UPLAND BARREN HABITAT OF SOUTHERN BANKS ISLAND EXCLUDED FROM GRAZING BY LARGE HERBIVORES FOR FIVE YEARS: EFFECTS ON ABOVEGROUND STANDING CROP

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ABSTRACT

Grazing exclosures of approximately 1.25m^2 were erected in upland barren habitat on southern Banks Island in mid-June, 1993, at the start of the growing season. Exclosures (n=10) were established in habitat patches located in areas of high (1.6-1.9 muskox/km^2) and low (0.3-0.4 muskox/km^2) muskoxen density. Exclosure integrity was monitored annually. In mid-July 1997, at the peak of the growing season, we removed the exclosures and clipped the aboveground standing crop of forages in each exclosure. Concurrently, we clipped the aboveground standing crop of forages in one 0.125m^2 plot adjacent to each exclosure. We determined the aboveground standing crop (dry weight) of forage inside and adjacent to exclosures and the proportion of 8 different forage types that made up the aboveground standing crop. Because there were no site effects, data were pooled. Median total aboveground standing crop and mean proportions of the 8 forage types were similar regardless of exposure to grazing. Although making up relatively small proportions of the total aboveground standing crop, median aboveground standing crop of grass (live and dead material) and other forbs was greater (P#0.02) in areas excluded from grazing.

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INTRODUCTION

In the early 1970s Wilkinson and Shank (1973) studied the range relationships of muskoxen and caribou on Banks Island in an attempt to assess potential competition between the two ungulate species. Their conclusion was that grazing pressure was low to moderate and was not having a negative impact on plant communities (Wilkinson *et al*. 1976). Subsequent studies into competitive interactions between the same two species in other areas of their range drew similar conclusions; the lack of competition resulted from little overlap in forages and or habitats used (Kevan 1974; Parker 1978; Vincent and Gunn 1981; Thomas and Edmonds 1984). However, McKendrick (1981) implied that under high concentrations of muskoxen, competition for food may occur, and competition for food may be responsible for caribou declines on islands (White *et al*. 1981).

Changes in grazing pressure exerted by erupting ungulate populations modify forage availability through changes in species composition (Caughley 1970; McNaughton 1979; Henry *et al*. 1986). From 1972 to 1994, the population of muskoxen on Banks Island increased from 3,800 to 64,608 ($\geq$1 year-olds); subsequently the population declined and was estimated at 45,833 in 1998. During the same period the Peary caribou population decreased from 12,098 to 436 (Nagy *et al*., 1996; Nagy and Branigan, unpubl. data). Recent dietary studies indicate a substantial overlap in the diets of caribou and muskoxen (Larter and Nagy 1997) and indicate that summer availability of arctic willow (*Salix arctica*) may be potentially reduced following winters when high numbers of muskoxen and arctic hares (*Lepus arcticus*) have been feeding on arctic willow (Larter 1999). During winters with greater snow depth and density, muskoxen foraged more in upland habitats than in lowlying wet sedge meadow habitat (Larter and Nagy

2001a), and willow made up a greater proportion of the diet (Larter and Nagy 1997; unpubl. data).

As the muskoxen population continued to increase, so did local concern that high densities of muskoxen would impact the range and alter the amount and/or types of forage available for caribou. The impact on arctic willow was a major concern because arctic willow constitutes a substantial portion of the summer diet, particularly in July (Larter and Nagy 1997), when animals are replenishing their body reserves and females are nursing young. As part of a comprehensive range study on Banks Island we used exclosures to examine the impact of herbivore foraging on upland barren habitat over a 5-year period from 1993-1997. In this report we compare: 1) aboveground standing crop (dry weight) in upland barren habitat where animals grazed and areas where animals (except lemmings) were excluded from grazing for a period of 5 years and 2) the proportion of aboveground standing crop composed of 8 different forage classes in areas subjected to and excluded from grazing (except lemmings) for a 5-year period.

METHODS

Habitat Description

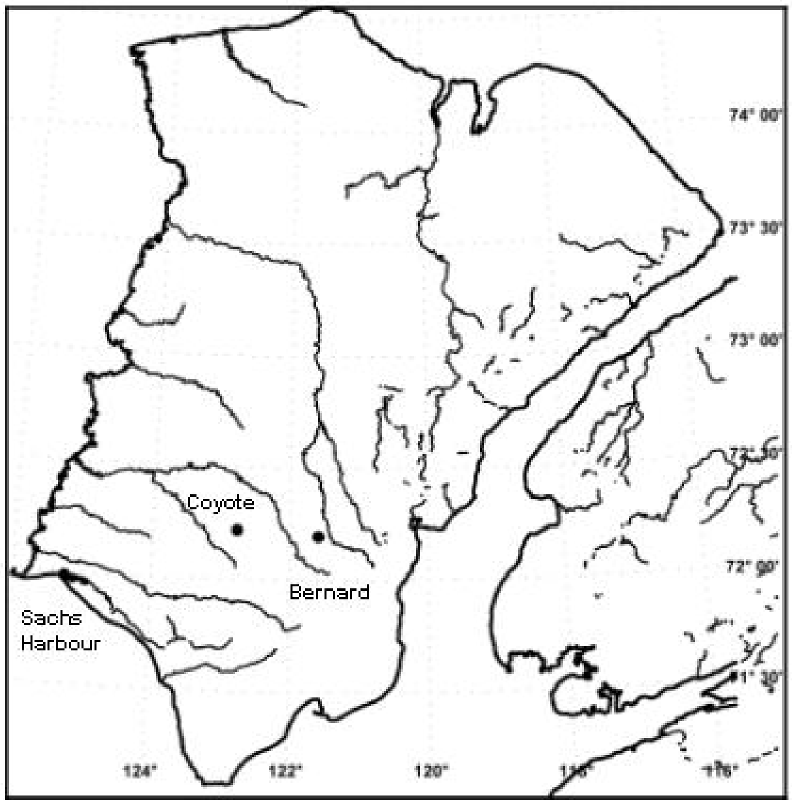
The flora of Banks Island is well documented with four major habitats being identified (Kevan, 1974; Wilkinson *et al*., 1976; Porsild and Cody, 1980; Zoltai *et al*., 1980; Ferguson, 1991). Upland barren habitat (UB) is found on well-drained sites on the upper and middle parts of rolling upland slopes. *Dryas integrifolia* is the predominant vegetation. Flowering plants including legumes (*Astragalus* spp. and *Oxytropis* spp.), lichen, *Carex* spp, and *Salix arctica* are also present. Vegetative cover is 20-50% and is generally associated with the drainage rills and patterns on the landscape. About 20-25% of Banks Island is UB (Larter and Nagy, unpubl. data).

Experimental Design

During the start of the 1993 growing season (15-17 June) ten exclosures were erected in UB near each of two recently established field camps: Coyote and Bernard (Fig. 1). Field camps were located in areas of high (1.6-1.9 muskox/km^2) and low (0.3-0.4 muskox/km^2) muskoxen density, respectively. Each exclosure consisted of a *ca*. 2.3m x 1.7m piece of 5cm x 5cm chainlink fencing that was pegged into the ground with 6-8 pegs made out of 1cm diameter rebar. Once pegged into the ground, the fencing created a domed exclosure of approximately 1.25m^2.

Exclosures were monitored for their integrity during June (12-20), July (16-22), and August (18-28) of 1993-97. Exclosures located near camp Bernard were more susceptible to damage and/or solifluction; only 5 of 10 exclosures maintained their integrity throughout the 5-year duration of study.

Figure 1. Banks Island and the two study sites, Camp Coyote and Camp Bernard.



During the peak of the 1997 growing season (July 20-22), we clipped the aboveground standing crop of forage in one $0.125m^2$ plot, located 2m NW of the northernmost corner of the exclosure, and clipped aboveground standing crop found within the exclosure. We grouped forages into the following 8 classes: sedge (*Carex* spp,), willow (*Salix arctica*), grass (*Poaceae*), lichen, legumes (*Astragalus* spp. and *Oxytropis* spp.), avens (*Dryas integrifolia*), saxifrages (*Saxifraga* spp.), and other forbs. All new growth forage, except willow, was clipped at ground level; plant litter was not collected. We clipped leaves and current annual growth from willow; buds were included in the leaf component. Lichen was plucked from the substrate.

Another experiment running concurrently over this 5-year period, measured the change in aboveground standing crop of UB during the course of the summer. Standing crop was clipped from randomly placed plots on permanent line transects in the habitat during mid-June, mid-July, and late-August. Twelve plots were clipped for each sampling period.

All clipped forage was separated by forage class in the field, placed in labeled paper bags or envelopes and allowed to air dry. At the laboratory in Inuvik, sedge and grass was further separated into their live green and dead components. All plant material was oven dried at $60^{o}C$ for 48 hours and weighed on a Sartorius electronic balance to ± 0.0001g.

We calculated the total aboveground standing crop of each plot and exclosure as well as the aboveground standing crop of each of the 11 standing crop components: live green sedge, dead sedge, willow leaf, willow stem (current annual growth), live green grass, dead grass, lichen, legume, aven, saxifrage, and other forbs. Standing crop was converted into kg/ha for comparisons. We calculated what proportion each of the 8 different forage classes contributed to the total estimated standing crop for grazed and excluded areas. Live green and dead material were pooled for the calculation of the proportions.

Statistical Analyses

Data on aboveground standing crop were pooled across sites to increase sample size and because biomass estimates were similar between sites (N. Larter unpubl. data). We used a two-tailed Mann Whitney-U test to compare each of the 11 components of the aboveground standing crop between areas exposed to and excluded from grazing. We transformed all proportion data with the arcsine square-root transformation (Zar 1999). Because there were no site differences in proportions of the 8 forage classes available in mid-July over 5 summers in a concurrent experiment (N. Larter unpubl. data), we pooled data across sites. We used a paired t-test to compare mean proportions of the 8 forage classes found in areas exposed to grazing with those found in areas excluded from grazing.

RESULTS

There was no difference (P=0.62) between total aboveground standing crop estimated for grazed and excluded areas. Aboveground standing crop of most forages was similar regardless of exposure to grazing except for grass and other forbs. Aboveground standing crop of live and dead grass and other forbs was greater (P#0.02) in areas that had been excluded from grazing for 5 years (Table 1). The proportions of the 8 forage classes making up the total aboveground standing crop were similar for grazed and excluded areas (Table 2; P>0.5).

Table 1. Median aboveground standing crop (kg/ha) for the 11 components from areas exposed to and excluded from grazing over a 5-year period. P values from two-tailed Mann Whitney-U, significance at ∀=0.05 indicated by bold text.

	Live Sedge	Dead Sedge	Willow Leaf	Willow Stem	Live Grass	Dead Grass	Lichen	Legume	Aven	Saxi	Other Forbs
Exposed n=16	4.7	7.6	0.0	0.0	0.0	0.0	14.6	0.0	247.6	0.0	0.0
Excluded n=15	9.7	13.7	8.7	0.9	2.3	2.6	27.7	1.4	183.9	1.4	6.9
P-value	0.14	0.32	0.10	0.14	**0.02**	**0.02**	0.59	0.24	0.29	0.89	**0.02**

Table 2. The transformed proportions of the total aboveground standing crop contributed by the 8 different forage classes in areas exposed to and excluded from grazing over a 5-year period.

	Sedge	Willow	Grass	Lichen	Legume	Aven	Saxifrage	Other
Exposed	13.05	9.46	2.92	24.65	20.88	49.31	10.63	6.29
Excluded	17.66	12.79	10.78	21.56	16.74	46.55	10.14	12.52

DISCUSSION

Vegetation in upland barren habitat is typically distributed along drainage rills resulting in a patchwork landscape of bare ground and vegetated areas. Following Wein and Rencz (1976), we chose the most appropriate shape and size of plots to assess aboveground standing crop in this landscape. Data from a concurrent study estimated mean aboveground standing crop for the peak of the growing season (mid-July) during 1993-1997 at 308 kg/ha (N. Larter unpubl. data). Similar to findings elsewhere in the High Arctic (Murray 1991; Smith 1996), annual variability in aboveground standing crop of forages on Banks Island was evident (N. Larter unpubl. data). Mean aboveground standing crop during mid-July 1997 was estimated at 368 kg/ha (n=24 plots), very similar to the 376 kg/ha estimated from the 15 plots located in grazed areas adjacent to the exclosures found in the same habitat. Therefore, we feel we have an adequate number of exclosures and plots to assess changes related to the exclusion of herbivores (except lemmings) over a 5-year period.

For the dominant forages in this habitat (aven, lichen, legume) the exclusion of grazing through 5 growing seasons made little difference in their proportional representation or biomass of the aboveground standing crop (Tables 1 and 2). Such was not the case for the less dominant forages, in particular grasses and other forbs. From 1993-1997 grasses and other forbs each accounted for *ca*. 4% of the aboveground standing crop of upland barren habitat during the peak of the growing season (N. Larter unpubl. data). After being excluded from grazing through 5 growing seasons these forages made relatively significant increases in aboveground standing crop and their proportions of the aboveground standing crop shows a similar trend (Tables 1 and 2). To a lesser degree, similar changes occurred with sedge and willow. These less dominant forages also showed relative increases in aboveground standing crop when excluded from grazers through 5 growing seasons (Tables 1 and 2).

Our data indicate that the exclusion of herbivores (except lemmings) lead to measurable changes in the aboveground standing crop of some forages found in upland barren habitat. We did not detect measurable change in the relative proportions each of 8 forage classes made to the total aboveground standing crop in this habitat. Whether these changes have resulted in poorer range conditions on Banks Island for herbivores, caribou in particular, is open to debate.

When caribou numbers were at their historical highest in the early 1970s, studies on the diet of caribou and muskoxen revealed that grass was an major dietary component (Wilkinson *et al*. 1976; Shank *et al*. 1978). Studies in the mid-1990s noted an absence of grass in the monthly diet of both caribou and muskoxen (Larter and Nagy 1997; unpubl. data). Sedge has always been a major component of both the summer and winter diet of muskoxen here and elsewhere in the High Arctic (Wilkinson *et al*. 1976; Parker 1978; Thomas and Edmonds 1984; Larter and Nagy 1997). Willow is an important component of the diets of many herbivores on Banks Island, predominating the diet of Peary caribou during summer and arctic hare during winter as well as being used extensively by muskoxen in June (Larter and Nagy 1997; Larter 1999). In winters of greater snow depth and density, muskoxen forage more in upland barren habitat and consequently forage on willow to greater extent (Larter and Nagy 2001a). Caribou forage on other forbs more than muskoxen do.

Herbivory usually modifies the productivity and chemical composition of forages and at moderate levels stimulates aboveground productivity of graminoids in the Arctic tundra (Archer and Tieszen 1980). Forages exposed to grazing and browsing by caribou, both simulated (manual clipping) and actual, have shown changes in chemical composition. Both sedges, willow leaves and willow stems exposed to herbivory had higher crude protein content than similar plants that were not exposed to herbivory (Ouellet *et al*. 1994; Larter and Hik accepted). The same trend, to a lesser degree, was also found for avens, *Dryas integrifolia* (Ouellet *et al*. 1994).

Early in the growing season live grass and willow leaves have the highest crude protein content of forages on Banks Island. Levels were not determined for other forbs (Larter and Nagy 2001b). An increase in the availability of such forages should imply increased available crude protein and superior range for all herbivores utilizing these forages. However, if increased availability can arise only from excluded herbivory, we are left with the dilemma of increasing biomass at the expense of forage quality which is unlikely to provide any net increase in available crude protein.

Larter and Nagy (2001b) documented significant annual variation in the quality of forages on Banks Island from 1993 to 1997. This variation was mostly attributed to annual variation in summer moisture. Crude protein content of most forages on Banks Island declines over the course of the growing season; in grass, the decline is most rapid (Larter and Nagy 2001b). Significant increases in standing crop of forages, which make up minor proportions of the total aboveground standing crop, may have no noticeable effect in overall range quality of upland barren habitat because of the inherent annual variability in forage quality. Given the inherent annual variability in standing crop and forage quality it is unlikely that the level of grazing and browsing by herbivores from 1993-1997 resulted in any directional change in biomass distribution that could be interpreted as range deterioration of upland barren habitat.

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