FEDERAL AID RESEARCH FINAL PERFORMANCE REPORT

ALASKA DEPARTMENT OF FISH AND GAME
DIVISION OF WILDLIFE CONSERVATION
PO Box 115526
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PROJECT TITLE: Analysis of the nitrogen budget of moose in Unit 13A, Nelchina Basin

PRINCIPAL INVESTIGATOR: William B. Collins

COOPERATORS: University of Alaska Anchorage, University of Alaska Fairbanks, US Bureau of Land Management, US Fish and Wildlife Service, and US Forest Service.

FEDERAL AID GRANT PROGRAM: Wildlife Restoration

GRANT AND SEGMENT NO. W-33-7

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STATE: Alaska

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I. PROBLEM OR NEED THAT PROMPTED THIS RESEARCH

Deficiencies of protein or other nutrients can significantly reduce the productivity of herbivore populations, and can potentially alter predator prey dynamics by inducing "weak calf syndrome", potentially making calves more susceptible to predation. Such dynamics have not been documented for large herbivores to date, but this is not surprising given the complexity and potentially cryptic nature of the interactions. Our recent investigations on the protein levels of at least a few of the principal forages of moose in the Nelchina Basin and the Kenai Peninsula indicate that such interactions are possible. It is therefore important to examine such hypotheses and either reject them or determine their significance and role in population dynamics.

If nutritional limitations are verified, then causal mechanisms must be sought to explain these apparent shifts in habitat quality in recent years. Causal factors may include successional change, climate change and its effect on plant chemistry, or herbivore-induced changes in plant chemistry. Although the treatment of habitats to modify nutritional status ultimately may not be possible, prescribed fire is a feasible management tool for manipulating forage availability and nutritional characteristics under some conditions.

Regardless of whether feasible habitat improvement options are available, an understanding of all ecological influences (and their interactions) on moose population dynamics is necessary for managers to make informed and appropriate decisions regarding moose, habitat, and predator population management, and to set reasonable and achievable population objectives.

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

Recent work of Collins (1997), Jenkins et al. (2002) and Schoen (2002) suggested that moose within the Nelchina Basin and the Kenai Peninsula may be nutritionally limited, particularly by nitrogen. In the NSA, digestible protein levels in diamondleaf willow (*Salix pulchra*), an important summer forage of moose (Van Ballenberghe et al. 1989), ranged from a high of 9% in June to a low of approx. 1% in August/September (Fig. 1). In addition, digestible protein levels in willows of the NSA in winter ranged from approximately 1% in *S. alaxensis* to –1% in *S. pulchra*. Apparently, nitrogen availability is below maintenance levels for moose for much of the year in the NSA.

Low dietary nitrogen levels may explain the low productivity of moose in the Nelchina study area over recent years, including the relatively low pregnancy rates, extremely low twinning rates, and high age of first reproduction observed over the period from 1995 to 2001 (Testa 2001). Although predation on calves, as documented by Testa (2001) and others (Ballard et al. 1990, Ballard et al. 1991), clearly has a dramatic effect on the population dynamics of moose in the NSA, nutritional deficiencies can potentially exacerbate such interactions. Clarification of the role of nutrition of moose is fundamental to an informed and integrated approach to management of habitats, moose and their predators.

Ballard, W.B., S.D. Miller, and J.S. Whitman. 1990. Brown and black bear predation on moose in southcentral Alaska. Alces 26:1-8.

Ballard, W.B., J.S. Whitman, and D.J. Reed. 1991. Population dynamics of moose in south-central Alaska. Wildlife Monographs 55:1- 49.

Collins, W.B. 1997. Interrelationship of Forage and Moose in Game Management Unit 13. Federal Aid in Wildlife Restoration Research Progress Report Grant W-24-5, Study 1.5, Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau.

Jenkins, S.G., T.R. Stephenson, J.A. Crouse, D.E. Spalinger, and C.T. Robbins. 2002. Effects of plant architecture and chemistry on moose (Alces alces) browsing behavior. Canadian Journal of Zoology (submitted).

Schoen, E.R. 2002. Does summer diet quality limit moose populations? Honors Thesis. Dartmouth.

Testa, J.W. 2001. Population Dynamics of Moose and Predators in Game Management Unit 13. Federal Aid in Wildlife Restoration Research Final Report Grant W-27-1 Study 1.49, Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau.

Van Ballenberghe, D.G. Miquelle, and J.G. MacCracken. 1989. Heavy utilization of woody plants by moose during summer in Denali National Park, Alaska. Alces 25:31-35.

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

OBJECTIVE 1: Clarify the role of nitrogen as a potentially limiting nutrient to moose in NSA and the KPSA.

One objective of this study was to clarify the role of nitrogen as a potentially limiting nutrient to moose. We compared dietary nitrogen availability in the major forage species of moose in portions of the Nelchina Basin, Denali National Park, Placer Valley and Togiak Valley. At the outset, this comparison required that we quantify the diets of moose unambiguously in each of the ranges studied. To do this, we developed a technique for determining diet based on the signature of plant alkanes found in the feces. We tested this technique against bite counts and microhistological analysis of feces of tame moose.

We examined the phenological progression of leaf nitrogen concentration, tannin-protein precipitation capacity, and digestible protein over 2 – 3 years in each of these regions. We then modeled the potential nutritional consequences for a cow moose consuming representative diets on each range, predicting both net protein intake and lean body mass accumulation each year.

We found significant differences in dietary nitrogen availability between ranges and between years within individual forage species. Our net protein intake model predicted differences of up to 3 weeks in positive protein balance between Nelchina and Denali ranges. These differences could account for annual differences of up to 18 kg accumulated lean body mass in cows. We have not completed our analysis of Togiak data, but we expect much greater accumulation of lean body mass there, because of greater accumulation of plant nitrogen, lower tannin concentration, and a substantially longer growing season. We conclude that summer dietary nitrogen availability may act as a nutritional constraint on moose and suggest more emphasis be placed on determining its role in population dynamics and conservation of moose and of northern ungulates in general.

We conducted a series of total collection digestion trials with captive moose to examine the ability of moose to compensate for high tannin concentrations in their foods and to compare their digestive capabilities to other browsing cervids. We fed 4 moose 13 single-species diets including 10 native tannin-containing forages and 3 non-tanniferous foods over 3 winters.

We found that moose were nearly identical to mule and white-tailed deer in their ability to digest protein, neutral detergent fiber, dry matter and energy of tanning-containing foods. True protein digestibility in moose was 94%, and metabolic fecal N excretion was estimated at 0.416 g N/100 g dry matter intake. Tannins reduced protein digestion by an average of 20%, and the rate of reduction in protein digestion was estimated to be 8.48 g protein/100 g DM/unit protein precipitating capacity. These results were not significantly different from those of similar trials with mule and white-tailed deer. Although digestibility of neutral detergent fiber, neutral detergent solubles, dry matter, and energy in moose was accurately predicted by equations developed for mule and white-tailed deer, our experiments provide refined assays for better evaluating the nutritional quality of browses for moose, especially for tannin-rich foods typically comprising their diets.

IV. MANAGEMENT IMPLICATIONS

We observed significant and substantial differences in available nitrogen within individual forage species between ranges and between years. While selective browsing by moose overcomes some of the limitations imposed by the quality of individual species, overall diet quality can vary significantly from one range to another and across years, having significant effects on animal performance, including reproductive success and survival. These differences may occur even where forage availability is relatively unlimited. Thus, traditional examinations of ranges for forage abundance fail to give adequate evaluation of the range resource.

Our observations lead us to believe that available nitrogen can be as significant in the productivity of moose populations as any other limiting factor—predation, forage availability, snow, etc.—and that it is fundamental to an informed and integrated approach to management of habitats, moose and their predators.

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

JOB/ACTIVITY 1: Moose forage nitrogen and protein binding capacities of moose forages.

Analysis of forages for nitrogen and protein binding capacities was extended to three additional ranges—Placer, Togiak, and Colville drainages—to broaden our analysis of these variables relative to the reproductive performance of moose.

JOB/ACTIVITY 2A: Forage selection and food habits by tractable moose in Nelchina Basin.

Analyses of these data were completed, and manuscripts are being prepared for publication.

JOB/ACTIVITY 2B: Moose diet based on microhistilogical and alkane analysis.

Alkane analysis was completed. Microhistilogical analysis is currently being carried out by an independent laboratory. This will allow an unbiased comparison to the alkane analysis we have developed. As soon as these data are received, a manuscript will be submitted for publication.

JOB/ACTIVITY 2C: The influence of fire history on diet selection, intake rates, and digestible N intake in moose on the Kenai NWR.

This job was not attempted after all, due to time and budgetary constraints incurred in completing other jobs.

JOB/ACTIVITY 3: Nitrogen balance tials and determining the digestibility of nitrogen by moose in presence of forage tannins.

Nitrogen, tannin, and energy contents of forages, orts, fecal and urine samples collected in digestion balance trials, and analyses of results were completed. A manuscript was completed and submitted for publication.

VI. ADDITIONAL FEDERAL AID-FUNDED WORK NOT DESCRIBED ABOVE THAT WAS ACCOMPLISHED ON THIS PROJECT DURING THE LAST SEGMENT PERIOD, IF NOT REPORTED PREVIOUSLY

We examined 'bypass' in moose: passage of fluid ingested versus fluid inserted into the rumen in fistulated moose, and we determined differential passage of fluids and different-sized particles in fistulated moose. Manuscripts were submitted for publication. We also investigated the possibility of moose serving as a vector for dispersal of viable white sweetclover and hawksbeard seeds, and we submitted a manuscript for publication.

VII. PUBLICATIONS

McArt, S.H., D.E. Spalinger, J.M. Kennish, and W.B. Collins. 2006. A modified method for determining tannin-protein precipitation capacity using accelerated solvent extraction (ASE) and microplate gel filtration. Journal of Chemical Ecology 32:1367-1377.

McArt, S.H., D.E. Spalinger, W.B. Collins, E.R. Shoen, T. Stevenson, and M. Bucho. 2009. Sumerdietary nitrogen availability as a potential bottom-up constraint on moose in south-central Alaska. Ecology 90(5):1400-1411.

Lechner, I., P. Barboza, W. Collins, D. Günther, B. Hattendorf, J. Hummel, M. Clauss. 2009 No 'bypass' in adult ruminants: passage of fluid ingested vs. fluid inserted into the rumen in fistulated muskoxen (Ovibos moschatus), reindeer (Rangifer tarandus) and moose (Alces alces). Comparative Biochemistry and Physiology A 154: 151-156.

Lechner, I., P. Barboza, W. Collins, J. Fritz, D. Günther, B. Hattendorf, J. Hummel, K. Südekum, M. Clause. (submitted). Differential passage of fluids and different-sized particles in fistulated oxen (Bos taurus), muskox (Ovibos moschatus), reindeer (Rangifer tarandus) and moose (Alces alces): rumen particle size discrimination is independent from contents stratification. Comparative Biochemistry and Physiology

Seefeldt, S, W.B. Collins, and J.C. Kuhl. (in press). White sweetclover and narrowleaf hawksbeard seed viability after passing through moose. Invasive Plant Science and Management.

Spalinger, D.E., W.B. Collins, T.A. Hanley, N.E. Cassara, and A.M. Carnahan. (submitted). The impact of tannins on protein, dry matter, and energy digestion. Ecology.

VIII. RESEARCH EVALUATION AND RECOMMENDATIONS

None.

IX. APPENDIX

None.

PREPARED BY: APPROVED BY:

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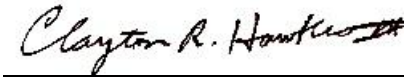
Wildlife Biologist III



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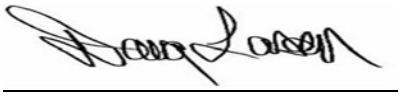

Douglas Larsen, Director
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APPROVAL DATE: _____