Utilization of forage by bison in the Gibbon, Madison, and Firehole areas of Yellowstone National Park
by Steven Ray Dawes

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management
Montana State University

Abstract:
Bison in Yellowstone National Park have increased nearly 15-fold since 1968, from 300 to 4,300 by 1994, decreasing to 3,500 in 1996. This population expansion has led to increased numbers of bison migrating out of the Park, especially during severe winters. Egress from the Park led to controversial population control measures to combat the threat of brucellosis transmission to livestock outside the Park. During the winter of 1996/1997, the population was reduced (-38%) due to harsh winter conditions and brucellosis control procedures. It has been suggested that winter migration from the Park is the result of reduced winter forage availability due to excessive summer grazing on winter ranges in the Park. This study was designed to determine how bison used winter ranges during the summer months in the northwest portion of Yellowstone Park. The objectives were to:(I) determine summer use impacts on forage availability on the Gibbon, Madison, and Firehole winter ranges; (2) estimate plant productivity, removal, and fall standing crop at 6 study sites; (3) track bison distribution within the study area; (4) determine if seasonal use patterns are related to plant community, snow depth, or utilization intensities at specific sites; and (5)evaluate the efficiency of portable multispectral radiometer technology (MSR) in assessing range utilization. Exclosure cages were moved, and plots were clipped 3 times each summer to determine forage use and estimate productivity and removal. Fall standing crop was estimated with clipped plots adjacent to the cages. Road and site counts were conducted weekly to track bison distribution in the study area. Spearman correlations were used to test for associations between seasonal use patterns and utilization intensities, plant communities, and snow depth. MSR technology was evaluated with calibration clipping and regression analysis. ANOVA revealed moderate and highly variable differences between biomass in protected (caged) and unprotected (uncaged) plots. The extensive variability among paired plots makes a weak case for ungulate impacts. Only eleven of 92 paired t-tests (12%) indicated differences in standing biomass between caged and uncaged plots ($p < 0.05$). The Terrace Springs study site had significant tests in nearly all clipping periods probably, due to bison use. Estimates of forage production and removal were generally higher when calculated with cages moved at 5-6 week intervals than with cages fixed for the whole growing season. The MSR normalized difference vegetation index (NDVI). readings were not well correlated ($r2 < 0.80$) with clipped biomass. Overall correlation coefficients were 0.71 in 1996 and 0.42 in 1997. Unless refinements in sampling techniques improve correlations, MSR technology should be used only to supplement conventional clipping treatments. Road and site counts in summer were not significantly correlated with estimated forage utilization. Winter counts of bison indicated that Terrace Springs, Fountain Flats Drive, and the Interchange site received almost constant use from November 1996-May 1997. Average snow depth over 6 sites was 27.3 cm. Use by bison at specific sites was not well correlated with snow depth. While increasing populations numbers have probably caused bison to feed on winter ranges during summer, I found little evidence such use is causing a broad detrimental effect on winter forage availability on the Gibbon, Madison, Firehole winter ranges.

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APPROVAL

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Steven Ray Dawes

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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Date 24 APR 1998

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ABSTRACT

Bison in Yellowstone National Park have increased nearly 15-fold since 1968, from 300 to 4,300 by 1994, decreasing to 3,500 in 1996. This population expansion has led to increased numbers of bison migrating out of the Park, especially during severe winters. Egress from the Park led to controversial population control measures to combat the threat of brucellosis transmission to livestock outside the Park. During the winter of 1996/1997, the population was reduced (≈38%) due to harsh winter conditions and brucellosis control procedures. It has been suggested that winter migration from the Park is the result of reduced winter forage availability due to excessive summer grazing on winter ranges in the Park. This study was designed to determine how bison used winter ranges during the summer months in the northwest portion of Yellowstone Park. The objectives were to: (1) determine summer use impacts on forage availability on the Gibbon, Madison, and Firehole winter ranges; (2) estimate plant productivity, removal, and fall standing crop at 6 study sites; (3) track bison distribution within the study area; (4) determine if seasonal use patterns are related to plant community, snow depth, or utilization intensities at specific sites; and (5)evaluate the efficiency of portable multispectral radiometer technology (MSR) in assessing range utilization. Exclosure cages were moved, and plots were clipped 3 times each summer to determine forage use and estimate productivity and removal. Fall standing crop was estimated with clipped plots adjacent to the cages. Road and site counts were conducted weekly to track bison distribution in the study area. Spearman correlations were used to test for associations between seasonal use patterns and utilization intensities, plant communities, and snow depth. MSR technology was evaluated with calibration clipping and regression analysis. ANOVA revealed moderate and highly variable differences between biomass in protected (caged) and unprotected (uncaged) plots. The extensive variability among paired plots makes a weak case for ungulate impacts. Only eleven of 92 paired t-tests (12%) indicated differences in standing biomass between caged and uncaged plots ($p < 0.05$). The Terrace Springs study site had significant tests in nearly all clipping periods probably, due to bison use. Estimates of

forage production and removal were generally higher when calculated with cages moved at 5-6 week intervals than with cages fixed for the whole growing season. The MSR normalized difference vegetation index (NDVI) readings were not well correlated ($r^2 \leq 0.80$) with clipped biomass. Overall correlation coefficients were 0.71 in 1996 and 0.42 in 1997. Unless refinements in sampling techniques improve correlations, MSR technology should be used only to supplement conventional clipping treatments. Road and site counts in summer were not significantly correlated with estimated forage utilization. Winter counts of bison indicated that Terrace Springs, Fountain Flats Drive, and the Interchange site received almost constant use from November 1996-May 1997. Average snow depth over 6 sites was 27.3 cm. Use by bison at specific sites was not well correlated with snow depth. While increasing populations numbers have probably caused bison to feed on winter ranges during summer, I found little evidence such use is causing a broad detrimental effect on winter forage availability on the Gibbon, Madison, Firehole winter ranges.

INTRODUCTION

History

The role of the American Bison (*Bison bison*) in the history of Indian and European people in North America is significant (Dary 1974). The plains Indian tribes were intimately tied to the bison, and their civilization declined as the bison herds were extirpated. The bison slaughter began in earnest in the early 1870's and lasted approximately 12 years. At its peak, the economic importance of the bison industry to the United States exceeded that of the beaver and whaling industries combined (Dary 1974).

Bison population estimates from settlement to the late 1800's are problematic, spotty, and mostly anecdotal. All contain serious flaws, and none were the result of methods remotely approaching today's scientific standards (Shaw 1995). While estimates range from 30 to 65 million animals (Reynolds et al. 1982), any accuracy finer than tens of millions is questionable (Shaw 1995).

Modern Management

The historical population of mountain bison (*B. bison athabascae*) in Yellowstone National Park (YNP) was thought to be about 1,000 in 1880. Numbers declined to 40-50 by 1902 due to sport, subsistence, and market hunting, the capture of calves for private herds, and poaching (Meagher 1973). By 1902, intensive management was initiated to ensure the survival of the species, and plains bison (*B. bison bison*) were introduced to YNP to augment the native population, producing the hybrid inhabiting the park today. Three wintering herds (Lamar Valley, Pelican Valley, and Mary Mountain herds) eventually formed and remained distinct from one another until the early 1980's (Dobson and Meagher 1996). None are now geographically isolated year round, but the names have been retained to designate the winter populations (Meagher 1973).

Until 1966, bison were managed under a variety of programs, with population control only on the northern range (Dobson and Meagher 1996). Actions included: feeding hay in fenced pastures, capture and live removals, regulated public

hunts, and shooting by Park personnel within Park boundaries (YNP Interagency Fact Sheet 1994). Beginning in 1966, a "limited interference" approach was adopted, whereby fencing was removed and no supplemental feeding was undertaken (Meagher 1973). Bison were free to roam the Park and subjected to minimal interference from man.

Following the adoption of this policy, the population of bison increased from 300 in 1968 to 4,300 animals in 1994 (YNP Interagency Fact Sheet 1994) declining to 3,500 animals by 1996. However, with the harsh winter of 1996/1997 and the killing of more than 1,000 bison in an attempt to prevent the spread of brucellosis to cattle, the July 1997 population was estimated at 2,200 animals (Meagher, unpubl. data). Brucellosis was first diagnosed in park bison in 1917 (YNP Interagency Fact Sheet, 1994).

As population levels increased over the last 30 years, bison have been reported, with increasing regularity, foraging on their traditional wintering grounds during the summer months (Irby pers. commun., Meagher unpubl. data). The impacts of summer foraging on winter forage availability are unknown. It has been suggested, however, that summer use of winter sites has led to winter forage shortfalls

which in turn cause bison to migrate from the Park, particularly during harsh winters (Irby pers. commun., Meagher unpubl. data). This study was designed to assess summer foraging impacts on winter ranges in the northwest portion of the Park.

The 6 winter forage areas selected for study consist mainly of grass/forb communities. Bison feed mostly on grasses. Seasonal diets in North Dakota consist of 75-90% grasses, with browse species in late winter to early spring contributing 16% (Norland et al. 1985). Reynolds et al. (1982) found the diets in 3 of 4 free-roaming bison herds dominated by grasses and sedges. Bison select flat landscapes dominated by grass. Breaks, timber stands, and sagebrush bottoms are used much less frequently (Norland et al. 1985). In YNP, forage availability within preferred sedge and upland feeding sites appears to regulate bison feeding patterns (Meagher 1973). Observations by Vinton and Hartnett (1992) showed bison do not discriminate among plant species in grazed patches. However, Reynolds et al. (1982) stated that where available, sedges and grasses are selectively grazed with dietary shifts between the 2 associated with plant phenology.

Defoliation of grasses can have positive or negative short or long-term effects depending on timing, intensity, and species (Vinton and Hartnett 1992). Overuse of grasses often reduces nutrient allocation to roots or may stop growth completely (Coughenour 1991). In overgrazed grass communities, reductions in litter and leaf shade reduce water available for growth because of increased runoff and evaporation due to higher soil temperatures (Coughenour 1991). Winter grazing increases shoot nitrogen in grasses in spring (Coughenour 1991, Merrill et al. 1994), but 2 abundant grasses on winter ranges in YNP, *Agropyron spicatum* and *Festuca idahoensis*, are sensitive in a number of biological parameters to grazing during the growing season (Evanko and Peterson 1955).

Although no studies have been done to quantify bison forage utilization of seasonal ranges in and around the Park, information collected by Dr. Mary Meagher (1973 and unpubl. data) indicates changes in distribution and habitat use have occurred as bison numbers have increased and man's activities in and around the Park have intensified over the last 4 decades. The consequences of these changes on winter

forage plants and affiliated habitats are unknown, and this lack of knowledge is 1 factor behind the current controversy surrounding bison management in Yellowstone National Park.

Hypotheses

Ho: Summer grazing by bison on winter ranges will produce no significant differences in dry forage weight between grazed (unprotected) and ungrazed (protected) plots.

H_1: Summer grazing by bison on winter ranges will produce significant differences in dry forage weight between grazed and ungrazed plots.

The specific study objectives were to:

1. Examine how bison utilized forage on winter ranges during the summer and early fall, May-October 1996 and May-August 1997, in the Gibbon, Madison, and Firehole drainages.

2. Estimate productivity, removal, and fall standing crop at 6 study sites.

3. Evaluate the portable multi-spectral radiometer (MSR) technology as another method of estimating forage availability in YNP.

4. Track bison seasonal distribution and habitat use within the Gibbon, Madison, and Firehole drainages.

5. Determine if seasonal use patterns are related to plant community composition, snow depth, or utilization intensities at specific sites.

STUDY AREA

YNP occupies 9,000 km^2 in the northwest corner of Wyoming and adjacent areas in eastern Idaho and southwestern Montana. A generic description of the Park was given by Meagher (1973) and of the study area by Craighead et al. (1973). Park geology is dominated by glaciated tertiary and quarternary volcanic deposits (Keefer 1976). Soils are mainly volcanic rhyolite in origin (Aune 1981).

The study area was located within the Gibbon, Madison, and Firehole River drainages (Figure 1). Elevations ranged from 2,079-2,252 m. Portions of the area were dominated by lodgepole pine (*Pinus contorta*) stands of varying densities, open meadows or parks, and geothermal areas.

Based on preliminary observations, 6 winter pastures with varying vegetation features were chosen to evaluate summer forage utilization on winter ranges. The Gibbon Meadows site was a grass/forb/shrub community bounded on 3 sides by lodgepole pine stands. Snow melt flooded the site each spring. The site dried out slowly over summer, but