# INFLUENCE OF PREDATORS ON SUMMER MOVEMENTS OF MOOSE IN SOUTHCENTRAL ALASKA

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Abstract: During late spring and early summer from 1977 through 1979, 168 moose (*Alces alces gigas*) calves were radio-collared for mortality studies in the Nelchina and upper Susitna River basins. These studies provided an opportunity to monitor cow-calf movements during summer and to evaluate some factors influencing these movements. Moose movements during summer in areas of different brown bear (*Ursus arctos*) densities were compared. Moose calf movements were correlated with age and brown bear densities. Cow-calf home ranges and linear movements during the 6 weeks following parturition were greater in areas of high bear densities and decreased following removal of bears from one area. Larger cow-calf home ranges resulted, at least partially, from attempts by moose to avoid predators. Observations of brown bear-moose interactions are reported. We believe that once calves attain an age of 6-8 weeks, their ability to evade bears is considerably greater than before.

Movements of moose have long been a subject of interest and study by North American naturalists and scientists (LeResche 1975). Relationships between moose movements and snow, rainfall, food quantity and food quality have been recognized for a number of years (op. cit.); undoubtedly other types of relationships exist.

Summer movements of cow and calf moose are one aspect of moose movements which has not been thoroughly studied. From 1977 through 1979 a total of 168 newborn moose calves were radio-collared in the Nelchina and upper Susitna River basins of southcentral Alaska in an effort to determine causes of mortality. Background for this study was provided by Ballard and Taylor 1978ab, Ballard and Spraker 1979, Ballard et al. 1980a, and Ballard et al., in review. These studies provided an opportunity to intensively study cow-calf movements during late spring and summer.

Calf mortality studies in 1977 and 1978 indicated that approximately 80 percent of the natural mortality resulted from predation by brown bears (Ballard et al. In Press). These findings were further substantiated in 1978 by the results of our observations of 23 adult, radio-collared brown bears (Spraker and Ballard 1979) which preyed upon ungulate species an average of once every 6.1 days (Ballard et al. In Press). In 1979 we initiated studies to determine whether compensatory mortality factors would replace bear predation if bear densities were substantially reduced (Ballard et al. 1980b). Consequently, in late spring and early summer 1979 we reduced bear densities within one of the areas where we had studied causes of calf mortality in 1977 and 1978. This reduction program also allowed us to compare cow-calf movements in areas of low and high bear densities. This paper presents information on summer cow-calf moose movements in relation to brown bear densities.

# STUDY AREA

Causes of moose calf mortality were studied in 3 areas of Game Management Unit (GMU) - 13, located in the upper Susitna and Nelchina River Basins of Southcentral Alaska (Fig. 1). The areas included: Area 1 the Susitna River Study Area, Area 2 the Mendeltna Creek Study Area, and Area 3 the Hogan Hill Study Area. This report concerns only Areas 1 and 2 where movements were intensively studied. Topography, vegetation, elevation, weather and range conditions in these areas have been thoroughly described (Skoog 1968, Rausch 1969, Bishop and Rausch 1975, Ballard and Taylor 1978ab, Ballard and Spraker 1979, and Ballard In Press).

Initially, Area 1 was selected for study because of its low wolf (*Canis lupus*) densities (averaging approximately 1/567 $km^2$) resulting from experimental wolf reductions by the Alaska Department of Fish and Game (Ballard et al. In Press). In Areas 2 and 3 wolf populations averaged 1 wolf/277 $km^2$ (op. cit.). All areas supported populations of alternate prey species and brown and black bears (*Ursus americanus*), the latter in low densities.

Brown bear densities in 1979 were reduced by capturing and transplanting all bears which could be found within a 3397 $km^2$ portion of Area 1 (Fig. 1). Causes of moose calf mortality in 1979 were studied in that portion of Area 1 from which bears had been transplanted. Causes of calf mortality had been studied in this area in 1977 and 1978. Calf mortality studies were not conducted in Areas 2 and 3 during 1979 but were in 1977 and 1978.

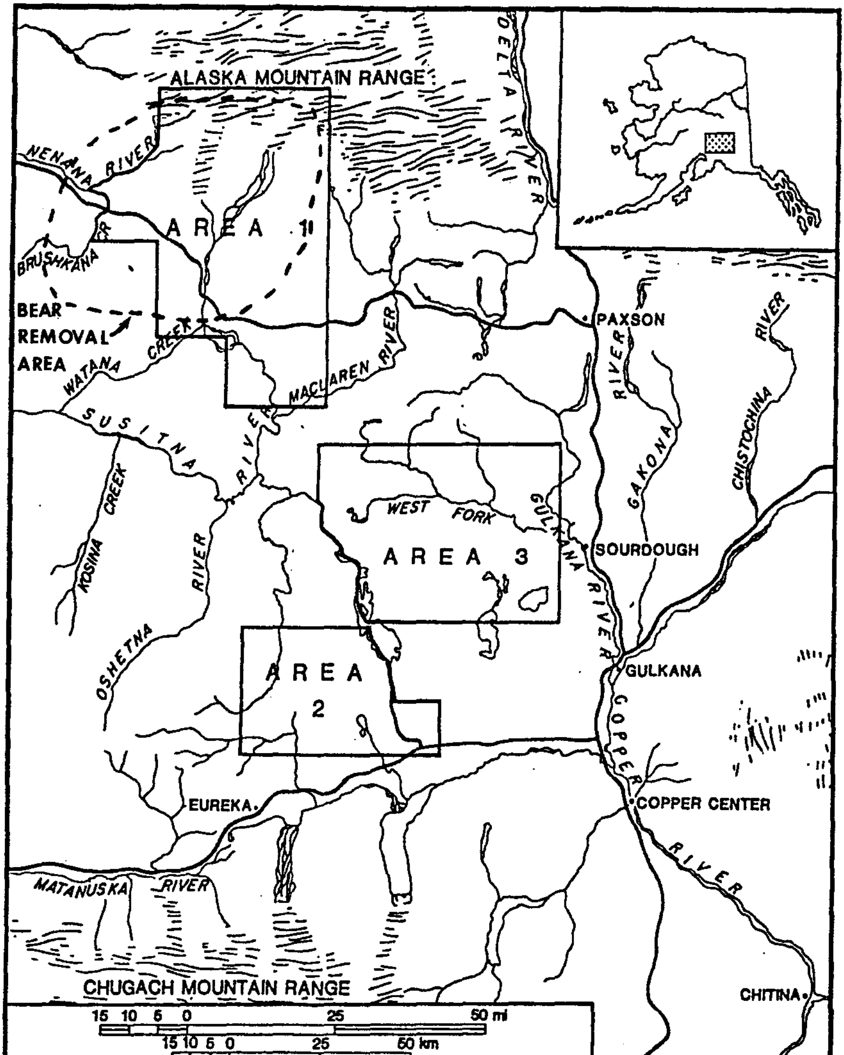


Fig. 1. Locations of study areas where causes of moose calf mortality were studied from 1977-1979 and where brown bear densities were manipulated in 1979 in the Nelchina and upper Susitna River Basins of Southcentral Alaska.

## MATERIALS AND METHODS

Procedures and equipment utilized in the moose calf mortality study were described by Ballard et al. (1980a). Briefly, newborn moose calves were captured on foot with the aid of helicopter. Calves were fitted with expandable collars similar to those designed for elk (*Cervis canadensis*) calves by Schlegel (1976). Each radio collar was equipped with a mortality sensor which doubled or tripled the radio pulse rate when the collar remained motionless for either a 4- (1977) or 1-hour (1978 and 1979) time period.

Radio-collared calves were observed from fixed-wing aircraft twice daily for 2 weeks following capture and then once daily until they were approximately 7 weeks of age. Thereafter they were monitored less frequently, averaging once per week to 1 August and then every 6-8 weeks until collars fell off or radio contact was lost. Locations of calves were recorded on standard USGS topographic maps (scale 1:63,360). Habitat type at each moose sighting was classified into 1 of 8 aerial classifications and moose activity was classified as either bedded, standing, feeding, or traveling (Ballard et al. 1980c). Causes of mortality were determined by procedures described by Ballard et al. (1980a).

During late May and early June 1979, 48 brown bears were transplanted from a 3397 $km^2$ portion of Area 1. Bears were captured by darting from helicopter and then transported by pickup truck and/or aircraft (Cessna 206) to release sites 159-254 km distant. Details of the capture and fate of transplanted bears will be presented elsewhere (Miller and Ballard in prep.).

For the purposes of this report, we utilized the home range definition provided by LeResche (1975): "the area in which the individual accomplishes its normal activities during a given period of time." According to this definition "local movements occur within a home range, home range may shift seasonally, and individuals may occupy more than one home range in a year." In this study home ranges were computed by connecting outer location sightings of each radio-collared calf and then tracing this area with a compensating polar planimeter. Weekly linear movements were defined as the sum of the distance moved between daily observations for a given week. Means for each week were calculated using all calves. All references to a calf or calves from this point also include the cow unless otherwise stated.

## RESULTS

While conducting the 1977 calf mortality studies we noticed a number of cow-calf movements which occurred for no other apparent reason than the presence of a bear in the area. At that time we suspected that either the cow-calf pair was being pursued by bears or that they were attempting to avoid bears. For example, calf 036 was observed at essentially the same location from 26 May to 7 June 1977. On 8, June, however, the pair was 4.8 km from this site. On 7 June a female brown bear with a yearling cub had been observed about 2 km from calf 036. On the basis of this and similar observations, we began analyzing movements data to determine if relationships existed between the presence of bears and moose movements.

During their first 6 weeks of life in 1977, Area 1 calves occupied an average area encompassing 37.8 $km^2$ (n=7) while Area 2 calves occupied an average area of 15.9 $km^2$ (n=8). Both areas were larger than those LeResche (1975) reported used by cow-calves during similar time periods. We were unable to explain the differences in moose movements between Area 1 and Area 2, but they appeared to be at least partially related to habitat differences. Brown bear densities in Areas 1 and 2 appeared similar, but there were substantial differences in wolf densities between these areas.

This same difference in calf home range sizes appeared to exist in 1978; however, our emphasis in 1978 was on monitoring radio signals rather than on visual observations. As a result home range size data for 1978 were not directly comparable with those from 1977. Data on home range and movements of calves, after bears had been transplanted in 1979 were, however, comparable with 1977 data.

Thirty-two moose calves were captured and collared within Area 1 during 1979, 12 of these were killed by brown bears. Following bear reduction in portion of Area 1, two adult brown bears were individually identified on the basis of color, pelage, and size within the bear removal area. These two bears, both in the vicinity of Monahan Lake, were responsible for killing at least 50% (6) of the moose calves.

Observations of cow-calf movements in relation to these two bears provided an excellent opportunity to appraise the relationship between moose movements and bear activities. For example:

1. Monahan Lake calves were observed and their locations plotted on the morning of 8 June. By 5 p.m. one member of a set of twins had been killed by a brown bear and the other twin and 3 other cow-calf pairs had moved from 1.6 to 4.4 km away from the bears kill site (Fig. 2). Previously each calf had moved less than 0.8 km.
2. Between 6:14 p.m. 14 June and 6:16 a.m. 16 June, one member of a set of twins was killed by a brown bear. Five adjacent cow-calf pairs and the remaining twin moved away from the kill site. Prior to the bear observation they had remained within a 0.8 $km^2$ area.

Distances moved by the pairs ranged from 2.0 km to 6.6 km (Fig. 3). These examples strongly suggest that some cow-calf pairs moved to avoid bears.

In 1979, average linear movements per week during the first 6 weeks of life were significantly greater ($P<0.05$) for the Monahan Lake calves than for those calves in the remainder of Area 1 (Fig. 4). Since all calves were observed at the same frequency and no bears were observed except at Monahan Lake, we believe this difference reflects differential disturbance by bears. Supporting this premise was the greater prevalence of bear predation upon calves at Monahan Lake (80%) than in the remainder of Area 1 (20%) during the first 6 weeks of study in 1979.

As expected, home ranges of Monahan Lake calves in 1979 were also significantly larger ($P<0.05$) than those of the Area 1 calves believed to be in areas with fewer bears. Home ranges of Monahan Lake calves averaged 47.1 $km^2$ (n=5, S.D. = 9.0) while in the remainder of Area 1, calves had an average home range of 20.67 $km^2$ (n=9, S.D. = 15.6).

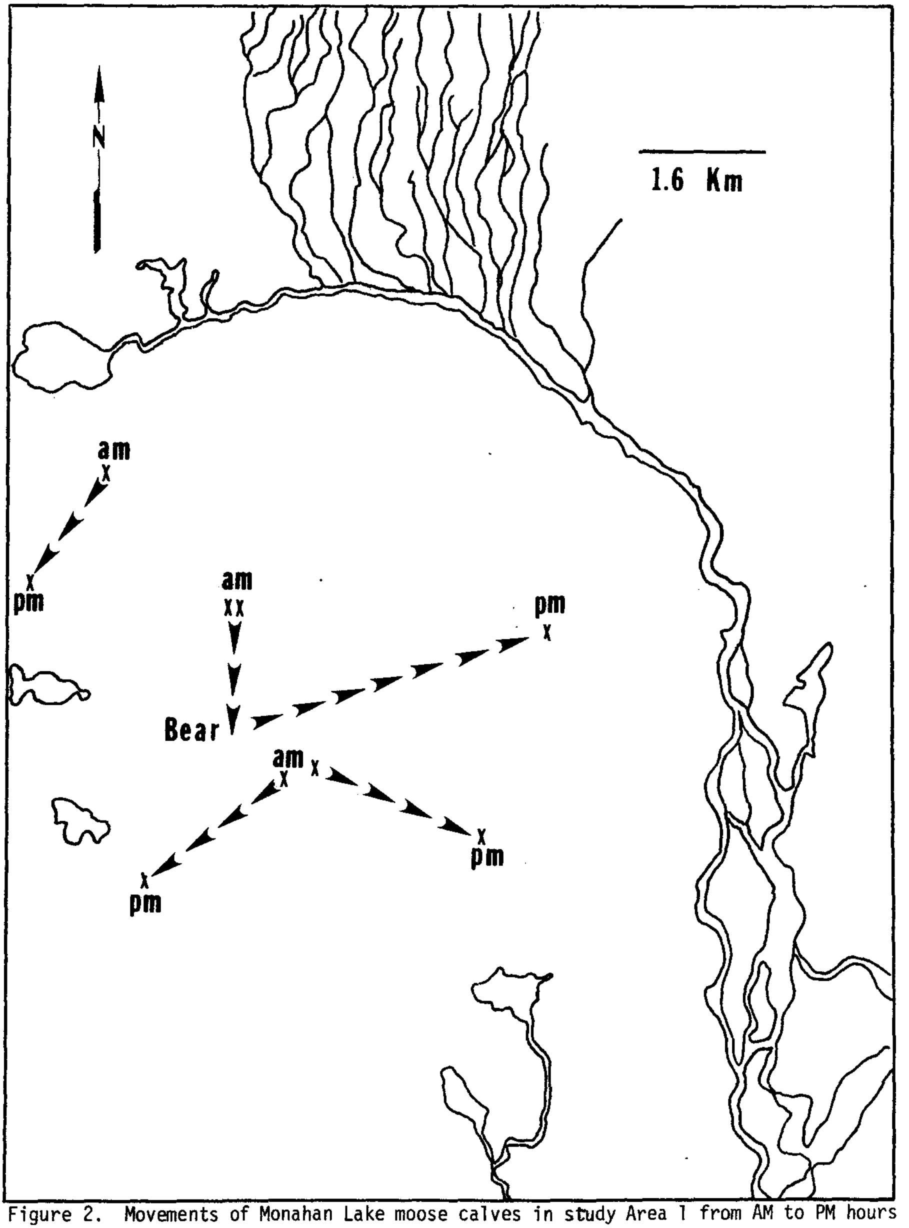


Figure 2. Movements of Monahan Lake moose calves in study Area 1 from AM to PM hours on 8 June 1979 in relation to brown bear observation during AM hours.

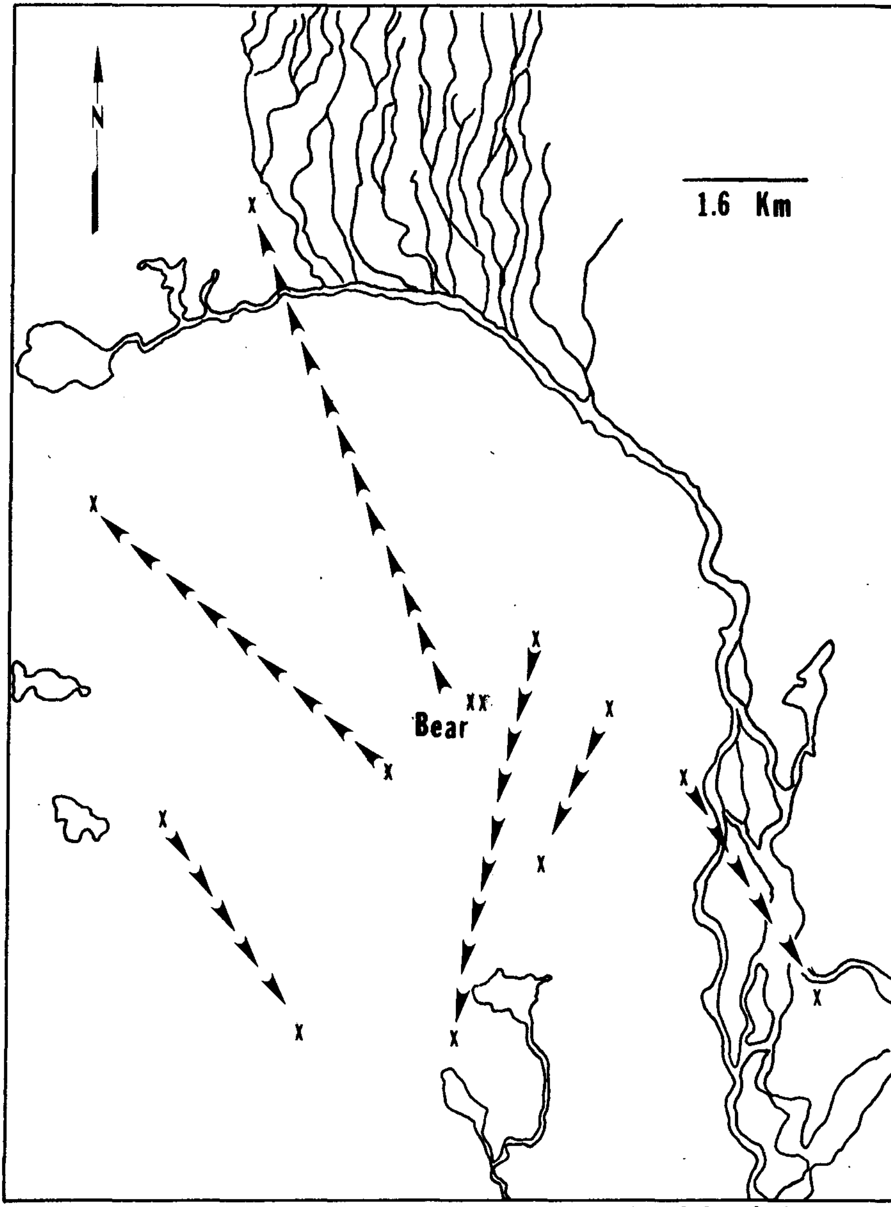


Figure 3. Movements of Monahan Lake moose calves in study Area 1 from AM hours on 14 June to AM hours on 16 June 1979 in relation to brown bear observation on 14 June 1979.

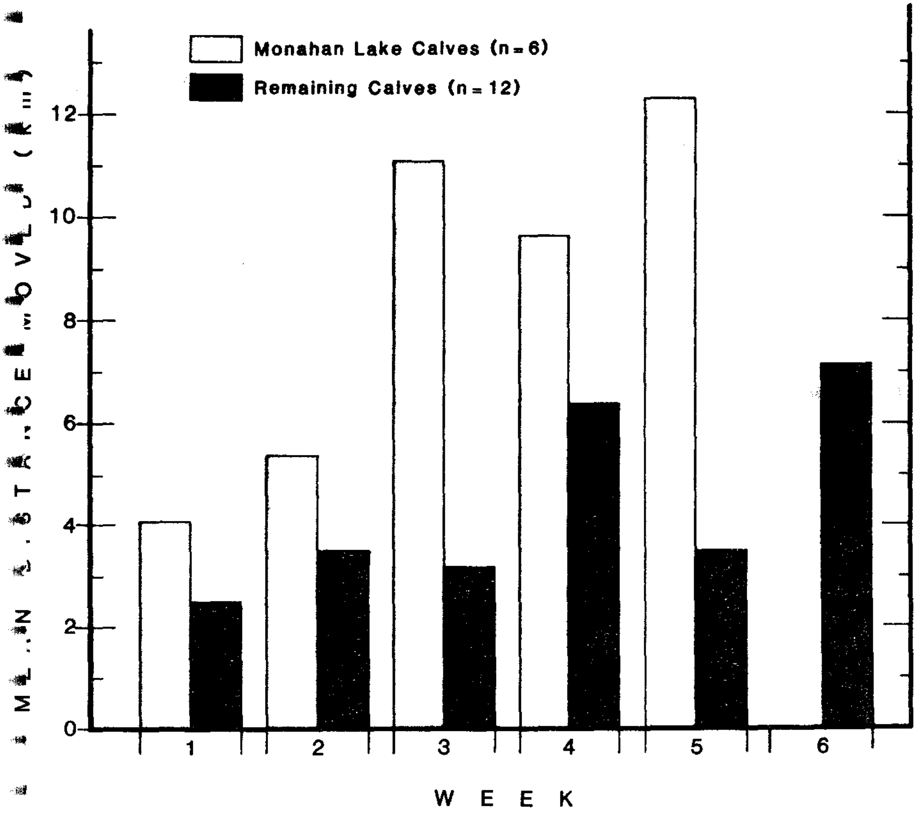


Fig. 4. Comparison of weekly linear movements of Monahan Lake radio-collared moose calves in relation to movements of other Area 1 calves for the first 6 weeks following parturition in 1979.

Mean linear movements per week and home range sizes for all Area 1 calves were compared between 1977 and 1979. Overall, calves in 1979 had greater weekly movements during weeks 2, 3 and 4 than did 1977 calves (Fig. 5). However, when 1979 data from Monahan Lake calves, were excluded from this analysis, the 1977 calves moved greater distances overall (Fig. 6).

These differences, as expected, also were reflected in 1977 and 1979 home range sizes. Home ranges of calves in 1977 averaged 37.8 $km^2$ in comparison to 1979 calves (Monahan Lake calves included) which averaged 29.5 $km^2$. When the Monahan Lake calves were excluded, home range sizes in 1979 averaged 20.7 $km^2$, a significant difference ($P<0.05$) from the 1977 home range sizes. Cow-calf pairs in 1977, prior to bear removal, used almost twice as large a home range as calves within the area of bear removal.

As expected, as moose calves became older and more mobile their average linear movements per week increased (Fig. 7). A similar relationship ($r = 0.98$, $P<0.05$) existed for 1979 Area 1 calves.

There was a significant relationship ($P<0.05$) between mean linear movements per week and percent weekly mortality due to predation for 1977 Area 1 and Area 2 calves (Fig. 8). As moose calves became older and more mobile their apparent ability to evade predators increased. This relationship was not evident ($r = 0.22$, $P>0.01$) for 1979 Area 1 calves after bears had been transplanted away from the area. In spite of increasing mobility associated with age these cow-calf pairs were relatively sedentary; we believe this reflected reduced disturbance by bears. However, return of adult bears probably influenced the relationship between age and mortality.

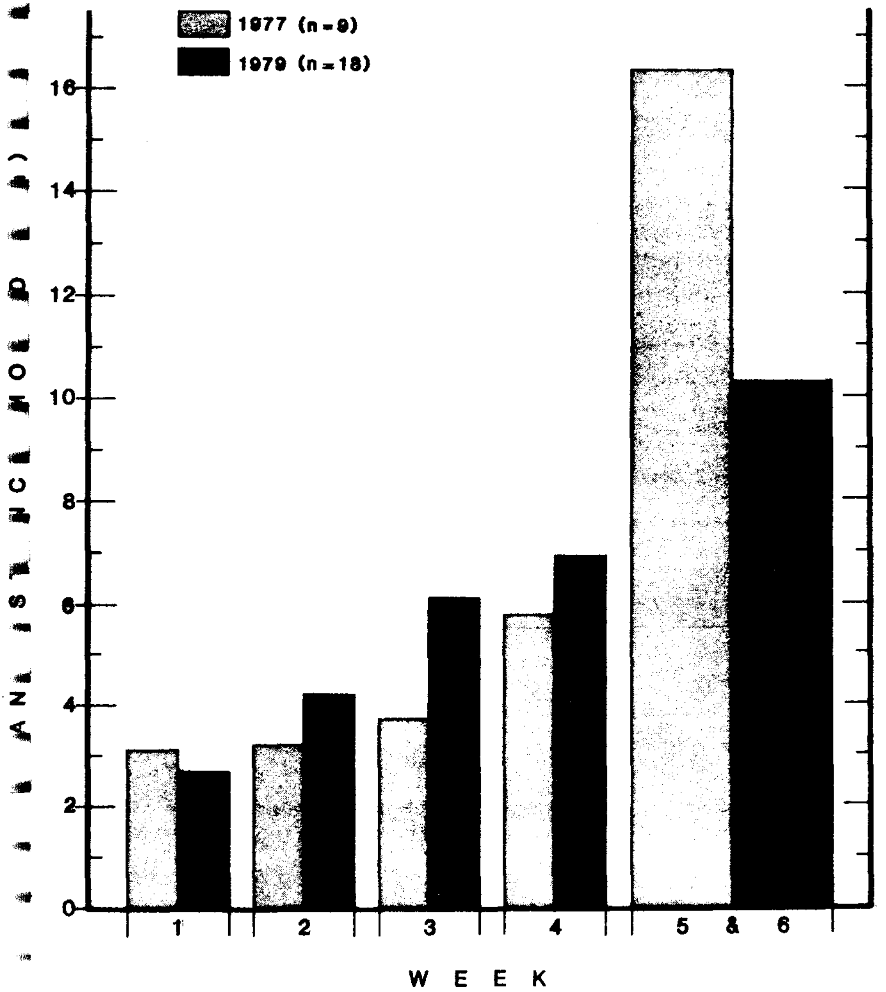


Fig. 5. Comparison of weekly linear movements of Area 1 radio-collared moose calves in 1977 to those in 1979 for the first 6 weeks following parturition.

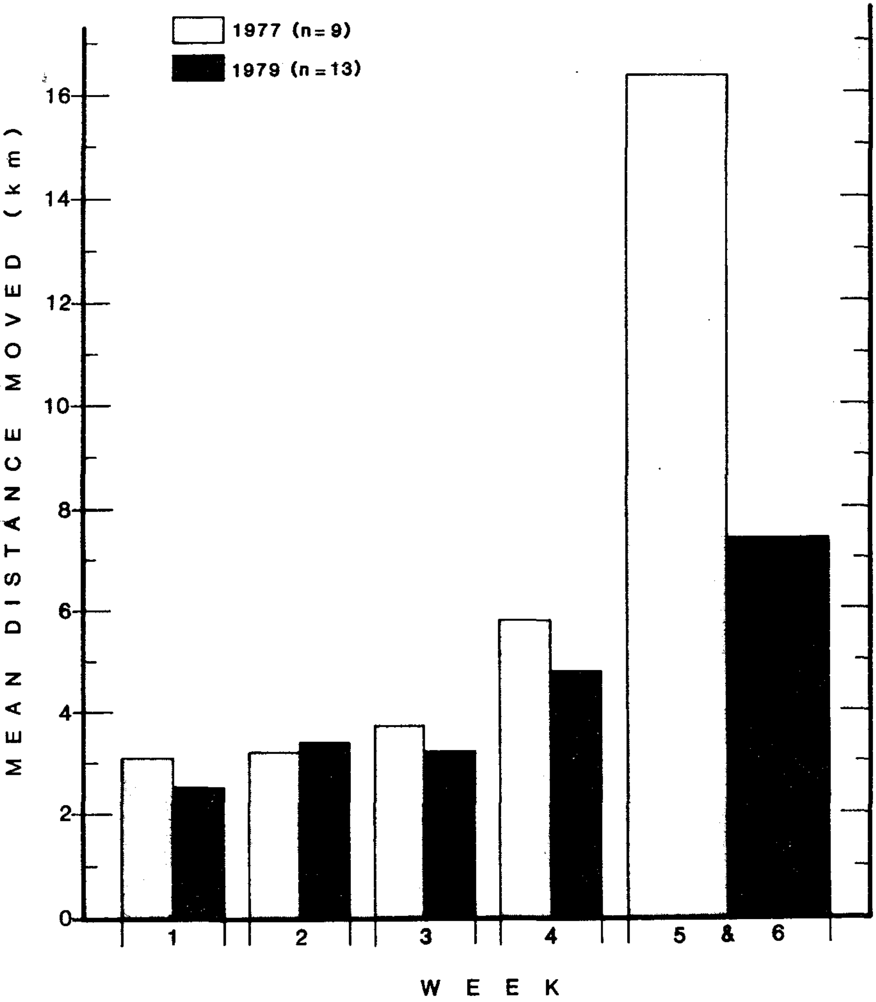


Fig. 6. Comparison of weekly linear movements of 1979 Area 1 radio-collared moose (excluding Monahan Lake calves) to those in 1977.

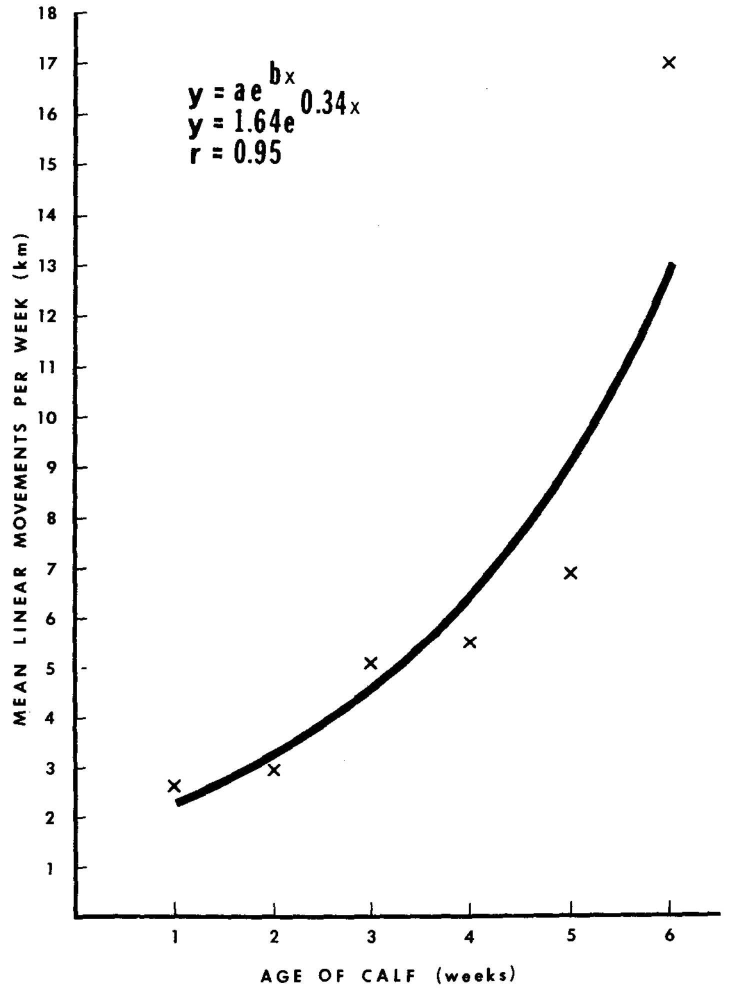


Fig. 7. Relationship of age to weekly linear movements of Area 1 and Area 2 radio-collared moose calves during 1977.

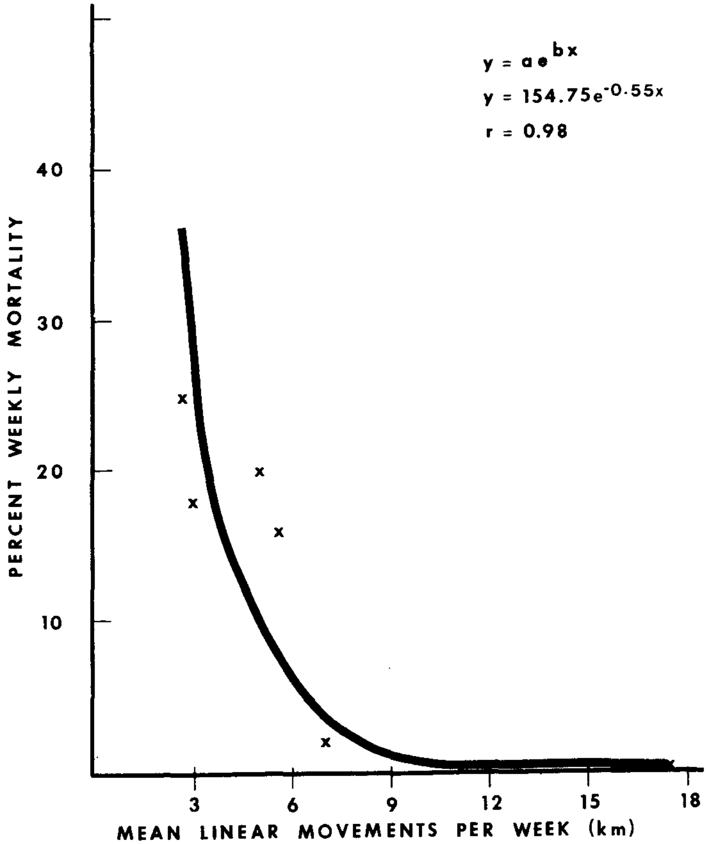


Fig. 8. Relationship of weekly linear movements to percent weekly mortality of radio-collared moose calves in Area 1 and Area 2 during 1977.

Bear removal efforts were concentrated from 22 May to 7 June. Following transplant, a number of bears returned to the area within 3-4 weeks (Miller and Ballard in prep.). We suspect that the bear removal program reduced mortality of calves from 1-3 weeks of age, but that as bears returned, mortality increased in the 4-6 week old calves. However, overall, total calf mortality was reduced as a result of the removal experiment (Ballard et al. 1980b).

## DISCUSSION

Casual observations and formal studies in many areas of North America indicate that during any given season a moose's home range rarely exceeds 5-10 $km^2$ (LeResche 1975). Studies of adult cow movements in the Nelchina and upper Susitna River basins resulted in summer home range estimates of from 8 to 210 $km^2$ while winter home ranges varied from 21 to 389 $km^2$ (Ballard et al 1980c). The large home ranges observed in this part of southcentral Alaska probably reflect poorer quality habitat and more severe climatic conditions than those found in the more southerly latitudes discussed by LeResche (1975).

Summer home ranges of cow-calf pairs in this study were compared with those presented by LeResche (1975) in Table 1. However, our home range sizes were calculated by connecting outermost locations while those reported by LeResche (op. cit.) were computed by multiplying maximum length by width. Therefore, the home range sizes are not directly comparable but do serve to demonstrate the magnitude of the differences. The average summer home range sizes reported in this study exceed those previously reported. Our reported mean value of 25.7 $km^2$ (average range

Table 1. Comparison of reported home range sizes of cow and calf moose in North America (adapted from LeResche 1975).

| Locality | Time interval | Home range size $km^2$ | Home range size $mi^2$ | Reference |
|---|---|---|---|---|
| Montana | 6 July-23 Sept. | 2.2 | 0.9 | Knowlton 1960 |
| Wyoming | 6 June-15 Sept. | 5.1 | 2.0 | McMillan 1954 |
| Ontario | 15 Aug.-31 Oct. | 6.0 | 2.3 | DeVos 1956 |
| Minnesota | 11 June-22 Aug. | 5.9 | 2.3 | VanBallenberghe and Peek 1971 |
| Minnesota | 15 May-1 Oct. | 15.4 | 6.0 | Berg 1971 |
| Minnesota | 15 May-1 Oct. | 16.9 | 6.5 | Berg 1971 |
| Alaska | 6 June-31 Oct. | 8.4 | 3.2 | LeResche 1966 |
| Alaska | 24 May-15 July | 25.7 | 9.9 | This study |

of 15.9 to 47.1 km$^2$) was based upon 43 calves that survived for 6 weeks following parturition and over 500 visual observations. All other reported home range sizes have been based on considerably fewer calves and relatively few location sightings. We do not intend to infer that there are not true differences between the home range sizes listed for the different studies; however, perhaps a greater range of values exists in those areas than what has been reported.

To our knowledge there are only a few references in the literature concerning predators, particularly brown bears, influencing movements of cow-calf moose. Franzmann and Peterson (1978) reported that certain movements of radio-collared moose calves on the Kenai Peninsula, Alaska may have been associated with predation or predation attempts. Calves killed by black bears moved 3.2, 4.8, 14.4 and 20.0 km 1 to 2 days prior to predation, whereas calves killed by wolves or brown bears all died within 1.6 km of their capture site. This sort of relationship was not evident in this study, except possibly for wolf predation; however, our sample of wolf-killed calves was too small (n = 2) to draw conclusions. Moose calves killed by brown bears moved a wide range of distances before being killed. It was apparent that a number of these movements were directly related to predation and predator avoidance.

Our comparison of cow-calf movement data, before and after bear removal, indicates that density and movement of bears were at least partially responsible for the observed values. Calf movements and home range sizes became smaller after bear densities were reduced.

Eighty percent of the bear-related calf mortalities occurred within 6 weeks following moose parturition. It was apparent that a calf's ability to evade brown bears was a function of its age and related mobility.

From this study we conclude that moose calf movements and home range sizes are altered by density and movement of brown bears. Whether calf-cow movements and home range sizes are influenced by other species of predators is untested, but appears likely for black bears (Franzmann and Peterson 1978). We do not maintain that predator density is the primary factor governing moose movements and home range size, but merely that it is an additional factor which has not previously received adequate consideration. We recommend that future references to movements and home range sizes of moose should include mention of the species of predators present and, preferably, provide some measurement of relative density.

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