Habitat condition, diet, and nutritional quality of available forage: implications for a declining moose population in northwest Wyoming

STATEMENT OF ISSUE:

Phase I suggested that the population decline observed in Jackson moose is being caused by poor habitat quality, however, direct evaluation of habitat has yet to be conducted. The primary goals of phase II are to assess the condition and nutritional quality of forage within moose seasonal ranges and to connect these measures of habitat quality with the performance of individual moose (i.e., do moose using poor habitat have lower survival, pregnancy, or twinning?). This approach will clarify the degree to which habitat condition and quality are responsible for the current population decline.

BACKGROUND:

Shiras moose in the north Jackson Herd Unit winter along the Buffalo Fork and upper Snake River drainages (Brimeyer 2004). While a portion of these moose are non-migratory, the majority migrate north into the Teton Wilderness and southern YNP (Becker 2008). Research has shown that moose, including those in the proposed study area, select for low elevation riparian habitats (Langley 1993, Becker 2008). Much of the study area experienced fires in the late 1980s. Fire usually creates habitats favorable to moose, creates higher quality and quantities of edge habitat (Davis and Franzmann 1979), and is often followed by an increase in moose reproduction and density (Bangs and Bailey 1980). However, moose in the north Jackson herd unit have continued to decline despite an abundance of fires in the last 20 years. Thus, the influence of fire (including the 1988 fires) on moose population performance remains unclear for Jackson moose.

Habitat condition is often measured by assessments of browse intensity over time (Keigley 2002). Browsing by ungulates has been shown to influence the composition of vegetation (Horsley et al. 2003, Rooney and Waller 2003) and its regeneration (Liang and Seagle 2002, Persson et al. 2005). Seaton (2003) reported that areas with high moose densities experienced increased browse removal and decreased twinning rates. In addition, moose in areas with higher proportions of intensely browsed willows (broomed) also experienced lower twinning rates (Seaton 2002). Winter habitat surveys that assess browse intensity have been conducted in the Buffalo Valley, but have been inconclusive. The condition of forage on summer range, including the effects of wildfire, has never been evaluated.

Research has shown high variability in moose diets and nutritional quality (Renecker and Hudson 1988) among habitat types and snow depths (Stevenson 1970). During winter, moose diets often consist of >84% willow species (Harry 1957, Stevenson 1970, Reisenhoover 1989). McMillan (1953), and Dungan and Wright (2005) reported a range of 30% - 90% willow use in moose summer diets. Because forage species vary in nutrient content (Nielsen 1985), diet composition must be calculated in order to assess overall nutritional quality of available forage.

Becker (2008) found Shiras moose in the north Jackson Herd Unit to be in poor-moderate nutritional condition and potentially deficient in various macro and micro-minerals, which may have resulted in the low parturition rates and *in-utero* losses documented over winter. Research has suggested that while foraging, ungulates select for plants high in nitrogen (Tripler et al. 2002) and that browsing can negatively affect the nutrient, fiber and nitrogen content of plants

(Danell et al. 1994) and soil (Harrison and Bardget 2004). Low levels of Cu can result in decreased reproductive rates and mortality under increased stress (Flynn et al. 1977, O'Hara 2001), as observed in this study, as well as immunosuppression (Flynn and Franzmann 1987 and Puls 1988), and antler abnormalities in white tailed deer (*Odocoileus virginianus*) and elk (Gogan et al. 1989). Research has shown that forage quality varies seasonally due to availability (Nieminen and Heiskari 1989), structurally (Ohlson 1988, Ohlson and Malmer 1990), regionally due to soil substrate, shade intensity, and transport by water and animal interactions (Nieminen et al. 1987, Staaland and Saebo 1993) and that more than 24 minerals are required by ungulates for growth and survival (McDowell 1992, Robbins 1993, McDonald et al. 1995). Examining the nutritional quality of browse can determine the availability of minerals in the diet, fiber and protein content, and other necessary nutritional factors (O'Hara 2001). Characterizing the nutritional quality of forage, its potential variation and availability to Jackson moose is necessary to understand its role in the current population decline. Nonetheless, Becker (2008) did not directly evaluate the condition of the moose range nor the quality of available forage.

The majority of the research on Shiras moose is greater than 20 years old (McMillan 1965, Harry 1957, Knowlton 1960, Stevens 1970) and thus does not cover the period of recent declines (11-16 years). Research has shown that intense browsing can reduce the quality of available forage and thus moose nutritional condition, which can result in developmental abnormalities, reduced reproductive success, and reduced survival of ungulates. Becker (2008) inferred rather than quantified the effects of poor habitat quality on moose survival and reproduction. To better characterize the factors causing the decline of Jackson moose and to project future population trends, it is necessary to directly measure the condition and nutritional quality of available moose forage.

OBJECTIVES:
The overall goal of this work is to increase our current understanding of Shiras moose and determine the cause of the population decline observed in the Jackson Herd Unit. The primary objective of phase II is to characterize the condition and nutritional quality of seasonal habitats in the north Jackson Herd Unit. An important secondary objective is to determine if moose demographic performance (i.e., survival and reproductive success) is reduced in areas of poor habitat condition or quality. The specific objectives are as follows:

1. Characterize moose habitat condition (i.e., browsing intensity) in winter and summer.
2. Compare the nutritional quality of winter and summer browse, and evaluate the factors that influence forage quality (i.e., wildfires).
3. Evaluate the influence of habitat condition and forage quality on cow survival, pregnancy, parturition, and calf survival of collared moose from both phases of the study.
4. Characterize the timing of moose calf mortality and develop indices of predator use and diet in order to inform our knowledge of the potential influence of wolf and bear predation on calf survival.

METHODS:

Objective 2: Characterizing habitat condition

Radio collar relocations—In order to identify the foraging habitats used by moose during winter and summer, we are using GPS technology to track study animals. Moose are currently fitted with both VHF and GPS collars. Recent research on Shiras moose in the Jackson Herd Unit (Becker 2008) used GPS collars to evaluate seasonal range use and migration. To refine our understanding of moose habitat use, 19 GPS collars were deployed via helicopter net-gunning in February 2008. These collars will collect locations every hour June 1– November 15 (summer), every 3 hours December 15- April 31 (winter), and once a day during May and November 16- December 14 (migration). Helicopter captures and moose handling protocols were approved by the University of Wyoming Institutional Animal Care and Use Committee, January 2008.

Habitat condition—To provide a consistent and comparable assessment of habitat condition we are using a habitat condition survey method developed by Keigley and others (2002) and used by Montana Fish Wildlife and Parks, WGFD, and the Teton Science School, as well as other Rocky Mountain states with Shiras moose. This method provides a measure by which researchers can assess the level of browsing intensity on key forage species, including determination of overbrowsing. Line transects (45 winter and 29 summer) 200m in length (Fig. 1) were set and monitored via the Keigley method in winter 2007-2008 and summer 2008. In addition to habitat condition trend data we are conducting monthly measures of % of stems browsed and diameter at browse point (DBP) to monitor potential change in intensity of use over the seasons and to assess biomass removed within the winter ranges. Ten biomass removal plots (15 m diameter), located at the Keigley transects, are also being monitored during winter. Snow depth's and weights for snow/water equivalents are also being recorded at each transect location during winter. Collection of this data will extend annual monitoring of existing transects and enhance long-term trend data for habitat condition already being collected by WGFD in the Buffalo Valley.

Objective 3: Comparing the nutritional quality of browse

Diet—To accurately assess the nutrition available to moose from selected diets we must first determine diet composition. To enhance the collection of forage species consumed during summer, foraging moose will be observed and plant species will be identified after the moose leaves the area. In addition, approximately 10 pellets from each of 10-15 distinct moose pellet groups will be collected from each of 11 defined winter and summer ranges. Composite samples from the sample areas will be analyzed at the University of Washington Wildlife Habitat Nutrition Laboratory. One hundred microscope views to identify forage classes and major plants species (>5%) in the diet will be conducted for each composite sample. This analysis will characterize the percentage of preferred forage species in moose fecal samples.

Nutritional quality of vegetation – To assess the nutritional quality and nutritional availability of moose browse we will evaluate the quality of moose diets via the analysis of forage species. From each sampling area (see Fig. 1), 40 vegetation samples will be collected for nutritional quality assays. From each plant, 30g (wet weight) of material will be removed, stored in paper bags, oven dried at 55˚C, and stored until analysis. To assess the nutritional quality of browse identified from fecal analyses and direct observations, vegetation clippings will be analyzed at the Colorado State University Soil, Water and Plant Testing Laboratory for determination of % crude protein, crude fiber, acid detergent fiber, neutral detergent fiber, and in-vitro dry matter digestibility. To assess the mineral deficiencies found in moose blood in phase I (Becker 2008) we will also evaluate both macro and micronutrient levels in collected vegetation. This analysis will be performed for each of the main forage species (up to 6) identified from the diet composition analysis in each of the identified seasonal ranges. Analysis of forage species will allow us to determine nutrient content of preferred forages while quality analysis based on diet composition will provide insight into the availability of those nutrients to moose.

Objective 4: Evaluating the influence of habitat condition and quality on survival, pregnancy and parturition.

Survival— Moose will be located monthly to assess survival. Ground telemetry will be the primary method of monitoring. Moose not located via ground tracking, will be located during telemetry flights. Helicopters (Savage Air) and fixed-wing (Sky Aviation) aircraft will be used during this project to monitor for neonate and adult survival. Parturition and neonate survival helicopter surveys will be initiated for 3 days during the first week of June and the third week of July, respectively. Each collared cow documented with a calf in July will be relocated on winter range to determine calf survival.

Mortality signals will be investigated and where feasible, field necropsy will be conducted to determine cause of death (O'Gara 1978). Navigation to mortality sites will occur on foot or with assistance of horse stock. During the necropsy, we will collect a 3-inch section of bone marrow to assess condition at time of death, as well as a mandible (or tooth), to verify the age of the animal. During 2008, moose captures were conducted without immobilization agents and when feasible, estimates of age were done by gross examination of molars.

Objective 5: Characterize the timing of moose calf mortality

Predation- Bears tend to prey on moose neonates (0-3 months; Bertram and Vivion 2002) and wolves prey on calves (>3 months; Larsen et al. 1989). Helicopter surveys allow us to distinguish between rates of neonate mortality during these two time periods. To monitor bear presence and species (i.e., brown bears (*Ursus arctos*) and black bears (*U. americanus*), scats will be collected from summer sampling areas. Scats will be analyzed for diet composition and DNA up to the species or individual level. These collections are not intended to provide a conclusive test of the influence of bears or wolves on moose population decline. Rather, this information will provide us with a better understanding of bear distribution and diet in indentified moose parturition areas, and of the seasonal timing of moose calf losses.

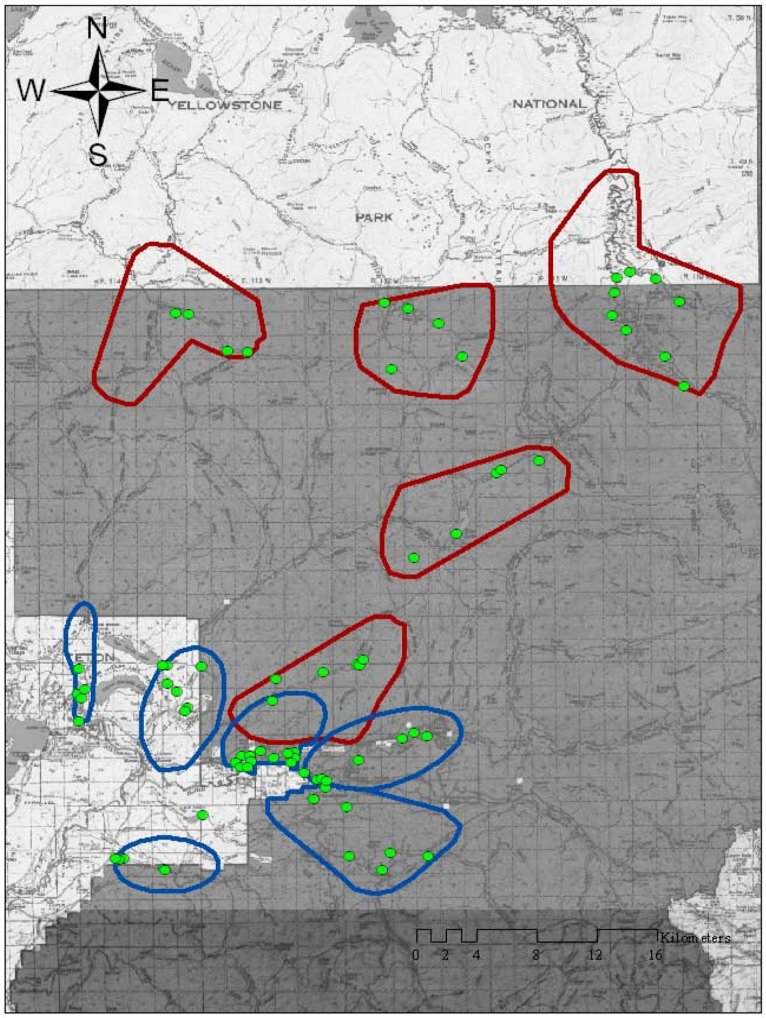

Figure 1. Locations of willow sampling areas. Winter range is depicted by blue polygons and summer range by red polygons.

PHASE II, 2008 FIELD SEASON SUMMARY:

Collaring

- 32 collars (19 GPS and 13 VHF) were added to the study in February 2008, which brought our total to 68 moose (13 bulls, 55 cows).

Pregnancy/Adult Survival

- Pregnancy of captured moose (BY 2007) was low compared to phase I (75% vs 91.5%).
- 17 mortalities of collared adult female moose (31%), occurred during winter 2007-2008.
  - 19 cows : 0 bulls
  - 17 confirmed mortalities
  - 1 dropped collar
  - 1 not investigated yet

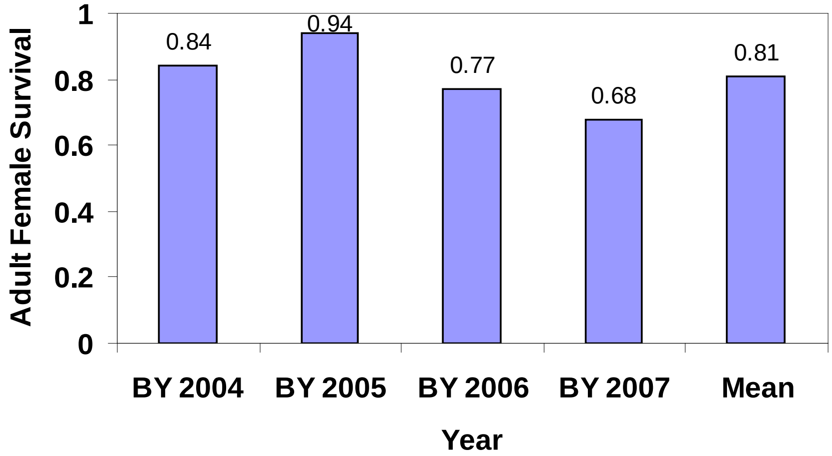

Figure 2. Survival of adult female moose across both phases of the Jackson moose study

Please note that 2007adut survival is an estimate trying to account for mortalities post Scotts cut off.

Parturition and Neonate Survival

- Decreased parturition was observed for non-handled moose compared to previous years due to heavy snow in winter 2007-2008.
- Neonate survival was consistent with previous years.
- Calf survival will be assessed this winter upon return of moose to winter range.

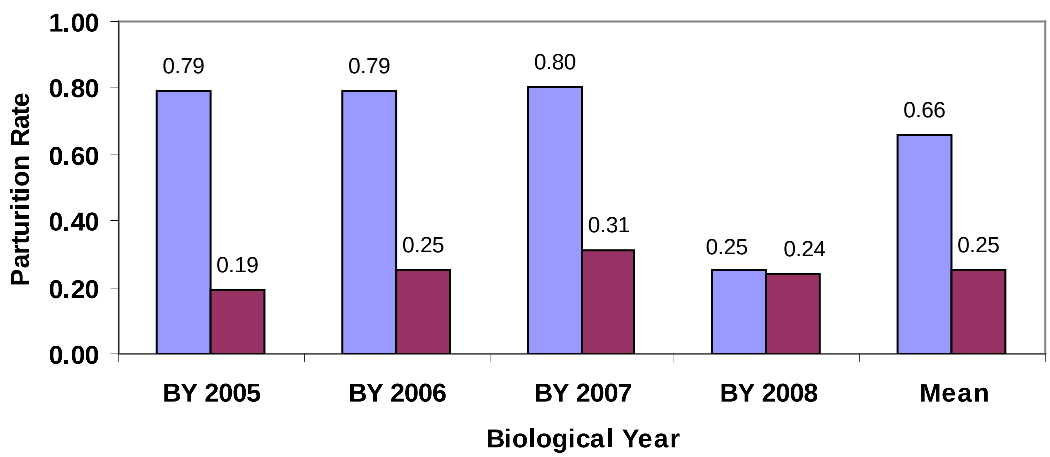

Figure 3. Parturition of non-handled (blue) and handled (purple) moose across both phases of the Jackson Moose Project.

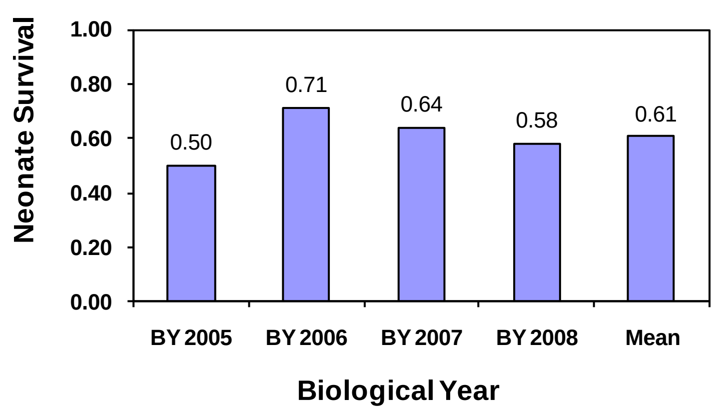

Figure 4. Neonate survival for both phases of the Jackson moose study.

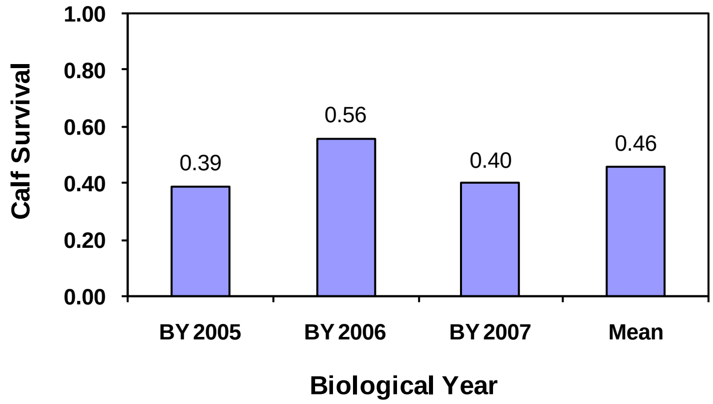

Figure 5. Calf survival during phase I of the Jackson moose study.

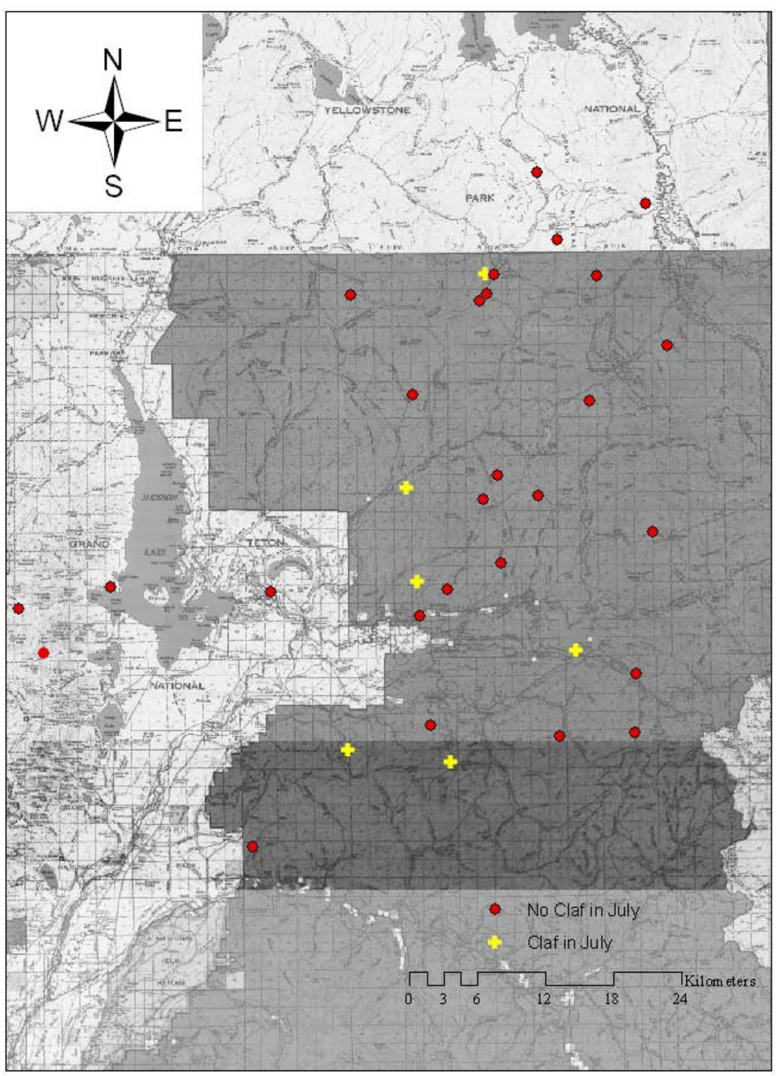

Figure 6. Locations of moose with (yellow) and without (red) calves at side during neonate surveys, July 2008.

Habitat Condition

- We successfully monitored 45 Keigley transects within 6 sample areas during winter 2007-2008 and 29 transects within 5 sampling areas during summer 2008. Data from winter 2008 suggest overall, that winter range is in poor condition (see Fig. 8 below). The calculated L/D indexes indicate declining habitat condition as index numbers decrease (i.e. Geyer willow with a condition score of <60 is considered in poor condition). Biomass and summer data are still being entered. Please note that the cutoff of 60 will alter based on measurements taken this coming winter. This is just to give you an idea of the possibilities, I believe Keigley stated that <80 was in poor condition for Geyer, however we will determine a better measure for the BV soon.

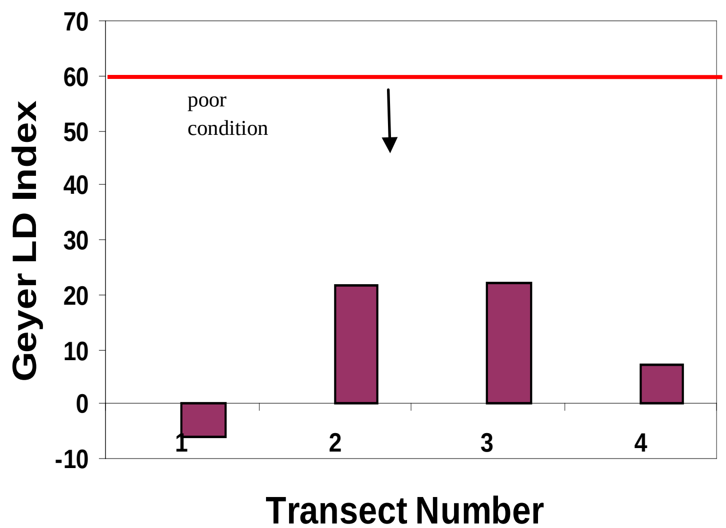

Figure 7. Example of winter Keigley transect L/D index for geyer willow in the Buffalo Valley. For geyer willow, L/D indices of <60 are considered in poor condition.

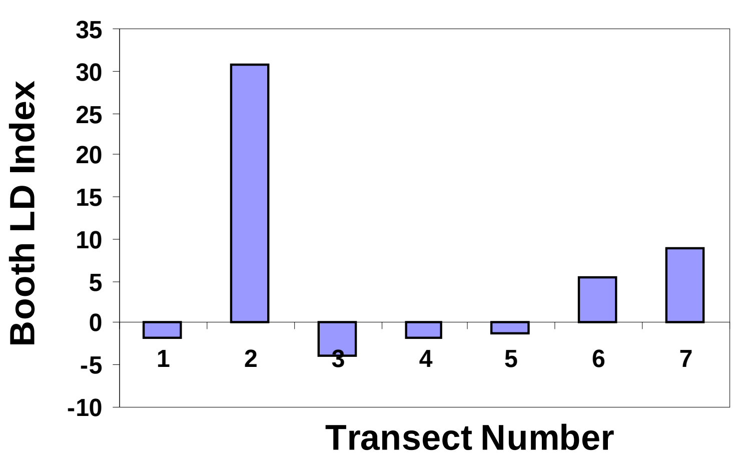

Figure 8. Example of winter Keigley transect L/D index for booth willow in the Buffalo Valley. Booth willow is a preferred winter forage of moose and heavily utilized, as seen by the low (poor) index values.

Diet and Nutritional Quality

- Winter fecal composite samples for diet analysis and vegetation samples for nutrition analysis were sent to the lab in May 2008. Due to delays, results are pending.
- Summer fecal samples are being compiled into composite samples for diet analysis.
- Summer vegetation samples have been dried and stored for future analysis. Analysis will commence after results from summer diet analysis have been completed.

Moose Condition

- Blood parameter data obtained during capture are still being entered
- Bone marrow samples, as a condition assessment (n=11) have been dried (Neiland 1970) and initial results show that moose that died this winter were in poor condition. The majority of moose (10/11) were found to be in poor to starvation condition (Figure. 9). Additional samples from mandible collections have yet to be analyzed.

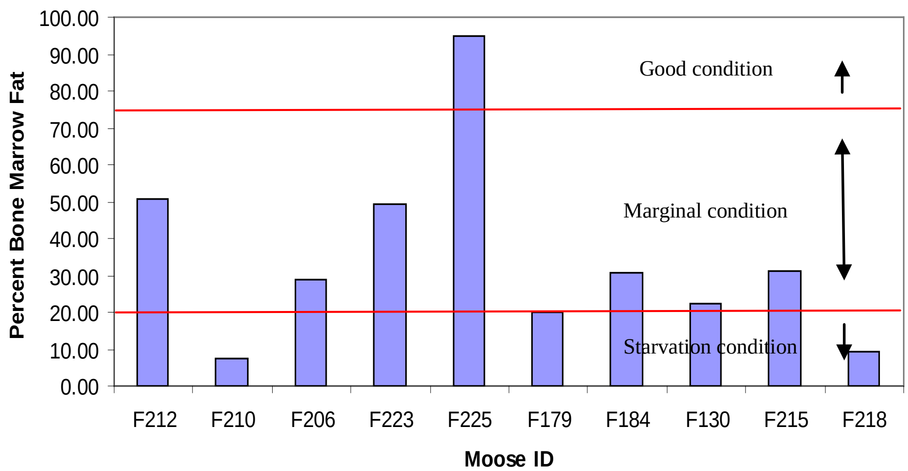

Figure 4. Percent bone marrow fat of dead moose, winter 2008.