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MOOSE RESEARCH REPORT

by

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Project Progress Report
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JOB PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperators: Alaska Department of Fish and Game, U. S. Bureau of Sport Fisheries and Wildlife, Kenai NWR

Project No.: W-17-3 Project Title: Moose Investigations

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

Period Covered: July 1, 1970 through June 30, 1971

SUMMARY

Natality, mortality and yearling recruitment of moose (*Alces alces gigas*) were determined in four one-square-mile pens. During the period June 1968 through June 1971, calf production ranged from 43 to 72 calves per 100 adult females (mean 58:100). Yearling recruitment varied between 11 and 41-45 yearlings per 100 adult females (mean 25-27). Adult mortality almost balanced yearling recruitment, with an overall change over four years of + 3 percent of the adult population.

Mortalities exceeded proportion of presence in the penned populations among calves (28 percent of recorded mortalities vs. 21 percent presence in the population $P > .20$; t-test) and animals 12-24 months of age (24 percent vs. 14 percent $P < .10$; t-test). Mortalities of females over 24 months of age (48 percent of mortalities) were fewer than adult females' proportion in the population (55 percent) ($P > .20$, t-test).

On 1 July 1971 the pens contained 29 adult females, 22 calves, 13 yearlings and 11 adult males: total 75 moose, or a mean density of 18.8 moose per square mile. Age structures of penned populations were equivalent to one another and to the population immediately outside the pens ($P > .10$; x^2 test).

Since July 1969, 417 sera, 174 whole blood specimens and 170 smears were collected from moose of all ages during all months of the year. Sera were analyzed by standard auto-screening (SMA-12) processes and electrophoresis for 16 parameters. Whole blood specimens and smears were analyzed for standard hematologic values. Multiple regression analyses are being performed on all parameters with respect to season, location and method of collection and age, sex, reproductive condition, body measurements and body weight of the moose. Calculations are not complete.

Sera from 12 winter-killed moose showed depressed levels of calcium, phosphorus, glucose, uric acid, total protein, albumin and a depressed albumin/globulin ratio. BUN was elevated 250 percent over previously estimated "normal" values.

Twig-count methods for determining browse utilization proved more precise in heavily-overused range than in normally browsed range.

Forty whole body weights of moose were obtained and a weight/age curve was constructed. Body weight fluctuated seasonally as much as 30 percent over basal June weight, but June and September weights appeared to increase progressively through at least the 13th year of life. Cows with calves weighed 8-18 percent less in summer than the same or similar individuals when without calves.

Girth/total length ratio was found to be a probably valid indication of relative weights of sequentially-handled individuals, but was not valid as a weight estimator for different individuals.

Food intake and activity patterns of three tame moose (two males) were observed for 99 hours during summer on normal range, for 19 hours in winter on normal range and for 30 hours during winter on depleted range.

Moose consumed approximately the same number of bites of forage each day in winter and summer, but the consumption was concentrated into approximately two-thirds the time in winter. In winter, moose spent a greater proportion of each daylight hour in feeding (61 percent vs. 43 percent in summer) and consumed slightly more bites per hour of feeding (730 vs. 646).

Food eaten varied between summer and winter, and moose ate a greater variety of forage during all seasons than previously realized. Birch (Betula papyrifera) leaves comprised 56 percent (by number of bites) of the summer diet, forbs 25 percent, grasses, sedges and aquatics 10 percent and willow (Salix spp) 5 percent. In winter, diet on range that had supported average moose numbers for the area was 72 percent birch twigs, 21 percent lowbush cranberry (Vaccinium vitis-ideae), and 6 percent willow and alder (Alnus crispa). On depleted winter range, stocked for 18 months with abnormally high moose densities, birch twigs composed only 22 percent of the diet. The bulk of bites taken were of lowbush cranberry (51 percent) and fruticose lichens (23 percent). Bites cranberry: bites birch and bites lichen:bites birch ratios reached 10-30 in May.

Identifiable food from moose killed in early December on climax willow range was (by volume) 59 percent willow, 33 percent birch and 8 percent aspen (Populus tremuloides). Similar values for animals in seral birch range were 39 percent willow, 36 percent birch, 14 percent lowbush cranberry and 6 percent aspen. Willow was selected out of proportion to its abundance in the seral range.

Numbers of rumen protozoa per cc. of rumen liquor and proportion of microorganisms (by volume) in the liquor were greater on climax willow range than on seral birch range, indicating perhaps the former range type is of higher quality.

Snow cover at the Moose Research Center was a minor factor in limiting available food for moose during 1970-71.

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BACKGROUND

Management of moose (Alces alces) in Alaska has always relied on gross knowledge: 1) of population indices (eg: relative numbers, sex ratios, age composition, apparent natality) gained through observation (usually by air) of large numbers of animals; 2) of hunter harvest learned from reporting procedures; 3) of unusual mortalities ("die-offs") when noticed; 4) of in utero pregnancy rates; and 5) of occasional crude and subjective observations of browse conditions. The state's expanding human population makes these methods, by themselves, obsolescent for various biological and political reasons.

For example, on the Kenai Peninsula, an extensive (more than 350,000 acres) burn occurred in 1947, with a subsequent striking increase in the number of moose present (Spencer and Hakala, 1964). By the late 1950's or early 1960's, numbers seemed to have stabilized at a high level; yet the predominately birch seral type was noticably browsed in very few areas, and hedged in even fewer places. Moose production had fallen behind browse production. No major "die-off" had been recorded, browse was not (to the superficial observer) over-used, hunter harvest was low in relation to the moose population size, and most (more than 90 percent) cow moose were pregnant in fall and early winter. Less-than-obvious factors were at work. More sophisticated knowledge of and means of quantifying moose physiological and vegetation parameters were needed.

Situdtions requiring such knowledge are not localized on the Kenai Peninsula. The information is needed for solving present and future problems wherever moose occur in the state. The Tanana River flats near Fairbanks support a moose population similar in density to that in the Kenai 1947 burn. In spring 1965, gross signs of loss of condition were observed, few viable calves were produced, and collections revealed severely undernourished calves. Classical symptoms of severely browsed shrubs and high moose densities were present, but more specific analysis was impossible given the then-and-present state of knowledge. At about the same time (1962 through 1965) moose numbers apparently declined markedly in the Nelchina Basin: no explanation but severe winters was possible. Matanuska Valley populations, the only ones in the state even possibly manipulated by hunting, fluctuate in ways that could be better understood and predicted by more specific knowledge of moose-habitat interrelationships than is currently available.

During the winter and spring of 1970-71, die-offs occurred in at least two areas of the state: the Tanana Flats and various drainages on the west side of upper Cook Inlet. These winter snow-caused mortalities will likely affect moose numbers and browse for at least several years.

The overall project objective of jobs carried out at the Kenai Moose Research Center is to obtain a more thorough and specific knowledge of how moose affect vegetation and how vegetation affects moose.

Within the last decade, classical theories of ungulate population regulation have been increasingly questioned. The idea of moose populations being controlled catastrophically by quantity of available winter range (eg: Spencer and Chatelain, 1953), while still the best explanation of some populations' fluctuations, did not fully describe others. As more data became available, nuances of selective mortality by age and sex and the importance of range quality (Klein, 1970; Flook, 1970) to Cervids became more evident. Some populations appeared to be self-regulating without catastrophy. These populations were often characterized by low productivity and medium to high densities (Wynne-Edwards, 1970; Cole, 1971; Houston, 1971).

The ecosystem approach to such problems has become increasingly popular as methods have developed. The approach is a multi-variant one, with feedback mechanisms, predation, food quality and quantity and other variables considered from an energy-flow standpoint (cf: Petrides et al, 1968; Lewis, 1969; Wagner, 1969). To date, probably no big game populations are well enough known for study by proper ecosystem-type analyses. The one attempt to thus consider a moose population, though confined primarily to only a consideration of biomass, (Jordan and Botkin, 1970) failed because of many incomplete data being inserted into the model.

The logical first step in determining energy-flow relations in an ungulate ecosystem is determination of the energetics of individual animals. Several ungulate studies to date have considered energetics of wild herbivores (eg: Abrams, 1968; Rogerson, 1968; Silver et al, 1969; Silver et al, 1971) but none have investigated moose. Similarly, recent studies have evaluated nutritional requirements of ungulates other than moose (eg: Nordan et al, 1968; Taylor, 1968; Ulbrey et al, 1969; McEwan and Whitehead, 1970).

The study of animal nutrition as it affects reproduction is especially relevant to considerations of population regulation, especially in moose, where maximum mortality probably occurs within several days postpartum (LeResche, 1968). Studies of ungulates (eg: Thomson and Thomson, 1948; Verme, 1962; Verme, 1969) and other mammals (eg: McLean and Usher, 1970; Nobmann and Adams, 1970; Shoemaker and Wurtman, 1971) confirm the importance of good nutrition to maximal reproduction.

Moose research dealing with nutritional aspects of productivity has been slight. Most work has involved a population approach to learning productivity, mortality and recruitment, often by aerial counts (eg: Denniston, 1956; Pimlott, 1956, Spencer and Hakala, 1964; Knowlton, 1960; Rausch and Bratlie, 1965; Simpkin, 1965; Rausch and Bishop, 1968; Bishop, 1969). Fewer studies have used physiological or behavioral approaches to learning productivity (eg: Rausch, 1959; LeResche, 1968; Houston, 1968; Markgren, 1969). No other productivity records for individual moose (except by ovarian analyses) over more than one season appear in North American literature (cf: LeResche, 1970), although Soviet domestication work at Pechora-Ilych Reservation (Knorre, 1961) has undoubtedly gathered such information.

Evaluation of the nutritional status of animal populations remains difficult despite many newly suggested techniques (Jeliffe, 1966). Analyses of urine (Blaxter et al, 1966), epithelial tissue (Nutr. Res. 1970), saliva (Murphy and Connell, 1970), blood constituents and body weight and size have been attempted as indicators of nutritional status. The latter two methods were selected as most practical and promising for use on moose populations.

Blood studies of moose and other wildlife species have been few and superficial and only sometimes related to nutrition. Braend (1962) considered blood groups in moose, Nadler et al (1967) studied serum proteins and transferrins, and Houston (1969) analyzed several serum parameters from 13 moose. Dietrich (1970) reported hematology of six moose and several other arctic mammals. More thorough nutrition-related studies have been carried out on other Cervidae. Herin (1968) reported 14 blood parameters for 39 elk (*Cervus canadensis*). Kitts et al (1956) related age and nutrition to hematological values in black-tailed deer (*Odocoileus hemionus c.*). More recently, Seal and Erickson (cf: 1969) have begun quite sophisticated blood studies of several large mammals. LeResche (1970) published serological and hematological values for more than 250 moose, but considered the data incomplete at that time. Nevertheless, he suggested that several parameters (calcium, phosphorus, BUN, uric acid, cholesterol, albumin SGOT) were promising as indicators of nutritional status.

Literature regarding domestic animal and human clinical chemistry is much more complete than that concerning wild animals (cf: Swenson, 1970; Davidson and Henry, 1969 for major review texts). This literature has established the value of blood analyses in nutritional and other studies. Useful parameters include calcium (Kendall et al, 1970; Ramberg et al, 1970a; Ramberg et al, 1970b) glucose (Khan et al, 1970; Young et al 1970), urea (Preston et al, 1965; Eggum, 1970; Metzger et al, 1970), protein (Kuttler and Marble, 1960; Beaton and McHaney, 1966), fatty acids (Mackenzie et al, 1970), insulin (Trenkle, 1970), hematologic values (Anderson et al, 1970), and others (Davidson and Henry, 1969).

Special problems are presented when one attempts to evaluate nutritional status of wild animals using serologic and hematologic techniques. Sampling may be done only when animals are captured or killed and serial sampling of individuals is often impossible. Further, it is seldom possible to adequately evaluate food intake or environmental stresses. One of the most important problems in studying wild animals is that they are unaccustomed to restraint, and the very collection of samples can result in stresses that alter the parameters measured. Few studies have evaluated these factors satisfactorily. Wilson (1970) reviewed stressor agents on domestic animals and their effects, including some mention of changes in blood values. Leise et al (1970) studied effects of restraint on enzymes in leucocytes of rabbits. The uncertainty involved in such measurements indicates the importance of standardizing collecting methods as much as possible and of exercising extreme caution in evaluating blood constituents (eg: glucose) most reactive to the acute stresses of capture.

Measurements of body weight and morphometry are potentially valuable techniques in wild animal studies primarily because data are easy to obtain and values are not subject to acute stress-related changes. Although not acutely variable, whole body weight is subject to certain variation because of changes in rumen volume (Ledger, 1968), genetic characteristics (Tamer et al, 1970) and normal seasonal variability (Verme, 1970). Varying proportions of body constituents (eg: fat, muscle, water) (Short et al, 1969; Tamer et al, 1970; Seltzer et al, 1970) by season, nutrition, etc., further complicate this measurement of live animals. Growth patterns and body measurements, especially when used in conjunction with body weights (Klein, 1968; Wood and Cowan, 1968; Verme, 1963, 1970), minimize some of these problems if valid baseline values are available.

A tremendous number of herbivore/range studies have concentrated on the range itself, with little knowledge of animal health, reproduction parameters, etc. Many of these studies have inferred animal abundance from evidence of plant use. Studies have, in the main, concentrated on browsed species, (eg: Julander, 1937; Young and Payne, 1948), but others (eg: Harlow, 1959) have taken a broader approach. Since many big game species commonly inhabit seral ranges, many management-oriented studies have concentrated on factors affecting plant succession (cf: Heinselman, 1954; Patton and McGinnes, 1964; Halls and Epps, 1969; Mutch, 1970). Others have investigated herbivores' effects on succession and production (Garrison, 1953; Hendrick, 1958; Lay, 1965; Crouch, 1966; Krefting et al, 1966; Bergerud, 1968; Goodiman and Marquis, 1969; Jordan and Rushmore, 1969) and artificial ways of slowing succession or restoring a seral state (Gibbens and Schultz, 1962; Pienaar, 1968; Leege, 1969).

A major stumbling-block in range-oriented studies has been the difficulties involved in developing statistically valid browse production and utilization measuring methods (cf: USDA, 1970). These problems result in part from the extreme variances found in most random measurements

(LeResche, 1970), which suggest nonrandom utilization. Further difficulties stem from previous lack of exact knowledge of how many animal-days use a unit of range was sustaining. Previous studies have estimated forage production primarily by canopy cover (Evans and Jones, 1958; Goebel et al, 1958; Daubenmire, 1959; Peek, 1970), or stem counts and measurement (Bishop, 1969). Many studies have estimated browse utilization by time-consuming methods of twig counting (Heady et al, 1959; Shafer, 1963; Telfer, 1968; Bishop, 1969), but these methods have proven too imprecise in instances where they have been sufficiently tested (LeResche, 1970). Other methods involving browse form class are in wide use in survey-type work (Cole, 1963; Patton and Hall, 1966) but present no precise animal-use estimates.

Since utilization estimates from plants are impossible with current techniques, many studies examine animals and their behavior to discover patterns of use. Most of these studies (eg: Bassett, 1951; McMillan, 1953; Harry, 1957; Knowlton, 1960; McMahon, 1964; Houston, 1968; Bell, 1970; Nicholson et al, 1970) are concerned primarily with the kinds of food eaten, but many also attempt to estimate quantity of food consumed (cf: Van Dyne, 1968). Common techniques range from feeding trials of captive or domesticated animals (Palmer, 1944; Bilby, 1968; Reid, 1968; Marsh et al, 1971; Ulrey et al, 1971) to micro- and macro-analyses of stomach contents or feces from killed or living animals (Mulkorn and Anderson, 1959; Brusven and Mulkern, 1960; Storr, 1961; Bear and Hansen, 1966; Stewart, 1967; Field, 1968; Gaare, 1968; Sparks, 1968; Sparks and Malechek, 1968; Veckert, 1968; Galt et al, 1969; Hansen and Flindere, 1969; Nellis and Ross, 1969; Williams, 1969; Medin, 1970; Rice, 1970; Ward, 1970), chemical methods (Theurer, 1970) and observations of wild (Harper et al, 1967; Miller, 1968; Houston, 1968) or tame (Bjugstad et al, 1970; Bergerud and Nolan, 1970; Hungerford, 1970; Laycock and Price, 1970; Martin, 1970; Nixon et al, 1970; Short, 1970; Wallmo and Neff, 1970; LeResche et al, 1971) animals.

Tame animal studies solve most of the problems associated with measuring use from what is left behind and demonstrate food habits not obvious when browsed plants are observed (LeResche et al, 1971). However, other variables are introduced when tame animals are dealt with. Feeding behavior of tamed animals may be altered by taming or by supplementary feeding necessary to tame the animals. Little objective evidence is available to dispute these problems, but much empirical data (Buechner, 1950; Wallmo, 1951; McMahan, 1964; Wallmo and Neff, 1970) suggest these are minimal, especially if supplemental feeding ceases when observations begin. Problems of individual variation and quantification are more serious (cf: Wallmo and Neff, 1970).

Once range production and response to utilization and species composition and quantity of food consumed are known, the elements of food quality become important (Klein, 1970). Chemical composition, palatability and digestibility all determine the ultimate usefulness of a gram of available forage to a particular animal in a particular physiological state.

Early chemical composition studies stressed analyses of protein and sometimes phosphorus content of forages (Einarsen, 1946; Jameson, 1952; Swank, 1956; Taber, 1956; Murphy and Coates, 1966; Boyd, 1970; Klein, 1970b). These values were found, in a general way, to be directly related to range quality as indicated by ungulate browsing level, survival and reproduction. Later, proximate analyses, for crude protein, crude fat, crude fiber, ash and nitrogen-free-extract were commonly used to define forage quality (eg: Swift, 1948; Smith, 1957; Halls and Epps, 1969). Many more complex analyses of plant material (Van Soest, 1964; Short, 1966; Dietz, 1970) were undertaken, and very complete chemical and energy data are now available for many plant species (Hamilton, 1958; Cowan et al, 1970).

Nutritive value of plants was found to vary with many factors (Oelberg, 1956), including site (Cook, 1959), time since burning (Cowan et al, 1950; DeWitt and Derby, 1955), season (McConnell and Garrison, 1966; Tew, 1970), palatability and digestibility.

"Palatability" is a conglomerate term and includes elements of food selection, nutritive value and digestibility, as well as inherent variabilities in tastiness of a plant to a given animal. All studies have shown that what an animal eats is almost invariably the most nutritive and digestible forage available. Thus, discussions of "palatability" are in truth considerations of digestibility and nutritive values (eg: Albrecht, 1945; Plice, 1952; Heady, 1964; Longhurst et al, 1968, 1969).

That some plants were high in nutrients and/or energy, but little eaten by herbivores led to considerations of digestibility factors and the discovery of digestive inhibitors. Regardless of its nutritive value as determined chemically, a plant's usefulness to its consumer is only as great as its digestibility (Johnston et al, 1968; Ulrey et al, 1970). Digestibility has been found to vary by season (Christian et al, 1970; Haggar and Ahmed, 1970), by mixture of forages consumed (Dror et al, 1970), by various plant constituents that decrease forage digestibility by their own inherent undigestibility (Short, 1966; Van Soest and Jones, 1968; Jones, 1970; Rittenhouse et al, 1970; Short and Reagar, 1970) or by inhibiting microbial action in the rumen and thereby decreasing digestibility for all food taken in (Oh et al, 1967; Oh et al, 1968; Mueggler, 1970). Techniques for determining digestibility include feeding trials (Short, 1966), and in vitro (Tilley and Terry, 1963; Pearson, 1970) and in vivo (Short, 1970) methods.

Concurrent with in vivo digestibility techniques, studies of rumen metabolism are of use in determining dietary quality of domestic and wild ruminents (Nagy, 1970). These studies range from simple field-adapted collecting and processing procedures (Klein, 1962; Short et al, 1966; Klein, 1970; Klein and Schonheyder, 1970) to comprehensive treatises on microbiology and energetics (eg: Blaxter, 1962; Hungate, 1966). Studies relevant to wild animal work have considered rumen structure (Hofmann, 1968), micro-organisms (Hobson and Mann, 1968; McBee et al, 1969; Coen and Dehority, 1970; Takayama et al, 1970) and specific food substances (Lough and Garton, 1968; Clarke and Hawke, 1970). Volatile fatty acid determination has proved most useful in many practical studies (Maloiy et al, 1968; Oh et al, 1969; Dror et al, 1970).

OBJECTIVES

To measure natality, mortality and general condition of moose within four one-square-mile enclosures.

To establish baselines by season, age and sex for the following serological and hematological parameters in moose and to evaluate their usefulness as indicators of nutritional status in moose:

A. calcium
B. inorganic phosphorus
C. glucose
D. urea nitrogen (BUN)
E. uric acid
F. cholesterol
G. total protein
H. albumin
I. albumin/globulin ratio
J. alpha-1, alpha-2, beta and gamma-globulins
K. bilirubin
L. alkaline phosphatase
M. lactic dehydrogenase (LDH)
N. glutamic oxalacetic transaminase (SGOT)
O. hemoglobin
P. hematocrit
Q. white blood cells
R. differential cell count (including segmenters, lymphocytes, eosinophils, monocytes, basophils)

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

To learn changes in rumen protozoa levels in moose on various winter diets.

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

PROCEDURES

General Description of the Moose Research Center Facility

The Kenai Moose Research Center comprises four one-square-mile enclosures located in the area of the 1947 burn near Kenai, Alaska. These enclosures contain representative vegetation of both burned (regenerative: predominately birch *Betula papyrifera* and white spruce *Picea glauca*) and remnant: (mixed birch-spruce-aspen *Populus tremuloides* stands). Marshland typical of summer range is included as are well-drained hillocks supporting winter browse-species.

The entire area has been type-mapped into 11 vegetation types, and soil profiles of representative types have been completed. One hundred and forty permanent plant-succession measuring plots have been installed subjectively (five in each pen for each of seven major vegetation types), and each has been read once. A modified Daubenmire (1959) canopy estimate was employed. Eight hundred and forty permanent browse production/utilization plots have been established randomly within habitat types and these have been used to measure production (once within two of the four pens) and use (four times in one pen, three times in one pen, and once in two other pens). Twig-count and clipping methods are employed. Five five-acre exclosures are present, at least one within each enclosure.

Nine fenceline traps were constructed during the reporting period, bringing the total to 21; twelve of which are within pens and nine of which are on the outside of the fenceline. Fig. 1 is a generalized map of the facility showing traps, exclosures, etc.

The log headquarters building sleeps eight, and is accessible by road during dry seasons. Two-mile-long Coyote Lake provides access by float or ski plane. The Center may be reached by light plane from Anchorage in one-half hour.

Populations of moose within the enclosures as of February 1, 1970, five months after enclosing pens 3 and 4, were:

Pen	Cows	Calves	Bulls	Total
1	5	0	2	7
2	9	1	2	12
3	7	4	1	12
4	11	5	2	18
	32	10	7	49

Pens 1 and 2 will be left unmolested in terms of moose numbers, allowing the populations to increase, decrease, or remain constant as they will. Pen 3 will be retained at its present population level and sex structure, as representative of extra-pen populations in this area. Pen 4 will be stocked with as many as 50 moose (four to five times "normal" density).

Table 1 is a history of major events in construction of the facility and provides reference as to timing of events leading to the current description.

Figure 1. Diagramatic layout of Kenai Moose Research Center.

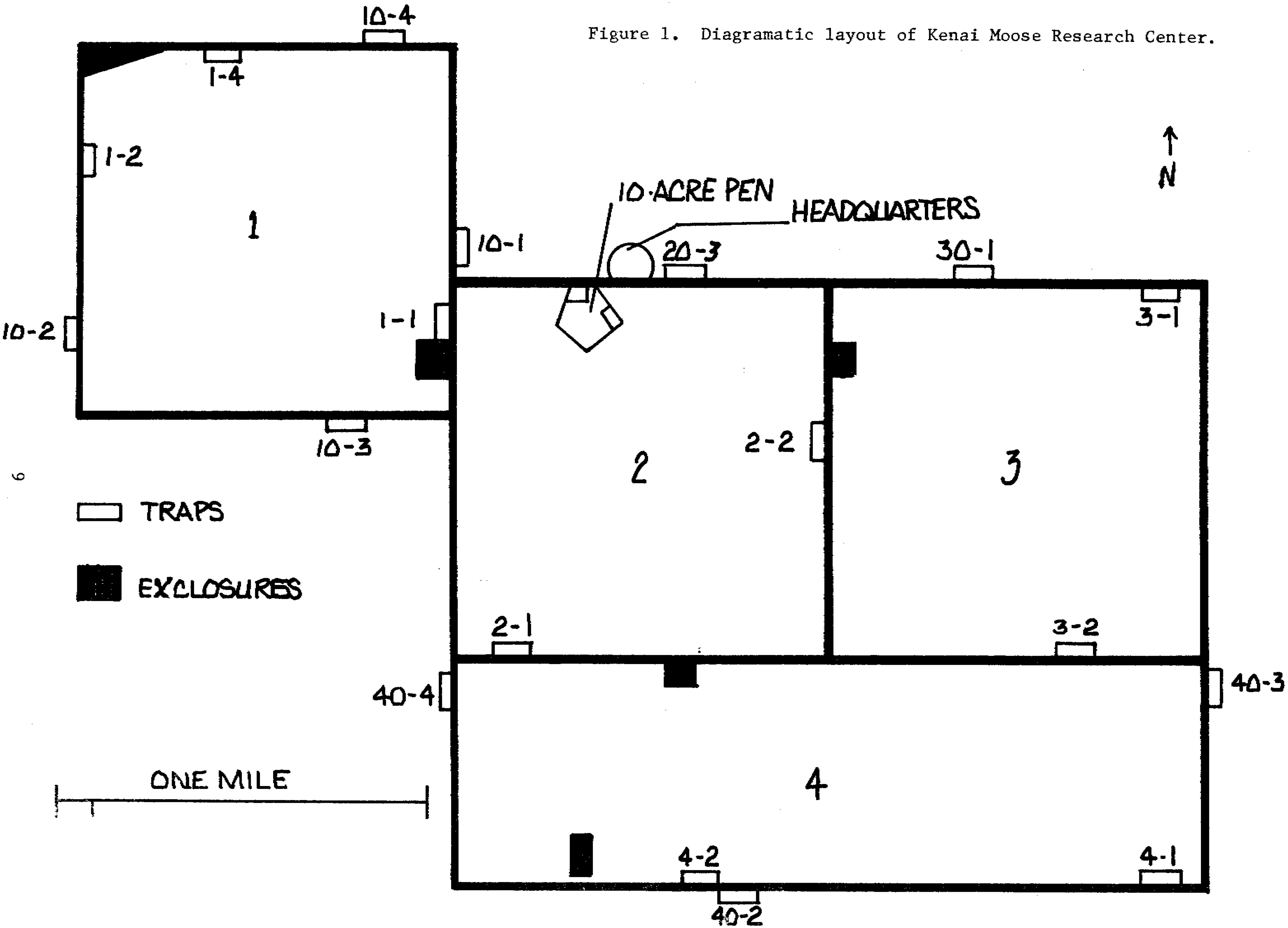


Table 1. Chronology of establishing the Kenai Moose Research Center.

June 1966:	Construction begun.
September-October 1967:	Browse production estimated in Pens 1 & 2. Successional plots established and read in Pens 1 & 2.
January 1967:	Pens 1 & 2 enclosed.
January 1968:	Moose in Pens 1 & 2 collared.
April 1968:	Browse utilization estimated in Pens 1 & 2.
1968:	Yearling bull introduced into Pen 1.
April 1969:	Browse utilization estimated in Pens 1 & 2.
June 1969-January 1970:	Eleven traps constructed in all pens. Blood collections begun.
June-July 1969:	Successional plots established and read in Pens 3 & 4.
August 1969:	Pens 3 & 4 enclosed.
October 1969:	Two male calves introduced into 10-acre pen in Pen 2.
January-February 1970:	Numbers of moose in Pens 3 & 4 determined. Replicate count experiments conducted.
April 1970:	Browse utilization estimated in all four pens. Plots cleaned of pellets.
May 1970:	Female calf introduced into 10-acre pen in Pen 2.
August 1970:	Twenty traps complete: 11 inside pens; nine outside.
November 1970:	Two male yearlings released from 10-acre pen into Pen 2.
March 1971:	Replicate count experiments conducted.
May-June 1971:	Pellet-plots counted and cleared in Pen 1. Browse utilization estimated in Pen 1.
June 1971:	Numbers of moose in pens redetermined and calves counted.

Productivity and Mortality

Mortality and natality within pens are measured by daily ground observations, periodic aerial observations, trapping and use of radio-tracking devices. General condition is estimated for trapped animals by methods described below.

Blood

Blood values are determined from serum and whole-blood samples obtained from trapped and hunter-killed moose and animals immobilized for marking outside of traps (Job 3). Table 2 lists sources of blood material.

Blood is obtained from live immobilized animals in sterile evacuated containers by jugular venepuncture. Four or five cc of whole blood are preserved with EDTH and a thin smear is made; serum is secured by centrifugation of cooled and clotted blood. Serum is separated into: 1) a NaF tube (1.5-2 cc) for glucose determination; and 2) a 4-5 cc. untreated sample for other parameters.

Analyses are performed by Alaska Medical Laboratories (Anchorage) using a Technicon Autoanalyzer SMA-12, standard hematological techniques and electrophoresis.

Browse Production and Utilization

Browse production and utilization and plant succession are estimated using methods previously described in detail (Bishop, 1969). A canopy-cover method after Daubenmire (1959), employing exclosures, is used for successional measurements and a twig-count method with clipping is used for production and utilization estimates. During this reporting period use was estimated in all old plots in pen 1, the ten-acre holding pen.

Weights and Measurements

Weights and measurements were obtained from trapped immobilized animals.

Tame Moose Feeding

Feeding habits of tame moose were studied by standing about one meter from the moose and recording species and size of each bite eaten by pencil on an IBM optical page reader sheet or by speaking into a tape recorder. Bite size was recorded by number of leaves (estimated) in summer and by twig length (also estimated) in winter. Hours of observation were distributed throughout daylight hours and periods of inactivity, urinations, defecations, breakage of shrubs and abnormal behavior were also recorded.

Ninety-nine hours of observation of two males and one female (all aged 12-14 months) took place in a 10-acre holding pen during July and

Table 2. Sources of moose blood for analysis: June 1969-May 1971.

	NUMBER OF SPECIMENS		
Source	Serum	Whole Blood	Slides
Trapping at Moose Research Center:			
Pen 1	20	15	5
Pen 2	25	16	10
Pen 3	15	13	7
Pen 4	22	15	12
Outside pens	40	26	9
Total Moose Research Center	122	85	43
Hunts:			
1969-70			
GMU 15C	32	26	49
15B	13	6	21
14A	39	26	42
14B	14	6	9
1970-71			
GMU 7	7	2	0
15A	28	0	0
Total Hunts	133	66	121
Tagging:			
Bottenintnin Lake (1970)	38	23	6
Moose River Flats (1970)	61	0	0
Skilak-Tustumena Beach (1971)	3	0	0
Moose River Flats (1971)	60	0	0
Total Tagging	162	23	6
TOTALS	417	174	170

August, 1970. Forty-one hours of observation of the same two males free-ranging in pen 2 and the same female confined to the 10-acre pen took place from February through May, 1971.

Tame animals were obtained as calves in October 1969 (males) and May 1970 (female) from Dr. Jack Luick of the Reindeer Experimental Station at Cantwell. They had been raised on browse and artificial feed and were supplementally fed calf pellets until July 1970.

The three were confined together until 11 November 1970, when the males were placed in pen 2. The female gave birth to a single calf on about 2 July 1971.

Average bite sizes were converted to weight by collecting and weighing 500 birch (Betula papyrifera) leaves (20 from each of 25 plants selected randomly) and twigs and whole plants representative (subjectively) of various bite sizes recorded during feeding observations.

Food Habits from Rumen Analysis

Rumen samples were collected during antlerless moose hunts in upland range (Juneau Creek; Unit 7; 2-6 December 1970; n = 8) and lowland seral range (Unit 15A; 15-16 December 1970; n = 8). One-liter samples of least-digested rumina were collected from these animals. The samples were taken from recently killed animals (less than 24 hours) and placed in plastic bags. They were washed with water on a 10 mesh/inch soil sieve within the next 24 hours and the washed solid fractions were placed in jars with 5 cc's of 10 percent formalin, shaken vigorously and frozen.

For subsequent analysis the procedure used by Martin and Korschgen (1963) and Brown (1961) was used. Each sample was thawed and washed over a 10 mesh/inch soil sieve. A subsample of approximately four tablespoonfuls (50-150 ml) of the material retained on the sieve was used for the detailed analysis. The unused portion was examined for species not found in the subsample and for parts of species that would aid in recognition of smaller parts in the subsample.

The subsample was placed in a flat-bottomed pan and floated in about 1/2 inch of water. Individual particles were picked up with forceps, identified, and placed with others of the same species or typed into a small dish. Unknown species and plant parts were separated and ultimately identified by comparison to better preserved portions of the same species. Plants that could not be identified to species were identified to a main group such as gramineous plants, sedges, browse, etc. A reference collection of browse twigs and reference to Morris et al (1962) and Hulten (1968) also aided in identification of plant parts and species.

When examination failed to show any more identifiable particles, the remainder of the sample was measured volumetrically by water displacement in a graduated cylinder, and listed as unidentifiable. Practically all unidentifiable material was believed to be browse. Over 90 percent (approx.) was woody material with all bark and other diagnostic parts removed. The remainder consisted of parts too small to recognize.

The separated particles were measured by the same volumetric method, and the volume of each species or plant type recorded. Quantities too small for measurement were recorded as traces.

Rumen Protozoa

Twenty cc. of rumen liquor were collected from 18 animals killed in the same hunts, strained through cheesecloth and the liquor was fixed with 0.25 cc. 10 percent formalin. A drop of liquor was diluted 1:10 with Lugol's iodine and shaken and then placed on a hemacytometer, where the protozoa in 10 mm^2 were converted to protozoa/ml.

After thorough mixing, 5 cc. of rumen liquor was placed into each of three graduated centrifuge tubes. Tubes were spun for 15-20 minutes at maximum centrifuge RPM (Aloe International Clinical Centrifuge) and proportion of sediment was recorded by measuring the supernate in a syringe.

Chemical Composition of Plants

Birch, willow, lowbush cranberry and aspen (bark) were collected for nutritional analysis according to plant height, diameter and use-form class. All specimens were oven-dried at 70° C for 14 days.

Snow Monitoring

Seven snow plots were established in pens 1 and 2. One plot was placed in each of the following habitat types: dense hardwoods, thin hardwoods, sedge meadow, spruce regrowth, birch-spruce regrowth (thin), birch-spruce (dense), spruce-ledum. At approximate 10-day intervals, a trench was dug in each plot and thickness and general consistency (eg: crystals, powder, ice) of each snow layer was recorded. Visibility of lowbush cranberry (*Vaccinium vitis ideae*) was also recorded at this time.

FINDINGS

Productivity and Mortality Within Pens

Table 3 presents raw tagging, breeding, and mortality data for all moose within the enclosures. Table 4 summarizes these data in terms of numbers calving and dying. Table 5 calculates natality, yearling recruitment and change in population size for penned and unpenned populations. Figure 2 compares trends of natality and recruitment inside and outside the pens.

On 1 July, 1971, populations within the four pens totaled 75 moose (18.8 per square mile). Components of the populations are tabulated in Table 6. Although the matter is complicated by introductions, experimental collections and escapes, it appears that numbers have returned to their approximate level when the pens were first enclosed. Populations in each pen declined initially for various reasons (pen 1 because of escapes and

Table 3. Histories of individual moose in Kenai Moose Research Center enclosures, January 1968 through June 1971

PEN 1

Moose #	Sex	Event	Date	Age	Circumstances
1	F	Tagged	January 1968	4+ years	Helicopter; not with calf
		Pregnant	January 1968		Palpation
		With 2 calves	7 June 1968	5 years	
		With 1 calf	17 June 1968		
		Escaped into pen 2 with 1 calf	4 September 1968		
2	F	Tagged	January 1968	4+ years	Helicopter; not with calf
		With 1 calf	4 June 1968	5 years	Observed
		Escaped into pen 2 with 1 calf			
3	F	Tagged	January 1968	5+ years	Helicopter; not with calf
		Pregnant	January 1968		Palpation
		With 1 calf	17 June 1968	6 years	Observed
		With no calf	11,14 October 1968		Observed
		With no calf	2,11,12,14 June 1969	7 years	Observed and trapped
		Radio installed	14 June 1969		Trapped
		Radio removed	20 August 1969		Trapped
		In oestrus	15 October 1969		Trapped
		With 1 calf (#370UC)	2 July 1970	8 years	Observed
		Weight, 920 pounds	10 September 1970		Trapped
		Calf survived to yearling	3 June 1971		Observed (#370UC)
		With 1 calf	3 June 1971	9 years	Observed
4	F	Tagged	January 1968	15+ years	Helicopter, not with calf
		With no calf, does not appear pregnant	5 June 1968	16 years	Observed
		Dead, not pregnant	18 May 1969	17 years	Apparent cause: old age
5	F	Tagged	18 January 1968		Helicopter; not with calf
		Last seen (presumed dead)	18 January 1968		Tagging

Table 3. (cont'd.) Histories of individual moose in Kenai Moose Research Center enclosures, January 1968 through June 1971

PEN 1

Moose #	Sex	Event	Date	Age	Circumstances
6	F	Tagged	January 1968	10+ years	Helicopter; not with calf
		With calf	22 October 1968	11+ years	Observed
		With no calf	2,4,11,12 June 1969	12 years	Observed, trapped
		Weight, 910 pounds	12 August 1970		Trapped
		With one calf (#670 Female)	23 July 1970	13 years	Trapped, weight 820 pounds
		Calf survived to yearling	3 June 1971		Observed
		No calf produced	3 June 1971	14 years	Observed
8	F	Tagged	24 January 1968	Calf	Helicopter
		Dead	2 February 1968		Killed during tagging
10	F	Tagged	January 1968	Calf	Helicopter
		With no calf	19 June 1969	2 years	Observed
		With 1 calf (#1070UC)	27 July 1970	3 years	Observed
		Weight, 725 pounds	6 August 1970		Trapped
		Calf survived to yearling	3 June 1971		Observed
		With 1 calf	3 June 1971	4 years	Observed
R70-8	F	Tagged, radio installed	10 July 1970	2 years	Trapped
		With 1 calf	3 June 1971	3 years	Observed
40	F	Five observations	21 May 1969 through 30 June 1970		Observed
		With 1 calf (4070)	27,28 July 1970		Observed
		Tagged	1 September 1970	2 years	Trapped
		Calf survived to yearling	3 June 1971		Observed
		With 1 calf	3 June 1971	3 years	Observed

Table 3. (cont'd.) Histories of individual moose in Kenai Moose Research Center enclosures, January 1968 through June 1971

PEN 1

Moose #	Sex	Event	Date	Age	Circumstances
41	F	Broke into pen with 4170 (calf)	13 October 1970		Observed, hole in fence
		Tagged	14 October 1970	7+ years	Trapped
		Released outside pen as #83	23 February 1971	7+ years	Trapped
UC	F	Broke into pen	14 October 1970		Observed
		With 1 calf	3 June 1971		Observed
35	M	Tagged	28 May 1970	2 years	Trapped
		Weight, 605 pounds	17 July 1970	2+ years	Trapped
		Weight, 715 pounds	22 September 1970		Trapped
		Antler spread 77.5 cm.			Trapped
		Last seen	7 March 1971	2+ years	Observed
43	M	Tagged & put into pen 1	7 June 1968	1+ years	Helicopter immobilization
		Apparently did not successfully breed	May-June 1969	2+ years	No calves in pen 1, May-June 1969
		Bred successfully	1969		Calves in pen 1, May-June 1970
		Right antler: 10 points 100 cm. spread est. 120 cm., weight 5 lbs.			Recovered
		Bred successfully	1970	3+ years	Calves in pen 1, May-June 1971
		Last seen	3 June 1971	4 years	Observed
670	F	Born to #6 Female	May-June 1970	Calf	
		First observed	22 July 1970		Observed
		Tagged	23 July 1970		Trapped
		Survived to yearling	3 June 1971	1 year	Observed
370UC	M	Born to #3 Female	After 21 May 1970	Calf	#3 Female observed pregnant
		First observed	2 July 1970		Observed
		Survived to yearling	3 June 1971	1 year	Observed

Table 3. (cont'd.) Histories of individual moose in Kenai Moose Research Center enclosures, January 1968 through June 1971

PEN 1

Moose #	Sex	Event	Date	Age	Circumstances
1070UC	M	Born to #10 Female	May-June 1970	Calf	
		First seen	27 July 1970		Observed
		Trapped - escaped	15 September 1970		Trapped
		Survived to yearling	3 June 1971	1 year	Observed
4070UC	?	Born to #40 female	May-June 1970	Calf	
		First seen	15 September 1970		Observed
		Survived to yearling	3 June 1971	1 year	Observed

PEN 2

Moose #	Sex	Event	Date	Age	Circumstances
1	F	Escaped into pen 2 with 1 calf	4 September 1968	5+ years	
		With no calf	10 October 1968		Observed
		With no calf	15 July 1969	6+ years	Observed
		Weighed 675 pounds	5 September 1969		Trapped
		With no calf	10 June 1970	7 years	Trapped
		With no calf	3 June 1971	8 years	Observed
2	F	Escaped into pen 2 with 1 calf	4 September 1968	5+ years	
		With 1 calf	4 September 1968		Observed
		Calf not seen	21 April 1969		Observed
		With no calf	30 May, 7 July 1969	5 years	Trapped
		Radio installed	13 August 1969		Trapped
		Not pregnant	28 May 1970	6 years	Trapped
		With no calf			Observed
		With 1 calf	3 June 1971	7 years	Observed

Table 3. (cont'd.) Histories of individual moose in Kenai Moose Research Center enclosures, January 1968 through June 1971

PEN 2

Moose #	Sex	Event	Date	Age	Circumstances
7 (R70-7)	F	Tagged	January 1968	4+ years	Helicopter; not with calf
		With no calf	18 June 1968	5 years	Observed
		With 1 calf	9 July 1969	6 years	Observed
		With 1 calf; weight 710 pounds	29 July 1969		Trapped
		In oestrus, with 1 calf	23 September 1969	6+ years	Trapped
		With no calf	26,27 February 1970		Helicopter; observed
		Not pregnant, with no calf	4 June 1970	7 years	Trapped
		Radio installed	4 June 1970		Trapped
		Weight: 865 pounds	23 July 1970	7+ years	Trapped
		With 1 weak, deformed calf	25 May 1971-7 June 1971	8 years	Observed
9	F	Tagged	January 1968	5+ years	Helicopter; with 1 calf
		With no calf	5,17 June 1968	6 years	Observed
		With 2 calves	11 June 1969	7 years	Observed; calves tagged
		With 1 calf	12 June 1969		Tagging-induced mortality
		With no calves	10 July 1969		Tagging-induced mortality
		Breeding (?)	31 October 1969	7+ years	With #45 male
		With no calves	4,25 June 1970	8 years	Trapped, observed
		With 2 calves	14 June 1971	9 years	Observed
11	F	Tagged	January 1968		Helicopter; not with calf
		With no calf	21 May, 10 October 1968		Observed
		"Especially" poor condition	1 May 1969		Observed
		With no calf	1 July 1969		Observed
		In oestrus	24 September 1969		Trapped
		Last seen alive	26 January 1970		Observed
		Carcass found	3 June 1971		Dead more than a year

Table 3. (cont'd.) Histories of individual moose in Kenai Moose Research Center enclosures, January 1968 through June 1971

PEN 2

Moose #	Sex	Event	Date	Age	Circumstances
12	F	Tagged	January 1969	6+ years	Helicopter; not with calf
		Not with calf	21 May 1968	7 years	Observed
		Not with calf	18 February 1969	7+ years	Observed
		Lost. Seen alive	1 May 1969	8 years	Observed
		Found dead	7 July 1969	8+ years	Died 3-6 July
	Autopsy:	Massive hemmorage left of rib cage; dead along fenceline			
		Lactating			
		Flaccid uterus			
		Weight: 610 pounds			
		Conclusions: Death perhaps due to combination of poor condition and hitting fence.			
13	F	Tagged	January 1968	7+ years	Helicopter with 1 calf
		With no calf	4 October 1968	8+ years	Observed
		With 1 calf; wt. 580#	30 July 1969		Trapped
		Found dead	August 1969	9+ years	Drowned in hole
16	F	Tagged	January 1968	9+ years	Helicopter with no calf
		With no calf	18 June 1968	10 years	Observed
		With no calf	9 July 1969	11+ years	Observed
		Hock tumor & displasia	3 August 1969		Observed
		Last seen (presumed dead)	26,27 January 1970	11+ years	Observed from helicopter
17	F	Tagged	January 1968	Calf	Helicopter
		Found dead	25 April 1968		Dart in carcass
52	F	Tagged	23 July 1969	2+ years	Trapped
		With 1 calf	18 June 1970	3 years	Observed
		Calf survived to yearling	3 June 1971		Observed
		With 1 calf	7 June 1971	4 years	Observed

Table 3. (cont'd.) Histories of individual moose in Kenai Moose Research Center enclosures, January 1968 through June 1971

PEN 2

Moose #	Sex	Event	Date	Age	Circumstances
R70-2	F	Tagged	22 May 1970	3 years	Trapped
		Lactating; wt. 635 pounds	17 July 1970		Trapped
		Calf last seen (survival unknown)	4 September 1970	4 years	R70-2 not seen until 3 June 1971
		With no calf	3,7 June 1971		Observed
R70-4	F	Tagged & introduced into pen 2 from outside	23 May 1970	3 years	Trapped
		Deserts calf	23 May 1970		Trapping-induced desertion
		With 1 calf	3 June 1971	4 years	Observed
R70-5	F	Tagged, introduced into pen 2, radio installed	24 May 1970	9 years	Trapped
		Died giving birth	27 May 1970		Twin fetuses; one breech presentation
Raquel	F	Brought from Cantwell as tame calf: In 10-acre pen	May 1970	1 year	Tame moose
		Confined with 2 1+ year old males	Through 30 November 1970	1+ years	
		With no calf	7 June 1971	2 years	Observed
Uncollared	F	Observed	1 June 1969	2 years(?)	Observed
		Six observations	Through 25 May 1970		Observed
		With 1 calf	8 June 1970	3 years(?)	Observed from helicopter
		Last seen with calf (calf seen 21 Jan.--survival probable)	30 September 1970		Observed
		With 2 calves	25 May-7 June 1971	4 years(?)	Observed

Table 3. (cont'd.) Histories of individual moose in Kenai Moose Research Center enclosures, January 1968 through June 1971

PEN 2

Moose #	Sex	Event	Date	Age	Circumstances
3995	F	Tagged	January 1968	5+ years	Helicopter; with no calf
		Dead	Smelled: 2 July 1969 Found: 8 July 1969	7 years	No autopsy possible
15	M	Tagged	January 1968	2+ years	Helicopter
		Last seen alive	10 October 1968	3+ years	Observed
		Carcass found	3 June 1970		Dead more than a year
4250	M	Tagged	January 1968	Calf	Helicopter
		Last seen (presumed dead)	January 1968		Tagging
36	M	Observed	23 July 1969	2+ years	Observed
		Breeding (?)	3,14,15 October 1969	2+ years	Observed with adult females
		Bred successfully	Fall 1969	2+ years	At least 2 calves in pen 2
		Antler spread (velvet): green	29 July 1970		Trapped
		Breeding	Fall 1970	3+ years	Observed with adult females in rutting behavior
		Bred successfully	Fall 1970	3+ years	Calves in pen 2 May, June 1971
		Last seen	3 June 1971	4 years	Observed
45	M	Tagged	21 October 1969	1+ year	Trapped-no antler development
		Antler spread (velvet): 23 cm.	5 April 1970		Trapped
		Breeding condition	October 1970	2+ years	In rutting group--forced away by #36 male
		Last seen	3 June 1971	3 years	Observed
Walter	M	Brought from Fairbanks as tame calf: In 10-acre pen	September 1969	Calf	Tame moose
		Rutting Weight, 660 pounds Antler spread 71 cm.	October 1970 to November 1970	1+ years	Observed Freeze-branded

Table 3. (cont'd.) Histories of individual moose in Kenai Moose Research Center enclosures, January 1968 through June 1971

PEN 2

Moose #	Sex	Event	Date	Age	Circumstances
Walter (cont'd.)		Released into pen 2 with bell	30 November 1970		
		Last seen	21 April 1971	2 years	Observed
Richard	M	Brought from Fairbanks as tame calf: In 10-acre pen	September 1969	Calf	Tame moose
		Weight: 690 pounds antler spread: 75 cm.	11 November 1970	1+ years	Freeze-branded
		Released into pen 2 with radio	30 November 1970		Released
		Last seen	3 June 1970	2 years	Observed
R70-2-70UC	?	Born to R70-2	22 May 1970	Calf	R70-2 trapped - placenta observed
		First seen	12 June 1970		Observed
		Last seen with cow	14 September 1970		Observed
		Survived to yearling(?)	3 June 1971	1 year	Two yearlings observed in pen 2
UC70UC	?	Born to UC	May-June 1970	Calf	
		First seen	27 July 1970		Observed
		Last seen with cow	30 September 1970		Observed
		Survived to yearling(?)	3 June 1971	1 year	Two yearlings observed in pen 2
5270UC	?	Born to 52	May, June 1970	Calf	
		First seen	18 June 1970		Observed
		Survived to yearling	3 June 1970	1 year	Observed with 52
5050	F	Tagged; with no calf	August 1969	2+ years	Trapped
		Killed; in oestrus	23 October 1969	2+ years	Overdose of M50-50 diprenorphrine

Table 3. (cont'd.) Histories of individual moose in Kenai Moose Research Center enclosures, January 1968 through June 1971

PEN 3

Moose #	Sex	Event	Date	Age	Circumstances
20	F	Tagged; with 1 calf	6 August 1969	9+ years	Trapped
		With 1 calf	27 February 1970	9+ years	Observed from helicopter
		Calf survived to yearling (#2069UC)	29 June 1970	10 years	Observed
		With 1 calf	3 June 1971	11 years	Observed
26	F	Tagged; with 1 calf	23 September 1969	8+ years	Trapped
		In oestrus	29 October 1969		Trapped
		With no calf	26,27 January 1970		Observed from helicopter
		Killed	19 May 1970	9 years	Overdose M-99 Etorphine
	Autopsy:	One fetus			
		Total weight - 600 pounds			
		Weight less fetus & fetal membranes - 560 pounds			
27	F	Tagged	26 September 1969	3+ years	Trapped
		With 1 calf	8 October 1969, 27 January 1970		Trapped & observed from helicopter
		With no calf; not lactating	10 July 1970	4+ years	Trapped
		With no calf	3 June 1971	5 years	Observed
28	F	Tagged; lactating	6 October 1969	7+ years	Trapped
		In oestrus			
		With no calf	26,27 January 1970		Observed from helicopter
		With 1 calf; weight 760 pounds	17 July 1970	8+ years	Trapped
		Weight 765 pounds	15 September 1970		Trapped
		Calf survived to yearling (#2870)	3 June 1971	9 years	Observed
		With no calf	3 June 1971		Observed

Table 3. (cont'd.) Histories of individual moose in Kenai Moose Research Center enclosures, January 1968 through June 1971

PEN 3

Moose #	Sex	Event	Date	Age	Circumstances
38	F	Tagged: not lactating	10 July 1970	16 years	Trapped
		With no calf	3 June 1971	17 years	Observed
39	F	Tagged: with 1 large calf	28 July 1970	5+ years	Trapped
		Calf survived to yearling	ca: 20 May 1971		Observed
		With 1 calf	3 June 1971	6 years	Observed
UC	F	Observed	9,15 July 1970; 7 March 1971	1+ years(?)	Observed
60	M	First seen	6,7 October 1969	2+ years	Observed, trapped
		Bred successfully	Fall 1969	2+ years	2 calves in pen 3 May,June 1970
		Tagged	15 May 1970	3 years	Trapped
		Bred successfully	Fall 1970	3+ years	2 calves in pen 3 May, June 1971
		Last seen	3 June 1971	4 years	Observed
2069UC	M	Born to #20	May-June 1969	Calf	
		First seen	12 August 1969		Observed
		Last seen with #20	14 October 1970	1+ years	Observed
		Last seen	3 June 1971	2 years	Observed
2870	F	Born to #28	May-June 1970	Calf	
		First seen	17 July 1970		Observed
		Tagged; weight 246 pounds	12 August 1970		Trapped
		Survived to yearling	3 June 1971	1 year	Observed
3970UC	?	Born to #39	May-June 1970	Calf	
		First seen	17 August 1970		Observed
		Survived to yearling	3 June 1971	1 year	Observed

Table 3. (cont'd.) Histories of individual moose in Kenai Moose Research Center enclosures, January 1968 through June 1971

PEN 4

Moose #	Sex	Event	Date	Age	Circumstances
22	F	Tagged, with calf	August 1969	4+ years	Trapped
		With 1 yearling	25 May, 8 June 1970	5 years	Observed
		With no calf; not lactating; weight 660 pounds	17 July 1970	5+ years	Trapped
		Weight 785 pounds	1 September 1970		Trapped
		With 1 calf	20,25 May; 3 June 1971	6 years	Observed
23	F	Tagged	4 September 1969	11+ years	Trapped
		With 2 calves			
		In oestrus			
		With 2 calves	29 October 1969		Trapped
		Found dead	13 April 1970	11+ years	
	Autopsy:	No fat			
		Flaccid vascularized empty uterus			
24	F	Tagged, no calf seen	August 1969	7+ years	Trapped
		With 1 calf	26 January 1970		Observed from helicopter
		With 1 calf	25 May, 2 July 1970	8 years	Observed
		Calf survived to yearling	3 June 1971		Observed
		With 1 calf	3 June 1971	9 years	Observed
25	F	Tagged; with 1 calf weight 920 pounds	5 September 1969	10+ years	Trapped
		With 1 calf	29 December 1969		Trapped
		Seen alive; with no calf	26,27 February, 4 February		Observed from ground & helicopter
		Found dead	20 July 1970	11+ years	Dead before 1 June, cause unknown
29	F	Tagged; with 1 calf	14 October 1969	5+ years	Trapped
		In oestrus	14 October 1969		Trapped

Table 3. (cont'd.) Histories of individual moose in Kenai Moose Research Center enclosures, January 1968 through June 1971

PEN 4

Moose #	Sex	Event	Date	Age	Circumstances
29 (cont'd)		Last seen alive with 1 calf	21 October 1969		Trapped
		Counts	26 January, 4 February 1970		
		Found dead	23 April 1970	5+ years	Not pregnant; dead more than 4-6 weeks in sitting position
31	F	Tagged with 1 calf	12 August 1969	5+ years	Trapped
(R70-1)		With 1 calf	29 December 1969		Observed
		Calf not seen	26 January 1970		Observed from helicopter
		Calf born	25-28 May 1970	6 years	Observed
		Calf survived to yearling	3 June 1971		Observed
		With 1 calf	6 June 1971	7 years	Observed
34	F	Tagged	11 December 1969	13+ years	Trapped
		With no calf	26 January 1970		Observed
		With no calf	3 June 1971	14 years	Observed
36	F	Tagged: with 1 calf	23 July 1970	7+ years	Trapped
		Calf survived to yearling	ca: 25 May 1971		Observed
		With 1 calf	3 June 1971	8 years	Observed
37	F	Tagged: weight 585 pounds	1 October 1971	1+ years	Trapped
		With no calf	3 June 1971	2 years	Observed
R70-3	F	Tagged	20 May 1970		Trapped
		One calf born	22-23 May 1970	3 years	Observed
		Weight: 825 pounds	1 September 1970		Trapped
		Calf survived to yearling	3 June 1971		Observed
		With 1 calf	3 June 1971	4 years	Observed

Table 3. (cont'd.) Histories of individual moose in Kenai Moose Research Center enclosures, January 1968 through June 1971

PEN 4

Moose #	Sex	Event	Date	Age	Circumstances
A60	F	Tagged; no calf seen	17 July 1970	13+ years	Trapped
		Not lactating			
		Weight 840 pounds			
		With 1 calf	3 June 1971	14 years	Observed
21	M	Tagged	August 1969	1+ years	Trapped
		Bred successfully	Fall 1970	2+ years	Calves in pen 4; May-June 1971
		Last seen	3 June 1971	3 years	Observed
44	M	Tagged; large staph infection lwdt buttock	9 October 1969	1+ years	Trapped
		Not seen during aerial counts or after (presumed dead)	26 January-4 February 1970		
7	M	Tagged	4 June 1970	1 year	Trapped
		Last seen	3 June 1971	2 years	Observed
UC	M	Observed	4 September 1970	1+ years	Observed
		Observed	3 June 1971	2 years	Observed
2470UC	?	Born to #24	ca: May 1970	Calf	
		First seen	25 May		Observed
		Survived to yearling	3 June 1971	1 year	Observed
3670UC	?	Born to #36	May-June 1970	Calf	
		First seen	27 July 1970		Observed
		Survived to yearling	3 June 1971	1 year	Observed
R70-1-70UC	?	Born to R70-1	3 June 1970	Calf	Observed
		Survived to yearling	3 June 1971	1 year	Observed

Table 3. (cont'd.) Histories of individual moose in Kenai Moose Research Center enclosures, January 1968 through June 1971

PEN 4

Moose #	Sex	Event	Date	Age	Circumstances
R70-3-70UC	?	Born to R70-3	23 May 1970	Calf	Observed
		Survived to yearling	3 June 1971	1 year	Observed
NB		Three dead calves/short yearlings were discovered in pen 4: one died on 14 February 1970 and was discovered that day. One apparently died during winter before 22 April 1970 near the carcass of #39 female. The third died probably during early April 1970. Six calves were present in the pen the summer and fall of 1969. Four of them were offspring of females that died during the 1969-1970 winter (#23, #29, and #25). Three yearlings (#7, #U/C, #37) survived the winter. Therefore, at least one yearling must have survived a winter during which its mother died.			
4170	M	Born to #41 outside of pens	May-June 1970	Calf	
		Broke into pen 1 with #41	13 October 1970		#41 Trapped
		Tagged, placed in pen 4	23 February 1971		Trapped
		Probably did not survive to yearling	June 1971		Not observed since 23 February 1970

Table 4. Moose natality, mortality and recruitment in four one-square mile enclosures.

	FF	Adult (MM)	Calves	Calves Lost	Yearlings Recruited	Adults Died (Including long yearlings)	Net Gain (+) or Loss (-) of Adults (discounting experimental manipulation)
PEN 1							
January 1968*	6	(0)	1				
June 1968	6	(1)**	5		1		
June 1969	4***	(1)	0		2		
June 1968-June 1969				1***	2	1	+1
June 1970	5	(2)	4				
June 1969-June 1970				0	0	0	0
June 1971	6	(2)	5	4			
June 1970-June 1971				4		0	+4 (1 female broke in)
PEN 2							
January 1968*	8	(1)	3				
June 1968	8	(1)	1		4***		
June 1969	11***	(1)	4		1		
June 1968-June 1969				0	1	3	+1
June 1970	10****	(2)	3		0		
June 1969-June 1970				4	0	2°°°	-1
June 1971	9	(4)	8		2-3		
June 1970-June 1971				0	2-3	2	0 (2 males, 1 female introduced)

* Ignoring tagging mortality
** Introduced into pen
*** 2 Calves + 2 cows escaped into pen 2 Sept. 1968
**** One adult female introduced May 1970

° 2 Adult females killed
°° One killed female contained 1 fetus
°°° One adult trapped in man-made hole

Table 4. (cont'd.) Moose natality, mortality and recruitment in four one-square mile enclosures.

	FF	Adult (MM)	Calves	Calves Lost	Yearlings Recruited	Adults Died (Including long yearlings)	Net Gain (+) or Loss (-) of Adults (discounting experimental manipulation)
PEN 3							
August 1969	8	(1)	4		0		
June 1970	6°	(1)	2°°	1	3	2 (killed)	
August 1969-June 1970					3		+1
June 1971	6	(2)	2		2	2	
June 1970-June 1971					2		0
PEN 4							
August 1969	12	(2)	10		1		
June 1970	9	(1)	4+		4		
August 1969-June 1970				5-6	4	4	-3
June 1971	8	(3)	6		4		
June 1970-June 1971				0	4	3	+1

* Ignoring tagging mortality
** Introduced into pen
*** 2 Calves + 2 cows escaped into pen 2 Sept. 1968
**** One adult female introduced May 1970

° 2 Adult females killed
°° One killed female contained 1 fetus
°°° One adult trapped in man-made hole

Table 5. June calf crops and yearling recruitment in Moose Research Center enclosures.

Year	Calf Crop Calves/100 F	(No. F)	Yearling Recruitment Yrlgs/100 F	(No. F)	Population (Adult) % Gain/loss (excluding manipulations)	(No. 1+ years old)
Pen 1						
1968	83	(6)	17	(6)		
1969	0	(4) (no breeding bull)	50	(4)	+17%	(6)
1970	100	(4)	No recruitment		No change	(7)
1971	83	(6)	80		+52%	(12)
$\bar{x}$ (not incl. 69-70)	88		47		+38%	
Pen 2						
1968	12.5	(8)	25-38	(8)		
1969	50	(8)	9	(11)	+11%	(11)
1970	30	(10)	0	(11)	-8%	(12)
1971	100	(8)	25-38	(8)	No change	(13)
$\bar{x}$	41		13-18			
Pen 3						
1969 (August)	50	(8)	0	(8)	No data	
1970	29	(7)	38	(8)	No change	(10)
1971	33	(6)	33	(6)	No change	(10)
$\bar{x}$	38		23			

Table 5. (cont'd.) June calf crops and yearling recruitment in Moose Research Center enclosures.

Year	Calf Crop Calves/100 F	(No. F)	Yearling Recruitment Yrlgs/100 F	(No. F)	Population (Adult) % Gain/loss (excluding manipulations)	(No. 1+ years old)
Pen 4						
1969 (August)	83	(12)	8	(12)	No data	
1970	45+	(9)	44-56	(9)	-21%	(14)
1971	75	(8)	50	(8)	+ 7%	(15)
$\bar{x}$	69+		31-34		- 7%	
All Pens						
1968	43	(14)	21-29	(14)		
1969	59	(27)	11	(35)	+13%	(15)
1970	43	(30)	25-29	(28)	-10%	(39)
1971	72	(29)	41-45	(29)	+11%	(44)
$\bar{x}$	56	(100)	2 25-27	(106)	+ 3%	(98)
Unit 15A (Aerial counts by Richey (unpublished) and LeRoux (unpublished) and LeResche)						
1968	47	(1520)	18 (est.)	(1520)		
1969	48	(438)	7 (est.)	(438)		
1970	ca: 30	(ca: 500)	23	(496)		
1971	21	(657)	14	(166)		
$\bar{x}$	39	(ca: 3115)	17	(2620)	+ 4%**	

** Kenai National Moose Range stratified random mile-square quadrant counts (unpublished) indicated populations north of the Kasilof River of 6700 ± 1410 in winter 1967 and 7900 ± 1460 in winter 1971. This represents a mean annual increase of 04+ % for the four years, disregarding the variations in weather and observers and ignoring the confidence intervals.

Figure 2. June calf and yearling crops inside and outside Moose Research Center enclosures, 1968 - 1971.

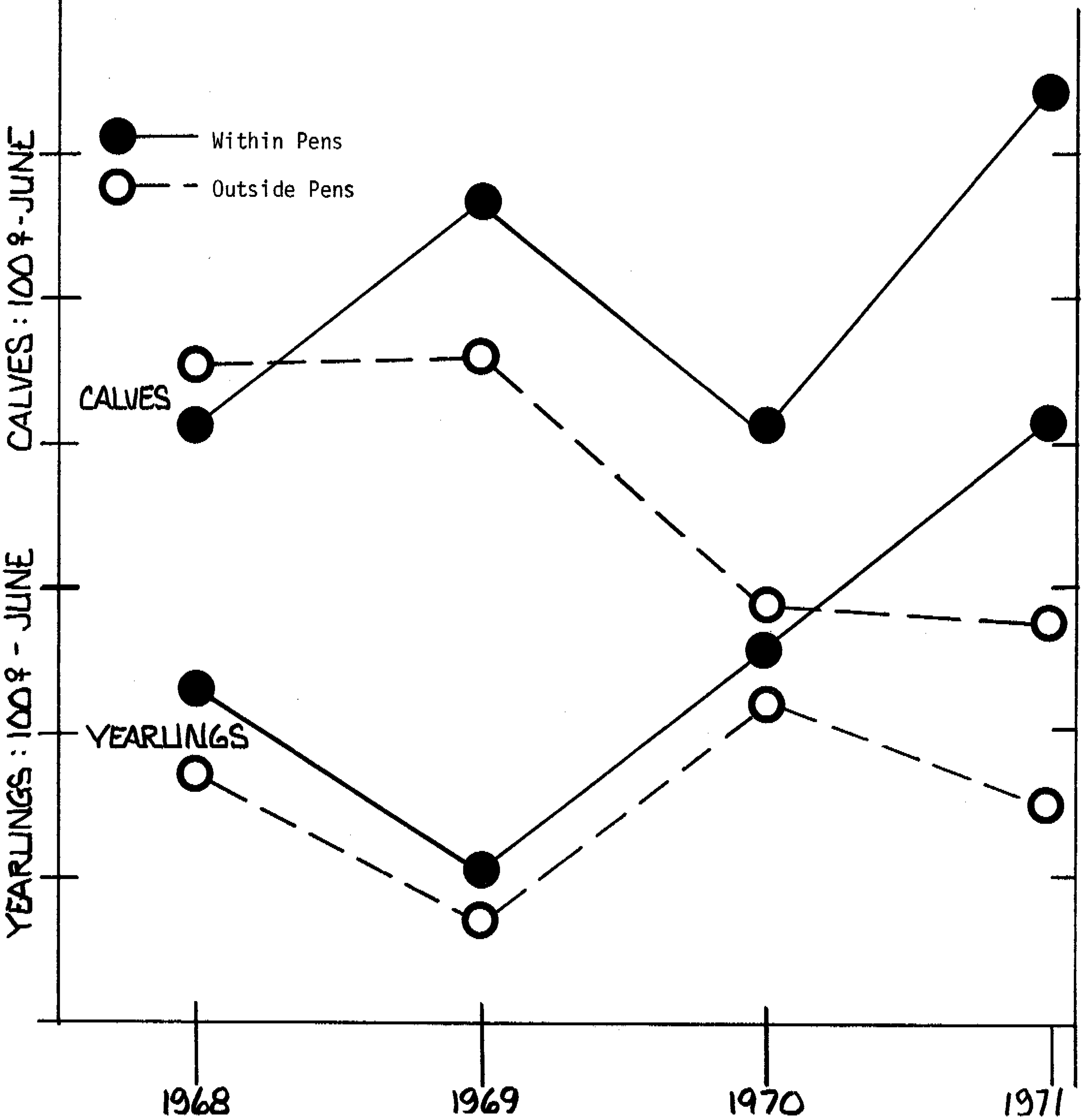


Table 6. Populations within Kenai Moose Research Center enclosures as of 14 June 1971.

	Females with No Calves	Females with 1 Calf	Females with 2 Calves	Yearlings	Males	Total
Pen 1	1	5	0	4	2	17
Pen 2	2	5	2	(2):3	4	25
Pen 3	4	2	0	2	2	12
Pen 4	2	6	0	4	3	21
All Pens	9	18	2	13	11	
Moose	9	36	6	13	11	75

Summary

	FF	Yrlgs	Calves	MM	Total
Pen 1	6	4	5	2	17
Pen 2	9	3	9	4	25
Pen 3	6	2	2	2	12
Pen 4	8	4	6	3	21
All Pens	29	13	22	11	75

lack of available bulls; pen 2 by collection and mortality; pen 3 by human-caused mortality; pen 4 by mortality), to the levels of February 1970 (see Methods Section). Upon closure, the pens contained 16, 24, 12 and 18 moose (total = 70), respectively, by best counts. This agrees approximately with a population of 75 immediately following calving.

Probability of each animal's dying seems to peak in the first year after its enclosure in a pen (Table 3). Animals remaining after that time seem to have adapted to the relative confinement and to more closely follow norms for unenclosed moose. Of 12 adults (greater than 24 months of age) dying naturally, eight died after being in the pens less than one year.

As reported (LeResche, 1970), calf production and yearling recruitment for the years 1968-1970 were similar inside and outside the pens (Tables 4, 5; Fig. 2). During the past year (July 1970-June 1971) the relationship appears to have altered. Calf production and yearling survival were both much greater within the pens than outside (73 vs. ca:25 calves:100 cows and 45 vs. 14 yearlings:100 cows). Whether the differences are artifacts of small numbers (only 29 adult females are present in the pens), are due to imprecise sampling outside the pens, or represent a true biological response remains to be seen. The possibility that increased calf production and yearling survival resulted from the temporarily depressed population inside the pens is an intriguing one.

Overall adult population change within the four pens since 1968, eliminating experimental alterations, was +3 percent (Table 5). Annual changes ranged from +13 percent (1968-69) to -10 percent (1969-70). Outside the pens, the only estimates of moose numbers are from stratified random mile-square quadrant counts accomplished by Kenai National Moose Range personnel in winter 1967 and again in winter 1971 (unpublished). In 1967, the population north of the Kasilof River was estimated at 6700 ± 1410 moose. In 1971, the count estimated 7900 ± 1460 in the same area. Disregarding variations in weather, counters, etc., and the confidence intervals, this represents approximately a four percent annual increase for the four-year period. Thus, there is the secondary possibility that increases within the pens are truly reflecting outside changes.

LeResche (1970) tabulated mortalities within the pens through July 1970. Table 7 updates this information to include mortalities and carcasses discovered since then. Both calves and animals 12-24 months of age died in numbers greater than expected from their proportions in the population. Seven of 25 nonhuman-related mortalities (28 percent) were calves, whereas during the three years calves comprised only 23/107 (21 percent) of the population (difference not significant; $P > .20$; t-test). Similarly, animals 12-24 months old represented 6/25 (24 percent) of recorded mortalities, while making up only 15/107 (14 percent) of the population ($P < .10$; t-test). In contrast, adults comprised 48 percent of the mortalities while making up 55 percent of the population during the period. During 1970-71, no adult mortalities occurred. During the same period six moose 12-24 months old died, as did one calf, which had been

Table 7. Mortalities within pens January 1968 - June 1971.

Moose #	Sex	Age	Pen #	Month - Year	Cause
4	F	17+	1	April 1969	Winter - old age: carcass found
5	F	Ad	1	January 1968	Never seen after tagging
11	F	Ad	2	After January 1970	Winter-kill. Carcass found
12	F	8+	2	May-July 1969	Unknown. Carcass found
13	F	Ad	2	After June 1968	Unknown. Disappeared
14	F	9+	2	August 1969	Drowned in hole. Very poor condition
15	M	3+	2	After October 1968	Unknown. Carcass found with antlers intact
16	F	11+	2	After January 1970	Unknown. Disappeared
R70-5	F	9	Outside: put in pen 2	May 1970	Calving complications, carcass found
3995	F	7	2	July 1969	Unknown, carcass found
5050	F	1+	3	October 1969	Killed with drug
26	F	9	3	May 1970	Killed with drug; pregnant; wt. 600 pounds
P3691	?	1+	3	Nov. 1970-June 1971	Unknown, disappeared
P3692	?	1+	3	Nov. 1970-June 1971	Unknown, disappeared
23	F	11+	4	Oct. 1969-Apr. 1970	Unknown; had aborted; no fat; carcass found
25	F	11+	4	Feb. 1969-May 1970	Unknown; carcass found
29	F	5+	4	Oct. 1969-Apr. 1970	Unknown; carcass found; not pregnant
44	M	1+	4	Oct.-Dec. 1969	Disappeared; badly infected rump when last handled
P4691	?	1+	4	Feb. 1970-Mar. 1971	Unknown; disappeared
P4692	?	1+	4	Feb. 1970-Mar. 1971	Unknown; disappeared
P4693	?	1+	4	July 1970-Mar. 1971	Unknown; disappeared
8	F	Calf	1	January 1968	Killed during tagging
17	F	Calf	2	January 1968	Killed during tagging
4250	M	Calf	2	After Jan. 1968	Never seen after tagging
4170	M	Calf	1-4	After 23 Feb. 1971	Never seen after put into pen 4
368	?	Calf	1	June-October 1968	Unknown; disappeared
168	?	Calf	1-2	Sept.-Oct. 1968	Unknown; disappeared
769	?	Calf	2	January 1970	Unknown; carcass found
969	M	Calf	2	June 1969	Deserted after tagging
969	F	Calf	2	June 1969	Deserted after tagging
1269	?	Calf	2	July 1969	Mother died July
25(69)	M	Calf	4	1 February 1970	Pneumonia; wt. 160 pounds
2969	?	Calf	4	Oct. 1969-Jan. 1970	Mother died (see above)
GM69	?	Calf	4	March-April 1970	Unknown; carcass found

experimentally removed from its mother on 23 February. Although mortality in the 12- to 24-month-old age group (rather than before 12 months) is surprising, shift of mortality to younger age groups does indicate acclimation of adults to the pens, as well as implying that maximum sustainable numbers of adults are present.

Age structures of the penned populations are statistically equivalent ($x^2 = 36.7$; df = 51; P ⟩ .10) to one another. Ages of male penned animals retain characteristics of hunted surrounding outside populations, for no penned bull is greater than four years of age. Age structures of all penned populations are statistically equivalent ($x^2 = 26.4$; df = 17; P ⟩ .10) to those of animals trapped outside the pens.

Blood Values as Indicators of Nutritional Status

Specimens of blood analyzed through May 1971 are listed in Table 2. In addition, sera from 12 winter-killed animals from Fairbanks (collected by J. Coady) were analyzed. Seasonal, sexual and age-specific and pregnancy means of about 250 samples were reported previously (LeResche, 1970).

The current data are presently being analyzed using factor-anlaysis and other multi-variant methods. The analytical scheme relates each parameter to several others and to age, sex, hind foot, total length, girth, girth/total length ratio, weight, date (season), reproductive status, location, and method of collection of the blood.

Preliminary electrophoretic analyses were not reported in 1970. Table 8 lists seasonal means for albumin, total protein and albumin/globulin ratio for samples collected since then. Results suggest a decrease in TP, albumin and H/G ratio during the winter months. A more thorough analysis is being compiled using the above analytical program.

Fig. 3 compares eight blood values of the 12 Fairbanks winter-killed specimens with early-winter means from Kenai (LeResche, 1970 and this paper) assumed to represent "normals." Though certainly inconclusive, Fig. 3 suggests results to be expected from the detailed analyses described above. Winter-killed animals had the following blood values:

Calcium 9.1 ± 2.0 SD mg% (90% of "normal").
Phosphorus 5.7 ± 2.3 SD mg% (83% of "normal").

Calcium and phosphorus levels decrease with decreased intake (associated with hypoproteinemia) and vitamin D deficiency (LeResche, 1970).

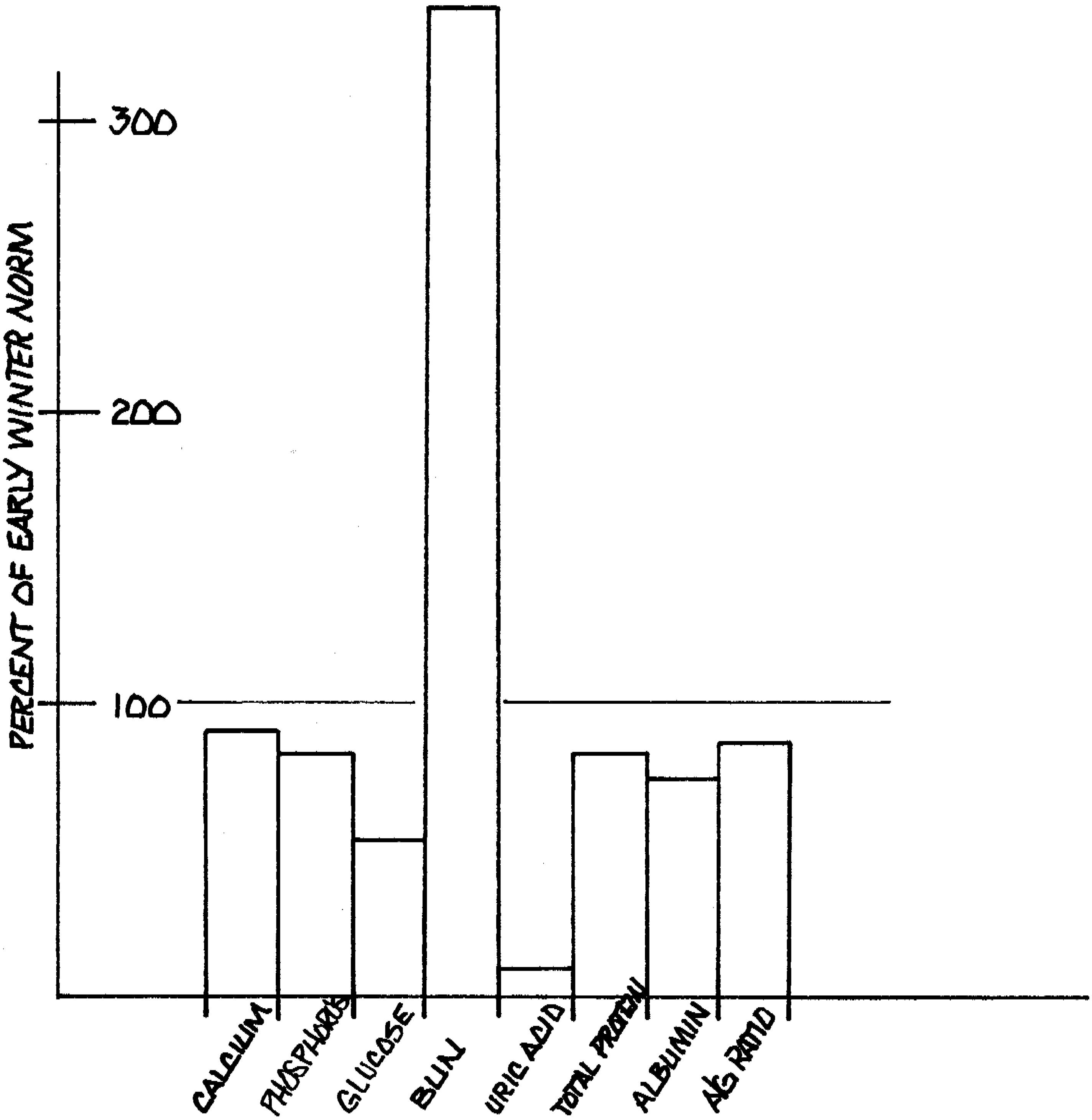
Glucose 54 ± 42 SD mg% (52% of "normal").

Glucose depletion usually accompanies terminal starvation, but values are maintained at near normal even in severe starvation. Possibly, "normal" mean from trapped and drugged animals is actually abnormally high and this lower value in winter-kills is closer to that found in undisturbed animals. In bovines and ovines, values vary from 35-74 mg% (Coles, 1964).

Table 8. Seasonal means (mg%) for total protein, albumin and albumin-globulin ratios in moose sera. Kenai Moose Research Center.

Season	n	Total Protein	Albumin	A/G Ratio
Rut	27	7.99 ± 0.69SD	5.07 ± 0.50SD	1.77 ± 0.304SD
Early Winter	43	6.49 ± 0.96SD	3.76 ± 0.55SD	1.45 ± 0.28SD
Spring	9	7.54 ± 0.70SD	4.66 ± 0.51SD	1.63 ± 0.28SD
Summer	23	7.90 ± 0.89SD	4.98 ± 0.69SD	1.79 ± 0.45SD

Figure 3: Selected blood values of winter-killed moose in relation to norms for the same time of year.



Undisturbed winter-killed moose best approximate this range.

Blood urea nitrogen 20.5 ± 12.6 SD mg% (340 percent of "normal).

Preliminary results (LeResche, 1970) were ambivalent, in that highest values were recorded in spring but mean values decreased progressively from summer through late winter. The former suggested elevations in low nutrition, possibly due to protein catabolism; whereas, the latter pattern suggested values falling concurrently with nitrogen intake. Houston (1969) observed something similar to the latter in 12 moose. Current results (elevation of BUN in starvation) suggest that BUN produced by protein catabolism caused an elevation greater than the depression caused by decreased nitrogen intake. Dror et al (1970) and others have reported a negative correlation between nitrogen retention and BUN values, indicating that poorly digestible foods were correlated with elevated BUN values. Oh et al (1969), in contrast, showed that BUN levels were elevated in sheep on low quality range forage when the animals were fed supplemental urea, and that BUN levels were significantly and positively correlated with rumen gas and VFA production and with dry matter intake. The apparent elevation of BUN in starving moose is only partially understood at present, therefore.

Uric Acid 0.25 ± 0.15 SD mg% (10% of "normal).

Theoretically, uric acid should be elevated in starvation (LeResche, 1970). The apparent decrease in winter-killed animals is unexplained at present.

Total protein 5.8 ± 1.3 SD mg% (85% of "normal").
Albumin 3.3 ± 0.8 SD mg% (76% of "normal).
A/G ratio 1.31 ± 0.29 SD (87% of "normal").

Total protein, albumin and A/G ratio could all be expected to decrease in starvation, with albumin being the most sensitive indicator (LeResche, 1970). Present results follow the expected pattern.

Browse Production and Utilization

Studies of browse utilization using previously described methods (Bishop, 1969) proved to be too imprecise for practical use, even with relatively large sample sizes (LeResche, 1970). This portion of the job was therefore subordinated during this period as U.S. Fish and Wildlife Service personnel began to redesign the sampling procedure. R. Seemel and J. Oldemeyer did estimate utilization in pen 1. Results are given in Table 9 for comparison with previous years' data for the same plots (Bishop, 1969; LeResche, 1970).

Utilization was also estimated on 38 plots in the tame moose holding pen (Table 10). This approximately ten-acre pen (including one ca:four-acre lake) was protected from moose browsing from August 1967 until October 1969, when two calf moose were introduced. These two occupied the pen during the winter of 1969-70, with supplemental feeding. A third short

Table 9. Numbers of birch stems browsed by habitat type. Pen 1, June 1971. Kenai Moose Research Center.

	Birch Regrowth					Mature Hardwoods	
	Dense	Medium	Thin	Spruce-Birch	Spruce	Dense	Thin
n	25	24	26	23	19	20	22
$\bar{x}$ stems browsed	69.7	61.3	38.4	24.1	1.1	0.8	11.4
S.D.	53.2	42.6	35.5	29.6	3.69	2.68	20.8

Table 10. Numbers of birch stems browsed and broken in a 10-acre holding pen. June 1971. Kenai Moose Research Center.

	Birch Regrowth				
	Dense	Medium	Thin	Spruce-Birch	Spruce
Stems browsed:					
Number of plots	3	5	13	9	8
$\bar{x}$ stems browsed per plot	53.5	118.0	37.0	43.1	59.8
S.D.	95.5	116	23.5	32.1	64.5
Stems broken:					
Number of plots	3	5	13	9	8
$\bar{x}$ stems broken per plot	4.5	1.4	2.3	1.55	1.62
S.D.	5.75	1.95	2.6	2.2	2.8

yearling was introduced in May 1970 and the first two were removed in early November 1970. Only one moose (18-24 months old) occupied the pen during the winter of 1970-71. This moose ate much Vaccinium and lichens, and number of browsed twigs in birch habitat types from the winter of 1970-71 is no greater than in pen 1. However, browsing was severe by comparison in spruce and spruce-birch types. This suggests that birch utilization in birch types might well be maximal in most of the birch habitat of the 1947 burn, since overstocking did not increase measurable use.

Although broken stems per unit area (Table 10) were not estimated for habitat outside the holding pen, the number within the small pen (2.2 per plot or 490 per acre) is much greater than that in habitat supporting lower moose densities. Broken stems per acre may be an indicator of moose utilization for this habitat, therefore.

Results (Table 10) show that this small pen received the heaviest use yet recorded and other data (tame moose feeding studies, this report) indicate the range's depleted state by May 1971.

Weights and Measurements

Table 11 lists forty-one whole body weights of moose trapped and immobilized. Fig. 4 illustrates the relationships between weight and age and time of year.

Fig. 4 suggests that growth in weight possibly continues throughout a moose's lifetime, with major seasonal fluctuations. Mean September (maximum for the year) weights increased from 700 pounds (318 kilograms) for 2+ year-olds to 840 pounds (382 kilograms) for 5+ year-olds and 900 pounds (409 kilograms) for animals over 10 years of age. Basal (June) weights increased similarly, but were 15-30 percent (100-250 pounds) lower than maximum weights. Sequential weighings of individuals, though complicated by changes in reproductive status (Table 12) and possibly in rumen weights (Ledger, 1968), confirm seasonal changes. These sequential weights are connected by dashed lines in Fig. 4.

Verme (1970) also documented seasonal weight fluctuations (of 15-24%) in moose, but believed they reached maximum weight by 2-1/2 (females) or 3-1/2 (males) years of age. In contrast, Jordan et al (1971), after reviewing old literature, assumed full body growth was not reached until 6 (females) and 11 (males) years of age. They reported (again, from literature) seasonal weight fluctuations of less than seven percent for full-grown females.

Our data suggest longer growth periods than either of these authors, and also indicate greater seasonal fluctuations in weight. Both these factors suggest crowded conditions (cf: Klein, 1970) and agree with our estimates of moose densities in excess of 15 per square mile in the 1947 Kenai burn (cf: above). Unfortunately, there are no other weight data yet compiled for Alaska moose; therefore, it is impossible to compare

Table 11. Forty-one whole weights of moose of known age, sex and reproductive status. Kenai Moose Research Center. 1969-1971.

Date	Moose	Pen	Sex	Age	Reproductive Condition and Remarks	Weight (lbs.)
12 August	2870	3	F	2-5 months	Survived to yearling	246
29 December	8170	0	M	7 months		385
1 February	P469	4	M	8 months	Died of pneumonia	160
23 February	4170	1	M	9 months	Died within 3 months	340
25 February	8570	0	F	9 months		350
8 July	SL	0	M	13 months		550
22 September	76	0	F	16 months		580
1 October	37	4	F	16 months		585
10 November	WA	2	M	17 months	"Tame" - hand reared	660
11 November	RI	2	M	17 months	"Tame" - hand reared	690
17 July	35*	1	M	25 months)	110 lb. gain in 36 days	715
22 September	35*	1	M	26 months)	(3.1 lbs/day)	
23 February	82	0	F	5+ years	With no calf	850
25 February	85	0	F	8+ years	With one calf	820
19 May	26	3	F	9 years	One fetus; moose killed with normal drug dose	600
17 July	R70-2	2	F	3+ years	With 1 calf, calf probably did not survive to yearling. Did not calve following spring.	635
17 July	22*	4	F	5+ years)	With no calf; gain, 125 lbs/45 days	660
1 September	22*	4	F	5+ years)	Conceived; (2.8 lbs/day)	785
29 July	R70-7*	2	F	6+ years)	1 Calf; did not survive to yrlg.	710
23 July	R70-7*	2	F	7+ years)	No calf produced	865
7 July	12	2	F	8+ years	Dead; had lost calf recently	610
30 July	14	2	F	8+ years	Dead; with 1 calf	580
28 July	DM	0	F	8+ years	Calf recently lost (?)	880
17 July	28	3	F	8+ years)	With 1 calf-survived to yearling	760
15 September	28	3	F	8+ years)	With 1 calf-no calf next spring	765
17 July	A60	4	F	13+ years	With no calf-did not produce calf next spring	840
6 August	10	1	F	3+ years	With 1 calf-survived to yrlg-10 conceived	725
1 September	R70-3	4	F	3+ years	With 1 calf-survived to yrlg-70-3 conceived	
12 August	6*	1	F	12+ years)	No calf-produced calf next spring	910
23 July	6*	1	F	13+ years)	One calf-survived to yrlg	820
22 September	6*	1	F	13+ years)	Did not produce new calf	870
2 September	R70-4	2	F	3+ years	With no calf(lost in May)-Produced calf next spring	710
5 September	1	2	F	6+ years	With no calf-did not calve next spring	675
9 September	72	0	F	8+ years	With 1 calf	850
10 September	3	1	F	8+ years	With 1 calf-calf survived-3 produced calf next spring	920
1 September	20	3	F	10+ years	With no calf-produced calf next spring	875
22 September	75*	0	F	Adult	With no calf-90 lb loss/29 days	960
21 October	75*	0	F	Adult	With no calf (4.3 lbs/day)	870
15 October	PA58	0	F	Adult	Unknown	910
22 October	79	0	F	13+ years	With one calf	970
14 October	56	0	M	4+ years	Rutting	1050

* Indicates serial weights of an individual.

Figure 4. Whole body weight by age of Kenai Peninsula moose. Kenai Moose Research Center. 1969-1971. (Dotted lines connect sequential weights of individuals.)

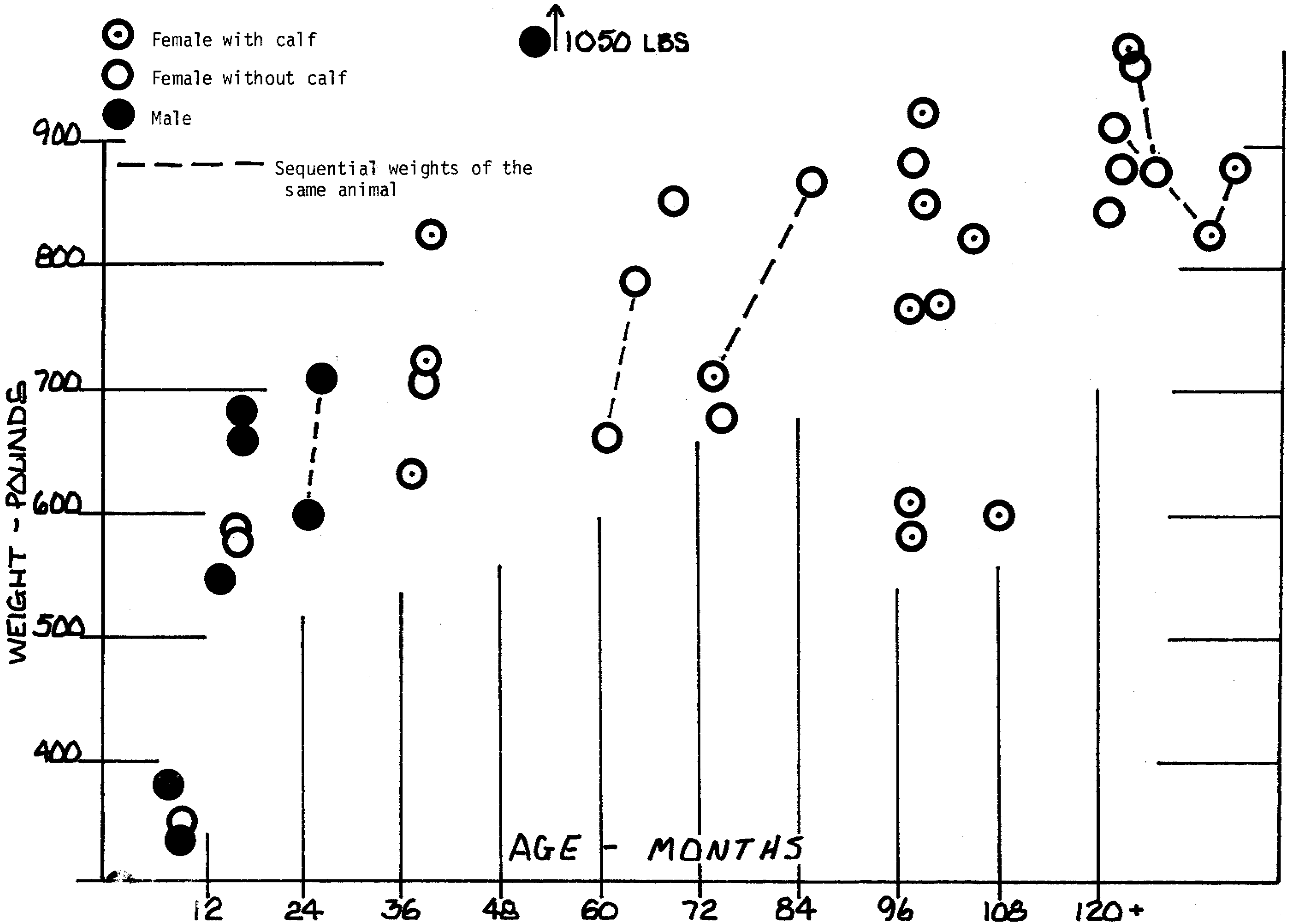


Table 12. Weight data suggesting the nutritional "cost" of calving and rearing young.

Moose	Age	Date	Circumstances	Weight (lbs.)
6	12+	12 August	With no calf	910
6	13+	23 July	With one calf	820
6	13+	22 September	With one calf	870
(Calf rearing "cost" ca: 75/910 pounds or 8 percent of total body weight in mid-August)				
R70-7	6+	29 July	With one calf	710
R70-7	7+	23 July	With no calf	865
(Calf rearing "cost" 155/865 pounds or 18 percent of total body weight in late July)				
22	5+	17 July	With no calf) +19%	660
22	5+	1 September	With no calf)	785
28	8+	17 July	With one calf) +0%	760
28	8+	15 September	With one calf)	765
6	13+	23 July	With one calf) +6%	820
6	13+	22 September	With one calf)	870

(22 gained 125/660 pounds = 19% of mid-July weight by September
28 gained 5/760 pounds = 0% of mid-July weight by September
6 gained 50/820 pounds = 6% of July weight by September
By not rearing a calf, 22 "gained" 16% of mid-July weight, or 106 pounds.)

maximum weights of this dense population with others. Verme's (1970) Alces americana females weighed a maximum of 850 pounds; whereas, our largest cow weighed 970 pounds (445 kilograms) and nine of our 12 females over four years of age weighed more than 850 pounds in August-October.

Table 12 lists sequential weights of cows with and without calves, and calculates the implied cost of calf-rearing in terms of weight loss. Of course other variables than a calf's presence or absence were probably involved, but the three cases outlined suggest that calf rearing "costs" 8-18 percent of a cow's July-August weight. Skuncke (1949) noted similar differences in weight between cows with calves and cows without calves.

Morphometric measurements (total length, hind foot, girth, height at shoulder, ear and tail) were taken of most moose handled. Such measurements are assumed to be indicators not only of growth but also of condition (Klein, 1968). In order to select the measurements not indicative of condition, sequential measurements of individuals were tabulated and examined. Ear and tail measurements were discarded because they varied little if at all between individuals. Height at shoulder was discarded because it is difficult to measure accurately in a sternally recumbent animal and hence varied in a patternless way in sequential measurements of individuals. Hind foot was found to vary a mean of 4.2 percent in sequential measurements; total length 2.2 percent; and girth 16.4 percent (in a seasonally-consistent manner). Therefore the ratio of the most seasonally variable (girth) and most stable (total length) measurements was taken as the most probable nutritional indicator.

Fig. 5 plots girth/length (G/L) ratios and weights for all animals weighed. Correlation coefficient for the relationship is +0.34 ($P > .10$), indicating that G/L ratio is not a valid indicator of weight for animals of all ages and weights lumped. It is, therefore, probably not a valid condition indicator, either, for many animals lumped.

The four dashed lines in Fig. 5 connect weights and G/L ratios for individuals weighed and measured sequentially. In three of the four cases, G/L ratio was positively correlated with weight. In the fourth instance, total length measurement changed from 303 centimeters to 281 centimeters (7.3%) from the first handling to the second a month later, indicating an inaccurate measurement. Thus, for individual animals, changes in G/L ratio may be a valid indicator of change in weight.

Fig. 6 plots seasonal changes in G/L ratios for seasonally measured (but not weighed) individuals. The figure indicates that G/L ratios fluctuate seasonally just as do weights (Fig. 4). The ratios reach a minimum in May-June and maximize in September-October, as does weight.

Tame Moose Feeding Habits

Close observations of tame moose revealed winter and summer differences in time budget and hourly forage consumption, but showed little differences in quantity of food consumed during each hour of active feeding.

Figure 5. Relationship of girth:length ratios to whole body weights of 20 moose. Kenai Moose Research Center, 1969-71. Dotted lines connect values for the same individuals.

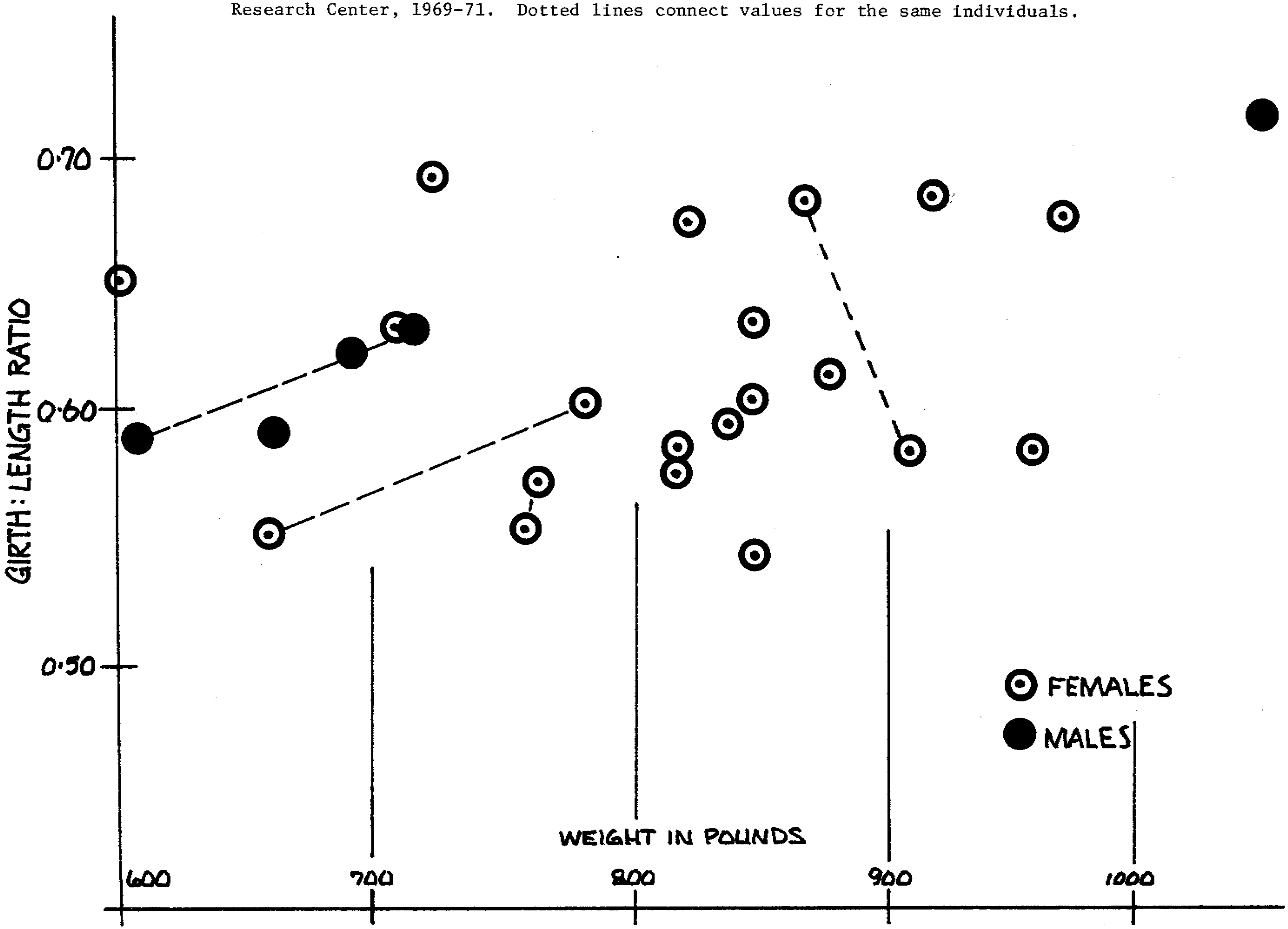


Figure 6. Seasonal variation of girth:length ratio in seven individual moose. Kenai Moose Research Center, 1970-71.

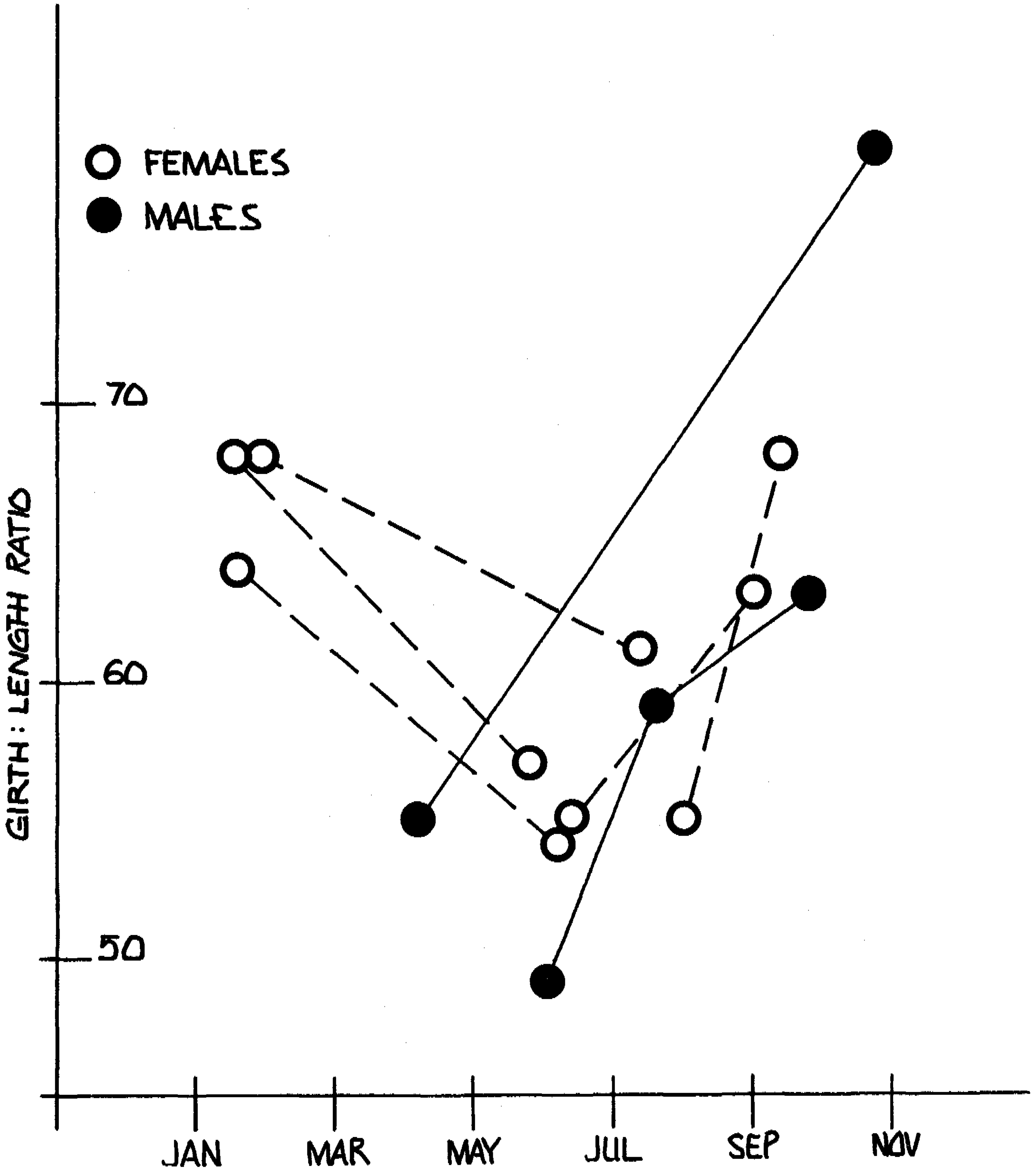


Fig. 7 and Table 13 show concentration of feeding periods into reduced daylight hours during winter. During summer (July-August) feeding activity peaks occurred between 0400 and 0600 hours, when animals fed 89 percent of the time they were observed, and between 1600 and 2000 hours, when feeding occupied about 55 percent of the time. Feeding occurred for less than 43 percent of the time during all other daylight hours. In contrast, only one activity peak was evident in winter (February-May), but feeding occupied more than half the time during all daylight hours observed (Fig. 7).

Forage consumption (bites per hour of day) was similarly concentrated in winter (Fig. 8; Table 14). Peak consumption in summer was 508 bites per hour between 0400-0800 hours. More than 350 bites per hour were consumed only during this period and between 1600-1800 hours in summer, when 380 bites per hour were eaten.

During summer, moose averaged 237 bites per daylight hour, or 4270 bites per day (on a basis of 18 hours of daylight).

By contrast, in each daylight hour during winter, moose consumed more than 350 bites, averaging 381 bites per hour and 4572 bites per 12-hour daylight period. Thus, number of bites consumed per day increased by seven percent in winter $\left(\frac{4572-4270}{4270}\right)$ but all consumption occurred in only two-thirds the time during winter.

A good part of the increased bites per daylight hour in winter is explained by the greater proportion of time spent feeding during winter (Fig. 7; Table 13). This proportion increased from a mean of .38 to a mean of .64, a 68 percent increase during winter. In addition, bites consumed per hour *of feeding* increased slightly in winter (Fig. 9; Table 15). In summer, moose averaged 646 bites per hour of feeding. In winter, consumption increased by 13 percent, to 730 bites per hour of feeding. Thus, increase in forage consumption (bites) per daylight hour and per day in winter may be attributed 84 percent $\left(\frac{68}{68+13}\right)$ to increased activity during each daylight hour and 16 percent to increased intensity of feeding during each active hour.

The increase in mean bites per day by seven percent (from 4270 to 4572) from summer to winter is probably insignificant because of a change in data collection procedure and observer. Summer data were all recorded on IBM optical page reader sheets with a pencil. This required glancing from moose to sheet and may have caused missing some bites. Most winter data were spoken into a magnetic tape recorder and few bites, if any, were missed.

Food habits varied significantly between summer and winter and moose ate a greater variety of forage during all seasons than was previously thought. Previous studies of deer species (Lay, 1964; Cowan *et al*, 1970; Cushwa *et al*, 1970) have stressed that variety is important in diet and

Figure 7. Proportion of time spent feeding during each of 9 daily two-hour periods. 148 hours of observation of three moose. July and August, 1970. Kenai Moose Research Center.

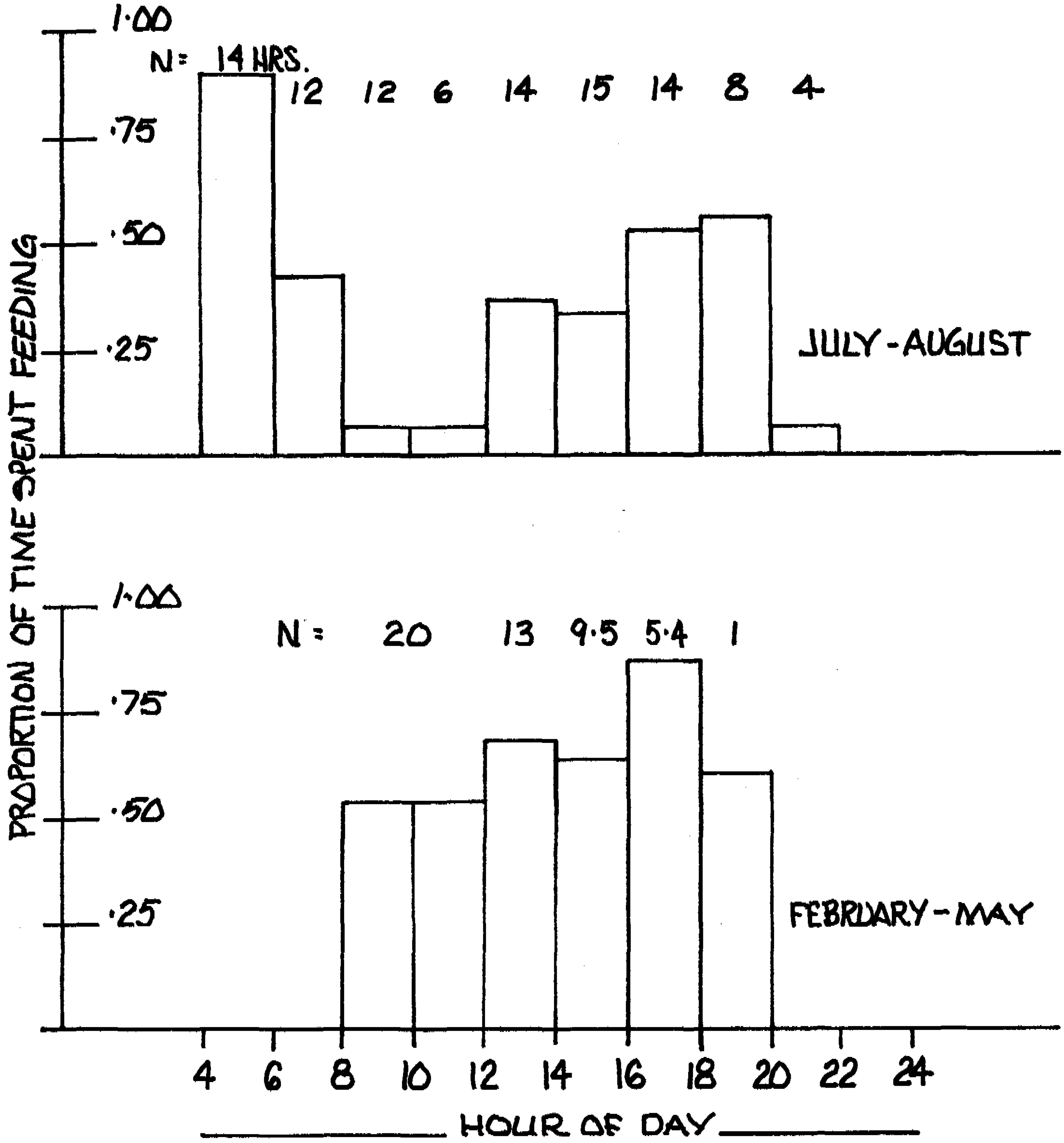


Table 13. Proportions of two-hour time periods spent feeding by two male and one female tame moose, 99 hours of observation, July and August 1970 and 41 hours, February-May 1971. Kenai Moose Research Center.

	Time Period (ADT-hrs.)								
	July-August								
	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22
Hours feeding	12.5	5.0	1.0	0.5	5.5	5.5	7.5	4.5	0.25
Hours observed	14	12	12	6	14	15	14	8	4
Proportion of time spent feeding	.89	.42	.08	.08	.39	.37	.54	.56	.06

	February-May (AST-hrs.)				
	8-12	12-14	14-16	16-18	18-20
Hours feeding	10.8	9.2	5.9	4.7	0.6
Hours observed	20.2	13.3	9.5	5.4	1.0
Proportion of time spent feeding	.53	.69	.62	.87	.60

Figure 8. Total consumption of natural forage by three tame yearling moose in relation to time of day. 99 hours of observation in July and August, 1970 and 49 hours in February - May, 1971. Kenai Moose Research Center.

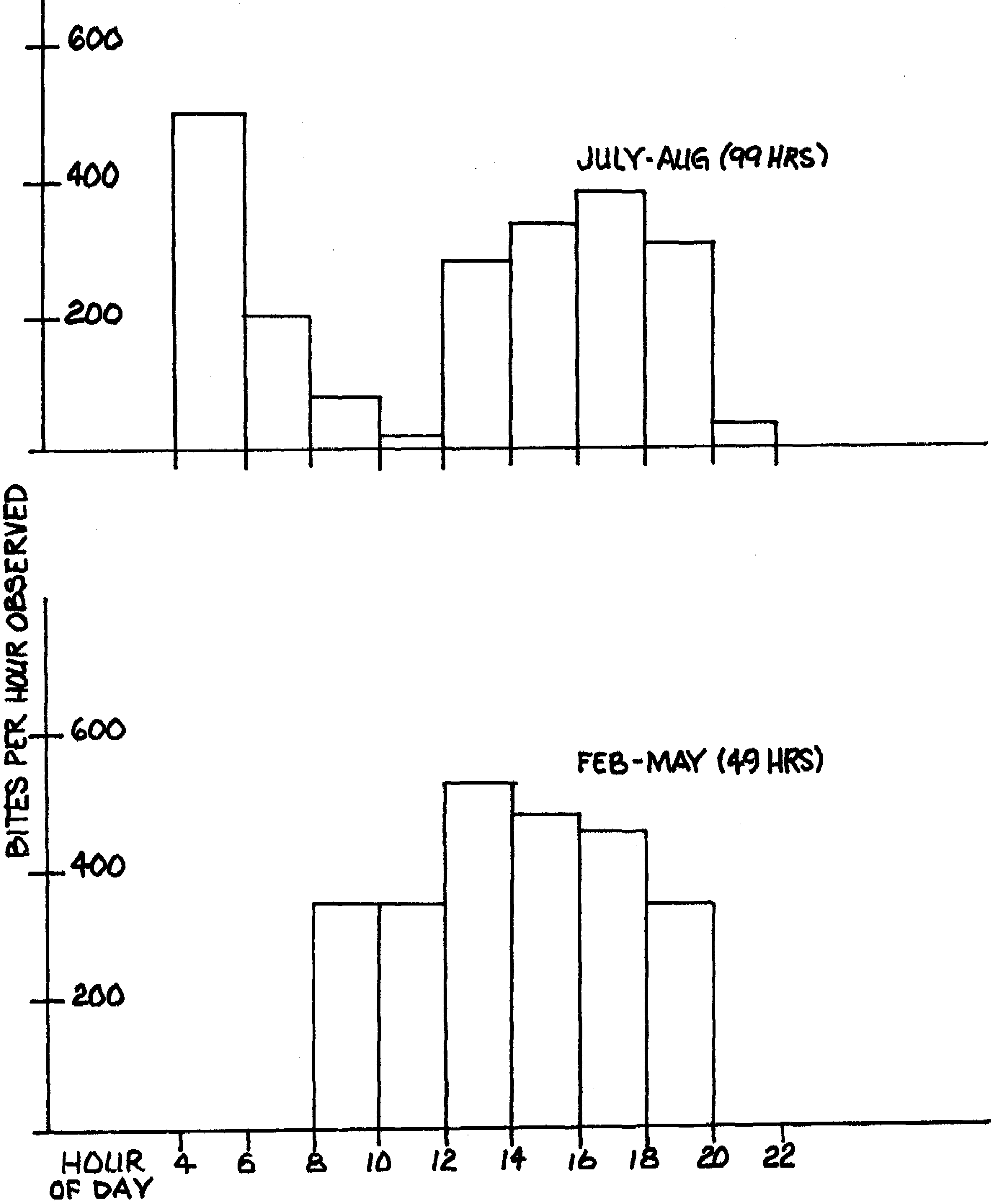


Table 14. Bites per hour by time of day by two male and one female tame moose, 99 hours of observation, July and August 1970, and 49 hours, February-May 1971. Kenai Moose Research Center.

Time Period (ADT-hrs.)

July-August

	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	Totals (4-22)
Number of bites	7124	2403	938	100	3913	4969	5325	2386	123	27,281
Hours observed	14	12	12	6	14	15	14	8	4	99
$\bar{x}$ bites/hour	508	200	78	17	280	332	380	299	31	237*

February-May

	8-12	12-14	14-16	16-18	18-20	Totals
Number of bites	7166	6356	4569	2459	363	20,913
Hours observed	20.2	13.3	9.5	5.4	1.0	49.4
$\bar{x}$ bites/hour	355	478	480	455	363	381*

* Corrected for number of hourly observations (difference significant P (.01; t-test).

Figure 9. Mean number of bites of natural forage per hour of feeding. 71.95 hours of feeding by two male and one female moose. July and August, 1970 and February - May, 1971. Kenai Moose Research Center.

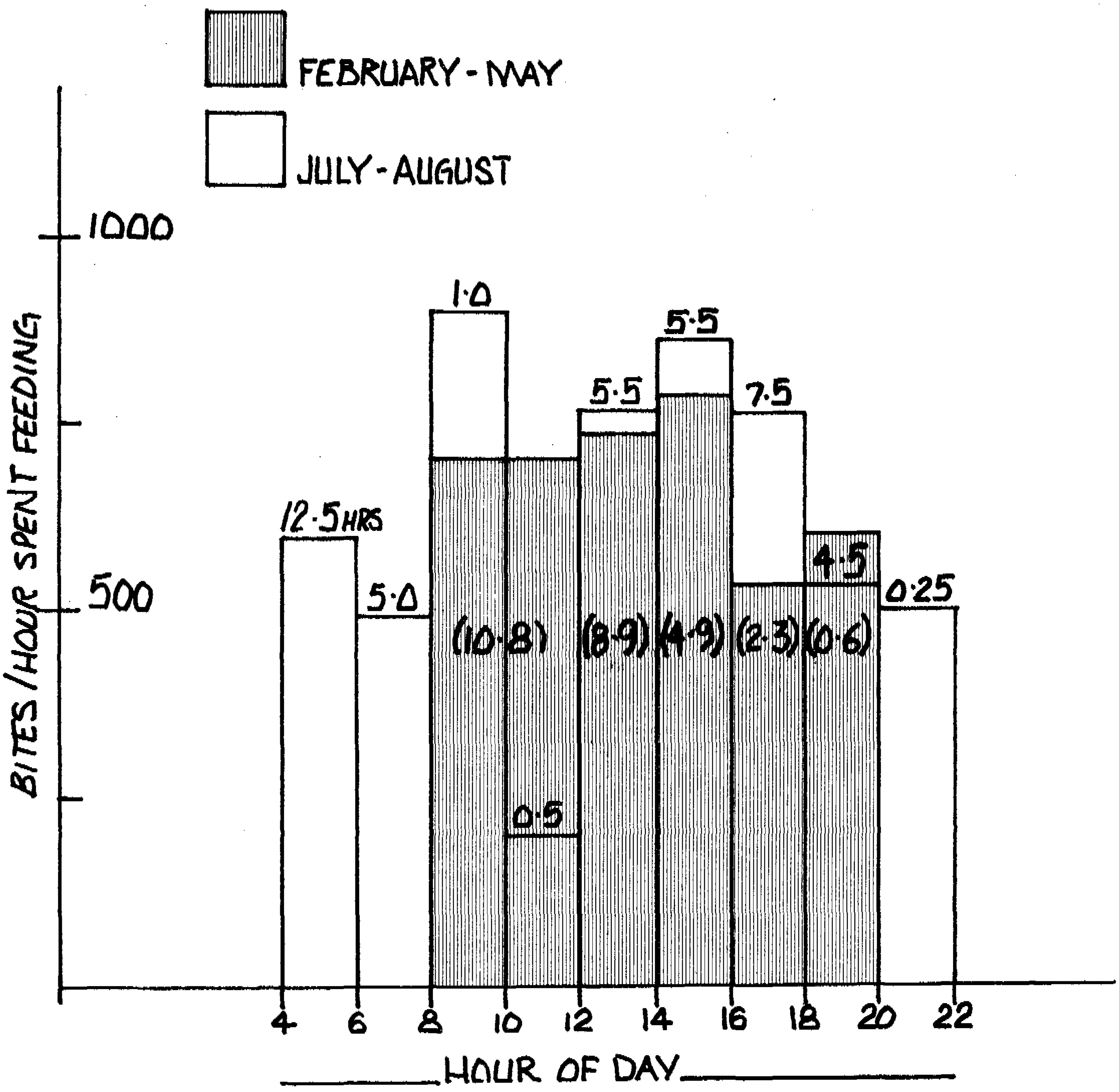


Table 15. Mean number of bites taken per hour of feeding by two male and one female tame moose, 42.25 hours of feeding during July and August 1970 and 29.7 hours February-May 1971. Kenai Moose Research Center.

	Time Period (ADT-hrs.) July-August									
	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	Totals (4-22)
Bites taken	7124	2403	938	100	3913	4969	5325	2386	123	27,281
Hours fed	12.5	5.0	1.0	0.5	5.5	5.5	7.5	4.5	0.25	42.25
Bites/hour of feeding	571	491	938	200	712	904	711	531	492	646

	February-May (Assorted Hours)					
	8-12	12-14	14-16	16-18	18-20	Totals
Bites taken	7166	6009	3708	1235	363	20,913
Hours fed	10.8	8.9	4.9	2.3	0.6	29.7*
Bites/hour of feeding	663	675	753	534	622	730

* Some observations over several time periods.

that, in some situations, woody twigs are of only minimal importance, contrary to common belief. Physiological studies (eg: Dror et al, 1970) also indicate the importance of variety for proper functioning of the rumen flora.

Our tame moose and rumen analysis (described later in this report) studies show that in the 1947 Kenai Burn forbs, lowbush cranberry (Vaccinium vitis-ideae) and lichens are much more heavily used in winter than in summer and that their degree of utilization depends upon snow-determined availability. Although lowbush cranberry becomes more important on depleted range, it is a significant dietary component on normal winter range when available. Lichen seems important only on depleted winter range.

Table 15 and Fig. 10 list bites taken of various forage types and species during the 149 hours of feeding observations. Winter observations were divided between the female enclosed in the ten-acre pen of birch-spruce regrowth and two males free-roaming within pen 2 (one square mile). As discussed above, range was considered depleted in the small enclosure, which had supported two animals the previous winter on ca: six acres of land, and had carried three moose throughout the summer. This pen (cf: above) was thus browsed by densities equivalent to approximately 213 moose per square mile (216 x 640) during the preceding winter and by 107 moose-equivalents per square mile during the winter of observations. Despite this, the range was nutritious enough to allow the cow to produce a calf on her second birthday, sired by a 16-month-old bull also living in the small enclosure.

Birch leaves made up 56 percent of the mooses' summer diet, forbs 25 percent, sedges, grasses and aquatics 10 percent, willow (Salix spp.) 5 percent and dwarf birch (B. nana) approximately 4 percent (Table 16). Other species, including alder (Alnus crispa), lowbush cranberry and aspen (Populus tremuloides) were included as traces in the diets, as were fungi (Boletus spp.) and soil. Forbs consumed were primarily lupine (Lupinus arcticus)--usually taken in the preflower stage), dwarf dogwood (Cornus canadensis) and wintergreen (Pyrola secunda) in order of preference.

On "normal" seral winter range, (supporting 15 moose/square mile) 76 percent of bites consumed were B. papyrifera woody twig ends. Twenty-one percent of bites were of lowbush cranberry, 3 percent willow, 3 percent alder, 1 percent white spruce (Picea glauca) and traces of aspen and highbush cranberry (Viburnum edule). On depleted seral winter range, only 22 percent of bites taken were woody twig ends of birch. Vaccinium vitis-ideae made up 51 percent of bites, fruiticose lichens (Peltygra spp.) 23 percent, grasses 2 percent, willow 1 percent, foliose lichens (Cladonia spp.) 1 percent and Ribes spp. 1 percent. Forbs, sedges, dwarf birch, aspen, white spruce, fungi and rose (Rosa acicularis) were consumed in trace amounts.

Conversion of bite size and numbers to weight of forage consumed is risky due to difficulty in translating visually-estimated bites to collected specimens after a time lapse (cf: Wallmo and Neff, 1970).

Figure 10. Plant species consumed by tame moose in summer on normal range and in winter on normal and depleted range. Kenai Moose Research Center, 1970-71.

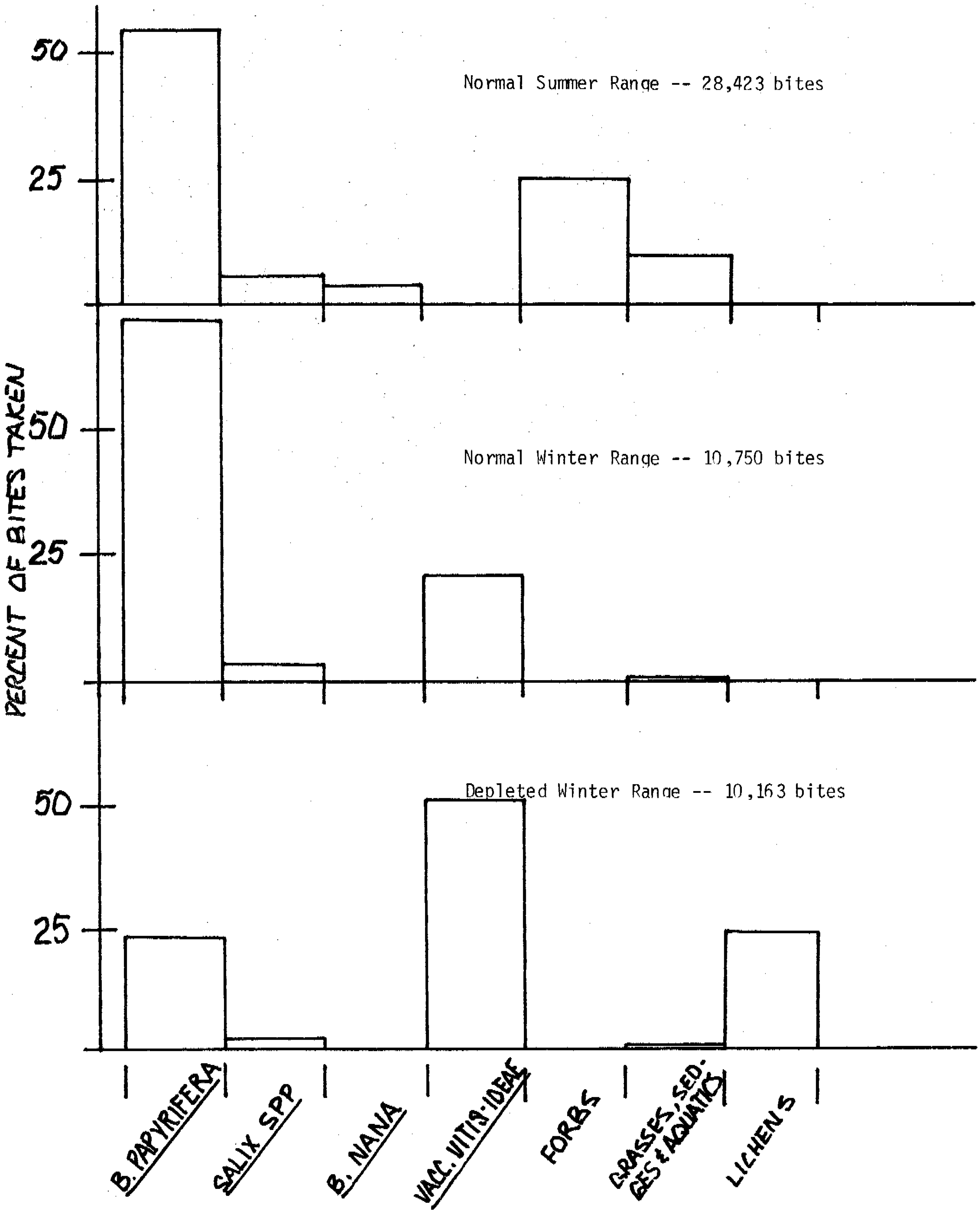


Table 16. Feeding preferences of two male and one female tame moose on natural forage; 28,423 bites in July and August. Kenai Moose Research Center.

	Plant Species or Group										
	B. papyrifera (leaves)	Forbs	*Salix*	Grasses	Sedges	Aquatics	*B. nana*	*Alnus crispa*	*Vacc. vitis-ideae*	*Populus tremuloides*	Total Bites
Male - Richard											
No. Bites	5942	1607	628	70	1	150	709	21	--	16	9,144
Proportion	.65	.18	.07	.01	t	.02	.08	t	--	t	
Male - Walter											
No. Bites	5277	3847	437	575	253	310	151	1	--	--	10,851
Proportion	.49	.35	.04	.05	.02	.03	.01	t	--	--	
Both Males											
No. Bites	11,219	5454	1065	645	254	460	860	22	--	16	19,957
Proportion	.56	.27	.05	.03	.01	.02	.04	t	--	t	
Female - Raquel											
No. Bites	4626	1584	448	169	838	485	247	--	31	--	8,428
Proportion	.55	.19	.05	.02	.10	.06	.04	--	t	--	
All Moose											
No. Bites	15,845	7038	1513	814	1092	945	1107	22	31	16	28,423
Proportion	.56	.25	.05	.03	.04	.03	.04	t	t	t	

Table 16. (cont'd.) Feeding preferences of two male and one female moose on natural forage; 21,603 bites in February-May. Kenai Moose Research Center. 10,750 bites by male moose on normal range and 10,163 by a female on depleted range.

Plant Species or Group	Normal No. Bites	Normal Proportion	Depleted No. Bites	Depleted Proportion	Total No. Bites	Total Proportion
B. papyrifera (stems)	7646	.72	2195	.22	9871	.49
Forbs	14	t	30	t	44	t
Salix	335	.03	86	.01	421	.02
Grasses	--	--	229	.02	229	.01
Sedges	--	--	4	t	4	t
Aquatics	--	--	--	--	--	--
B. nana	--	--	17	t	17	t
Alnus crispa	364	.03	--	--	364	.02
Vaccinium vitis-ideae	2225	.21	5136	.51	7361	.35
Populus tremuloides	18	t	12	t	30	t
Lichens						
Foliose	--	--	76	.01	76	t
Fruticose	--	--	2308	.23	2308	.11
Picea glauca	99	.01	2	t	101	t
Viburnum edule	15	t	--	--	19	t
Fungi	--	--	7	t	7	t
Ribes sp.	--	--	61	.01	61	t
Rosa acicularis	--	--	2	t	2	t
Total Bites	10,750		10,163		20,913	

Tables 17 and 18 list distribution of bite sizes on different ranges and during different seasons and mean weights of bites consumed, as estimated by subsequent collections. Combining these data (Table 19) gives estimates of about 4-7 pounds/day wet weight consumption (3 pounds/day dry weight) in winter and 42 pounds/day wet weight in summer. The winter estimate is exceedingly low in light of other estimates (eg: Verme, 1970) and our observations that the same tame animals when fed supplementally the preceding winter were each capable of consuming 25-35 pounds pelletized food per day. It thus appears that if previous estimates are accurate, tame moose feeding observations are valuable only in determining proportions of various forages taken in and not for determining biomass relationships.

Fig. 11 illustrates seasonal changes in proportions of various foods eaten in relation to snow. Vaccinium was used slightly in late February-early March when snow cover was slight (cf: following sections). During the last half of March and early April, when the Vaccinium availability index (percent of snow plots in which Vaccinium was visible) was lowest, very little was used by moose. From mid-April through May, Vaccinium became of major importance to moose on both normal and depleted ranges, with Vaccinium and birch ratios (bites) reaching a mean of 15:1 on depleted range and ca:8:1 on normal range. Lichen:birch ratio reached ca:15:1 on depleted range at this time.

Food Habits from Rumen Analysis

Tables 20 and 21 summarize plant species and proportions by volume found in rumens of animals shot in seral birch habitat (Game Management Unit 15A) and in climax willow-dwarf birch range (Game Management Unit 7, Juneau Creek). Approximately 80 percent of each sample mean was unidentifiable. Of the identified material (Fig. 12) willow comprised 59 percent in the climax range and 39 percent in the 1947 burn. The latter proportion is much higher than expected from this range, where previous estimates (Bishop, 1969) have suggested that willow is less than one percent as abundant as birch in terms of stems per acre. Birch represented 33 percent of the diet in the climax upland range, and 36 percent in the burn; the latter similarly being an under-representation of available birch on the range. Thus, moose are selecting willow over birch where possible, thereby perhaps attaining more variety in their diet (LeResche, 1970).

Aspen was present as 8 and 6 percent of the diet in the climax and seral ranges. Lowbush cranberry was a moderately important food item (14 percent by volume) in the seral range, corroborating evidence given by tame moose studies. It was present as a trace in only one of the eight samples from climax range. Forbs (mostly Lupinus sp.) represented five percent of the diets of climax range moose.

Rumen protozoa levels on birch and willow and seral ranges and proportions of micro-organisms present in rumen liquor are presented in Table 22. Animals from climax willow range had a mean of 283,000 protozoa/ml, statistically equivalent ($P > .10$; t-test) to those from seral birch range. The higher mean may indicate that the willow range

Table 17. Bite size distribution by plant species for two male and one female moose; 45,708 bites; July and August 1970 and February-May 1971. Kenai Moose Research Center.

SUMMER

		Bite Size (no. leaves)				
		‹ 5	6-10	11-20	20	Total
B. papyrifera	- no.	6758	6084	2224	789	15,855
	- %	42	38	14	5	
Forbs	- no.	6969	58	10	3	7,040
	- %	100	t	t	t	
Salix spp.	- no.	552	758	176	27	1,513
	- %	36	50	12	2	
B. nana	- no.	71	307	361	368	1,107
	- %	6	28	33	33	

WINTER

		Small	Medium	Large	Very Large	Total
B. papyrifera						
Normal Range	- no.	1413	3285	2458		7696
	- %	.184	.498	.319		
Depleted range	- no.	295	760	1151		2206
	- %	.134	.345	.523		
Total	- no.	1708	4045	3609		9902
	- %	.172	.408	.362		
Vaccinium vitis-ideae						
Normal Range	- no.	108	1358	556	177	2199
	- %	.049	.617	.253	.081	
Depleted range	- no.	2003	2754	301	135	5163
	- %	.389	.528	.058	.026	
Total	- no.	2111	4082	857	312	7362
	- %	.287	.514	.116	.042	
Salix sp.						
Normal Range	- no.	.291	23	150		464
	- %	.628	.050	.324		
Depleted Range	- no.	50	16	13		79
	- %	.633	.202	.165		
Total	- no.	341	39	.63		543
	- %	.628	.072	.300		
Lichens						
Normal Range	- no.	0	0	0		0
	- %					
Depleted Range	- no.	691	1349	346		2386
	- %	.279	.565	.145		
Total	- no.	691	1349	346		2386
	- %	.279	.565	.145		

Table 18. Wet and dry weights of bites of natural forage taken in February-May 1971. Kenai Moose Research Center.

Plant Species	Bite Size	n	Wet Weight (g)	Dry Weight (g)	% H_2O
Betula papyrifera	(large)	30	0.66	0.55	17
Betula papyrifera	(medium)	30	0.27	0.22	19
Betula papyrifera	(small)	30	0.08	0.05	38
Salix	(large)	30	0.78	0.45	42
Salix	(medium)	30	0.26	0.15	42
Salix	(small)	30	0.07	0.04	57
Vaccinium vitis-ideae	(very large)	32	1.13	0.69	39
Vaccinium vitis-ideae	(large)	31	0.56	0.35	38
Vaccinium vitis-ideae	(medium)	32	0.32	0.21	35
Vaccinium vitis-ideae	(small)	32	0.14	0.09	36
Cornus canadensis	(average)	30	0.24	0.12	50
Forbs	(large)	30	0.35	0.34	3
Forbs	(small)	30	0.04	0.04	0
Grass	(large)	30	2.76	2.60	6
Grass	(small)	30	0.50	0.49	2
Lichens	(large)	30	5.45	1.06	81
Lichens	(medium)	30	1.59	0.39	76
Lichens	(small)	30	0.67	0.19	72
Birch leaves (July-August)	each leaf	500	0.38 ± 144SD		

Table 19. Estimated consumption of forage by tame moose. Kenai Moose Research Center.

Season	Range	Birch	Forbs	Vaccinium	Lichens	Other	Total
					Pounds/day wet weight		
Winter	"Normal"	2.6		0.9		0.3	3.8 lbs/day
Winter	"Depleted"	1.0		1.5	4.7	0.2	7.4 lbs/day
Summer	"Normal"	26.7	11.9				42.0 lbs/day
					Pounds/day dry weight		
Winter	"Normal"	2.1		0.6		0.2	2.9 lbs/day
Winter	"Depleted"	0.8		1.0	1.0	0.2	3.0 lbs/day

Figure 11. Ratios of bites *Vaccinium vitis-ideae* and bites lichen to bites of *Betula papyrifera* eaten by moose in normal and depleted habitat, February - May 1971. Kenai Moose Research Center.

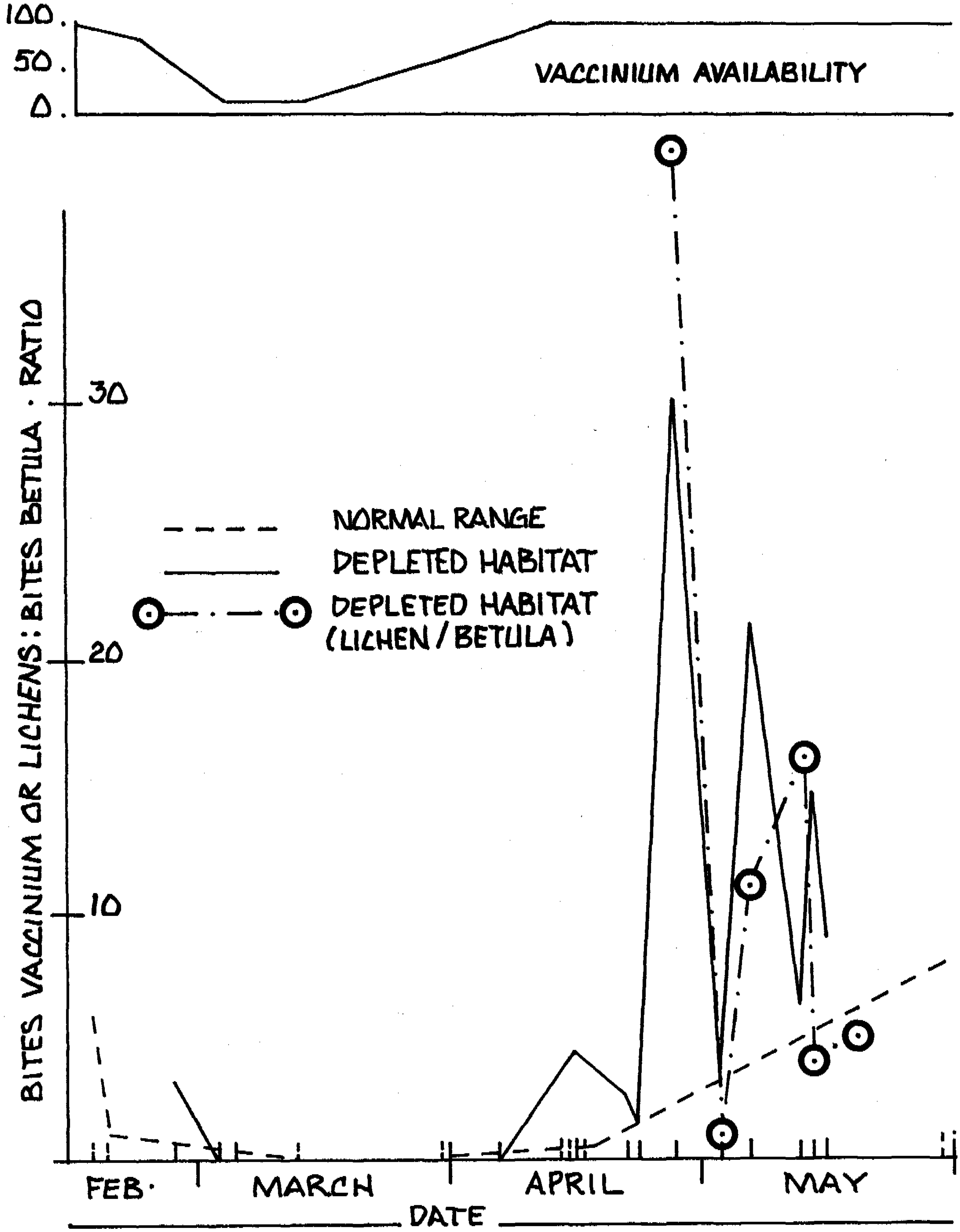


Table 20. Food habits of Kenai Peninsula moose as determined by analysis of rumen contents of eight moose collected during the December, 1970 antlerless hunt in Unit 15A (Seral birch range).

Specimen Number	Percent of Sample Unident.	PERCENT BY VOLUME (of the sample fraction identified)							
		Salix spp.	*Betula* spp.	*Populus tremuloides*	*Vaccinium vitis-ideae*	Dried Leaves	Monocots[1/]	Forbs[2/]	Others
22794	48	68	8	6	8	8	2	–	t
22793	91	23	23	–	35	12	–	t	t
22821	71	70	28	–	–	2	–	t	–
#5 Davis	91	38	58	–	4	t	–	–	–
22820	–	65	32	–	–	3	t	–	–
#2 Davis	78	17	56	10	16	t	t	–	–
#4 Davis	84	–	28	24	46	2	–	–	t
#1 Davis	86	31	55	8	6	–	–	–	t
Average percent of the eight	78	39	36	6	14	3	t	t	t
Average percent when occurred	78	45	36	12	16	5	t	t	2
Percent frequency of occurrence	100	88	100	50	75	88	50	25	50

1/ Recognizable monocots included: family Gamineae
2/ Recognizable forbs included: *Pyrola* sp.
3/ Others included: *Rosa* sp. and *Ledum*

Table 21. Food habits of Kenai Peninsula moose as determined by analysis of rumen contents of eight moose collected during the December, 1970 antlerless hunt in Juneau Creek, Unit 7 (Climax willow range).

		PERCENT BY VOLUME (of the sample fraction identified)							
Specimen Number	Percent of Sample Unident.	Salix spp.	Betula spp.	Populus tremuloides	Vaccinium vitis-ideae	Dried Leaves	Monocots1/	Forbs2/	Others
#3	76	91	6	-	-	-	3	-	-
#6	85	46	43	-	-	t	-	11	-
#5	86	60	19	18	-	t	-	3	-
#2	73	50	34	7	t	t	t	9	t
#1	86	64	27	-	-	t	-	9	t
#7	76	50	50	t	-	-	-	-	-
#4	78	54	39	-	-	-	-	7	-
#8	85	54	46	-	-	t	-	-	t
Average percent of the eight	81	59	33	3	t	t	t	5	t
Average percent when occurred	81	59	33	8	t	t	1	8	t
Percent frequency of occurrence	100	100	100	38	13	62	38	63	38
#3a4/	78	90	7	-	-	t	3	-	4
#3b5/	86	44	48	2	2	t	-	-	4
#6a6/	72	55	37	7	1	t	t	-	-

1/ Recognizable monocots included: Carex sp. and family Gamineae
2/ Forb species utilized included: Lupinus sp. and unknowns
3/ Others included: Ledum and Andromeda
4/ This was a subsample from the same one liter sample as #3.
5/ This was a subsample from the same rumen as #3 and #3a, but from a different one liter sample.
6/ This was a subsample from the same rumen as #6.

Figure 12. Identified plant species found in rumens of moose on two types of range. Kenai Peninsula, December 1970.

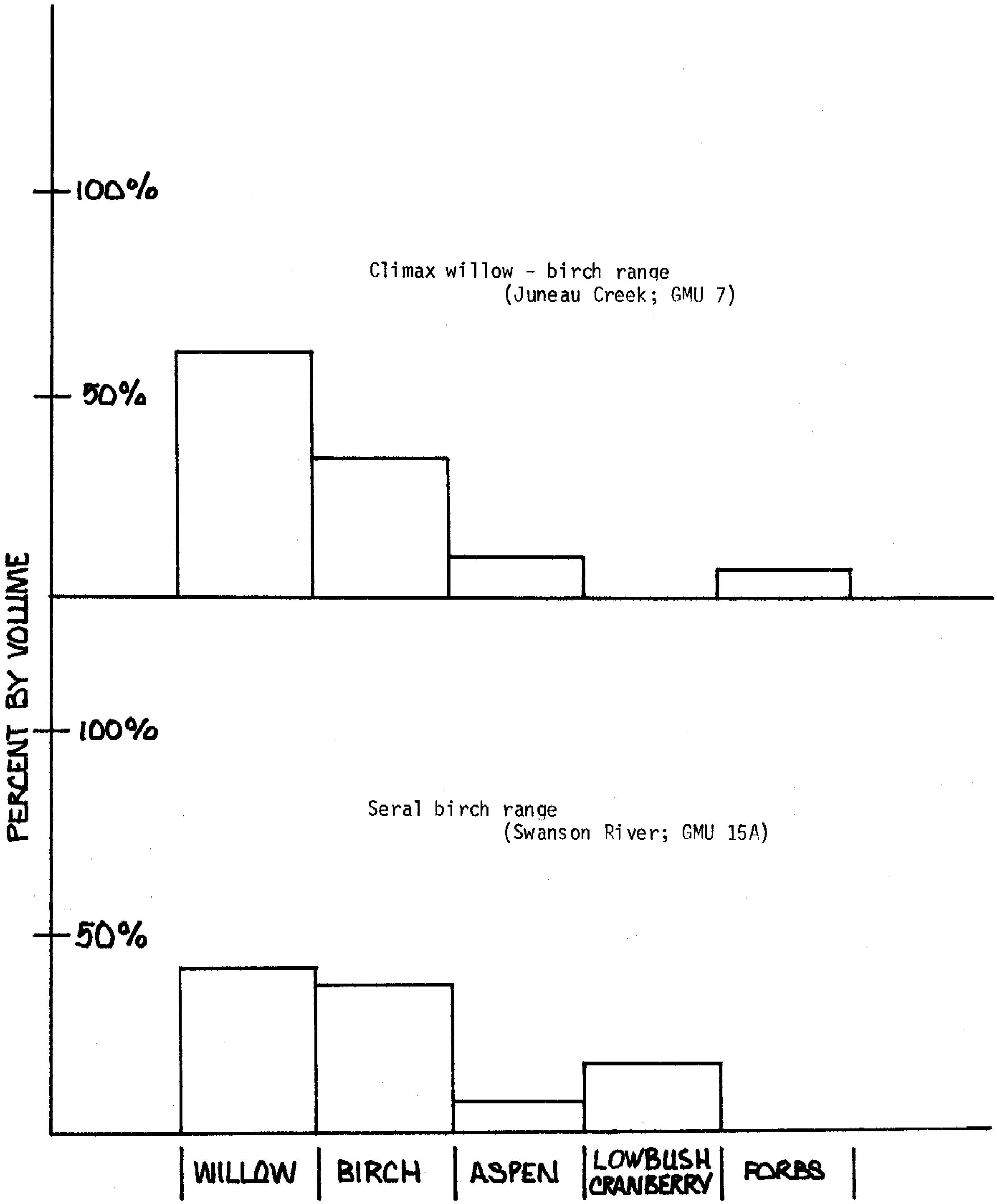


Table 22. Concentration of protozoans and proportion of sediment material in rumens of moose from climax willow (Game Management Unit 7) and seral birch (Game Management Unit 15A) winter ranges. December 1970.

Sample	Date	Location	Sex	Age	Protozoa/ml	% Sedimentation ($\bar{x}$ of 3 aliquots)	Fat Index
1	2 December	7	F	5+ yrs.	40,000	28	Moderate
2	2 December	7	F	13+	420,000	36	Heavy
3	2 December	7	F	18+	130,000	22	Moderate
4	2 December	7	F	13+	280,000	28	Moderate
5	2 December	7	F	8+	400,000	34	Moderate
6	4 December	7	F	14+	140,000	26	Unknown
7	5 December	7	F	Unk.	570,000	32	Unknown
8						30	
Means for climax willow range					283,000 ± 202,100 SD*	29% ± 1.5 SD*	
1	16 December	15A	F	4+	460,000	32	Moderate
2	16 December	15A	M	Calf	240,000	20	Light
3	16 December	15A	F	7+	290,000	28	Heavy
4	16 December	15A	F	2+	140,000	23	Moderate
5	16 December	15A	F	2+	230,000	26	Heavy
6	16 December	15A	F	12+	160,000	28	Moderate
7	15 December	15A	M	Unk.	220,000	32	Moderate
8	15 December	15A	F	Calf	230,000	24	Light
9	16 December	15A	Unk.	Unk.	230,000	29	Unknown
10	16 December	15A	Unk.	Unk.	190,000	26	Unknown
Means for seral birch range					239,000 ± 89,000 SD*	27% ± 1.2 SD*	

* Neither difference significant ($P < .10$; t-test).

was of higher quality (ie: higher in nitrogen), for Klein (1962) suggested a positive correlation between nitrogen content of rumina and protozoa concentration on summer range. Samples of dried digesta are being analyzed to determine if this is so. The present values for protozoa concentrations are 4-9 percent of values Klein (1962) reported for deer (*Odocoileus hemionus sitkensis*) in summer. This is logical, for winter range and browse forage are lower in nitrogen than summer forage species and leaves.

Proportions of microorganisms in centrifuged factions of rumen liquor were not significantly higher ($P > .10$; t-test) in rumens from the upland climax willow range.

Chemical Composition of Forage Plants

No results are available on this portion of the job.

Snow Studies

Minor snow studies initiated in February are summarized in Table 23. The studies only touch on this factor that becomes very important to large mammals in many areas (Formozo, 1946; Des Meules, 1964). The primary purpose of snow plots was to determine availability of *Vaccinium vitis-ideae* to moose during winter. Fig. 13 shows that *Vaccinium* remained visible in sedge habitat throughout the sampling period and was not visible for only 46 days at most in other habit types. *Vaccinium* was visible only in sedge type for only 28 days, and at all other times was visible in at least three habitats. During most of the rest of the winter snow was not deep enough to prevent crater-digging moose from feeding on *Vaccinium*, maximum depth being only 60 centimeters and this persisting for less than 12 days.

Although snow cover was associated with consumption of *Vaccinium* and lichens (cf: Fig. 13) it was only a very minor factor in food availablilty for only a very short time during the winter. In an average winter on the 1947 Kenai burn, ground plants are almost continuously available to moose, especially around the bases of young spruce trees and beneath fallen timbers.

Miscellaneous Observations

Miller and Parker (1968) reported finding placental tissue in rumens of eight maternal barren-ground caribou (*Rangifer rangifer*). On 22 May 1970 a piece of tubular tissue approximately 20 centimeters x 1 centimeter was observed hanging from the anus of moose R-70-4, trapped and immobilized in pen 2. The animals's vulva was flaccid from recent parturition and her calf was later observed with her in the pen.

RECOMMENDATIONS

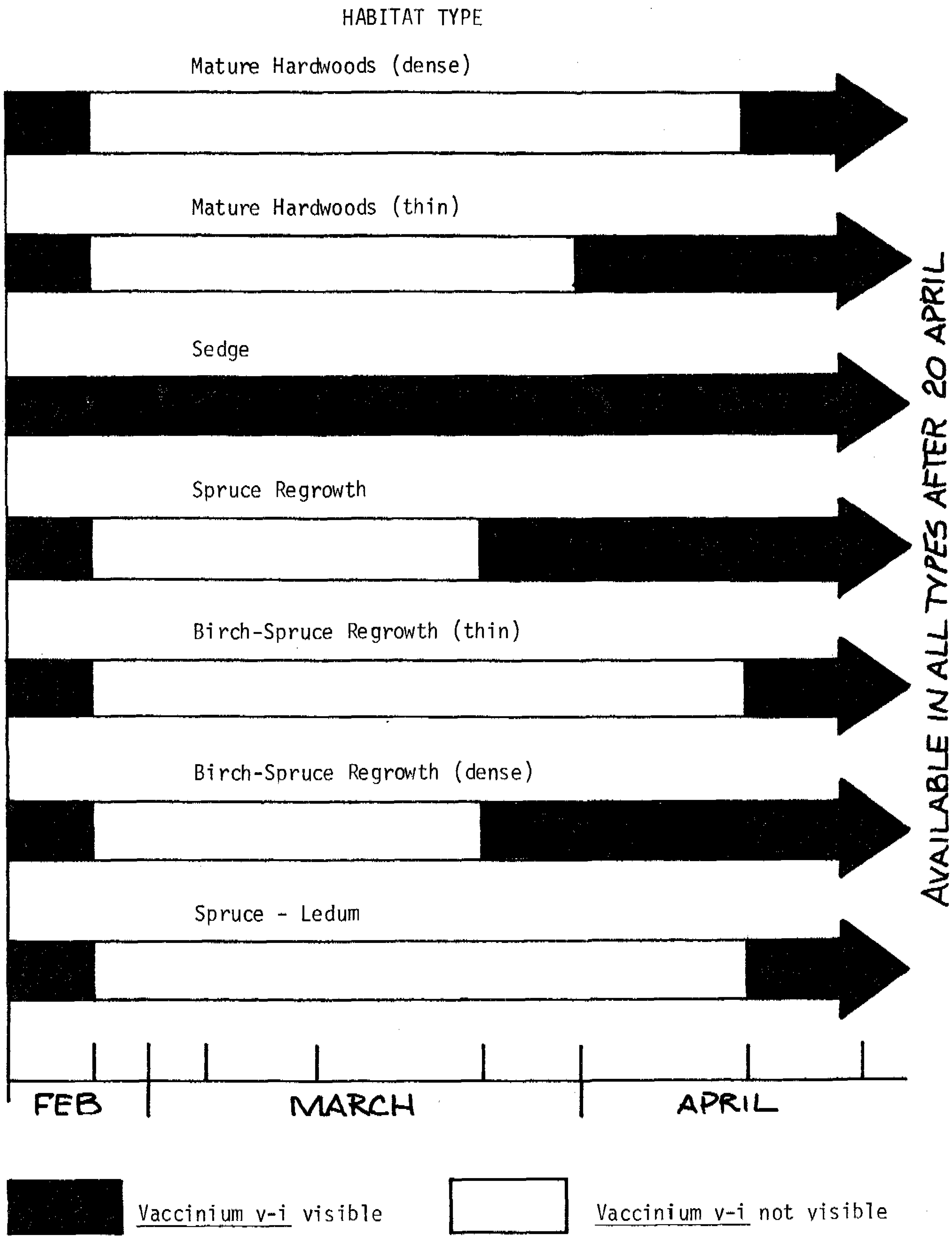
1. Moose populations on the northern Kenai Peninsula as represented by penned animals seem to be stabilized or possibly increasing very slightly.

Table 23. Snow depth (cm.) in each of seven habitat types. Kenai Moose Research Center. 1971.

	24 February	4 March	12 March	24 March	31 March	13 April	20 April
Mature hardwoods (dense)	8*	27	33	24	22	13*	13*
Mature hardwoods (thin)	19	38	47	46	39*	30*	18*
Sedge	13*	33*	41*	27*	33*	22*	13*
Spruce regrowth	19*	39	44	44*	29*	15*	14*
Birch-spruce (thin)	20*	43	51	39	38	33*	22*
Birch-spruce (dense)	28*	51	60	47*	36*	26*	23*
Spruce-ledum	28*	48	56	43	41*	36*	28*

* _Vaccinium vitis-ideae_ visible.

Figure 13. Vaccinium vitis-ideae availability by habitat type. During spring, 1971. Kenai Moose Research Center.



Long growth period, great seasonal fluctuations in weight, relatively low neonate survival and high mortality before 24 months of age all suggest a near maximum density of moose is present. This density is likely in excess of 15 animals per square mile. Therefore moose in the 1947 burn should not be managed for increased herd size.

2. Blood sera should be collected from as many weak/moribund animals as possible and from animals maintained on low-quality rations to substantiate suspected nutritional influence on blood parameters.

3. Broken stems per unit area should be further investigated as an indicator of habitat use by moose.

4. Girth/length ratios should be investigated relative to blood parameters, season and other factors to determine their suitability as indicators of moose condition.

5. Proportion of lichens and lowbush cranberry in moose diets in late winter should be considered positively correlated with range quality when evaluating habitat in this range.

6. Range evaluations on seral ranges where Vaccinium vitis-ideae is an abundant understory plant should consider winter availability of this species as an important factor in carrying capacity for moose.

7. Experiments should be conducted to determine whether willow and/or Vaccinium synergistically improves digestibility of birch woody browse.

8. Counts of rumen protozoa and sedimental proportion of micro-organisms in rumen liquor should be further evaluated as indicators of range quality.

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JOB PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperators: Alaska Department of Fish and Game; U. S. Bureau of Sport Fisheries and Wildlife; Kenai National Moose Range; Alaska Cooperative Wildlife Research Unit.

Project No.: W-17-3 Project Title: Moose Investigations

Job No.: 1.2R Job Title: Moose Behavior

Period Covered: July 1, 1970 through June 30, 1971

SUMMARY

Five gravid cow moose were radio-collared in May within the Moose Research Center pens. Three other cows and one yearling bull were similarly marked from June through March. The animals were followed to study when and why early calf mortality occurs and to determine patterns of use within the four one-square-mile enclosures.

No natural mortality of followed calves occurred after parturition during this study period.

Home ranges varied from 94 to 299 acres, or only 15 percent to 47 percent of the available areas within each one-square-mile pen. Overlap of home ranges was considerable (36-47 percent) and activity centers were close to one another, indicating nonrandom habitat use within the pens. Birch-spruce habitat types were used most frequently throughout the year. No hourly preference for habitat types was demonstrated.

Distances moved were lowest during late summer and in January and February and greatest in August, November and December.

Associations with other moose were highest during rut and in February, and lowest in December, January, and just before parturition. Nonpregnant cows showed reduced sociality during the precalving period similarly to pregnant animals.

A student project concerning maternal behavior and the cow-calf bond (Stringham and Lent, 1971) was carried out at the Center during part of the reporting period.

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BACKGROUND

Kenai Peninsula moose calf-cow ratios obtained shortly after calving have consistently been much lower than expected when compared to winter pregnancy data. Pregnancy rates of less than 90 percent in winter have never been recorded yet June calf-cow ratios are commonly less than 40:100 (LeResche, 1970; LeResche and Davis, this report). Most counts made several weeks after calving show substantially lower calf-cow ratios than those made immediately after calving (LeResche, 1968; Kenai NMR Files). These data show the need for determining when and why calves are lost.

Past research showed calf mortality was greatest within several weeks <u>post-partum</u> (LeResche, 1968). This research depended upon chance observations of marked calves. Assured relocation of cows by radio-telemetry would increase the chances of rapidly locating still-born calves or recently dead calves so that an autopsy could be diagnostic.

Past studies at the Moose Research Center showed a need to determine if patterns of moose use are random within the enclosures. Pellet group and forage production and utilization plots were originally located randomly within habitat types. Analyses of data from these studies suggested other than random use of habitat types (LeResche, 1970). Movements of radio-collared moose could be recorded to test patterns of use.

The need to capture and recapture moose for serial blood and milk sampling and measuring and weighing led to the design and construction of traps within the enclosures. Radio locating moose and immobilizing them with cap-chur equipment was one possibility for obtaining serial data if the moose were not trapped at desired intervals.

So many studies have suggested the importance of population density and social behavior to productivity (cf: review in Watson and Moss, 1970) that such phenomena have become accepted by some as generally applicable to vertebrates. Still, the most definitive studies have concerned small mammals (eg: Southwick, 1955; Chitty, 1960) and avian species (eg: Lack, 1964, 1966), and any behavioral limitation of large ungulate populations (eg: Wynne-Edwards, 1962; Buechner, 1961) remains conjectural.

OBJECTIVES

Primary: To locate parturient cows during the calving period and post-partum cows during succeeding weeks to ascertain time and cause of early calf mortality.

Ancillary: To determine patterns of moose use within the enclosures. To locate dead animals soon enough for post-mortem autopsy to be diagnostic. To locate animals to obtain needed serial data. To investigate the development of behavior of moose calves.

PROCEDURES

Eight cow moose were marked with radios in the 30 mhz range and located daily during late May and early June and at irregular intervals of about one week thereafter. They were located from the ground with a hand-held directional receiver (D 11/m). Transmitters and receiver were obtained from Boyd's Hobby Shop, Tumwater, Washington.

All ancillary objectives: Relocating of all radio-collared moose was continued at irregular intervals (approximately one week) until the radios failed or until April, 1971. Each observation was plotted on a 1:10,105 scale vegetation-type map. Habitat type, time of day, activity, date and other moose present were recorded.

A student project was initiated during May-August 1970 to investigate the cow-calf behavioral bond and other aspects of calf behavior, as another approach to evaluation of behavioral aspects of productivity. Stephen F. Stringham, a (MS) student at the Alaska Cooperative Wildlife Research Unit, is responsible for the work, which will continue through August 1971. His plan for the study follows:

CALF BEHAVIOR AND THE COW-CALF BOND:

Stephen F. Stringham
Cooperative Wildlife Research Unit
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OBJECTIVE: To investigate the development of behavior of moose calves. Emphasis will be on social interrelationships and activity patterns. Particular attention will be paid to (a) calving and post-calving periods and, time permitting, to (b) pre-rut and rut periods.

I. <u>Social Interrelationships</u>:

A. <u>Interactants</u>:

1. cow and calf (or calves)

2. calves of the same cow

3. calf (or calves) and yearling (or yearlings) of the same cow

4. calf-dam pair and other moose

5. calf (when its dam is not involved) and other moose

B. <u>Factors to be considered</u>:

1. size and composition (age and sex) of groups interacting with calf or calf-dam pair

2. dominance rank--relative to cow--of the other moose

3. spatial orientation of the animals relative to one another

   a. direction of ears and head
   b. orientation and posture of body (including "display" characteristics such as erection of the mane)

4. distancing of the moose relative to one another

5. rates of travel toward, away from, or tangential to one another

6. nature of interaction

   a. maternal
   b. gregarious
   c. convergence or avoidance
   d. play
   e. "indifference"
   f. disturbance
   g. interruption (e.g., interruption of courtship by the dam's calf)
   h. other

7. which moose initiate(s) interactions

8. frequency, duration, rate and intensity of interaction

II. Activity Patterns:

A. Activities to be emphasized:

1. social interactions (see above)

2. feeding

   a. nursing
   b. browsing or grazing
   c. drinking
   d. ruminating

3. resting or sleeping

4. investigation of surroundings

5. play

6. other

B. Factors to be considered:

1. time of day, season and year

2. weather

3. duration and frequency of each type of activity (above)

4. location

5. synchronization between activity patterns of calf and dam and between calf-dam pair and other moose with which they are interacting

III. Observations during the 1970 field season indicated that ontogenetic changes are both qualitative and quantitative. Close attention will thus be paid to onset of new patterns and transformation or extinction of established patterns, and to changes in duration, frequency, rate and intensity throughout the first four months of development.

IV. Sample questions typical of those for which answers will be sought in this study:

A. In what ways and to what extent does the cow appear to "determine" the behavior of her calf?

1. Which activities does the cow initiate; which does she terminate?

2. What behavior patterns (e.g., reactions to disturbance) of the cow appear to be mimicked by the calf?

3. Under what circumstances do calves "heel" to their dams? What percentage of the time when traveling with their dams do they "heel"; for how long at a time? What percentage of the time do cows seem to follow their calves, rather than vice versa?

B. How does the cow react to "display" behaviors (e.g., threat postures) by her calf; how do other moose react to them?

C. How do calves react to disturbance? Under what circumstances do they drop to the ground or stand and "freeze"; under what circumstances do they flee?

D. When a calf is left alone by its dam, how much of the time, and under what circumstances, does it remain bedded down; when it is not bedded down, what else is it doing?

E. What differences occur in interactions between male versus female calves and their dams or other moose?

PROCEDURES:

I. Observations will be made on cow-calf pairs in pens 2 and 4.

A. Attention will be concentrated on:

1. The untagged cow with twins in pen 2.

2. R-70-3 in pen 4, and either

3. R-70-1 in pen 4, or

4. R-70-7 in pen 2

II. Though habituation of the moose will be continued, observations will be made while undetected whenever possible.

III. Work Schedule:

A. Cow-calf pairs will be observed every other week beginning with their first week of life. Since the cow with twins and R-70-3 gave birth a week apart, they will be observed during alternate weeks. The schedule for the third cow to be observed will depend upon when she gives birth.

B. The 24 hour day is divided into two periods:

1. A: dawn to 1 p.m.

2. B: 1 p.m. to dusk

C. Two A and two B periods will be devoted to the cow with twins and R-70-3 every other week; the third cow-calf pair will be observed during one A and one B period on alternate weeks. Thus, six A and six B periods will be spent in the field every two weeks.

FINDINGS

Of the eight radio-collared cows utilized for the study, four gave birth to single calves, three had none and one died giving birth to twins because of a breech delivery (Table 1). Of the four females producing viable calves, only two cow-calf combinations were followed daily because radio R-70-2 malfunctioned the day after installation and cow R-70-4 abandoned her calf due to human influence (she gave birth while in a trap and was moved from outside the enclosures to within).

Observations of the two viable cow-calf combinations indicated that luck would be involved in locating a recently dead calf via the cow unless she remained by the dead calf for many hours. Even within the first two days of the calf's life, one cow and calf moved a minimum of 460 meters (1,380 feet) in heavy cover. This illustrates that even with daily checks, locating a dead calf would be difficult.

Home Ranges and Activity Centers

Characteristics of home ranges and activity centers were calculated from 175 observations involving six radio collared moose (Table 2). The number of observations upon which the following discussions of home ranges, activity centers, mobility, habitat use and associations are based are presented in Table 3.

Many researchers have utilized, and defined differently, home range and activity center concepts in calculating areas of animal activity (Mohr and Stumpf, 1966; Robinette, 1966; Sanderson, 1966; Bayless, 1969; Hawkins and Montgomery, 1969; Rongstad and Tester, 1969; Goddard, 1970, Telfer, 1970; and VanBallenberghe and Peek, 1971).

Activity centers were determined by the method of Mohr and Stumpf (1966). This entailed locating a major and minor axis each of which divided the radio location points into two equal groups, while making the sum of the distances of all points from each axis as small as possible. All radio location points were utilized. Activity centers of moose in pens 2 and 4 were much closer together than would be expected by chance (Fig. 1), suggesting nonrandom use patterns by selection of areas of better habitat.

Home ranges were calculated after Godfrey (1954) from Mohr and Stumpf (1966). This method consisted of connecting all outside points of observation and calculating the area of the enclosed polygon.

Table 1. Identity of radio-collared moose in the Moose Research Center during May 1970 to April 1971.

Moose	Radio Color	Installed	Quit	Pen	Sex	May 1970 Age. Yrs.	Reprod. 1970 & Remarks
R-70-1	Gr. & Blk.	19 May 70	16 June 70	4	F	6	1 calf born 20 May
R-70-2	Blk. & Silver	22 May 70	23 May 70	2	F	3	1 calf born 22 May
R-70-3	Org. & Yellow	20 May 70	22 Oct. 70	4	F	3	1 calf born 23 May
R-70-4	Blu/wh.	23 May 70	Working	2	F	?	1 calf born 23 May deserted
R-70-5	Red & Gr.	24 May 70	Working	2	F	?	Female died, 2 calves, 1 breech
R-70-7	Red & Gr.	4 June 70	Working	2	F	7	
R-70-8	Gr, wh, yel.	10 July 70	Working	1	F	2	
R-69-3	Gr. & Blk	13 Aug. 69	Working	2	F	6	
Richard	Bk, yel, wh.	11 Nov. 70	20 Nov. 70	2	M	1	
Richard	Yel, Red	30 March 70	Working	2	M	1	

Table 2. Observations of each of six radio-collared moose by month. Kenai Moose Research Center. 1970-71.

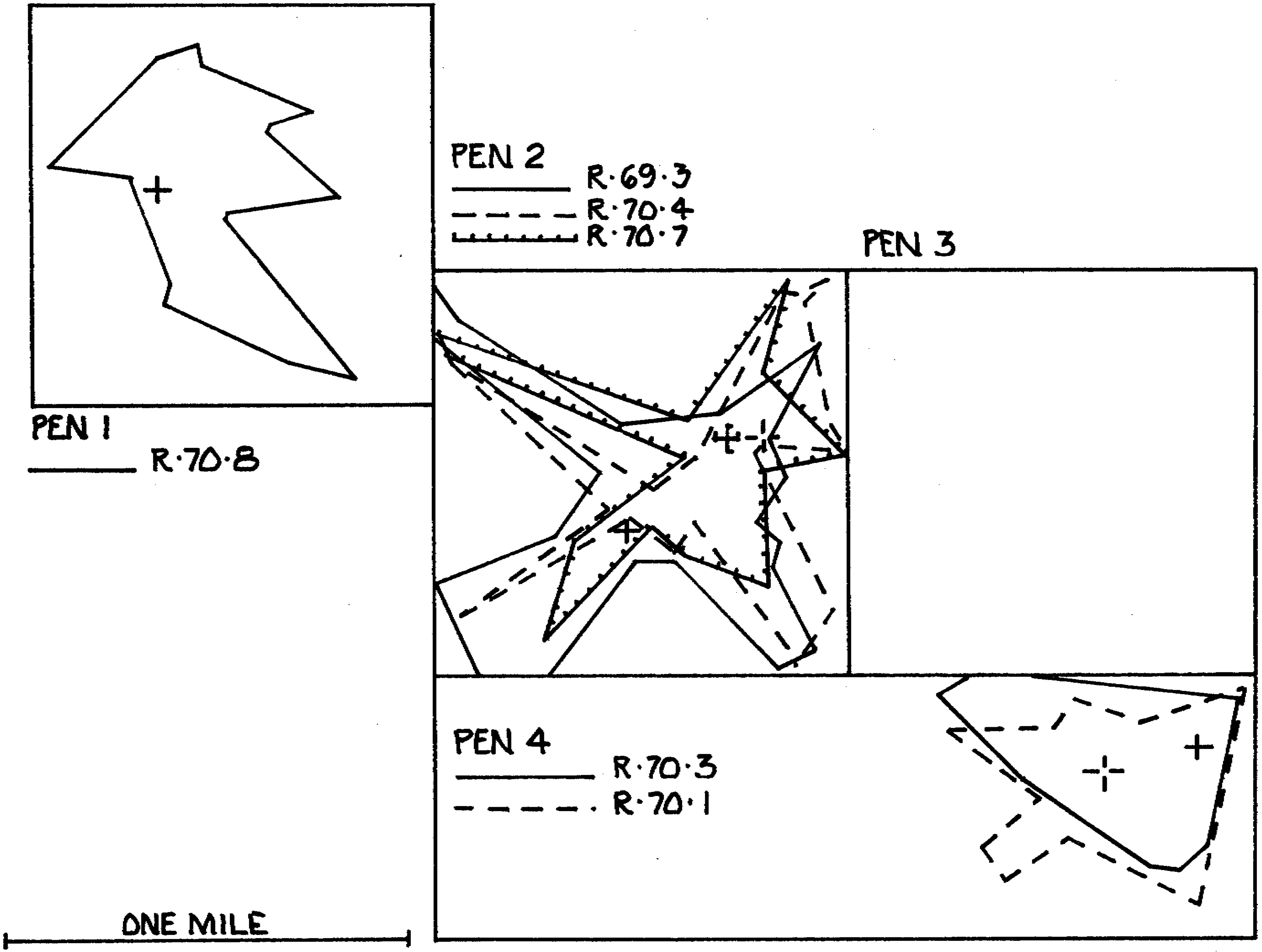
	Pen 1	Pen 2				Pen 4			ALL PENS
	R-70-8	R-69-3	R-70-4	R-70-7	Total	R-70-1	R-70-3	Total	
May 1970		4	4		8	9	9	18	26
June		11	10	8	29	9	10	19	48
July	3	3	5	4	12	2	4	6	21
August	4	5	2	4	11		3	3	18
September	3	3	3	3	9		4	4	16
October	2	2	1	2	5		2	2	9
November	3	2	2	3	7				10
December	2	2	2	2	6				8
January	2	1	1		2				4
February	2	3	2	2	7				9
March	2	1		1	2				4
April		1		1	2				2
TOTAL	23	38	32	30	100	20	32	52	175

Table 3. Characteristics of home ranges of radio-collared moose within one-square-mile enclosures. Kenai Moose Research Center. 1970-1971.

Moose	Home Range (acres)	Pen (acres)	Percentage of Pen	Times Located	Dates Located From	Dates Located To	Index of HR size	Pen
R-70-8	175	640	27	22	14 July 70	30 Mar. 71	.59	1
R-69-3	299	640	47	40	22 May 70	21 Apr. 71	1.00	2
R-70-4	247	640	39	33	24 May 70	30 Mar. 71	.83	2
R-70-7	234	640	37	31	5 June 70	14 Apr. 71	.78	2
(partial) R-70-3	148	640	23	22	21 May 70	14 July 70	.50	4
R-70-1	107	640	17	20	21 May 70	14 July 70	.36	4
(complete) R-70-3	94	640	15	32	21 May 70	22 Oct. 70	.31	4

Acres Common to Home Ranges of:		Percent of Individual's Home Range Overlapping with Other Moose:
R-69-3) R-70-4) R-70-7)	109 acres	R-69-3:36% R-70-4:44 R-70-7:47
R-69-3) R-70-4)	172	R-69-3:58 R-70-4:70
R-69-3) R-70-7)	145	R-69-3:49 R-70-4:59
R-70-4) R-70-7)		R-70-4: R-70-7:
R-70-1) R-70-3)	53	R-70-1:50 R-70-3:56

Figure 1. Activity centers and home ranges of radio collared moose within the Kenai Moose Research Center.



Determining home ranges and activity centers for moose confined within one square mile may be of limited usefulness as home ranges might likely include the entire one mile if enough observations were made over a long period. However, it is interesting that during one year, with a considerable number of observations, individuals moved over a relatively small portion of each one square mile enclosure (Table 3; Fig. 1). These home ranges were also considerably smaller than those (2-10 square miles) reported for free-ranging moose by Phillips and Berg (1971). This may be due to the enclosures or the the excellent and diverse habitat present in small areas in the 1947 Kenai Burn.

The home range data also suggest that utilization of the pens is probably not random. While none of the three radioed moose in pen 2 had a home range encompassing over 47 percent of the one-square-mile pen, all three of the animals shared a common portion of the pen that amounted to 36, 44 and 47 percent, respectively of their total home ranges (Table 2). Also, activity centers for R-70-4 and R-70-7 were only 190 meters apart and that of R-69-3 was about 600 meters from the others. This may be due partially or wholly to confinement.

Two radioed animals in pen 4 utilized only about one-fifth of the pen during a 10-week period. Both animals were caught in a trap in that portion of the pen. Further evidence that penned moose have home ranges of relatively small size is that individually marked moose are often predictably observed by chance in small portions of the pens.

Mobility

Average distance moved between observations by month (Figs. 2 and 3), average distance moved between all observations, and greatest and least movement between two consecutive observations (Table 4) were computed from the radioed moose relocations. Utility of these data is obviously restricted because of limits on movements placed by the enclosures. However, minimum distances moved and differences in distances moved by month perhaps indicate true movement patterns. Also, the small proportion of the total pen area used by each animal indicates that the pens are not as restrictive as might be expected.

Observations were made at irregular intervals, varying from one day to over a week. However, relative monthly average distances between relocations correspond closely for most moose in all pens. The exceptions were that average distances moved: 1) decreased from July to August for all except pen 1, where they increased; 2) all decreased from August to September except for that of the cow in pen 4, which increased slightly (possibly because of calf development); and 3) decreased sharply in all pens from December to February except in pen 1 where it increased from January to February (possibly accounted for by few observations).

The most striking inter-pen differences were: 1) the much smaller average distance moved in pen 4. This was expected because the two cows here were the only ones studied that had live calves. Their average distance moved increased from June to July as expected because of increasing calf mobility with age but decreased again for August and September.

Figure 2. Mean distance between radio collared moose relocation for individuals in Pen 2. Kenai Moose Research Center. 1970 - 1971.

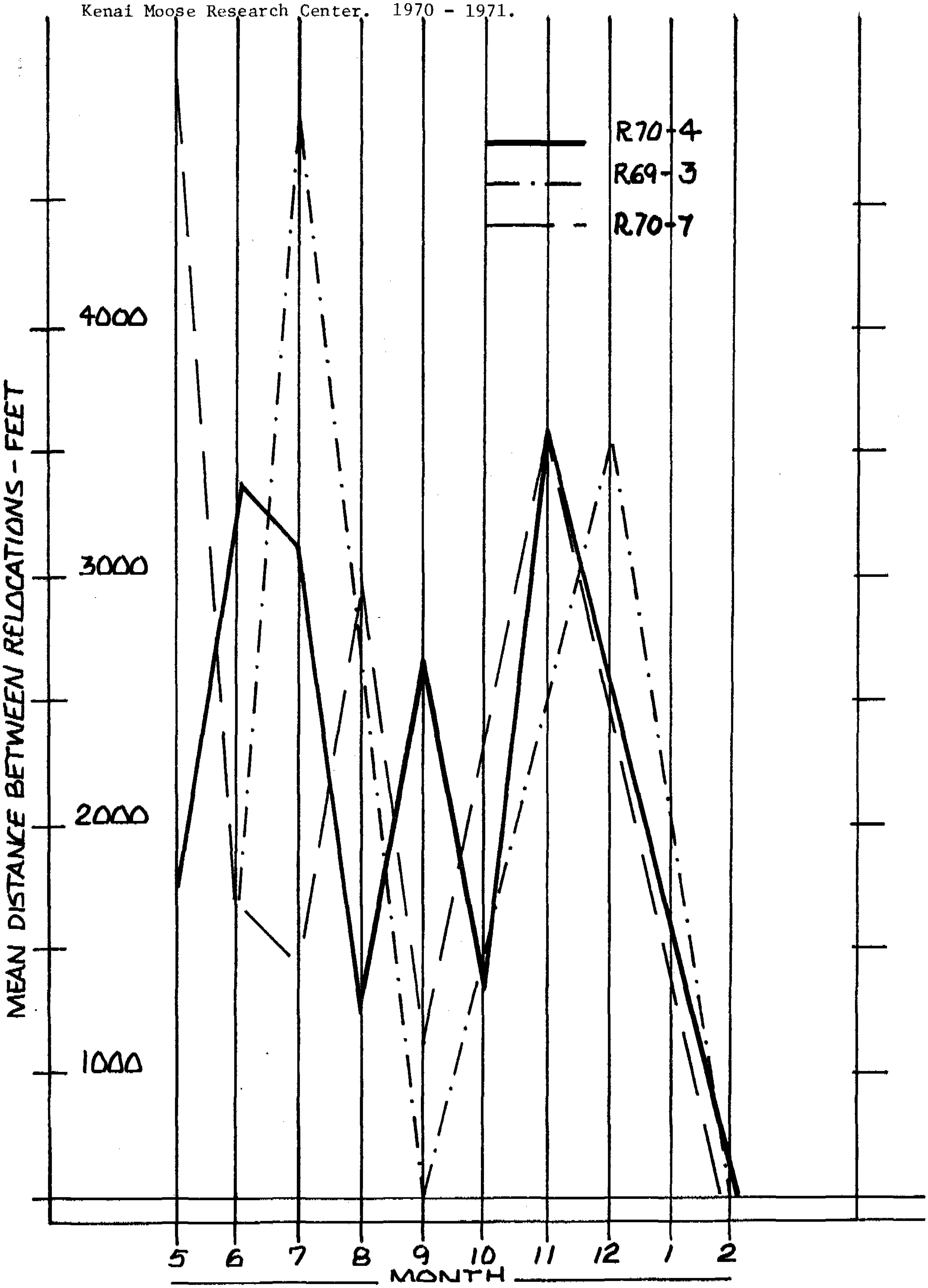


Figure 3. Mean distance between radio collared moose relocations for all pens occurring within each month. Kenai Moose Research Center. 1970 - 1971.

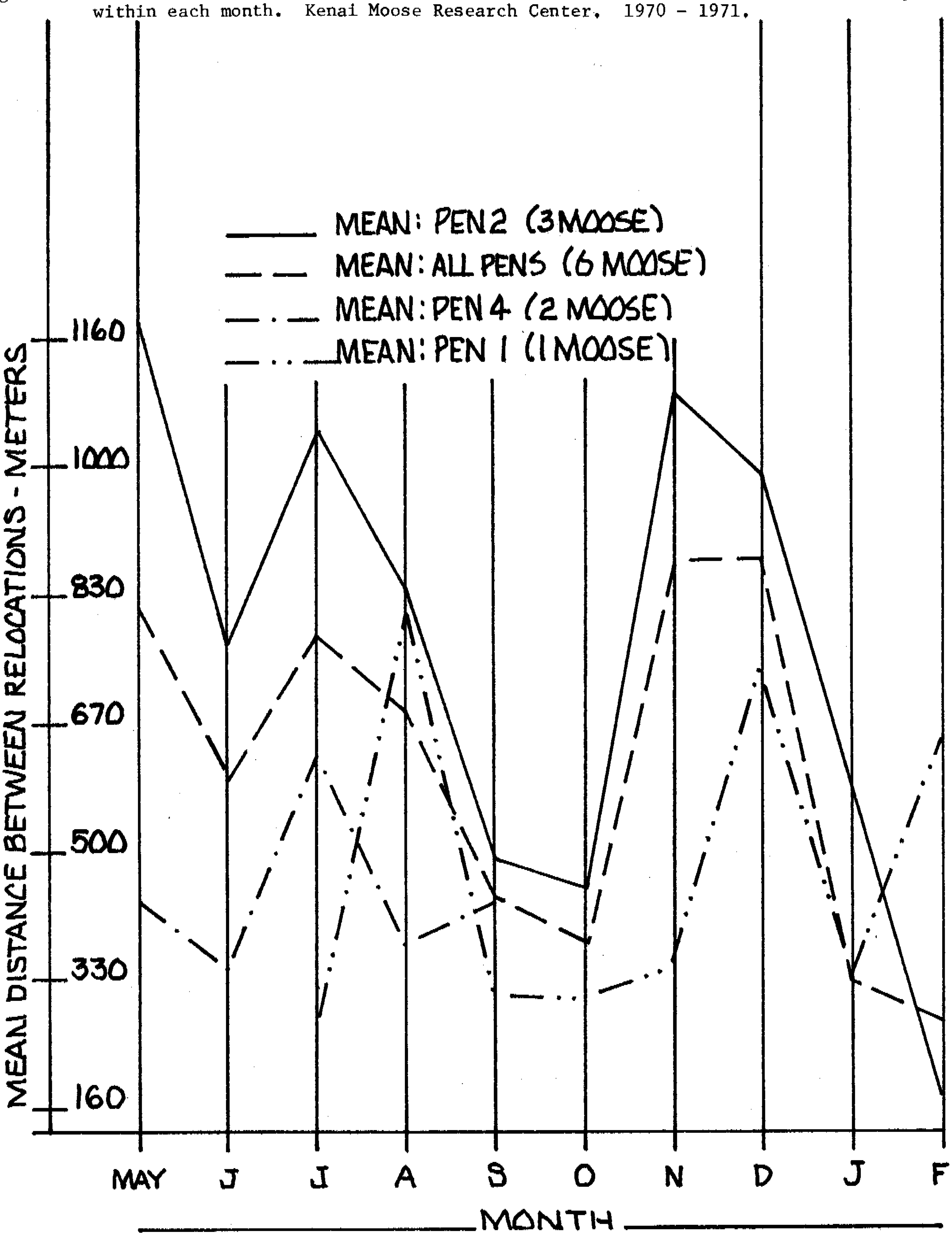


Table 4. Greatest, least and mean distances moved between radio relocations of moose. Kenai Moose Research Center. 1970-71.

Moose	Pen	Distance between relocating points (m)		
		Greatest	Least	Mean
R-70-8	1	1560	25	607
R-70-7	2	1840	184	688
R-70-4	2	2160	44	680
R-69-3	2		70	813
All	2		99	724
R-70-3	4	1883	53	486
R-70-1	4	1250	33	386
All	4	1570	43	436

The consistently smaller monthly average distance moved for pen 1 compared to pen 2 possibly occurred because of having data from only one individual in pen 1. That animal may have been a more sedentary individual or perhaps restricted movement reflected the habitat juxtaposition of cover types.

Other noticeable changes in average distance moved per month were: 1) the decrease from May to June for all animals without calves; 2) the increase from June to July and subsequent decrease to August (the August decrease coincided with a shift to mature hardwood type suggesting pre-rut behavior alteration or perhaps a seasonal preference for the type); and 3) the low average distance between movements during the months of September and October, (associated with the breeding season) the subsequent increase after the rut, and the decrease as winter progressed.

Habitat Use

Considering observations of radioed moose as an index of habitat use, birch-spruce regrowth types were by far the most heavily utilized vegetational type throughout the year (Fig. 4). On a seasonal basis this type received over 50 percent of the total use during all months except August and September when it received 22 and 33 percent of total use, respectively. During these two months mature hardwood was utilized at rates of 61 and 40 percent, respectively. The only other habitat types receiving much utilization were sedge and spruce-ledum from May through October. Utilization of sedge and spruce-ledum types occurred (primarily by R-70-1 and R-70-3 and their calves) from May through September. Several observations in other pens occurred in these types during this period also. Spruce regrowth and mature spruce type utilization was negligible during most months.

Percentages of total observations of each individual occurring in each habitat type were quite consistent with the exception of pen 4 individuals (Figs. 5 and 6). Both animals here were observed more often in sedge, spruce-ledum, and hardwood types, and less frequently in birch-spruce type than were other moose. This likely occurred because the pen 4 animals had calves.

Associations of Moose

The association of each radioed moose with all other moose with which it was observed was quantitatively expressed (Table 5). The method used for computing was that which Knight (1970) presented as:

"Formula for the coefficient of association:

$$\frac{2\ ab}{a + b}$$

Where a is the number of times animal A was observed throughout the season, b is the number of times animal B was observed throughout the season, and ab is the number of times that animals A and B were observed together throughout the season.

Figure 4. Percent of total monthly observations of all radio collared moose by habitat type. Kenai Moose Research Center. 1970-1971.

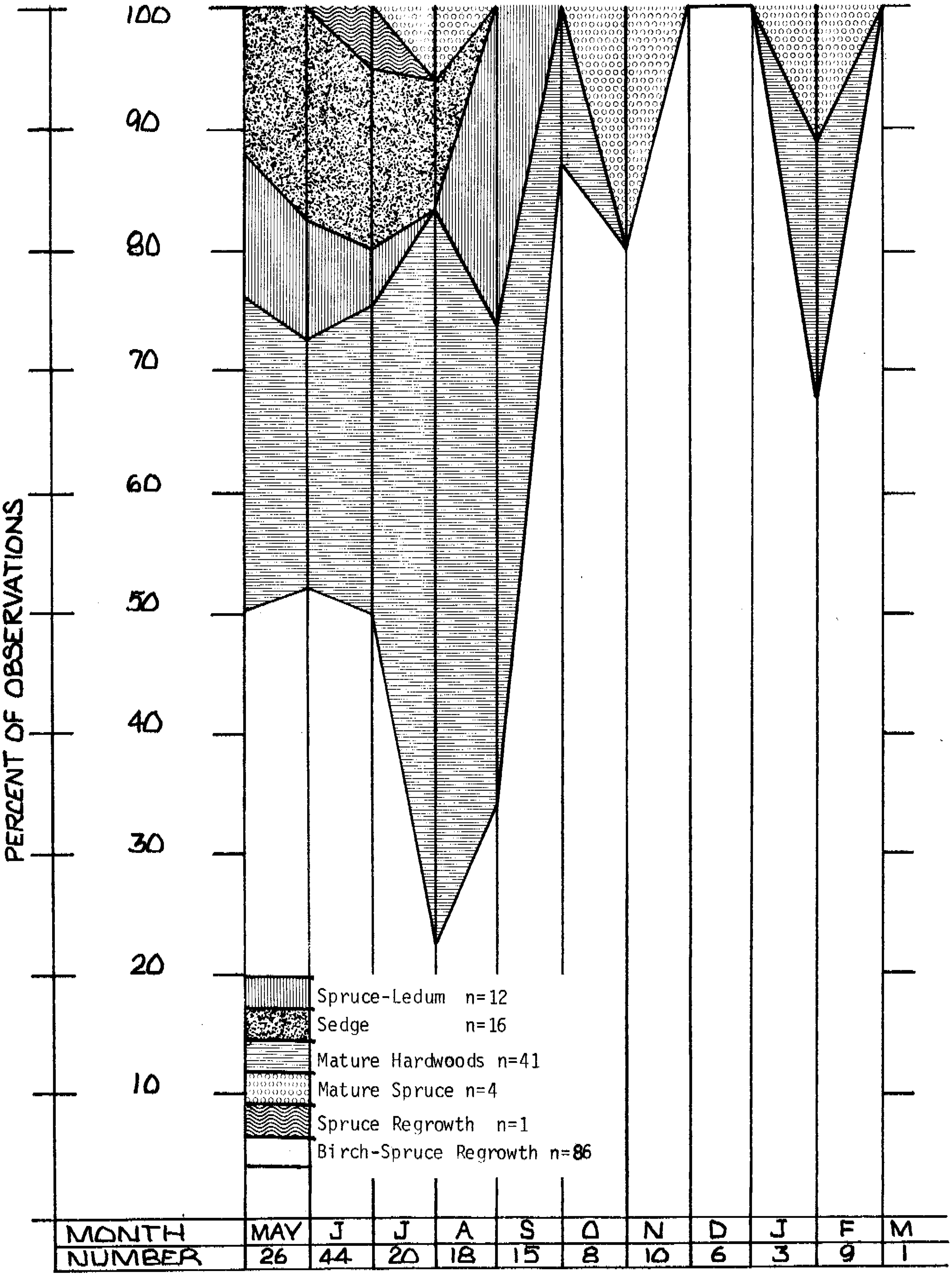


Figure 5. Percent of total occurring in each observation of radio collared moose in Pen 4 by habitat type. Kenai Moose Research Center. 1970 - 1971.

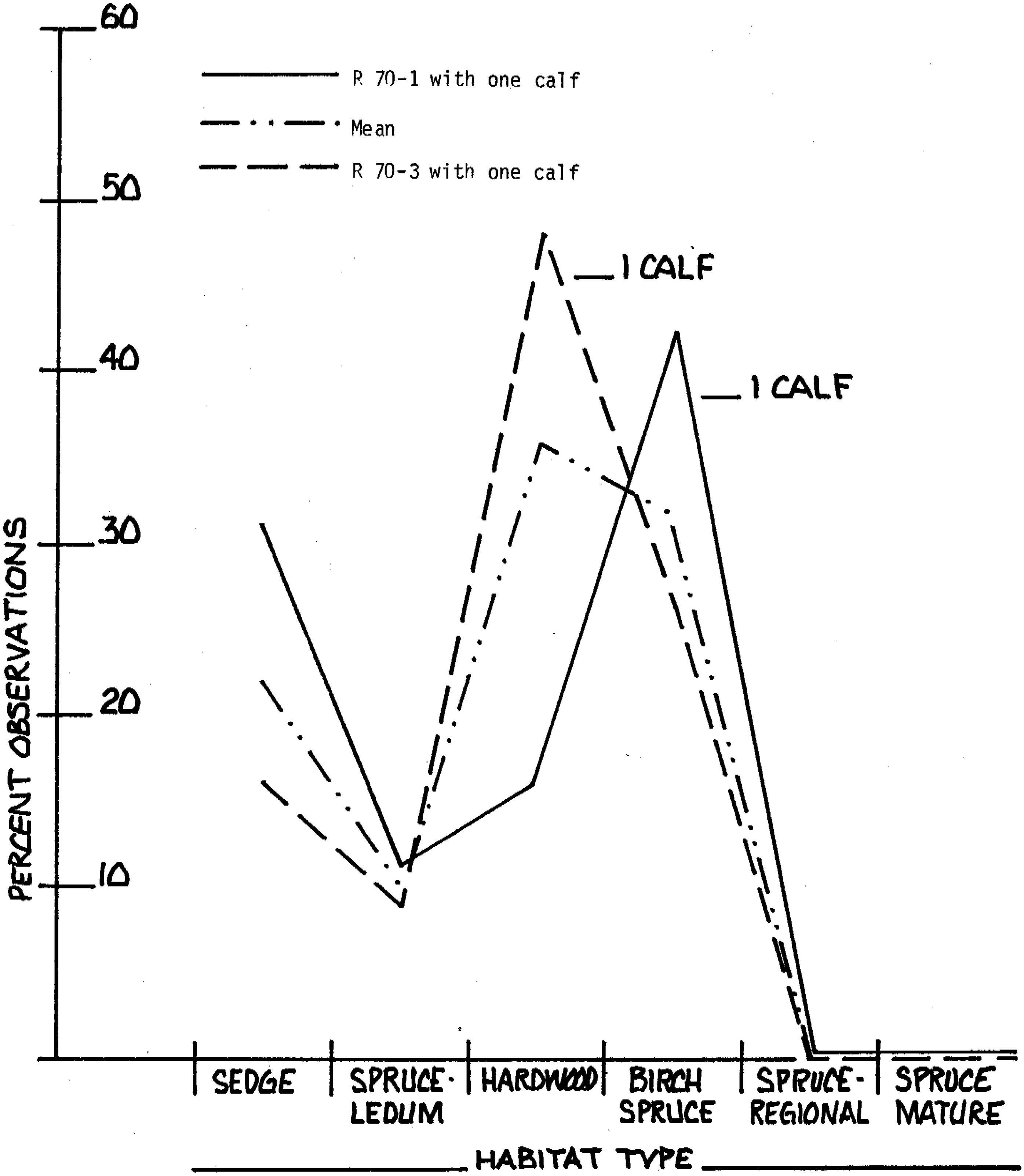


Figure 6. Percent of total observations of radio collared moose in each pen by habitat type. Kenai Moose Research Center. 1970-1971.

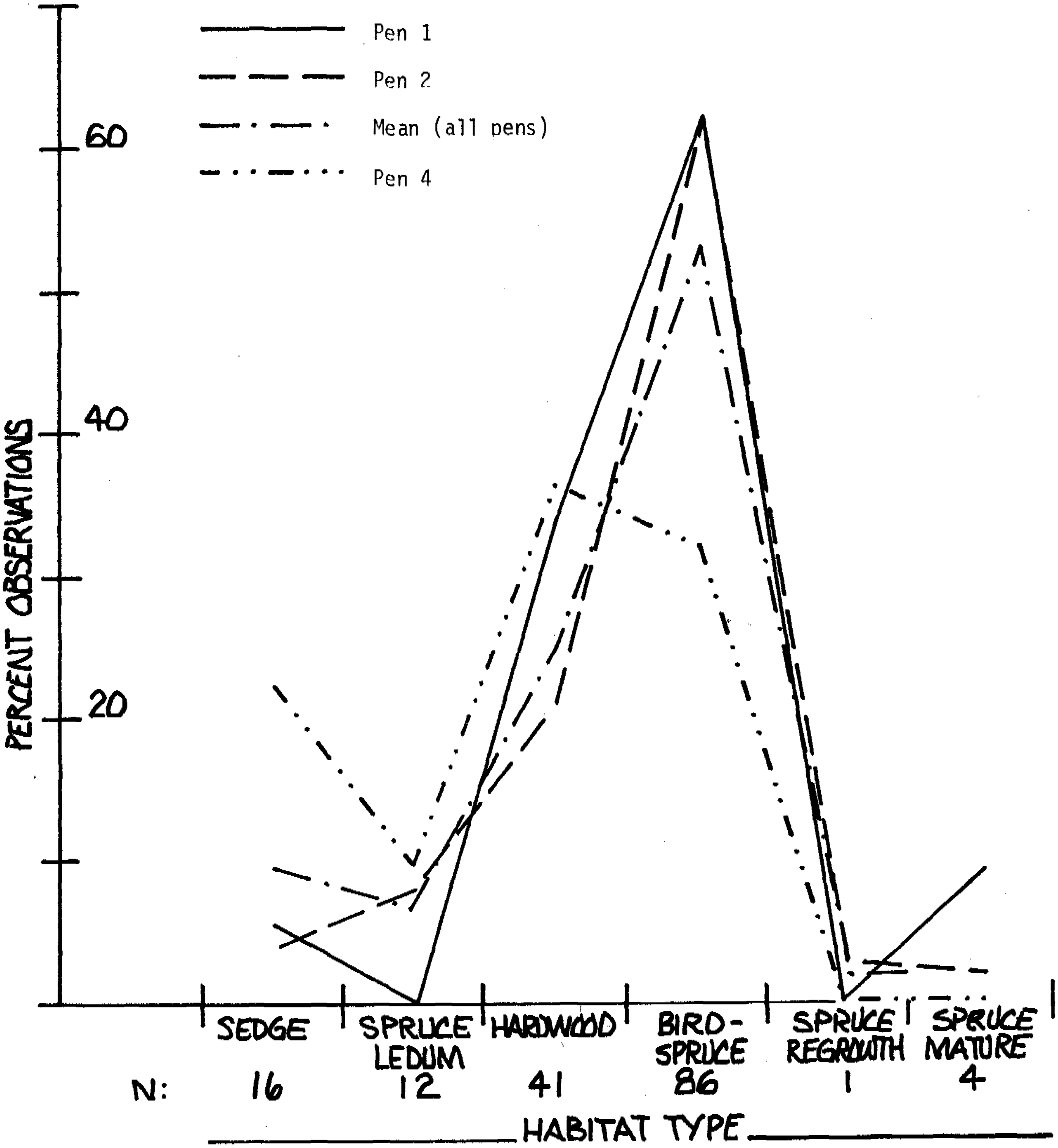


Table 5. Coefficients of association for moose within three one-square-mile enclosures. Kenai Moose Research Center. 1970-71.

Association With

Moose	43 M	40 F	6 F	Mean
R-70-8 F	.28	.07	.07	.14

	1 F	36 M	R-70-7	9 F	R-70-4	45 M	Rich	Walt	R-69-3	Unmarked	Mean
R-69-3 F	.08	.18	.17	.12	.09	.04	.14	.08	-	-	.11
R-70-7 F	.16	.23	-	.21	.24	.18	.09	.06	.17	.06	.16
R-70-4 F	-	.33	.24	.16	-	.12	.05	.05	.09	-	.06
All pen 2	.02	.25	.20	.16	.16	.11	.09	.06	.13	.04	-

	21 M (before calving)	Calf
R-70-1 F	.13	.80
R-70-3 F	-	1.0

Pen 2 means: males = .13
females = .14

Using this formula, a value of 1 would indicate perfect association or the probability that A and B would occur together all of the time."

As shown in Table 5, there was no strong association between any animals other than the two cows and their calves in pen 4. Even these associations were followed only through the first four months of the calves' lives. An explanation for the less than 1.0 association between R-70-1 and her calf is that the calf was not always observed when the cow was located in heavy cover. Even during her calf's first week of life, R-70-3 was observed over 300 meters from it, illustrating that the animals may not be observed together even while closely associated behaviorally.

The nearest day to a parturition date that either cow was observed associated with another adult animal was when R-70-1 was observed with male #21 on May 23, five days before her calf was born on May 28.

There was no significant difference in degree of association between individuals within the various pens, individuals of one pen compared with those in another, or between sexes.

The highest degree of association occurred during the rut and during February (Fig. 7). These were also the times of most restricted movements. The February high was unexpected in light of the lowest monthly associations of the year occurring during December, January, and March.

Even though the four cows in pens 1 and 2 had no calves, they all showed a lowered degree of association during the pre-calving period of May, similar to the gravid cows in pen 4.

RECOMMENDATIONS

1. Radio-telemetry of parturient cows is an unpromising way to study early calf mortality. If this type of study is to be pursued, a method should be found for radio-tracking calves themselves or for enclosing cows into areas small enough to allow location of calves but large and ecologically complete enough to support a cow and her calf.

2. One-square-mile pens appear large enough to enclose moose at normal densities without unduly restricting movements and home ranges.

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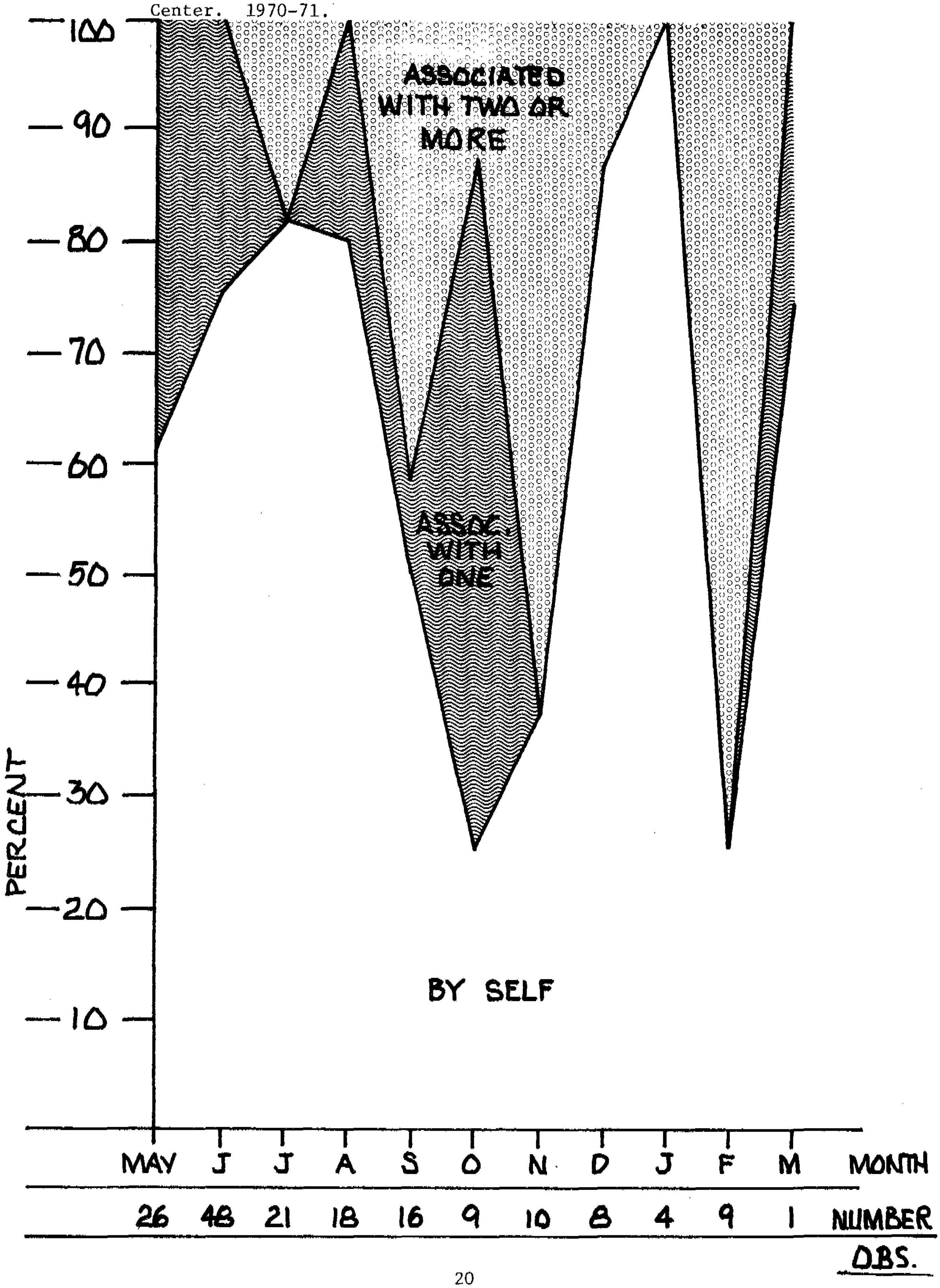
Figure 7. Percentage of total monthly observations of radioed moose in Pens 1 & 2 that involved associations with other animals. Kenai Moose Research Center. 1970-71.



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JOB PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperators: Alaska Department of Fish and Game, U. S. Bureau of Sport Fisheries and Wildlife (Kenai National Moose Range)

Project No.: W-17-3 Project Title: Moose Investigations

Job No.: 1.3R Job Title: Development and Testing of New Techniques

Period Covered: July 1, 1970 through June 30, 1971

SUMMARY

Techniques of aerial censusing, pellet-count censusing, immobilizing, radio tracking, freeze-branding and otherwise marking moose were tested in the Moose Research Center enclosures and nearby.

Experienced observers saw a mean of 69 percent of moose flown over in excellent counting conditions, when flying 15 minutes over each one-square mile. They saw significantly ($P < .02$; t-test) more moose than experienced observers in good conditions, (61 percent), and experienced observers in poor conditions (40 percent). In all conditions, experienced observers saw more than did inexperienced observers (43 percent, 44 percent and 19 percent, respectively for excellent, good and poor conditions). Observers with past experience but little or no current experience saw a proportion of moose (46 percent) equivalent ($P > .10$; t-test) to that seen by inexperienced observers and significantly lower ($P < .01$; t-test) than that seen by experienced/current observers (excellent conditions).

No significant ($P > .10$; x^2) difference in ability to see moose was detected in relation to time of day, although highest proportions were seen between 1000-1200 hours and after 1400 hours, in March.

Counting of pellet groups within 159 plots cleared of pellets in 1970 suggested a defecation rate of 32 groups per day, or 0.59 ± 0.90 groups per plot deposited in one year.

M-99 Etorphine and succinylcholine chloride were drugs of choice for moose. Addition of hyaluronidase to injected drugs increased absorption rate and apparently stabilized drugs' effect on different individuals. Effects of the drugs varied seasonally. Other drugs were less useful with moose.

Freeze-branding experiments were unsuccessful on two moose.

An easily read collar-pendant marker was placed on 135 adult moose.

CONTENTS

BACKGROUND

Moose research and management require methods of estimating numbers and of handling, marking and following animals. These techniques necessarily vary with species, location and nature of the management/research problem. The Moose Research Center, with known numbers of confined animals, provides a unique test-ground for numbers-related techniques and for methods and equipment whose effectiveness can be learned only by relocation of animals.

Aerial censusing is at present the only practical method of estimating moose numbers in most of Alaska (cf: Rausch and Bratlie, 1965; Rausch and Bishop, 1968; Bishop, 1969; Bergerud and Manuel, 1969), but determination of the extent to which this method underestimates numbers has been a major problem when absolute numbers are sought. Benson (1966), Goddard (1966) and Bergerud (1968) have reviewed aerial censusing techniques.

LeResche (1970) reported that moose aerial census results depended upon observers and counting conditions and that fewer than 70 percent of moose present were seen by experienced observers flying with good counting conditions.

Siniff and Skoog (1964) developed a random stratified, quadrat sampling method for caribou (*Rangifer tarandus*), but even in intensively counted quadrats, some animals were missed. Evans *et al* (1966) used a similar technique on moose. The presence of four one-square-mile pens with known numbers of moose provided an opportunity to test the accuracy of aerial censusing and to test the value of previous experience in aerial counting.

Pellet-count census techniques have been used for various species of big game animals since the 1930's (cf: Bennett *et al*, 1940; Rasmussen and Dovan, 1943; Bowden *et al*, 1969). Several studies have been done with penned ungulates (summary in Neff, 1969) and others have used the technique in intensive studies of habitat use (DesMeules, 1962). The known numbers of animals enclosed in the Moose Research Center also provided opportunity to test this population-estimation technique for moose.

Immobilization of big game animals by drugs has progressed rapidly in a very few years, with different drugs indicated for different species (cf: Harthoorn, 1964, 1968; Miller, 1968; Houston, 1969). An ideal immobilizing drug should have 1) short induction time, 2) wide tolerance range, 3) rapid reversibility, 4) no lasting or cumulative side effects and 5) should leave meat consumable by a subsequent hunter. To find such a drug for a given animal, the logical approach is to try agents as they become available, preferably on recoverable animals.

Succinylcholine chloride (Bergerud et al, 1964) has been the most often used drug for immobilizing moose in Alaska primarily because it alone fulfills condition (5) above. The drug is less than ideal because it has a very narrow range of safe dosage (20 percent or less--LeResche, 1970), is irreversible and leaves moose with no muscle control to resist drowning in wet places. A recent report (Fuyita, 1970) has documented a delayed hypersensitivity reaction to the drug in a human subject.

Pienaar (1968a, b) has reported in detail on effects of various thebaine derivatives (eg: M-99 Etorphine) when used alone and in combination with tranquilizers and parasympatholytic agents. These neuroleptic-analgesic mixtures proved ideal because of their reversibility, wide safety range (230 percent for M-99 administered to moose reported by LeResche, 1970) and favorable therapeutic index. Houston (1969) and LeResche (1970) reported on M-99's effectiveness in handling moose.

Migration and other behavioral studies of big game animals may be accomplished by marking many animals and searching for them. Recently, radio-tracking devices have come into vogue for continuous location of animals (cf: Slater, 1963 for one review). In programs requiring regular relocation of moose for sampling blood or other specimens, radio-tracking gear is invaluable to insure timely recapture.

Methods of marking moose for subsequent identification have stressed assorted collars, pendants and earflags. In work with domestic animals, freeze branding (Farrell et al, 1969; Kambitsch et al, 1969) has recently come into greater use. The method involves killing pigment-producing cells in hair follicles by freezing and produces white hair in the pattern of the brand applied.

OBJECTIVES

To develop and for test techniques for: aerial censusing, pellet-count censusing, immobilizing radio-tracking and marking of moose.

PROCEDURES

On January 26-February 4, 1970, three helicopter counts and 19 counts by PA18-150 supercubs were made of moose in the four Moose Research Center pens. Thirty-three additional supercub counts were made on 6-9 March, 1971. Observers were instructed to direct pilots how to fly the survey and were allowed 15 minutes to count each square mile. Pilots did not participate in locating moose and observers recorded each moose seen. Observers could direct pilots to circle over one small area, to fly transects, dive, etc.

Conditions were good-excellent, with snow cover at least adequate, for 15 counts in 1970 and poor for 4 that year. Conditions were excellent, with complete snow cover, during all 1971 counts.

Time of day, pilot and previous moose-counting experience of the observer were noted for each observer and the total number of moose seen in each pen was recorded.

In spring 1970 (LeResche, 1970) 728 permanent 8' x 24' browse-utilization plots were used as pellet-count plots. Fecal groups in each plot were classified as "winter" (pellets) or "summer" (non-pelletized), counted and cleared from the plot. Data analysis was by habitat type and an estimate was made of required sampling intensity. Pellet groups in two pens were separated into "new" (the preceding winter) and "old" by guess, and endurance of pellet groups was estimated from these data. Habitat use index was calculated from numbers of pellet-groups. On 2-4 June 1971, newly deposited pellet-groups were counted on 159 plots in Pen 1. These plots had been cleared of pellets in spring, 1970.

M-99 Etorphine and M-50-50 Diprenorphine were tested on 28 trapped animals since October 1970. An additional 116 animals were immobilized using succinylcholine chloride. Hyaluronidase was used to speed absorption of the drugs. One animal each was handled with sernalyn and sparine, "Bay-Va" (Bauer-Werke, Belgium), succinylcholine chloride and sodium pentabarbitol, and succinylcholine chloride and "tranvet".

Radio transmitters in the 30 mhz range were used to periodically relocate 10 moose within the pens (cf: Job 1.2R).

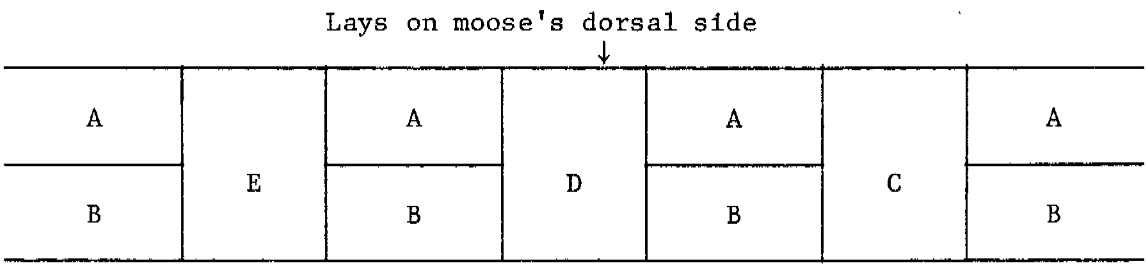
On 10-11 November 1970, two tame 17 month-old male moose (Walter and Richard) were freeze-branded. Hair was shaved off with electric animal clippers and cold copper branding "irons" were applied to the skin. Numbers were 6" high and approximately 1" wide (L & H Mfg. Co., Mandan, S.D. 58554). Irons were cooled with a mixture of acetone and dry ice and applied for various lengths of time (Table 1).

Thirteen x eighteen cm (5 x 7") pendants with 8 cm (3") high by 8 mm (5/16") wide letters and numerals (eg: "A1-A100"; "C1-C100") were suspended from collars under the necks of 135 moose immobilized from helicopters in the Moose River Flats. Pendants were of laminated plastic, red outside-

Table 1. Experimental applications of freeze-brands to moose. Kenai Moose Research Center, November 1970.

Moose	Site	Brand Number	Time Applied
Walter	Right Flank	3	40 seconds
	Right Rump	2	20 seconds
	Left Shoulder	9	50 seconds
	Left Rump	8	60 seconds
Richard	Left Shoulder	0	60 seconds
	Left Flank	5	20 seconds
	Left Rump	4	40 seconds

Figure 1. Canvas-webbing collars placed on moose, with colored plastic facing material for individual identification.



A: Red, orange, pink, yellow.
B: Red, orange, pink, yellow.
C: Green, brown, black, silver, yellow.
D: Green, brown, black, silver, yellow.
E: Green, brown, black, silver, yellow.

white inside. Numbers were routed out of both sides so that they appeared as white numbers on a red background. Seventy pendants were hung perpendicular to the mooses' longitudinal axis (ie: facing forward) and 65 were hung facing sideways. Attempts were made to read pendants from supercub aircraft.

In May 1971, 63 canvas-webbing collars each with a unique stripe combination (Fig. 1) were placed on free-ranging moose. These collars also carried pendants (cf: above). Attempts were made to determine animal identity from supercubs using these color combinations.

FINDINGS

Aerial Census Evaluation

Table 2 presents new data of number of moose seen by individual observer in 1971. Similar data for the 1970 counts were presented in Table 25 of LeResche (1970). Table 3 summarizes mean results by year, conditions and counters' experience.

Results with experienced observers in good conditions (61 percent moose seen in 1970; 69 percent in 1971) differ significantly ($P < .02$; t-test) between 1970-71, but inexperienced observers in good conditions performed equivalently (44 percent vs 43 percent; $P > .10$; t-test) both years. The difference among experienced observers is probably related to better snow cover in 1971 (see below). However, since inexperienced observers in good conditions did not vary between the two years, they are lumped in the following analyses.

Proportion of moose seen during aerial surveys depended upon: observer, snow cover (counting conditions), pilot, time of day, aircraft and (to the extent we could determine) terrain.

Effect of Observer Skill

Under all conditions tested, experienced observers (those who had counted game often before and had done so recently) saw a significantly greater ($P < .01$;t-test) proportion of moose flown over than did inexperienced observers. In excellent conditions (1971), experienced observers ($n = 12$) saw 69 percent of the moose they flew over. Inexperienced observers ($n = 10$) saw but 43 percent. In good conditions (1970), experienced observers ($n = 4$) saw 61 percent, inexperienced ($n = 11$) saw 44 percent. In poor conditions, three experienced observers saw 40 percent. One observer with no experience saw 19 percent. Variation among observers with current experience was great (ranges: 45 percent - 80 percent, 49 percent - 76 percent and 35 percent - 44 percent in excellent, good and poor conditions, respectively) as it was among inexperienced observers (ranges; 33 percent - 50 percent; 27 percent - 61 percent in excellent and good conditions, respectively).

Table 2. Results of moose counting experiment by individual counter: 6-9 March 1971.

Inexperienced	Time	Pilot	Pen (number present) 1(12)	2(16)	3(12)	4(15)	Total(55)	Percent	Rank in Group
1	11 am	II	8	8	5	8	29	53%	1
2	1 pm	I	6	8	3	10	27	49%	2
3	10 am	I	3	13	4	7	27	49%	2
4	10 am	I	7	10	6	3	26	47%	3
5	9 am	II	6	7	7	5	25	45%	4
6	12 noon	I	7	4	6	5	22	40%	5
7	11 am	II	5	6	5	5	21	38%	6
8	12 noon	II	4	9	4	4	19	35%	7
9	1 pm	II	6	5	4	4	19	35%	7
10	1 pm	I	5	3	3	7	18	33%	8
11	10 am	II	4)	Counted only Pen 1					
12	2 pm	I	7)						
Experienced-but-not-current									
13	9 am	I	6	8	9	9	32	58%	1
14	3 pm	I	5	13	8	6	32	58%	1
15	3 pm	I	8	10	6	7	31	56%	2
16	4 pm	II	7	10	6	7	30	55%	3
17	7 am	I	6	6	5	7	24	44%	4
18	12 noon	I	7	5	6	6	24	44%	4
19	8 am	II	5	7	3	6	21	38%	5
20	9 am	II	4	7	3	3	17	31%	6
21	12 noon	I	2	4	4	6	16	29%	7
Experienced-Current									
22	11 am	I	12	14	8	10	44	80%	1
23	2 pm	II	10	8	9	15	42	76%	2
24	3 pm	I	11	11	8	12	42	76%	2
25	3 pm	I	6	13	6	15	40	73%	3
26	4 pm	II	8	9	9	14	40	73%	3
27	1 pm	I	9	13	7	10	39	71%	4
28	3 pm	II	11	10	7	10	38	69%	5
29	12 noon	II	12	10	4	11	37	67%	6
30	10 am	I	9	9	7	12	37	67%	6
31	1 pm	I	6	10	8	11	35	64%	7
32	9 am	I	9	7	6	11	33	60%	8
33	3 pm	II	8	6	4	7	25	45%	9

Table 3. Summary of mean proportions of moose observed in four one-square mile enclosures by observer, weather conditions and aircraft. January-February 1970 and March 1971. (Each square-mile searched 15 minutes.)

Observer (n)	Conditions	Aircraft	Pen (n) I(7)	II(12)	III(12)	IV(18)	Total (n)
1970							
Pilots (2) plus observers	Good	PA 18-150 Supercub	1.00	.75	.71	.64	.73(49)
Experienced (4)	Good	PA 18-150 Supercub	.82	.56	.67	.53	.61(49)
Experienced (3)	Poor	PA 18-150 Supercub	.43	.33	.44	.39	.40(48)
Inexperienced (11)	Good	PA 18-150 Supercub	.57	.46	.45	.37	.44(49)
Inexperienced (1)	Poor	PA 18-150 Supercub	.14	.25	.25	.12	.19(48)
Experienced* (3)	Excellent	BG 4A Helicopter	.93	.78	.58	.80	.75(48)

* 2 Observers

Observer (n)	Conditions	Aircraft	I(7)	II(12)	III(12)	IV(18)	Total (n)
1971							
Inexperienced (12)	Excellent	PA 18-150 Supercub	.47	.46	.37	.39	.43
Experienced-but-not-current (9)	Excellent	PA 18-150 Supercub	.46	.48	.46	.42	.46
Experienced-current(12)	Excellent	PA 18-150 Supercub	.77	.63	.58	.77	.69
All (1971)(33)			.58	.53	.48	.54	.53

Currency of experience was important. Nine observers who had regularly counted animals from aircraft at one time but had not done so within one to several years of the experiment saw only 46 percent of the moose flown over (range 29 percent - 58 percent) in excellent conditions. This proportion is statistically equivalent ($P > .10$; t-test) to that of inexperienced observers and significantly lower ($P < .01$; t-test) than that of experienced/current observers.

Effect of Counting Conditions

As suggested above, counting conditions significantly affected proportion of moose seen during aerial counts. As used here "conditions" roughly means "snow cover". Other factors such as turbulence and light conditions are important also. However, turbulence is usually minimal when flights are made and lighting depends primarily upon time of day (cf: below).

"Excellent" counting conditions as used here indicate the 40-45 cm (16-18") of snow present on 6-9 March 1971 (cf: Job 1.1R). This amount of snow covered essentially all dark spots on the ground and clung to some small spruce trees.

Good conditions (1970) were approximately 20-25 cm (8-10") snow cover, with a few bare patches and no spruce snow-covered. Poor conditions (1970) included only patches of snow on the ground.

Experienced observers saw significantly ($P < .01$; t-test) more (69 percent) moose in excellent conditions than in good (61 percent) and significantly ($P < .01$; t-test) more in good conditions than in poor conditions (40 percent). Inexperienced observers saw statistically equivalent proportions ($> .10$; t-test) of moose in excellent (43 percent) and good conditions (44 percent) indicating variation in snow conditions (when some snow cover does exist) is important only to experienced observers. Only one inexperienced observer counted in poor conditions. He saw but 19 percent of the moose present.

Effect of Pilot

The present experiment attempted to minimize the effect of the pilot on the success of the counter by not allowing the pilot to point out moose he saw. This was necessary to eliminate effects of the pilot's "learning" the moose in a pen after several flights. However, this design differed from actual counting conditions, where the pilot assists in counting game.

On the initial flights (1970) in good conditions (Table 3) by each of two pilots, record was kept of total moose seen by pilot and observer, as well as by the observer only (the pilot made mental notes only).

These two pairs saw 65 percent and 80 percent of the 49 moose present, significantly ($P < .02$; t-test) more than seen by four experienced observers alone the same day.

Individual nonobserving pilots (1971) did not significantly ($P > .10$; t-test) affect proportion of moose seen by observers of any category nor observers' rank within their category (Table 4).

Effect of Time of Day

Moose surveys are traditionally flown at dawn and shortly after to coincide with mooses' most active period (cf: Geist, 1960; LeResche, 1966; LeResche and Davis, this report Job 1.1). While early morning counts may take advantage of moose activity, lighting conditions may be more conducive to observing moose at other times during the day. Table 5 summarizes mean ranks within counter groups of observers flying before 1000 hours A.S.T., 1000-1200 hours, 1200-1400 hours and after 1400 hours. No statistically significant differences were detected between observers of the same category flying in these time periods. However, the data do suggest that during early spring, moose are more easily seen in mid-morning and after 1400 hours (through about 1530 hours).

Effect of Type of Aircraft

PA-18-150 Piper "Supercubs" have become the aircraft of choice for aerial surveys in Alaska because of their slow flight characteristics. Canadian federal and provincial (pers. comm.) biologists use other types of aircraft either not generally available in Alaska (eg: Pilatis-Porter; Dornier; DeHavilland Beaver) or too fast for anything but transect work (eg: Cessna 180-185). Some provincial agencies use helicopters in composition surveys of a pre-determined sample size of animals. Helicopters were used with two observers (plus pilot) on three counts of the enclosures under excellent conditions in January 1970 (LeResche, 1970). These observers saw a mean of 75 percent of moose flown over, significantly more ($P < .01$; t-test) than seen by single experienced observers in excellent conditions in 1971. However, the cost:benefit ratio (Bell G4A helicopter:$135/hr; PA-18-150:$35/hr) indicates use of supercubs even when attempting total enumeration of moose.

Effect of Terrain and Habitat

The four Moose Research Center enclosures are similar in habitat type and therefore it is difficult to ascertain effect of terrain and habitat on proportion of moose seen. Previous experiments (LeResche, 1970) showed significant ($P < .01$) differences between proportions of moose seen in all pens with most moose (proportionately) being seen in the pen (Pen 1) with fewest present and fewest being seen in the pen (Pen 4) with most present. Results from 1971 show significant differences only between Pens 1 and 3 (58 percent vs 48 percent; $P < .01$; t-test). During experiments this latter year, number of moose present varied less between pens (7-18 in 1970 vs 12-16 in 1971); whereas terrain and habitat remained essentially the same. Thus, number of moose present seems correlated with proportion of animals seen and no difference re: habitat is demonstrable in this rather homogeneous four-square-mile area of seral range interspersed with remnant stands.

Table 4. Effect of pilot on ability of observer to see moose, Kenai Moose Research Center, 6-9 March 1971.

	Inexperienced (A)	Experienced/not current (B)	Experienced/current (C)
Pilot I	43 percent	48 percent	70 percent
Pilot II	41 percent	41 percent	66 percent

Mean rank in group by pilot.

Pilot	Number of Observers	Counter Group			All
		A	B	C	
I	18	4.0	3.2	4.8	3.9
II	13	5.0	4.7	5.0	4.9

NB: Pilot-pilot differences not statistically significant (P ⟩ .10; t-test).

Table 5. Effect of time of day on proportion of moose seen, Kenai Moose Research Center, 6-9 March 1971.

Time	Number of Counters	Mean Rank, All Counters	"Moose Observability"
Before 10 a.m.	6	4.7 ± 1.3	23
10 a.m. - 12 noon	6	3.2 ± 1.3	31
12 noon - 2 p.m.	10	5.7 ± 0.7	18
After 2 p.m.	9	3.3 ± 1.1	30

* 1/mean rank x 100

NB: Mean ranks do not vary significantly statistically ($P > .10$; t-test).

Pellet-count Census

Table 6 summarizes pellet groups found in 159 8 x 24' plots in Pen 1 (2-4 June 1971). All groups were deposited between April 1970 and these dates, for plots had been cleared of pellets the past year (LeResche, 1970). The table also includes similar data for 1970, when plots had not been cleared the previous year.

In 1970 (LeResche, 1970) an attempt was made in two pens to visibly separate groups deposited during the previous winter. It was estimated that only one-third of pellet groups removed were new and, from this, it was calculated that each moose deposited 10.3 groups per day during a hypothetical 210-day winter period. Current data, from cleared plots in only one-square-mile pen, suggest a defecation rate of 32.2 groups/day. This indicates visual estimates of age of pellets were incorrect and that plots should be cleared to validate the technique (cf: Neff, 1968).

Plots will be read in all four pens in 1972, at which time the technique's validity will be substantiated or disproven.

Immobilizing Drugs

M-99 Etorphine and M 50-50 Diprenorphine: These drugs (immobilizing agent and antagonist, respectively) continued to be most useful for handling animals within the pens. They were the only safe drugs for use on calves, yearlings and rutting bulls. Dosage could be varied to make the animal tractable but still able to walk or immobile (ie: for halter-leading). Multiple doses are safe with no waiting period. Antagonist injected intravenously usually produced complete reversal of effects within 40-50 seconds. Immobilizing doses varied by season, the animal's age and size. Standard doses ranged from 4-5 mg per 700-800 pound cow in spring to 6-9 mg per 900-980 pound cow in October. Antagonist was administered at twice the dose of M-99.

A narcotics license is required to possess the expensive ($1.25/mg) drugs and animals treated with the substances should not be consumed.

Succinlycholine chloride ("Anectine"): This drug, in concentrations of 10 mg/cc, continued to be most used because it is easy to secure and cheap, and meat from treated animals is fit for consumption. Therapeutic ratio is very small, however, and some animals (6 of 116) are killed. The drug should be considered unsafe for use on calves, yearlings and rutting bulls. Dosages of 20 mg/adult moose are usually nonlethal but sometimes do not produce immobilization. Multiple doses are almost always lethal unless separated by at least one hour. Doses of over 23 mg/adult are likely to be lethal.

Table 7 summarizes effects of Anectine when administered by dart from helicopter and emphasizes seasonal variability in the drug's effect. The table also demonstrates the effect of hyaluronidase ("Wydase") when mixed with the drug.

Table 6. Pellet groups deposited between April 1970 and June 1971 on 159 8 x 24 foot plots randomly selected by habitat types in Pen 1. Kenai Moose Research Center.

	Birch			Spruce		Mature Hardwoods		All	
	Dense	Medium	Thin	Spruce-Birch	Spruce	Dense	Thin		
Winter Groups	32	18	8	8	3	10	14	93	
Summer Groups	0	2	2	1	0	0	0	5	
Total Groups	32	20	10	9	3	10	14	98	
Plots	25	24	26	23	19	20	22	159	
$\bar{x}$ Winter	1.28	0.75	0.31	0.35	0.16	0.50	0.64	0.59	
$\bar{x}$ Summer & Winter	1.28	0.84	0.38	0.39	0.16	0.50	0.64	0.62	
s	1.37	0.94	0.55	0.57	0.36	0.82	0.79	0.90	
1970 plots (from LeResche, 1970)	22	25	25	24	20	19	21	157	
$\bar{x}$ Summer & Winter	.409	1.00	0.84	0.92	0.65	0.21	0.43	0.67	196
s	.651	1.44	1.08	0.95	0.73	0.52	0.58	0.97	

Table 7. Knock-down times and effects of succinylcholine chloride and "Wydase" administered to free-range adult moose. (Sample sizes in parenthesis).

Drug	succinylcholine chloride		succinylcholine chloride + Wydase 500 ml units		succinylcholine chloride	
Sex	M	F	M	F	M	F
Dose/animal:						
20 mg					11.7 (6)	11.8 (10)
21 mg	7.3 (8)	10.4 (27)	4 (1)	8.4 (5)	6.3 (7)	7.0 (2)
22 mg		9.1 (9)	7.8 (5)	6.7 (32)		
23 mg					7.6 (7)	9.7 (17)
% Immobile	65-70		86		65-70	
% Killed	4		3		16	
Mean knock-down time	7.3 (8)	10.1 (36)	7.2 (6)	7.2 (37)	8.0 (20)	10.2 (29)
Both Sexes	9.6 (44)		7.2 (43)		9.4 (49)	

In June, when moose reach their lowest physiological state (cf: this report, Job 1.1), immobilization with succinylcholine-chloride is dangerous. The drug was injected into 83 bulls and females without calves in early June. Minimal doses (20 mg) immobilized fewer than 60 percent of moose darted and still killed 11 percent (2 of 18). Dosage sufficient to immobilize 80 percent of moose darted (23 mg) killed 20 percent (8/40). Therefore, the drug was unsuitable for use on animals during this time of year.

In contrast, of 72 animals immobilized in March with succinylcholine chloride, only three (4 percent) died--two after rising and moving off. Immobilization proportion when using succinlycholine chloride alone was still low, however.

Hyaluronidase ("Wydase"): This enzyme was added to succinlycholine chloride (10 mg/cc) at the rate of 500 nf units per dart (21-22 mg). In May, of 80 animals darted (Table 7), 69 (86 percent) were immobilized and only two of these (3 percent) died from the drug. Knock-down time was decreased 25 percent, from a mean of 9.5 minutes to 7.2 minutes under these free-ranging conditions. Hyaluronidase, by increasing drug absorption, seems to 1) increase the proportion of animals immobilized without increasing mortality and 2) shorten knock-down time. The latter effect is beneficial both in decreasing stress and lowering cost.

Under penned conditions, immobilization of trapped animals was hastened even more (ca: 45 percent). Although enough strictly-comparable data are lacking as yet, reduction in knock-down time from ca: 9 minutes to ca: 5 minutes in the same individuals under the same dosage was common.

"Sernalyn" (phencyclidine hydrochloride) plus "Sparine" (promazine hydrochloride) were used on one trapped eight-year-old cow moose with poor results. A total of 1050 mg Sernalyn plus 225 mg Sparine was injected via six darts in a six hour period (600 mg + 150 mg within 45 minutes initially). The animal weighed approximately 850 pounds.

Although ataxia and respiratory distress were evident within three minutes of the first 200 mg Sernalyn + 50 mg Sparine dose, the animal was never tractable and had to be roped and tied for dart removal after seven hours. Survival has not been confirmed.

"Tranvet" (Propriopromazine hydrochloride): This tranquillizer was used on two moose with mixed results. In June a seven-year-old cow, weighing an estimated 800 pounds (360 kg) immobilized with 24 mg succinylcholine chloride, was given 200 mg tranvet. She recovered from the succinlycholine chloride in 32 minutes, but remained approachable to within 10 m (yet able to rise and walk) for 5.5 hours. She was still too alert to handle. She remains healthy.

In July a tame yearling bull (weight: 550 pounds - 250 kg) was immobilized with 19 mg succinylcholine chloride. Knock-down time was five minutes. At 10 minutes after injection he was given 250 mg tranvet and died at 12 minutes when respiration stopped. Whether death was from succinylcholine chloride only or the combination of drugs is unknown. Since tranvet was given intramuscularly it is unlikely it had significant effects.

"Bay-Va 1470" (Bauer-Werke; Belgium): This drug was supplied by Dr. A. Bubenik with a recommended dosage of one mg/kg. It is a CNS depressant. In September a 580 pound (264 kg) yearling cow was given an initial dose of 250 mg. She became slightly ataxic and hyperactive, but could not be roped and tied until she had received an additional 100 mg at 37 minutes and 200 mg at 52 minutes. When down (84 minutes) she had no eye reflex, but good blood pressure and respiration. After four hours in a recumbent position, she rose alertly and ran off, slightly ataxic. She died in the woods 100 m from the trap.

Pentabarbital sodium ("Halatal" 1.0 gr/cc): A seven-year-old cow (weight estimated: 850 pounds - 390 kg) was given 100 cc of this drug (6500 mg) intravenously after immobilization with succinylcholine chloride. She showed no effects--rising and walking off 37 minutes after immobilization. She remained healthy therafter.

<u>Radio-Telemetry</u>

Results of this study are reported in Job 1.2.

<u>Freeze-Branding</u>

The two attempts were not successful. The 60 second brands created scar tissue and a standard burn-brand, which was covered by hair in summer. Twenty and 40 second brands were not evident after hair regrowth. No unpigmented hair emerged.

<u>Other Marking Methods</u>

The described pendants, when hung parallel to the mooses' longitudinal axes, were readable from Supercubs more than 90 percent of the time, upon repeated passes. Hung perpendicular to the axis, they could be read fewer than 30 percent of the time. Striped collars were individually identifiable readily from aircraft. Moderate collar loss is suspected, but its extent is unknown as yet.

RECOMMENDATIONS

Aerial counts of moose should be considered only as trend indicators, never as total counts. To be comparable year-to-year, they should be conducted only under excellent snow conditions, with only currently experienced observers.

Hyaluronidase should be used when free-ranging moose are being immobilized with succinylcholine chloride.

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JOB PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperators: Paul LeRoux; Alaska Department of Fish and Game; U. S. Bureau of Sport Fisheries and Wildlife: Kenai National Moose Range

Project No.: W-17-3 Project Title: Moose Investigations

Job No.: 1.4R Job Title: Kenai Peninsula Moose Population Identity Study

Period Covered: July 1, 1970 through June 30, 1971

SUMMARY

Four hundred and thirteen sightings of 283 adult moose tagged on the Kenai Peninsula revealed migratory patterns, concentrating areas, and separate population identities of moose representing an aggregate number of nearly 10,000 animals.

Most of the groups studied were seasonally migratory, and moved from lowland wintering areas to calving areas in springtime, thence (in early summer) to upland summering--rutting areas, and back to wintering areas in early-mid winter. This group comprised many large bulls and cows, but very few calves. Sexes were segregated during the early summer migration to the highlands, when males migrated earliest. Sexes intermingled during rutting in fall.

The other population segment (comprising predominately cows with calves and younger bulls) remained resident in lowland areas of the 1947 burn year-round.

Specific drainages appeared to be the sites of rutting by the same individuals year after year. Individuals also followed stereotyped circular migration paths for more than one year.

One calving area (the Moose River Flats) was a concentrating spot for individuals from all rutting areas studied (many 60-80 kilometers distant).

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BACKGROUND

Moose in the lowland areas of the northern Kenai Peninsula receive considerable hunting pressure in the few restricted areas where access exists. In late fall, moose herds in these areas characteristically have a low proportion of bulls, and trophy-size bulls are extremely rare. Although lowland areas contain a higher proportion of calves within the herd, calf production in some years is lower than anticipated (eg: 33 calves:100 cows in November, 1970). Most of the area in question is seral birch range remnant from the 1947 burn, and birch browse is in great abundance. However, substantial numbers of moose have died during severe winters in the area. Population estimates by personnel of the Kenai National Moose Range suggest substantial numbers of moose (7900 ± 1400 minimum north of the Kasilof River in early 1971), but concern has been expressed regarding the numbers and welfare of the "lowland" moose, especially in relation to hunting pressure.

The moose traditionally using climax willow ranges in foothills and mountains, but wintering on the lowland areas, receive little hunting pressure. These groups characteristically exhibit a high bull:cow ratio and a low proportion of calves.

With the formalization of moose management plans for the Kenai and the designation of certain areas as trophy, foot-hunting 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, and the studies that have been undertaken have shown that such movements vary with the population studied. Goddard (1970) reported an Ontario study similar to ours. His recoveries were few (59 of 328 marked moose) but he documented movement from summer to winter ranges (done previously by Edwards and Ritcey, 1956; Kraft, 1964 and Houston, 1968) and suggested there was no net movement into heavily hunted areas.

Phillips and Berg (1971), with many relocations (2,000) of few (27) radioed Minnesota moose, recorded individual home ranges of 2-10 square miles, winter confinement to less than 100 acres, average daily movement of 0.60 miles, identical mean daily movements of cows and bulls, and 0.5-21 mile movements from winter to summer ranges. VanBallenberghe and Peek (1971) also radio-tracked moose in Minnesota. They showed summer localization, winter confinement by snow, adjacent winter and summer ranges of an individual, and a rapid 12-mile movement by a rutting bull. Mercer and Kitchen (1968) described dispersal of moose introduced onto the Labrador Peninsula. LeResche (1968) and LeResche and Davis (this report; Job 1.2R) reported localization of parturient females and their new calves, and LeResche (1970) suggested internal triggering as a factor in moose migrations. Bishop (1970) reported that a Tanana Flats (Alaska) calf-tagging study suggested that both resident and migratory individuals were present in these lowlands in spring. Didrickson (pers. comm.) reported adult moose tagged in the Matanuska Valley (Alaska) moved nearly 60 miles on occasion.

OBJECTIVES

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

PROCEDURES

Table 1 lists moose marked 1) in October 1968 at Mystery Creek ("highlands"), 2) in March 1970 at Bottenintnin Lake ("lowlands"), 3) in June 1970 at the Moose River Flats ("lowlands"), 4) in March 1971 at the Skilak-Tustumena Benchland ("highlands"), 5) in May 1971 at the Moose River Flats, and 6) from August 1969 through May 1971 at the Moose Research Center ("lowlands"). The moose represent, respectively: 1) a rutting group, 2) a wintering concentration, 3) a calving concentration, 4) a late-winter remnant group in a fall rutting concentration area, 5) a calving concentration, and 6) inhabitants of the 1947 burn area during all months of the year. Fig. 1 shows tagging areas and associated geography.

Table 1. Moose tagged in GMU 15A, Kenai Peninsula, October 1968-May 1971.

	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)	3	40	0	7	50
Moose River Flats May 1971	10	51	0	0	61
Skilak-Tustumena Bench April 1971	2	2	0	0	4
Totals	67	206	3	7	283

Area	Male		Female		Pendants
	Collar	Ear	Collar	Ear	
Mystery Creek	Yellow	Left Orange	Red	Right Orange	None
Bottenintnin Lake	Blue	Left Orange	White	Right Orange	None
Moose R. Flats (1970)	Blue	Left Green	White	Right Green	Red A1-A100
MRC	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	Yellow/ orange*	Left Yellow	Radio	Right Yellow	Red: "C-series"

* Colored stripes on both sides of collar make the moose identifiable as individuals.

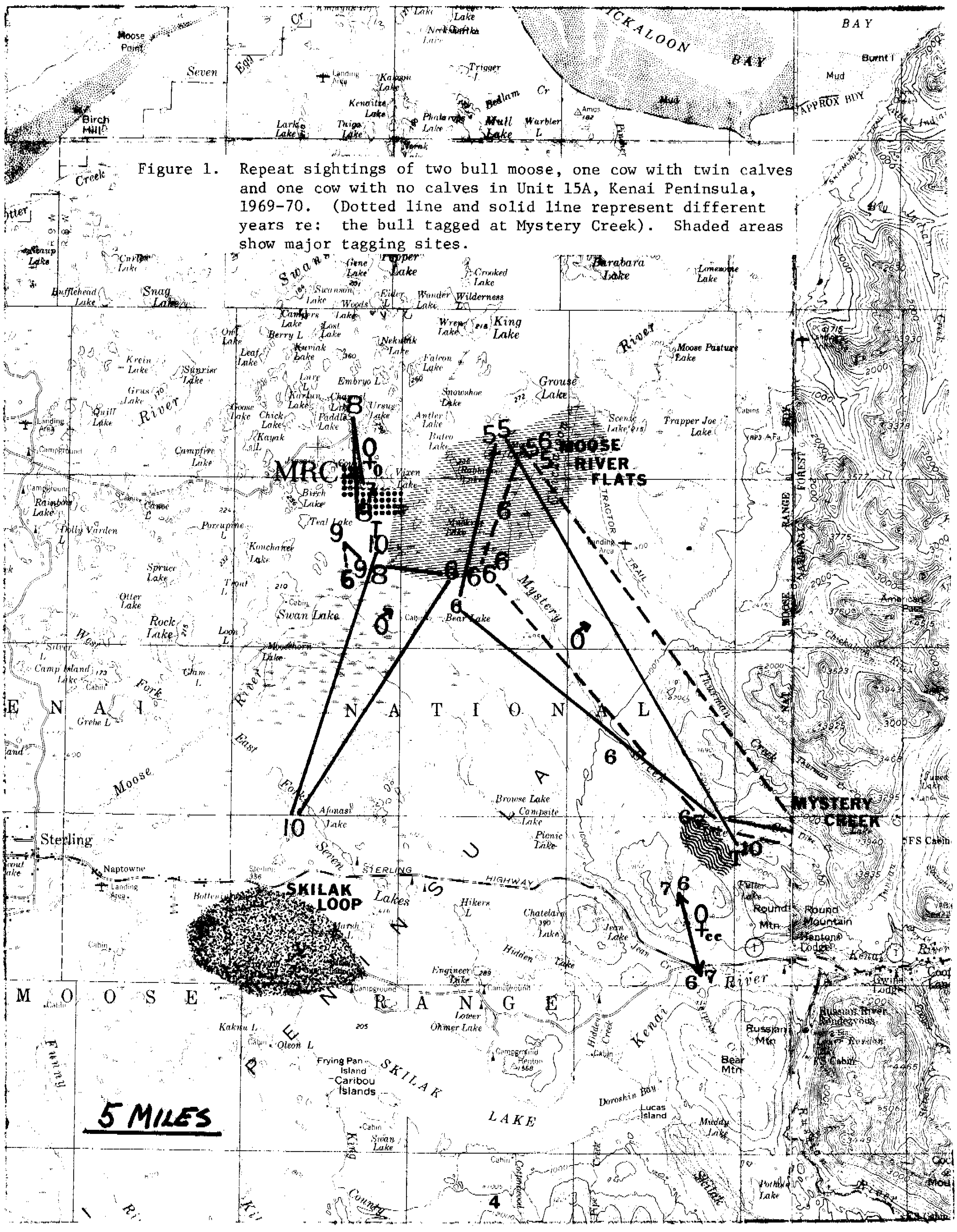


Figure 1. Repeat sightings of two bull moose, one cow with twin calves and one cow with no calves in Unit 15A, Kenai Peninsula, 1969-70. (Dotted line and solid line represent different years re: the bull tagged at Mystery Creek). Shaded areas show major tagging sites.

Moose were tagged using helicopters (or fenceline traps--Group 6) and succinylcholine chloride in projectile syringes. Groups 1, 2 and 6 were ear-tagged and collared to be distinguishable from afar by group and sex but not (except for a few pendant-carrying animals in Group 6) as individuals. Animals in Groups 3, 4 and 5 were made identifiable as individuals by numbered pendants and/or collars and/or color-coded collars. All animals are distinguishable individually when "in hand" by numbered metal ear-tags.

Table 2 lists reconnaissance or counting flights made by Alaska Department of Fish and Game personnel. Several additional flights were made by R. Richey of the U. S. Bureau of Sport Fisheries and Wildlife and many resightings of marked moose were reported by the public.

FINDINGS

Table 3 lists the 413 recoveries and sightings of tagged moose recorded through 15 June 1971. When analyzed by season, location and (tagging) groups, these sightings suggest several facts relative to population identities, movements, and concentrating areas.

Population Identities

Several biological "populations" (ie: randomly interbreeding groups) are represented by the groups of tagged moose. In one case certainly (Mystery Creek) and at least partially in another (Moose Research Center tagged animals), true populations were tagged as such. In the other sites of concentrated tagging effort, various separate breeding populations apparently were tagged together during nonbreeding aggregations.

The Mystery Creek population is perhaps typical of 10-15 separate breeding groups, which gather in separate drainages on the west slopes of the Kenai Mountains north of Skilak Lake (eg: Mystery-Dike, Thurman, Chickaloon, Indian and other creeks) and in the mountain canyons of the Resurrection Creek drainage. This (Mystery Creek) population is the most easily understood of all those groups tagged, both because the group has been tagged longest and because it does represent a true population rather than an aggregation of many.

All but one recovery of moose tagged in Mystery Creek in October made between September and October in the two years since tagging has occurred within approximately two miles of the tagging site. All drainages of the area described have been searched during this time. This group of moose, then, is very traditional in concentrating in a precise drainage during breeding season.

During winter, most sightings of moose from this population have occurred along the Sterling Highway and in the large flatland areas of the 1947 burn to the west of Mystery Creek. During this time of year, Mystery Creek moose intermingle with lowland residents (eg: Moose

Table 2. Reconnaissance flights by ADF&G searching for collared moose.

Date	Area	Collared Moose Located*
26 March 1970	Skilak Lake N. of Kenai R.	12 BL
31 March 1970	Same	10 BL
3 April 1970	Same	6 BL
6 April 1970	Same	4 BL
6 April 1970	South of Kenai River to benchland	0
6 April 1970	North of Sterling Hwy. 0-5 miles	3 BL, 1 MRC
8 April 1970	Skilak Lake area	4 BL
14 April 1970	Moose R. Flats	1 MRC
14 April 1970	Skilak Lk. area	7 BL
22 April 1970	Same	6 BL
24 April 1970	Moose R. flats, Hidden Lk. Skilak Lk.	0
27 April 1970	Moose R. flats to Sterling Hwy.	0
4 May 1970	Mystery Creek	0
4 May 1970	Skilak Lk. area	6 BL
11 May 1970	Moose R. flats; upper Funny R.	0
11 May 1970	Skilak Lk. area	6 BL
17 May 1970	Tustumena-Skilak benchland + Skilak area	0
1 June 1970	Moose River flats	1 MC
1 June 1970	Skilak Lk. area	1 BL
23 June 1970	Moose R. flats	3 MRF
23 June 1970	Mystery Creek	1 MC
10 July 1970	Moose R. flats, benchland	2 BL, 2 MRF
17 July 1970	Mystery Creek	7 MC, 3 MRF
29 July 1970	Mountains N. of Mystery Creek	7 MRF
4 August 1970	Moose R. flats, Skilak Lake area	2 MRF
10 August 1970	Benchland	1 BL, 1 MRF
22 August 1970	Mystery Creek	1 MC, 1 MRF
24 August 1970	Moose R. flats	1 MRF
1 September 1970	MRC	1 MRF
1 September 1970	Resurrection Creek	3 MRF
5 October 1970	Benchland	2 BL
5 October 1970	Mystery Creek	4 MC, 3 MRF, 1 BL
22 October 1970	Skilak Lk.	3 BL
22 October 1970	Benchland	5 BL
18 November 1970	MRC	1 MRC
19 November 1970	Juneau Creek	4 MRF, 1 MC
23 November 1970	Resurrection Creek	3 MRF
30 November 1970	Skilak Lake	1 BL
30 November 1970	Mystery Creek	1 MC, 1 MRF
1 December 1970	1947 Burn N. of MRC	3 MRC, 1 MC, 1 MRF
2 December 1970	Thurman Creek, Fuller Lk., Mystery Creek	5 MRF, 2 MC, 1 BL
2 December 1970	Skilak Lake	3 BL, 1 MRC
3 December 1970	Skilak Lake	4 BL, 1 MRF

Table 2. (cont'd.) Reconnaissance flights by ADF&G searching for collared moose.

Date	Area	Collared Moose Located*
3 December 1970	Benchland	1 BL
4 December 1970	West of Skilak Lake	1 BL
21 December 1970	Skilak Lake	6 BL
21 January 1971	Skilak Lake	1 MRF, 2 BL
21 January 1971	Moose R. flats	1 MRF
21 January 1971	MRC	1 MRF
12 February 1971	MRC, Moose R. flats, Skilak Lk., Benchland	0
23 February 1971	Moose R. flats, MRC area	3 MRF, 1 MRC
30 March 1971	Benchland, Skilak Lake, Mystery Creek	1 MRF
24 May 1971	Moose R. flats	2 MRC, 1 MRF
25 May 1971	Moose R. flats	2 MRF
27 May 1971	Moose R. flats	2 MRF
27 May 1971	Moose R. flats	3 MRF, 1 MRC
15 June 1971	Moose R. flats	25 MRF, 1 MRC

* Code: Tagged at Mystery Creek: MC
Tagged at Bottenintnin Lake: BL
Tagged at Moose River Flats: MRF
Tagged at Moose Research Center: MRC

Table 3. Recoveries and sightings of collared moose, Kenai Peninsula, through June 1971.

	MONTH						
Tagging Site	I-II	III-IV	V-VI	VII-VIII	IX-X	XI-XII	Totals
Mystery Creek	21 FF	14	14	12	7	16	87
	1 MM	1	14	6	5	1	115
	22	15	31	18	12	17	115
Bottenintnin Lake	4 FF	51	15	19	20	19	128
	2 MM	9	2	0	1	1	15
	6	60	17	19	21	20	143
Moose Research Center	3 FF	4	7	1	6	5	26
	0 MM	1	4	1	4	0	10
	3	5	11	2	10	5	36
Moose River Flats	6 FF	4	49	11	7	8	85
	4 MM	1	8	8	2	11	34
	10	5	57	19	9	19	119

Table 4. Proportion of sightings outside of four contiguous townships from tagging site, Kenai Peninsula, 1968-15 March 1971.

Tagging Site	FF	%	MM	%	N
Mystery Creek	35	43*	14	50*	109
Bottenintnin Lake	34	27	2	13	141
Moose Research Center	7	30	2	22	32
Moose River Flats	16	29	21	72*	84

* Tagged in concentrating areas

Table 5. Seasonal locations of tagged moose "populations," Kenai Peninsula.

Tagging Site	Winter	Late Winter	Calving	Summer	Rut	Post-Rut
Mystery Creek	Sterling Hwy. East of 1947 Burn and 1947 Burn West	Sterling Hwy. East of 1947 Burn and 1947 Burn West	Moose River Flats and Kenai River	Sterling Hwy. East and Mystery-Dike Basin	Mystery-Dike Basin	Mystery-Dike Basin and Sterling Hwy. East and West
Moose River Flats	1947 Burn West, Moose River Flats and Sterling Hwy. West	1947 Burn West and probably Skilak Loop	Moose River Flats	Kenai Mts. North, Bench-land and Moose River Flats	Kenai Mts. North and Benchland	Kenai Mts. North and 1947 Burn West
Skilak Loop (Bottenintnin Lake)	?	Skilak Loop-Naptowne	Skilak Loop-Naptowne and probably Brown's Lake Area	Benchland and Below	Benchland and Skilak Loop and Kenai Mts. North	Skilak Loop-Naptowne and Benchland
1947 Burn (Moose Research Center)	1947 Burn	1947 Burn	1947 Burn and Moose River Flats	1947 Burn	1947 Burn, Moose River Flats-Skilak Loop	1947 Burn

Research Center tagged animals) and moose from other Kenai Mountain drainage breeding groups (Table 6).

Mystery Creek moose typically calve along the Kenai River. Bulls inhabit the Moose River Flats during calving. Table 4 and Fig. 2 illustrate the circumstantial data for the identity of this population, and Table 5 summarizes its locations during 6 two-month periods. As shown in Table 4, most observations throughout most of the year are far from the tagging (breeding) site. All sightings during September-October were near the tagging site. Thus, this population concentrates on the breeding grounds. Fig. 2, which represents the mean distance of recoveries from tagging (October) site of Mystery Creek moose by month, shows differential male and female migrations to and from the breeding grounds. Aggregation of both sexes during September-October--ie: demonstration of population status--is evident.

Tables 4 and 5 and Figs. 3, 4 and 5 present similar data from sightings of moose tagged at Bottenintnin Lake (Skilak Loop), the Moose River Flats and the Moose Research Center. Table 4 shows that the Moose River Flats was a concentrating area for bulls from other areas when tagging occurred there (June), for 72 percent of subsequent sightings of these bulls were more than six miles from the tagging site.

Figs. 3, 4 and 5, like Fig. 2, imply certain things about the population status of the groups in question. Since these groups were tagged outside of their breeding areas, breeding area was "estimated" by circumscribing the smallest polygon about all September and October sightings of moose from each tagged group and taking the polygon center as the breeding ground. Mean distance from this center, during September-October, thus becomes a measure of group dispersal during the breeding season. A widely dispersed group obviously represents several breeding populations. In addition, difference in this distance between males and females further illustrates intersexual mixing of animals from within the tagged group during rut. For example, Fig. 4 shows that both males and females (tagged at the Moose River Flats in June) are dispersed an average of more than 10 miles from the "center" of their breeding range. In other words, they are not concentrated on one breeding ground and the group concentrated at Moose River in June represents more than one breeding population.

Since males and females in this group had approximately equal dispersals from the breeding center, we may infer that at least some males and females from the group do breed with one another (that moose were tagged from some true populations). Sightings plotted on a map confirm this. Fig. 3 shows that the group tagged while wintering in the Skilak Loop area likely represents individuals from many populations. In contrast, Fig. 5 implies that males and females tagged at the Moose Research Center are from a true breeding population concentrated near the tagging site (see Table 4).

Figs. 6-9 present seasonal sighting locations of moose tagged at Mystery Creek, Skilak Loop (Bottenintnin Lake), Moose River Flats and the Moose Research Center. These figures were used to construct Table 4.

Table 6. Groups of moose seasonally occupying various Kenai Peninsula areas.

Area	Winter	Late Winter	Calving	Summer	Rut	Post-Rut
Benchland				Bot. Lake winterers, MR Flats calvers	Bot. Lake winterers, MR Flats calvers	A few Bot. Lake winterers
Kenai River upstream of Skilak Lake	Mostly Mystery Creek breeders	Mostly Mystery Creek breeders	Mostly Mystery Creek breeders	Mostly Mystery Creek breeders	Mystery Creek, Bot. Lake, '47 Burn	Mostly Mystery Creek breeders
Mystery-Dike Creek Basin		A few Mystery Creek breeders		Mystery Creek breeders and Moose River Flat calvers		Mystery Creek breeders, MR Flat spring, Bot. Lake winterers
Kenai Mts. north of Mystery Creek				Moose River Flats calving population		
Moose River Flats		Moose River, Mystery Creek and '47 Burn calving grounds				
1947 Burn north and west	Residents Moose River Flats calvers	Residents	Residents Bot. Lake winterers	Residents	Residents	Residents Moose River Flats calvers
Skilak Loop-Naptowne	Benchland breeders and some Moose River calvers	Benchland breeders				Benchland breeders and some Moose River calvers

Figure 2. Mean distance from tagging site by month of 109 sightings of moose tagged in Mystery-Dike Creek Basin in October 1968.

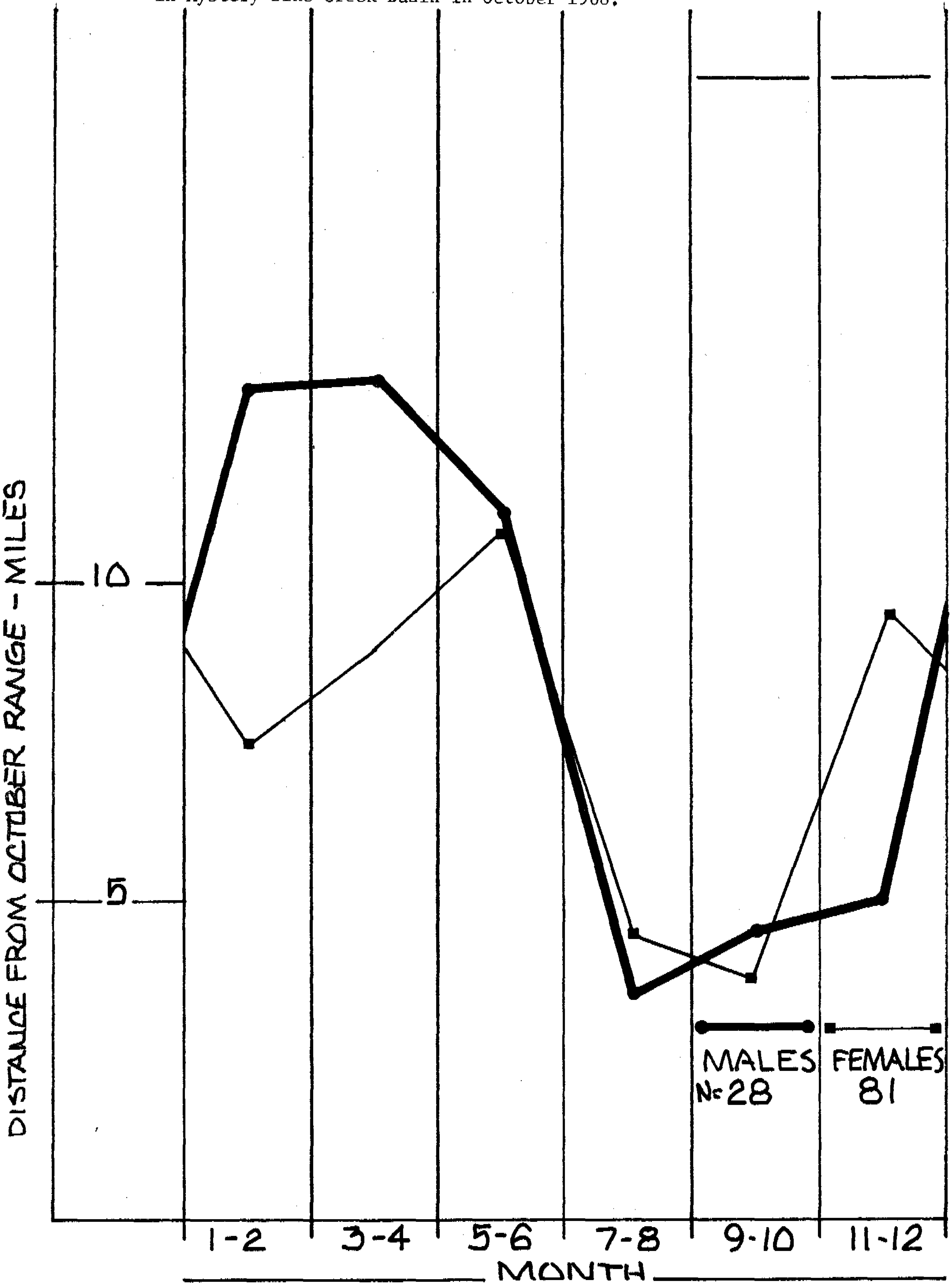


Figure 3. Mean distance from the center of a polygon enclosing all September - October sightings by month of 141 sightings of moose tagged in Skilak Loop area in March 1970.

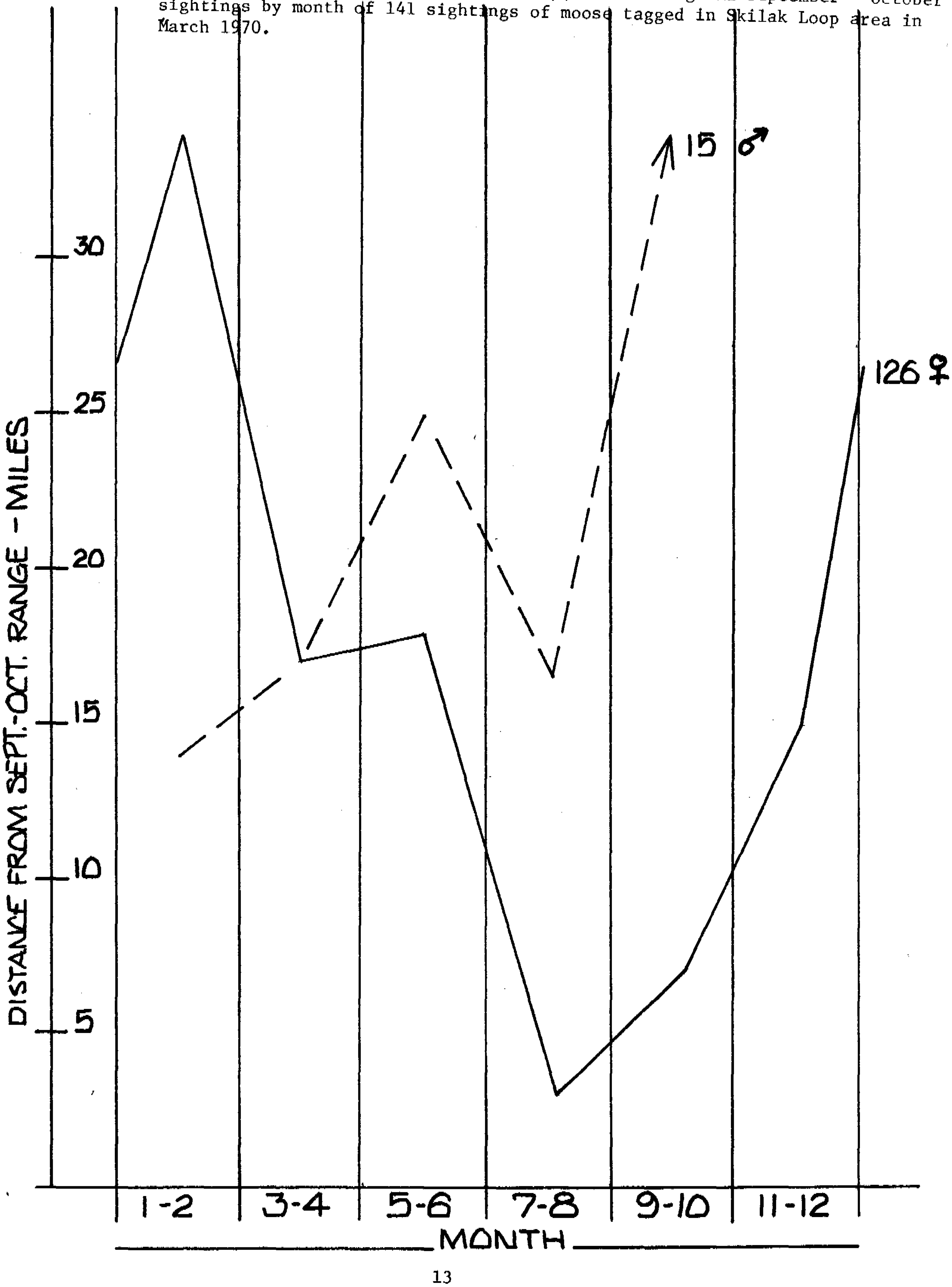


Figure 4. Mean distance from the center of a polygon enclosing all September - October sightings by month of 84 sightings of moose tagged on the Moose River Flats in June 1970.

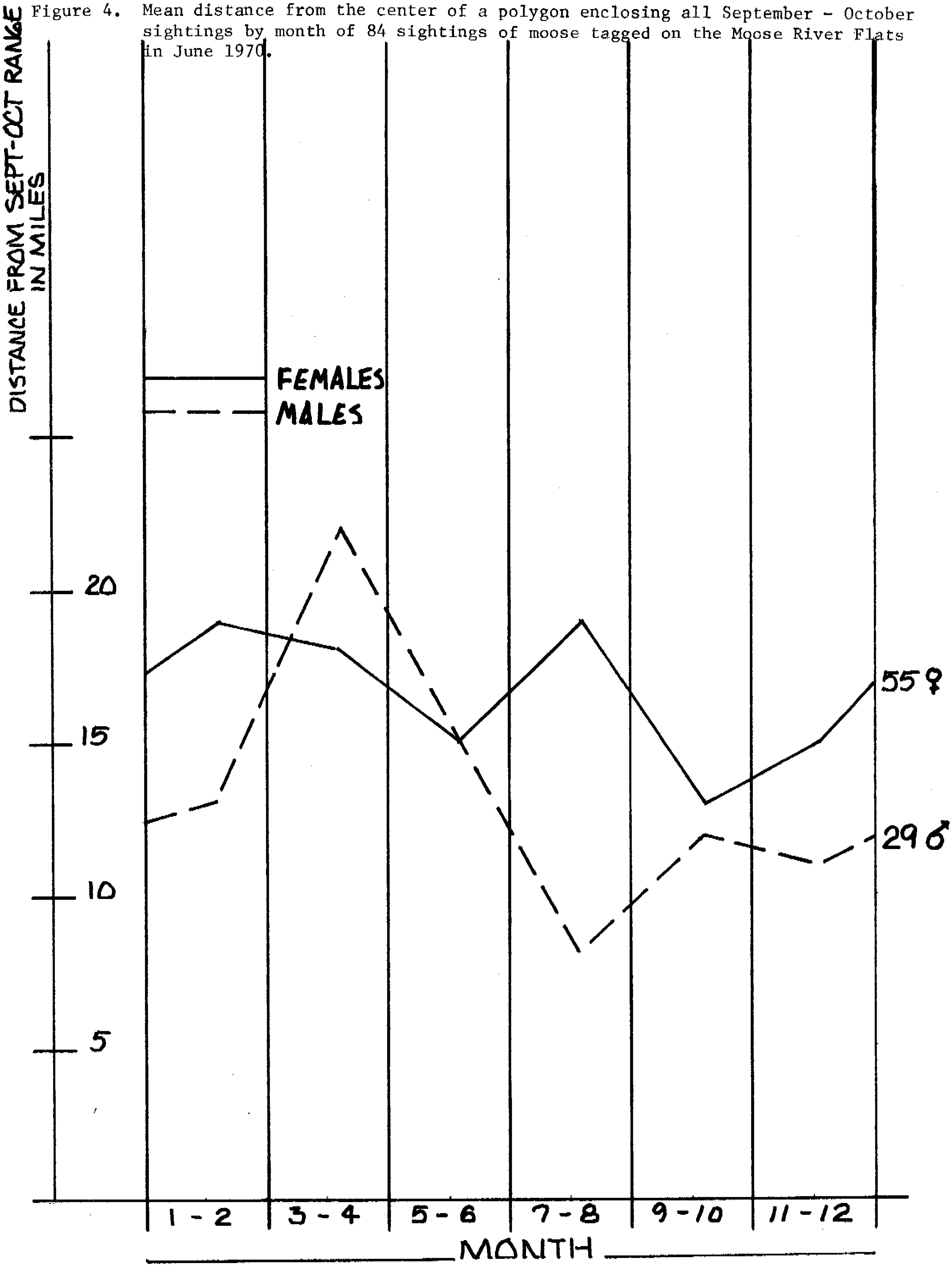


Figure 5. Mean distance from the center of a polygon enclosing all September - October sightings by month of 32 sightings of moose tagged at the Moose Research Center (1947 Burn) year-round in 1969 - 1970.

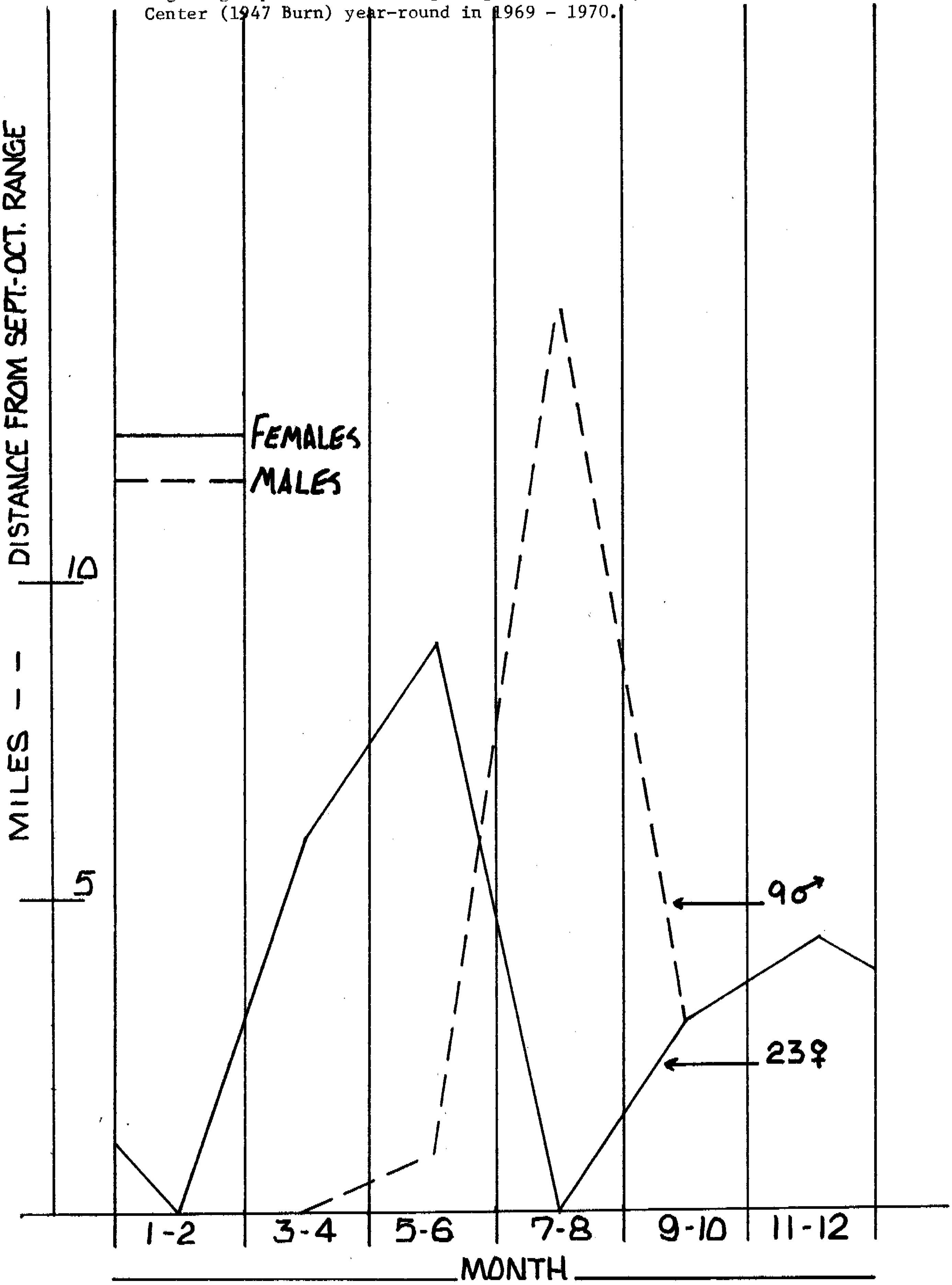


Figure 6. Monthly locations of moose tagged in Mystery-Dike Creek Basin in October 1968.

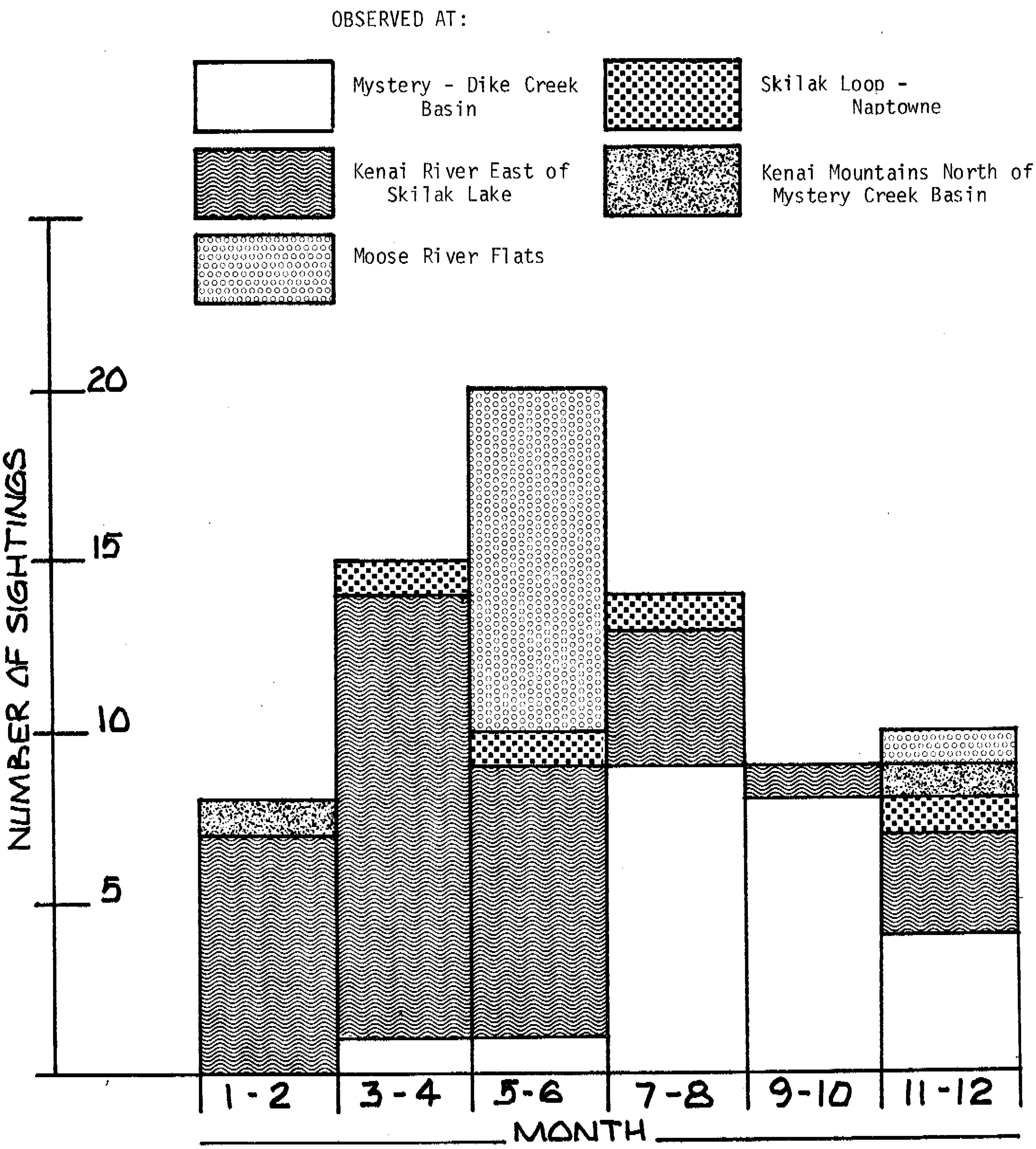


Figure 7. Monthly locations of moose tagged in Skilak Loop area in March 1970.

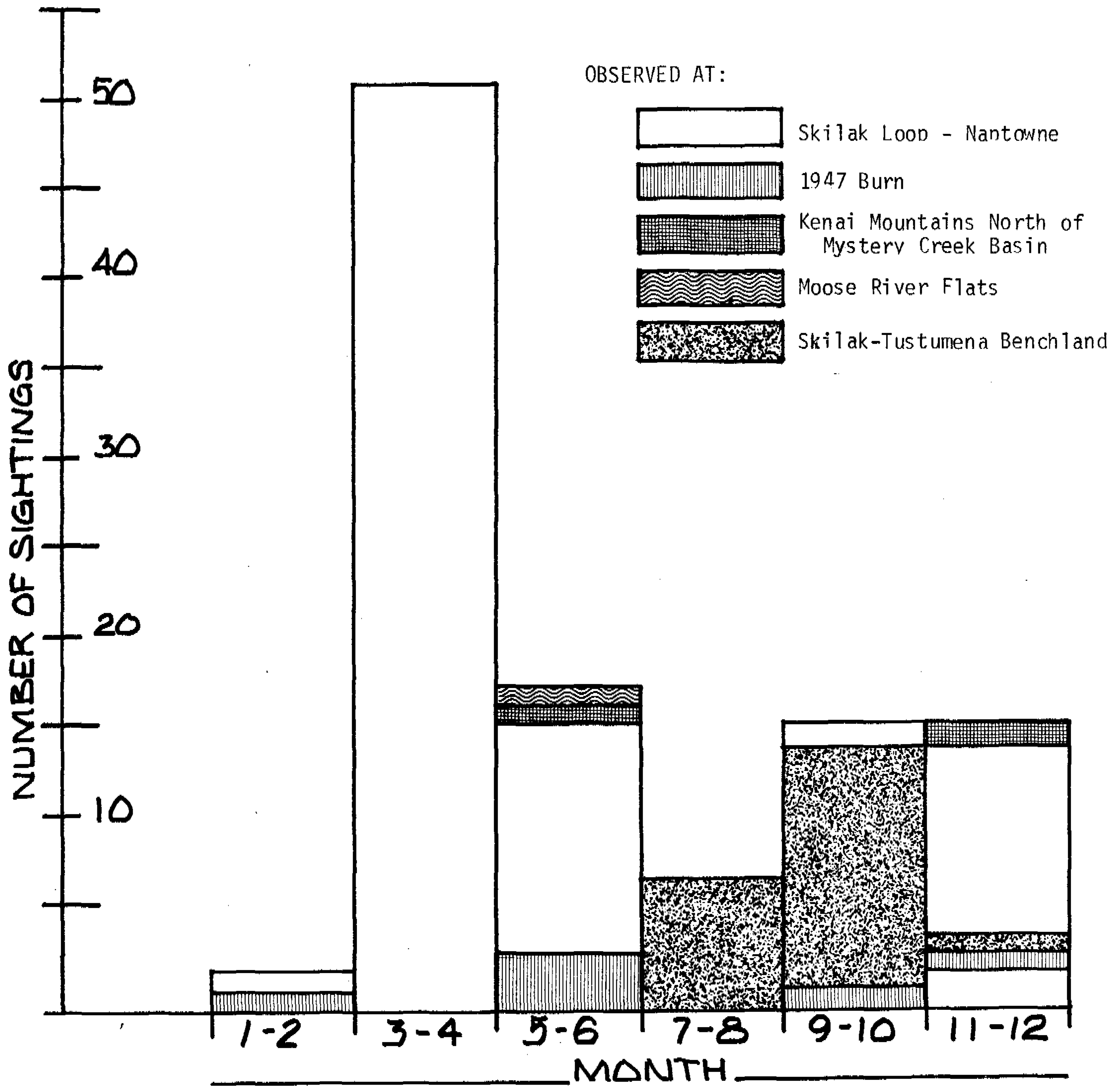


Figure 8. Monthly locations of moose tagged on the Moose River Flats in June 1970.

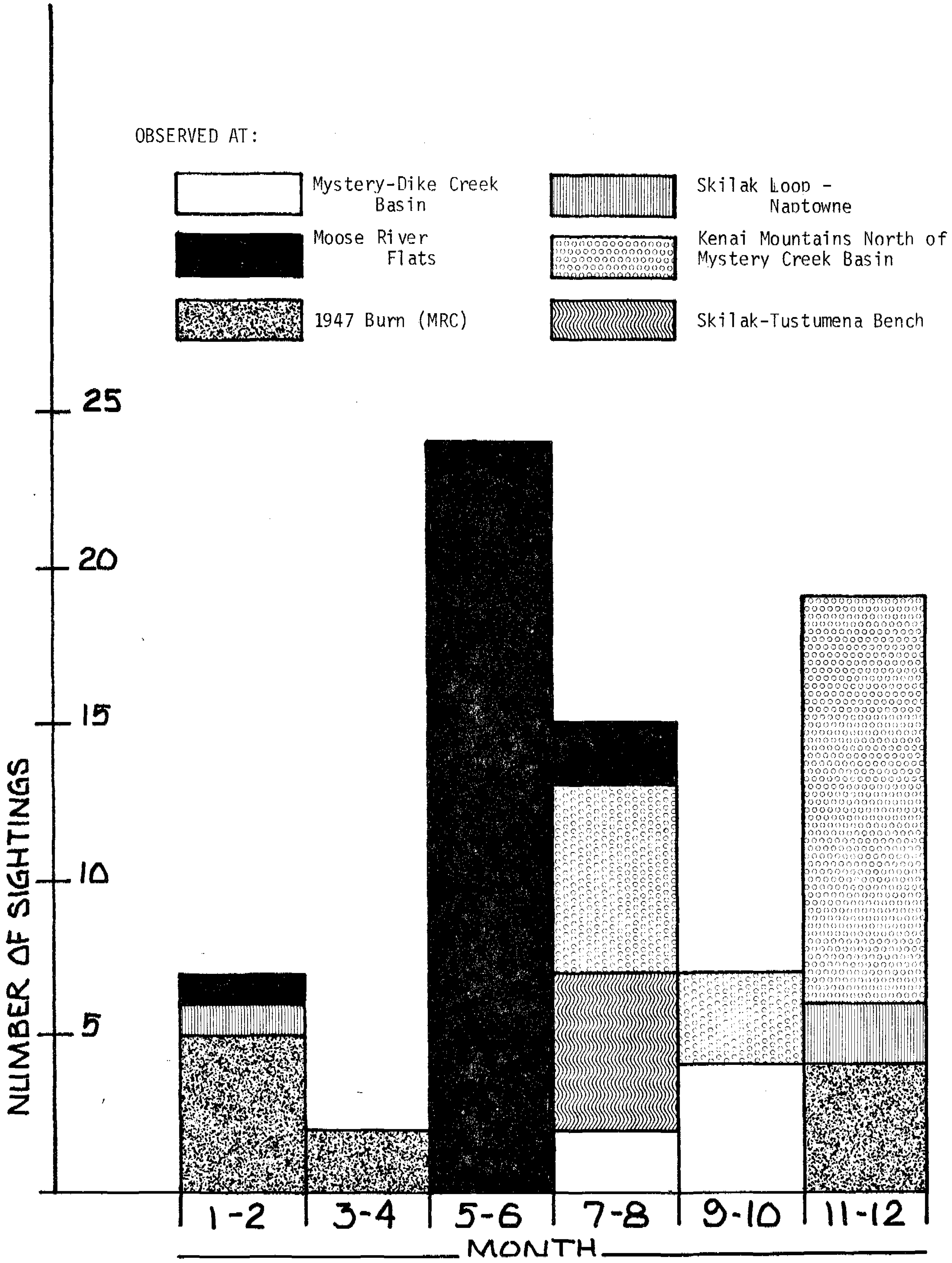
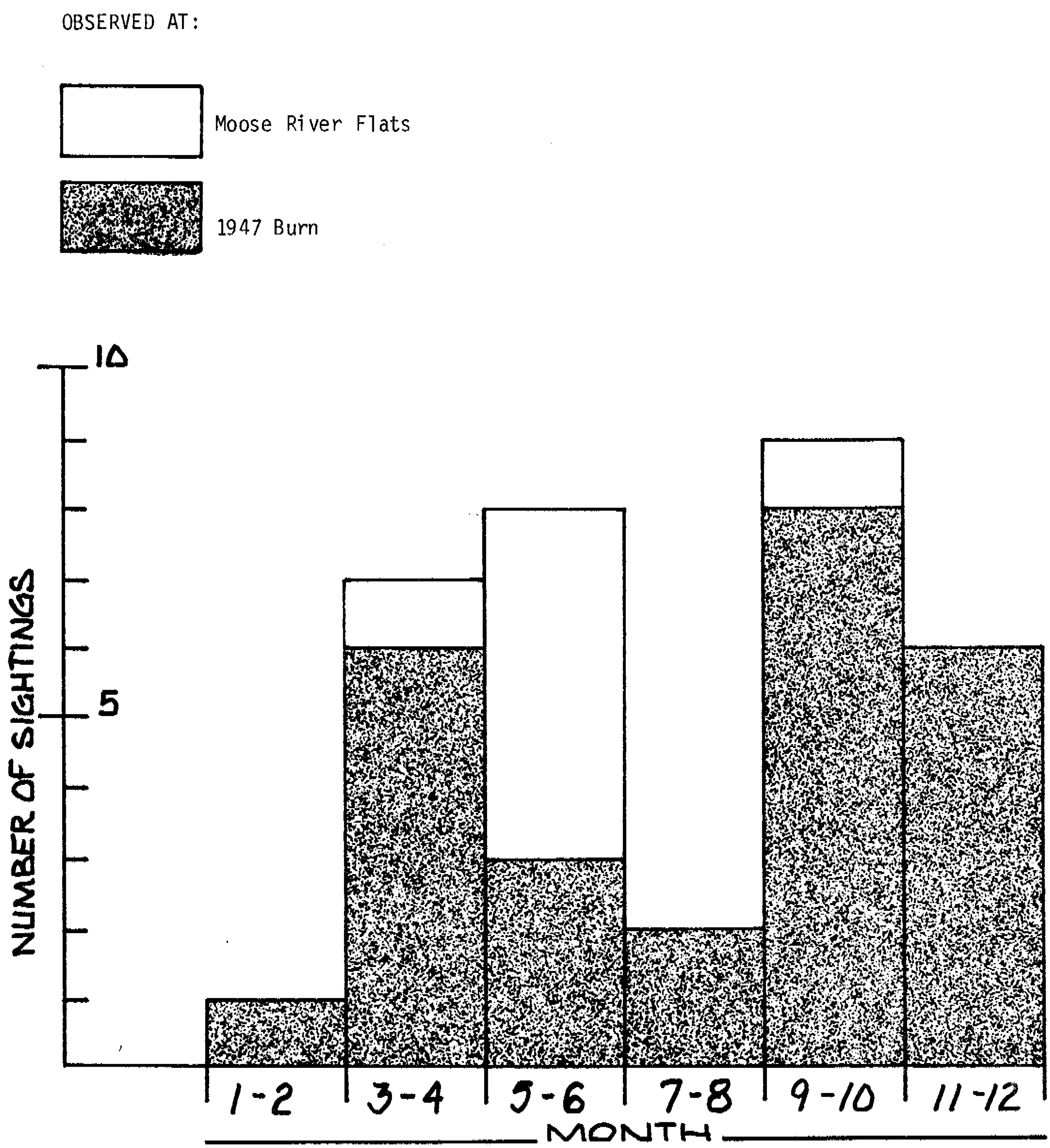


Figure 9. Monthly locations of moose tagged at the Moose Research Center (1947 Burn) year-round 1969-1970.



Primarily, they illustrate group dispersal and reaggregation at the tagging site during the season of tagging. For example, Fig. 8 shows that moose aggregated at the Moose River Flats calving grounds in May-June (5 - 6) disperse to many areas during other months. In the July-October (7, 8, 9, 10) period moose tagged in this group were seen 1) on the Moose River Flats, 2) in various Kenai Mountain drainages, 3) on the Skilak-Tustumena benchland, and (a special case of (1) above) in the Mystery-Dike Creek basin. The other figures illustrate similar aggregations and dispersals by the other tagged groups. Areas represented on the figures are large (for example, "Kenai Mountains north of Mystery Creek Basin" includes more than 20 drainages and more than 450 square miles--2180 square kilometers). Therefore, aggregations apparent on the figures may be exaggerated. The areas do represent the major physiographic areas of the northern Peninsula, however. Further, they adequately define areas suitable for separate management practices.

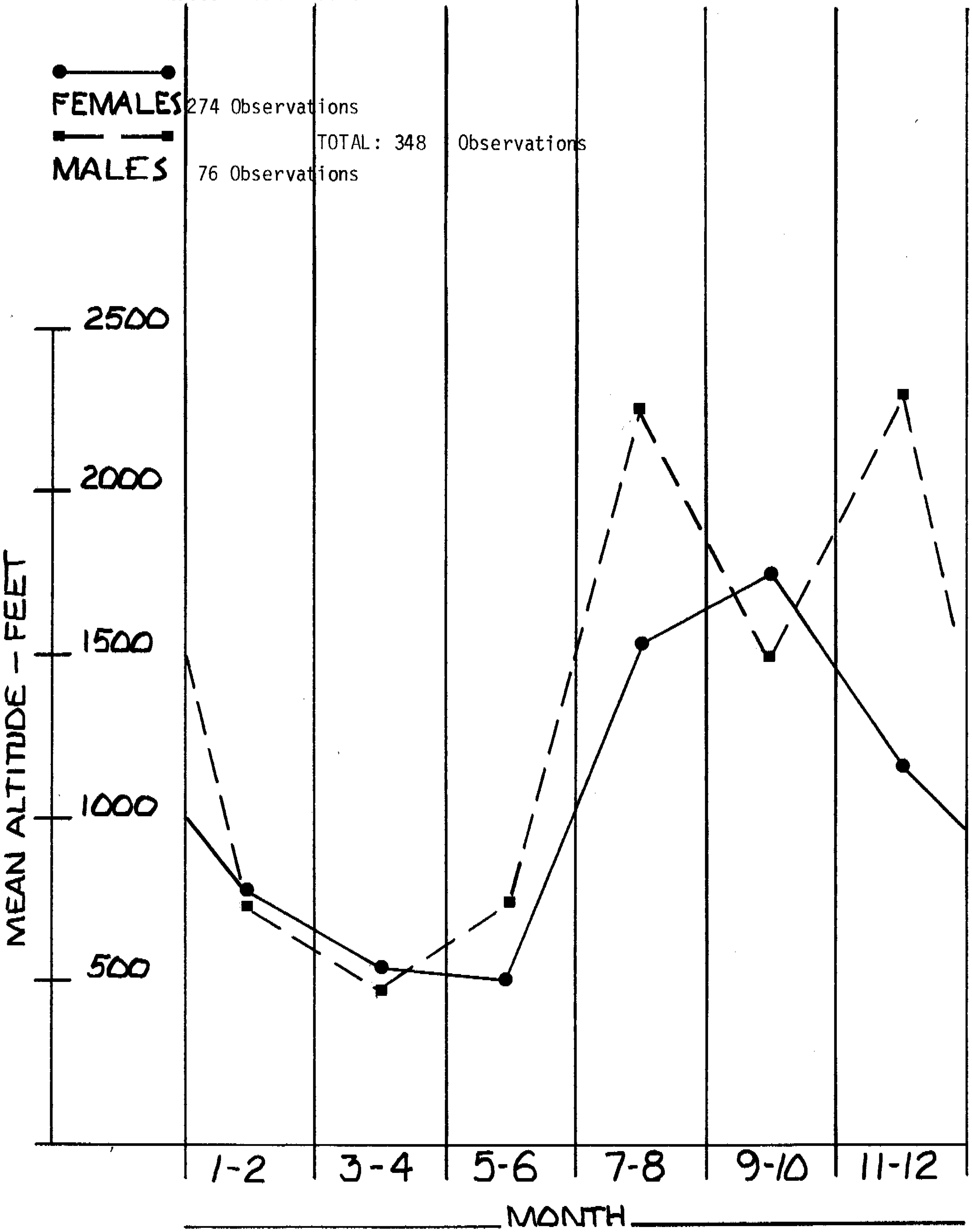
Movements

Much movement information is implicit in the above discussion of population identity and the following account of concentrating areas. Seasonal migrations, their year-to-year differences and individual movements merit special mention, however.

A major migration, as suggested above, occurs from the Moose River Flats (and other scattered calving areas) to the Kenai Mountains and the Skilak-Tustumena benchland. This movement typically occurs from July through September-October. Fig. 10 defines the movement by plotting mean altitude of males and females by season. Sexes are partially segregated from May through August because males migrate to high country earlier than do females, which remain on calving lowlands longer. Further, males migrate to the very heads of mountain drainages, but females typically do not move so high. Intermixing occurs at breeding (months 9 - 10). After rut, males typically return to upper drainages as females begin migrating to lowland wintering areas. Most males join them in January-February and the sexes remain mixed through June, when the upland migration once again begins. Some males remain near timberline all winter.

There are important exceptions to the above pattern. A substantial portion of the population tagged at the Moose Research Center (in the 1947 burn adjacent to the Moose River Flats) is resident in that area. This is suggested by the sightings of Moose Research Center tagged individuals (cf: Table 4, Figs. 5 and 9) of which 33/36 (92 percent) have been within four miles of the tagging site. It is further suggested 1) by trapping success of traps outside the Moose Research Center fenceline, which is uniformly high during all seasons, 2) by the average of more than 15 moose per square mile enclosed by building the Center's four enclosures (two completed in January, two in August) and 3) by observations adjacent to the Moose Research Center during all months of the year.

Figure 10. Mean altitude by month of 348 sightings of collared moose; Kenai Peninsula. 1968. March 1971.



Concentrating Areas

Concentrations of moose occur during calving, rutting and late winter. On the northern Kenai Peninsula, greatest numbers are most concentrated during calving and rutting. Wintering areas are so vast (ie: the 1947 burn of more than 350,000 acres) that winter concentrations, though impressive (ca: 500-1000 animals in a township near Skilak Lake in March 1970), do not occur to such an extent as calving and rutting concentrations.

Table 6 summarizes present data re: which moose occupy which areas of the northern Kenai during which seasons. This table is organized by tagging group rather than by breeding population because of the limitations of group tagging. Fig. 11 graphically presents the data summarized in Table 6. Tallest bars represent areas where moose are most concentrated during each two-month period. They show concentrations 1) on the Skilak Loop area during March-April (largely of animals tagged there--resighted shortly after tagging), 2) on the Moose River Flats during May-June (moose tagged there and at Mystery Creek) and 3) on the Skilak-Tustumena benchland and Mystery-Dike Creek basin and other Kenai Mountain drainages from July through October or December (moose tagged in Moose River Flats and Mystery Creek).

RECOMMENDATIONS

Reconnaissance flights throughout Subunits 15A and 15B should be continued weekly to derive maximum information from tagged animals. More moose should be tagged in late winter concentration areas near the Sterling Highway to adequately define calving and rutting areas of these animals.

Moose should be tagged in fall in the Skilak-Tustumena benchland to determine wintering areas of this trophy-class population.

Moose should be tagged in fall in one Kenai Mountain drainage in addition to Mystery Creek to determine if the Mystery Creek population is typical.

In the interim, seasons should be set with the following probabilities in mind:

1. Late summer and fall "highland" populations are likely older animals (LeResche, 1970) and fewer in number than the substantial lowland resident populations.

2. Populations are predictable in their movements; therefore, harvest of various groups can be controlled by properly timed field announcement hunts. Tables 5 and 6 can serve as guidelines for such harvests.

Figure 11. Moose present in seven major areas of the Kenai Peninsula by month, as surmised from sightings of tagged animals, 1968 - 1970.

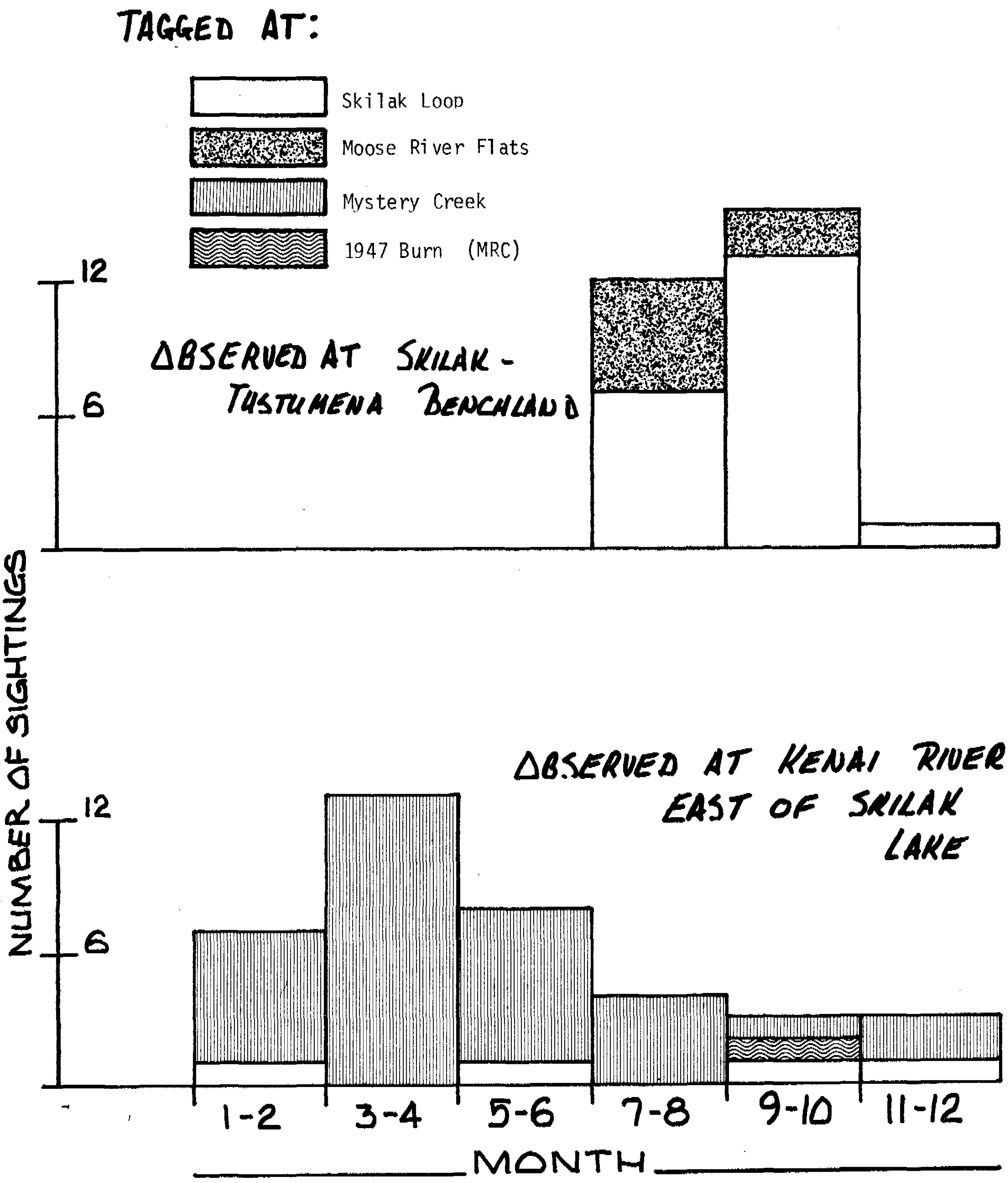


Figure 11. (cont'd.) Moose present in seven major areas of the Kenai Peninsula surmised from sightings of tagged animals, 1968 - 1970.

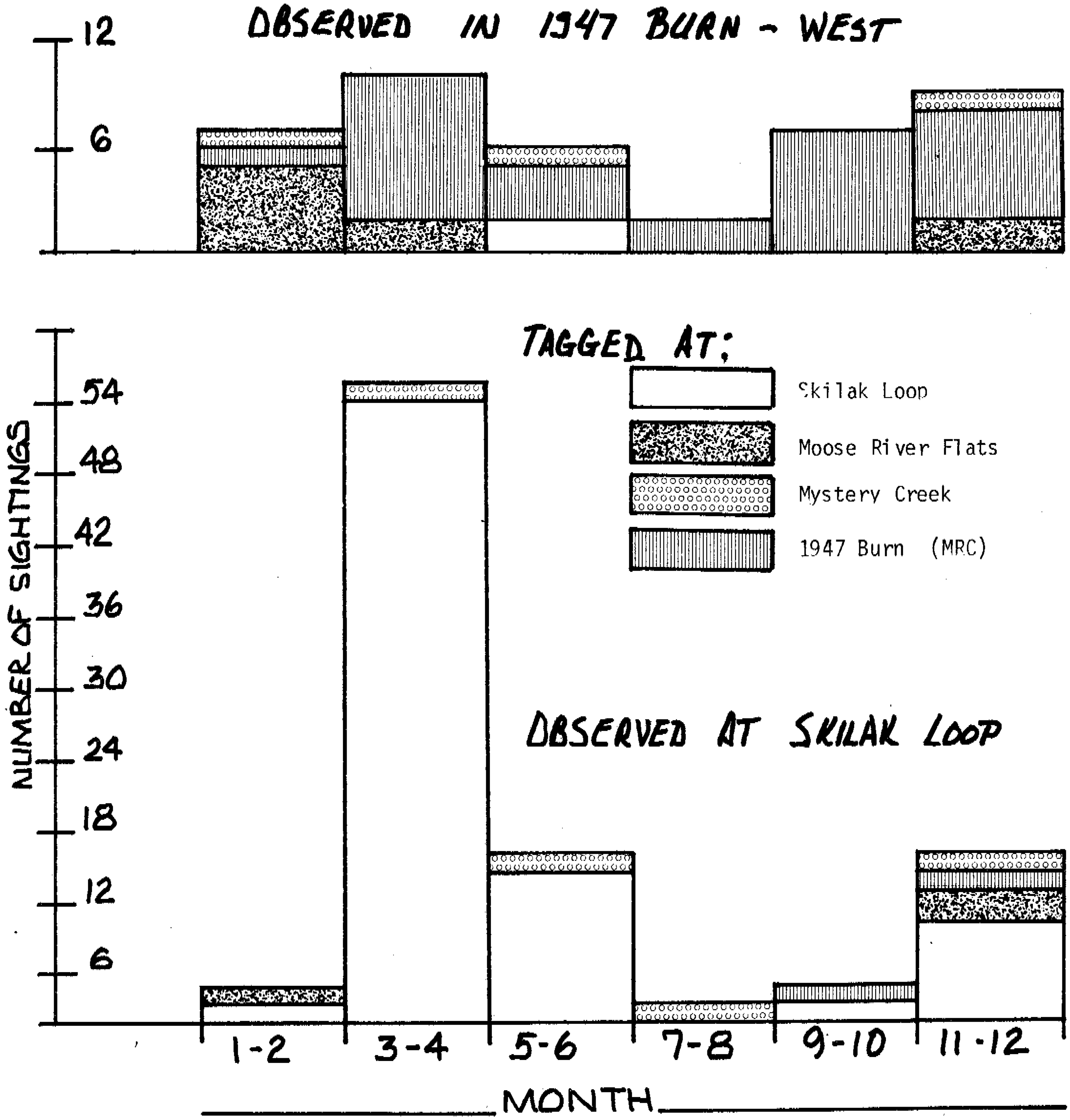


Figure 11 (cont'd). Moose present in seven major areas of the Kenai Peninsula surmised from sightings of tagged animals, 1968 - 1970.

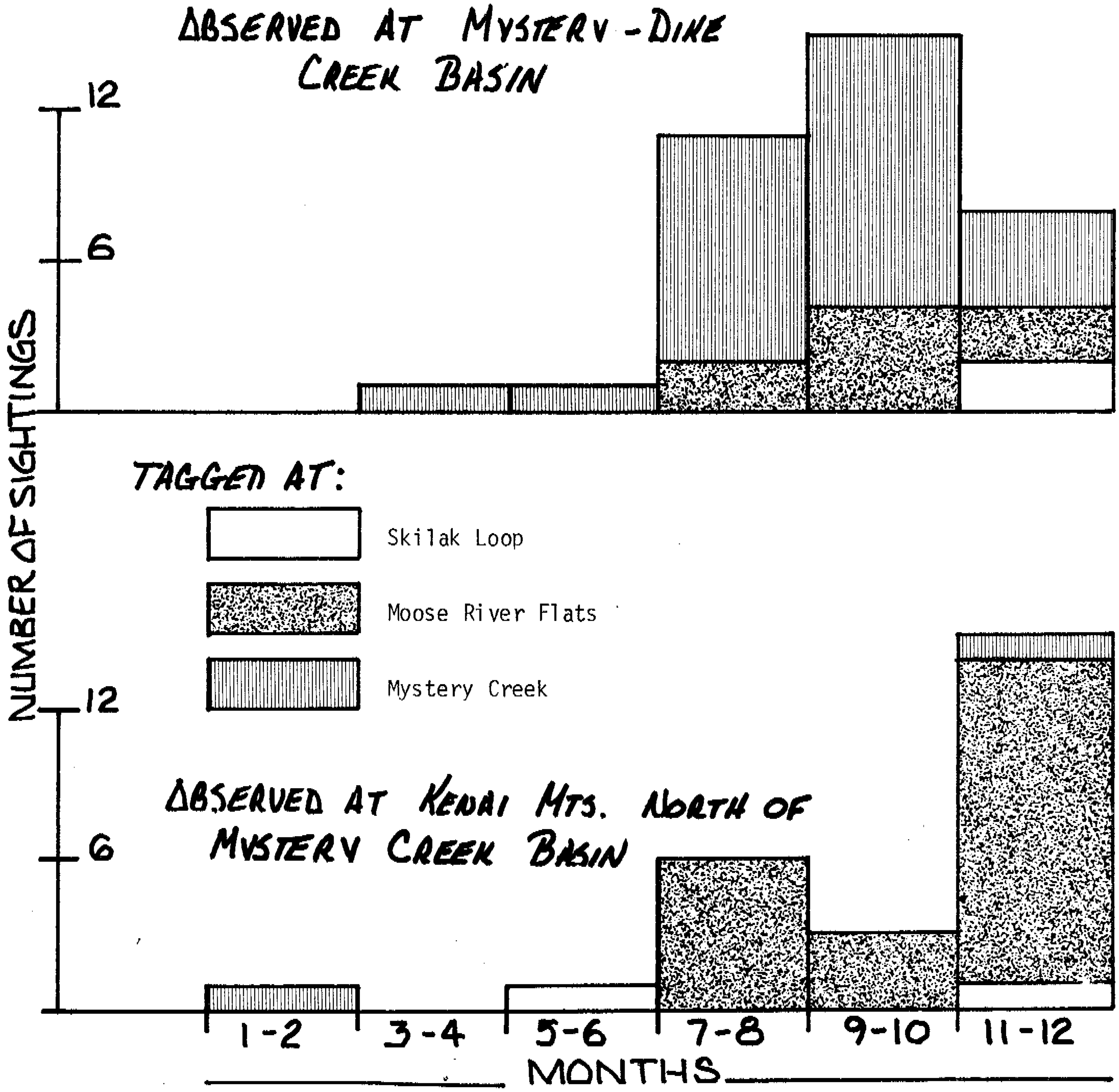
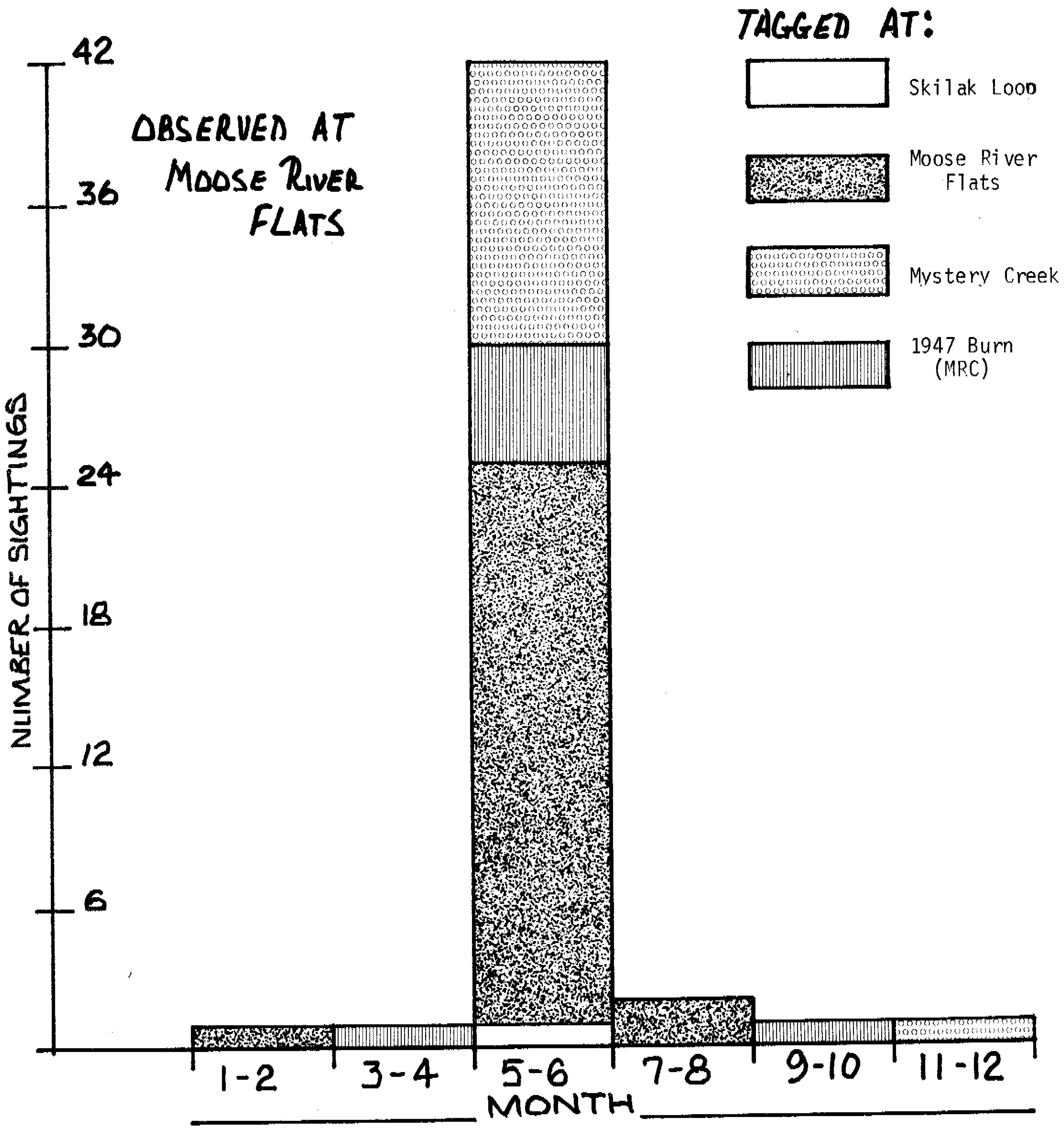


Figure 11. (cont'd.) Moose present in seven major areas of the Kenai Peninsula as surmised from sightings of tagged animals, 1968 - 1970.



3. Even though migratory populations may be adequately harvested every several years (on a maximum sustained yield basis) local resident populations in the 1947 burn remain essentially unharvested with present access.

4. Fall rutting populations in mountain drainages are probably composed of the same individuals year after year. Therefore concentrated hunting in certain drainages should be avoided.

5. Migration routes of many (perhaps 3,000-5,000) moose cross the Moose River lowlands in an east-west direction. A barrier (eg: a fenced highway) across this route could be disastrous to these animals.

6. Moose breeding in the Skilak-Tustumena "benchland" (trophy-hunting area of Game Management Unit 15B) utilize the Skilak Loop-Sterling Highway area for wintering and the Moose River Flats for calving. These areas should be managed to preserve maximum numbers of trophy moose during these times of year.

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