MOOSE POPULATIONS ON THE KENAI NATIONAL MOOSE RANGE

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Abstract: Moose populations on the Kenai National Moose Range have fluctuated following major wildfires since at least the mid-1800's. After a 1,255 km^2 wildfire in 1947, the moose population increased at least 13 percent per year to 1959, fluctuated around a peak of 8,000 moose between 1960 and 1971, then declined at least 10 percent per year to an estimated 4,000 moose in 1976. The primary cause of the decline appears to be the loss of quality winter range associated with plant succession and perhaps browse overutilization. During severe winters, natural mortality rates are high and among calves may reach 87 percent. The poor condition of the range is reflected in the poor physiological condition of moose. Moose may also be affected by a copper deficiency in their diet. Hunting and natural predation may also have contributed to the present decline. To stabilize the herd, harvests have been reduced and winter range is being maintained by mechanically crushing areas of advanced plant growth.

This paper reviews and summarizes information on moose numbers, population composition, productivity, mortality, physiological condition and migratory behavior on the Kenai National Moose Range (KNMR), Alaska. The impact of the changing habitat on the moose population and attempts to manage the habitat are discussed.

The KNMR was established by executive order of President Franklin Roosevelt in 1941: " . . . for the purpose of protecting the natural breeding and feeding range of the giant Kenai moose . . . " Moose are harvested

on the KNMR and hunting regulations are established by the Alaska Department of Fish and Game (ADFG). The climate, topography and vegetation characteristic of the KNMR is described by Karlstrom (1964), Spencer and Hakala (1964) and LeResche et al. (1974).

CHARACTERISTICS OF THE KENAI MOOSE POPULATION

Numbers

An apparently once popular belief that moose were not present on the Kenai Peninsula prior to about 1870 is unfounded. Archaeological evidence (Laguna 1934) and reports by early Russian settlers and words for moose in the language of early natives (Lutz 1960) suggest moose have been on the Kenai Peninsula for at least 2,000 years. However, at least one early account (Palmer 1938a) suggests that moose may have been scarce on the peninsula in the mid-1800's. At that time, caribou (Rangifer tarandus) and wolves (Canis lupus) were apparently numerous until hunting reduced their numbers and man-caused wildfires destroyed caribou habitat. Shortly after wildfires in 1871, 1891 and 1910, the moose population apparently increased, sometimes dramatically, to such an extent that they damaged their food supply. For example, Palmer (1933) reported moose were so abundant in 1913 that they overbrowsed and killed many willows (Salix spp.), a preferred browse species.

Abrupt declines characteristically followed the rapid increase of moose numbers on the Kenai Peninsula. Total moose on the Kenai Peninsula was estimated at 4,000 in 1920 (Bailey 1921), but five years later, numbers were only one-half (Culver 1923) to one-tenth (Palmer 1938a) their pre-1920 peak numbers. However, ten years after an abrupt decline in 1923, moose were again abundant and Lucas (1932) estimated 4,000 - 10,000 moose on the entire peninsula. In the spring of 1939, Palmer (1939) estimated a density of 0.6 moose/km^2 in the central benchlands. The area's carrying capacity several years earlier had been estimated at 0.5 moose/km^2 (Palmer 1938a). Apparently moose in 1939 were close to or exceeding the carrying capacity of the range.

The annual increase in numbers of moose following wildfires on the Kenai Peninsula was not documented until a 1,255 km^2 wildfire swept over the northern lowlands in 1947. Aerial strip and quadrat censuses suggest the moose population increased at least 13 percent per year up to twelve years after the fire, fluctuated around a peak of probably 7,000 - 8,000 moose for the next eleven years, then declined at least 10 percent per year to about 4,000 in 1976 (Table 1). These observations support the earlier views of Spencer and Hakala (1964) that favorable forage conditions for moose on the Kenai decline about twenty years after major wildfires.

Gradual loss of winter range capable of supporting high over-wintering moose densities appears related to the latest population decline on the KNMR. Habitat classified during reconnaissance flights as high moose density strata for census purposes has declined in significance since 1964. The average number of moose per square kilometer later observed in the strata has also declined since the 1960's (Table 2). Although habitat classified as medium and low density strata increased on the KNMR, the average density of moose remained unchanged.

Available information thus indicates that in recent times, moose populations on the Kenai Peninsula have fluctuated, sometimes dramatically, in response to habitat disturbances caused by wildfires. These fluctuations are probably normal numerical responses of the moose population to the vegetational sequence following habitat disturbances, particularly the wildfires of 1910 and 1947. It should be remembered that moose are adapted to

Table 1. Moose Populations North of Tustumena Lake on the Kenai National Moose Range. (Data from KNMR files.)

Year	Moose Counted in 1947 Burn	Estimated Population
1950	140	2500
1951	451	2700
1952	498	3100
1953	900	3500
1954	758	4100
1955	1629	4600
1956	1610	4500
1957	1669	4200
1958	2353	4700
1959	2501	5800
1960	2217	5800
1961	1603	5300
1962	1760	5300
1964	1787	5500
1964	-	6979 ± 1605
1965	-	7432 ± 1560
1966	-	7150 ± 1262
1967	-	6732 ± 1413
1971	-	7904 ± 1461
1973	-	5692 ± 1348
1974	-	4850 ± 1045
1975	-	3374 ± 986

Aerial strip counts, 1950-1964.
Aerial quadrat counts, 1964-1976.

Table 2. Areas of and Average Densities of Moose Counted on Winter Range during Aerial Quadrat Counts on the Kenai National Moose Range. (Data from KNMR files.)

	Census Strata					
	High Density		Medium Density		Low Density	
Year	Area (km^2)	Moose/km^2	Area (km^2)	Moose/km^2	Area (km^2)	Moose/km^2
1964	730	3.1	3825	1.1	285	0.5
1965	585	4.9	4046	1.1	396	0.1
1966	622	5.4	3507	1.0	914	0.1
1967	583	6.1	3551	0.9	917	0.2
1971	508	6.6	3191	1.4	1349	0.1
1973	453	5.2	3206	0.7	1378	0.7
1974	295	5.1	2699	1.0	1987	0.3
1975	127	2.2	2209	1.1	2637	0.3
1976	106	3.0	2072	1.4	2789	0.2

successional habitats and that high moose densities cannot be expected on the KNMR unless habitat disturbances regularly occur over vast areas. Because of their potential reproductive capacity and dispersal patterns, moose characteristically increase in numbers when forage is abundant. However, because of the relatively long life-span of moose, populations are probably unable to rapidly adjust their reproductive rate as range conditions deteriorate. In the absence of hunting or natural predation, moose populations in successional habitats apparently decline as forage grows out of reach of moose and the species composition of the plant community changes from browsing pressure or vegetational succession. Available forage may be abundant, but poor in nutritional quality. Poor

range conditions would be expected to influence the condition of the moose which could predispose moose to predation or high rates of mortality during times of stress. Intensive hunting or predation during a natural decline would tend to hasten the process.

Sex and Age Composition

Because of a long history of hunting for bulls only, the sex composition of the KNMR moose population has changed from one of nearly equal sex ratio to a skewed sex ratio favoring females. In early times, about 90 percent of the moose killed by natives were cows (Walker 1924) and about 75 percent of the moose killed for market purposes were also cows (Palmer 1938a). Males may therefore have been more numerous in local accessable areas. However, despite this hunting of cows, the sex ratio of moose in the 1930's was apparently nearly equal, at least in the benchland area (Lucas 1932, Palmer 1938a).

Early hunting regulations indicated that on the Kenai Peninsula only bulls could be legally harvested from at least 1927 to about 1959, cows could be harvested from 1960 to 1973, and bulls only from 1974 to the present. By the late 1950's, aerial composition surveys indicated the adult sex ratio was already 44 bulls per 100 cows (Table 3). From 1958 to 1977, the sex ratio varied from 11 to 49 and averaged 25.4 bulls per 100 cows. Sex ratios varied within the KNMR and were undoubtedly related to the degree of hunting pressure and accessibility. The average sex ratio recorded in the hunter-accessable northwestern KNMR was 18.6 bulls per 100 cows from 1962 to 1977. In the more remote benchlands, an average of 37.4 bulls per 100 cows have been recorded over the past fifteen years (data from ADFG files).

Table 3. Bull:Cow Ratios Observed during Fall-Winter Aerial Counts on the Kenai National Moose Range North of Tustumena Lake. (Data from ADFG and KNMR files.)

Year	Bulls:100 Cows	Total Counted
1958	44	2597
1959	11	2747
1961	49	2206
1962	30	3113
1964	25	3394
1965[1]	44	987
1966[1]	51	683
1967	17	1287
1968	17	1848
1969	27	1354
1970	14	1236
1971	21	1607
1972	22	2174
1973	18	2071
1974	15	1385
1976	28	1027
1977	26	848
Average	25.4	

[1]North of Skilak Lake Only.

The age composition of the KNMR moose population has not been intensively studied. Limited age data based on tooth cementum layers from hunter-killed cows from 1970 to 1972 suggested that in at least the northern region of KNMR, survival of cows may be related to severity of winter the year previous to and following birth (Table 4). Ages of live-trapped and helicopter-captured moose from this intensively hunted

Table 4. Severity of Winters and Ages of Hunter-Killed Cow Moose on the Kenai National Moose Range North of Skilak Lake.

Year of Birth	Winter Severity Index Previous to Birth[1]	Number Aged[2] 1970	1971	1972
1972	3	-	-	20
1971	2	-	78	15
1970	1	-	66	17
1969	1	10	48	15
1968	2	14	35	9
1967	1	11	34	13
1966	2	7	24	3
1965	2	9	24	5
1964	1	13	21	8
1963	1	13	20	7
1962	2	11	23	6
1961	2	6	14	4
1960	1	9	13	3
1959	1	10	17	1
1958	1	9	11	1
1957	3	8	11	0
1956	3	6	4	0
1955	2	2	2	0
1954	1	2	1	0
1953	1	0	0	0
1952	2	2	0	0

[1]Snow persisting over ten days in depths approximately less than 50cm (1=mild), 50-60cm (2=average) or exceeding 60cm (3=severe). (Weather data from KNMR files and Kenai FAA.)

[2]Age data from ADFG files.

area indicated males averaged 4.3 years of age compared to 7.6 years for females, but in the more remote benchlands, males were older, averaging 5.7 years compared to 7.0 years for females (Bailey et al. 1978). The age distribution of males and females from the northern and southern regions of the KNMR were significantly different. Only a small proportion (6-7 percent) of live-captured males were over ten years old. In contrast, 28 to 34 percent of the live-captured females were over ten years old.

Sex and age information indicated that the sex ratio of the KNMR moose population has been significantly altered by a long history of hunting for bulls only, and that during certain years, in intensively hunted areas, few older bulls may be available for breeding. The impact of this skewed sex ratio favoring females on the KNMR moose population is unknown. The age structure of the KNMR moose population may reflect the frequency of severe winters as well as the hunting pressure on males. Poor winter survival may be influencing productivity of the population if cows in their prime productive years are poorly represented in the population. In the northern KNMR, few males apparently survive over five years from hunting pressure, yet a substantial proportion of the cows are over ten years old. The social consequences of this atypical social structure during the rut remains unknown.

Productivity

Aerial observations at the Moose River Flats, a major calving area on the KNMR, indicated that the proportion of cows observed with twin calves in the spring declined from 11 percent in 1959 to 2 percent in 1970, the last census year (KNMR files). In the northern KNMR, proportion of calves in the fall-winter population has ranged from 30 percent in 1969 to 19 percent in 1977. In the central benchlands, calves

comprised 20 percent of the fall population in 1962, but only 5 percent in 1977 (ADFG files). Pregnancy rates of moose examined between January and April, inside and outside the Moose Research Center enclosures in the northern lowlands, indicated 50-62 percent and 64-76 percent, respectively, of the examined cows were pregnant in 1973 and 1974 (Franzmann and Arneson 1973 and 1974, P-R Progress Report, Project W-17-5 and W-17-6, Alaska Department of Fish and Game, Juneau).

The declining proportion of twin and single calves in the KNMR moose population suggests that productivity and calf survival have been declining since the late 1960's and early 1970's. Some relatively low pregnancy rates suggest that perhaps a substantial proportion of cows may not be producing young. The steadily declining occurrence of twin calves indicates that forage conditions are deteriorating. The declining proportion of calves in the fall population could mean that fewer cows are producing calves or calves are experiencing high early mortality rates.

Mortality

The extent of natural mortality among moose on the KNMR is not well known. Percent calf winter mortality in the northern KNMR has often exceeded 40 percent since 1970 and has reached 87 percent during severe winters (ADFG files). The extent of adult mortality during winters is unknown. The cause of this overwinter mortality includes starvation due to deteriorating winter range (Oldemeyer et al. 1977), predation and highway deaths. Even less is known about early calf mortality, but on the Moose River Flats calving areas, black bear predation may at times be significant (Franzmann and Peterson 1978). The influence of wolf predation on calf and adult survival is currently being assessed. Wolves in four packs have been radiocollared and pack territory boundaries, pack sizes, movements and kill frequencies are being determined (Peterson and Woolington 1978).

The impact of hunting on the KNMR moose populations is difficult to assess because of various antlerless and bulls-only seasons, accuracy and timing of censuses and the lack of specific information regarding the location of hunter-killed moose. If one accepts the quadrat census population level, uses the fall-early winter calf composition (an unknown amount of mortality has occured by census time) and subtracts losses from over-winter calf mortality, then harvests in 1971, 1973 and 1974 removed the equivalent of 67 to 168 percent of the estimated yearling recruitment into the population (Table 5). Natural adult mortality is excluded. Efforts to reduce the impact of hunting on the declining moose population have included the termination of antlerless seasons, shortening of bulls-only seasons and establishment of permit hunts. As a result, fewer moose (bulls-only) have been taken over the past five years.

Early records suggest that overwinter mortality, especially among calves, may have always been high in the KNMR moose population during severe winters. The moose population is also now subject to wolf predation, a mortality factor which was absent or insignificant during the 1950's and early 1960's. Wolves were absent by 1906 (Palmer 1938b), but now there are an estimated 100 wolves on the Kenai Peninsula (ADFG files). Their impact on the moose population coincides with a period when moose would probably be declining because of successional patterns alone. At times, especially after severe winters, hunting may also have had a significant impact on annual population growth.

Table 5. Equivalent Proportion of Yearling Recruitment Harvested by Hunters on Kenai National Moose Range North of Tustumena Lake 1971, 1973 and 1974.

Year	Population			Recruitment		Harvest	
	Early Winter Population[1]	Calf Composition of Herd[2]	Number of Calves in Herd	Percent Calves Surviving Winter[3]	Number of Surviving Yearlings (A)	Number of Moose Harvested[4] (B)	Equivalent Proportion of Recruitment Harvested (%) (B/A)
1971	7904 ± 1461	20.6	1628 ± 301	49.8	811 ± 150	1109	115-168
1973	5692 ± 1348	21.8	1241 ± 294	32.3	401 ± 95	537	108-175
1974	4850 ± 1045	24.8	1230 ± 259	25.6	308 ± 66	249	67-103

[1]Aerial quadrat census estimate (±90% C.L.). February-March (KNMR files).
[2]Average of calf composition in Game Management Units 15A and 15B, November-December (ADFG files).
[3]Based on overwinter mortality (ADFG files).
[4]Total harvest for Game Management Units 15A and 15B (ADFG files).

Range and Moose Condition

Moose population fluctuations on the Kenai Peninsula appear directly related to range condition. After the 1947 burn, birch (Betula papyrifera), aspen (Populus tremuloides) and willow regrowth supplied abundant forage, but after moose apparently altered the relative abundance of preferred species such as willow and aspen, available winter browse is now predominantly paper birch, a relatively poor quality winter forage (Spencer and Hakala 1964, Oldemeyer et al. 1977). Earlier high overwintering moose populations may also have been supported by use of low-lying non-browse species (LeResche and Davis 1973, Oldemeyer and Seemel 1976) during mild winters. However, during more severe winters, when low-lying plants were covered by deep snows, starvation occurred. Oldemeyer et al. (1977) concluded that a variety of winter browse species was probably more important to overwintering moose than any single browse species. Thus, selective browsing by overwintering moose during peak population levels may have resulted in a plant community now dominated by birch. Birch alone appears unable to support previous overwintering moose densities.

The deteriorating condition of the range is also reflected in the poor condition of Kenai moose as measured by various blood and hair mineral parameters and body measurements (Franzmann 1977). Compared to four other moose populations in Alaska, moose from the Kenai Peninsula ranked the lowest for packed cell volume and three of seven other blood parameters. Hair samples also indicated Kenai moose appear to be suffering from a copper deficiency which may influence fertility (Flynn et al. 1977). Differences in growth rates based on morpho-metric measurements among four adult female moose populations in Alaska (Franzmann et al. 1978) and antler measurements (Gasaway 1975) also suggest that Kenai Peninsula moose are generally in

poorer condition than other moose populations studied in Alaska.

Lowland Resident and Migratory Moose

Moose on the KNMR can be subdivided into at least two major population segments of lowland residents and migratory individuals (LeResche 1972, Bailey et al. 1978). Lowland residents are characterized by their relatively sedentary habits, high population densities, small home range, solitary behavior and a low proportion of bulls in the population. Migratory moose move considerable distances between seasonal ranges, have lower population densities and large summer home ranges, aggregate during the rut and have a low proportion of bulls in the population. Migratory moose often exhibit strong traditional behavior by regularly returning to the same rutting areas which are often located in distinct mountainous drainages. In September and October (rutting period) collared migratory moose aggregated into groups containing 1 to 4 males and 1 to 20 females, but collared lowland residents were usually observed only in pairs. Collared lowland resident females were also observed alone more often during the rut than were collared benchland migratory females (ADFG files).

Some data suggests that migratory moose may be in better condition than lowland resident moose. Hair from benchland (migratory) moose contained higher amounts of six minerals, nearly equal amounts of three minerals and a less amount of only one mineral compared to hair from enclosed lowland resident moose in October 1972 (Franzmann et al. 1976). This suggests that migratory moose may be feeding on better quality range during the summers than lowland resident moose. Rumen contents analysis from moose shot in seral birch and climax willow-dwarf birch range indicated that upland (migratory) moose fed on more willow than lowland moose and that lowland moose were probably selecting willow over birch in order to obtain more variety in their diets (LeResche and Davis 1971, P-R Progress Report, Project W-17-4, Alaska Department of Fish and Game, Juneau). LeResche and Davis reported higher rumen protozoa levels in moose from climax willow ranges and suggested that willow ranges might be of higher quality than lowland birch ranges.

Management

Harvest control and habitat manipulation are used to manage moose on the KNMR. Although most hunting pressure has been on males since the earliest days of the refuge, antlerless seasons were periodically held on a permit basis and/or during a special hunt until 1972. As numbers declined, late seasons were abolished to prevent local over-harvest of moose during migration and length of the seasons was shortened. For example, bulls were harvested by limited permits in 1977 in the eastern benchlands between Skilak and Tustumena Lakes, after the season was closed for two years. Harvest control efforts have thus been directed at reducing total kill, providing quality hunting and improving the bull:cow ratio.

Habitat manipulation for moose includes logging, prescribed burning and mechanical crushing. Logging, as a management tool, has been difficult to implement because of poor local market conditions, poor quality timber and limited accessibility. Prescribed burning has been unsuccessful because of the limited period control burns can be used, difficulties in obtaining desired burn conditions during this period and problems associated with fire control. An experimental burn is still being attempted in one area and the technique appears to have considerable potential.

Mechanical tree crushing by three 40-ton LeTourneau tree crushers has been the most effective habitat management tool to date. Approximately

6,800 acres have been crushed in three different areas since the winter of 1974-75. Vegetational analysis in the Willow Lake area two years after crushing indicated that the density of spruce was considerably reduced, aspen density generally increased and willow density increased, but not significantly (Oldemeyer 1977). During crushing, winter moose densities in the crushed area reached at least 8.3 moose/km^2 (21.6 moose/mi^2) as moose fed on the twigs and buds of fallen mature birch and aspen. Two years after crushing, winter moose densities in the crushed area dropped from an average of 7.1 moose/km^2 in late November to 1.2 moose/km^2 in late March. Monthly winter counts in two other crushed areas were similar, indicating decreased use of crushed areas as winter progressed (Table 6).

Table 6. Winter Densities of Moose Observed in Mechanically-Crushed Areas on the Kenai National Moose Range, 1977-78.

		Average number moose/km^2				
Area	Year Crushed	Nov	Dec	Jan	Feb[1]	Mar
Willow Lake	1974-75	7.1	4.3	1.5	2.3	1.2
South of Moose Research Center	1975-76	4.6	1.5	1.3	0.9	0
Mystery Creek (west)	1976-77	1.0	1.9	1.0	0.7	0
Uncrushed (control)	-	1.0	2.2	2.6	1.2	1.5

[1]Counted in early March, other counts near end of month.

Counts in a nearby control area suggested that movements of moose were limited later in the winter and that moose use of areas with more cover increased. Contributing factors reducing moose use of crushed areas may include increasing snow depths reducing availability of low-lying browse and non-browse species, progressive hardness of crust on snow reducing movements and lack of cover needed for energy conservation. Response of vegetation and moose after crushing are being documented.

SUMMARY

Since it is unlikely with today's fire control techniques that major wildfires may again create vast areas of seral range for moose on the KNMR, management will probably involve stabilizing lower numbers of moose than have been present in the recent past. Stabilization of numbers will have to take into account natural winter mortality as well as predation, hunting and road kills. A vigorous range rehabilitation program may be complicated by increased energy costs, establishment of wilderness areas, potential public opposition to vegetation manipulation programs and an increasing demand to consider other species influenced by habitat management. Predator management may be complicated by an increased public concern for certain predators and a desire to maintain a diversity of species on refuge lands. A rapidly increasing human population in southcentral Alaska and demands by hunters may result in pressure on wildlife management agencies to provide more moose for harvest. All these factors suggest that there will continue to be controversy, as in the past, over the future of the Kenai moose.

ACKNOWLEDGEMENTS

I wish to acknowledge all those who reviewed, commented and provided information for this manuscript: V. Berns, A. Franzmann, J. Frates, W. Gasaway, T. Johnson, P. LeRoux, J. Oldemeyer, R. Peterson, W. Regelin, R. Richey and K. Schneider.

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