Factors Limiting Moose at High Densities in Unit 20A

Research Final Report
1 July 1996 – 30 June 2002

RODNEY BOERTJE

Alaska Department of Fish and Game
Division of Wildlife Conservation

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Publications Specialist
ADF&G, Wildlife Conservation
P.O. Box 25526
Juneau, AK 99802-5526
(907) 465-4176

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FEDERAL AID
FINAL RESEARCH REPORT

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

PROJECT TITLE: Factors limiting moose at high densities in Unit 20A

AUTHOR: Rodney D Boertje

COOPERATORS: Layne Adams, USGS, Anchorage

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SUMMARY

We studied moose in central Unit 20A from 1996–2002 during a period of high, stable densities (11,500 moose in 5000 mi^2); this density is among the highest in North America for any 5000-mi^2 area. The proximate factor allowing moose to reach high densities has been uniquely high calf survival (>50%). The ultimate factors contributing to high calf survival in Unit 20A include (1) the apparent relative natural scarcity of grizzly bears and, to a lesser extent, black bears on the Tanana Flats; 2) the movement precalving of virtually all moose to the Tanana Flats; (3) the proximity of a large trapping population and winter access that has kept wolf numbers below prey-limited levels (high moose:wolf ratios), yet wolves are at relatively high densities for Alaska; (4) adequate moose habitat, although declining habitat quality is evident from declining moose production; and (5) adequate weather, although following periodic short summers, productivity declined below already low rates and survival declined. Initial rapid growth of the moose population occurred simultaneous to Alaska Department of Fish and Game wolf control from 1976 to 1982, but the population continued to increase through the early 1990s. Reduced productivity has contributed to the stability of the population. Productivity declined to the lowest levels observed on the continent as density increased, and has been at low levels since at least 1993. In some years, short summers contributed to extremely low productivity. We recommended changing harvest strategies during this study because bull:cow ratios were declining yet hunters desired continued high harvests. Limited drawing hunts for cows and calves were implemented as a result of our research. Harvest accounted for 5% of the immediate postcalving population, and was several-fold higher per unit area than in low-density moose populations. A review of case histories indicates that survival has a greater effect on Alaskan

moose populations than productivity because the total effect of survival is more variable. Relatively high calf survival continues to distinguish this premier moose resource from its counterparts at lower densities.

I. CUMULATIVE 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 reviewed available scientific literature during each of the 6 years.

OBJECTIVE 2: Estimate and evaluate the usefulness of several reproductive and condition indices for moose in Unit 20A.

Moose reproductive parameters in Unit 20A indicate that this moose population is experiencing the poorest nutrient regime measured among North American wild continental populations. Twinning rates declined in the mid-1980s when moose density was rapidly increasing. Since 1991 moose density has been relatively high and stable, and since 1996 we have observed a parturition rate of only 74% (n = 219) among random radiocollared moose ≥3 years old. Also, only 8% of 250 parturient cows ≥3 years old gave birth to twins, based on aerial transect surveys immediately postcalving or, when lacking, on age-justified samples of radiocollared moose.

We are the first investigators to radiocollar large samples of short-yearling moose and to acquire reproductive indices as these cohorts matured through 5 years of age. Age-specific reproductive indices were particularly useful in evaluating moose condition and in modeling moose demography. For example, (1) no 24-month-old moose (n = 38) were pregnant, (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 <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, Idaho USA) analyses produced identical results of pregnancy status in 1996, the only year when both results are available. However, daily observations during the calving seasons indicate lower 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 population modeling efforts.

Management staff have flown spring twinning rate transect surveys in central portions of the Tanana Flats for several decades without the benefit 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. We 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 60 kg differences between average bodyweights in the adjacent Denali and Unit 20A populations. We also noted significant differences in weights between subpopulations within the study area. Short yearlings in the Tanana Flats have weighed significantly less (about 17 kg less on average) than those in the Alaska Range foothills every year for 5 years. 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 bodyweights 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 unique 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 body weights 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 body weights, 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 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: Determine causes and respective rates of mortality among radiocollared moose of various age classes in Unit 20A.

Compared with results from similar moose mortality studies, our results were unique in 2 ways. First, our radiocollared calves experienced a mean annual mortality rate of only 46% in contrast to 67–81% in other studies. Second, wolves were the dominant proximate cause of moose mortality in our study, whereas 1 or 2 species of bears dominated annual moose mortality elsewhere.

Predation was the proximate cause of death in 34 (92%) of 37 cases where calves were collared as newborns. Wolves killed slightly more calves (n = 13) than either black (n = 9) or grizzly bears (n = 8), but differences were not significant ($\chi^2 \geq 1.03$, 1 df, $P \geq 0.31$). In 4 cases the predator could not be ascertained. Drowning, malnutrition, and injuries inflicted from a bull moose appeared to be the proximate causes of death in the remaining 3 cases. Sources of mortality were similar between the 2 years of the calf study ($\chi^2 = 8.85$, 4 df, $P = 0.065$) and annual rates did not differ significantly ($z = 0.602$, $P = 0.547$).

Wolf predation was also the most important proximate cause of death among radiocollared moose older than 12 months of age. Of 35 radiocollared yearlings for which we determined cause of death, wolves killed 25 (71%), black bears killed 4 (11%), grizzly bears killed 4 (11%) and nonpredation accounted for 2 (6%) of the deaths. Of 24 radiocollared adults ≥3 years old for which we determined cause of death, wolves killed 16 (67%), grizzly bears killed 4 (17%), and nonpredation accounted for 4 (17%) of the deaths.

Elevated moose calf percentages immediately following 2 wolf control programs in our study area indicated that wolves had been killing many moose calves that would otherwise live and reproduce. Regressions between calf percentages and wolf numbers indicated that the removal of about 100 wolves resulted in about 5% more moose calves in November. Wolf control occurred at both low and high densities of moose and results were similar indicating that wolf predation should be considered more additive than compensatory mortality over a wide range of moose densities in this system.

Moose survival rates were highly dependent on age. Based on a composite Kaplan-Meier survival curve, the survival rate was lowest among calves (54%, 95% CI = ± 5.0%, n = 48–223 at risk) and moderate among female yearlings (81% ± 6.5%, n = 115–203 at risk). Survival rates were highest during the next 5 years of life; 97% ± 7.3% survival among

female moose 24 through 83 months of age (n = 17–115 at risk) and 100% survival among females 47 through 83 months of age with an average of 33 moose at risk. Annual survival rates of females 7 years through 12 years of age ranged from 83% ± 13.1% to 96% ± 7.9% and did not differ significantly ($P < 0.05$, $\bar{x}$ = 89%). Annual survival rates of females 13 years through 16 years of age ranged from 68% ± 37.7% to 77% ± 21.8% and did not differ significantly ($P < 0.05$, $\bar{x}$ = 73%). No moose survived to the age of 17 years.

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.

II. WORK NOT ACCOMPLISHED AS CONTRACTED

All work was accomplished as contracted.

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

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

We reviewed available scientific literature during each of the 6 years.

JOB 2: Estimate reproductive and condition parameters of moose.

We initially immobilized 44 random adult moose in March 1996, 4 in March 1999, and 16 in March 2000. Rumpfat measurements, ages from tooth sectioning, PSPB blood values, transrectal ultrasonography, and observations of birth each subsequent May provided reproductive and condition data. We captured 46 newborn calves in May 1996 and 45 in May 1997; weights and blood values were used to evaluate condition of the moose population. Additionally, we captured and radiocollared 40 short yearling moose each March from 1997 through 2001 (5 years); observations of birth each subsequent May and initial March bodyweights provided the desired reproductive and condition data. We divided our study animals evenly between the Alaska Range foothills and Tanana Flats subpopulations to identify potential condition differences.

JOB 3: Assess causes and rate of mortality of moose.

To assess causes and rates of mortality of moose since March 1996, we listened to the radios of all moose at least monthly using fixed-wing aircraft deployed from Fairbanks. Additionally, flights were daily during each calving period and weekly during the summers, when causes of death are more difficult to determine. We listened for a doubling of the normal pulse rate of radios during these flights. When rapid pulse rates were heard, we obtained a latitude and longitude for the signal and immediately deployed a helicopter to

the site. We investigated causes of mortality and recovered the radio. Data were entered into Kaplan-Meier staggered entry spreadsheets.

JOB 4: Report writing and integration of results into ongoing management reports.

During this 6-year study, we published 4 P-R reports summarizing the data. These were printed in July 1997, February 1999, December 1999, and December 2000. In addition, data collected from the project was used repeatedly in Unit 20A moose management reports, advisory committee meetings, and oral and written reports to the Board of Game and area biologists.

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

Three graduate students studied Unit 20A moose or moose habitat under this project and either completed or are working toward completion of a Master of Science Degree in Wildlife Biology at the University of Alaska Fairbanks. Mark Keech focused his studies on moose calf mortality and he related condition indices of cows to the survival and condition of their offspring. C Tom Seaton gathered baseline moose habitat and dietary data on both subpopulations of moose in Unit 20A. Kalin Kellie is studying various aspects of moose movements in Unit 20A, including dispersal, fidelity to birth sites, migration, and home range size.

V. RESEARCH RESULTS

Since 1996 the Unit 20A posthunt moose population was stable at about 11,500 moose in 13,044 km^2 (880 moose/1000 km^2) with a declining bull:cow ratio. Moose productivity was compromised at these high densities, particularly twinning in all moose and birthrates in the 2- to 4-year-old cohorts. However, survival was 97% in the 2- to 7-year-old cohorts. Compared to low-density moose populations in interior systems, Unit 20A moose annually experience (1) a heavily-used range where browsing damage is readily apparent (80% of browsed plants are broomed), (2) extremely low twinning rates (8% of observed parturient cows) and low pregnancy rates (74% of cows ≥3 years old), (3) high calf survival (53%) and normal adult survival (88% for randomly selected cows ≥3 years old), (4) low annual bear predation (8% of post-calving population), (5) normal annual rates of wolf predation (14%) despite double the normal moose:wolf ratios, and (6) slightly elevated annual harvest rates by humans (5% of the postcalving population) and 4- to 6-fold higher harvests per unit area.

The following factors ultimately contribute to high moose densities in Unit 20A: (1) bears are a secondary predator on the Unit 20A moose population; in contrast to all 6 other study sites in Alaska where bears were the dominant predator on moose; (2) the proximity to a large trapping population and good access has allowed for a continual harvest of wolves sufficient to keep wolves below food-limited levels (i.e., moose:wolf ratios are high), although wolf densities are relatively high in Unit 20A; (3) moose habitat has generally been favorable with climax willow communities dominating subalpine habitat and wetland shrub and sedge communities common at lower altitudes, but alder is encroaching on these systems and habitat quality has been in a steady decline in recent years, which is evident in

the declining rates of production; and (4) suitable weather, although we detected that following short summers productivity declined below already low rates and calf survival declined.

VI. PUBLICATIONS

Four Pittman-Robertson research progress reports were printed on this project and several papers are in the early stages of preparation for publication. In addition, the following 5 abstracts are provided.

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 were 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 mo 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 rumpfat 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.

WINTER RANGE CHARACTERISTICS OF A NUTRIENT-STRESSED, PARTIALLY MIGRATORY MOOSE POPULATION

SEATON CT, DB GRIFFITH, JM VER HOEF, RD BOERTJE, AND K KIELLAND. In prep. *Journal of Wildlife Management* 00(0):000–000.

Abstract: We studied woody browse distribution, production, removal, species composition, twig size and moose diets in the Tanana Flats and adjacent foothills, Alaska, 2000. Moose density had been stable and at high (1.1 moose/km^2) density for approximately 9 years (1992–2000). Moose were partially migratory; all spent the summer in the flats and about 50% migrated to the foothills in autumn. Cow moose had a 6% adult twinning rate (n = 210), zero yearling pregnancy (n = 36), and postwinter weight of calves averaged 17.5 kg higher for the migratory segment of the population than for the resident segment (1997–2000). Because of the density, twinning rate, and yearling pregnancy rate,

we considered this population to be near carrying capacity. The large area average of current annual growth (CAG) browse production was 213 kg/ha, ±57 (95% CI) and removal by moose was 84 kg/ha, ±8 (95% CI). Of all willow, poplar, and paper birch plants sampled, 74% had a broomed architecture attributed to heavy use by moose. Using a model of daily moose intake based on bite mass and bite density we estimated that moose could not meet their expected daily intake on the mean twig dry mass (0.26 g) remaining unbrowsed at end of winter. Willow decreased in the diet from December through March from 56% to 35% while less preferred species compensated. Sites on the foothills had a higher proportion of species preferred by moose and mean bite mass was 36% greater in the foothills than in the flats, which may have influenced the late winter calf weight difference.

A PRELIMINARY RELATIONSHIP BETWEEN BROWSE PLANT ARCHITECTURE AND MOOSE TWINNING RATE

SEATON CT. In prep. *Alces* 00(0):000–000

Abstract: A preliminary study was performed in an attempt to find a characteristic of browse that showed a relationship to moose productivity. Emphasis was also placed on simplicity. We were searching for a method simple enough to be incorporated into most agency moose manager's yearly fieldwork. Browse plants of willow (*Salix* spp.), poplar (*Populus* spp.), and birch (*Betula paperifera*) were classified by their history of browsing by moose and resultant physical characteristics, called architecture. The classes used were Broomed, Browsed, and Unbrowsed. An index based on the proportion of broomed plants out of all plants with a history of moose browsing showed a strong relationship with moose production. The index to moose production was twinning rate.

VII RESEARCH EVALUATION AND RECOMMENDATIONS

We were pleased with the results of our unique study of cohort-specific moose productivity and mortality. We highly recommend this procedure, i.e., collaring large samples of short yearlings for several years, in all future studies of moose population health and demography. Far more information can be gathered in this manner than through conventional collaring of random adults.

A portion of this work is being continued because we do not yet know how this high-density moose population will respond in detail to severe winters. Previous detailed studies of Unit 20A caribou in the early 1990s indicated that annual reductions of 30% of the population could occur from the synergistic effects of deep snow and simultaneous increased wolf predation. However, the Unit 20A moose population did not decline during the early 1990s. Continued studies of Unit 20A moose are warranted at a reduced scale to investigate the possible adverse effects of deep snow on Unit 20A moose and to investigate the potential of a recent large fire on improving moose reproduction.

VIII FEDERAL AID TOTAL PROJECT COSTS FROM BEGINNING TO END OF PROJECT

$451,500

VII. 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

Wayne L Regelin, Director
Division of Wildlife Conservation

APPROVAL DATE: _____