
**Monitoring Vegetation Trends on the Mentasta Caribou
Range,
Wrangell-St. Elias National Park/Preserve**

WRST Research and Resource Management Report

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Executive Summary

1. We compared cover and height of vegetation inside and outside 5 ungulate exclosures on the Mentasta caribou range in 1993 to evaluate range conditions and trends following 11 years of ungulate exclusion. We hypothesized that composition and structure of vegetation would not differ between inside and outside the exclosures (i.e., null hypothesis), unless differences in grazing and trampling pressures influenced vegetation successional patterns between protected and unprotected plots (i.e., alternative hypothesis). We also reviewed the range monitoring protocol established in 1982, report modifications made in 1993, and provide recommendations for future monitoring.
2. We modified the monitoring protocol developed in 1982 to overcome several limitations in sampling methods and design. Instead of measuring plant frequency and biomass in a single 1x1-m frame, we measured and compared cover and heights of all identifiable taxa within 28 20x50-cm sampling frames distributed along three transects inside and outside each exclosure.
3. Cover and heights of vegetation forms (e.g., lichens, shrubs, dwarf shrubs, graminoids and mosses) differed among 4 exclosure sites, indicating that vegetation varied among sampling units. Further, cover of graminoids differed between grazing treatments and was greater outside than inside the exclosures ($P < 0.05$). Though not significant, cover of shrubs and dwarf shrubs tended to be greater inside than outside exclosures, whereas cover of mosses and bare ground tended to be greater outside than inside. There was no difference in cover of lichens inside and outside the vegetation exclosures, but lichens tended to grow taller inside than outside the exclosures ($P = 0.06$).
Lichen condition was highest (e.g. fair) at the Windy Ridge site, based on comparatively high cover and stature of *Cladina* (mostly *arbuscula*) and *Stereocaulon*. Lichen condition generally was poor at the remaining sites with either low cover or heights of lichens, primarily *Cladina arbuscula*, *Cetraria* spp., and *Cladonia* spp.
4. Vegetation differences inside and outside the exclosures could reflect confounding influences of the exclosure fences, initial vegetation conditions, or potential responses to grazing exclusion. Nonetheless, differences in graminoid cover found inside and outside the exclosures and incipient differences in lichen heights, suggest that grazing and trampling may favor graminoids and limit abundance of lichens. Long-term monitoring is needed to elucidate and confirm these and other potentially important patterns of sedge, lichen, and caribou dynamics on the Mentasta Range.
5. We recommend continuing to monitor caribou and vegetation trends in the Mentasta grazing system. Ideally, a comprehensive vegetation monitoring program would require expanded monitoring using larger vegetation exclosures than those presently in use. Realistically, the existing network of small exclosures may be the only affordable, sustainable monitoring option available at the present time. Because small exclosures have been shown in other areas to accumulate snow, thereby possibly influencing growing conditions, we recommend measuring snow accumulation and ablation patterns near the existing exclosures. If the current exclosure fences do not appear to influence snow patterns (hence growing conditions), we recommend continuing to measure the existing exclosures. The four existing exclosures, though limited in scope, now represent fifteen years of protection from grazing and opportunities to increase

understanding of lichen recovery rates and long-term dynamics of sedge-dominated subarctic grazing systems. We make several additional recommendations for minor adjustments in methods of sampling and analyzing future range trends in the existing exclosures.

Introduction

In 1982, Wrangell-St. Elias National Park and Preserve (WRST) and Alaska Department of Fish and Game (ADFG) initiated a program to monitor condition and trend of range vegetation on spring-fall range of the Mentasta caribou herd in WRST (Martin 1983). Six small exclosures were built on the Mentasta range in 1982, designed to exclude large ungulates (e.g., caribou and moose) and patterned after 39 similar exclosures built in the 1950's and 1960 on the adjoining Nelchina caribou range (Lieb et al. 1985). At the time of construction, the Mentasta herd had been relatively stable for over 15 years while the adjoining Nelchina herd had decreased dramatically and then increased during the same period (Van Ballenberghe 1985, Bergerud and Ballard 1988). The program was established to compare range and caribou population trends in the two areas and provide insights on potential habitat limitations for caribou.

Since the range monitoring program was established, the Mentasta herd has declined over 75% from approximately 3200 caribou in 1987 to fewer than 900 in 1994 (Jenkins 1995), while the Nelchina herd has continued to increase (ADFG 1993). The rapid decline of the Mentasta herd led to controversial closures of state and federal hunting seasons in 1991 and 1992, respectively, and new research into the causes of the decline in 1993. Although previous studies suggested that heavy predation on caribou calves was the primary proximate cause of the decline (Lieb et al. 1993), the potential effects of forage limitations were not examined. Increased range overlap with an expanding Nelchina caribou herd, however, suggested the potential for increased intraspecific competition for forage (Lieb et al. 1993).

We compared cover and height of vegetation inside and outside 5 ungulate exclosures on the Mentasta caribou range in 1993 to evaluate range conditions and trends following 11 years of ungulate exclusion. We hypothesized that composition and structure of vegetation would not differ between inside and outside the exclosures (i.e., null hypothesis), unless differences in grazing and trampling pressures influenced vegetation successional patterns between protected and unprotected plots (i.e., alternative hypothesis). We also reviewed the range monitoring protocol established in 1982, report modifications made in 1993, and provide recommendations for future monitoring.

Study Area and Methods

General Description

The Mentasta range exclosures, built in 1982, were distributed over approximately 4000 km² of the known spring-fall range of the Mentasta caribou herd, from the Klawasi River, near the south limit of the range, northeast to the Nabesna Road (Figure 1). The exclosure sites were chosen subjectively near existing airstrips for access, and in representative vegetation

types used seasonally by the Mentasta herd. Exclosures at Long Lake, Chelle Lake and Windy Ridge were in open black or mixed spruce (*Picea mariana* or *P. glauca*) forests between 750-1000 m in elevation (Table 1) in areas used primarily as spring and fall ranges by the Mentasta herd. Vegetation consisted of sparse overstory of black or white spruce, a shrub layer composed of *Betula glandulosa*, *Vaccinium uliginosum*, and *Ledum palustre*, and a diverse ground layer composed of many forbs, grasses, and lichens. Exclosures at Sanford and Klawasi Rivers were in dwarf scrub tundra between 1000-1250 (Table 1), in areas used primarily as summer range. Vegetation consisted mainly of *V. uliginosum* at Klawasi, and *V. uliginosum* and *Carex bigelowii* at Sanford River. The exclosure at Drop Creek was in open low mixed shrub-sedge tundra at 4000 feet, with vegetation dominated principally by *B. glandulosa*, *Empetrum nigrum*, and *Carex vaginata*. The exclosure site at Drop Creek was used both as summer and fall range by the Mentasta herd.

The exclosures, each 6.1 x 6.1 m (20x20 ft) in dimension, were constructed with 10-ft metal t-posts and two overlapping rows of graduated-mesh hog wire (Martin 1983). Although details of plot selection methods were not reported, presumably each exclosure was paired at the time of construction with a comparable 6.1 x 6.1-m unfenced control plot containing vegetation as similar as possible to within the exclosure. No mention was made of whether or not the enclosed plots were selected at random or subjectively from the initial pairings. The unfenced control plots ranged from 4-40 m in distance from the exclosures.

We measured vegetation inside and outside 5 of the Mentasta range exclosures during July 1993. We excluded the Long Lake study site from further measurements because vegetation inside and outside the exclosure reflected obvious differences in microtopography and soil moisture. We also questioned the initial comparability of the enclosed and control plots at the Drop Creek exclosure site, but we measured the Drop Creek plots and postponed judgement on whether or not to retain that exclosure in the study until after reviewing the data.

Previous Monitoring Protocol

Here, we review the exclosure monitoring protocols developed in 1982 to provide context for the changes in sampling methodologies we implemented in 1993. In the original monitoring protocol, 9 1x1-m quadrats were laid out both inside and outside each exclosure in a 3x3 array, with 0.6 m (2 ft) separating individual quadrats (Figure 2). One quadrat was identified as a permanent reference quadrat in each array, never to be clipped. The remaining 8 were to be clipped at the rate of one every 5 years. In 1982, species frequencies and heights were determined in the permanent 1x1-m quadrats inside and outside each exclosure using a 100-pin point-sampling frame with 10-cm spacing between pins. One destructive quadrat was clipped inside and outside each exclosure, but samples from 4 of the 6 exclosures were never sorted or weighed due to personnel and time limitations.

We identified several problems with the original monitoring protocol, including: (1) Measures of ground cover and heights of lichens, rather than frequency and biomass, have been used in the past to assess range condition on the adjoining Nelchina caribou range (Hanson 1958, Lieb et al. 1985). Differences in methodologies limited the usefulness of data for comparing between ranges. (2) A single 1-m² quadrat did not adequately sample the variability found inside and outside the exclosure plots. (3) By clipping a different quadrat every

five years, the protocol confounded space and time as variables. (4) the monitoring program was too time-intensive.

New Monitoring Protocol

To overcome the limitations identified above, we modified the monitoring protocol substantially before measuring vegetation inside and outside the exclosures in 1993. We estimated cover and heights of all species within nested quadrats placed systematically along three transects in each of the paired exclosure and control plots (Figure 3). Endpoints of the three transects, each 5 m long and 1.5 m apart, were marked with reinforcing bar driven into the ground. We estimated cover and mean heights of shrub and tree species within 15 1-m² quadrats, with 5 quadrats distributed along each transect forming a contiguous 1x5-m belt. We estimated cover and mean heights of all taxa in 30 20x50-cm quadrats, with 10 quadrats spaced at 0.5-m intervals along each transect. We estimated cover of all species whose canopy covered any portion of a quadrat using the following cover classes of Daubenmire (1959): T=<1%, 1=1-5%, 2=6-25%, 3=26-50%, 4=51-75%, 5=76-95%, 6=96-100%. We measured the average vegetative height of each species within each quadrat to the nearest 1.0 cm, and recorded heights <0.5 cm as "Trace". We recorded reproductive heights of flowering culms or stems separately if they differed from vegetative growth. We did not differentiate among moss species. We differentiated among genera of lichens in all cases, and among species if they could be discerned in the field. We collected a voucher sample of all species present in each exclosure so unknown lichens could be differentiated later. We photographed each transect from the endpoints and each of the 1982 destructured and permanent quadrats. Photographs, detailed protocol, exclosure layouts, and species lists are stored in a bookshelf box labeled "Caribou Exclosure Monitoring Project-1993" found in the Natural Resources files. Additional detail on the field sampling protocol is attached as Appendix A of this report.

Data Analysis and Presentation

Estimates of shrub and tree cover derived from the 1x1-m and 20x50-cm quadrats were redundant and comparable, so we limited our analyses to data derived from the 20x50-cm quadrats. We deleted from our analysis all data from quadrats that overlapped the 1-m² areas clipped in 1982. Therefore all analyses were based on coverage and heights of vegetation measured in 28 20x50-cm quadrats, both inside and outside the exclosures.

We compared percent of bare ground as well as total cover and mean vegetative heights of the following vegetation forms inside and outside each exclosure: shrubs, dwarf shrubs, graminoids, lichens, forbs, mosses, and lower vascular plants. We computed total cover of each vegetation form by summing coverages of individual taxa that comprised each form. We computed average height of each vegetation form as the mean of taxa heights, weighted by cover of each. We evaluated differences in total cover and mean heights of each vegetation form inside and outside of individual exclosures using Wilcoxon's 2-sample test. We appreciate the fact that inferences drawn by comparing vegetation from sub-samples inside and outside of individual exclosures cannot be used to infer range-wide trends (i.e., subsampling constitutes pseudo-replication *sensu* Hurlbert 1984). We analyzed the individual exclosures only to examine if vegetation differed inside and outside the individual plots. All differences were considered significant at $P \leq 0.05$.

We sought inferences at the more appropriate scale (i.e., rangewide) by examining differences in the mean cover and heights of vegetation forms inside and outside 4 independently distributed exclosures. We excluded the Drop Creek exclosure from this analysis because we were convinced after examining the vegetation further that differences we observed were more likely related to site differences (i.e., poor initial pairing of plots) than to effects of ungulate exclusion. Therefore, we tested differences using a randomized block analysis of variance (ANOVA) with the 4 exclosures as independent sampling units (blocks) and comparisons between inside and outside as the main treatment effect.

We present the tabulated data on cover and heights of lichens by genus in this report (e.g., Tables 2-6), primarily because species of several lichens were unknown or unverifiable in the field. For future reference, however, pending additional verification, we also report data for individual species and unknowns as they were recorded in the field in Appendix B.

All statistical analyses were conducted using Statistical Analysis Systems (SAS) statistical software. Copies of programs used to condense the data for subsequent analyses, and for conducting the Wilcoxon two-sample tests and randomized block analysis of variance are contained in Appendices C-E. A description of permanently stored data sets is provided in Appendix F.

Results

Windy Ridge

Shrubs, lichens, and dwarf shrubs dominated vegetation at the Windy Ridge exclosure (Table 2). *Vaccinium uliginosum* and *Empetrum nigrum* were the dominant shrubs, whereas *Stereocaulon* spp. and *Cladina* spp. were dominant lichens. "Reindeer" lichens, defined here as the genus *Cladina*, which is highly preferred as caribou forage (Pegau 1975), averaged approximately 13% of ground cover and grew approximately 2.5 cm tall both inside and outside the exclosure.

Cover and heights of several vegetation forms varied inside and outside the Windy Ridge exclosure (Table 2). Cover and heights of shrubs and lichens, the two dominant forms, did not differ between inside and outside; however, dwarf shrubs were taller inside than outside the exclosure. Grasses and mosses both were more abundant, and grasses were also taller outside the exclosure than inside (Table 2). Forbs were more abundant outside the exclosure than inside, but cover was so low in both cases (<1%) that we are unsure of the biological significance of that relationship.

Chelle Lake

Shrubs, mosses, and lichens dominated vegetation cover at the Chelle Lake exclosure (Table 3). *Betula glandulosa*, *Ledum palustre* and *Vaccinium uliginosum* were the dominant shrubs, whereas *Peltigera* spp. and *Cladonia* spp. were dominant lichens. "Reindeer" lichens (e.g. *Cladina* spp.) averaged <1% of ground cover both inside and outside the exclosure.

Cover of shrubs was greater inside the enclosure than outside, due primarily to high cover of *Vaccinium uliginosum* inside the enclosure (Table 3). Cover and heights of lichens also were greater inside than outside the enclosure, whereas cover of mosses and grasses, primarily *Festuca altaica* and *Poa glauca*, were greater outside. Cover of forbs, entirely *Cornus canadensis*, was greater outside than inside the enclosure.

Sanford River

Graminoids, shrubs, and lichens dominated vegetation cover at the Sanford River enclosure (Table 4). *Carex biglowii* and *Vaccinium uliginosum* were the dominant graminoids and shrubs, respectively. *Stereocaulon* spp. was the dominant lichen, but twelve genera comprised a diverse lichen community overall. Of all the vegetation forms, only lichens differed in cover inside and outside the enclosure (Table 4). Lichens were more abundant outside than inside the enclosure, due principally to greater cover of *Stereocaulon* outside, but lichens were lower in height outside the enclosure. Cover of "reindeer" lichens averaged approximately 4% of ground cover both inside and outside the enclosure and averaged ≤ 1.1 cm tall. By contrast, mosses grew taller outside the enclosure than inside, and graminoids were taller inside.

Klawasi River

Shrubs, mosses, lichens, and dwarf shrubs dominated vegetation cover at the Klawasi River enclosure (Table 5). *Vaccinium uliginosum* was the dominant shrub, whereas lichens were dominated principally by *Cetraria* spp., *Cladina* spp., and *Stereocaulon*. Together, the "Reindeer" lichens contributed 5-7% of ground cover but grew ≤ 1 cm tall both inside and outside the enclosure. Shrubs were more abundant inside than outside the enclosure, due primarily to greater cover of *Vaccinium uliginosum* and *Betula glandulosa*. Graminoids were more abundant outside than inside, due principally to greater cover of *Carex* spp. and *Eriophorum angustifolium*. Cover of lichens did not differ inside and outside the enclosure, but grew slightly higher within. Mosses were more abundant inside than outside the enclosure.

Drop Creek

Mosses, shrubs and graminoids dominated vegetation at the Drop Creek enclosure, but dwarf shrubs and lichens were prominent also (Table 6). Mosses were mostly dead, for reasons not understood. *Betula glandulosa* and *Salix planifolia* dominated the shrub layer, whereas *Empetrum nigrum* was the dominant dwarf shrub. Graminoids were dominated by *Carex vaginata* and *C. scirpoidea*. "Reindeer" lichens averaged approximately 8-10% of ground cover both inside and out, but grew ≤ 1 cm tall.

Vegetation cover differed appreciably between inside and outside the Drop Creek enclosure, as anticipated from the initial reconnaissance. The shrub layer was higher inside the enclosure than outside, due mainly to higher stature of *Betula glandulosa* inside. Cover of dwarf shrubs was greater outside than inside the enclosure, whereas cover of graminoids was greater inside, due mainly to differences in cover of *E. nigrum* and *Carex* spp. Cover of lichens was greater outside the enclosure than inside.

Collective Analysis

Randomized-block ANOVA revealed that cover and heights of most vegetation forms differed among exclosure sites ($P \leq 0.05$), indicating that vegetation was highly variable among sampling units. Of the vegetation forms examined, cover of only graminoids differed between grazing treatments (Table 8; $P \leq 0.05$) and was greater outside than inside the exclosures. Though not significant, cover of shrubs and dwarf shrubs tended to be greater inside than outside exclosures, whereas cover of mosses and bare ground tended to be greater outside than inside. There was no difference in cover of lichens inside and outside the vegetation exclosures, but lichens tended to grow taller inside than outside the exclosures ($P = 0.06$).

Discussion

Interpreting the results of grazing exclusion studies is rarely straightforward, and this study is no exception. Unfortunately, the Mentasta range exclosures, like most other ungulate exclosures of their era, may be too small to reliably separate the effects of ungulate exclusion from other possible influences of the fence. Fences may influence animal movements around the outside of the fence, which may affect adjacent vegetation plots if they are too near the fence, or they may influence microclimate and growing conditions within the fence, and provide safe haven for small herbivores that could alter vegetation in unforeseen ways (Daubenmire 1940, Heady 1968, Houston 1982, Sharpe 1956 [reviewed in Woodward et al. 1993]). The Mentasta exclosures were less than 4% of the minimum size Heady (1968) stated was needed to minimize these troublesome 'fence effects' in long-term studies of ungulates and vegetation succession. Of particular concern are photographs from Houston et al. (1984), which show small exclosures in subalpine meadows of the Olympic Mountains, Washington, accumulating snow drifts that could alter soil moisture, growing season, and possibly, vegetation composition.

We never examined the snow-holding capacities of the Mentasta exclosures, but we urge careful inspection of snow-deposition and ablation patterns near the exclosures before investing in long-term collection of potentially uninterpretable data. Further, we recommend developing a more comprehensive caribou range monitoring program using larger exclosures than those presently in use.

Interpreting results of the Mentasta range exclosure studies is further complicated by constraints in initial study design. Because no comparable data on plant cover and heights were measured at the time the exclosures were constructed, it's not possible to distinguish whether differences seen inside and outside of individual exclosures reflected differences in grazing pressure or initial differences in vegetation that may have existed when the exclosures were erected. Fortunately, differences in mean vegetation cover in 4 exclosures, analyzed collectively, probably represented real changes associated with grazing protection. Further, data collected in 1993 provide a benchmark for assessing future changes associated with continued protection from large herbivores, thereby increasing the value of future measurements.

We observed relatively minor differences associated with the exclosures and grazing treatment; only cover of graminoids differed between grazing treatments (i.e., cover greater outside exclosures), and height of lichens tended to be greater inside than outside the

exclosures ($P=0.06$). Hence, our studies, to date, suggest that grazing and trampling by large mammals have not had a pronounced influence on vegetation structure and succession since the exclosures were constructed. Several possible interpretations exist. First, seasonal densities of caribou on the Mentasta range, which approximated $0.4/\text{km}^2$ in the early 1980's and have declined since (Lieb et al. 1985), are lower than those reported for other reindeer or caribou ranges where more pronounced influences of caribou on vegetation trends have been reported (Pegau 1968, Klein 1987, Crete et al. 1990). Moreover, 2 exclosure sites (i.e., Chelle Lake and Klawasi River) appeared to be outside the core summer range used by the Mentasta herd, which could further reduce grazing effects. Lastly, 11 years of grazing protection may not be sufficient time for differences in animal-driven changes in vegetation structure to be fully expressed, particularly given the current low caribou density. Previous research elsewhere suggests that responses of lichens to grazing protection may be evident as soon as 10-20 years after protection from grazing (Lieb et al. 1985) but may require 20-40 years before climax range conditions are fully evident (Pegau 1968, Skoog 1968). Incipient differences in heights of lichens we observed inside and outside the Mentasta exclosures may be only an initial expression of lichen responses to ungulate exclusion.

Our results are an important baseline for future monitoring and assessing current condition of lichens at the exclosure sites. Hanson (1958) classified condition of lichen winter ranges as:

Excellent:	Lichen cover >20%, and approximately 2.5-6 inches tall. Lichens dominated by <i>Cladina stellaris</i> , <i>C. arbuscula</i> , and <i>C. rangiferina</i> .
Good:	Lichen cover >20%, and approximately 1-2.5 inches tall. <i>Cladina arbuscula</i> and <i>C. rangiferina</i> abundant.
Fair:	Lichen cover >20%, but 0.5-1 inch tall. <i>Cladina arbuscula</i> and <i>Stereocaulon</i> spp. abundant
Poor:	Lichen cover >20%, but <0.5 inch tall. <i>Cladina arbuscula</i> , <i>Stereocaulon</i> spp., <i>Cetraria</i> spp., <i>Cladonia</i> spp., and <i>Peltigera</i> spp. present.

Based on those criteria, lichen ranges at five exclosure sites we examined were in poor or fair condition. Lichen condition was highest (e.g. fair) at the Windy Ridge site, based on comparatively high cover and stature of *Cladina* (mostly *arbuscula*) and *Stereocaulon* (Table 2). Lichen condition generally was poor at the remaining sites with either low cover (e.g., Chelle Lake) or heights (e.g., 0.7-1.3 cm) of lichens, primarily *Cladina arbuscula*, *Cetraria* spp., and *Cladonia* spp. Skoog (1968; cited in Lieb 1985) equated these condition classes generally with early to medial stages of lichen succession.

Special care must be exercised in interpreting such value-laden concepts as range 'condition', particularly in National Parks where management objectives do not stress commodity production from rangelands. Entirely plant-based assessments of range condition do not consider natural processes and dynamics of the grazing system. For example, perhaps "fair" and "poor" lichen conditions are characteristic of unmanaged grazing systems in the Mentasta range and entirely appropriate for NPS management objectives. Setting all judgements aside,

we present these qualitative ratings of range condition as convenient benchmarks for future comparisons and not to make any statement of what constitutes an appropriate range management objective for National Park Service lands.

Historical patterns of lichen abundance and primeval composition of lichen communities are not known on the Mentasta range, making it difficult to interpret range trend from such short-term monitoring. Low abundance of lichens may reflect conditions favoring graminoids and low shrubs, or alternately, past heavy use by caribou. Previous studies have shown that reduction of lichens due to grazing and trampling by caribou can lead to increased dominance of vascular plants, particularly low shrubs (Pegau 1975, Helli and Aspi 1983) or graminoids (Klein 1987, Crete et al. 1990, Thing 1984 [reviewed by Crete et al. 1990]). Klein (1987) suggested that dense lichen mats may limit growth of vascular plants by restricting access to light, limiting substrate available for germination, and possibly increasing insulative cooling of the soil. Our results, indicating that graminoids have increased outside 4 exclosures suggest that grazing and trampling may favor graminoids and limit abundance of lichens. Persistent, long-term monitoring is needed to elucidate and confirm these and other potentially important patterns of sedge, lichen, and caribou dynamics on the Mentasta range.

Recommendations

1. We recommend continuing to monitor caribou and vegetation trends in the Mentasta grazing system. Ideally, a comprehensive vegetation monitoring program would require increased sampling efforts using larger vegetation exclosures than those presently in use. If opportunities arise to build or expand the current vegetation monitoring program, we recommend building at least 3 new exclosures each in low-elevation open-black spruce forests (*circa* 1000 m elevation) and dwarf-scrub tundra communities (*circa* 1500-m elevation). Exclosures should be a minimum of 50 x 50 m, and preferably even larger (up to 0.5 ha). Exclosure sites should be randomly selected from among the appropriate vegetation classes within the core area of the Mentasta range (Jenkins and Barten, in prep). At each site, 2 comparable exclosure-sized plots should be identified, no closer than 100 m apart, followed by a random assignment of control and enclosed plots within each pair. We recommend monitoring cover and heights of principal vegetation forms and forages of caribou in a minimum of 50 1x1-m sampling quadrats, distributed as far from the exclosure fences as proves practical.
 2. Realistically, the existing network of small exclosures may be the only affordable, sustainable monitoring option available at the present time. Because small exclosures have been shown in other areas to accumulate snow, thereby possibly influencing growing conditions, we recommend measuring snow accumulation and ablation patterns near the existing exclosures. Many sampling strategies exist, but consider measuring snow depths along 60-m transects arranged in such a manner as to cross through each of the existing Mentasta range exclosures in the direction of prevailing winter winds. Ideally snow depths should be measured at 1-m intervals along each transect, both in the exclosure and on windward and leeward sides of each exclosure, preferably during mid-winter (i.e., peak accumulation) and during the spring thaw (i.e., ablation). We cannot overemphasize the importance of investigating these potentially troubling "fence effects" before making a final decision on whether to retain and continue measuring the
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existing set of range exclosures. No amount of monitoring will increase understanding of Mentasta grazing systems if vegetation changes within exclosures are related to uncontrollable influences of the experimental protocol.

3. If no differences are detected in snow depths and persistence inside and outside the enclosures, we recommend continuing to measure vegetation trends in the Windy Ridge, Chelle Lake, Sanford River and Klawasi River exclosures. We recommend repeating the 1993 measurement protocols (Appendix A) at approximately 5-year intervals, with one procedural modification. We recommend estimating plant cover using the following narrower cover classes: <1=1%; 1-10, estimate at 1% intervals; 11-90, estimate at 5% intervals; 91-100, estimate at 1% intervals. The narrower cover classes may be more likely to detect changes through time. We also recommend reexamining the 100-point frames that were established in each of the permanent 1-m² plots inside and outside each exclosure. Although limited in scope, those 1-m² plots remain our only link with data collected in 1982 and may prove very instructive of vegetative changes over a longer period than since 1993. A trained two-person crew should be able to sample each of the existing exclosures in a long day provided a helicopter is used for access. At least one member of the crew must be able to identify vegetation visually, including the lichens, to at least the generic level. Maps of each exclosure, associated transects, and detailed notes on sampling design are filed in the Wildlife building in a bookshelf box labeled "Caribou Exclosure Monitoring Project, 1993".
 4. If the existing exclosures are retained for future monitoring, they will need to be maintained. We recommend checking each of the existing exclosures from aircraft annually (preferably from a helicopter) to ensure they continue to exclude ungulates. This could be accomplished during the spring or fall caribou composition surveys. Latitudes and longitudes of each exclosure are provided in Table 1 to help facilitate making routine inspections as cost-effectively as possible. Each year it should be noted whether the fences are upright, and if the guy wires, anchor posts, and fencing are in place. Whenever there is an opportunity to visit the exclosures on the ground, it should be noted if the wood stakes marking the 1 x 1 permanent reference quadrats and if rebar marking the transect endpoints are in place. We recommend making all repairs to damaged exclosures in as timely a manner as possible.
 5. We recommend analyzing future vegetation changes associated with the Mentasta exclosures using the 1993 data set as a benchmark in time. Changes relative to 1993 should be analyzed as a repeated measures analysis of variance with exclosure sites serving as independent replicates (i.e., blocks), inside versus outside the exclosure as the main treatment, and year as a split-plot in time. Evaluation of the treatment x time interaction term is the appropriate test of whether ungulate exclusion has affected plant successional trends between sampling periods. We make one additional recommendation for analyses of future data sets: in addition to analyzing changes in the principal vegetation forms, we recommend also analyzing changes in 'preferred forages' within each vegetation form. Changes in abundance or heights of preferred 'reindeer' lichens or deciduous shrubs could be obscured by pooling these preferred forages with unpalatable forages within the same vegetation form. The original data collected from each exclosure are stored as DBASE data files (e.g. dbf files) named
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DROP, SANFORD, KLAWASI, CHELLELK, and WINDY. Data sets are stored on the former Research Biologist's computer under d:\dbdat\excl, as well as on separate diskettes stored in the bookshelf box labeled "Caribou Exclosure Monitoring Project, 1993".

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