Effects of Livestock Grazing on Forage Production, Forage Quality, and Soil Properties at Six Sites in the Southern Interior

FREP

Extension Note #27

December 2012

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1.0 INTRODUCTION

Sustainable livestock operations depend on healthy plant communities. "Maintaining or enhancing forage quantity and quality for livestock and wildlife" is one of government's key regulatory objectives under the *Forest and Range Practices Act* (FRPA). The Forest and Range Evaluation Program (FREP) is assessing whether this act, its regulations, and associated management standards and practices are effective in managing the province's forest and range resources sustainably. Through its priority evaluation question for the Forage and Associated Plant Communities objective, FREP specifically seeks to determine: "what impacts are forest and range practices having on the quality and quantity of forage, and on species composition and structure of the forest understorey."

This extension note describes a research project that tested the magnitude of grazing impacts by comparing species biomass and forage quality, both inside and outside range exclosures, over a 3-year period in the Southern Interior of British Columbia. Six sites near Kamloops, B.C., were selected that represented a broad spectrum of range areas with different grazing histories (Table 1). Two of the locations had different tree canopy covers, allowing an additional comparison of the effect of canopy closure on both forage production and forage quality. The research project also identified variations in soil chemistry in range exclosures at five of the sites.

Hunter's Range Inside Enclosure

Hunter's Range Outside Enclosure

The FREP Mission:
To be a world leader in resource stewardship monitoring and effectiveness evaluations; communicating science-based information to enhance the knowledge of resource professionals and inform balanced decision-making and continuous improvement of British Columbia's forest and range practices, policies and legislation. *http://www.for.gov.bc.ca/hfp/frep/index.htm*

BRITISH COLUMBIA

Table 1. Characteristics of six study sites near Kamloops, B.C.

Site	Elevation (m)	Community type	Management history	Primary treatment	Secondary treatment
Hunter's Range	1865	Subalpine Tall Forb	Light grazing (30%) for the last 5 years; heavy cattle grazing (> 60%) for the previous 20 years	Inside ungrazed exclosure (built 1994) vs. Outside grazed area	Not applicable
Smith Camp	1140	Douglas-fir/ Pinegrass	Moderate cattle use (35%) for at least 20 years; some year-long horse grazing	Inside ungrazed exclosure (built 1997) vs. Outside grazed area	Not applicable
Will Lake Lodgepole Pine	1250	Lodgepole Pine/ Pinegrass	Light to moderate cattle use (25%) for at least 40 years	Inside ungrazed exclosure (built 1997) vs. Outside grazed area	Not applicable
Tunkwa Lake	1200	Rough Fescue grassland	Heavy livestock use (> 60%) for about 100 years; year-long horse use	Inside ungrazed old exclosure (built 1960) vs. Inside ungrazed new exclosure (built 1993) vs. Outside grazed area	Not applicable
Yellow Pine Spacing Trial	610	Yellow Pine/Rough Fescue–Pinegrass	Severely burned in 1959 and planted to yellow pine in 1960 at various spacings; heavy grazing (> 60%) since 1960	Inside ungrazed exclosure (built 1960) vs. Outside grazed area	2.4m spacing ungrazed vs. 6.1m spacing ungrazed
Will Lake Douglas-fir	1070	Douglas-fir/ Pinegrass	Moderate cattle grazing (35%) for about 50 years; Heavy cattle grazing (> 60%) beginning in early 1990s	Inside ungrazed exclosure (built 1997) vs. Outside grazed area	Recently logged vs. Not logged for at least 60 years

2.0 BACKGROUND

Grazing is suspected of affecting species composition and biomass, forage quality, and soil properties. As part of a comprehensive system of more than 350 range reference areas across British Columbia, range exclosures have been established on rangelands to protect vegetation from grazing and browsing and aid in determining the impact of livestock, wildlife, and other disturbances on British Columbia rangelands. These permanent vegetation sampling plots allow the study and monitoring of climax species composition on grassland and forested range types that exhibit similar site conditions. These sites are subject to the same year-to-year climatic fluctuations as adjacent managed grasslands and thus also allow for direct comparison of changes over time. As such, range exclosures provide evidence of recovery from the effects of grazing.

Some exclosures examined in this research project were established over the past 15 years and baseline information was collected on vegetation cover at the time of establishment; however, pre-treatment data was not collected on plant biomass, foliar chemical composition, or soil nutrient levels. Consequently, it is not possible to determine whether distinctions observed between plots reflect pre-existing conditions. Nevertheless, in un-replicated range exclosure studies such as this one, it is reasonable to test for significant differences between conditions inside and outside an exclosure and then discuss these differences in light of responses that are likely a result of grazing treatments. It is important to note, however, that grazing practices are only one possible explanation for the differences observed; follow-up studies are often needed to directly test such inferences.

3.0 METHODOLOGY

To estimate annual above-ground forage production, litter accumulation, and forage quality, grass and forb species were clipped in five 0.5 m2 plots inside and outside livestock exclosures. The six locations where sampling took place included Hunter's Range, Smith Camp, Tunkwa Lake, Will Lake Lodgepole Pine, Will Lake Douglas-fir, and Yellow Pine Spacing Trial. Clipped material was separated to species, dried at 60°C for 24 hours, and weighed to the nearest .01 g. For the forage quality analysis, samples were pooled and analyzed for nitrogen and acid detergent fibre. An index of available digestible nitrogen for each species at each location each year was used as a surrogate for forage quality. Although sampling involved no interspersed replication, care was taken to select sites that were similar in the expression of abiotic factors (elevation, slope, aspect, and soil type, soil depth and parent material), leaving grazing or canopy closure effects as the most likely cause of any observed differences.

To estimate the effects of grazing on soil chemistry, soil samples were collected inside and outside of livestock

exclosures at all locations except Smith Camp. Samples were analyzed for pH, cation exchange capacity and electro-conductivity, exchangeable Al, Na, Ca, Fe, K, Mg, and Mn, extractable Al, B, Ca, Cu, Fe, K, Mg, Mn, Na, P, and Mn, available P, and total C and total N.

Depending on the number of the treatments tested at each site, a two- or three-factor analysis of variance was used to detect significant differences between the forage quantity and quality samples collected inside and outside exclosures. Significant differences within factors were determined by a Tukey's multiple range test. For the soil chemistry analyses, simple t-tests or a single-factor analysis of variance were used to detect significant differences between samples collected inside and outside exclosures.

4.0 RESULTS AND DISCUSSION

The statistical analyses revealed that few differences were evident in soil chemistry inside and outside the exclosures, suggesting that grazing did not affect the soil properties at any of the sites. However, the results of the statistical analyses for forage quantity (Table 2) and forage quality (Table 3) showed that biomass production and digestible nitrogen were lower outside the exclosures than inside at four of the sites (Hunter's Range, Tunkwa Lake, Yellow Pine Spacing Trial, and Will Lake Douglas-fir); at the two other sites (Smith Lake and Will Lake Lodgepole Pine), no statistically significant differences were observed.

Table 2. Result summary: Differences of biomass in grazed and ungrazed plots at the six study sites

Location	Herbage production differences	Litter differences	Selected species	Production differences
Hunter's Range	Δ	√	Hairy arnica Arctic lupine	Δ Δ Δ Δ
Smith Camp	√	√	√	—
Will Lake Lodgepole Pine	√	√	√	—
Tunkwa Lake	Δ Δ Δ	Δ Δ Δ	Rough fescue Kentucky bluegrass	Δ Δ Δ Δ Δ Δ
Yellow Pine Spacing Trial	Δ Δ	Δ Δ Δ	Pinegrass Rough fescue	Δ Δ Δ Δ Δ Δ
Will Lake Douglas-fir	Δ Δ	Δ Δ Δ	Pinegrass	Δ Δ Δ

√ = no difference in production.
Δ = small difference in production (ungrazed is less than 2 grazed)
Δ Δ = large difference in production (ungrazed is 2–3 grazed)
Δ Δ Δ = very large difference in production (ungrazed is more than 3 grazed)

Table 3. Result summary: Differences of digestible nitrogen between grazed and ungrazed plots at six study sites

Location	Herbage digestible nitrogen	Litter digestible nitrogen	Selected species	Digestible nitrogen
Hunter's Range	Δ Δ Δ	Δ	Hairy arnica Arctic lupine	Δ Δ Δ Δ Δ
Smith Camp	√	Δ	√	—
Will Lake Lodgepole Pine	√	√	√	—
Tunkwa Lake	Δ Δ Δ	Δ Δ Δ	Rough fescue Kentucky bluegrass	Δ Δ Δ Δ Δ Δ
Yellow Pine Spacing Trial	Δ Δ	Δ Δ Δ	Pinegrass Rough fescue	Δ Δ Δ Δ
Will Lake Douglas-fir	Δ Δ	Δ Δ Δ	Pinegrass	Δ Δ Δ

√ = no difference in digestible nitrogen.
Δ = small difference in digestible nitrogen (ungrazed is less than 2 grazed)
Δ Δ = large difference in digestible nitrogen (ungrazed is 2–3 grazed)
Δ Δ Δ = very large difference in digestible nitrogen (ungrazed is more than 3 grazed)

These results suggest an effect of grazing on forage production and digestible nitrogen at four locations and no effect at the other two. In particular, management favouring heavy use (> 60%) and lack of rest (annual grazing) at the Tunkwa Lake, Yellow Pine Spacing Trial, and Will Lake Douglas-fir sites led to reduced forage biomass, lower accumulations of litter, and reduced forage and litter digestible nitrogen. Lower litter digestible nitrogen has serious consequences because the inherent low soil nitrogen on these sites and few mechanisms for nitrogen inputs. The Smith Camp and Will Lake Lodgepole Pine sites both had lower levels of livestock grazing (< 25%), and showed no difference in forage productivity or digestible nitrogen between the grazed and ungrazed sites.

These results also suggest that the benefit of the heavily grazed sites to the livestock industry has diminished. Short-term gains from this management may be offset in the future by severe reductions in productivity, susceptibility to invasive plants, and an elevated risk of erosion. Care needs to be taken to select stocking rates and grazing regimes that will maintain appropriate levels of forage production.

It is also reasonable to conclude that as canopy cover increases, forage production and forage digestible nitrogen decreases. Opportunities are available to manage for both optimal tree canopies and forage production. Management for either maximum timber production or maximum forage production will lead to reduced net benefits.

MORE INFORMATION

For more information about this study, please refer to to FREP Report #34 at: http://www.for.gov.bc.ca/hfp/frep/publications/reports.htm#rep34.