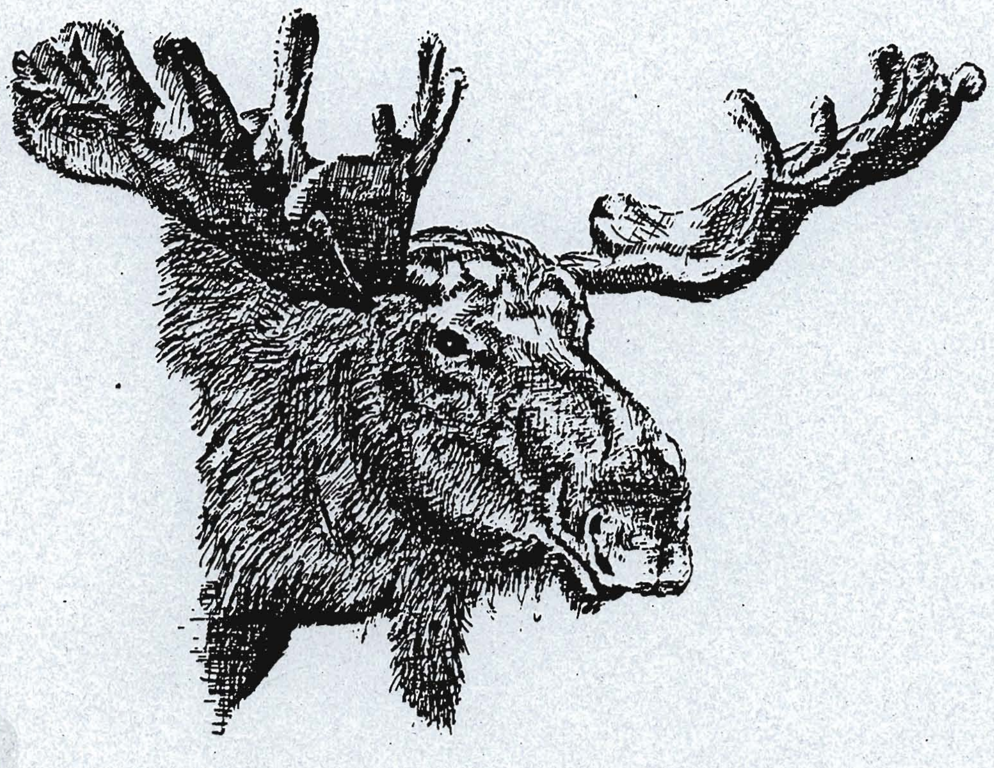
Alaska Department of Fish and Game
Division of Wildlife Conservation

Federal Aid in Wildlife Restoration
Research Progress Report

Lower Susitna Valley Moose Population Identity and Movement Study

by
Ronald D. Modafferi



Project W-23-5
Study 1.38
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PROGRESS REPORT (RESEARCH)

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SUMMARY

Moose-kills (n=3,054) because of train collisions along 756 km of railway in Alaska were analyzed by year (May-April), location (railway milemark), season (winter and non-winter) and month from 1963-90. Train moose-kills were numerous in deep-snow years, during winter months (November-April), and in sections of railway that pass through moose lowland winter concentration areas. In a high kill section of railway in the lower Susitna Valley (milemarks 185-275), we studied interrelations between train moose-kills, snowpack depth, timing of snowfall, and moose distribution in lowland winter and alpine postrut areas during 1981-90. Moose distribution in lowland winter concentration areas along the railway was positively correlated with timing and depth of snow. Train moose-kills were highest in early, deep-snow winters. Moose distribution in alpine postrut concentration areas was negatively correlated with timing and depth of snow. In low-snow winters many moose remained in alpine postrut areas. The study 1) pointed out the importance of understanding moose movements to assess and resolve the train-moose problem and 2) identified importance of alpine postrut areas for moose.

To study aspects of reproduction in female moose we gathered records from ADF&G archives on *in utero* pregnancy rates and litter size and age class of female moose killed (n=677) in 12 late November-late February antlerless moose hunts in southcentral Alaska in 1964-73. Productivity parameters, pregnancy rate, 2-fetus pregnancies and fetus production, were studied in relation to 5 age-class based moose social classes in 4 area/hunt samples. Calf cows (age class = 0, n=31) were not productive. Yearling (age class = 1, n=58) cows pregnancy rate was low (19.1%), highly variable between samples and did not include 2-fetus pregnancies. Ninety percent of teen cows (age classes 2-4, n=223) were pregnant; frequency of 2-fetus pregnancies varied widely between samples. Among moose social classes, prime cows (age classes 5-11, n=300) exhibited the highest pregnancy rate (94.7%), 2-fetus production (24.3%), and fetus production (117.7 fetuses:100 cows). Prime cow pregnancy rate was least variable among yearling-senior social classes. Fetus production and the 2-fetus pregnancy rate were higher in senior cows (age classes 12+, n=65) than in teen cows. Non-calf cows (n=646) examined carried 102.3 fetuses:100 specimens. In 2-fetus pregnancies, second fetuses accounted for 16.8% of fetus production in gravid non-calf specimens. In one sample, pregnancy rate differed

little during three years in which frequency occurrence of 2-fetus pregnancies and fetus production exhibited large differences year-to-year. Large differences in fetus production between two area/hunt samples with similar pregnancy rates were attributable to 2-fetus litters.

Records of point location and descriptive information data gathered in three interrelated studies of radio-marked moose movements in lower Susitna Valley during 1980-90 were joined in a database file (n=9,805 records). Data records of radio-marked females (n=7,879) were isolated, perused and "cleansed" of errors to study aspects of cow moose reproduction.

We used visual observations (n=5,023) of radio-marked female moose to study chronology of birthing, aspects of productivity and lifetime reproductive success of female moose in the lower Susitna Valley in 1980-90. Productivity and chronology of birthing were studied intensively in 1981-84 and 1990 when 1,086 telemetry pursuits of 83 radio-marked moose provided 628 observations of marked moose during May-June. Dates moose were first observed with calves ranged from 8 May to 21 May in 1990 which followed a deep-snow winter and late spring. Dates moose were first observed with 2-calf litters ranged from 11 May in 1983 to 21 May in 1981, 1984, and 1990. Few observations of marked moose included calves (10 out of 148) during 1-15 May. In 1990, none of 42 moose observed before 15 May were associated with calves. Considering the 5 years, > 50% of the monitored cows observed during 16-31 May were associated with calves. Frequency of calves with cows decreased between 1-15 June and 16-30 June. Three of 9 moose observed with calves during 1-15 May were associated with 2 calves. During 16-31 May, 48% of moose with calves were with 2-calves. Frequency of calves with cows varied between 66.7% in 1984 and 85.7 in 1982. Frequency occurrence of 2-calf litters varied from 22% in 1984 to 65% in 1983. Number of calves per 100 marked cows observed, ranged from 81.5 in 1984 to 131.4 in 1982. Size of litters with marked cows during spring and winter seasons was different in 1982 and than in 1983. In the same years, spring to winter changes in size of litters were inconsistent for year and litter size categories except in both years about 25% of the spring 2-calf litters were intact in winter. Cow moose were associated with fewer calves in the year immediately after capture than in subsequent years. This year-to-year difference occurred more frequently in 2-calf litters than 1-calf litters. One marked moose, observed with a calf(s) in 10 consecutive years, produced at least 15 calves in 10 years. Four years was the longest interval a monitored moose was not observed with a calf. Frequency occurrence of 2-calves in litters of marked moose varied greatly depending on year. For the next report period, data on year-to-year variation in occurrence of 2-calf litters will be analyzed in relation to weather the preceding summer, winter and spring.

Key words: Moose, *Alces alces*, Susitna Valley, radiotelemetry, habitat, movements, aerial survey, counts, population identity, Southcentral Alaska, subunits, snowpack depth, concentration areas, railroad, migration.

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BACKGROUND

Before statehood in 1959, the Susitna River Valley was ranked as the most productive moose (*Alces alces*) habitat in the territory (Chatelain 1951). Today, the innate potential of this area as habitat for moose is unsurpassed throughout the state. The lower Susitna River Valley is the focal point of more development than any other non-urban region in Alaska. Proposed and progressing projects involving grain and crop agriculture, dairy and grazing livestock, commercial forestry and logging, personal-use cutting of firewood, mineral and coal mining, land disposals, wildlife ranges and refuges, human recreation, human settlement, urban expansion, development of highway and railway systems, and increased railroad traffic in the region may greatly detract from the area's potential to support moose.

Although development and associated activities may reduce the moose population in the Susitna River Valley, resource users have demanded increased allocations to satisfy consumptive and nonconsumptive uses. This conflict created a tremendous need by local, state, and federal land and resource management agencies for timely and accurate knowledge about moose populations in Subunits 13E, 14A, 14B, 16A, and 16B. These informational needs will intensify in response to (1) increased pressures to develop additional lands, (2) increased numbers of users and types of resource use, and (3) more complex systems for allocating resources to potential users.

The Division of Wildlife Conservation lacks necessary information about moose populations in the lower Susitna River Valley to assess the ultimate impacts from these increasing resource demands accurately. The division is unable to dispute or condone specific demands, or provide recommendations to regulate and minimize negative impacts on moose populations or habitat. The division must be knowledgeable about moose population behavior to mitigate unavoidable negative impacts to moose populations or their habitat.

The division is the source of much information on moose populations for decisions on land use and resource allocation in the lower Susitna River Valley. To be more effective in this capacity, the division should consolidate available data and expand that database with studies on movements and identity of moose populations. Data from these studies will improve the division's ability to recognize, evaluate, minimize and/or mitigate activities that will impact moose populations and their habitat.

Habitat and environmental conditions vary greatly in the lower Susitna Valley. Large environmental differences may lead to area-specific differences in moose population behavior. Therefore, a series of interrelated moose movements and population identity studies should be conducted at different locations in the lower Susitna River Valley. Studies should be initiated where immediate conflicts in resource use already exist.

After evaluating conflicts in resource use in the lower Susitna Valley, it was apparent that studies should begin in the western foothills of the Talkeetna Mountains in Subunits 14A and 14B. Some of the most dense postrut aggregations of moose in the region and, perhaps, the state occur on Bald Mountain Ridge and Willow Mountain in the western foothills of Talkeetna Mountains. Subunits 14A and 14B provide recreation and resources to over half of Alaska's human population. This area is the focus of many development activities and conflicts in resource use. These subunits have unique problems involving moose and transportation systems.

Environmental information required for the recent Susitna River hydroelectric project emphasized the inadequacy of basic knowledge about moose populations in the area. Data obtained from environmental impact studies for the hydroelectric project pointed out inaccurate assumptions about moose populations in the lower Susitna River Valley.

Historical information available on moose populations in the Susitna Valley is limited to (1) harvest statistics (ADF&G files), (2) inconsistently conducted sex-age composition surveys (ADF&G files), (3) inconsistently collected data for train- and vehicle-killed moose (ADF&G files), (4) a population movement study based on resightings of "visually collared" moose (ADF&G files), (5) studies on railroad mortality and productivity of the railbelt subpopulation (Rausch 1958, 1959), (6) a radiotelemetry population identity study in the Dutch and Peters hills (Didrickson and Taylor 1978), (7) an incomplete study of moose-snowfall relationships in the Susitna River Valley (ADF&G files), (8) a study of extensive moose mortality in a severe winter (1970-71) for which there is no final report and (9) a pilot study to develop a rapid-assessment technique to identify and characterize moose winter range (Albert and Shea 1986).

Recent studies designed to assess impacts of a proposed hydroelectric project on moose provided much data on moose populations in areas adjacent to the Susitna River downstream from Devil Canyon (Arneson 1981; Modafferi 1982, 1983, 1984, 1988b). These studies suggest that moose sex-age composition counts conducted in alpine habitat postrut concentration areas of Subunits 14A and 14B were biased, including samples from unhunted moose populations and excluding samples from segments of hunted moose populations. Moose killed by hunters and trains during winter in Subunit 14B were fall residents of Subunit 16A. Fall resident moose of Subunit 16A migrated to winter areas in Subunit 14A. Moose vulnerable in fall hunts in Subunit 16A were included in Subunits

14A and 14B population composition and trend surveys. Moose that calved in Subunit 16A were fall residents of Subunit 14B. These data indicate that assumptions about movements and identities of moose populations in Subunits 14A and 14B (i.e., western foothills of the Talkeetna Mountains) may be incorrect or too simplistic. Previous progress reports on lower Susitna Valley moose population identity and movement studies have been published (Modafferi 1987, 1988a, 1990, 1992).

OBJECTIVES

The primary objectives of this study are to:

- Identify and delineate major moose populations in the lower Susitna Valley.
- Delineate moose annual movement patterns and location, timing, and duration of use of seasonal habitats more precisely.
- Assess effects of seasonal timing on results of annual fall sex-age composition and population trend moose surveys.
- Relate findings to moose population management in lower Susitna Valley.

Peripheral objectives of this study are to:

- Identify habitats and land areas that are important for maintaining the integrity of moose populations in the lower Susitna Valley.
- Locate moose winter concentration areas and calving areas in the lower Susitna Valley.
- Identify moose populations that sustain "accidental" mortality in highway and railroad rights-of-way and hunting mortality.
- Determine moose natality and mortality rates. Determine timing of calving and timing of calf and adult mortality.

STUDY AREA

The study area is located in the lower Susitna River Valley in southcentral Alaska (Fig. 1). It is bordered on the north and west by the Alaska Mountain Range, on the east by the Talkeetna Mountains, and on the south by Cook Inlet. The roughly 50,000-km^2 area encompasses all watersheds of the Susitna River downstream from Devil Canyon. It includes all or portions of Subunits 14A, 14B, 16A, 16B, and 13E (Fig. 2).

Monthly mean temperatures vary from about 16 C in July to -13 C in January; maximum and minimum temperatures of 25 and -35 C are not uncommon. Total annual precipitation varies from about 40 cm in the southern portion to over 86 cm in the northern and western portions. Maximum winter snow depth can vary from less than 20 cm in the southern portion to over 200 cm in the northern and western portions. Climatic conditions generally become more inclement away from the maritime influence of Cook Inlet. Elevations within the area range from sea level to rugged mountain peaks well above

1,500 m. Vegetation in the area is diverse, and varies depending on the elevation: wet coastal tundra and marsh, open low-growing spruce forest, closed spruce hardwood forest, treeless bog, shrubby thicket and alpine tundra (Viereck and Little 1972). Dominant habitat and canopy types in the area are characterized as: (1) floodplains dominated by willow (*Salix* spp.) and poplars (*Populus* spp.), (2) lowland dominated by a mixture of wet bogs and closed or open mixed paper birch (*Betula papyrifera*)/white spruce (*Picea glauca*)/aspen (*Populus tremuloides*) forests, (3) mid-elevation dominated by mixed or pure stands of aspen/paper birch/white spruce, (4) higher elevation dominated by alder (*Alnus* spp.), willow, and birch shrub thickets or grasslands (*Calamagrostis* spp.), and (5) alpine tundra dominated by sedge (*Carex* spp.), ericaceous shrubs, prostrate willows, and dwarf herbs. Fall-winter postrut area moose surveys were conducted above timberline in higher elevation and alpine tundra habitats, roughly between elevations from 600 to 1,200 m. Winter area moose surveys were conducted in lowland floodplain riparian habitats between elevations of 30 to 300 m.

METHODS

Overall Study

Individual moose were captured and marked with ear tags and radio-transmitter neck collars (Telonics, Inc., Mesa, AZ). Each ear tag featured a discrete numeral, and each radio collar featured a discrete radio-transmitted frequency and a highly visible number.

Moose were typically immobilized with 4-6 mg carfentanil (Wildlife Laboratories, Fort Collins, CO) dissolved in 2-3 cc H_2O. The drug was administered with Palmer Cap-Chur equipment by personnel aboard a hovering Bell 206B or Hughes 500D helicopter. While immobilized, moose were marked with ear tags and radio collars and aged by visual inspection of wear on incisor teeth. Antler size and conformation were considered when assessing age of males. Moose were assigned to the following age categories: calves, yearlings, 2- to 5-year-olds, 6- to 12-year-olds, and > 12-year-olds. Sex of marked moose and their association with young of the year were noted. Immobilized moose were revived with an intramuscular injection of 90 mg naloxone hydrochloride (Wildlife Laboratories, Fort Collins, CO) per mg of carfentanil administered.

Forty-four moose were captured and marked in seven discrete postrut areas in Subunits 14A and 14B (Fig. 3) from 23 December 1985 to 4 February 1986. Marking procedures began after 18 November 1985, when aerial surveys indicated peak numbers of moose present in postrut areas (Modafferi 1987). Distribution of sampling effort between postrut areas paralleled moose distribution observed on aerial surveys. On 14 December 1987 and 21 December 1988, 6 and 2 moose, respectively, were captured and radio-marked to replace those that had shed transmitting collars or died.

On 28 January 1987, 7 moose were captured and marked in lowland forest habitat (Fig. 4) located between Little Willow Creek and the Kashwitna River in Subunit 14B. Sampling effort paralleled distribution of moose observed on a previous survey (Modafferi 1988a). This area is included within the Kashwitna Corridor Forest, where the Alaska Department of Natural Resources (DNR), Division of Forestry (DOF), initiated a forest management program in 1988. Access and sales were provided to make timber available for commercial harvest. On 9 February 1989, 5 moose were captured and marked near timber sale sites between Willow Creek and Iron Creek (Fig. 4).

During February and March 1988, 6 moose were captured and marked near Coal Creek (Fig. 4), where DNR permitted cutting firewood for personal use. Moose frequented this area to feed on buds, catkins, and twigs trimmed from birch trees cut for firewood.

During April 1990, seven moose were captured and marked at five sites along the Parks Highway between the Little Susitna River in Subunit 14A and Sheep Creek in Subunit 14B (Fig. 1). On 16 April 1990, six moose were captured, marked, and released at sites where supplemental food was provided for moose nutritionally stressed by exceptionally deep snow. On 19 April 1990, one moose accidentally caught in a snare trap was tranquilized, marked, and released at the Houston landfill.

During 1987, parallel moose population identity and movement studies began in riparian moose winter areas in the western lower Susitna River Valley in Subunit 16B (Faro 1990, Modafferi 1990). During March 1987, 23 moose were captured and radio-marked in the Alexander Creek floodplain (Fig. 4). During February 1988 and 1989, 21 and 6 moose, respectively, were captured and radio-marked in floodplains near Skwentna and McDougall (Fig. 4). Marked moose with operational radio transmitters were radio-located in my study.

Moose captured and marked during previous studies along the Susitna River floodplain in Subunits 13E and 16A (Arneson 1981; Modafferi 1982, 1983, 1984, 1988b) ranged within my study area. I incorporated information from these marked moose into the database. Moose marked during these studies were radio-located until transmitters failed.

Radio-marked moose were telemetry located at 2- to 4-week intervals in Cessna 180 or 185 and Piper PA-18 aircraft equipped with 2-element "H" or 3-element Yagi antennas (Telonics, Mesa, AZ). Moose locations (audio-visual or audio) were noted on USGS topographic maps (1:63,360). Location points were later transferred to translucent overlays of those maps for computer digitization and geoprocessing. A maximum of 200, 70, 55, 39, 27, and 13 point locations were recorded through 20 October 1990 for moose radio-marked in the Susitna River floodplain, Talkeetna Mountains, Little Willow Creek, Coal Creek, Willow Creek, and Parks Highway area, respectively.

During this study, radio transmitters on some individuals marked along the Susitna River in March 1981 and February 1982 exhibited either weak, infrequent, or no signals. These transmitters were presumed to be weakening and expiring from battery failure.

Moose distribution, abundance, and herd composition were assessed by aerial surveys conducted at different times and locations. Timing, magnitude, and duration of moose use of postrut areas were determined by aerial moose count surveys in Subunits 14A and 14B. Each fall-winter from October 1985 to March 1990, seven discrete alpine areas in the western foothills of the Talkeetna Mountains were surveyed (Fig. 3, Areas A—G). Timing, magnitude and duration of moose use of lowland winter areas were determined by aerial moose count surveys in sections of the Susitna River floodplain in Subunits 13E and 16A. Each fall-winter between October 1981 and April 1985, the floodplain between Talkeetna and Devil Canyon in Subunit 13E was surveyed. The floodplain between the Yentna River and Talkeetna in Subunit 16A was surveyed each fall-winter from November 1982 to April 1984. Surveys were conducted at 2- to 3-week intervals as weather permitted and snowcover was sufficient to observe moose. Antlered yearlings, antlered adults, non-antlered adults, and calves were counted. Data were tallied by survey and area.

The Alaska Railroad Corporation (ARC) provided location and date data on train moose-kills along the 470 mi section of railway between Seward and Fairbanks from 1963 to 1990. Data were analyzed for year, season, month, and location. Train moose-kill data were related to data on snowpack depth, number of moose in postrut areas and winter areas, location of moose winter areas, and movements of marked moose.

Snowpack depth data for Wasilla, Willow, Talkeetna, Skwentna, and Chulitna River Lodge (Fig. 1) were obtained from *Alaska Climatological Data Reports* (ACDR). Data for daily snow depth measurements were summarized by selecting maximum depths recorded during three periods (1-10, 11-20 and 21-31 days) in each month. Willow and Talkeetna snowpack data were used as indices of snowpack depth in moose postrut areas.

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Interrelations of Train Moose-Kill, Snowpack Depth and Moose Distribution: Data on 3,054 train moose-kills during 1963-90 in Alaska were obtained from the ARC and analyzed by season, month, year, and railway milemark location. Data on moose distribution obtained on aerial surveys in the lower Susitna River Valley during 1981-90 were analyzed by month, year and location. Data on snowpack depth at Talkeetna and Willow during October-April in 1981-90 were obtained from (ACDR) and analyzed by month, year and location. Information on train moose-kills, moose distribution and snowpack depth were summarized and analyzed for interrelations.

Data Management: Descriptive data and point location data from three interrelated studies of radio-marked moose in the lower Susitna River Valley during 1980-90 were joined in a single database file (n=9,805). Data on radio-marked females monitored telemetrically from aircraft were isolated to study chronology of calf birthing and aspects of productivity. Database file fields containing information on survey date and number of calves associated with radio-marked females were perused and "cleansed" of errors.

Data Collection: In Alaska, moose hunters may be required to collect biological data from animals they kill. Stipulations in certain antlerless moose hunts during 1964-74, required that hunters collect lower jaws with incisor teeth and gather data on the number of *in utero* fetuses from female moose they killed. Hunters and/or biologists examined reproductive tracts in killed female moose specimens to count the number of *in utero* fetuses. Lower jaws and incisor teeth collected from killed moose were submitted for age class determination (Sergeant and Pimlott 1959).

In this study, I gathered information on *in utero*-pregnancy rates and *in utero*-litter size and age class of female moose killed in 12 late November-late February, antlerless moose hunts in southcentral Alaska from the ADF&G archives.

Study Area: The study area is located in southcentral Alaska (Fig. 5) and includes Unit 7 and Subunits 14A, 14B, 14C, 15A, 15B and 15C. Unit 7 and Subunits 15A, 15B and 15C are on the Kenai Peninsula (Kenai). Subunits 14A and 14B are in the Matanuska and Susitna River valleys (Mat-Su). Subunit 14C is situated between Subunit 14A and the Kenai Peninsula. The Fort Richardson hunt area is in Subunit 14C near Anchorage.

Data Analysis: Specimen data were grouped into the following four samples based on hunt area location and/or hunt date: Kenai 1964, Kenai 1970, Fort Richardson and Mat-Su (Table 1). Sample specimen data were assigned to five social classes based on moose age class: calf (C) or infant (age class 0), yearling (Y) or pre-teen (age class 1), teen (T) (age classes 2, 3, and 4), early prime or prime (P) (age classes 5, 6, 7, 8, 9, 10, and 11), and late prime or senior (S) (age classes 12 and greater (Bubenick et al. 1975). In addition to justifications stated by Bubenick et al. (1975) for age class break points between moose social classes, I used age class 4 as the break point between teen and prime social classes because female moose attain maximum body size at 4 years (Schwartz et al. 1987:305) and age class 11 as the break point between prime and senior social classes because antler size measurements indicate senescence occurs in males at about this age class (Gasaway 1975). In this report, moose in age classes 2 or greater (i.e., 2+ year-old moose or T-S moose social classes) are referred to as adults.

Reproductive parameters, *in utero*-pregnancy rate, -litter size and -fetus production, were used to: (1) describe and quantify aspects of moose productivity and (2) examine relationship between productivity and social class in cow moose.

Reproduction and Productivity of Radio-Marked Cow Moose in Lower Susitna River Valley Alaska

Data Collection. Frequent monitoring (n=7,879 pursuits) and visual observations (n=5,023) of radio-marked female moose, during moose movement studies in the lower Susitna River Valley during 1980-90, provided data to examine aspects of cow moose reproduction. Data on number of calves observed in association with telemetry monitored radio-marked female moose were used to study chronology of birthing, aspects of productivity, and lifetime reproductive success of moose in the lower Susitna River Valley. Information on aspects of productivity and lifetime reproductive success of individually identifiable cow moose were collected during 1980-90. During 1980-90, some individually identifiable radio-marked cow moose were telemetrically pursued as many as 203 times and monitored over a 121 month period. Cow moose were monitored less intensively in 1980 and 1985-89 than in 1981-84 and 1990.

Data on chronology of birthing, productivity, and lifetime reproductive success of cow moose were gathered during visual observations of radio-marked individuals monitored from 1980 to 1990. Productivity and birthing chronology were studied intensively during 1981-84 and 1990. In those years, most radio-marked cow moose were telemetrically pursued every 10 days in May-June and every 15 days in other months. During other years, cow moose were monitored less frequently.

Data Analysis: Data on number of calves associated with radio-marked cows were analyzed by date, 2-week periods during May-June, and year in 1981-84 and 1990. Data on association of calves with radio-marked cows collected in 1980 and 1985-89 were analyzed by year (May-April).

I organized birthing date and productivity data to examine the hypothesis that moose reproduction is influenced by weather conditions in July-June preceding parturition. Relationship between weather and moose reproduction was examined in 1981-84 and 1990, the years radio-marked moose were monitored intensively in May-June when parturition occurs. Measurements of precipitation, temperature and snowpack depth in Talkeetna were collected to assess weather conditions in the lower Susitna River Valley where reproduction of radio-marked moose was studied. Weather data were obtained from ACDRs. Precipitation and temperature data were obtained for the snowfree period, May-September. Precipitation and temperature data for the snowfree period were summarized for summer (July-September) and spring (May-June) seasonal periods. Snowpack depth data were obtained for October-April, the winter seasonal period when snowcover is usually present. To study relationship of moose reproduction with climate, weather data were organized in consecutive summer, winter, and spring seasonal periods for comparison with reproductive data collected in the spring seasonal period. I contended that moose reproduction would be negatively affected by "inclement" climatic conditions during July-June preceding and/or overlapping the May-June birthing season of moose. Birthing dates and productivity parameters were used as indices of moose reproduction. I contended that delayed birthing and/or low productivity of moose would be preceded by "inclement" weather conditions. I assumed that negative affects of weather on moose productivity would be evidenced in higher percentages of barren females, lower ratios of 2-calf:1-calf litters and/or lower calf:cow ratios.

References in the literature point out relationships between moose reproduction and weather in the preceding summer (Edwards and Ritcey 1958:267), winter (Markgren 1973:69) and spring (Verme 1974:30). Weather can affect reproduction in moose by influencing nutritional regimes which affect body condition or growth of prebreeding or gravid females. Warm summers promote rapid phenological development and maturation of vegetation, shortening the time during which forage is high quality which negatively affects moose nutritional regimes (Klein 1965, White 1983, Hjeljord 1987, Saether 1987). Moist cool summer climatic conditions, which would protract the time period forage is high quality, positively affect moose productivity (Markgren 1973, Edwards and Ritcey 1958). Early, long lasting, deep snow winters negatively affect moose energy expenditure (Coady 1974) and influence the forage moose consume (Hundertmark et al. 1990, LeResche and Davis 1973, Sandegren et al. 1985:334). Summer weather, particularly during June, was an important factor in determining body weights of Norwegian reindeer (Skogland 1983) and moose in northern Norway (Saether 1985:979). Saether (1987) provided evidence that moose fecundity was related to body weight. Clutton-Brock et al. (1982:88) indicated that birth dates of calf red deer were probably influenced by condition of the hind in autumn. Time of parturition in doe wild reindeer was delayed following restriction of food supplies in late winter (Skogland 1983).

I expected low productivity in moose to be associated with warm dry summers, early long deep snow winters, and/or late cold wet springs. In contrast, I expected moose productivity to be higher following cool moist summers, late short shallow-snow winters and/or early warm springs.

RESULTS

Interrelationships of Train Moose-kill, Snowpack Depth and Moose Distribution

A manuscript titled: "Train Moose-kill in Alaska: Characteristics and Relationship With Snowpack Depth and Moose Distribution in Lower Susitna Valley" was prepared and submitted for publication in the journal *Alces*. The manuscript was accepted and published in *Alces* 27:193-207. The title page and abstract of this publication are in Appendix A.

In Utero Pregnancy Rates, Litter Size and Productivity For Social Classes of Cow Moose in South-Central Alaska

Sampling: Reproductive and age data were collected from 677 female moose specimens. Specimens were distributed among four area/hunt samples as follows: Kenai 1964 - 143; Kenai 1969 - 240; Ft. Rich - 154; and Mat-Su - 140. Sample specimens were distributed among five social classes as follows: C (calf) - 31; Y (yearling) - 58; T (teen) - 223; P (prime) - 300; and S (senior) - 65. Sample specimen distribution by area/hunt is presented in Table 1. Sample specimen age class frequency distribution is presented in Fig. 6.

<u>Pregnancy</u>: None of the calves (n=31) examined carried fetuses (Figs. 6 and 7). Yearlings in each sample were gravid. Eleven of 58 yearlings (19.0%) examined were pregnant. Yearling pregnancy rate varied more than 3-fold between Kenai 1964 and Fort Richardson samples (12.5% vs. 40.0%, respectively); mean pregnancy rate for samples of yearlings (n=4) was 23.1% (Table 2). Ninety percent of 223 teens examined were gravid. Pregnancy rate of teens ranged from 82.4 to 93.3% among samples (n=4); the mean of samples was 90.2%. Prime specimens (n=300) exhibited the highest pregnancy rate (94.7%) among social classes (n=5) and the smallest range (93.3-95.1%) in pregnancy rate among samples (Fig. 7). The mean pregnancy rate for samples of primes was 94% (SD=0.72). Pregnancy rate for senior specimens (n=65) was 88%. Senior pregnancy rate varied widely (66.7-100%) among samples; mean pregnancy rate for samples of seniors was 86% (SD=12.86). Pregnancy rate for specimens excluding calves (n=646) was 85% (Fig. 7). Among samples, pregnancy rate for non-calf specimens ranged from 80 to 92%; the mean was 87% (SD=4.25) (Table 2). Pregnancy rate for 588 adult specimens was 92%. Pregnancy rate for samples of adults ranged from 87% to 94%; the mean was 92% (SD=3.15).

<u>Two-Fetus Pregnancies</u>: None of the 11 gravid yearlings examined were carrying twin fetuses (Figs. 6 and 7). Fourteen percent of 200 gravid teens examined carried 2 fetuses. Rate of twinning for gravid teens varied from 4-23% among samples. Referring to samples, twinning rate for gravid teen specimens was highest (23%) in the Kenai 1964 sample; the sample with lowest (12%) yearling pregnancy rate. Considering gravid specimens in the teen, prime, and senior social classes, twinning rate was highest in the primes (24%, n=284) and lowest in the teens (14% n=200) (Fig. 7). Twelve of 57 (21%) gravid senior specimens carried 2 fetuses. Referring to samples (n=4), twinning rate of seniors varied more widely (0-35%, SD=12.78) than twinning rate of teens (5-23%, SD=6.68) or primes (19-42%, SD=9.15) (Table 2). Twinning rate of gravid specimens, excluding calves, (n=552) was 20%; twinning rate of gravid adult specimens (n=541) was 20%. Mean twinning rate for samples of gravid moose and gravid adult moose was 20% and 21%, respectively (Table 2). One 6-year-old Fort Richardson specimen carried 3 fetuses.

<u>Contribution Of Second Fetuses To Fetus Production</u>: None of 89 specimens < 2 years old examined carried two fetuses (Figs. 6 and 7 and Table 2); second fetuses did not contribute to fetus production in moose calf and yearling social classes (Figs. 7 and 8). Second fetuses accounted for 17% of the fetus production in gravid adult moose specimens (n=541). Referring to specimens in teen, prime and senior moose social classes, second fetuses contributed to fetus production least in the teen (12%) and most in the prime (20%) moose social classes. Considering gravid moose in teen, prime and senior

moose social classes and area/hunt samples, second fetuses contributed to fetus production least (0%, n=4) in the Kenai 1970 teens and most (30%, n=50) in the Fort Richardson primes (Fig. 8). Second fetuses contributed 21% to fetus production of gravid adult (T-S) specimens (n=110) in the Fort Richardson sample.

Fetus Production By Gravid Moose: Non-calf (n=552) and adult (n=541) moose specimens examined carried 119.7 and 120 fetuses:100 gravid cows, respectively. Among samples, *in utero* fetus production ranged from 113.8 (Kenai 1970, n=203) to 126.3 (Fort Richardson, n=114) fetuses:100 non-calf gravid specimens. Considering samples of gravid adults, the number of fetuses:100 cows was lowest in Kenai 1970 (114.0; n=200) and highest in Fort Richardson (127.3; n=110).

Number of Fetuses:100 Female Moose: None of the calves (n=31) examined carried fetuses (Fig. 7). Yearlings (n=58) averaged 19 fetuses:100 yearling specimens. The number of *in utero* fetuses in yearling specimens ranged from 12.5 (Kenai 1964) to 40 (Fort Richardson) fetuses:100 specimens among area/hunt samples (Fig. 8). With all area/hunt samples lumped, prime specimens (n=300) carried the most fetuses (117.7 fetuses:100 cows); teen specimens (n=223) carried the fewest (102.2 fetuses:100 cows) (Fig. 7). Comparing the means of all samples, primes carried the largest number of fetuses (119.4 fetuses:100 females); adults (T-S) carried 103.4 fetuses:100 females (Table 2). Among samples, number of *in utero* fetuses in senior specimens varied from 66.7 (Fort Richardson, n=6) to 127.8 (Mat-Su, n=18) fetuses:100 cows. In area/hunt samples, fetus production of adult moose ranged from 105.6 (Kenai 1970, n=216) to 115.9 (Kenai 1964, n=119) fetuses:100 cows among samples (Fig. 7). Adult moose (n=588) carried 110.5 fetuses:100 cows.

Year Differences In Reproductive Parameters: In the Fort Richardson area/hunt sample, the percent of yearling-senior specimens that carried fetuses varied from 74.3% in 1973 to 88.5% in 1964 (Fig. 9); percent of adult (teen-senior) specimens with fetuses varied from 74% to 93% in the same years. Percent of gravid adults with more than one fetus ranged from 17% in 1965 to 52% in 1969 (Fig. 9). Frequency of pregnant specimens differed little among the years 1965, 1968, and 1972. However, frequency of pregnancies with 2-fetuses was much higher in 1968 (52%) than in 1965 (17%) or in 1972 (26%). In 1+ and 2+ year-old cow moose age classes, twinning rates did not always vary in relation to pregnancy rates (Fig. 9). Pregnancy rates in Fort Richardson adult cow moose specimens differed little between years 1965 and 1968 (Fig. 9). In the same years, twinning rate in gravid adult specimens differed greatly (17% vs. 52%, respectively) (Fig. 9). Fort Richardson adult specimens carried 31% more fetuses in 1968 than in 1965 (140 versus 108 fetuses:100 cows, respectively) (Fig. 9).

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Chronology of Birthing: The date a radio-marked moose was first observed with calves varied from 8 May in 1981 to 21 May in 1990 (Tables 3-8). The date a 2-calf litter was first observed varied from 11 May in 1983 to 21 May in 1981, 1984 and 1990. During 1-15 May (period 1) in the years moose were studied intensively, cow moose birthed earliest in 1984 and latest in 1990 (Table 9 and Fig. 10). Referring to all observations in those 5 years, < 10% of the marked moose birthed before 15 May. In 1990, none of 42 (0.0%) moose observed during 1-15 May were associated with calves. In 1982, 25 of 34 (73.5%) marked moose observed during 16-31 May (period 2) were associated with calves. Considering years 1981-84 and 1990, > 50% of the monitored moose observed during period 2 were associated with calves. In 3 of the 5 years, percent of marked moose observed with calves decreased from 16-31 May (period 2) to 1-15 Jun (period 3). Means of the yearly (n=5) percent of marked cows with calves in period 2 (58.6%) and period 3 (58.9%) were similar (Table 9). Observations of cows associated with calves decreased from period 3 to period 4. Referring to the 5 years, calf association with marked cows in 1984 was highest in 3 of 4 date periods.

Chronology of Two-Calf Litter: Three of 9 (33.3) moose with calves in period 1 were with 2 calves (Table 10 and Fig. 11). Forty of 84 (48%) moose litters observed in period 2 were 2-calf litters. Considering all years and referring to periods, 2-calf litters were most common in period 3 (50%). Referring to periods 1-4, frequency occurrence of moose with calves (Table 9) and frequency occurrence of 2-calf litters (Table 10 and Fig. 10) followed a similar pattern. Values were at low levels in period 1, increased to peak levels in periods 2-3 and decreased to lower levels in period 4. Forty-three of 118 (36%) moose litters observed during 1 May-30 June in 1981-84 and 1990 were 2-calf litters (Table 11). Of the years marked moose were intensively studied, 2-calf litters were least common in 1981; 22% of observed litters were 2-calf litters (Table 8). In 1982 and 1983, 53% and 65%, respectively, of observed litters were 2-calf litters.

Considering observations of calves with cows at capture and during telemetry monitoring from 1 May-30 April in 1979-90, frequency occurrence of multiple-calf litters varied from 0% (n=1 litter) to 69% (n=26 litters) (Table 12). In 8 different years, less than 25% of the litters were 2-calf litters. In 1985 and 1990, 30% and 35%, respectively, of marked moose litters were 2-calf litters. In 1982 and 1983, 50% and 69% of the marked moose were observed with 2 calves. In late winter 1990, a record deep-snow winter, 2 marked moose were observed with 3 calves. On numerous occasions before late winter, these 2 moose were observed with 2 calves.

Changes in Litter Size From Spring To Winter: Data in 1982 and 1983 on marked moose observed with calves in May-June (spring) and subsequently observed in Dec-Jan (winter) indicate the number of calves associated with cows in spring and winter varied differently between years and inconsistently when considering litter size (Fig. 12). In 1983, all (n=7) moose associated with 1 calf in spring were associated with 1 calf in winter. In 1982, 54% of 1 calf litters in spring were 1 calf litters in winter. Percent 2-calf litters observed in spring that were 2-calf litters in winter was similar in 1982 and 1983, 25% and 27%, respectively. Percent loss of calves from 2-calf litters was greater in 1983 than in 1982. In 1983, 53% of moose observed with 2 calves in spring were not associated with calves when observed in winter.

Capture of Cows and Subsequent Calf Production: Marked moose were associated with less calves the first year after capture than in 3 of 4 subsequent years (Table 13). Forty-two percent of the cow moose monitored cow (n=112) were not observed with calves in the year after capture. In second, third and fourth years after capture, respectively, 26%, 32%, and 28% of the observed cows were not with calves. Percent of cows associated with 1 calf varied little in 5 consecutive years (48% (n=112), 45% (n=103), 46% (n=81), 49% (n=61) and 43% (n=40), respectively) after capture. In all years, percent of cows associated with 2 calves the first year after capture (9.8%) was less than the percent of cows with 2 calves in the 2nd-5th years after capture (29%, 22%, 23% and 15%, respectively) (Table 13).

Lifetime Productivity: Marked moose were observed with calves in 317 of 472 (67.2) moose observation years. In moose monitored from 1 to 10 consecutive years (n=112), the average of percent of years (n=10) moose were observed with calves was 67%. Percent of years marked moose were observed with calves was lower in moose monitored 1-4 years than in moose monitored 5-10 years. One moose was observed with a calf(s) in 10 consecutive years; 15 different calves in that 10 year period. Four years was the longest interval a moose was monitored and not observed with a calf(s). One moose monitored during 9 years, was observed with a calf(s) in 3 years.

Weather Conditions: Analyses of summer, winter, and spring weather data were not completed for this report but will be completed for the next report.

DISCUSSION

Interrelationships of Train Moose-Kill, Snowpack Depth and Moose Distribution

See the title page and abstract of publication entitled: Train moose-kill in Alaska: Characteristics and relationship with snowpack depth and moose distribution in lower Susitna Valley (Appendix A). Complete discussion of findings in this study are available in this publication (*Alces*3 28:193-207).

In Utero Pregnancy Rates, Litter Size and Productivity For Social Classes of Cow Moose in Southcentral Alaska

Fetus production of hunter killed cow moose in south-central Alaska varied in relation to the age-class based moose social classes, calf, yearling, teen, prime and senior in the following manner: 1) calf cows - were not productive; 2) yearling cows - were productive, did not produce 2-fetus litters and their pregnancy rate and fetus production were low and variable; 3) teen cows - exhibited high variability in relatively high rates of pregnancy and fetus production and in low rates of producing 2-fetus litters; 4) prime cows - exhibited low variability in high rates of pregnancy, fetus production and producing 2-fetus litters; 5) senior cows - exhibited high variability in high rates of pregnancy, fetus production, and producing 2-fetus litters. In my study, prime cows were the most productive moose age class. This finding is not surprising, since the lower age class break point selected for the prime moose social class (age class 4) corresponded to the age class that most cow moose attain maximum body weight (Schwartz et al. 1987:309) and fecundity rates in moose have been related to maternal body weight (Saether and Haagenrud 1983, Saether 1987). Relationship between body size and reproduction in cow moose can explain lack of fetus production in calves; lack of 2-fetus litters and low, variable productivity rates in yearlings; and low production of 2-fetus litters in teens. Calf cows do not attain mature body size and were non-productive. Low and variable productivity in yearling and teen moose correlates with variability in growth rate and body size in 1-4-year-old moose. Growth in body weight of moose is influenced by interaction of the proximate factors, nutrition (Saether and Haagenrud 1983) and genetics (Pimlott 1959). Variation in nutrition and genetic factors can lead to variability in growth and body weight of moose greatly influencing productivity in adolescent moose social classes. Low productivity in moose yearling and teen social classes may also be attributable to the observation that very few cow moose produce 2-fetus litters in their 1st two pregnancies (Saether and Haagenrud 1983:228). Comparing the 5 moose social classes, prime social class moose, exhibited highest and least variable rates of pregnancy, producing 2-fetus litters, and fetus production of the 5 moose social classes studied.

Moose in the prime social class have attained mature body size and, in most cases, have previous reproduced 1-2 times. Senior social class moose exhibited rates of pregnancy, fetus production, and production of 2-fetus litters, that were higher than in teen and lower and more variable than in the prime social classes. Location and year differences in moose productivity pointed out in my study and in other moose studies, may be also be related to nutrition and/or genetics. In many studies, regional variation in productivity of moose was attributed to differences in range quality and its affect on nutritive condition of cows before parturition (Markgren 1973, Pimlott 1959, Edwards and Ritcey 1958, Blood 1973, Schladweiler and Stevens 1973, Franzmann and Schwartz 1985, Sweanor and Sandegren 1987). In other studies, year-to-year differences in productivity of moose were attributed to quality or quantity of forage available to cows before birthing (Blood 1973, Crichton 1988). Seather (1985) found that annual variation in carcass weight of moose was correlated with climate. One hypothesis to explain this relationship was that climatic conditions affected quantity and quality of forage available to pre-parturient cow moose and thus affected body weight growth of cow moose. He subsequently found that productivity in moose was related to cow body weight (Seather 1987).

Results of this study indicate that social class (age-class) of cow moose is an important factor to consider in management and modeling dynamics of moose populations in southcentral Alaska. To accurately depict reproductive characteristics of moose populations, cow moose social class must be a component in models of moose populations dynamics. To alter productivity of moose populations, managers must focus attention on different social classes of cows. To regulate productivity of a moose population, managers should control the numbers of prime social class cows. To increase harvest in a population without having immediate affects on productivity of the population managers should selectively harvest moose in adolescent moose social classes. Moose managers should not justify hunting of cow moose as a means to remove old, non-productive females from a population. In my study, cows without calves ("barren") were more likely to be adolescent moose in the yearling-teen social classes than aged moose in the senior social class. In my study, number of *in utero* fetuses in 1+ year-old (non-calf) moose ranged from 98.6 to 111.5 fetuses:100 cows in the 4 area/hunt samples. In this same area, roughly 20-55 calves:100 (non-calf) females are observed in moose fall sex/age composition surveys (ADF&G files). Data *in utero* productivity and composition surveys indicate that more than 50% of calf moose produced in May-June are lost by late November-early December. Considering these data, it appears more productive for managers with mandates to increase recruitment into moose populations to consider implementing programs that decrease calf mortality before pursuing management programs that increase calf natality.

Reproduction and Productivity of Radio-Marked Cow Moose in Lower Susitna Valley Alaska

Because results of weather data analyses were not available for this report, findings in this study will not be discussed in this progress report.

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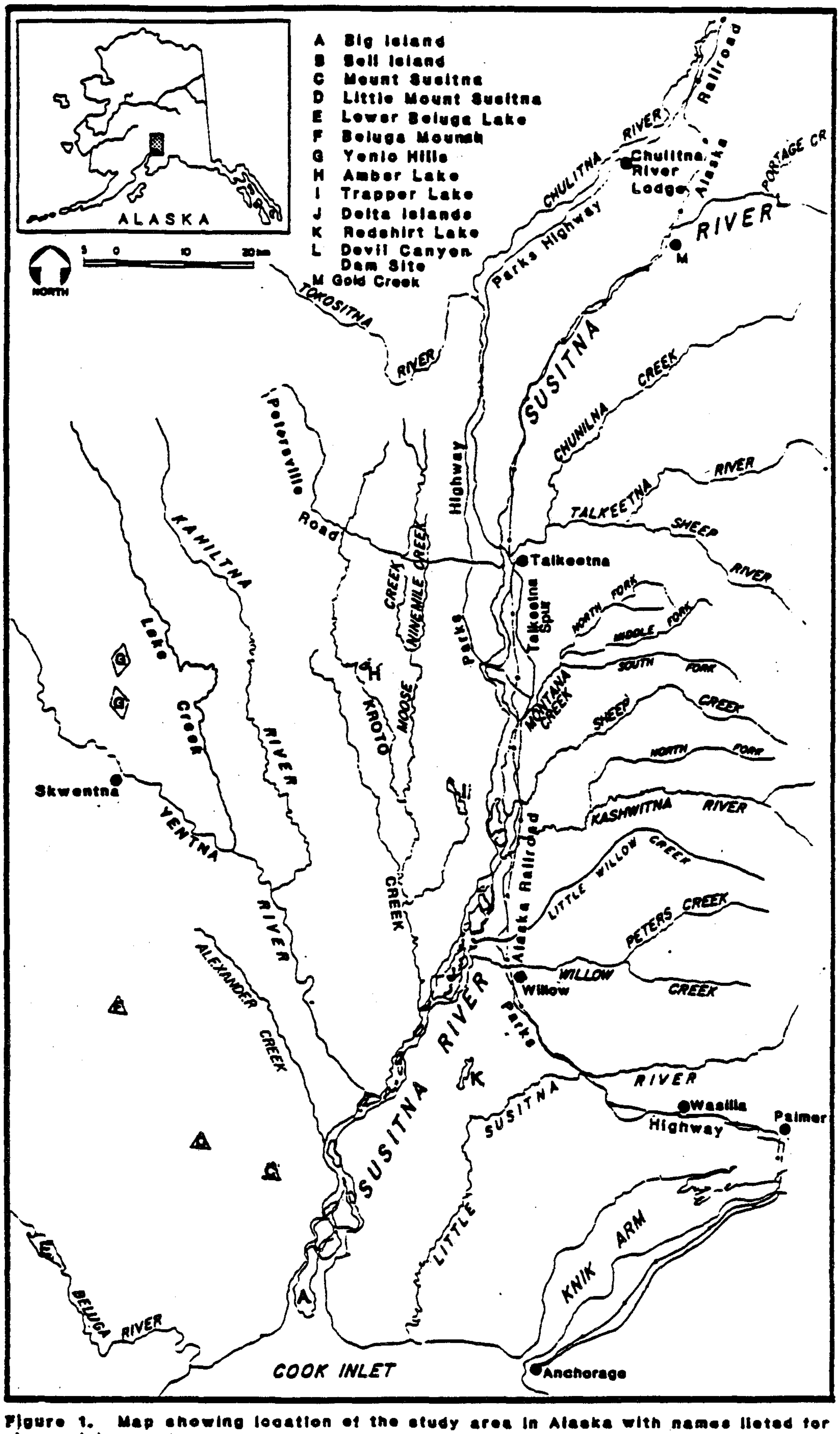

Figure 1. Map showing location of the study area in Alaska with names listed for rivers, lakes and other prominent landscape features.

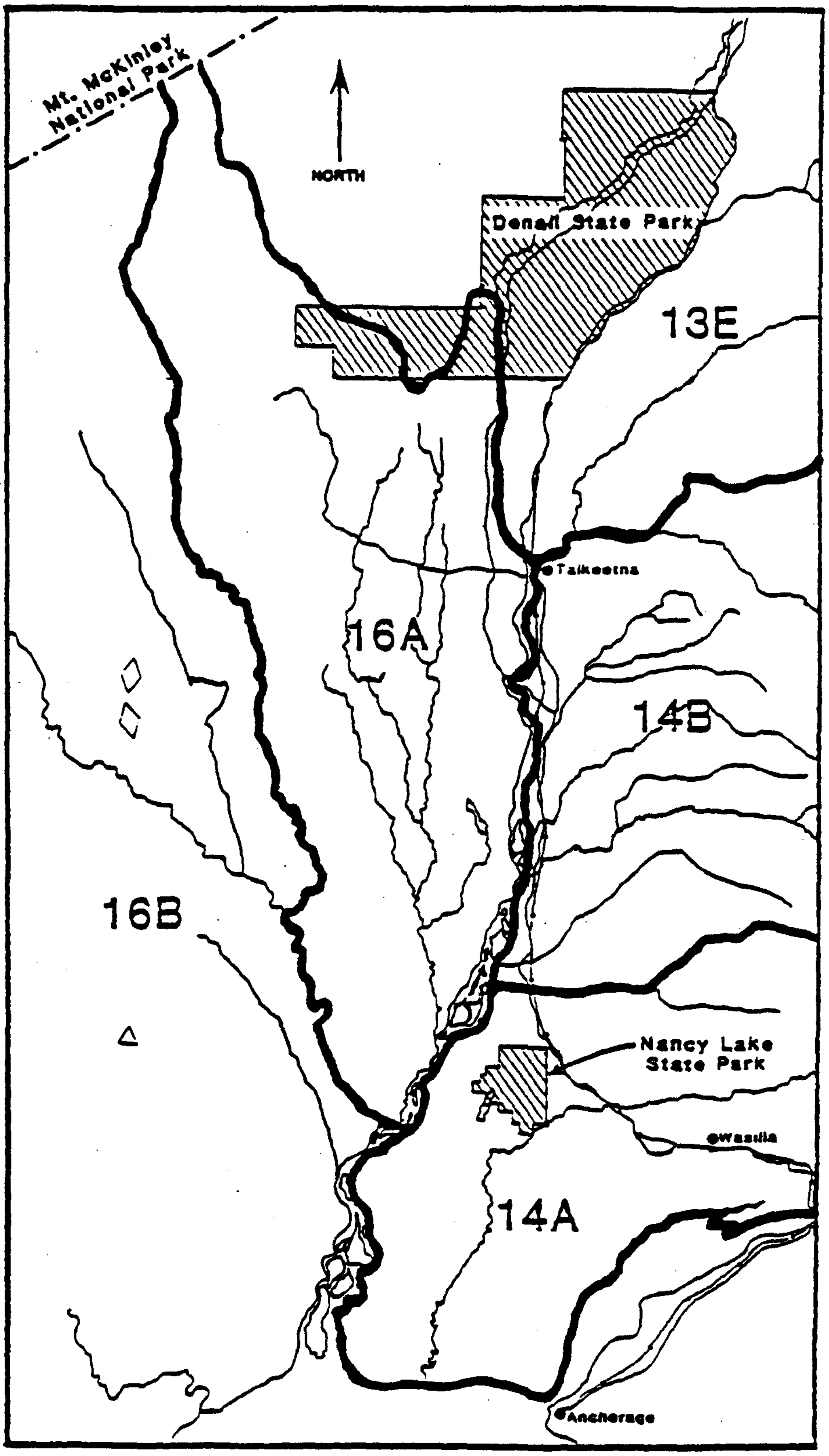

Fig. 2. Location of Game Management Subunits (13E, 14A, 14B, 16A and 16B) and state and national parks in the study area.

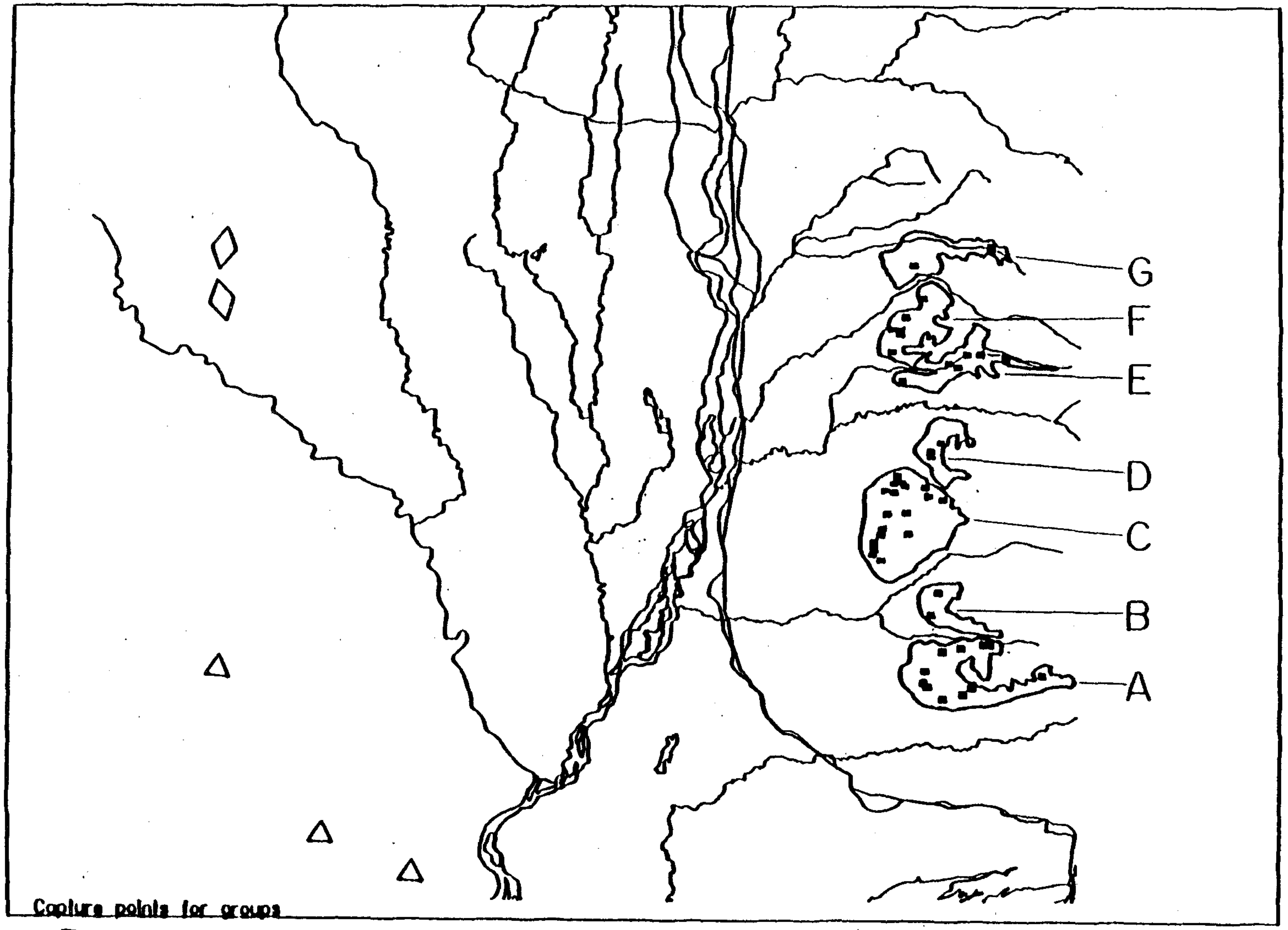

Fig. 3. Point locations where individual moose were captured and radio-marked in 7 alpine habitat postrut areas in game management Subunits 14A and B in the western foothills of the Talkeetna Mountains in southcentral Alaska. A = Bald Mtn., B = Moss Mtn., C = Willow Mtn., D = Witna Mtn., E = Brownie Mtn., F = Wolverine Mtn., and G = Sunshine Mtn.

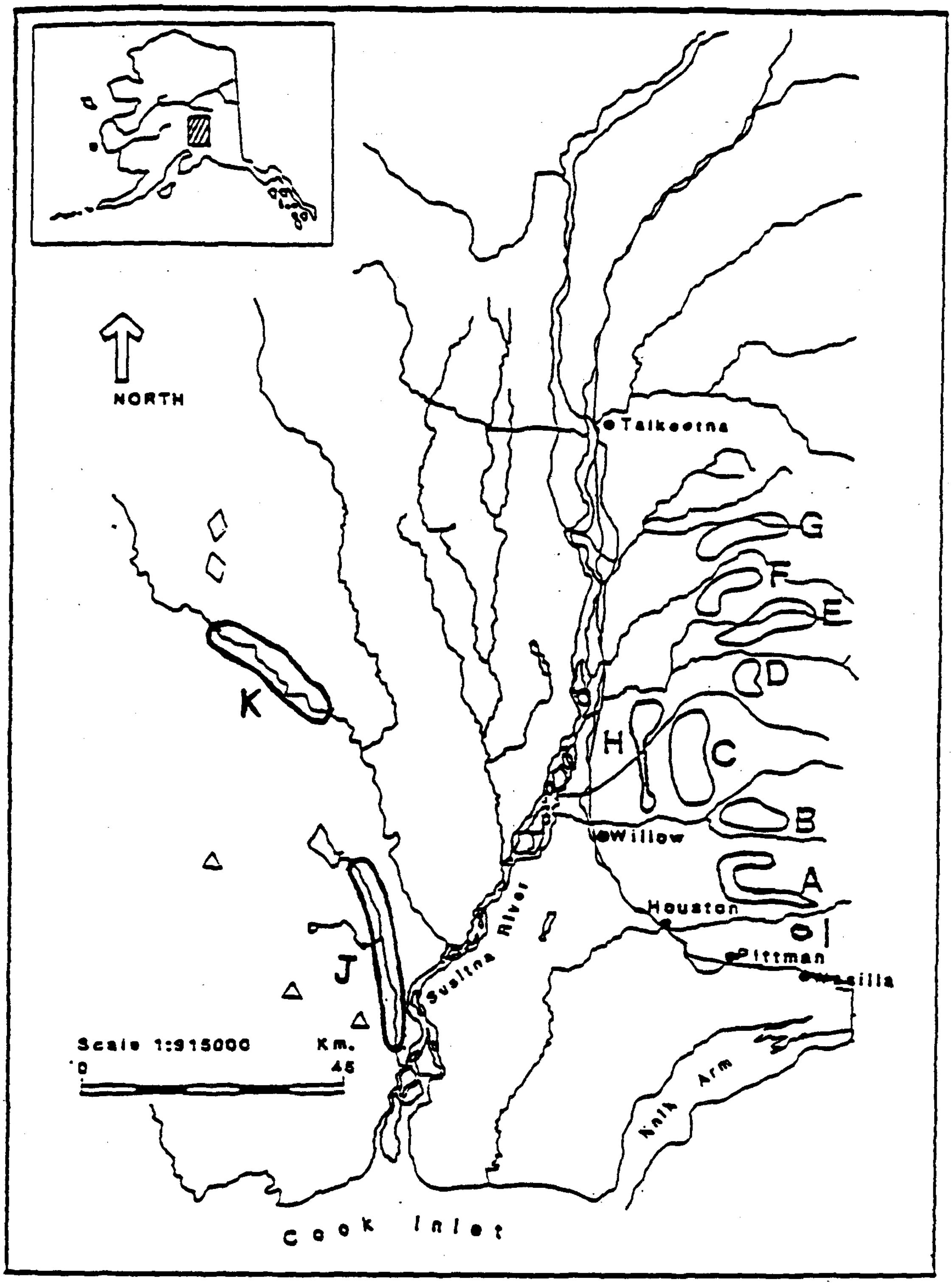

Fig.4 . Locations of Talkeetna Mountains alpine habitat moose postrut areas (A-G), Kashwitna Corridor Forest (H), Coal Creek timber cut area (I), Alexander Creek (J) and the Lake Creek/Skwentna area (K) where moose were captured and radio-marked. A = Bald Mountain, B = Moss Mountain, C = Willow Mountain, D = Witna Mountain, E = Brownie Mountain, F = wolverine Mountain, and G = Sunshine Mountain.

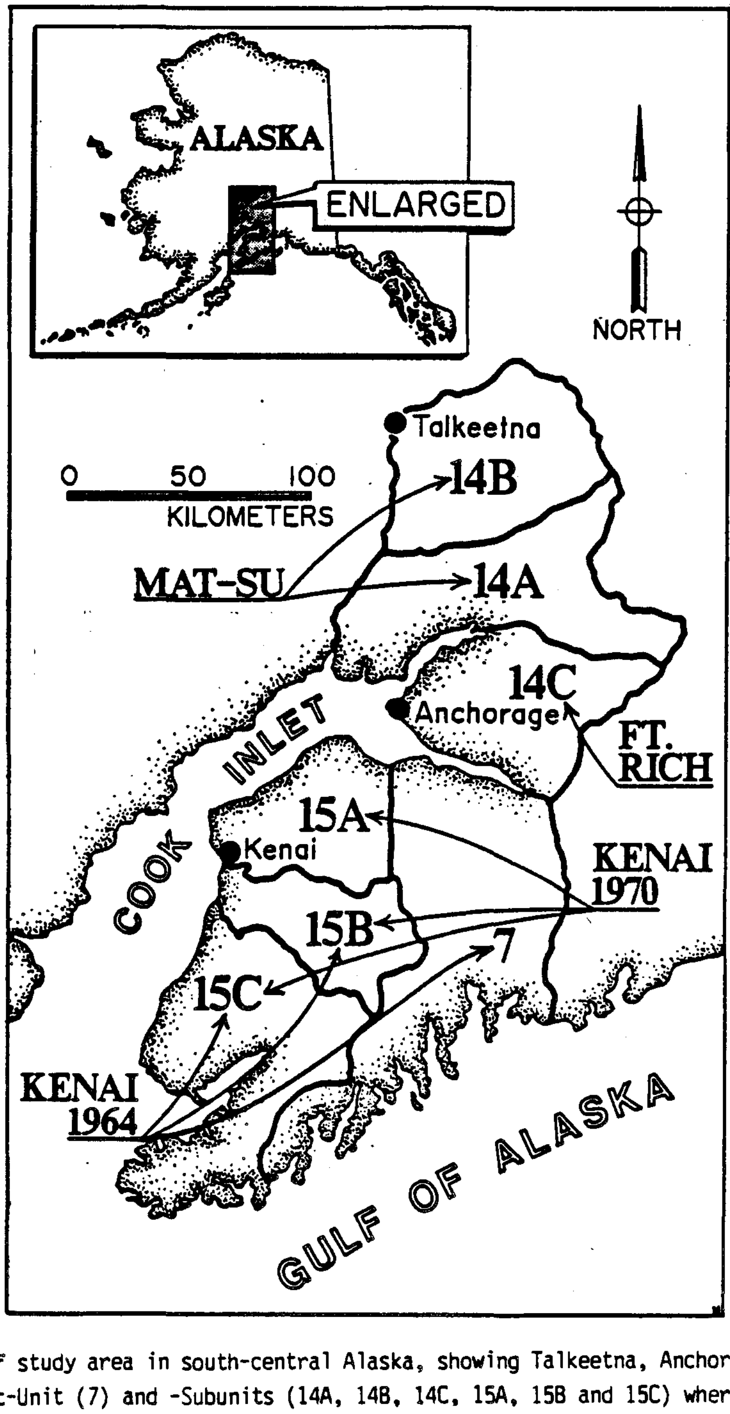

Fig. 5. Location of study area in south-central Alaska, showing Talkeetna, Anchorage and Kenai and Game Management-Unit (7) and -Subunits (14A, 14B, 14C, 15A, 15B and 15C) where the, Mat-Su, Ft. Rich, Kenai 1970 and Kenai 1964 cow moose specimen samples were collected.

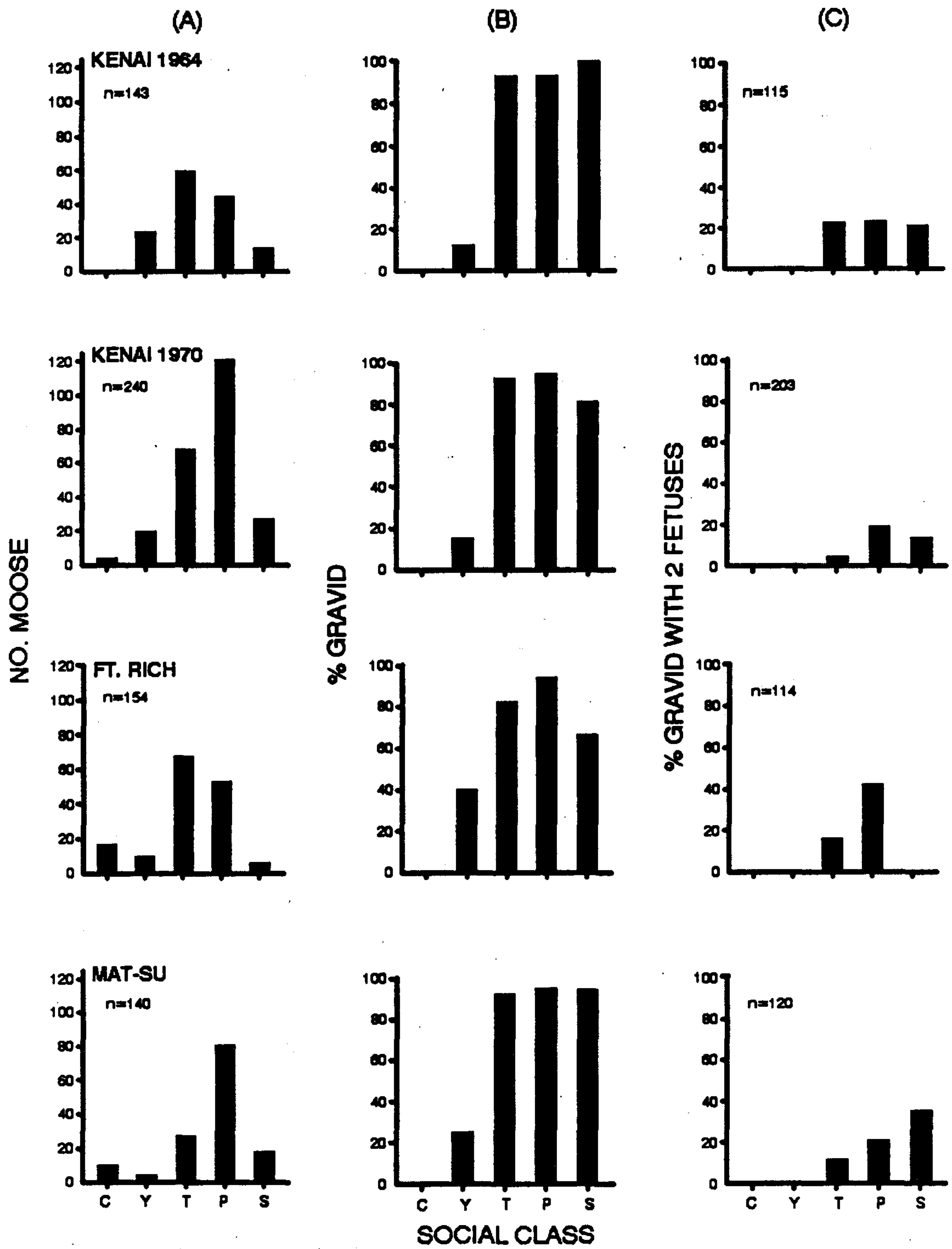

Fig. 6. Distribution of specimens (A), frequency of gravid specimens (B), and frequency of 2-fetuses in gravid specimens (C) in 5 social classes (C=calf, Y=yearling, T=teen, P=prime and S=senior) and 4 samples (Kenai 1964, Kenai 1970, Ft. Rich, and Mat-Su) of cow moose killed in antlerless-moose hunts in south-central Alaska. In A and B, n=number of specimens. In C, n=number of gravid specimens.

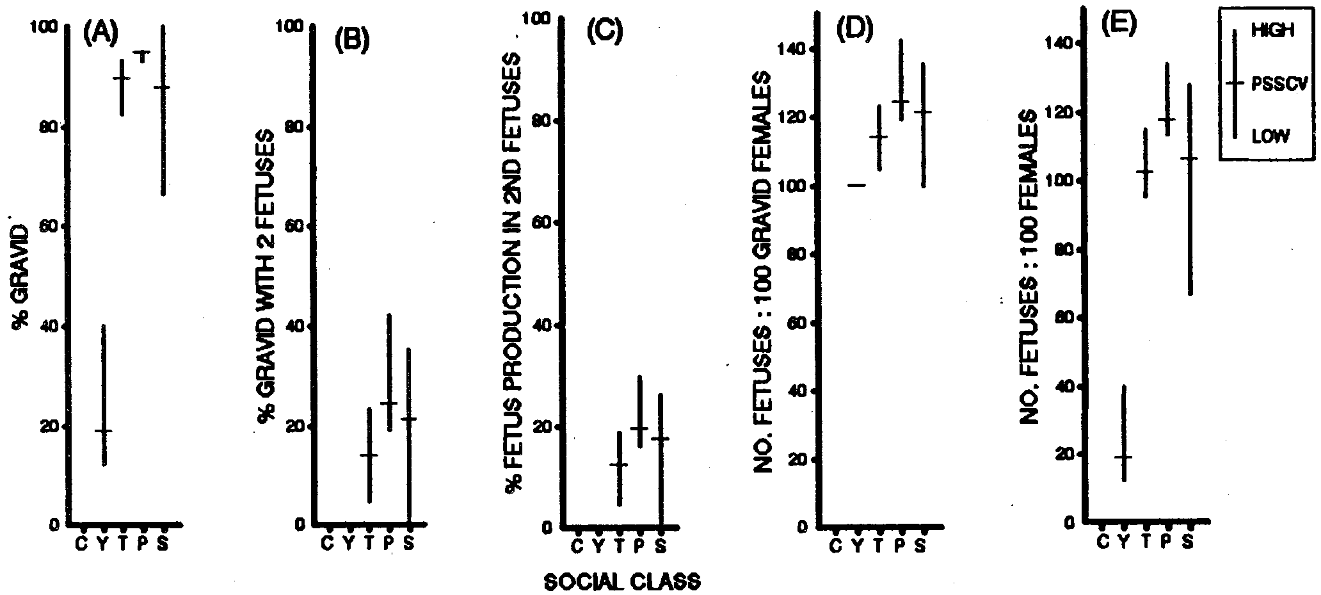

Fig. 7. Range extremes (high, low) among 4 samples and percent of specimens gravid (A), frequency of 2 fetuses in gravid specimens (B), percent fetus production in 2nd fetuses (C), fetus production : 100 gravid females (D) and fetus production : 100 females (E) in 5 social classes (C=calf, Y=yearling, T=teen, P=prime and S=senior) of cow moose killed in antlerless-moose hunts in south-central Alaska. N=143, 240, 154 and 140 cow moose specimens in the Kenai 1964, Kenai 1970, Ft. Rich and Mat-Su area-hunt samples, respectively. N=31, 58, 223, 300 and 65 cow moose specimens in the C, Y, T, P and S moose social classes, respectively. PSSCV=pooled sample social class value=value obtained for social class obtained by pooling sample specimens.

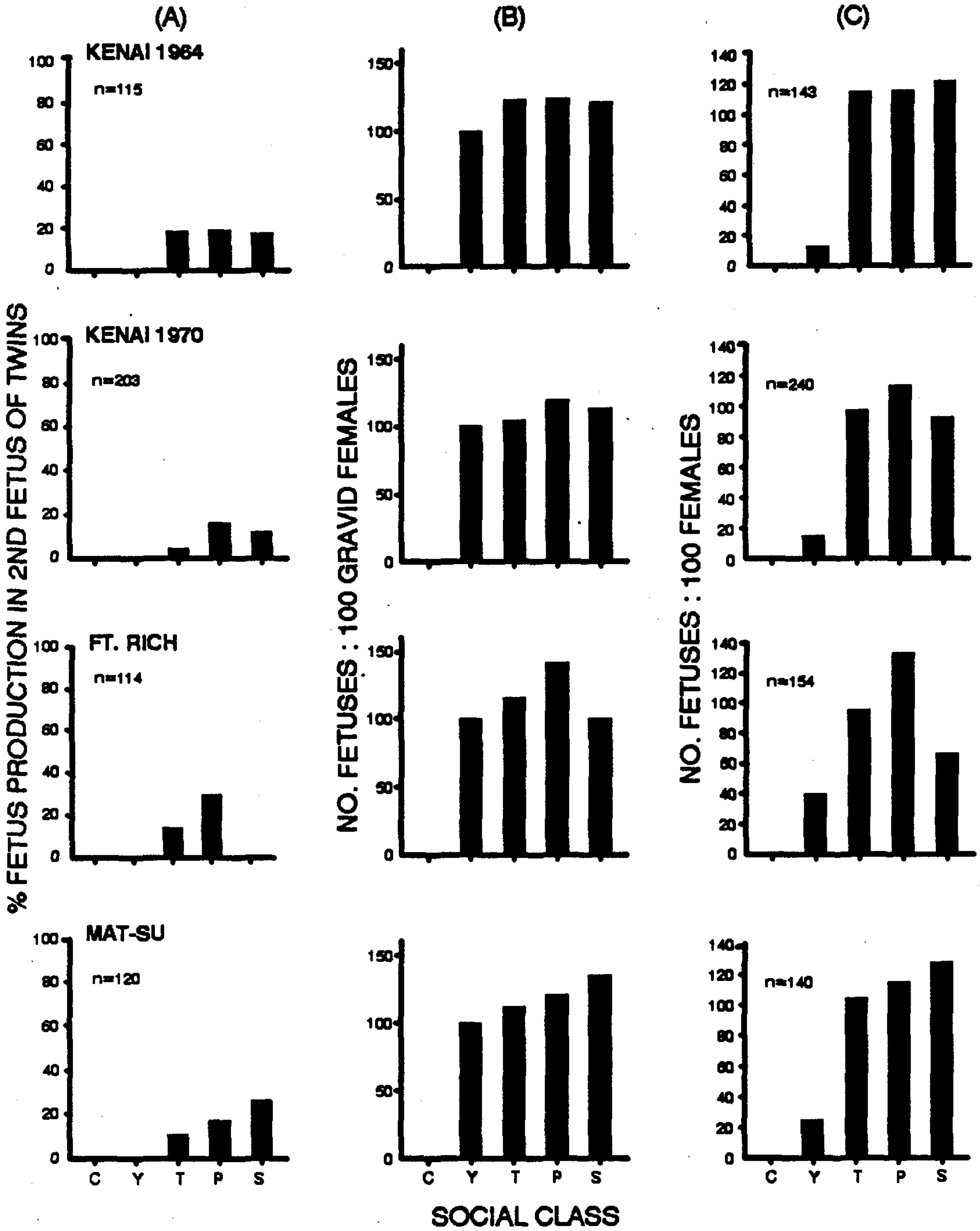

Fig. 8. Percent fetus production in 2nd fetuses of twins (A), No. fetuses produced : 100 gravid females (B) and No. fetuses produced : 100 females (C) in 5 social classes (C= calf, Y=yearling, T=teen, P=prime and S=senior) in 4 samples of cow moose killed in antlerless-moose hunts in south-central Alaska. In A and B, n=No. gravid moose specimens. In C, n=No. moose specimens.

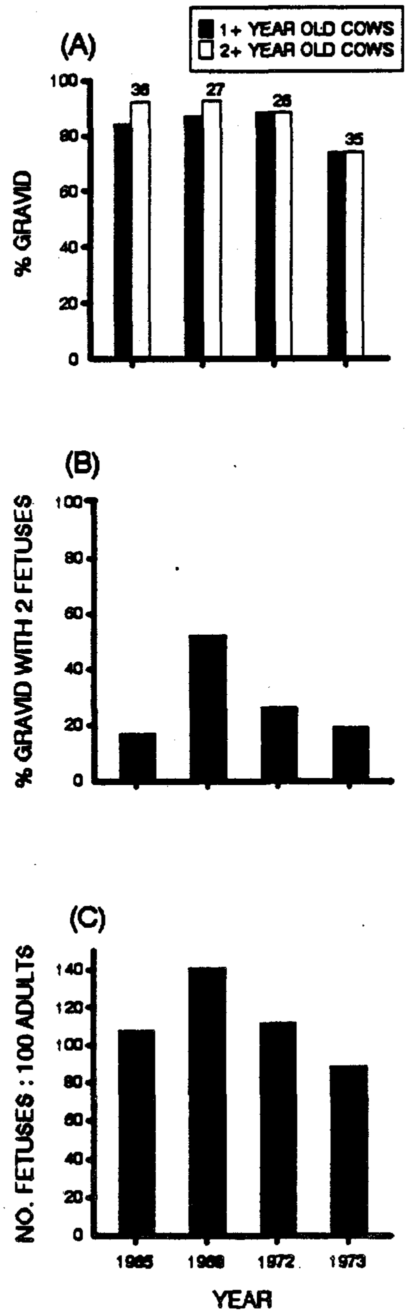

Fig. 9. Pregancy rate in 1+ and 2+ (adult) year-old females (A), percent gravid females with 2 fetuses (B) and fetus production : 100 adult females in 5 social classes of cow moose killed in antlerless-moose hunts in GMS 14C in south-central Alaska in 1964, 1969, 1973 and 1974. Year=year females became gravid. Numbers above bars=No. of adult specimens.

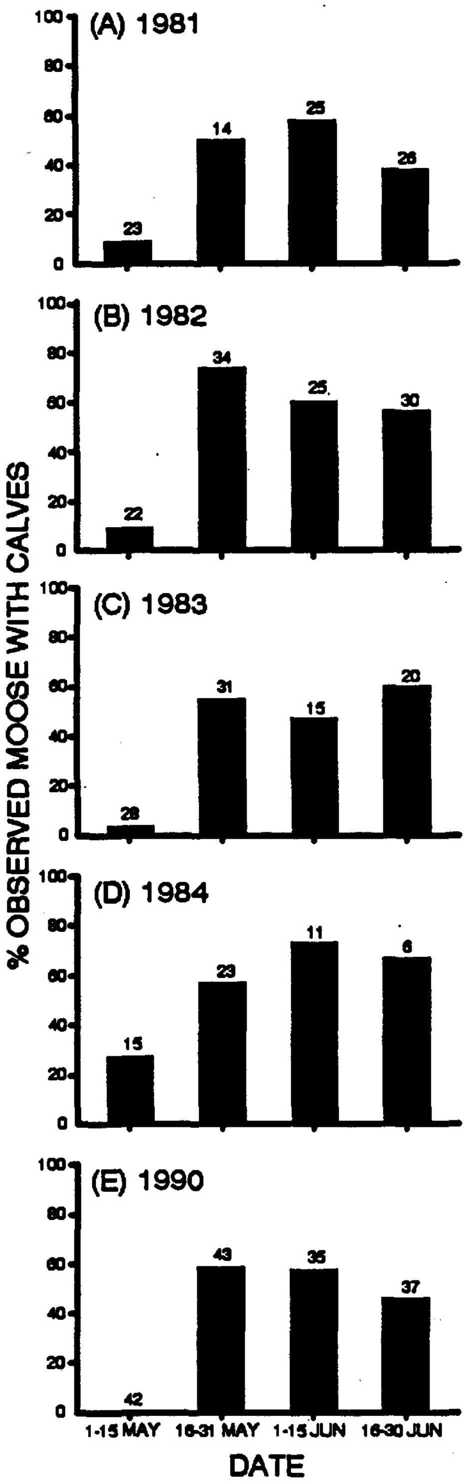

Fig. 10. Percent of observed radio-marked cow moose that were associated with calves during telemetry monitoring surveys conducted in lower Susitna Valley, Alaska in 4, 2-week periods in May-June, in 1981 (A), 1982 (B), 1983 (C), 1984 (D), and 1990 (E). Numbers above bars=No. of radio-marked cow moose observed.

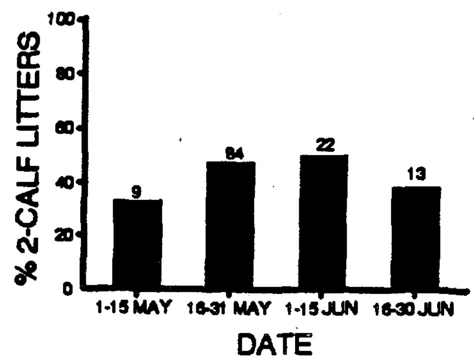

Fig. 11. Percent of radio-marked cow moose that were observed with calves were associated with 1st calves of 2-calf litters or 2 calves during telemetry monitoring surveys conducted in 4, 2-week periods in May-June in 1981, 1982, 1983, 1984 and 1990. Numbers above bars= No. moose observed with calves.

		LITTER SIZE		
YEAR	n	MAY - JUN	DEC - JAN	% n
1982	13	1	0	46.2
			1	53.8
	16	2	0	31.3
			1	43.8
			2	25.0
1983	7	1	0	0.0
			1	100.0
	15	2	0	53.3
			1	20.0
			2	26.7

Fig. 12. Percent change in number of calf moose associated with radio-marked cows telemetrically monitored during May-Jun (spring) and Dec-Jan (winter) in 1982 and 1983 in lower Susitna Valley, Alaska. N=No. of moose observed in both spring and winter surveys.

Table 1. Area, date and number of moose examined in 4 area-hunt samples in south-central Alaska.

SAMPLE	AREA	DATE	N
KENAI 1964	GMU 7	NOV 1964	52
	GMS 15B	NOV 1964	16
	GMS 15C	NOV 1964	75
KENAI 1970	GMS 15A	DEC 1970	101
	GMS 15B	FEB 1970	44
	GMS 15C	JAN 1970	95
FT. RICH	GMS 14C	NOV 1965	46
	GMS 14C	FEB 1969	38
	GMS 14C	JAN 1973	38
	GMS 14C	FEB 1974	38
MAT-SU	GMS 14A	JAN-FEB 1970	113
	GMS 14B	JAN-FEB 1970	27

Table 2. Number of specimens and mean (x) and standard deviation (SD) of moose producitivity parameters (frequency of pregancy, frequency of 2-fetus pregnancy, percent of fetus production in 2nd fetuses, fetus production : 100 females, fetus production : 100 gravid females in 4 samples in 7 social classes categories of cow moose specimens in south-central Alaska.

Social class	No. specimens	n	% gravid		% gravid with 2 fetuses		% fetus production in 2nd fetuses of twins		No. fetuses : 100 Gravid cows		No. fetuses : 100 Cows	
			$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
C	31	4	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
Y	58	4	23.1	10.81	0.0	0.00	0.0	0.00	100.0	0.00	23.1	10.81
T	223	4	90.2	4.56	14.0	6.68	12.0	5.18	114.0	6.68	102.8	7.66
P	300	4	94.4	0.72	26.4	9.15	20.5	5.35	126.4	9.15	119.4	8.46
S	65	4	85.6	12.86	17.6	12.78	13.9	9.48	117.6	12.78	102.1	24.39
Y-S	646	4	86.6	4.25	19.5	3.37	16.2	2.43	119.5	3.37	103.4	5.60
T-S	588	4	91.9	3.15	21.4	4.81	17.5	3.33	121.4	4.81	103.4	4.00

Table 3. Observations of calf moose associated with telemetry-monitored, radio-marked cows in lower Susitna Valley, Alaska, summarized in 4, 2-week periods during May-June, 1981.

Date Interval	1-15 May	16-31 May	1-15 Jun	16-30 Jun
Date Period	1	2	3	4
No. moose	27	27	26	26
No. moose pursuits	54	27	53	52
No. moose observations	27	14	25	26
No. moose observations with calves	3	7	17	8
No. different moose observed	23	14	19	21
No. different moose observed with calves	2	7	11	8
Accumulative No. different moose observed	23	25	25	26
Accumulative No. different moose observed with calves	2	7	13	17
No. moose newly observed with calves	2	6	5	4
No. moose observed with 1 calf	2	4	4	3
No. moose observed with 1st of 2 calves	0	1	0	0
No. moose observed with 2 calves	0	1	2	1
No. calves observed with different moose	2	8	8	5
Accumulative No. moose with 1 calf	2	7	10	13
Accumulative No. moose with 2 calves	0	1	3	4
Accumulative No. calves	2	9	12	21
Earliest date calf observed	8 May			
Earliest date 1st calf of 2-calf litter observed	before 21 May			
Earliest date 2-calf litter observed	21 May			

Table 4. Observations of calf moose associated with telemetry-monitored, radio-marked cows in lower Susitna Valley, Alaska, summarized in 4, 2-week periods during May-June, 1982.

Date Interval	1-15 May	16-31 May	1-15 Jun	16-30 Jun
Date Period	1	2	3	4
No. moose	35	35	35	35
No. moose pursuits	35	70	35	69
No. moose observations	22	49	25	42
No. moose observations with calves	2	29	15	21
No. different moose observed	22	34	25	30
No. different moose observed with calves	2	25	15	17
Accumulative No. different moose observed	22	35	35	35
Accumulative No. different moose observed with calves	2	25	26	30
No. moose newly observed with calves	2	24	2	4
No. moose observed with 1 calf	0	11	0	3
No. moose observed with 1st of 2 calves	1	1	0	0
No. moose observed with 2 calves	1	12	2	1
No. calves observed with different moose	3	36	4	5
Accumulative No. moose with 1 calf	1	12	11	14
Accumulative No. moose with 2 calves	1	13	15	16
Accumulative No. calves	3	38	41	46
Earliest date calf observed	12 May			
Earliest date 1st calf of 2-calf litter observed	before 12 May			
Earliest date 2-calf litter observed	12 May			

Table 5. Observations of calf moose associated with telemetry-monitored, radio-marked cows in lower Susitna Valley, Alaska, summarized in 4, 2-week periods during May-June, 1983.

Date Interval	1-15 May	16-31 May	1-15 Jun	16-30 Jun
Date Period	1	2	3	4
No. moose	33	32	32	31
No. moose pursuits	65	88	70	62
No. moose observations	42	59	22	27
No. moose observations with calves	1	24	8	17
No. different moose observed	28	31	15	20
No. different moose observed with calves	1	17	7	12
Accumulative No. different moose observed	28	32	32	32
Accumulative No. different moose observed with calves	1	17	19	23
No. moose newly observed with calves	1	16	3	4
No. moose observed with 1 calf	0	5	1	1
No. moose observed with 1st of 2 calves	0	1	0	1
No. moose observed with 2 calves	1	10	2	2
No. calves observed with different moose	2	26	5	6
Accumulative No. moose with 1 calf	0	6	6	8
Accumulative No. moose with 2 calves	1	11	13	15
Accumulative No. calves	2	28	32	38
Earliest date calf observed	11 May			
Earliest date 1st calf of 2-calf litter observed	before 11 May			
Earliest date 2-calf litter observed	11 May			

Table 6. Observations of calf moose associated with telemetry-monitored, radio-marked cows in lower Susitna Valley, Alaska, summarized in 4, 2-week periods during May-June, 1984.

Date Interval	1-15 May	16-31 May	1-15 Jun	16-30 Jun
Date Period	1	2	3	4
No. moose	33	33	33	32
No. moose pursuits	33	66	33	32
No. moose observations	15	34	11	6
No. moose observations with calves	4	17	8	4
No. different moose observed	15	23	11	6
No. different moose observed with calves	4	13	8	4
Accumulative No. different moose observed	15	26	28	28
Accumulative No. different moose observed with calves	4	16	18	23
No. moose newly observed with calves	4	12	2	0
No. moose observed with 1 calf	4	8	2	0
No. moose observed with 1st of 2 calves	0	0	0	0
No. moose observed with 2 calves	0	4	0	0
No. calves observed with different moose	4	16	2	0
Accumulative No. moose with 1 calf	4	12	14	14
Accumulative No. moose with 2 calves	0	4	4	4
Accumulative No. calves	4	20	22	22
Earliest date calf observed	14 May			
Earliest date 1st calf of 2-calf litter observed	before 21 May			
Earliest date 2-calf litter observed	21 May			

Table 7. Observations of calf moose associated with telemetry-monitored, radio-marked cows in lower Susitna Valley, Alaska, summarized in 4, 2-week periods during May-June, 1990.

Date Interval	1-15 May	16-31 May	1-15 Jun	16-30 Jun
Date Period	1	2	3	4
No. moose	46	43	43	43
No. moose pursuits	45	75	43	43
No. moose observstions	42	68	36	37
No. moose observations with calves	0	31	20	17
No. different moose observed	42	43	35	37
No. different moose observed with calves	0	25	20	17
Accumulative No. different moose observed	42	46	46	46
Accumulative No. different moose observed with calves	0	26	34	35
No. moose newly observed with calves	0	26	9	2
No. moose observed with 1 calf	0	16	4	1
No. moose observed with 1st of 2 calves	0	1	1	0
No. moose observed with 2 calves	0	9	4	1
No. calves observed with different moose	0	35	13	3
Accumulative No. moose with 1 calf	0	17	21	21
Accumulative No. moose with 2 calves	0	9	13	14
Accumulative No. calves	0	35	47	49
Earliest date calf observed	None 9 May	21 May		
Earliest date 1st calf of 2-calf litter observed	None 9 May	before 21 May		
Earliest date 2-calf litter observed	None 9 May	21 May		

Table 8. Observations of calf moose associated with radio-marked cows telemetry-monitored during 1 May-June 30 in 1981, 1982, 1983, 1984 and 1990.

	Year				
	1981	1982	1983	1984	1990
No. monitoring surveys	7	6	9	5	5
No. moose studied	27	35	33	33	46
No. moose pursuits	186	209	285	164	242
No. successful moose pursuits; i.e., No. moose observed	92	138	150	66	182
No. moose not observed or only observed dead after 15 May	3	0	1	5	2
No. moose observed during 1 May-30 June	24	35	32	27	43
No. moose observed with calves; i.e., productive moose	17	30	23	18	35
No. moose observed with 1 calf	13	14	8	14	21
No. moose observed with 2 calves	4	16	15	4	14
No. calves observed	21	46	38	22	49
Earliest date 1 calf observed	8 May	12 May	11 May	14 May	21 May
Earliest date 2-calf litter observed	21 May	12 May	11 May	21 May	21 May
% moose observed with calves; i.e., % productive moose	70.8	85.7	71.9	66.7	81.4
% moose with calves (i.e., productive moose) with 2 calves	23.5	53.3	65.2	22.2	40.0
No. calves:100 moose observed	87.5	131.4	118.8	81.5	114.0

Table 9. Percent of observed, telemetry-monitored, radio-marked cow moose in lower Susitna Valley that were associated with calves during 4, 2-week periods in May-June, 1981, 1982, 1983, 1984 and 1990.

	Date interval Date period			
Year	1-15 May 1	16-31 May 2	1-15 Jun 3	16-30 Jun 4
1981	8.7	50.0	57.9	38.1
1982	9.1	73.5	60.0	56.7
1983	3.6	54.8	46.7	60.0
1984	26.7	56.5	72.7	66.7
1990	0.0	58.1	57.1	45.9
Mean	9.6	58.6	58.9	53.5

Table 10. Number and percent of observed, telemetry-monitored, radio-marked cow moose that were in association with the 1st calf in a 2-calf litter or 2 calves during 4, 2-week periods in May-June in lower Susitna Valley, Alaska, in 1981, 1982, 1983, 1984 and 1990.

	Date interval	1-15 May		16-31 May		1-15 Jun		16-30 Jun	
	Date period	1		2		3		4	
Year	No. calves	1	2	1	2	1	2	1	2
1981		2	0	4	2	4	2	3	1
1982		0	2	11	13	0	2	3	1
1983		0	1	5	11	1	2	1	2
1984		4	0	8	4	2	0	0	0
1990		0	0	16	10	4	5	1	1
All years		6	3	44	40	11	11	8	5
% 2-calf litters		33.3		47.6		50.0		38.5	

Table 11. Data on calves associated with radio-marked cow moose telemetry monitored in lower Susitna Valley, Alaska during 4, 2-week periods in May-June in 1981, 1982, 1983, 1984 and 1990.

		Date interval Date period					
Year	No. calves	1-15 May 1	16-31 May 2	1-15 Jun 3	16-30 Jun 4	1 May- 30 Jun 1-4	% wo/calves & % litters w/2 calves
1981	0	21	7	8	13	7	28.0
	1	2	4	4	3	13	-
	1+	0	1	0	0	1	-
	2	0	1	2	1	4	22.2
1982	0	20	9	10	13	5	13.5
	1	0	11	0	3	14	-
	1+	1	1	0	0	2	-
	2	1	12	2	1	16	50.0
1983	0	27	14	8	8	9	28.1
	1	0	5	1	1	7	-
	1+	0	1	0	0	1	-
	2	1	10	2	2	15	65.2
1984	0	11	10	3	2	9	33.3
	1	4	8	2	0	14	-
	1+	0	0	0	0	0	-
	2	0	4	0	0	4	22.2
1990	0	42	18	15	20	8	17.8
	1	0	16	4	1	21	-
	1+	0	1	1	0	2	-
	2	0	9	4	1	14	37.8
All years	0	121	58	44	56	38	24.4
	1	6	44	11	8	69	-
	1+	1	4	1	0	6	-
	2	2	36	10	5	43	36.4

1+=single calves observed with cows that were observed in a subsequent period with 2 calves. Sum for No. calves=0 in date period 1-4=No. different moose observed without calves. Wo=without and w/2=with 2.

Table 12. Number of calves and % 2-calf litters associated with cow moose captured and telemetrically monitored during 1 May-30 April in lower Susitna Valley, Alaska, 1979-90. Most cow moose monitored during 1979-85 were captured in the Susitna River floodplain (i.e., migratory moose from GMS 16A populations). Most cow moose monitored in 1985-87 were captured in fall in the Talkeetna Mountains in GMS 14A and 14B. Most moose monitored in 1987-90 were fall residents in GMS in GMSs 14A, 14B and 16B. Includes data on calves observed associated with cows during capture or at any time thereafter.

	Year											
	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
No. 1 calf litters	1	15	26	16	8	23	15	35	37	39	32	23
No. 2 calf litters	0	2	4	16	18	4	8	5	8	11	10	10
No. 3 calf litters	0	0	0	0	0	0	0	0	0	0	0	2
% litters with 2+ calves	0.0	11.8	13.3	50.0	69.2	14.8	34.8	12.5	17.8	22.0	23.8	30.3

Table 13. Number of calves observed associated with radio-marked cow moose telemetrically monitored 1 to 5 consecutive years after capture in November-April in lower Susitna Valley, Alaska 1979-90.

No. years individual moose monitored	No. calves associated with cow moose														
	1st year after capture			2nd year after capture			3rd year after capture			4th year after capture			5th year after capture		
	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
2	5	3	1												
3	11	10	1	8	10	4									
4	9	11	0	6	8	6	8	9	3						
5	12	6	2	7	11	2	10	6	4	6	9	5			
6	7	9	1	4	8	5	2	11	4	6	7	4	7	7	2
7	2	1	1	1	2	1	0	4	0	1	1	2	0	3	1
8	0	3	2	0	2	3	2	3	0	0	5	0	2	2	1
9	0	5	0	0	2	3	1	2	2	1	2	2	3	2	0
10	0	3	2	0	1	4	3	1	1	2	3	0	3	1	1
11	1	3	1	1	2	2	0	1	4	1	3	1	2	2	1
n for 0, 1 and 2	47	54	11	27	46	30	26	37	18	17	30	14	17	17	6
n for 0-2			112			103			81			61			40
% 0, 1 and 2	42.0	48.2	9.8	26.2	44.7	29.1	32.1	45.7	22.2	27.9	49.2	23.0	42.5	42.5	15.0
mean % (2nd-5th year)													32.1	45.5	22.3

Table 14. Yearly observations of calves associated with radio-marked moose telemetrically monitored 1 to 10 years in lower Susitna Valley, Alaska, 1980-90.

No. years individual moose monitored after capture	No. moose	No. years moose observed w\calves: 0	1	2	3	4	5	6	7	8	9	10	No. moose observation years	No. moose years w/calves	% years w/calves	No. calves observed with moose: Min	Max	Maximum No. consecutive years: W/calves	Wo/calves
1	9	5	4										9	4	44.4	0	2	1	1
2	22	6	7	9									44	25	56.8	0	3	2	2
3	20	2	4	8	6								60	40	66.7	0	4	3	3
4	20	0	6	6	5	3							80	45	56.3	1	5	4	3
5	17	0	0	2	7	6	2						85	59	69.4	2	7	5	2
6	4	0	0	0	0	2	1	1					24	19	79.2	4	8	6	3
7	5	0	0	0	0	1	1	3					35	27	77.1	6	8	6	2
8	5	0	0	0	0	1	0	1	3				40	31	77.5	5	11	5	4
9	5	0	0	1	0	0	0	2	1	1			45	29	64.4	4	9	5	4
10	5	0	0	0	0	1	0	0	2	0	1	1	50	38	76.0	4	15	10	3
Mean for years															66.8				
Year totals	112	13	21	26	18	14	4	7	6	1	1	1	472	317					
Mean for total															67.2				

W/=with, Min= minimum, Max=maximum, and Wo/=without.

APPENDIX A.

TRAIN MOOSE-KILL IN ALASKA: CHARACTERISTICS AND RELATIONSHIP WITH SNOWPACK DEPTH AND MOOSE DISTRIBUTION IN LOWER SUSITNA VALLEY

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ABSTRACT: Trends in moose (*Alces alces*) mortality (n = 3,054) due to train collisions along 756 km of railway in Alaska from 1963-90 are presented. Annual (May-April) mortality ranged from 9 to 725 moose. Winter (November-April) mortality varied from 7 to 705 moose, with more than 73% occurring from January through March. Mortality was greatest in sections of the railway transecting winter range. During the 1989-90 winter, 50 % (352 moose) of the train moose-kills occurred in a 64 km section of railway (8.5% of the railway length) in the lower Susitna Valley. There was a positive correlation among snowpack depth and train moose-kill, and moose numbers on winter range for the years when I studied the relationship. There was an inverse relationship between snowpack depth and moose density in alpine habitat, and between alpine density and train moose-kill for the years the relationship was studied. There was a relationship between the timing of deep snow and timing of moose occurrence on winter range, and timing of train moose-kill in two winters with greatly dissimilar patterns of snow accumulation. My results emphasize the importance of understanding moose movements in assessing and resolving the train-moose problem. Findings also identify the importance of alpine postrut concentration areas as a component of moose habitat.

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