, 2 MM
16 May '73	Lowlands	6 FF, 1 MM
24 May '73	MRF	10 FF, 1 MM
14 June '73	Benchland	3 FF, 7 MM
15 June '73	MRF - Lowlands	4 FF, 1 MM
Total		222 FF, 57 MM

Table 3. Recoveries and resightings of collared moose, Kenai Peninsula, through June 1973.

Tagging Site	Number of Recoveries and Sightings
Mystery Creek	152
Bottenintnin Lake	152
Moose Research Center	95
Moose River Flats	330
Tustumena Benchland (1971-72)	4
Tustumena Benchland-Lower Funny River Airstrip Area	64
Big Indian Creek	15
Not properly identified*	171
Total	983

* Includes individuals that had lost part of their identifying marks, reports of moose with impossible markings and other irregularities.

Table 4. Resightings of individually identifiable moose through June 30, 1973.

Original Tagging Site	Number of Times Relocated 1	2	3	4	5	6	Number of Identifiable Individuals in Group
Moose River Flats 1970	20	12	7	1			71
% Ident. Indiv. Relocated	28.0	17.0	9.8	1.4			56.3% relocated
No. of Times							At least once
Moose River Flats 1971	16	13	4	2	2	3	61
% Ident. Indiv. Relocated	26.2	21.3	6.6	3.3	3.3	4.9	65.6% relocated
No. of Times							At least once
Upper Bear Cr. 1971				1			4
% Ident. Indiv. Relocated				25.0			25% relocated
No. of Times							At least once
Moose Research Center	26	6	1	1			53
% Ident. Indiv. Relocated	49.1	11.3	1.9	1.9			64.2% relocated
No. of Times							At least once
Upper Benchland	7	6	5				27
% Ident. Indivi. Relocated	25.9	22.2	18.5				66.7% relocated
No. of Times							At least once
Lower Funny River Strip	11	5	7		1		33
% Ident. Indiv. Relocated	33.3	15.2	21.2		3.0		72.7% relocated
No. of Times							At least once
Big Indian Cr.	5		1			1	12
% Ident. Indiv. Relocated	41.7		8.3			8.3	58.3% relocated
No. of Times							At least once

Big Indian Creek Population

Sightings of Big Indian Creek moose plotted on a map (Fig. 4) show that at least six marked individuals (both males and females) wintered above timberline in the general tagging vicinity. One female was observed wintering in the MRC vicinity. This cow remained in the area throughout February. She was sighted in May near Scenic Lake on the Moose River Flats. The relatively high percentage of individuals from this group that wintered above timberline in their rutting drainage differs from the wintering behavior previously described for the Mystery Creek population (LeResche and Davis, 1971). Winter severity could account for differences in movements and distribution between years. Quantitative weather data are not available for the areas, but the 1972-1973 winter appeared to be less severe than the preceding two in this area. Because tagged individuals were observed wintering above timberline during November-March but none could be located during flights in April and May, we assume that they moved to lower elevations where cover concealed them. This inferred movement pattern, coupled with observations in the past of bulls from Mystery Creek remaining high well into winter but showing up on the Moose River Flats in spring, lends credence to the idea that moose move down in late winter or early spring to lowland areas because of advanced plant phenology in lowland areas. This may in part explain why bulls occupy or concentrate in "calving areas". No cows from this group have been sighted with calves so calving areas remain unknown.

Lower Funny River Air Strip-Tustumena Benchland Populations

It appears likely that the group tagged near the Lower Funny River Airstrip and the group tagged above timberline in the Tustumena Benchland have different patterns of seasonal distribution. Both were rutting groups of high density separated by as little as 2-1/2 miles of timber at the time of tagging. There were no significant physical barriers separating the groups. The Lower Funny River group was tagged below timber line (Fig. 5) and 84 percent (27/32) of all resightings (December 1972-June 1973) occurred below timberline. Both males and females (5 males and 5 females) from the group moved north toward the Kenai River to elevations below 600 feet for wintering. Some moved as far as Robinson Loop Road (Sterling Area). However, 5 females and 4 males were observed wintering near the tagging area. One cow was observed with a calf only several days old near mile 76 of the Sterling Highway. No other females from the group were observed with calves. The only other female from the group sighted during May or June was observed in June above timberline near the head of Bear Creek (elevation 2,600') without a calf thus confounding delineation of a single calving-spring use area for the group.

In contrast to the Lower Funny River Airstrip group, 80 percent (24/30) of all resightings of the Tustumena Benchland group occurred above timberline (Fig. 6). Observations of only two cows and two bulls from this group were made in the area north toward the Kenai River from the tagging site and below 600 feet elevation. However, greater numbers of both males and females (10 males and 4 females) were observed throughout the winter in the original tagging area at elevations up to 3,000 feet. Determining proportions of the population exhibiting the localized versus migration to winter range tendencies is confounded by not having resighted most individuals. The probability of a resighting in the lowland area is much lower than in the alpine tagging area because of vegetational cover and the vastness of lowland area to reconnoiter. Nevertheless, 52 percent

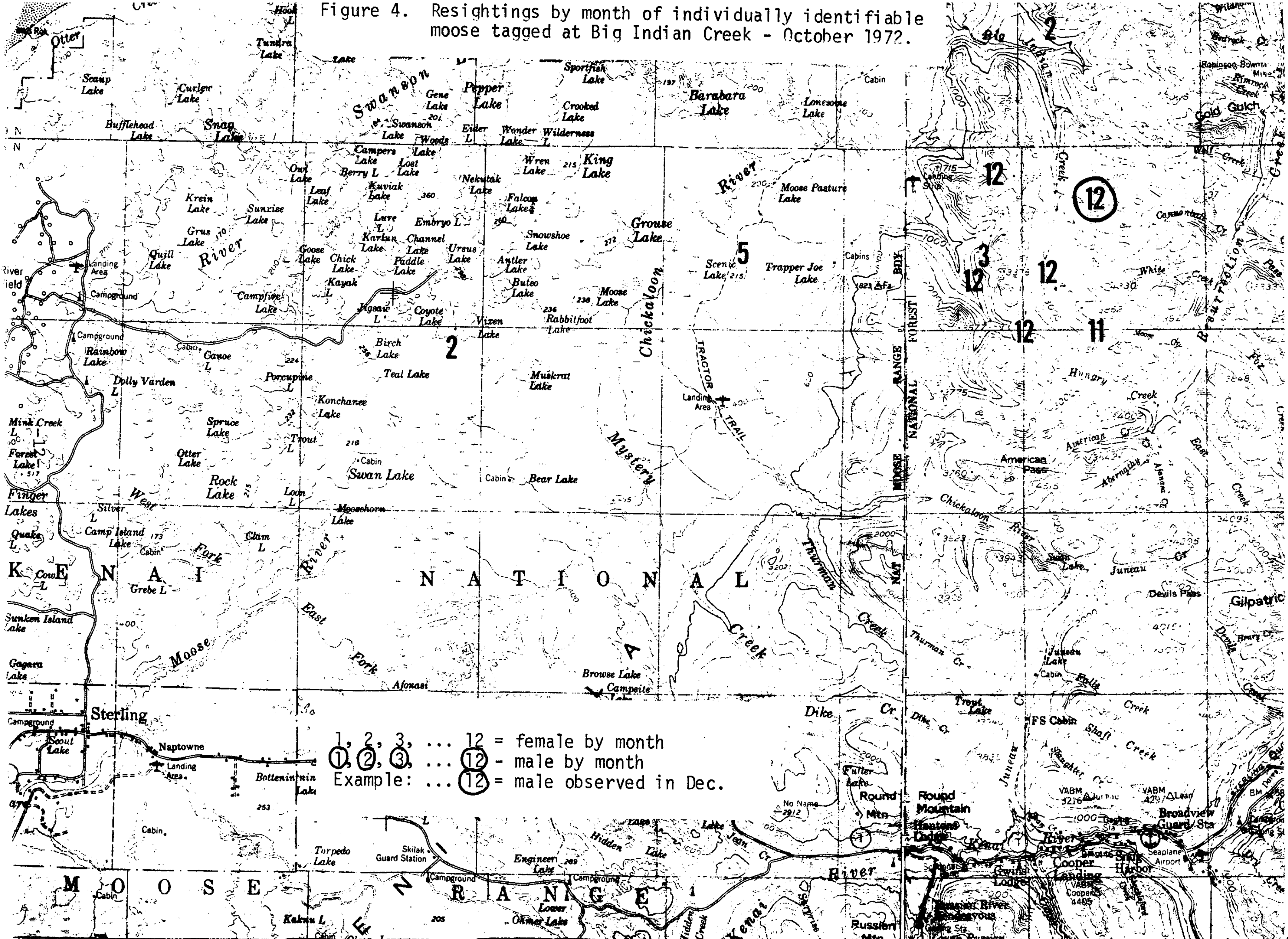


Figure 4. Resightings by month of individually identifiable moose tagged at Big Indian Creek - October 1972.

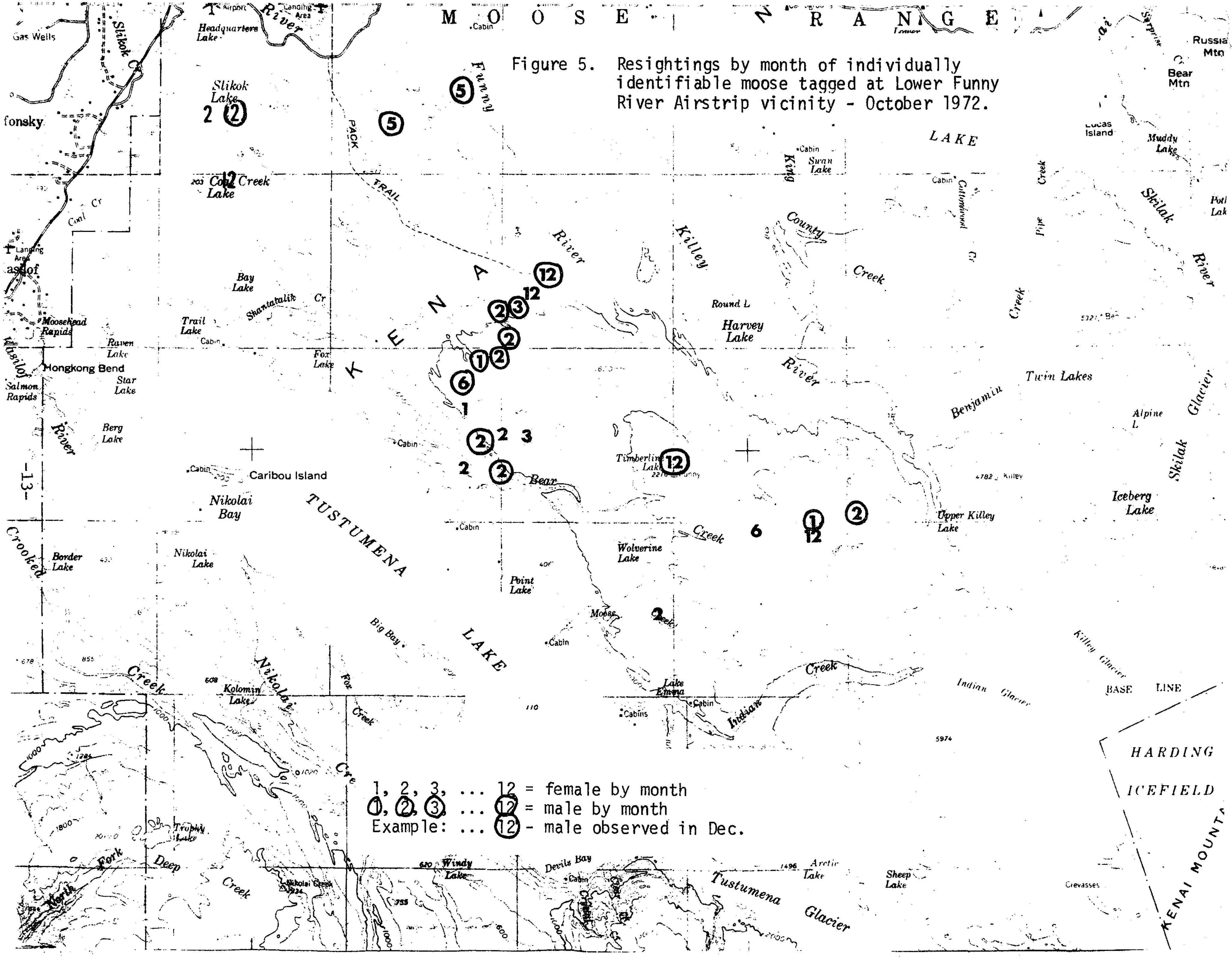
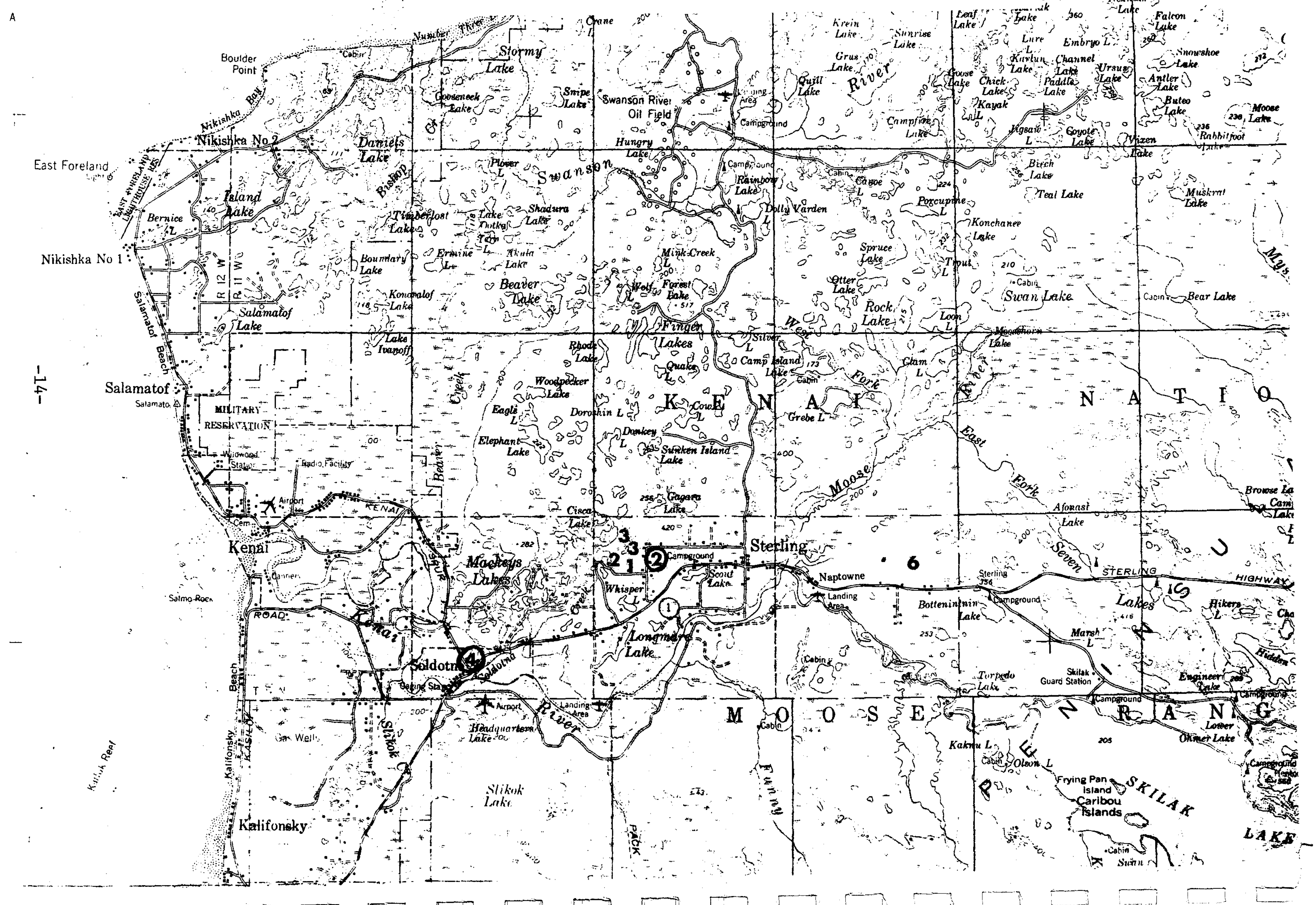


Figure 5. Resightings by month of individually identifiable moose tagged at Lower Funny River Airstrip vicinity - October 1972.

Figure 5. continued. Resightings by month of individually identifiable moose tagged at Lower Funny River Airstrip vicinity - October 1972.



-14-

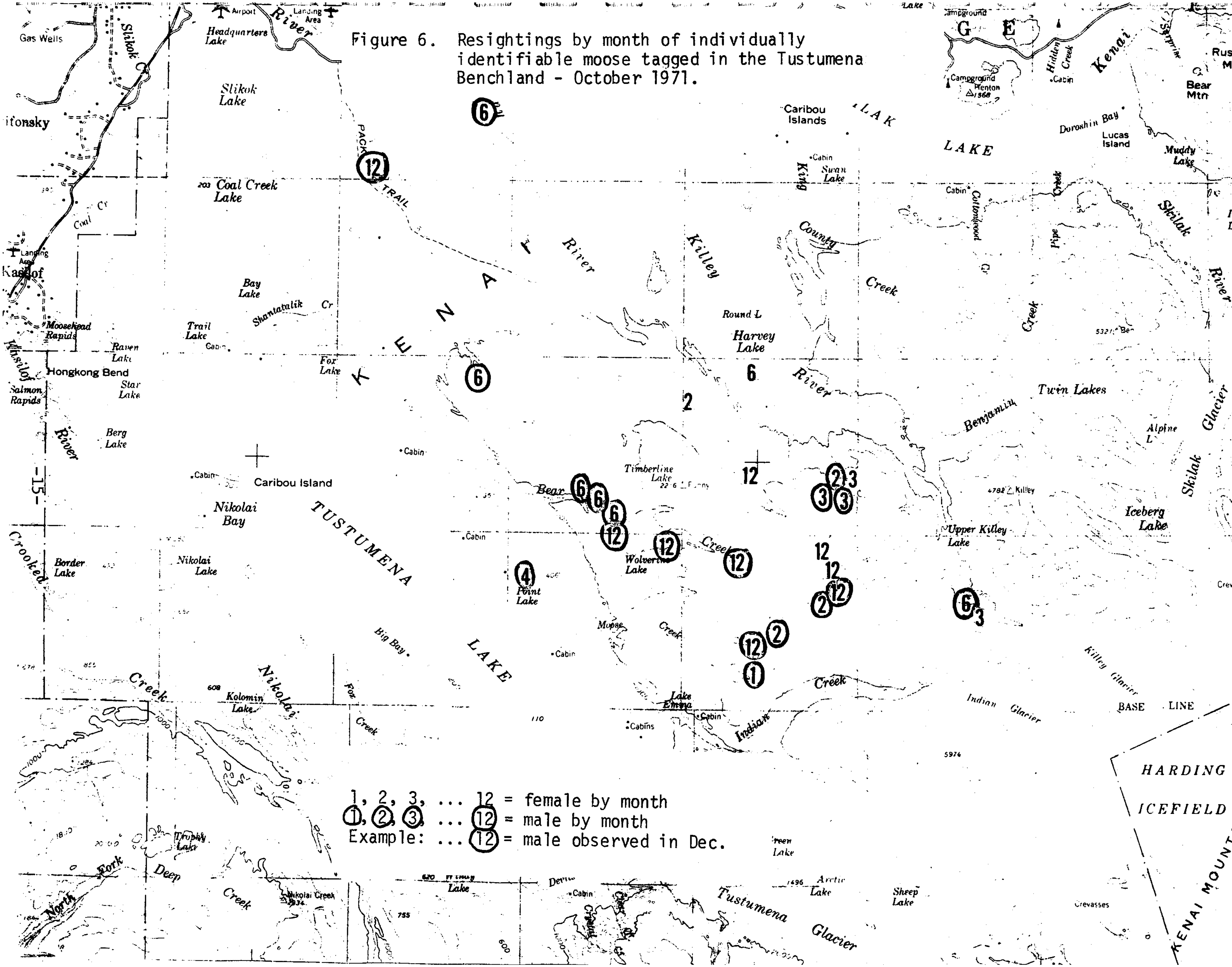
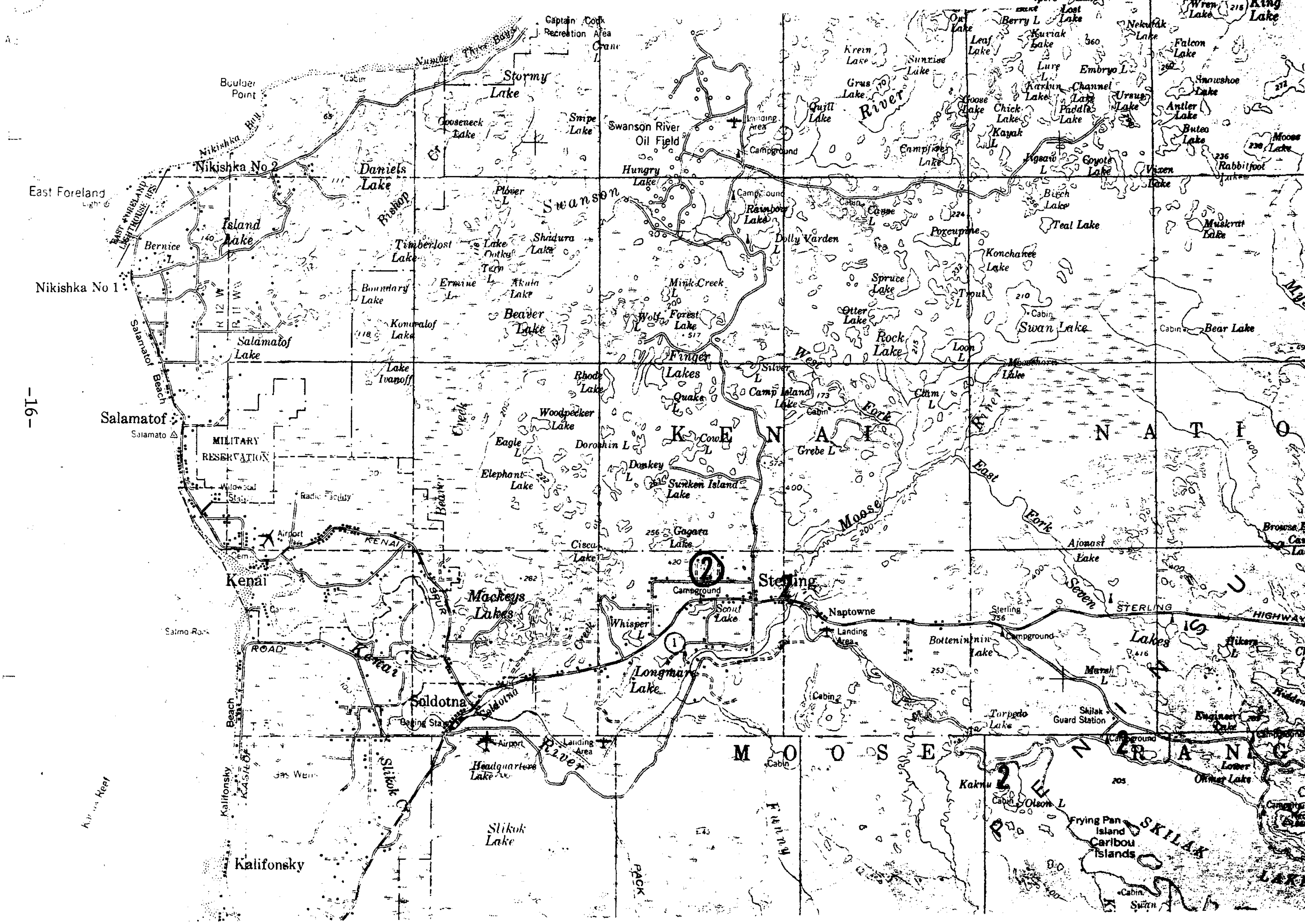


Figure 6. Resightings by month of individually identifiable moose tagged in the Tustumena Benchland - October 1971.

Figure 6. continued. Resightings by month of individually identifiable moose tagged in the Tustumena Benchland - October 1971.



(14/27) of the animals tagged in the benchland were located wintering near the tagging area. This suggests that a substantial portion of this population winters in its rutting area. Past observations by Alaska Department of Fish and Game personnel and U.S. Bureau of Sports Fisheries and Wildlife personnel (Bob Richey, *viva voce*) support the resident wintering idea. Browse form class in much of the area suggests extensive winter use in past years. Reconnaissance flights conducted from December, 1972 to April, 1973 revealed that most moose move into heavily timbered areas below 1800 feet elevation after snowstorms, but if winds occur and high areas are blown bare, within a day or two the animals will immediately move back to elevations up to 3,000 feet. Similar observations were made during flights conducted in late winter 1971. As was discussed with the Big Indian Creek population, May flights failed to locate animals in alpine areas where they were observed in all previous months (December-April), suggesting they were at lower elevations. In addition most sightings of bulls during late April and May were made at lower elevations than December-March sightings. Movements of three bulls that wintered above timberline, but moved lower in May, further substantiate this. All these observations indicate that to winter as high as possible then move lower in early spring may be a common pattern for many highland moose populations. Calving areas for the benchland group were not determined, as no May or June observations of females were made.

RECOMMENDATIONS

Reconnaissance flights throughout Subunits 15A and 15B should be continued on a once per week minimum basis to derive maximum information from tagged animals. Monthly flights should be conducted in Subunit 15C to look for possible tagged animals from 15B and to locate concentrations of moose for tagging in 15C.

The tagging program should be expanded to Subunit 15C. The first tagging effort should be in the Caribou Hills during September or October.

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

LITERATURE CITED

Berg, W. G. 1971. Habitat use, movements, and activity patterns of moose in northwestern Minnesota. M.S. Thesis Univ. Minnesota (unpubl.) 98pp.

Edwards, R. Y. and R. W. Ritcey. 1956. The migrations of a moose herd. J. Mammal. 37(1):486-494.

Goddard, J. 1970. Movements of moose in a heavily hunted area of Ontario. J. Wildl. Manage. 34(2):439-445.

Houston, D. B. 1968. The Shiras moose in Jackson Hole, Wyoming. Grand Teton Nat. Hist. Assoc. and Natl. Park Sev., U.S. Dept. Inter. Tech. Bull. 1. 110pp.

Knowlton, F. F. 1960. Food habits, movements, and populations of moose in the Gravelly Mountains, Montana. J. Wildl. Manage. 24:162-170.

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

______________. 1973. Moose migrations in North America. Proc. Int. Symp. Moose Ecology. Quebec. (in press).

______________. and J. L. Davis. 1971. Moose research report. Fed. Aid to Wildl. Rest. Proj. Seg. Rept. Vol. XII W-17-3.

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

Nielson, A. E. and W. M. Shaw. No date. A helicopter-dart gun technique for capturing moose. Idaho Dept. Fish and Game Publ. Mimeogr. 183-199pp. (In Soldotna office ADF&G files)

VanBallenberghe, V. and J. M. Peek. 1971. Radiotelemetry studies of moose in northeastern Minnesota. J. Wildl. Manage. 35(1):63-71.

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