FILE COPY

# FEDERAL AID
# ANNUAL RESEARCH PERFORMANCE REPORT

ALASKA DEPARTMENT OF FISH AND GAME
DIVISION OF WILDLIFE CONSERVATION
PO Box 25526
Juneau, AK 99802-5526

**PROJECT TITLE:** Population dynamics of moose in Alaska: Effects of nutrition, predation and harvest

**PRINCIPAL INVESTIGATOR:** Rodney D Boertje

**COOPERATORS:** Layne Adams (USGS)

**FEDERAL AID GRANT PROGRAM:** Wildlife Restoration

**GRANT AND SEGMENT NR.:** W-27-5

**PROJECT NR.:** 1.57

**WORK LOCATION:** Unit 20A

**STATE:** Alaska

**PERIOD:** 1 July 2001–30 June 2002

## I. PROGRESS ON PROJECT OBJECTIVES

OBJECTIVE 1: Review literature on moose biology, indices of nutritional status, ungulate population models, predator-prey relationships and harvest data.

We continued to review available scientific literature.

OBJECTIVE 2: Estimate and evaluate the usefulness of several reproductive and condition indices for moose in Unit 20A and investigate the influence of weather on these parameters.

During the previous 5-year study we documented that reproduction and body weights were compromised at the current high, stable density. A 10% decline in the expected proportion of calves in the immediate postcalving population was substantial enough to contribute to the stability of the population in a measurable fashion. To derive an expected proportion of calves in a postcalving moose population, we used a value measured in a low density moose population in Unit 20E where food was not deemed a significant limiting factor to moose (Gasaway et al. 1992). We concluded that density-dependent nutritional limitation is apparent today in Unit 20A, even though predation was a much more substantial component limiting population growth during this study. An untested hypothesis is whether large-scale adverse weather is needed to initiate a decline in numbers and how productivity responds during such adverse weather. Boertje et al. (1996:487) questioned the validity of a long-term carrying capacity because adverse weather has initiated strong declines in moose numbers in the past, and the adverse effects of weather and predation appeared to work in a synergistic fashion to rapidly reduce population size. If adverse weather further reduces productivity, this would be clear evidence that weather-induced resource limitation is a strong secondary influence on moose populations at least at the current high density. If adverse weather acts in a density-independent fashion to reduce high- and low-density moose populations as per conventional wisdom, then high-density populations should be left with more moose following adverse weather compared with low-density populations. This would be a potential benefit of managing moose at high densities, in addition to the consumptive and nonconsumptive benefits.

Weather was favorable during this reporting period and parturition rates were improved compared with the prior reporting period when poor parturition was related to a relatively short prior summer (relatively few snow-free days). This short summer (summer 2000) also was relatively cool with a relatively low total number of growing degree days.

Since 1996 we have observed a parturition rate of 64% ($n$ = 346) and a twinning rate of 11% ($n$ = 221) for radiocollared moose ≥3 years old. Strong age-specific indicators of nutritional stress were even more noteworthy: 1) no 24-month-old moose ($n$ = 38) were parturient, 2) only 29% of 76 36-month-old moose and 66% of 58 48-month-old moose were observed parturient, and 3) no moose observed less than 60 months old produced twins. We documented a minimum 20% decline in production with a 3.2-fold increase in density since 1978. However, the substantial increase in moose numbers has allowed far greater sustainable yields than would have been possible at the lower density.

Transrectal ultrasonography and pregnancy-specific protein B (PSPB) (Bio Tracking, Moscow, ID USA) analyses produced identical results in 1996, the only year in which both results are available. However, daily observations during the calving seasons indicate lower actual productivity in the population and less variability than indicated using ultrasound or PSPB. We use observed parturition rates as the best indicators of production in the population because they are most meaningful to the population and because of the likelihood of neonatal or intrauterine mortality in this high-density population.

Management staff have flown spring twinning rate transect surveys in central portions of the Tanana Flats for several decades without the use of radiocollared moose. Because these surveys more readily sampled moose from all age classes each year, these surveys more accurately estimated twinning rates in the population compared with our sampling of radiocollared moose. To further investigate the accuracy of twinning rate transect surveys, we tested whether differences in twinning rates could be observed with a helicopter versus a fixed-wing aircraft and found no significant differences.

Weighing short yearling moose appears to be a particularly useful and relatively inexpensive tool for evaluating moose population condition. For example, we noted substantial differences between weights in the adjacent Denali and Unit 20A populations. We also noted significant differences in weights between subpopulations within the study area. Short yearlings weighed in the Tanana Flats have weighed significantly less (about 17 kg less on average) than those in the Alaska Range foothills every year. Although virtually all calves are born in the Tanana Flats, calves that move to the Alaska Range foothills in summer or autumn must have an improved energy balance relative to those remaining in the Tanana Flats. Because of the reduced moose body weights in the Tanana

Flats, we have assigned the Tanana Flats a higher priority for improving moose habitat compared to the Alaska Range foothills.

We expected birthweights to provide a relatively sensitive index to winter and spring maternal and range condition and that elevated birthweights would occur among the Alaska Range foothills subpopulation, in part because short yearlings weighed significantly more in the Alaska Range foothills. However, birthweights may provide only a nonsensitive index to winter and spring conditions. For example, we found no significant differences in newborn singleton or twin birthweights with regard to dam collaring location or capture year. As expected, newborn weights in Unit 20A are relatively low compared with those from the Yukon Flats, where moose density is 85% lower and the observed twinning rate (63%) indicates a high nutritional status during ovulation. Our unusual finding of a significant difference in birthweights between singleton male and female moose calves may be an indication of the relatively poor nutritional status of moose in Unit 20A.

Depth of rump fat is an index to the condition of individual moose, and potentially an index to relative condition of a moose population. We initially hoped to contrast annual differences in rumpfat depths among young moose, e.g., moose in the 10- and 22-month-old cohorts, to provide a tool to evaluate annual differences in moose condition. However, we detected no rump fat among moose in these cohorts. This lack of rump fat apparently is a sign of malnutrition at the current high densities, given that some 22-month-old moose have fat in Denali National Park.

Because short yearling bodyweights differed between the Tanana Flats and the foothills we expected to find significant differences in adult rumpfat depths from these 2 subpopulations. However, we found no significant differences. We conclude that adult rumpfat depths are less sensitive indices of nutrient regime compared to short yearling bodyweights, presumably because rumpfat depths were gathered from a sample of adults of all ages and reproductive histories. Perhaps with a greater sample size, rumpfat depths could be used to detect significant differences in nutrient regimes in these subpopulations.

We conclude that rumpfat depth is a more expensive and, at times, less sensitive index to nutrient regime in moose compared to twinning rates and weights of short yearlings. We did find significant relationships between March rumpfat depths and reproductive status of females, but reproductive indices are much less expensive to collect than fat depths.

Mean maximum depth of rump fat was significantly greater among pregnant versus nonpregnant adult cow moose. Mean maximum depth of rump fat was also significantly greater for moose observed parturient versus those never observed with a calf and for dams giving birth to twins versus those with singletons. We also found that the fattest dams produced on average the heaviest calves. Further, as expected, regression indicated a negative relationship existed between calving date and maximum March rumpfat depth.

With the blood obtained from adult female moose in 1996 and 1997, we attempted to identify potential relationships between 22 serum constituents and rumpfat depth using multiple regression models. We conclude, at this time, that standard serum constituents are not useful indicators of rumpfat reserves in moose. In addition, the acute phase protein haptoglobin was not helpful in distinguishing stressed from nonstressed individuals.

OBJECTIVE 3: Estimate causes and respective rates of mortality among radiocollared moose of various age classes in Unit 20A.

A composite of all mortality of radiocollared moose by age from 1996 through March 2002 indicates that annual calf survival rate was 53% and the yearling rate was 81%. In comparison, the 2-year-old rate was 98%, the 3-year-old rate was 99%, the 4- through 6-year-old rate was 100%, the 7-year-old rate was 83%, the 8-year-old rate was 96%, the 9-year-old rate was 95%, the 10-year-old rate was 88%, the 11 year-old rate was 89%, the 12-year-old rate was 87%, the 13-year-old rate was 79%, the 14 –year-old rate was 73%, and the 15-year-old rate was 71%. Natural mortality of random adults ≥36-months-old varied from 7% to 21% annually during this study and averaged 12.5% from 1996–1997 through 2001–2002. Yearling mortality rates averaged 13% during 1997–1998, 33% during 1998–1999, 17% in 1999–2000, 18% in 2000–2001, and 5% in 2001–2002.

Wolf predation was the major cause of death among adult and yearling moose. In 23 cases where we were able to investigate the cause of death of random radiocollared adults, wolves killed 14 (61%), grizzly bears killed 4 (17%), and 5 (22%) died from factors other than predation. Of 35 yearlings (12–24 months old) that died, wolves killed 25 (71%), bears killed 8 (23%), and 2 (6%) died from other factors.

Hunters took a nominal harvest of cows in the study area during September 1996, 1997, 1998, 2000, and 2001. These were the first legal cow harvests since 1974. Annual cow harvests during these years in Unit 20A have averaged 71 cows.

The 1996 and 1997 radiocollared newborn calves experienced the highest annual survival rates (52–56%) among the 7 Alaska–Yukon moose calf telemetry studies conducted to date. High calf survival undoubtedly contributes to the reduced reproductive performance of this population.

Predation was by far the major proximate cause of death in this and all previous moose calf mortality studies. Wolves killed more calves than both bear species in this study, while grizzly bears and black bears killed about equal proportions of calves. In previous moose calf mortality studies, either black or grizzly bears were clearly the major predator. In addition to mortality detected using radiocollared calves, mortality prior to birth or neonatal mortality during the first 24 hours after birth apparently occurred in 7 (17%) of 42 pregnancies in 1996 and 3 (13%) of 23 pregnancies in 1997.

We studied the relationship between calf survival and birthweight, birth date, and sex for calves born during 1996 and 1997. These data indicate that all calves are equally vulnerable to mortality factors common to this first month of life. However, modeling indicated increased mortality of lightweight calves at older age classes. In addition, preliminary analysis of the data supports the hypothesis that no relationship exists between dam condition (age, fat reserves, and collaring location) and mortality of their calves within the range of values observed.

OBJECTIVE 4: Analyze movement data for moose captured within the study area. Specifically, we will investigate migration patterns, dispersal of subadults, home range sizes of adult moose, and calving-related movements.

Kalin Kellie began her graduate work on analyzing and collecting data on moose dispersal, migration, home range size, fidelity to birth sites, and movements immediately prior to calving. She compiled available data from the prior 6 years of work and flew additional flights during this reporting period as needed to accomplish objectives for her Master's thesis.

We hypothesize that dispersal rates of subadult moose and home range size of adults will be similar to those reported by Gasaway et al. (1980) when the Unit 20A moose population was at a low-density. Further, we hypothesize moose movements during calving will reflect an anti-predation strategy.

OBJECTIVE 5: Summarize existing statewide reproduction and population data for moose. Currently, there is a need for a single consolidated source for past moose survey information as well as other data collected on condition or reproductive parameters of moose populations within the state.

No progress was made on this objective because Mark Keech was reassigned to Unit 19D moose research studies.

## II. SUMMARY OF WORK COMPLETED ON JOBS IDENTIFIED IN ANNUAL PLAN THIS PERIOD

JOB 2: Estimate and evaluate the usefulness of several reproductive and condition indices for moose in Unit 20A and investigate the influence of weather on these parameters.

During late February and early March 2002, we recaptured 14 female 69-month-old moose, six 57-month-old moose, and one 33-month-old moose. We replaced the aging ATS collars that were deployed when these moose were 9 months old. We used blood samples from these moose to estimate pregnancy rates from PSPB values. We saved funds by using an R-22 helicopter for transportation to deploy collars. We also radiocollared 22 female short-yearling moose and weighed these moose; 11 individuals were captured in the Tanana Flats and 11 in the Alaska Range foothills. This is the sixth cohort we have sampled in this manner, and weights were consistently significantly higher in the foothills when sample sizes totaled 40 or more short-yearlings (1996–2000 cohorts). This trend continued in the 2001 cohort although the reduced sample size was inadequate to detect a significant difference in weights.

Approximately 30 fixed-wing radiotracking flights were flown between mid-May and mid-June 2001 to observe parturition and twinning rates of 105 radiocollared moose greater than 2 years old. Twinning rates from aerial transect surveys totaled 10% ($n$ = 59 cows with calves). Data on weather patterns will be compiled when available from the National Oceanic and Atmospheric Administration.

JOB 3: Estimate causes and rate of mortality among radiocollared moose of various age classes in Unit 20A.

To assess causes and rates of mortality of moose within the study area, all radiocollared moose (approximately 150 moose) were tracked at least monthly with fixed-wing aircraft during this reporting period. In addition, a helicopter (R-22 or R-44) was deployed to recover collars and investigate mortality sites of 13 collared moose.

JOB 4: Analyze movement data for moose captured within the study area. Specifically, we will investigate migration patterns, dispersal of subadults, home range sizes of adult moose, and calving-related movements.

Kalin Kellie radiotracked a subsample of about 25 collared moose at least monthly as part of the dispersal, home range, and migration studies. In addition, she organized the calving studies and radiotracked most of the 105 adult moose from mid-May through mid-June or until they calved. She also assisted with all phases of the March and April collaring work.

JOB 5: Summarize existing statewide reproduction and population data for moose. Currently, there is a need for a single consolidated source for past moose survey information as well as other data collected on condition or reproductive parameters of moose populations within the state.

No progress was made on this objective because Mark Keech was reassigned to Unit 19D moose research studies.

JOB 6: Write progress reports and publish a final report. Also, incorporate results into appropriate Alaska wildlife planning, discussions, and management activities.

During this reporting period we submitted the Final Research Performance Report (1 Jul 1996–30 Jun 2002) for the first 5 years of this study (Study 1.51). Data collected from these projects are used in Unit 20A moose management reports, advisory committee meetings, Board of Game meetings, and discussions with the public.

## III. ADDITIONAL FEDERAL AID-FUNDED WORK NOT DESCRIBED ABOVE THAT WAS ACCOMPLISHED ON THIS PROJECT DURING THIS SEGMENT PERIOD

CT Seaton completed his requirements for a Master's Degree in Wildlife Biology by summarizing data on browse use and availability in Unit 20A. These quantitative browse studies 1) provide a baseline of browse information for comparisons with other areas, 2) help explain why yearling moose residing in the Tanana Flats consistently weigh less than those migrating to the foothills, and 3) assist in prioritizing habitat management activities.

## IV. PUBLICATIONS

Several manuscripts are in preparation from CT Seaton's thesis work. We are also working on a manuscript entitled "Managing for high densities and yields of moose in Interior Alaska." This manuscript summarizes the management implications discovered during the 6 years of studying the moose population in Unit 20A.

**Relationships between blood-serum variables and depth of rump fat in Alaskan moose**
KEECH MA, TR STEPHENSON, RT BOWYER, V VAN BALLENBERGHE, AND JM VER HOEF. 1998. *Alces* 34:173–179.

*Abstract:* We studied the relationship between maximum depth of rump fat determined from ultrasound measurements and 22 blood values for Alaskan moose (*Alces alces gigas*) by sampling 38 pregnant, adult females. Moose were immobilized, and blood was drawn simultaneously with the determination of depth of rump fat during 1–4 March 1996. Multiple-regression models were used to detect relationships between blood-serum variables and depth of fat. Four of 22 blood-serum variables we emoved to control for multicollinearity. Remaining variables were regressed against induction time ($\bar{x}$ = 6.1 min, $s$ = 4.4 min). Glucose, sodium, and blood urea nitrogen were correlated with induction time ($R^2$ = 0.27, $P$ = 0.010) and likely represented a response to handling; these blood values also were removed from the final regression model. Mallow's *Cp* statistic indicated the most appropriate regression model included only 2 variables. Creatinine ($\bar{x}$ = 2.08 mg/dl, $s$ = 0.26 mg/dl) and aspartate aminotransferase (AST) ($\bar{x}$ = 79.10 U/l, $s$ = 13.61 U/l) met all necessary assumptions and explained a portion of the variability observed in fat depth ($\bar{x}$ = 1.5 cm, $s$ = 1.0 cm). Thus, our final model was: maximum depth of rump fat = 0.28 + 1.68 (creatinine) –0.03 (AST). This model was significant ($P$ = 0.0002) and accounted for 33.7% ($R^2$) of variability observed in fat depth. Partial regression coefficients for creatinine and AST were 0.222 ($P$ = 0.0025) and 0.150 ($P$ = 0.006), respectively, and indicated that creatinine we slightly more influential than AST in the model. These blood variables may provide insights into the predicted condition of moose and the response of moose to environmental conditions. A model using blood variables thought to be indicators of physical condition (protein, phosphorous, and calcium) did not explain significant variation in maximum depth of rump fat.

**Effects of birthweight on growth of young moose: Do low-weight neonates compensate?**
KEECH MA, RD BOERTJE, RT BOWYER, AND BW DALE. 1999. *Alces* 35:51–57.

*Abstract:* We studied the relation between birthweight and 3 measurements of body size in 10 female Alaskan moose (*Alces alces gigas*) at 10 months of age in a population where density was high (1.3 moose/km$^2$), compared with other areas of Interior Alaska. Our study area was located in Interior Alaska, USA, between the Tanana River and the Alaska Range, directly south of Fairbanks. We captured newborn (<5 days old) moose from helicopters, weighed them, and then affixed radio collars during 14 May–3 June 1997. These same moose were immobilized with a dart-gun fired from a helicopter, weighed, and measured during 13–16 March 1998. We used regression analyses to investigate the relationships between weight at birth and weight, metatarsus length, and total body length for recaptured individuals at 10 months of age. Positive linear relationships existed between each measure of size at 10 months and weight at birth, and were highly significant ($P$<0.02). Further, birthweight explained significant variability in each of those 3 measurements ($r^2$ = 0.63, 0.64, 0.53, respectively). Our results support the hypothesis that neonates with lower weights at birth in this population did not exhibit compensatory growth and remained among the smallest individuals in their cohort, at least during their first 10 months of life.

**Life-history consequences of maternal condition in Alaskan moose**
KEECH MA, RT BOWYER, JM VER HOEF, RD BOERTJE, BW DALE, AND TR STEPHENSON. 2000. *Journal of Wildlife Management* 62:450–462.

*Abstract:* We studied life-history characteristics of Alaskan moose (*Alces alces gigas*) including the effects of maternal condition of adult females (>33 months old) on survival and physical condition of young during their first year-of-life. We also examined the relation between maternal condition and reproductive parameters of individual adult moose, and tested for effects of those parameters on timing and synchrony of parturition. We radiotracked adult females captured in both March 1996 and 1997 throughout the year with intensive monitoring occurring during spring and early summer. That procedure enabled us to capture the offspring of females we monitored and record other variables related to reproductive success. Females with greater rump fat thickness had higher rates of pregnancy, gave birth to more twins, and produced young with higher birth masses than did females with less rump fat. Time-to-death for individual young increased as birth mass increased and decreased as birth date and litter size increased; those birth variables, however, did not act upon time-to-death independently. Our results indicated maternal condition influenced subsequent variables associated with birth, which ultimately affected future survival of offspring. Further, timing of reproduction varied between the 2 years, with births occurring earlier but not more synchronously in 1996 than in 1997. Time of parturition occurred earlier for individual females with the thickest rump fat. That outcome indicated that timing of parturition was the result of environmental factors acting on females prior to giving birth rather than effects of attempting to avoid predation.

## V. RECOMMENDATIONS FOR THIS PROJECT

We hope to eventually maintain moose at moderate to high densities without repeating predator control programs that apparently helped moose increase to high densities in Unit 20A. We will continue to monitor the population with the techniques we currently have in place. In addition, we hope to monitor the response of the population to greater environmental stress such as severe winters. Currently we have the right tools in place to do so.

## VI. APPENDIX

Publications listed below were from the first few years of the 6 years of studying the Unit 20A moose population.

**Relationships between blood-serum variables and depth of rump fat in Alaskan moose**
KEECH MA, TR STEPHENSON, RT BOWYER, V VAN BALLENBERGHE, AND JM VER HOEF. 1998. *Alces* 34:173–179.

*Abstract:* We studied the relationship between maximum depth of rump fat determined from ultrasound measurements and 22 blood values for Alaskan moose (*Alces alces gigas*) by sampling 38 pregnant, adult females. Moose were immobilized, and blood was drawn simultaneously with the determination of depth of rump fat during 1–4 March 1996. Multiple-regression models were used to detect relationships between blood-serum variables and depth of fat. Four of 22 blood-serum variables were removed to control for multicollinearity. Remaining variables were regressed against induction time ($\bar{x}$ = 6.1 min, $s$ = 4.4 min). Glucose, sodium, and blood urea nitrogen were correlated with induction time

($R^2$ = 0.27, $P$ = 0.010) and likely represented a response to handling; these blood values also were removed from the final regression model. Mallow's *Cp* statistic indicated the most appropriate regression model included only 2 variables. Creatinine ($\bar{x}$ = 2.08 mg/dl, $s$ = 0.26 mg/dl) and aspartate aminotransferase (AST) ($\bar{x}$ = 79.10 U/l, $s$ = 13.61 U/l) met all necessary assumptions and explained a portion of the variability observed in fat depth ($\bar{x}$ = 1.5 cm, $s$ = 1.0 cm). Thus, our final model was: maximum depth of rump fat = 0.28 + 1.68 (creatinine) –0.03 (AST). This model was significant ($P$ = 0.0002) and accounted for 33.7% ($R^2$) of variability observed in fat depth. Partial regression coefficients for creatinine and AST were 0.222 ($P$ = 0.0025) and 0.150 ($P$ = 0.006), respectively, and indicated that creatinine we slightly more influential than AST in the model. These blood variables may provide insights into the predicted condition of moose and the response of moose to environmental conditions. A model using blood variables thought to be indicators of physical condition (protein, phosphorous, and calcium) did not explain significant variation in maximum depth of rump fat.

**Effects of birthweight on growth of young moose: Do low-weight neonates compensate?**

KEECH MA, RD BOERTJE, RT BOWYER, AND BW DALE. 1999. *Alces* 35:51–57.

*Abstract:* We studied the relation between birthweight and 3 measurements of body size in 10 female Alaskan moose (*Alces alces gigas*) at 10 months of age in a population where density was high (1.3 moose/km$^2$), compared with other areas of Interior Alaska. Our study area was located in Interior Alaska, USA, between the Tanana River and the Alaska Range, directly south of Fairbanks. We captured newborn (<5 days old) moose from helicopters, weighed them, and then affixed radio collars during 14 May–3 June 1997. These same moose were immobilized with a dart-gun fired from a helicopter, weighed, and measured during 13–16 March 1998. We used regression analyses to investigate the relationships between weight at birth and weight, metatarsus length, and total body length for recaptured individuals at 10 months of age. Positive linear relationships existed between each measure of size at 10 months and weight at birth, and were highly significant ($P$<0.02). Further, birthweight explained significant variability in each of those 3 measurements ($r^2$ = 0.63, 0.64, 0.53, respectively). Our results support the hypothesis that neonates with lower weights at birth in this population did not exhibit compensatory growth and remained among the smallest individuals in their cohort, at least during their first 10 months of life.

**Life-history consequences of maternal condition in Alaskan moose**

KEECH MA, RT BOWYER, JM VER HOEF, RD BOERTJE, BW DALE, AND TR STEPHENSON. 2000. *Journal of Wildlife Management* 62:450–462.

*Abstract:* We studied life-history characteristics of Alaskan moose (*Alces alces gigas*) including the effects of maternal condition of adult females (>33 months old) on survival and physical condition of young during their first year-of-life. We also examined the relation between maternal condition and reproductive parameters of individual adult moose, and tested for effects of those parameters on timing and synchrony of parturition. We radiotracked adult females captured in both March 1996 and 1997 throughout the year with intensive monitoring occurring during spring and early summer. That procedure enabled us to capture the offspring of females we monitored and record other variables related to reproductive success. Females with greater rump fat thickness had higher rates of

pregnancy, gave birth to more twins, and produced young with higher birth masses than did females with less rump fat. Time-to-death for individual young increased as birth mass increased and decreased as birth date and litter size increased; those birth variables, however, did not act upon time-to-death independently. Our results indicated maternal condition influenced subsequent variables associated with birth, which ultimately affected future survival of offspring. Further, timing of reproduction varied between the 2 years, with births occurring earlier but not more synchronously in 1996 than in 1997. Time of parturition occurred earlier for individual females with the thickest rump fat. That outcome indicated that timing of parturition was the result of environmental factors acting on females prior to giving birth rather than effects of attempting to avoid predation.

**LITERATURE CITED**


BOERTJE RD, P VALKENBURG, AND ME MCNAY. 1996. Increases in moose, caribou, and wolves following wolf control in Alaska. *Journal of Wildlife Management*. 60:474–489.

GASAWAY WC, SD DUBOIS, AND KL BRINK. 1980. Dispersal of subadult moose from a low-density population in Interior Alaska. *Proceedings of the North American Moose Conference and Workshop* 16:314–337.

GASAWAY WC, RD BOERTJE, DV GRANGAARD, DG KELLYHOUSE, RO STEPHENSON, AND DG LARSEN. 1992. *Wildlife Monographs* 120.


## VII. PROJECT COSTS FOR THIS SEGMENT PERIOD

FEDERAL AID SHARE $84,871 + STATE SHARE $28,289 = TOTAL $113,160

## VIII. PREPARED BY:

Rodney D Boertje
Wildlife Biologist III

**SUBMITTED BY:**

Patrick Valkenburg
Research Coordinator

Laura A McCarthy
Publications Technician II

**APPROVED BY:**

Thomas W. Paul, Federal Aid Coordinator
Division of Wildlife Conservation

for Wayne L Regelin, Director
Division of Wildlife Conservation

**APPROVAL DATE:** 9/25/02