FEDERAL AID RESEARCH FINAL PERFORMANCE REPORT

ALASKA DEPARTMENT OF FISH AND GAME
DIVISION OF WILDLIFE CONSERVATION
PO Box 25526
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PROJECT TITLE: Evaluation of moose-habitat conditions in southeastern Alaska

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FEDERAL AID GRANT PROGRAM: Wildlife Restoration

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WORK LOCATION: Gustavus

STATE: Alaska

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I. PROBLEM OR NEED THAT PROMPTED THIS RESEARCH

In 2003, winter population density estimates for moose on the Gustavus forelands were among the highest recorded for the species in Alaska, and appeared to be increasing. These data combined with winter browse monitoring information, suggesting very high utilization rates of preferred forages (Barten, unpub.), and limited evidence of predator-caused mortality suggested that this population is near or above carrying capacity and exhibiting irruptive population growth .

Understanding how moose interact with their environment has important management and conservation implications. For example, moose populations in southeastern Alaska have a relatively short history as a result of recent de-glaciation of regional landscapes (Dinneford 1988). The colonization trajectories of populations in southeastern Alaska have been characterized by irruptive fluctuations. In such cases, following an initial period of establishment, populations typically undergo a period of explosive growth and exceed K-carrying capacity resulting in a dramatic population crash and an associated decline in short- and long-term carrying capacity (Caughley 1970, 1976, McCullough 1997). The negative, density-dependent effects of such outcomes can be particularly acute for species such as moose that predominantly feed on perennial plant species that can be slow to recover from effects of prolonged over-browsing.

The overall objective of this study was to determine how variation in habitat quality, availability and spatial distribution affect moose body condition and productivity in a rapidly increasing, high density moose population. The project focused on evaluating the extent to which vital biological parameters of moose, such as pregnancy and twinning rates, were influenced by harvest mediated changes in moose population density.

Ultimately, this project aimed to provide a more complete understanding of moose-habitat relationships and population dynamics in the Gustavus area.

II. REVIEW OF PRIOR RESEARCH AND STUDIES IN PROGRESS ON THE PROBLEM OR NEED

High rates of herbivory can negatively alter habitat carrying capacity following well-documented pathways (Augustine and McNaughton 1998). For instance, over-utilization of preferred browse species such as, perennial shrubs in the willow family (*Salix* sp.), result in suppressed productivity and/or direct mortality of individual plants thereby reducing the amount of plant forage biomass per unit area available to moose (Singer et al. 1998). Ultimately, such preferred species, which may be common in early successional landscapes, are out-competed by other less- or non-palatable plant species (Pastor et al. 1988) such as, conifers. Further, increased herbivory of preferred plants can result in associated increases in production of secondary plant compounds, such as tannins, that decrease nutritional quality of forage (Bryant et al. 1989). The net result is an overall reduction in the distribution, productivity and quality of preferred species and reduction in overall habitat carrying capacity. In relatively stable landscapes, such as post-glacial sites in southeastern Alaska, the transition from willow vegetative communities to conifer dominated types is likely to be accelerated and irreversible, and consequent reductions in carrying capacity permanent.

III. APPROACHES USED AND FINDINGS RELATED TO THE OBJECTIVES AND TO PROBLEM OR

<u>OBJECTIVE 1: Assess body condition, reproductive success, and population density of moose on the Gustavus forelands.</u>

Since the inception of the study (i.e. November 2003), adult female moose were live-captured each spring (n = 192 captures) and fall (n = 147 captures) in order to assess body condition and pregnancy (during spring only). Body condition and reproductive status was also evaluated for 92 harvested female moose. In addition, calf recruitment was assessed for each radio-marked animal during June, November and March of each year. Overall, 73 individual adult female moose were captured, radio-marked, and monitored during 2003 to 2010. Population density and composition was estimated annually via winter aerial surveys conducted during November to March, depending on survey conditions.

<u>OBJECTIVE 2: Evaluate relationships between moose winter range conditions, body condition and reproductive success.</u>

Moose diet composition was evaluated monthly during winter (November–April) during 2003 to 2010. In addition, moose habitat conditions have been monitored annually during fall and winter by assessing biomass productivity and consumption for 300 individually marked *Salix barclayi* ramets (i.e. plants), both inside and outside fenced exclosures. Moose habitat conditions have also been monitored along 7 long-term transects during

April of each year. Analyses were conducted to compare habitat conditions and population density to moose body condition and reproductive success.

OBJECTIVE 3: Evaluate landscape-level habitat use patterns and population carrying capacity.

Moose spatial use patterns have been gathered by deploying 5 to 8 GPS radio-collars during each year (2003–2010, n = 37). Additional, spatial use information has been collected via monitoring of VHF marked moose. Habitat-specific forage biomass and utilization data have been collected on 400 sampling plots across the winter range (2004–2006). Chemical analyses of key winter forages have been estimated via laboratory analyses. These data were integrated in a resource selection modeling framework and detailed a positive relationship between resource selection patterns (for GPS radio-marked females) and overwinter loss in body condition. Specifically, moose that exhibited high selection for areas with low snow loading and high willow and horsetail biomass lost less body fat than those that exhibited low selection for the key covariates described above.

OBJECTIVE 4: Develop an adaptive harvest management model (AHM) for the Gustavus forelands moose population.

A two-stage matrix population model was developed and validated using vital rate data gathered from radio-marked adult female moose in Gustavus. The model has been validated using actual population estimates and has been used to inform harvest management decisions for the Gustavus population

OBJECTIVE 5: Analyze data, prepare reports and present results.

Field data have been annually summarized in order to characterize moose population, habitat conditions, and relationships therein. Findings related to specific aspects of the study have been published in the peer-reviewed literature (White et al. 2007, Hood et al. 2007). In addition, several presentations of study results have been given for local communities, advisory committees, and resource managers each year.

IV. MANAGEMENT IMPLICATIONS

Results of this research project clearly documented density dependent effects on nutritional condition and reproduction in the Gustavus moose population. Specifically, at high densities moose body condition and reproductive rates were low (relative to other populations in Alaska and North America), but increased substantially as the moose population was reduced following liberalized harvest (i.e. cow hunts). Field data collected during this project was examined annually to inform and adjust management actions. As a result the integration of active field research and harvest management programs enabled a calculated reduction of moose population density to a moderate level. This resulted in a desirable management situation such that moose nutritional condition was high enough to buffer effects of severe winters and resulted in increased reproductive rates and improved winter range habitat conditions.

V. SUMMARY OF WORK COMPLETED ON JOBS IDENTIFIED IN ANNUAL PLAN FOR LAST SEGMENT PERIOD ONLY

OBJECTIVE 1: Assess animal condition and population status.

JOB/ACTIVITY A: Determine age-specific body condition and pregnancy of adult female moose.
Job was completed by June 30, 2010 (see Section III above).

JOB/ACTIVITY B: Determine age-specific body condition and pregnancy for harvested cows.
Job was completed by June 30, 2010 (see Section III above).

OBJECTIVE 2: Assess moose habitat on wintering grounds.

JOB/ACTIVITY A: Determine spatial distribution of GPS collared individuals.
Job was completed by June 30, 2010 (see Section III above).

JOB/ACTIVITY B: Conduct ground-based surveys to characterize habitat conditions within individual home ranges.
Job was completed by June 30, 2010 (see Section III above).

OBJECTIVE 3: Evaluate habitat use and carrying capacity.

JOB/ACTIVITY A: Develop resource selection models to determine winter habitat use patterns and range distribution.
Job was completed by June 30, 2010 (see Section III above).

JOB/ACTIVITY B: Estimate winter range carrying capacity for the Gustavus moose population.
Job was completed by June 30, 2010 (see Section III above).

OBJECTIVE 4: Develop adaptive management model.

JOB/ACTIVITY A: Develop quantifiable management objectives and a list of feasible management actions.
Job was completed by June 30, 2010 (see Section III above).

JOB/ACTIVITY B: Develop models relating objectives, management actions, monitoring data, and the Gustavus moose/habitat system.
Job was completed by June 30, 2010 (see Section III above).

JOB/ACTIVITY C: Develop monitoring protocols to obtain the necessary data for the moose/habitat models and for assessing whether management goals are being achieved.

Job was completed by June 30, 2010 (see Section III above).

OBJECTIVE 5: Data analysis and reports.

JOB/ACTIVITY A: Analyze data from field studies and literature. Conduct statistical analysis on data sets and develop predictive models that will be used in AHM.
Job was completed by June 30, 2010 (see Section III above).

JOB/ACTIVITY B: Prepare Reports. Write annual progress reports and final reports at the end of the study. Prepare manuscripts for publication for all appropriate data sets.
The analysis was completed.

JOB/ACTIVITY C: Report results.
The final report for this project was completed. A summary is attached as an appendix.

VI. PUBLICATIONS

White, K.S., N.L. Barten, and J.A. Crouse. 2007. Ecology of moose on the Gustavus forelands: Population irruption, nutritional limitation and conservation implications. Proceedings of the 4th Glacier Bay Science Symposium, 4: 25-28.

Hood, E., A.E. Miller, and K.S. White. 2007. Effects of moose foraging on soil nutrient dynamics in the Gustavus forelands, Alaska. Proceedings of the 4th Glacier Bay Science Symposium, 4: 20-24.

VII. APPENDIX

Summary

Moose are an ecologically and culturally important species in southeastern Alaska. However, the history of the species in the region is relatively short and only since the 1920's have moose been documented in southeastern Alaska. During the intervening time period moose have successfully colonized early-successional stage habitats along the mainland coast, predominantly in the vicinity of large transboundary river systems connected to interior regions of Yukon and British Columbia. The earliest colonization events in the Yakutat and Haines areas were characterized by irruptive population dynamics and ultimately resulted in substantial population declines following several years of rapid population growth. The actual cause of the post-irruptive population declines in Yakutat and Haines was inadequately documented, but was likely related to a combination of factors including poor range conditions due to overbrowsing by high density moose populations, severe winter conditions and ill-timed implementation of antlerless moose hunts (i.e. following severe winters when the populations were in decline). These case studies highlight the need for careful monitoring and improved understanding of irruptive moose populations in southeast Alaska, particularly in situations where management interventions are proposed.

By the late-1990's, the moose population inhabiting the Gustavus forelands winter range (1st documented moose observed in 1966, presumably originating from the Haines population) was growing at approximately 25% per year and by 2003 had attained winter range densities that were among the highest recorded in Alaska (5.1 moose/km^2, and as high as 24 moose/km^2 in localized areas). During this period, winter range browse (*Salix barclayi*) assessment surveys indicated extreme rates of browse utilization (95% of twigs browsed, 40% of total twig biomass removed) and suggested the moose population was near or above nutritional carrying capacity. In response to these conditions, state wildlife management biologists felt it was necessary to consider management actions (i.e. liberal harvest of antlerless moose) to reduce moose population density to a level that would be ecologically sustainable over the long-term. Given the undesirable precedent established by previous management of irruptive moose populations in Yakutat and Haines, the proposed management actions were not considered appropriate unless a rigorous habitat and population monitoring program could be implemented to closely track the effects of proposed harvest management activities. The intent of this strategy was to allow for careful monitoring and annual adjustment of harvest management objectives while simultaneously providing an opportunity to advance our understanding of irruptive population dynamics and moose-habitat relationships.

During 2003 to 2011, a research and monitoring project was implemented in order to examine movement patterns, foraging behavior, nutritional ecology, reproduction, survival, and population dynamics of moose that wintered on the Gustavus forelands. During this time period, the moose population was reduced via any bull and antlerless moose hunts from 5.1 moose/km^2 (2003) to 2.4–2.7 moose/km^2 (2009–2011). Corresponding with management-mediated population reduction, 73 adult female moose were captured and radio-marked (37 with GPS-linked radio-collars) to enable characterization of movement patterns, nutritional ecology, reproduction, and survival. In addition, field surveys and laboratory analyses were conducted to estimate availability and utilization of forage resources on the winter range. These data were annually synthesized and used to inform harvest management decisions which ultimately resulted in cessation of the antlerless moose hunt in 2008. This occurred because multiple population metrics indicated the population had reached a moderate level that was considered to be ecologically sustainable and capable of providing consistent harvest opportunities over the long-term.

Radio-marked adult female moose were captured during each fall and spring during 2003 to 2011 (n = 338 capture events) to quantify body condition (percent body fat), determine pregnancy status (spring captures only), and deploy VHF or GPS radio-collars. Radio-marked animals were also monitored to determine survival, parturition, and survival of associated calves. Foraging behavior and diet of moose was characterized by conducting direct observations and via microhistological analyses of fecal pellets collected during monthly field surveys. Available forage biomass and browse utilization was estimated using multiple complementary field methods that included that included annual sampling along long-term transects (n = 6), seasonal sampling of permanently marked *Salix barclayi* ramets (n = 330) inside and outside fenced exclosures and habitat-specific sampling at random 4m^2 plots (n = 401).

Microhistological analyses of fecal pellets and direct foraging observations indicated that unbranched horsetail (*Equisetum variegatum*) and, to a lesser extent, Barclay's willow (*Salix barclayi*) were the primary winter forages consumed by moose during winter. Plant chemical analyses indicated that horsetail and willow had comparable concentrations of digestible energy and protein. However, horsetail biomass was over twice as abundant as willow across the study area. Heavy reliance of low-growing horsetail by moose during winter is unusual and exacerbates constraints imposed by snow on forage availability. Winters were typically mild and snow depth averaged 5.5 inches between November to April. However, during period of deep snow horsetail consumption was reduced relative to willow, but only when moose density was low. When density was high, moose consumed horsetail under moderate snow depths (by digging) because willow biomass was often depleted, especially in late-winter. Other prominent (5–25% depending on month) forages consumed by moose included sweet gale (*Myrica gale*) and western hemlock (*Tsuga heterophylla*), but were generally consumed in low quantities, primarily when snow depth was deep.

The Gustavus moose population exhibited strong density dependent responses to harvest mediated changes in moose population density. Specifically, percent body fat, pregnancy, twinning and fecundity increased linearly as population density declined; the occurrence of reproductive pauses declined as population density decreased. The probability of an animal being pregnant or experiencing a reproductive pause was significantly related to percent body fat in both fall and spring. However, old females exhibited lower rates of pregnancy than prime-aged or young females. Also, females incurred a significant nutritional cost of reproduction such that animals with a calf at heel had significantly less body fat than those without a calf at heel. Consequently, the reduction of population density via antlerless harvest resulted in adult female moose being in improved body condition and higher reproductive rates.

Migration strategies of Gustavus moose exhibited explicit links to population performance. Sixty-six percent of the radio-marked adult females that wintered on the Gustavus forelands migrated to geographically distinct summer ranges prior to calving; primarily to either a coastal island archipelago or an upland ridge system. Animals that migrated did not gain more body fat over the summer period than animal that resided on the Gustavus forelands; nor did they have more body fat prior to migration. However, calf survival of females that migrated ($\hat{S}$ = 0.50, n = 68) was 2.6–2.9 times higher than those did not migrate ($\hat{S}$ = 0.19, n = 57). The causes of calf mortality could not be ascertained but anecdotal evidence suggests that females calving on the forelands may be more vulnerable to predation by black bears and wolves. Moose summering on the forelands are also more likely to be harassed by domestic dogs.

Resource selection patterns of over-wintering moose were examined for 25 GPS radio-collared adult females for which consecutive fall and spring body condition measurements were obtained. A resource selection function (RSF) modeling framework was used to examine forage-based factors that influence habitat selection and how selection patterns affect over-winter loss of body fat. During winter, moose selected for areas with low snow loads and high willow and horsetail biomass, relative to availability across the study area. Adult females that selected more strongly for these factors than the population as a whole tended to lose less body fat over-winter than females that selected weakly for these factors. The findings demonstrate an explicit linkage between resource selection patterns and a biologically informative measure of moose population performance.

Overall, this project examined a broad cross-section of topics related to moose-habitat ecology and population dynamics. Explicit measures of population performance and habitat conditions, acquired though extensive field research efforts, were integrated with a regionally high-profile and contentious population management program to provide a rigorous, data-rich framework for evaluating harvest objectives. These efforts resulted in successful accomplishment of management objectives and advancement of our knowledge about moose-habitat ecology, density dependence and irruptive population dynamics.

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