COMPARING FORAGE SELECTION AND EVALUATING TRAMPLING IMPACTS OF HORSES AND LLAMAS IN WILDERNESS AND BACKCOUNTRY MEADOWS

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by
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AUTHORIZATION TO SUBMIT THESIS

This thesis of Heidi A. Schantz, submitted for the degree of Master of Science with a major in Resource Recreation and Tourism and titled "Comparing Forage Selection and Evaluating Trampling Impacts of Horses and Llamas in Wilderness and Backcountry Meadows," has been reviewed in final form, as indicated by the signatures and dates given below. Permission is now granted to submit final copies to the College of Graduate Studies for approval.

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ABSTRACT

Packstock use is an accepted activity in many Wilderness, park, and wildland areas. Llamas (*Lama glama*) have joined the traditionally used horse (*Equus caballus*) and are becoming an increasingly popular choice of recreational packers. This study compared forage selection and evaluated trampling impacts of horses and llamas when used as recreational packstock. The intent was to provide information to managers who are often mandated to allow for packstock use while maintaining the ecological integrity of the area.

Forage selection was determined using fecal analysis. Grasses and grass-likes formed 98.3% of horse diets and 97.8% of llama diets. Kulcyznski's Similarity Index was used to examine dietary overlap between horses and llamas and considerable overlap was found among and between animal groups. Discriminate analysis identified *Senecio triangularis*, *Carex* spp., and miscellaneous grasses as important variables in discriminating between horse and llama diets in this study.

Animals were confined to plots and soil compaction and changes in soil surface roughness were examined for each animal type as indicators of trampling impacts. Soil compaction increased significantly after trampling for both animals. No significant change in soil surface roughness was found for either animal after grazing. Field observations suggest that horses and llamas differ in their impact to plants due to trampling and that these differences deserve further study.

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SECTION I

Introduction

Packstock are a common and traditional mode of travel in Wilderness and backcountry areas. Although stock use has diminished over the past 30 years, it is still an accepted recreational activity which will likely continue. In addition to the traditionally used horse and mule, llamas are becoming an increasingly popular pack animal. The use of horses and mules as packstock began to decline in the 1960's, leveling off in the past decade (McClaran 1989), while the use of llamas has increased. Although llama use accounts for less than five percent of total packstock use in the United States, llamas constitute more than 20 percent of the packstock in four Wilderness areas (McClaran and Cole 1993). Between 1985 and 1990, fifty-seven percent of Wilderness areas permitting stock use experienced some llama use (McClaran and Cole 1993). The increased popularity of llamas can be attributed to their ease of handling and transport as well as claims that they cause less damage to the backcountry environment (Daugherty 1989; Markham 1990). These claims have not yet been substantiated by research.

Cole (1989) points out that our understanding of recreational stock impacts in areas where stock are kept overnight and allowed to graze, is fragmentary at best. He also points out the need to investigate the differences among various pack animals in regard to diet preferences and impacts on soils (Cole 1993). This study addressed these research needs. The primary purpose of this study was to compare forage selection and evaluate trampling impacts of horses and llamas used as recreational stock.

A goal of this research was to contribute to quality resource management by increasing understanding of packstock impacts to backcountry and Wilderness areas and by providing information to land managers. Literature on recreational packstock impacts and management is sparse given the pervasiveness of packstock use (Cole 1990). This study focused on the recreational setting in an attempt to provide more useful information to managers. This research may also help to address the practical problem of setting regulations for llama use in Wilderness and backcountry areas. Due to the lack of information about the impacts llamas have on the backcountry environment, regulations concerning llama use have been set arbitrarily or they are managed similar to horses and mules. With an increased understanding of llama impacts, regulations can be tailored to their particular characteristics and behavior.

A model depicting theorized interactions of packstock with Wilderness or backcountry foraging areas is presented in Figure 1. The model demonstrates both the complexity of the interactions and the challenge of choosing a starting point to begin understanding the system. The model depicts that two primary ways in which packstock influence a site are grazing and trampling. This exploratory study began at these two starting points and examined forage selection and trampling impacts of horses and llamas. Due to budget constraints, the study was limited to a single season. This limitation made it impossible to assess the short- or long-term impacts of packstock on backcountry foraging areas. The information gained in this study should be used to direct long-term investigations.

Potential Impacts

Recreational packstock affects backcountry sites through both grazing and trampling, especially when stock are confined to one area. Damage to plants through excessive grazing and trampling reduces plant vigor, which can lead to a reduction in the vegetative cover of an area and subsequent changes in species composition of the stand (Cole 1981, 1989; DeBenedetti and Parsons 1979; McClaran and Cole 1993). This compositional change occurs because some plant species are more resistant to grazing and trampling damage and some species are selectively grazed. These conditions promote unpalatable species (DeBenedetti and Parsons 1979). Decreased plant cover can also favor establishment and expansion of native colonizer species or more seriously, exotic species brought to the area in feces, feed, or seeds transported on the stock animal's coat (Cole 1990, 1993; Whinam *et al.* 1994).

The extent of packstock impacts is influenced by a wide variety of factors. Grazing effects vary with the severity of defoliation (the amount of vegetative material removed), the phenological stage of the plant (i.e., emergence, anthesis, seed firm, etc.), stocking rate (amount of use), frequency of defoliation (how often grazing occurs), and timing or season of defoliation (McClaran and Cole 1993; Stoddart *et al.* 1975).

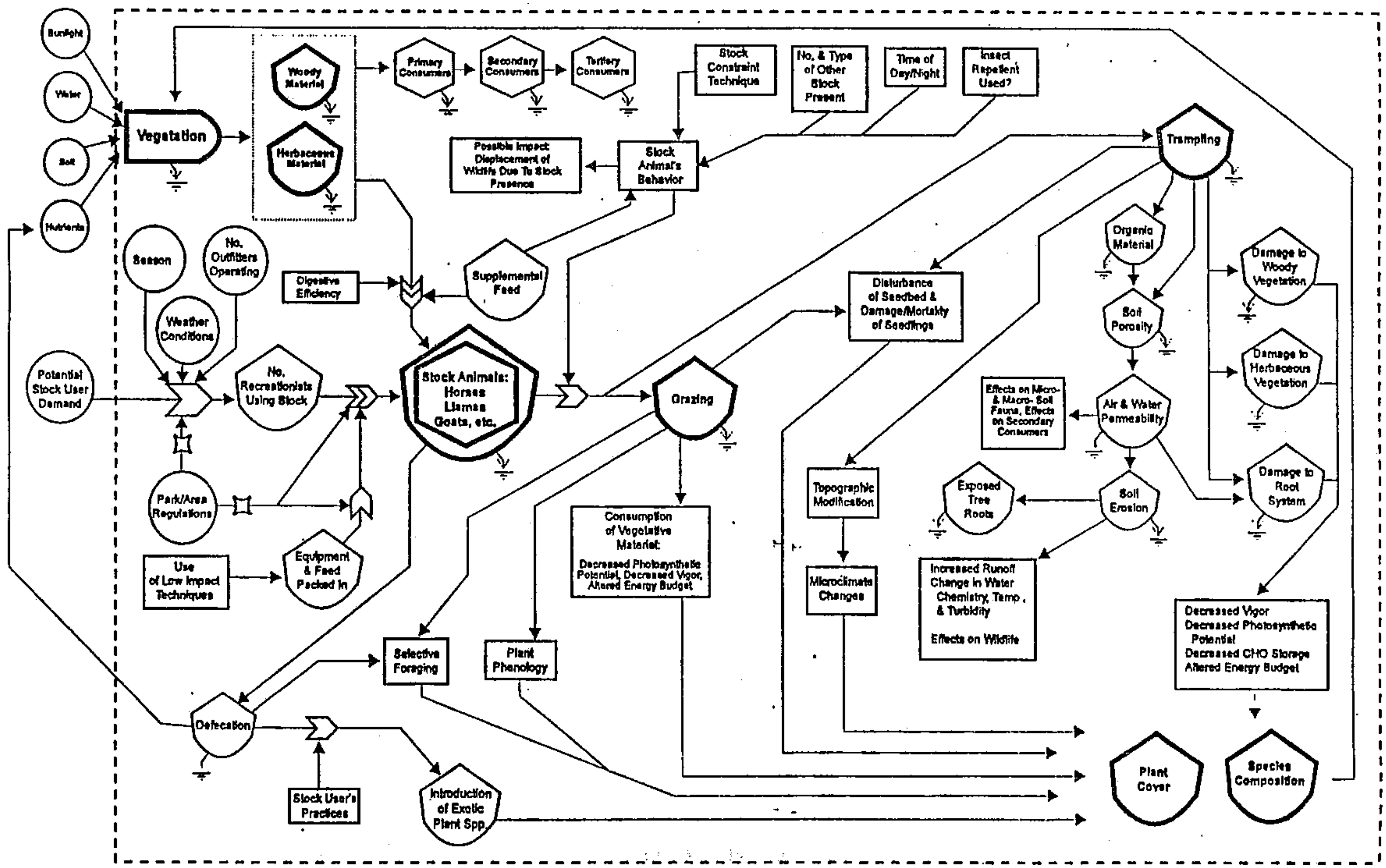

Figure 1. Model of theorized interactions of packstock with wildland foraging areas.

Trampling affects vegetation through defoliation and mechanical damage to above-ground plant structures, root damage caused by stock hooves shearing the soil (McClaran and Cole 1993), and modification of the soil surface topography (DeBenedetti and Parsons 1979; Liddle 1975). Trampling also affects vegetation by changing the characteristics of the soil medium. Trampling causes soil compaction, which decreases soil porosity, oxygen diffusion, root penetration, nutrient availability, and water infiltration into the soil (Kuss and Graefe 1985; Liddle 1975; McClaran and Cole 1993). Soil compaction also inhibits seed germination and seedling establishment (Kuss and Graefe 1985). Soil-dwelling biota are negatively impacted by soil compaction (Chappell *et al.* 1971, Murphy *et al.* 1995). These organisms are important for developing soil structure and promoting nutrient cycling (Cole 1993). Trampling effects depend on site conditions, particularly soil moisture (Cole 1985).

The dung and urine deposited by grazing animals on meadows have the potential to alter the meadow's productivity and species composition. These effects depend on a variety of plant, animal, soil, and climatic factors (Watkin and Clements 1978). Dung affects plants through physical smothering and creation of high nutrient concentrations (Crawley 1983). Species composition changes may occur around dung piles because herbivores may avoid grazing in these areas and some plant species thrive in the nutrient rich conditions (Crawley 1983; Watkin and Clements 1978). Herbivores have the potential to affect the spatial distribution of nutrients in an area. Herbivores which feed over a large area but defecate over a small area can cause nutrient dislocation (Crawley 1983).

Packstock also have the potential to impact wildlife populations by competing for available forage. The degree of competition depends on diet similarity, available forage, herbivores present, grazing intensity, and range overlap (Stoddart *et al.* 1975).

One of the primary goals of Wilderness management is the maintenance of naturally functioning ecosystems. Referring back to Figure 1, grazing and trampling emerge as two primary sources of impacts which have the potential to alter the natural ecosystem. Selective grazing may cause shifts toward unpalatable species while excessive trampling causes shifts in species composition toward trample-resistant species (Cole 1981, 1989; DeBenedetti and Parsons 1979; McClaran and Cole 1993). This study investigated these two important sources of ecosystem-level changes by comparing forage selection of horses and llamas to identify which species are selectively grazed and by evaluating changes in several soil characteristics following trampling by horses and llamas.

SECTION II

Comparison of Forage Selection Between Horses and Llamas in Wilderness and Backcountry Meadows

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Comparison of Forage Selection Between Horses and Llamas in Wilderness and Backcountry Meadows

Edwin E. Krumpe and Heidi A. Schantz

Abstract

A study was conducted on a subalpine meadow to test for differences in forage selection by horses and llamas when used as recreational packstock animals. Animals were placed on plots and diet selection was determined using fecal analysis. Both horse and llama diets consisted primarily of grasses and grass-likes. Horses consumed a significantly higher percentage of some grass species while llamas consumed higher percentages of *Carex* species. Kulcyznski's Similarity Index was calculated and dietary overlap was found between horses and llamas. Discriminate analysis identified *Senecio triangularis*, *Carex* spp., and miscellaneous grasses as important variables in discriminating between horse and llama diets in this study.

Introduction

Recreational packstock use is an accepted but controversial activity in Wilderness and other wildland areas. Managers of these areas are often mandated to protect wildland ecosystems while allowing for packstock use. Llamas (*Lama glama*) are joining the traditionally used horse (*Equus caballus*) and are becoming an increasingly popular choice for recreational packers. Between 1985 and 1990, fifty-seven percent of Wilderness areas in the United States allowing stock use reported some llama use (McClaran and Cole 1993). Llamas add a new dimension to the challenge of managing packstock impacts.

The interaction of recreational packstock with wildland ecosystems is a multivariate phenomenon, but one potential source of impacts is grazing. Damage to plants through excessive grazing reduces plant vigor which can lead to a reduction in the vegetative cover of an area and subsequent changes in species composition of the stand (Cole 1989;

McClaran and Cole 1993). Compositional change occurs because some species are more resistant to grazing and some species are selectively grazed. These conditions promote unpalatable species (DeBenedetti and Parsons 1979). Decreased plant cover can favor the establishment and expansion of native colonizer species or more seriously, exotic species brought to the area in feces, feed, or seeds transported on recreationists and their stock (Cole 1993, Whinam *et al.* 1994). Grazing effects vary with the severity of defoliation, the phenological stage of the plant, frequency of defoliation, and timing or season of defoliation (McClaran and Cole 1993; Stoddart *et al.* 1975).

Cole (1993) points out the need to investigate differences between various pack animals in regard to forage selection. Much of the research involving grazing impacts and forage selection involves livestock grazing, with less attention given to stock used in the recreational setting. The grazing behavior and impacts of recreational packhorses has been studied recently by Olson-Rutz *et al.* (1996a, 1996b). Other researchers have reported on the forage selection of free-ranging horses (Hansen 1976; Olsen and Hansen 1977; Reiner and Urness 1982). Research involving the grazing behavior and diet selection of llamas, however, is limited to studies of domestic herds in the Andes Mountains of South America (Genin *et al.* 1994; Pfister *et al.* 1989; San Martin and Bryant 1989).

This study was conducted to determine the forage selection and dietary overlap of horses and llamas grazing on a subalpine meadow. The study was designed to represent the recreational stock use situation in an attempt to provide wildland managers with more useful information for developing packstock management strategies.

Study Site

This study was conducted at Hard Creek Meadow, a dry, subalpine meadow in the Payette National Forest of Central Idaho (NW 1/4 S. 12, T. 21 N., R. 2 E.). Hard Creek Meadow was chosen because it parallels Wilderness conditions and represents an area typically visited by recreational stock users in western North America. The meadow is located at approximately 2135 m in elevation, in an area that receives dispersed camping and stock use. The meadow is part of an active sheep grazing allotment, being periodically grazed in early autumn. The meadow has been historically used by recreational stock and stock used by U.S. Forest Service managers.

Hard Creek Meadow lies in an area which was lightly scoured by glacial action followed by cryoplanation, resulting in localized transportation of materials. The dominant soil type is classified as a loamy, skeletal, mixed, Typic Cryumbrebt. Surface layers are silt loam, very dark grayish-brown to dark brown, with a fine moderate granular structure, 10-15% angular gravel, and a depth of 20-40 cm. Subsoil layers are gravelly silt loam to very gravelly loam, dark yellowish-brown to olive, with massive to coarse moderate subangular blocky structure, 30-50% angular gravel, and a depth of 50-120 cm. The granitic bedrock is composed of well to extremely well-fractured weakly andesitic rocks (USDA 1973). The meadow is generally flat, with slopes ranging from 0-10%.

Methods

Diet composition was determined in August, 1996. Three individuals of each animal type were used in this study to attempt to control for differences in forage selection between individuals. The animals were chosen to typify recreational packstock. The three pack horses weighed approximately 450 - 500 kg each. Two mares, ages 26 and 9 years, and one 21 year old gelding were used. The three pack llamas included two intact males and a gelding, all between the age of 5.5 and 6 years, and weighing approximately 160 kg each.

Study plots were chosen to be as homogenous as possible and were limited to grasses, grass-likes, and forbs, with trees and shrubs excluded wherever possible. Plots were enclosed by portable electric fencing, and water and mineral supplement were provided *ad libitum* in the center of each plot. Plot size was based on 35% forage utilization by each animal type over a period of 3-6 days, given a meadow forage production of at least 1250 kg/ha. Horse plots were approximately 0.10 ha and llama plots approximately 0.05 ha. The plots were replicated three times.

The vegetation present on the plots was described using frequency sampling and visual observation. Five, 30 m transects were located across each of the three plot areas. Twenty, 25 cm^2 quadrats were randomly located along each transect and the presence of species within each quadrat was recorded (Kershaw 1973; Mosley 1983). Frequency sampling was chosen because it was simple to obtain and allowed for characterization of plot vegetation given limited time and resources. In addition to frequency sampling, plots were surveyed for clustered or rare species.

Dominant grass species included bentgrass (*Agrostis* spp. L.), tufted hairgrass (*Deschampsia caespitosa* (L.) Beauv.), bluejoint reedgrass (*Calamagrostis canadensis*, (Michx.) Beauv.), slender muhly (*Muhlenbergia filiformis* (Thurb.) Rydb.), and blue wildrye

(*Elymus glaucus* Buckl.). Grass-likes included rushes (*Juncus* spp. L.), sedges (*Carex* spp. L.), and field woodrush (*Luzula campestris* DC.). Common forbs included agoseris (*Agoseris glauca* Raf.), entire-leaved aster (*Aster integrifolius* Nutt.), rockcress (*Arabis* spp. L.), buttercup (*Ranunculus alismaefolius* Geyer), lovage (*Ligusticum grayi* Coult. & Rose), pussy-toes (*Antennaria corymbosa* E. Nels.), and arrowleaf groundsel (*Senecio triangularis* Hook.). Woody plants were excluded from plots whenever possible, but isolated individuals of subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.), Engelmann spruce (*Picea engelmannii* Parry), elderberry (*Sambucus* sp. L.), and gooseberry (*Ribes* sp. L.) occurred in some plot areas. A complete list of plant species can be found in Appendix A.

Fecal analysis was used to determine diet selection. Three fecal samples were collected from each animal on each plot with approximately 5% of a fresh deposit being collected and air dried. The goal of this study was to determine the forage selected on the first day of foraging to represent the recreational situation. In horses, forage begins to show up in feces approximately 12 hours after consumption with the greatest rates of passage at 36 to 48 hours and nearly all of the digesta voided after 65 hours (Frape 1986; Vander Noot *et al.* 1967). In an attempt to capture the forage consumed on the first day on the plots, the first horse sample was collected approximately 24 hours after placement on the plots. Two more samples were collected after 48 and 72 hours. The mean forage retention time for llamas is approximately 63 hours (San Martin 1987). The first sample for llamas was collected approximately 72 hours after being placed on the plots with subsequent samples being collected after 90 and 120 hours.

A composite of the three samples was made for each animal on each plot for a total of 9 samples for each animal type. The samples were submitted to the Wildlife Habitat Laboratory at Washington State University for microhistological analysis (Sparks and Malechek 1968). Four slides with 25 views per slide were examined and plant fragments identified to species where possible. Percent diet composition was reported, using plant epidermal fragment cover as the sampling criterion.

Mean percent diet composition of plant species for each animal type were compared using a univariate F test with $\alpha = .05$. Kulcyznski's Similarity Index (Oosting 1956) was calculated to examine dietary overlap between animal types. Forage data were also subjected to discriminate analysis to identify plant species or forage classes which differentiate llama and horse diets (Genin *et al.* 1994; Hanley and Hanley 1982).

Results

Grasses and grass-likes together comprised the bulk of both horse and llama diets forming 98.3% and 97.8% of their diets, respectively. Considering forage classes, no significant differences were found between horses and llamas in the percentage of grasses, grass-likes, and forbs eaten (Table 1). Considering individual plant species, horses consumed a significantly greater percentage of bluejoint reedgrass (p = .042) and tufted hairgrass (p = .032) than llamas, while llamas ate a significantly higher percentage of sedges (p = .013).

Both horses and llamas consumed small percentages of a variety of forbs (Table 1). The percentage of forbs consumed by both animal types may be underestimated as microhistological analysis tends to underestimate the percentage of forbs in the diet and overestimate the percentage of grasses and browse due to differential digestion of plant species (Holechek *et al.* 1982, 1984; Vavra and Holechek 1980).

The only significant difference in diet composition among forb species was arrowleaf grounsel (p = .001). Arrowleaf grounsel was a fairly common but clustered species on all three sets of plots, being most prevalent in plot area 3. All three llamas ate small percentages of arrowleaf grounsel on two of their three plots, while it did not appear in any of the horse diets. This difference may be due to the fact that members of the genus *Senecio* are known to be toxic to horses, causing serious liver damage (Frape 1986).

Kulcyznski's Similarity Index (Oosting 1956), provides a measure of the common proportionality between two diets (Kingery *et al.* 1996; Olsen and Hansen 1977) (See Section IV for more details). For this study, two diets are considered similar if S > 50% (Kingery *et al.* 1996). The mean percent composition of plant species in each diet (Table 1) were used to calculate the similarity index between horse and llama diets. In this study, S = 83.9%, indicating substantial dietary overlap between the two diets.

Table 1. Mean percent diet composition of plant species and forage classes for llamas and horses across all plots.

Plant Species	Mean Percent Diet Composition Horses	Llamas	Sig. of F*
Agrostis spp.	32.39	31.73	.843
Calamagrostis canadensis	11.34	6.33	.042
Danthonia intermedia	1.57	2.21	.277
Deschampsia caespitosa	19.19	12.48	.032
Elymus glaucus	2.58	2.48	.943
Muhlenbergia filiformis	0.62	0.75	.785
Phleum alpinum	1.24	1.06	.748
Stipa lettermanii	3.70	2.20	.289
Trisetum spicatum	0.20	1.20	.081
Other grass spp.	5.35	7.28	.348
Carex spp.	9.56	19.00	.013
Juncus spp.	8.36	10.14	.535
Luzula campestris	2.22	0.95	.202
Agoseris glauca	0.00	0.03	.337
Antennaria corymbosa	0.08	0.00	.337
Aster integrifolius	0.09	0.03	.379
Lupinus spp.	0.00	0.07	.185
Penstemon globosus	0.23	0.06	.498
Polygonum sp.	0.10	0.00	.337
Potentilla gracilis	0.13	0.08	.720
Ranunculus alismaefolius	0.06	0.00	.337
Rumex acetosella	0.00	0.06	.337
Sambucus sp.	0.29	0.00	.337
Senecio triangularis	0.00	0.62	.001
Other forb spp.	0.67	2.19	.171
Total grasses	78.18	67.71	.070
Total grass-likes	20.14	30.09	.092
Total forbs	1.37	3.13	.155

*Significance values are for univariate F tests of differences in mean percent composition between animal type at the $\alpha = .05$ level.

Differences in diet selection between individual animals within an animal species may be significant. To investigate possible differences, similarity indices were calculated for each pairwise comparison of individual diets, on each plot, and within each animal type. This resulted in 9 pairwise comparisons per animal type. Similarity indices for horses ranged from 66.2% to 84.0% with a mean of 75.0%. Between llamas, the indices ranged from 64.2% to 89.1% with a mean of 76.0%. Similarity indices were also calculated for all horse-llama pairwise comparisons on each plot. These 27 comparisons yielded indices ranging from 59.7% to 85.4% with a mean of 73.0%. These results demonstrate that even when differences between individual animals are taken into account, there is still considerable dietary overlap among and between animal groups.

Discriminate analysis was used to identify plant species which differentiate llama and horse diets (Genin *et al.* 1994; Hanley and Hanley 1982). Plant species were included in the analysis if they were eaten by three or more individuals of either species or if they represented 5.0% or greater of an individual diet. This selection process was done to eliminate anomalous, low-percentage species which would heavily influence the discriminate analysis. Plant species included as variables in the analysis are presented in Table 2.

A stepwise selection was used to select variables with the criterion being minimizing Wilks' lambda. The minimum tolerance level was 0.001, minimum F to enter was 3.84, and the maximum F to remove was 2.71. The F ratio for the Mahalanobis distance between the group centroids was calculated to test for significance between groups (Hanley and Hanley 1982). The results of the analysis are shown in Table 3.

Table 2. Plant species included as variables in the discriminant analysis; Wilks' lambda, F, and significance of F.

Plant Species	Wilks' Lambda	F	Sig. of F
Agrostis spp.	.99775	0.0361	.8518
Calamagrostis canadensis	.85055	2.8114	.1130
Carex spp.	.66539	8.0462	.0119
Danthonia intermedia	.98149	0.3017	.5904
Deschampsia spp.	.74245	5.5504	.0316
Elymus glaucus	.99952	0.0077	.9312
Juncus spp.	.97878	0.3469	.5641
Luzula campestris	.87096	2.3705	.1432
Muhlenbergia filiformis	.99463	0.0864	.7726
Phleum alpinum	.99332	0.1076	.7471
Stipa lettermanii	.95131	0.8189	.3789
Trisetum spicatum	.90266	1.7253	.2075
Senecio triangularis	.55872	12.6370	.0026
Other forbs	.88826	2.0127	.1752
Other grasses	.95749	0.7103	.4118

Table 3. Variables and summary statistics of the discriminant analysis.

Variable *	Wilks' Lambda	Sig. of F	Standardized Canonical Discriminant Function Coefficient
Senecio triangularis	.55872	.0026	.97566
Other grasses	.41963	.0015	.75458
Carex spp.	.32262	.0010	.59641

Eigenvalue = 2.0997; Canonical Correlation = 0.8230; Wilks' Lambda = 0.32262; Chi-square = 16.404; Significance of F (3 df) = 0.0009; Group Centroids: Horse = -1.3662, Llama = 1.2665; F Statistic between groups (3,14 df) = 9.7984; Significance of F between groups = 0.001

These results show that *Senecio triangularis*, the miscellaneous grass category, and *Carex* spp. are the forage variables which are most important in discriminating between horse and llama diets with the given variable set.

Discussion

In this study, forage *selection* was measured rather than forage *preference* because animals were confined to plots and not given free access to all potential forage species present on the meadow. Because recreational stock are often confined, this was a reasonable limitation. An additional limitation was presented by the fact that the three replicates in this study were done over a three week period, during which time the phenology of the forage plants changed to some degree.

The forage selection of horses and llamas was compared in this study because it was hypothesized that llamas have the potential to forage more selectively than horses, and would consume more forbs. Hanley (1982) presents a conceptual framework to understand diet selection by various ungulates based on body size, type of digestive system (ruminant or cecal), mouth size, and rumino-reticular volume to body-weight ratio.

Following this framework, llamas were presumed to be more selective foragers than horses because they have a lower absolute nutrient requirement per day and can spend more time selectively foraging. Llamas are functional ruminants which requires them to forage selectively since the amount of forage they can process in a day is limited by food particle size and passage through the gastrointestinal tract. Horses are cecal digesters and food passage through the digestive system is not constrained by particle size, allowing them to process more plant material per day. The structure of the llama mouth enhances their ability to forage selectively. Llama mouths are small, the upper lip is split, and each side of the lip can be moved independently, giving them considerable selective capability (Fowler 1989). These three factors suggest that llamas are able to forage more selectively and if given the opportunity, may select more nutritious forbs over grasses. In contrast to these three factors, the stomach morphology of the llama has been shown to be well adapted for digestion of coarse forages (Pfister *et al.* 1989) which may suggest selection of grasses and grass-likes.

The results of this study show that the bulk of the llama diet consisted of grasses and grass-likes. This finding is consistent with studies of llamas done on pastures in South America (Genin *et al.* 1994; Pfister *et al.* 1989; San Martin 1987; San Martin and Bryant 1989). The dietary overlap between horses and llamas may result in competition for forage where both species are present. The high degree of dietary overlap heightens the importance of monitoring utilization of shared forage species. Such monitoring will help assure that utilization rates are within management guidelines designed to prevent a shift in species composition towards less palatable species.

This study was done when quality of all forage classes was relatively high. Forage selectivity may change as the quality of some forage declines with the advance of the season. Determining differences in forage selection in autumn may be of interest to wildland managers since many hunters use packstock during this time.

The study plots were laid out to exclude trees and shrubs in this study in an attempt to maximize plot homogeneity. In this study, both horses and llamas were observed consuming browse while being moved between plots. Genin *et al.* (1994) reported that shrubs represented less than 20% of llama diets. Further research is needed to determine the role of browse in horse and llama diets.

In summary, significant dietary overlap exists between horses and llamas grazing in mid-summer on a subalpine meadow. The potential competition for forage between horses and llamas and differences in total forage biomass consumed per day must be considered by managers when developing packstock grazing guidelines. Long-term monitoring of utilization of shared forage species is also recommended to help minimize the potential for a species composition shift towards unpalatable species. Additional research is needed regarding the role of browse in the diets of horses and llamas. Diet selection of horses and llamas during different seasons and under varying forage class quality conditions also needs further study.

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SECTION III

Evaluating Trampling Impacts of Horses and Llamas in Wilderness and Backcountry Meadows

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