Vegetation Analysis of Grazed and Ungrazed Alpine Hairgrass Meadows[1]

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Highlight

Alpine hairgrass meadows in Colorado and Wyoming were examined for plant species differences related to sheep grazing history. Nine alpine areas were studied and three of these had not been grazed by domestic sheep for many years. Frequency values for eight plants were found to be useful in determining whether or not hairgrass meadows have been predominantly grazed over the years by domestic sheep. No additional information was obtained by including species cover data for classification purposes.

The first information on alpine vegetation of the southern Rocky Mountains came from botanical explorations made in the early 1800's. Only new or rare plants to the area were listed and few detailed accounts were given of the vegetation as a whole (Cox, 1933). Griggs (1956) agreed with Weaver and Clements (1938) in their conclusion that alpine communities are little understood, and ascribed the limited work in alpine areas to the complex nature of tundra communities. The heterogeneity found in alpine species groupings is such that some botanists have concluded that there is no sense at all to tundra vegetation. Polunin (1948) said the more he learned about alpine vegetation as a whole, the less he felt inclined to generalize about it.

A greater portion of alpine tundra of the southern Rocky Mountain Region was categorized as alpine grassland than any other community type by both Cox (1933) and Weaver and Clements (1938). This categorization is an important factor in grassland management since management principles are often based on the predominant vegetation type. Included in six grassland types described by Cox (1933) are three associations which contain tufted hairgrass (*Deschampsia caespitosa*) in abundance. These are: snowflush association, alpine-moor association, and wet-meadow association. In the alpine-moor association, hairgrass is said to form a transition from wet areas to upper slopes of the dry alpine meadows. Hairgrass was considered the dominant in wet-meadow associations and as an important species in the other two associations.

Tufted hairgrass is a well-known montane species but has received little specific attention in alpine tundra studies. The species is distributed throughout alpine regions of the world and include the Alps, Pyrenees, and the Himalayas. A favorable habitat for tufted hairgrass is indicated by sub-

[1] Appreciation is extended to the National Science Foundation (GB-11335) for partial support of this study. Received July 21, 1971.

stantial snow cover or by snow melt water influence. Additionally, late-lying snowbanks are known to offer protection against grazing. Hairgrass meadows are also recognized as being the best developed of true grass meadows in alpine tundra (Marr, 1961). Lawrence (1945) observed that hairgrass requires permanent ground moisture and relatively cool to cold climates in order to survive. Cooper (1908) described hairgrass as being a secondary species in his classification of dry grassland tundra meadows. Holm (1908) on the other hand, included hairgrass as being more important in swamps of the aspen zone.

Tufted hairgrass has been observed to be the most important forage species occurring on alpine sheep ranges (U.S. Forest Service, 1956). Its importance is recognized because of its ecological range, abundance, amount of herbage produced, and use by domestic sheep. Moist to wet sites in alpine hairgrass meadows have been observed to produce 0.7 tons of air-dry plant material per acre, with at least 85% of this consisting of plants which were palatable to domestic sheep. In contrast, turf-sites which are well drained and located on ridge tops are known to produce about 0.4 tons per acre of air-dry material with approximately 65% palatable for sheep (U.S. Forest Service, 1956). The importance of tufted hairgrass as a component of other vegetation types of the alpine tundra has also been noted by several researchers.

A study was made of alpine tufted hairgrass meadows in the southern Rocky Mountain Region to determine if plant composition differed in historically grazed areas as compared to that of ungrazed areas. Some studies of a local nature have been conducted in alpine hairgrass meadows and to date no comparisons of any characteristic of phytosociological structure have been made for geographically separated areas. Furthermore, no reports have been made comparing alpine hairgrass meadows which have not been grazed for many years to those grazed by domestic livestock.

Methods and Procedures

Nine areas were selected from alpine regions located in southern Wyoming and throughout Colorado (Fig. 1). Criteria for selection of an area for study included: accessibility, geographic relationship to other areas in the study, past use by domestic sheep, and timberline relationships. All study areas were located well above timberline and included a geographical representation of the southern Rocky Mountain Region. A stand size 7 × 10 meters was selected as a macro-plot representing hairgrass meadow vegetation. Each stand was sampled by placing 50 quadrats (10 × 40 cm) at random within. Presence for all species encountered in quadrats was noted and frequency computed. Density of hairgrass only was recorded for all 50 quadrats in each stand. Cover values were visually estimated for each species that occurred in every fifth quadrat. Thus, a total of 10 samples for species cover values were obtained for each stand. Data

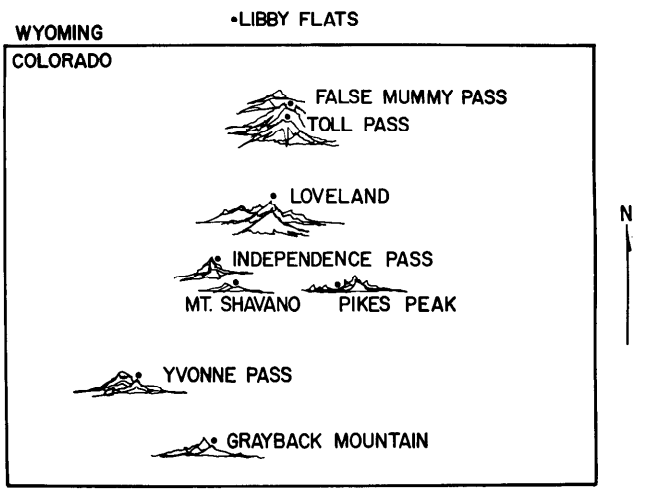

FIG. 1. Location of study areas containing alpine hairgrass meadows.

were obtained from three ungrazed areas having a total of 28 stands. These areas were False Mummy, Trail Ridge Road, and Pikes Peak. Grazing by domestic sheep has not been permitted for many years in the three areas and hopefully, an indication of hairgrass meadow vegetation differences due to continuous grazing can be assessed.

Cover data for species were available only for the two latter areas. The remaining six areas had a long history of use by domestic sheep and were represented by 49 stands. Generally grazed meadows were easily accessible and free of snow during the season of use by sheep. Relative soil moisture levels were determined for all stands, and included the following: very wet, wet, mesic, and dry-mesic. A total of 77 stands were sampled with the number of stands within areas ranging from 6 to 12.

Bonham and Ward (1970) reported that 20 species were found consistently throughout alpine hairgrass stands. These species were selected for use in this study. Multivariate analysis of variance in combination with step-wise discriminant analysis was performed on frequency and cover data in order to determine the set of species giving the largest significant difference between group means. This procedure was also used to evaluate the power of species occurrence to discriminate between grazed and ungrazed areas.

Results and Discussion

The abundance of hairgrass in alpine meadows was found to vary both within and between grazed and ungrazed areas. Density of hairgrass ranged from 18 plants/m² to 48 plants/m², in grazed and ungrazed areas respectively. However, at least 40 plants/m² were observed for one meadow in a grazed area while the greatest range in hairgrass density occurred in ungrazed areas. The range of hairgrass frequency, on a meadow basis, was from 10 to 100% occurrence in ungrazed areas while that of grazed areas ranged from 18 to 98%. The overall percentage frequency of hairgrass for areas ranged from 49 to 85%. The lower frequency values occurred in southern sample areas while the higher values occurred in northern areas (Fig. 1).

Table 1. Important species and their frequency (%) of occurrence in grazed and ungrazed alpine hairgrass meadows. Only eight species were significantly ordered.

Species	Frequency		Importance level as discriminator	Discriminant coefficient
	Ungrazed	Grazed		
Phleum alpinum	0	17	1	–0.126
Potentilla diversifolia	4	30	2	–0.115
Polygonum bistortoides	44	30	3	0.167
Poa alpina	0	11	4	–0.156
Caltha leptosepala	28	6	5	0.131
Geum rossii	60	38	6	0.130
Senecio dimorphyllus	9	14	7	–0.058
Oreoxis alpina	1	12	8	–0.011
Achillea lanulosa	2	22		
Androsace septentrionalis	3	11		
Arenaria obtusiloba	14	10		
Artemisia norvegica	38	18		
Erigeron simplex	20	24		
Festuca ovina	28	24		
Lewisia pygmaea	4	12		
Ranunculus adoneus	12	6		
Sibbaldia procumbens	16	38		
Taraxacum ceratophorum	0	8		
Trifolium parryi	32	18		

Alpine hairgrass meadows are known to be associated with heavy snow accumulation (Marr, 1961). It was evident from this study that late lying snowbanks prevented grazing of some meadows even in areas used by sheep. Thus, responses of vegetation to long-term grazing exposure have been confounded with snowmelt. However, it was generally noted that snow receded earlier in the southern part of the study region and subsequently hairgrass meadows were opened to grazing earlier. Correspondingly, more species of palatable forbs occurred in these hairgrass meadows, which gave a higher species diversity for grazed compared to ungrazed areas. Important forbs and their distribution in grazed and ungrazed meadows are listed in Table 1. Western yarrow (*Achillea lanulosa*) was the most widely distributed species throughout grazed areas and was a common species in several of these hairgrass meadows. In contrast, marsh-marigold (*Caltha leptosepala*) was observed to be common in ungrazed regions and occurred sparingly in a few meadows of grazed areas.

The importance of alpine avens (*Geum rossii*) as a component of ungrazed areas is evident from this study. Smith and Alley (1966) observed that alpine avens was an important member of several alpine vegetation types, and often dominated specific types. Furthermore, this species was recognized in their study as being unpalatable to sheep and other grazing animals. In contrast, Strasia et al. (1970) found that alpine avens made up 10% of sheep diets consistently throughout the summer on alpine ranges. In the present study, alpine avens occurred abundantly in hairgrass meadows of ungrazed areas and was found to dominate in meadows with mesic to wet habitats regardless of grazing history.

The common grasses occurring in alpine areas, for example Patterson bluegrass (*Poa pattersoni*), alpine bluegrass (*Poa alpina*), alpine timothy (*Phleum alpinum*), and sheep fescue (*Festuca ovina*) are more abundant in the drier habitats of alpine tundra. It was noted that these important grass species never occurred with hairgrass when density of the latter species exceeded 40 plants/m^2. Since it was suggested by Holway and Ward (1963) that hairgrass density is influenced by snow accumulation in alpine areas of Colorado, a covariance analyses was conducted on the data with hairgrass density as the covariate. No significant effect of the occurrence of other species with respect to hairgrass density was observed in this study.

Multivariate analysis of variance using all species, indicated that a significant difference existed in species mean occurrences for grazed versus ungrazed areas ($P < .01$). Step-wise discriminant analysis was then performed on the variance-convariance matrix for species listed in Table 1. This procedure yields coefficients for each species which are then used to classify the species group into grazed or ungrazed meadows. Eight species were found to be important discriminators for detecting significant differences in grazed versus ungrazed meadows. Alpine timothy was determined to be the most important discriminator for detection of ungrazed hairgrass meadows. It was obvious that two criteria were important: (1) the variance of the occurrence for the species and, (2) the absence of alpine timothy in ungrazed hairgrass stands. This species used alone as an indication of grazing history, correctly classified all ungrazed meadows, but misclassified 43% of the grazed meadows. Research on the management of alpine sheep ranges has indicated that alpine timothy is second only to hairgrass in importance according to its range, abundance, amount of herbage produced, and use by sheep (U.S. Forest Service, 1956) while bluegrass species were listed third. Neither alpine timothy nor bluegrass species occurred in hairgrass meadows of ungrazed regions.

Cinquefoil (*Potentilla diversifolia*) in addition to alpine timothy, increased classification accuracy to 70%. The former species was also more abundant in grazed areas than in ungrazed areas. The power to discriminate between grazed and ungrazed conditions concomitantly was reached only by using all eight species in order of their importance as indicated in Table 1.

The species coefficients give relative contrasts of the eight species and their importance as predictors of grazing relations in hairgrass meadows (Table 1). Approximately equal amounts of these species imply the existence of an intermediate stage between grazed and ungrazed conditions, historically. Two of the three species with positive coefficients were included by Strasia et al. (1970) as being important in diets of sheep. Furthermore, these two species, alpine avens and American bistort (*Polygonum bistortoides*) occur more abundantly in ungrazed hairgrass meadows.

Only three of the eight discriminator species occurred more frequently in ungrazed areas. Although alpine avens is an important species in ungrazed areas, its value as an indicator species was lowered by the fact that it occurred as the most frequent species in one of the grazed areas, Mt. Shavano. Snow accumulation on hairgrass meadows in this area however, indicated little or no grazing of these meadows early in the season.

Alpine timothy and alpine oreoxis (*Oreoxis alpina*) did not occur in meadows with hairgrass densities greater than 25 plants/m^2, while marsh-marigold did not occur when hairgrass densities were less than 12 plants/m^2. The remaining five indicator species occurred at all levels of hairgrass densities encountered.

Only five species were found to have cover values greater than one percent in ungrazed areas compared to only three species having in excess of one percent cover for grazed areas. The analysis of cover data using these procedures indicated that only three species were significant in distinguishing grazed areas from those ungrazed. Two of the three species were important both for cover and frequency of occurrences. American bistort was the most important discriminator using cover data. Previous studies have indicated that this forb is preferred early in the grazing season and make up a significant proportion of the diet of sheep (Strasia et al., 1970). The second most important species was found to be sandwort (*Arenaria obtusloba*), followed by marsh-marigold.

It is obvious from this study that the absence of other major grass species in hairgrass stands is ecologically significant and indicates that grazing history has affected the species composition of alpine hairgrass meadows. Furthermore, important forbs such as American bistort, which are eaten by sheep during the early part of the season were much more abundant in ungrazed areas. Additionally, forbs having low palatability such as western yarrow, were observed to be more abundant in grazed hairgrass meadows than in ungrazed hairgrass meadows. Forbs are preferred by sheep early in the season and those that are not preferred by sheep can be predicted from this study. Forbs classified as not used by sheep include: cinquefoil and western yarrow. In contrast, marsh-marigold, alpine buttercup (*Ranunculus adoneus*) and alpine sage (*Artemisia norvegica*) are forbs which have not been reported as important in sheep diets, yet this study suggested that they might be (Table 1). Further studies need to be carried out in order to determine more fully the relationship of species composition and abundance in hairgrass meadows with regard to the grazing affects of domestic sheep.

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