MOOSE MOVEMENT AND MORTALITY ASSOCIATED WITH THE GLENN HIGHWAY EXPANSION, ANCHORAGE ALASKA

Michael G. McDonald

Alaska Department of Fish and Game, Division of Wildlife Conservation, 333 Raspberry Road, Anchorage AK. 99518-1599.

ABSTRACT: Moose (*Alces alces*) movement and mortality were compared prior to and after widening the Glenn Highway near Anchorage, Alaska where an 11.3 km section was expanded from 4 to 6 lanes. Thirty eight moose/year were reported to be struck and killed in motor vehicle accidents during the 10 years prior to 1987. To mitigate the impacts of the highway upgrade a moose-proof fence, a moose underpass, one-way-gates, and highway lighting were installed. From November 1987 through October 1990 moose mortality caused by vehicle accidents declined by 70% overall and by 95% within the fenced portion of the highway when compared to the previous decade. There was no significant decline in the number of moose crossing the highway. Moose tracks indicated substantial movement through the underpass, however, movement across the highway in unfenced portions continued. Use and design of one-way-gates is discussed.

ALCES VOL. 27 (1991) pp.208-219

The effects of heavily used transportation corridors upon wildlife distribution, movement, and mortality are a growing concern throughout the world (Allen and McCullough 1976; Reed *et al.* 1979; Olbrich 1984; Singer and Doherty 1985; Feldhamer *et al.* 1986; Jakimchuk 1986; Child and Stuart 1987; Kelsall and Simpson 1987). In Alaska the Glenn Highway, serves as the only highway transportation link between Anchorage, Eagle River/Chugiak, and the Matanuska-Susitna Borough. The area between Anchorage and Eagle River approximately 16 km to the north, is a moose (*Alces alces*) winter range of approximately 3,075 ha. The highway essentially bisects this winter range resulting in numerous moose/vehicle accidents in recent years. Between 1976 and 1987 an annual average of over 38 moose/vehicle collisions have been reported along this portion of the highway (Alaska Department of Public Safety records).

The Alaska Department of Transportation and Public Facilities (ADOT&PF) widened a 11.3 km segment of the Glenn Highway from 4 to 6 lanes during 1987. To mitigate the impacts of this highway upgrade on moose mortality and movements and to reduce the number of moose vehicle accidents, ADOT&PF fenced the southern 5.5 km of the Highway. Elsewhere in the U.S., Canada, and Europe, fencing has proven to be an effective method of reducing wildlife/vehicle collisions along highways (Reed *et al.* 1979; Ward 1982; Olbrich 1984; Singer and Doherty 1985; Feldhamer *et al.* 1986; Jakimchuk 1986; Child and Stuart 1987; Kelsall and Simpson 1987: Olbrich 1984; Singer and Doherty 1985; Jakimchuk pers. comm.). One-way gates were constructed at several locations along the fence to allow moose to pass out of the highway corridor. One-way gates have been constructed for deer (*Odocoileus* spp.) and elk (*Cervus elaphus*) elsewhere in the U.S. and Canada (Reed *et al.* 1974; Jakimchuk pers. comm.)

The Ship Creek bridge was raised and lengthened and a pathway constructed to allow passage of moose below. Underpasses for deer, elk, and mountain goats (*Oreamnos americanus*) have been built and used (Reed *et al.* 1975, 1979; Reed 1981; Ward 1982; Olbrich 1984; Singer and Doherty 1985; Jakimchuk pers. comm.).

Literature describing underpasses or one-way gates built specifically for moose is lacking.

Highway lighting was installed along the entire 11.3 km.

This project studies the effectiveness of a moose-proof fence, underpass, one-way gates and highway lighting along a widened highway through a moose winter range.

Objectives of this study were: 1.) to determine abundance, distribution, and movement patterns, of moose before and after modifications to the Glenn Highway; 2.) to document use of a highway underpass and one-way gates by moose; 3.) to determine the impacts and effectiveness of a moose proof fence and highway lighting upon moose; 4) to develop an information base to assist with developing recommendations for mitigation of unforeseen project-related impacts and future transportation projects.

STUDY AREA

Study area boundaries were defined by the movements of radio-collared moose. Included were Elmendorf Air Force Base (EAFB) and Fort Richardson Army Base (FRAB), where the majority of moose were located. Also included were portions of Chugach State Park, the city of Anchorage, Little Peters Creek, upper Ship Creek, upper Bird Creek, and Eagle River drainages to the east. The study area was within Alaska Game Management Unit (GMU) 14(C) (Fig. 1).

Anchorage is a city of about 240,000 people, but greenbelts municipal parks, and other lightly developed areas are distributed throughout. EAFB and FRAB contain primarily undeveloped lands with localized developments.

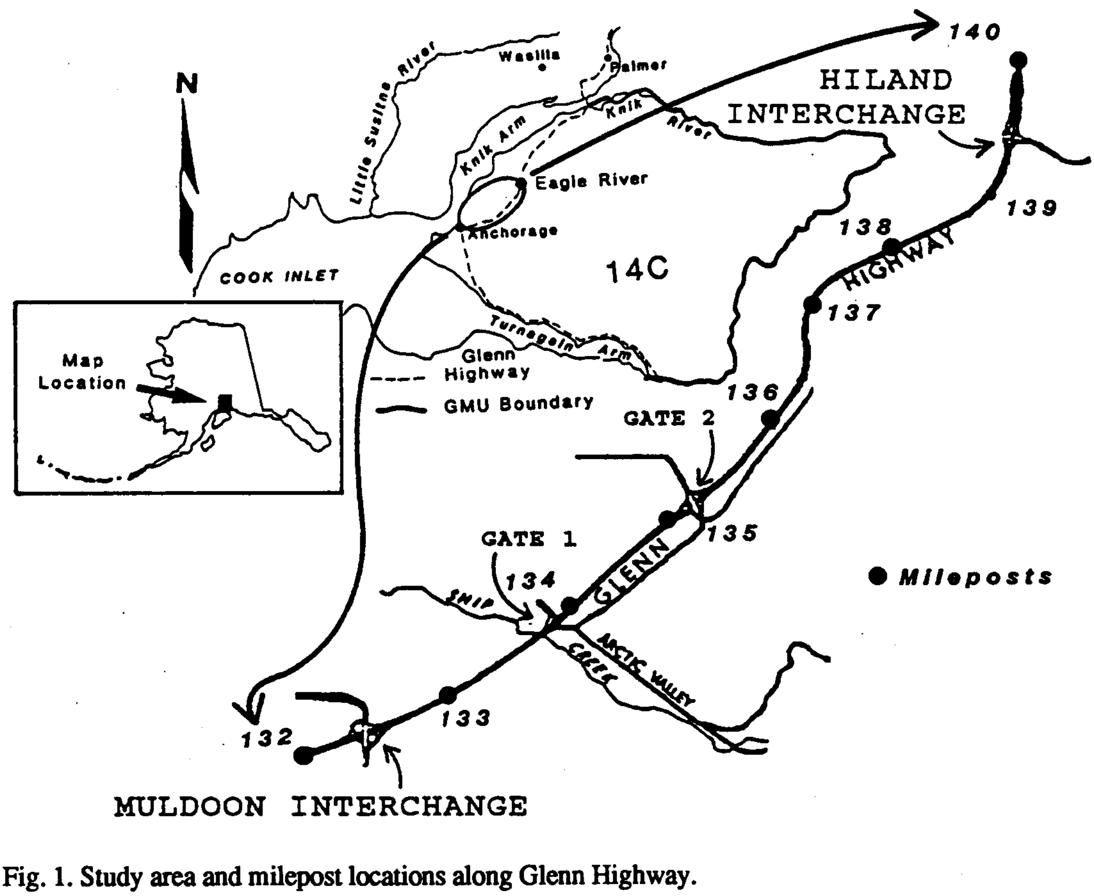

Fig. 1. Study area and milepost locations along Glenn Highway.

Below 150 m the undeveloped portions of FRAB contain a complex mosaic of old growth and even-age second growth forests because of numerous fires within the past 100 years. These forests are comprised primarily of 60-80 year old even-age class birch (*Betula Paperifera*) and white spruce (*Picea glauca*) and 80-200 year old uneven-age class birch and white spruce. There are some 200-250 year old even-age birch and white spruce and 60-80 year old aspen (*Populus tremuloides*) and white spruce. Disturbed areas, especially those along the outwash plains, contain pole-size stands of balsam popular (*Populus balsamifera*), willow (*Salix spp.*), birch, and aspen. Pure stands of thinleaf alder (*Alnus tenuifolia*) occupy about 485 ha of FRAB (Bennett 1983).

The undeveloped areas of EAFB are covered with 96.5% vegetation and 3.5% open water or tidal flats. The predominant cover is forest and woodland (78%) of which the largest component is a mixed forest of birch and white spruce. Thinleaf alder shrub community types cover 16% of EAFB (Rothe *et al.* 1983).

The sub-alpine areas of the study area are composed of alder (*Alnus spp.*) and willow interspersed with spruce stands and open grasslands.

METHODS

Moose were captured and fitted with visual and radio transmitting collars. Moose were captured on winter range during 1986, 1987, 1988, and 1989 on FRAB south of Eagle River and the Ship Creek drainage. Collars were evenly distributed to animals on both sides of the Glenn Highway.

Radio relocation flights were conducted in a Piper PA-18 Supercub. One flight was conducted with a Hughes 500-C helicopter to determine if study animals were accompanied by calves. Flights were initially scheduled at 2-3 week intervals prior to 1990, and one month intervals from 1990. Inclement weather or military training activities occasionally altered these schedules.

Moose relocations were plotted on 1:63,360 scale USGS topographic maps. The number of highway crossings were determined from plotted relocations.

A logit loglinear model (Agresti 1984) was use to determine if the distribution of moose was significantly different in relation to the Glenn Highway before and after fencing. Possible explanatory variables included pre and postfencing, month of the year, and sex. Furthermore the ordinal nature of the month was utilized to try to obtain a more parsimonious model.

To determine if fencing caused a population decline, censuses were conducted before and after fence installation. These moose censuses were conducted over EAFB, FRAB, and the Ship Creek drainage, an area considered to include most of the moose that might be affected by the highway project. The censuses were a modification of a technique developed by Gasaway *et al* (1986). Because the census area was relatively small (357 sq km), all sample units (14) were counted rather than a stratified random sampling of sample units.

A second population estimate was made using a Lincoln Index (Chapman 1952). Previously radio collared moose represented the marked population cohort.

The underpass and one-way gates were monitored by track counts when snow had accumulated and eye witness accounts. Bait composed of assorted vegetables culled from local supermarkets, alfalfa hay, and a moose ration developed at the Alaska Department of Fish and Game (ADF&G) Moose Research Center (Schwartz et al. 1985) was placed in the underpass to entice moose into it.

Alaska Department of Public Safety (ADPS) records are maintained for moose/vehicle accidents to which they respond and are recorded by highway route and milepost.

ADF&G moose road kill records are obtained from charities who salvage the animals

DISCUSSION

Radio-collaring

Initially 12 radio-collars were placed on moose during spring 1986. During 1987 another 32 collars were place on animals. During the course of the study collars that were shed or retrieved from dead animals were replaced on other moose.

Movements and Distribution

Analysis of moose distribution in relation to the Glenn Highway (east vs west) using a Logit Loglinear Model found no significant difference between 1987 (prefencing) and 1988 or 1989 (postfencing) (P=0.944). In this case the logit loglinear analysis was used to predict the odds of the number of moose on a particular side of the highway for a given month, year, and sex. The modeling was done on the natural log scale. Overall males were more likely to use the east side of the highway than females. Comparison of 1990 and 1991 were not statistically valid because of the reduced number of radio relocations between years. Fig. 2 shows monthly distribution of male and female moose in relation to the Glenn Highway.

Movements from the most heavily used winter ranges, those adjacent to the Glenn Highway on FRAB south of Eagle River, to spring ranges began in the last 2 weeks of March and were completed by mid April. Most noticeable was a shift of mostly female moose toward lower elevations west of the highway that consisted of forested coastal areas on EAFB and the vicinity of Eagle River Flats on FRAB. Most collared females that moved remained near the coast through August. Collared male moose tended to remain at higher elevations than females from March through August. Reasons for such segregation might be related to extra nutritional requirements of pregnant or lactating cows (LeResche and Davis 1973), cover requirements for calves or absence of predators (Stringham 1974 and Ballard *et al.* 1980).

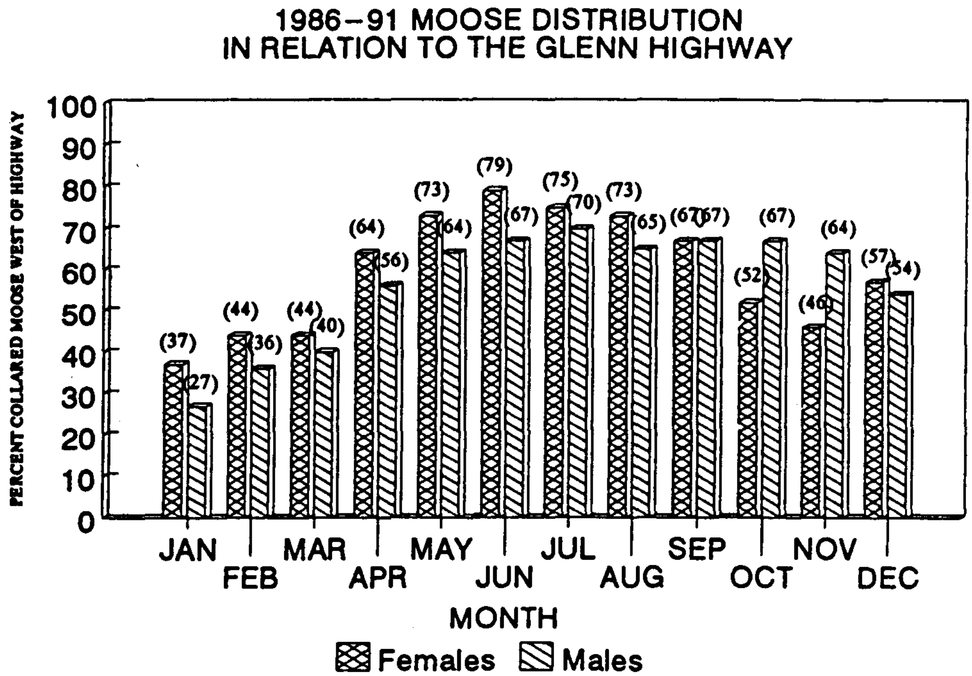

Fig 2. Distribution of collared moose in relation to the Glenn Highway. Percent found west of the highway.

During the rut in September and October, both sexes showed an elevation change toward each other. Males dropped from an average elevation of 211 m in August to 111 m and 165 m during September and October respectively. Females went from an average elevation of 151 m in August to 149 m and 193 m during September and October respectively. Both sexes tended toward upper elevations during November, December, and January (Fig. 3-5). Elevation of the Glenn Highway along the length of the upgrade ranges between 90 and 130 m. Most of the highway corridor and nearly all lands to the west are at or below 120

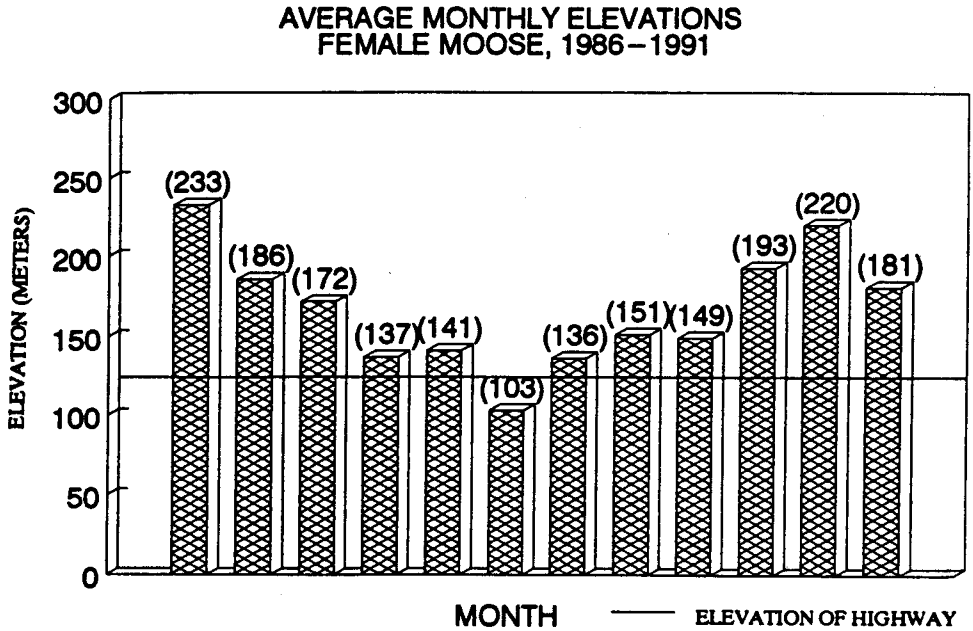

Fig. 3. Average monthly elevation use by radio-collared female moose.

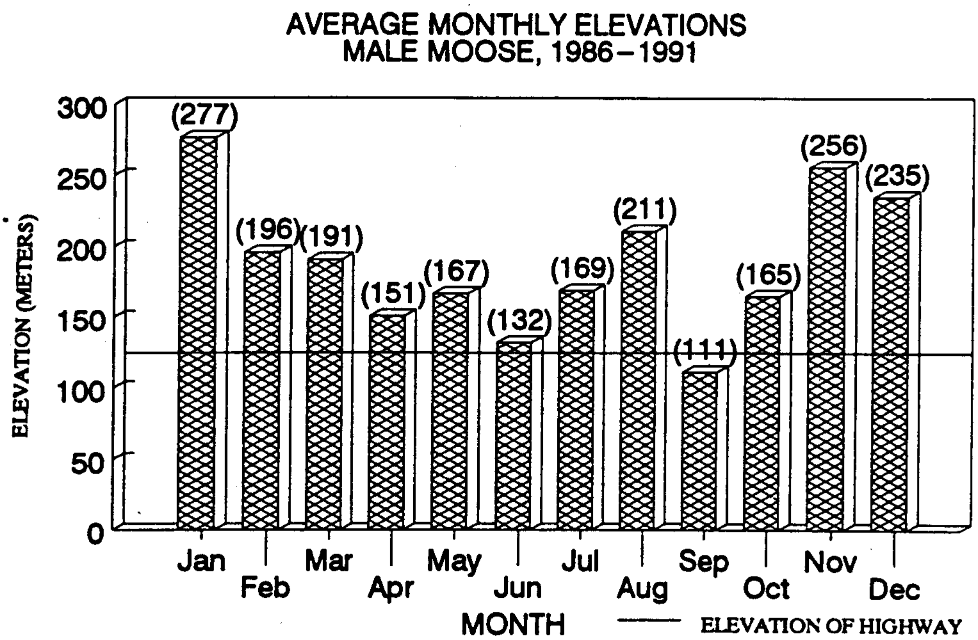

Fig. 4. Average monthly elevation use by radio-collared male moose.

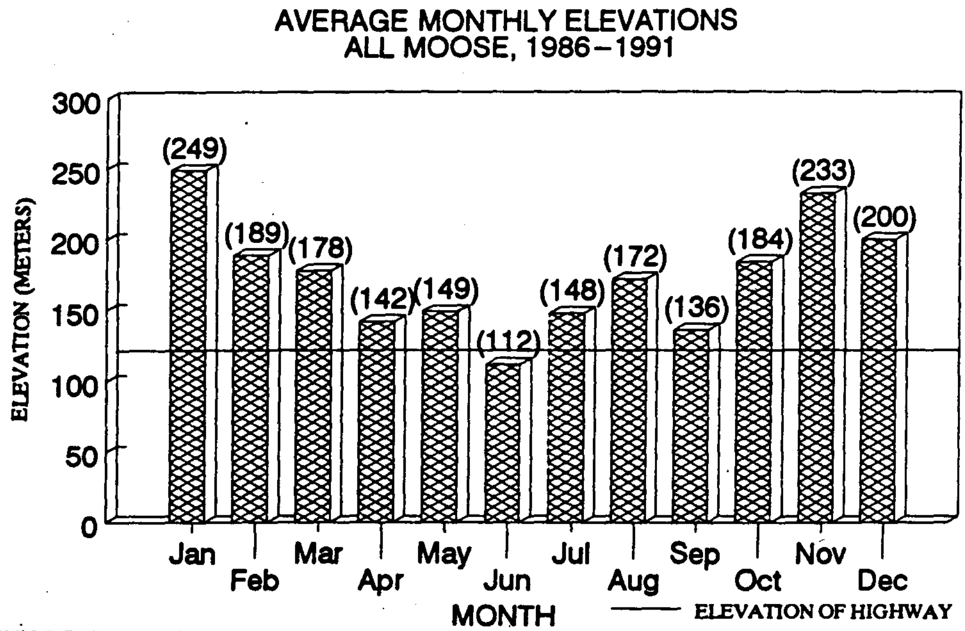

Fig. 5. Average monthly elevation by all radio-collared moose.

m ADPS accident records from 1977 through 1986 reflect increased moose/vehicle accidents from August through January and that accidents decreased dramatically after March (Fig. 6). Increases can be explained by seasonal moose movements and concentrations on winter range adjacent to the highway. Movement toward rutting areas began in late August and continued through mid October. From mid October through mid December movement to upper elevation post rutting areas was observed. From mid to late Decem-

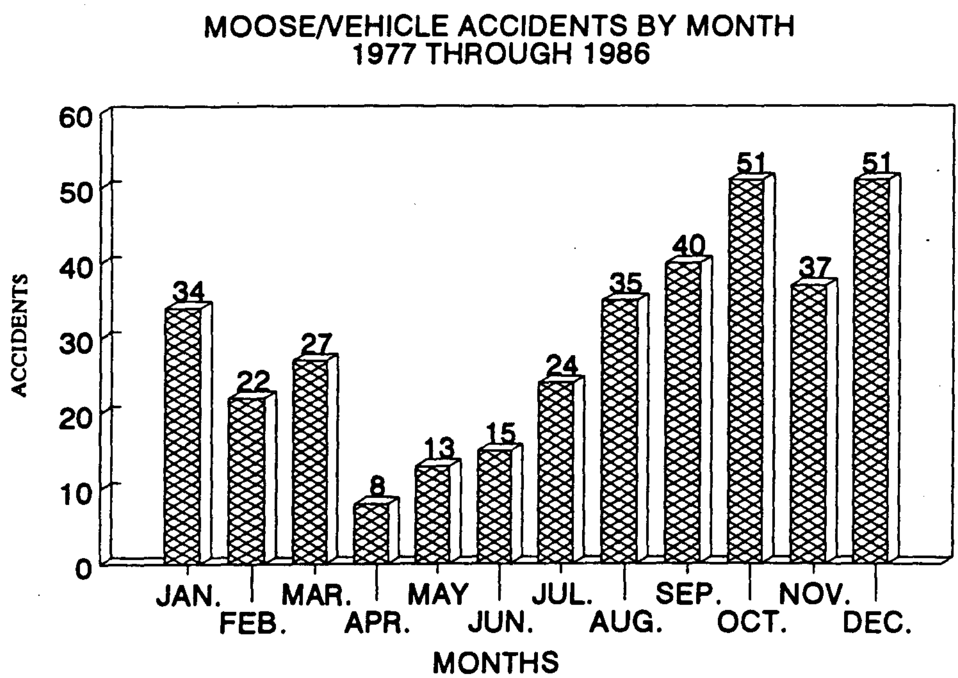

Fig. 6. Total accidents by month within the Glenn Highway project area from 1977 through 1986.

ber animals began to descend to lower elevation wintering areas adjacent to the Glenn Highway. Increased accidents during March reflect movement to spring range near the coast. Spring/summer ranges for most moose were not near the highway.

Assuming movements and distribution of radio collared moose are representative, and based on a census estimate of 650 wintering moose, estimates of moose crossings of the highway range from 1400 to 1800 per year during this study. These estimates are based on known crossings by collared animals and extrapolated to the remainder of the moose population. These are minimum estimates because radio-collared animals were relocated infrequently enough that undetected highway crossings probably occurred.

During a one year period crossings by individual moose ranged from 0-8. Over the course of the study it ranged from 0-25.

Based on ADPS accident records from 1977 through 1986, a Chi square goodness of fit test shows that moose/vehicle collisions do not occur randomly. In an analysis using a log-linear model, significantly more accidents ($P \approx 0.00001$) occurred in the area between milepost 133 and 134 (figure 8). This highway section includes the vicinity of Ship Creek (2.4 km from the Muldoon interchange) and a 1.6 km interval 9.5 km from the Muldoon interchange (mileposts 137-138).

Highway accident reports (Fig. 7) and mapped relocations of collared moose indicated an east/west seasonal movement corridor along Ship Creek. A heavily used wintering area exists directly to the east of mileposts 137 and 138 at elevations between 300 and 760 m.

Fencing and Lights and Their Effects on Moose/Vehicle Accidents

The Glenn Highway fence consisted of 2.4 m of wire mesh placed 25 cm above the ground. During 1987 phase 1 fencing was constructed on either side of the highway from the Muldoon interchange 2.7 km to the Arctic Valley exit. An additional 1.5 km wing was erected south of the highway between milepost 132 and 133 to prevent moose from walking around the end of the fence near the

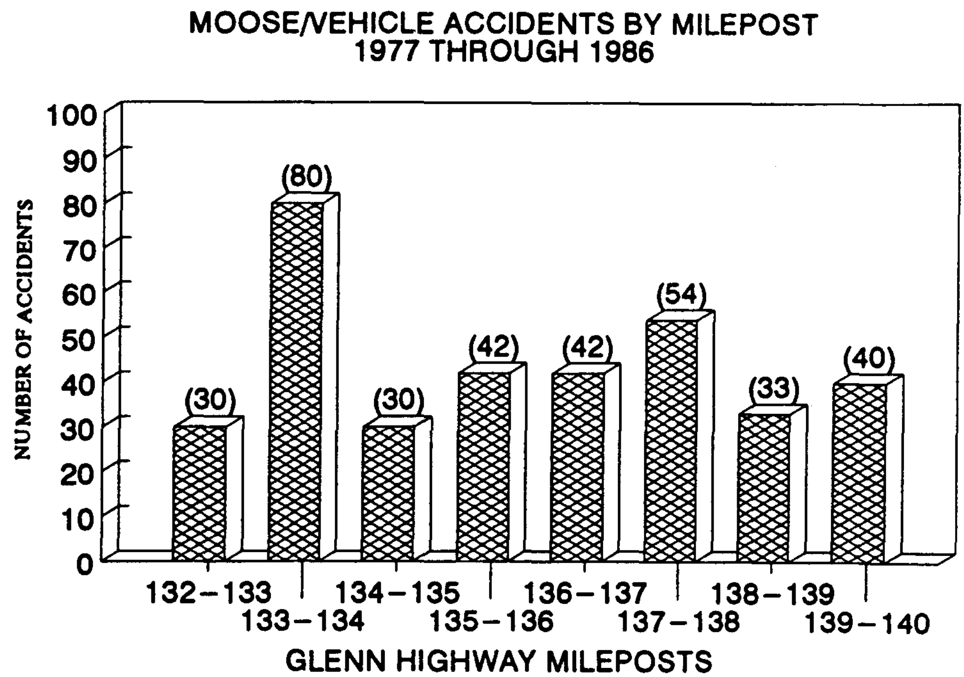

Fig. 7. Accidents by milepost from 1977 through 1986.

highway. An additional 2.8 km was fenced to the main FRAB interchanged during summer 1989 (phase 2). Also during 1989 a funnel fencing system was installed at the Arctic Valley entrance and exit to the highway to channel moose to one-way gates leading back behind the fence (Fig. 8).

During 1987 highway lighting was installed from the Muldoon interchange 11.3 km to the Highland Drive interchange.

From November 1987 through October 1988, the first full year after fencing and lighting had been installed, 12 moose/vehicle accidents (ADF&G records) were reported from the Muldoon interchange to the Eagle River bridge. During the same months in 1988-89 and 1989-90, 9 and 14 accidents occurred respectively. This represents a 95% reduction in accidents within the fenced portion of the highway and a 65% reduction in the unfenced portion. The total reduction over the entire length of the highway project was 70%. This reduction from the 1976-86 mean was significant (P > .95) based on the standard deviation of the previous 11 years of ADPS records (Fig. 9). There were only 2 accidents reported within the fenced portion of the highway from November 1987 through October 1990 compared to an annual average of 17 prior to fencing. Of the 35 accidents reported 8 (23%) occurred near the ends of the fence. Between October 1990 and July 1991 2 accidents were reported inside the fence. More moose killed by vehicles are recorded in ADF&G records than ADPS records because ADPS does not record hit and run accidents when moose are killed. The 1977-1986 average moose/vehicle accidents probably ranged between 41-46 rather than 38 reported by ADPS.

Fencing alone does not appear to account entirely for the reduction in accidents. Between 1977 and 1986, 42% of the moose-vehicle accidents occurred in what is now the fenced portion of the Glenn Highway. Although it was not proven significant, lighting may have repressed some crossing of the highway during mid winter months when moose were concentrated near the road. Highway lighting in conjunction with the widened highway may present a formidable barrier particularly from October through March when lights remain on the majority of the day. How much the lights reduced accidents because motorist were better able to see and avoid moose is another unknown factor.

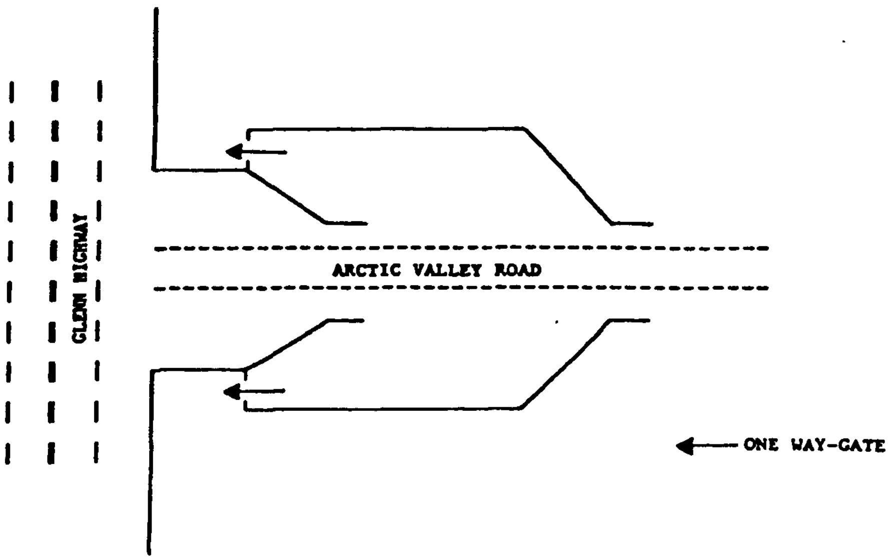

Fig. 8. Funnel fencing at Arctic Valley interchange.

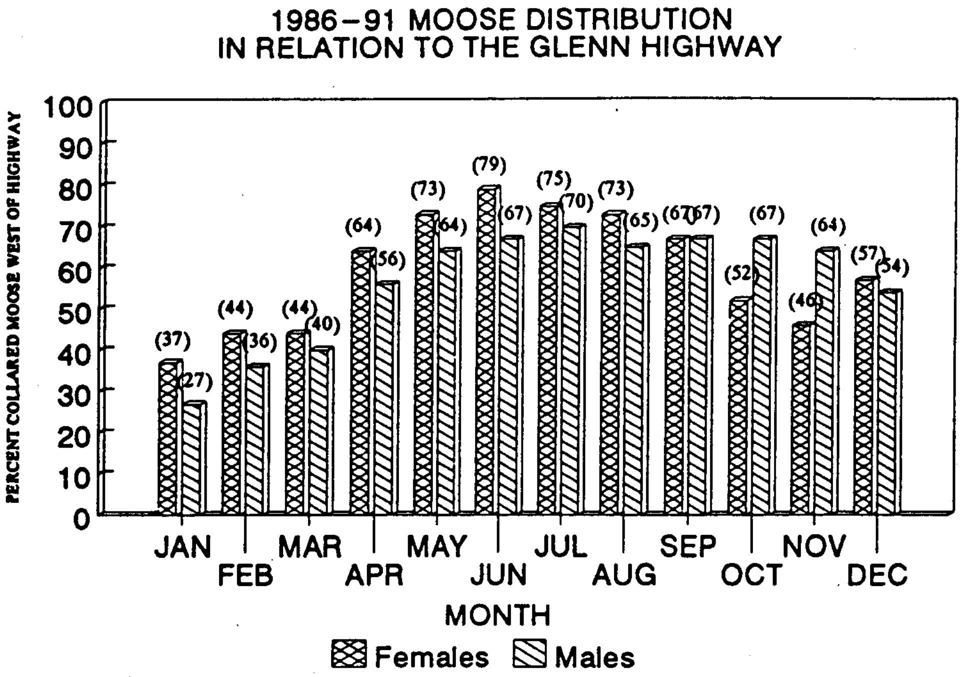

Fig. 9. Annual (November through October) moose/vehicle accidents 1976-1990.

Underpass

Modifications to the Ship Creek bridge for the moose underpass included raising and lengthening the bridge for placement of a pathway 3 m wide with a minimum 3.2 m of clearance above the path.

Glaciation caused the underpass to become iced-over during the first winter, probably preventing some crossings. Four moose were confirmed to have used the underpass prior to the icing. Three were documented by track counts in late November following baiting. The fourth crossing occurred in mid October 1987, just after the fence was in place and was witnessed by an ADOT&PF maintenance crew.

A cement retaining wall between the pathway and creek was lengthened and raised during the summer of 1988, effectively preventing Ship Creek from flooding the pathway during the following winters. Very little ice buildup has occurred since.

Moose use of the underpass increased during late 1988 and early 1989. Based on track counts a minimum of 25-30 animals used the underpass during October and November 1988. From mid January 1989 through mid March, when baiting with alfalfa hay was initiated, 50 to 60 animals were confirmed to have used the underpass. Tracks of moose were occasionally obliterated by tracks of people using the underpass. Also moose could easily use the stream adjacent to the pathway during ice free months.

One-way Gates

One-way gates were modifications of designs developed by Reed *et al.* (1974) and (Jakimchuk 1986). Thirty gates were installed, including 9 sets of double gates, 4 single gates at the corners of the fence's junction with the Ship Creek bridge, and 2 single gates in each of 3 funnel fencing systems.

Use of one-way gates was documented by track counts and eye witness accounts (ADF&G staff, ADOT&PF maintenance crews and members of the public). Seventeen moose were observed using the one-way gates including calves and adults of both sexes. Surveys for moose tracks at these gates indicated frequent use by moose. This however, also suggests that many moose were gaining access to the fenced highway corridor.

Several problems with the operation of the one-way gates were noted. Lubricant viscosity used in the hinges declined at temperatures below 0°C causing the gates to stick open. A lubricant that remains nonviscous to -50°C has been applied to the hinges. Future gate hinges should be lubricated with a dry molybdenum based powder.

Rubber hose boots, made from radiator hose, were used to protect the hinges from precipitation. They were too tight and had to be split in order to allow free movement of the joint. These boots should be replaced with lighter rubber hose half again as large in diameter. Fastened above the joint with hose clamps, the bell shaped covering over the joint would keep moisture out and allow free movement.

Gates constructed during phase I fencing, when swung all the way open, remained open because the hinge passes its midpoint. Members of the public opened the gates for various reasons allowing moose to enter the highway corridor. Stops, similar to those used to prevent the gates from being swung inward, were welded to the phase II gates preventing them from being swung beyond 90° yet allowing passage of moose.

Tracks of a calf moose were observed to have gone through the opening between the tines on the gates the "wrong" way. Bending the tines closer together solved this problem.

MORTALITIES

A total of 66 moose were captured and radio-collared during the study. There were 32 known mortalities (20 females and 12 males). There were 4 capture related mortalities. Six were struck by highway vehicles (3 within the highway project area). Seven were killed by hunters. Six were killed illegally. Five animals died of natural causes. Four died of unknown causes but 2 of these may have been killed illegally.

Censuses

Censuses were conducted in December 1987 (one month post fencing), 1988, and 1989. These censuses include all winter moose habitat found on EAFB, FRAB, and the Ship Creek drainage. The sample units ranged in size from 15.5-39 sq. km. Using PA-18 Piper Supercubs, 14 to 17 hours were spent in the census area. Search effort ranged from 1.4-3.0 minutes per square km. When possible, in each sample unit an intensive search plot of approximately 2.6 sq. km. was randomly selected to be recounted immediately after the standard search at a more intensive 3.0-7.0 minutes per square km. in order to determine a sightability correction factor.

The population estimates for 1987, 1988, and 1989 were 584 ±15, 630 ±40, and 650 ±50 (80% C.I.) respectively indicating a stable to slightly increasing population. A Lincoln Index (Chapman 1952) population estimate of 609 moose for 1987 and 634 for 1988 was calculated.

The number of moose legally killed by hunters or in vehicle accidents during the hunting regulatory year (July 1 - June 30) from 1984 through 1991 remained stable (102, SD ±18). Moose killed by hunters increased and the number killed by vehicles decreased while the population remained stable or increasing slightly. The Hunting season was liberalized in an attempt to reduce the moose population to a post-hunting season management objective of 500 animals. Although harvest increased, it has been offset by reduced moose/vehicle accidents.

CONCLUSIONS AND RECOMMENDATIONS

The Glenn Highway moose fence proved effective in reducing moose/vehicle accidents (95%). Lighting of the unfenced portion of the highway also appeared to be effective in reducing these accidents (65%) although the precise mechanism is not know. Moose use of the underpass was sufficient to allow animals access to major browse areas outside either side of the highway corridor. This was demonstrated by track counts and supported by no significant change in seasonal distribution relative to the highway. The design of the one-way gates proved to be an effective outlet for moose from the highway corridor. The reduced number of moose killed on the highway also allowed an additional harvest by hunters.

During initial planning of the Glenn Highway project, both fencing the entire project length and an overpass crossing were suggested. Because of the additional expense and lack of documented use of such a crossing these designs were not incorporated into the project. Twenty nine percent of the accidents occurring from November 1987 through October 1990 (postfencing) were either near the ends or inside the fence. Additional fencing does not appear economically feasible at this time because the additional reduction in moose/vehicle accidents would not add significantly to the decrease that has already taken place.

ACKNOWLEDGEMENTS

This study was funded by the Alaska Department of Transportation & Public Facilities. W. Ballard provided coordination between ADOT&PF and ADF&G and reviewed this manuscript. D. Harkness, K. Pitcher, and K. Schneider reviewed drafts of this manuscript. E. Becker helped with the statistical analysis. D. McAllister and W. Taylor provided assistance during radio-collaring of moose. I am grateful for the assistance provided by the air traffic controllers of Elmendorf Air Force Base, Fort Richardson, Anchorage International Airport, and Merrill Field. The competence of pilot B. Wiederkehr who was able to keep track of my voice in one ear air traffic control in the other, along with 5 airspace zones and numerous aircraft must be admired.

REFERENCES

AGRESTI, A. 1984. Analysis of ordinal categorical data. John Wiley and Sons, New York, New York. 287pp.

ALLEN, R. and D. MCCULLOUGH. 1976. Deer-car accidents in southern Michigan. J. Wildl. Manage. 40(2):317-325.

BALLARD, W. B., C. L. GARDNER, and S. D. MILLER. 1980. Influence of predators on summer movements of moose in Southcentral Alaska. Proc. N. Amer. Moose Conf. and Workshop. 16:338-459.

BENNET, A. 1983. Management of forestland for moose browse production on Fort Richardson. U.S. Army, Fort Richardson, Alaska. 42pp.

CHAPMAN, D. G. 1952. Inverse, multiple and sequential sample censuses. Biometrics 12:286-305.

CHILD, K. N. and K. M. STUART. 1987. Vehicle and train collision fatalities of moose: some management and socio-economic considerations. Swedish Wildl.

FELDHAMER, G., J. GATES, D. HARMAN, A. LORANGER, and K. DIXON. 1986. Effects of interstate highway fencing on white-tailed deer activity. J. Wildl. Manage. 50(3):497-503.

GASAWAY, W. C., S. D. DUBOIS, D. J. REED, and S. J. HARBO. 1986. Estimating moose population parameters from aerial surveys. Biol. Pap. Univ. Alaska, No. 22 (1986). 108pp.

JAKIMCHUK, R. D. 1985. Personal Communication. President, Renewable Resources Consulting Services Ltd., Sidney, British Columbia.

_______. 1986. Design principles for fencing and crossing structures to mitigate mortality of ungulates along highways. Prepared for Coquihalla highway phase III detailed design study team. 37pp.

KELSALL, J. and K. SIMPSON. 1987. The

impacts of highways on ungulates: A review and selected bibliography. Prepared for British Columbia Ministry of Environment and Parks, Kamloops and Penticton, B.C.

LERESCHE, R. E. and J. L. DAVIS, 1973. Importance of nonbrowse foods to moose on the Kenai Peninsula, Alaska. J. Wildl. Manage. 39:279-287.

OLBRICH, P. 1984. A study examining the effectiveness of game warning reflectors and suitability of game passages. Research Centre for Hunting and Game Damage Prevention. Nordrhein-Westfalen (Bonn), West Germany. 16pp.

REED, D. F. 1981. Mule deer behavior at a highway underpass exit. J. Wildl. Manage. 45(2):542-543.

_______, T. M. POJAR, and T. N. WOODARD. 1974. Use of one-way gates by mule deer. J. Wildl. Manage. 38(1):9-15.

_______, T. N. WOODARD, and T. M. POJAR. 1975. Behavioral response of mule deer to highway underpass. J. Wildl. Manage. 39(2):361-367.

_______, and T. D. I. BECK. 1979. Regional deer-vehicle accident research. Final Report No. FHWA-CO-RD-79-11. State of Colorado, Division of Wildlife. [Prepared in cooperation with the U.S. Dept of Trans., Fed. Highway Admin. 61pp.

_______, T. D. I. BECK, and T. N. WOODARD. 1982 Methods of reducing deer-vehicle accidents: benefit-cost analysis. Wildl. Soc. Bull. 10(4):349-354.

ROTHE, T. C., S. H. LANIGAN, P. A. MARTIN, and G. F. TANDE. 1983. Natural resource inventory of Elmendorf Air Force Base, Alaska. Part II: Management recommendations. United States Department of the Interior, Fish and Wildl. Serv., Special Studies. Anchorage, Alaska, USA. 43pp.

_______, W. L. REGLIN, and A. W. FRANZMANN. 1985. Suitability of a formulated ration for moose. J. Wildl. Manage. 49(1):137-141.

SINGER, F. J. and J. L. DOHERTY. 1985. Managing mountain goats at a highway crossing. Wildl. Soc. Bull. 13:469-477.

STRINGHAM, D. F. 1974. Mother-infant relations in moose. Naturaliste Can. 101:559-593.

WARD, A. L. 1982. Mule deer behavior in relation to fencing and underpasses on Interstate 80 in Wyoming. Transportation Research Record 859:8-13, Roadside Management. Transportation Research Board, National Research Council. Natl. Acad. Sci. Washington, D.C.