AN ABSTRACT OF THE THESIS OF

Enkhjargal Darambazar for the degree of Master of Science in Animal Science presented on October 13, 2003.
Title: Factors Influencing Diet Composition of Beef Cattle Grazing Mixed Conifer Mountain Riparian Areas

Redacted for privacy

Abstract approved: _____

Timothy DelCurto

Two trials were conducted to evaluate changes in the quantity, quality, and moisture of available forage in the pasture, and shrub utilization by cattle during a 30-d late summer grazing period (Trial 1) and the effect of cow age (experience) on grazing distribution and diet composition (Trial 2) in mountain riparian areas. In the trial 1, a pasture (44.7 ha) in the Catherine Creek site at OSU's Hall Ranch in northeast of Oregon was grazed with 30 yearlings and 30 mature cow/calf pairs from early August to early September in 2001, and from late July to late August in 2002. Sampling dates were d 0, d 10, d 20, and d 30 of the grazing period. The forage availability before grazing was 1058 kg/ha and declined to 323 kg/ha at the end of the grazing period ($P < 0.10$). Grasses dominated the pasture, followed by forbs, grasslikes, and shrubs. Kentucky bluegrass was the most prevalent forage species followed by timothy, sedges, and common snowberry. The highest percent disappearances of forage species was (83.7-92.7%) observed with quackgrass, western fescue, California brome, redtop, and heartleaf arnica, though their initial contributions to the available forage were less than 5%. High levels of shrub utilization were observed from d 20 through the end of the grazing period (45% for willow and 59% for alder). Forbs and shrubs did not vary in moisture content between the 10 d intervals and across the years averaging 59% and 61%, respectively ($P > 0.10$). In contrast, the moisture content of grasses were over 50% at the beginning of the grazing period but declined dramatically to 34% from d 10 to d 20. Likewise, forbs and shrubs were higher ($P < 0.05$) than grasses in CP (11, 14, and 6%,

respectively) and IVDMD (58, 49, and 42% respectively). In summary, our results suggest that cattle grazing late summer riparian pastures will switch to intensive shrub utilization when grasses decline in quality and quantity, and forbs decline in quantity. In the trial 2, thirty first calf heifers, and thirty mature cows were randomly assigned to four pastures (15 head per pasture, average 21.5 ha) in the Milk Creek site of Hall Ranch from late July to early September of 2000 and 2001. Botanical composition of diets was determined by analyzing the feces from 10 animals (5 per pasture) in each treatment during the fourth week of the trial using the microhistological procedure. Correction factors were calculated for the 22 major plant species. First calf heifers had higher portions of grasses (75% versus 71%; $P < 0.05$), but lower portions of shrubs and trees (9% versus 13%; $P < 0.10$) as compared to mature cow diets, respectively. On an individual species basis, ponderosa pine consumption was a major contributor with mature cows consuming greater quantities ($P < 0.10$) than first calf heifers. In summary, mature cows seem to have selected diet less in the amount of grasses and more in the amount of shrubs and trees as compared to younger cows.

Keywords: riparian areas, cattle, utilization, diet

Factors Influencing Diet Composition of Beef Cattle Grazing Mixed Conifer Mountain Riparian Areas

by
Enkhjargal Darambazar

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Science

Presented October 13, 2003
Commencement June, 2004

Master of Science thesis of Enkhjargal Darambazar presented on October 13, 2003.

APPROVED:

Redacted for privacy

Major Professor, representing Animal Science

Redacted for privacy

Head of the Department of Animal Sciences

Redacted for privacy

Dean of the Graduate School

I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Redacted for privacy

Enkhjargal Darambazar, Author

ACKNOWLEDGEMENTS

I would like to express my utmost gratitude to the many people whose help and support was invaluable throughout my education.

First, I would like to thank my husband and kids for their patience and support during this process. Daal, your endless support has carried me through this research project and school. Thanks for seeing my potential, encouraging me through this, and expecting more of me. Thanks for all the help with carrying this project, patiently working with me on clipping plots, taking shrub photos, collecting samples in the field, and doing lab analyses. Thanks for the help with data collection and data analysis throughout this project. Urnaa and Amaraa, my two lovely kids, your energy and excitement have kept me going through the tough and trying times. Urnaa, thanks for your help with data interpretation and my English in writing the thesis. Amaraa, thanks for your help with data collection in the field, and data processing. Thanks for your support and understanding during those times when I had to be away or in the office working.

I must thank the members of my graduate committee, Dr. Timothy DelCurto, Dr. Gary Pulsipher, Dr. Callan Ackerman, and Dr. Douglas Johnson for all the help with project design, data collection and data analysis throughout this project. Tim, I especially owe you for giving me the opportunity to study and work on this project, for believing and supporting me through it all. I appreciate your dedication and motivation towards your job and research. I would like to thank Ronney Slater for his help with adapting a research technique and for sharing his many years' knowledge and experience. To Dr. Dennis Sheehy, thanks for making it possible to come and get the opportunity to work here.

To the staff at the Eastern Oregon Agricultural Research Center, Union Experiment Station, I owe many thanks. Thanks for the help with fencing, data collection, livestock handling, and most of all letting me get this great experience working with you during the past years. You have all made this a very great and enjoyable experience.

CONTRIBUTION OF AUTHORS

Dr. Callan Ackerman assisted with the design and implementation of the project. Daalkhaijav Damiran, of Oregon State University, helped with organizing and collecting the data, analysis and interpretation of the data presented in Chapter 2 and Chapter 3. Dr. Gary D. Pulsipher of Oregon State University helped with the analysis and interpretation of the data presented in Chapter 2. Julie A. Morrison completed collection of the samples analyzed in Chapter 3.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF APPENDIX TABLES

Factors Influencing Diet Composition of Beef Cattle Grazing Mixed Conifer Mountain Riparian Areas

CHAPTER 1

SUSTAINABLE USE AND GRAZING MANAGEMENT IN MOUNTAIN RIPARIAN ECOSYSTEMS

INTRODUCTION

Improper use of riparian areas by livestock can result in removal of woody vegetation, over-utilization of streamside vegetation, soil compaction, soil erosion, reduced water quality, as well as streambank degradation (Buckhouse and Gifford 1976). Marlow et al. (1991) stated that livestock grazing does not have to be eliminated from riparian areas to maintain water quality and biodiversity. By balancing livestock nutritional demands with the recovery needs of forage plants livestock production can be sustained for long periods with few outside inputs (Marlow et al. 1991). Uneven grazing distribution patterns associated with cattle grazing heterogeneous environments may occur because they select feeding areas with higher forage quality more frequently than feeding areas with lower forage quality (Bailey 1995). Grazing management aimed at minimizing uneven use of rangelands requires an understanding of natural factors that influence the grazing patterns of livestock (DelCurto et al. 1999). The researchers imply that a number of factors including class of animal, grazing experience of animal, terrain of the land, climatic conditions, and vegetation composition can have a significant impact on the success of various management strategies. Little attention has been paid to coordinating specific management practices with changes in forage quality (Vavra and Raleigh 1976).

In addition, knowledge of the botanical composition of diets of grazing livestock is important because of its relevance to range or grazing management strategies (Volesky and Coleman 1996). Winder et al. (1996) suggested that important differences exist between breeds for diet botanical composition. But there is limited and inconsistent information available regarding effects of cattle age on diet botanical composition. Therefore, determining and more thorough understanding of these factors affecting animal diet selection is necessary.

RIPARIAN AREA USE AND GRAZING MANAGEMENT

Higher diversity, productivity, and other unique factors associated with the riparian zone when compared to the surrounding uplands are the primary factors that create the importance of these areas as focal points for the management of the livestock, fishery, and wildlife resources (Kauffman and Krueger 1984). Grazing can affect a riparian zone through two processes: removal of plant material and trampling (Marlow et al. 1991). Optimizing efficient use of riparian vegetation by livestock would promote improved livestock distribution, and more uniform vegetation utilization. Kauffman et al. (1983a) discussed that utilization of upland forages could be achieved independently from management requirements of the riparian zone, thereby allowing for proper use of the uplands without overuse of the riparian zone. Grazing strategies aimed at minimizing damaging effects to riparian areas from livestock grazing include manipulation of stocking rate, grazing system, and season of grazing (DelCurto et al. 1999). Kauffman and Krueger (1984) suggested that changes in the kind or class of animal as well as selective culling and breeding may be another positive tool for riparian rehabilitation or maintenance. In northeastern Oregon, Roath and Krueger (1982) estimated that 80% of the forage consumed on a mountain allotment came from the riparian meadows, which made up 1.9% of the total area. Marlow et al. (1991) stated that if forage is coming from a permanent pasture or from native rangeland the amount of forage consumed must be balanced with the amount of leaf area necessary for the plant to recover from each grazing event. Binnie and Chestnutt (1991) determined that lengthening the interval between defoliations by the grazing animal from 3 to 4 weeks produced an increase in harvested herbage OM of 11.0%. Svejcar and Vavra (1985) also suggested extending the period during which meadows are nutritionally adequate would help considerably in completing the summer forage cycle in this region. Similarly, Kauffman et al. (1983a) indicate that length of grazing in

riparian areas could be optimized to achieve desired use levels for the key riparian species, whether they be woody or herbaceous species. Another possible approach suggested by Gillen et al. (1985) is that the length of the actual grazing period for an area of critical concern or special interest could be shortened by turning cattle onto the pasture at a point far removed from the area of interest. Everitt et al. (1981) recommended a pasture rotation system for a native range in the extreme southern portion of the South Texas Plains which would give the lesser abundant but highly selected species enough time to produce more forage. Gillen et al. (1985) also suggested a possibility of an internal pasture rotation that could be alternated among years. Kauffman et al. (1983a) studied effects of grazing on riparian plant communities in northeastern Oregon and stated that land and /or livestock management flexibility is easily attained when the riparian zone is fenced separately and used as a special use pasture for late season grazing. Parsons et al. (2003) implied that early season grazing of riparian areas may be less detrimental to riparian zone, because during late season with increasing DM of forages cattle forced to utilize the stream, which could lead to over utilization of riparian vegetation and woody vegetation, increased bank trampling, and potentially decreased water quality.

Grazing Effect on Rangelands

Rangeland plant productivity and species composition are affected by moisture availability and grazing intensity (Skinner et al. 2002). For example, heavy grazing use promoted vegetative growth of tall fescue in subclover-tall fescue pastures and a higher dry subclover content in subclover-perennial ryegrass forage in summer (Bedell 1970). The response of graminoids to grazing appears to be dependent on the phenological stage of the plant at the time of grazing, amount of soil moisture available for regrowth and previous grazing pressure on the plant (Sheehy 1987). Moderate stocking levels (40-50% utilization) during and after drought did not adversely affect sustainability of dominant native grasses on the Northern Great Plains rangelands (Eneboe et al. 2002). Manley et al. (1997) reported that peak standing crop was not significantly affected by

grazing strategy or stocking rate, but there have been shifts in the botanical composition under heavy stocking rates. As stocking rate/grazing pressure increased, blue grama, western wheatgrass, and other graminoids decreased. Forbs increased, particularly on the time controlled rotation (Manley et al. 1997). Similarly, Leege et al. (1981) conclude that heavy season-long grazing by cattle changed species composition and lowered herbage production on dry and moist mountain meadows. In a study of grassland ranges in southern Saskatchewan, Bai et al. (2001) also revealed that grazing alters plant species composition, reduces the biomass of grasses and enhances that of forbs. The biomass of standing dead materials and litter is reduced by grazing (Bai et al. 2001). In contrast, Bryant (1985) found that vegetative production was accelerated with grazing and concluded that productivity of riparian zone and floodplain vegetation was rapidly increased when no more than 70 percent of the herbage was removed annually. Summarizing studies on vegetation-soils and vegetation-grazing relations on the Short Grass Plains, Hyder et al. (1966) concluded that summer-long grazing at different intensities for 23 years has not affected species frequencies to a great extent, but there has been a reduction in herbage yields from heavy grazing. In a New Mexico study, Orodho et al. (1990) suggest that long-term heavy grazing has resulted in a reduction of desirable shrub vegetation at the Chaco Canyon study area, but had little effect on grass cover, production, and density. Although the results of a grazing study by Buckhouse et al. (1981) in northeastern Oregon indicated no significant patterns of accelerated streambank deterioration occurred due to moderate livestock grazing (3.2 ha/AUM), Kauffman et al. (1983b) found streambank use at approximately 25-30 m of accessible streambank (MAS) per animal unit month (AUM) had significant impacts on streambank erosion.

FORAGE QUANTITY AND QUALITY

Nutritional differences exist among various vegetation types (Cook and Harris 1968). Generally, seasonal forage quality is related to degree of plant maturity and

precipitation patterns (Vavra and Raleigh 1976). Poppi et al. (1980) in their study on tropical grasses, found increasing maturity of the pasture caused a reduction in the mean digestibility of the dry matter, but there was no difference in the decrease according to pasture species, animal species or plant fraction. Chemical differences among herbage species are smaller after senescence than during the growing season suggesting that palatability among species might be more similar in winter than summer (Westoby 1974). Holechek et al. (1982) stated quantities of grass consumed depended upon period and the palatability of all forage available. Forb consumption by cattle was limited by short periods of forb palatability and /or limited production or distribution on the pastures (Holechek et al. 1982). Winder et al. (1996) implied that highly palatable plants, on Chihuahuan desert range, would be expected to occur at greater distances from water, increasing chances for cattle which travel greater distances encounter these species with greater frequency.

In a study on the protein content of important range grasses in the Blue Mountains of Oregon Skovlin (1967) reported that as the summer season progressed, protein content and hence forage quality declined. CP content of the grasses in the Pacific Northwest estimated by Cruz and Ganskopp (1998) was 18, 11, and 6%, respectively, during vegetative, anthesis, and quiescent periods. Pickford and Reid (1948) implied that summer ranges in the mountains of eastern Oregon do not provide enough forage for all the range livestock, so it is highly important to make efficient use of summer cattle ranges in order to assure sustained livestock production. Vavra and Raleigh (1976) indicated that calf and yearling daily gains decline and even cease toward the end of the growing season when forage quality on range in late summer and fall is not enough to provide for maintenance. Forage quality in mountain riparian areas of northeastern Oregon declines from early season to late season of use, reported Parsons et al. (2003), with forage in the latter season having higher DM, lower CP, greater fiber, and lower IVDMD. Willard and Schuster (1973) studying the seasonal differences in relative nutritive values of six grasses common to the deep hardland range site of the High Plains of Texas, reported that crude protein content was highest in

the spring and a low occurred in the protein content of all grasses during August. They indicated that during the summer months all species were higher in ether extract, and crude fiber, whereas water content was lowest throughout the dormant period. The dry month of August resulted in a partial drying out of plant material (Willard and Schuster 1973). Bedell (1970) reported that the normal drying sequence for subclover-perennial ryegrass and subclover-tall fescue forages would be annual grasses first, then subclover, then ryegrass and fescue, while the total forage reached or exceeded 70 to 90% dry matter by August.

DIET SELECTION

Grazing Behavior and Distribution

Cruz and Ganskopp (1998) suggested that when cattle are foraging in a nutritionally rich and diverse environment there are probably thresholds where the quest for a preferred but limited resource will cease, but there are also wide ranges of availability that affect little change in the animals selective behavior. Huber et al. (1995) reported that alteration in grazing behavior and area of use was attributed to the level of use rather than diet selection.

Bailey et al. (2001) indicated young cows (3yr) used steeper slopes and climbed farther up slopes and the differences among age classes in terrain use occurred early in the grazing season (June and early July). They suggested that social interactions may have been less important as the cows aged. The distribution of activity by the yearling steers grazing a sagebrush-bunchgrass range in eastern Oregon during the grazing day was similar to that of cows grazing semi-arid ranges (Sneva 1970).

Bailey and Sims (1998) investigated that cattle can remember the quality (or palatability) found at different spatial locations and suggested that strength of the association between food quality and spatial locations can decline over time.

Scarnecchia et al. (1985) suggested that on crested wheatgrass pastures, forage availability is a preeminent factor affecting grazing time and biting rate of cows. They imply that higher availability of green forage results in larger but fewer bites per minute. The higher percentage of stem in mature forage likely reduces biting rates as selectivity becomes more pronounced (Scarnecchia et al. 1985). The cattle feeding strategy is more selective for digestible tissue and being ruminants they must regurgitate and repeat the cycle of chewing until the particles are small enough to be passed in rumen liquor into the omasum (Olsen and Hansen 1977). Hodgson and Jamieson (1981) stated that cows spent consistently less time grazing and more time ruminating than calves. The rate of biting during grazing and the total number of grazing bites per day were higher overall for cows than for calves (Hodgson and Jamieson 1981).

Diet Selection

Winder et al. (1996) stated diet selection by free grazing cattle is a very complex, dynamic activity. It is complex in that diets may be composed of numerous plant species in varying quantities, and dynamic due to the changes in species composition and palatability over time (Winder et al. 1996). Milne (1991) concluded that in most circumstances, the overall diet obtained by the grazing ruminant is a combination of bite and site selection. Svejcar and Vavra (1985) implied that grazing pattern and diet selection are seldom uniform and can be influenced by such factors as species associations, grazing system, topography, climate, etc. Moisture level may affect selectivity of grazing, suggested Allison (1985), and more succulent plants will usually be grazed in preference to drier, more mature plants. In a study with steers grazing seeded, native, and old field pastures in southern Colorado, Beck (1975) concluded that steers given free-choice to many plant species are selective, and their diets change during a summer grazing season. Bedell (1970) stated that free grazing animals characteristically practice selective grazing, and in so doing they often select diets containing nutrient amounts differing from that in forage. The researcher

concluded that although forage and dietary protein levels declined during the season, dietary protein levels were significantly higher than forage protein levels, indicating a relatively high degree of animal selectivity even in all or mostly grass pastures. Cruz and Ganskopp (1998) have found that steers were extremely selective grazers during vegetative stage, but slightly less selective when grasses were in anthesis, and less focused grazers after grasses entered quiescence. Furthermore, Provenza and Balph (1987) found differences in diet selectivity have been attributed to numerous factors including maternal training. Winder et al. (1996) discussed that greater availability should result in less effort exerted by the grazing animals. In this case, they added, competition among animals would be expected to increase, and aggressive breeds (those which graze greater distances from water) would be expected to consume more palatable species in greater quantities. But if differences are a function of preference for specific plants, then greater breed differences would be expected in high versus low precipitation years due to enhanced variation of forage species allowing cattle to be more selective (Winder et al. 1996).

Cattle Diet Composition

Minson (1982) implied that the quantity of herbage eaten by the grazing animal depends on three factors: 1) the availability of suitable herbage, 2) the physical and chemical composition of the herbage, and 3) the nutrient requirements of the animal. Nitrogen value in mid August cattle diets was 1.58%, NDF 75-82%, and IVOMD was 54-59% in the seasonlong treatment in central North Dakota (Hirschfeld et al. 1996). The amount of moisture contained in the forage that is available to the grazing animal may affect its dietary preferences and, in turn, affect dietary nutritive value (Bedell 1970). McCollum et al. (1985) reported dietary NDF declined as time progressed from early August to the onset of dormancy (late Oct.) for the warm season grasses. ADF content of the diets rose from 41.9% in early August to 52.9% in late October. As season advanced and the lignocellulose fractions of the diets increased, the extent of

IVOMD declined from 66.5% in early August to 47.9% in late October (McCollum et al. 1985).

The botanical composition of the diet of a grazing animal is influenced by many factors including appetite, previous feed experience, the extent and type of forage available and the season of the year (Hercus 1960). Vavra et al. (1977) reported that a comparison of monthly diversity indices between diets and vegetation available within the same pasture were positively and significantly correlated. In a study in Northern Idaho Mitchell and Rodgers (1985) found grass and browse species were the major components of cattle diets and remained fairly consistent during midsummer, but changed significantly during spring and fall. On the blue grama rangeland, cattle diets contained an average of 83% grasses and 17% forbs in early August, late August and late September (McCollum et al. 1985). Similarly, Hirschfeld et al. (1996) reported that graminoids dominated the botanical composition of cattle diets and were 72.4% under seasonlong treatment in mid August, forbs were 27%, while shrubs were not prevalent in cattle diets at any time during their study. Conversely, browse tended to increase in the diet throughout both grazing seasons in the findings of Mitchell and Rodgers (1985) where a large proportion of the diet (at least 25% of the diet) consisted of browse, even when the quantity and quality of herbaceous vegetation were not limiting. They determined that proportions of grasses, forbs, and shrubs in diets changed among seasons. Grass contents of diets varied from as high as 78% in summer to as low as 14% in spring (Mitchell and Rodgers 1985). Annual grasses contributed substantially to cattle diets especially in late summer, while perennial grasses never comprised more than 50% of the steer diets on semidesert grassland, as reported by Rosiere et al (1975). Everitt et al. (1981) in their study on a native range of the South Texas Plains, found 74.7% grasses, 21.3% forbs, and 4.0% browse in the year-round cattle diet. They indicated that proportions of grasses, forbs, and browse changed greatly among seasons, and that cattle showed an increasing preference for forbs as several species of grasses decreased in availability. Holechek et al (1982) reported grass content of diets varied from as low as 36% in late spring to as high as 83% in late summer. Forb consumption

declined as the grazing season advanced in their study, while shrub consumption was erratic among years and periods and depended on the availability of green grass and forbs (Holechek et al. 1982). In addition, Mitchell and Rodgers (1985) revealed that the significant differences found between dates during midsummer for grass reflected a shifting among species, and not a change in the percentage of total grass consumption. Huber et al. (1995) indicated that grass consumption declined throughout the growing season, which they attributed to the effects of advancing plant maturity.

Cattle Preference

Cattle on summer ranges in Wyoming preferred the grass and grasslike species to forbs, and were also selective in their choice of grasses and sedges, reported Hurd and Pond (1958). Their study indicated preference for a particular species did not change much as the grazing season progressed. Conversely, Beck (1975) found that changes in species preferences due to availability and maturation of plants caused shifts in summer grazing use made on the different pastures. On Chihuahuan desert ranges, Rosiere et al. (1975) determined that plants of the genus *Sporobolus* were often preferred to the other major grass species in summer and fall. Cruz and Ganskopp (1998) observed that significant shifts occurred among the rankings of the grasses as the growing season advanced and all significant changes in preference indices within a species occurred with the advance from anthesis to the quiescent stage of phenology.

In large native rangeland pastures, a combination of forage quality and quantity predicted cattle's preference for plant communities more accurately than either forage quantity or quality alone (Pinchak et al.1991). Bailey (1995) suggested that within a plant community, forage quality may be more highly correlated with preference than a combination of forage quality and quantity. In the heterogeneous area, cattle developed preferences for patches with higher forage crude protein levels irrespective of forage quantity (Bailey 1995). In contrast, Willms and Rode (1998) suggested that cattle seemed to select plants that had the greatest available biomass, when rough fescue

produced the greatest standing crop biomass and was the most highly preferred forage species in both winter and summer. Heady (1964) observed that some species are grazed heavily when they occur in small quantities, whereas in dense stands they are used lightly. Possibly, it suggests that the scarcity of plant species may be influencing the intensity of use by cattle. The most abundant species furnished the bulk of diets, although they seemed to be neither preferred nor avoided (Everitt et al. 1981). Meanwhile, Cruz and Ganskopp (1998) suggested that forage availability, as expressed by biomass or cover, can account for approximately 50% of the variation in selection among the grasses. Bedell (1968) reported that on perennial ryegrass-subclover forage mixtures, grazing cattle preferred grass to clover during the spring-summer period. Cattle preference for major perennial grass species was significant and remained constant when grazing from April through August (Bedell 1968). Kie and Boroski (1996) observed that when cows ate grass-like plants, they most often took non-riparian species such as intermediate wheatgrass and orchard grass, and most of the browse they consumed were upland species as well. Most of the forbs eaten, however, consisted of willow herb and false Solomon's seal, both riparian species (Kie and Boroski 1996).

Cows in the Sierra Nevada of California favor riparian habitats, concluded Kie and Boroski (1996), suggesting the relative lack of herbaceous forage on upland sites likely contributes to cattle preferences for riparian habitats and for their proximity to water. Pinchak et al. (1991) studying beef cattle distribution patterns on foothill range reached a conclusion that cattle expressed preference for areas within 366 m of water and avoided areas beyond that. Bryant (1982) also reported that both cows and yearlings selected the riparian zone over the uplands.

In addition, grazing animals can also select within the vertical plane of the sward between different plant parts of the same species or different species (Milne 1991). Poppi et al. (1980) stated that cattle consumed 35% more leaf than stem fraction and the difference did not appear to vary significantly between pasture species or stage of maturity.

Physiological Requirements of First Calf Heifers and Mature Cows

In order for a 450 kg, 2-year old first calf heifer to gain 0.23 kg (1/2 lb) per day, she requires 9.4 kg of dry matter that includes 10% total protein each day. Her net energy requirements include 0.79 Mcal/kg of body weight for growth and 1.37 Mcal/kg of body weight for maintenance (NRC 1996). In contrast, a 590 kg mature cow requires 11.0 kg of dry matter that includes 9.1% total protein each day. Though the mature cows need greater amounts of dry matter a day, their protein requirements are lower than those of first calf heifers. Because they have reached mature body size, these cows do not have a net energy requirement for growth. Their maintenance net energy requirement is 1.15 Mcal/kg of body weight (NRC 1996).

Rangeland Grazing Experience of First Calf Heifers and Mature Cows

Cows of different age classes differ in the amount of experience they have grazing rangeland pastures (Morrison et al. 2002). Milne (1991) implied that experience may be important in influencing the foraging behavior of ruminants with more time being spent foraging and with less food being ingested. He further stated that there is no convincing evidence, however, on the effects of experience on changes in diet selection (Milne 1991). Howery et al. (1998) reported that peers influenced where yearling heifers grazed. When animals were older, they tended to graze where their dam or foster dam grazed, suggesting an effect of early learning on where older cattle graze. Typically, previous experience for first calf heifers would be grazing as calves at their dam's side (Morrison et al. 2002).

Effect of Age on Diet Selection

Allison (1985) suggested that younger animals may select a higher quality forage diet, resulting in faster food passage. Hodgson and Jamieson (1981), however, investigated that differences in age have little consistent influence on diet composition.

Grings et al. (2001) suggested that the effects of animal class (age or sex) on diet selection may be dependent on the quality as well as quantity of available herbage. Hodgson and Jamieson (1981) indicated that between-class differences in extrusa digestibility were significant in the autumn experiment in the order calves>lactating cows>non-lactating cattle on perennial ryegrass swards, but in spring the order was reversed and differences between classes were very small. Mohammad et al. (1996) found dietary overlap between cows and steers to vary with season with a range from 70 to 90%. Bryant (1982) observed that cows grazed the most productive areas more widely over the summer grazing season when both cows and yearlings selected the riparian zone over the uplands. Morrison et al. (2002) studied effects of cow age on grazing distribution and utilization in riparian areas of northeastern Oregon and reported that early in the grazing period, mature cows did appear to select areas farther from water and spend more time outside the riparian vegetation zone than did first calf heifers. As the grazing continued, the distribution and utilization patterns of the different age classes converged (Morrison et al. 2002). Le Du and Baker (1981) concluded that no differences was detected between lactating cows, weaned steer calves, milk-fed calves, and wether lambs grazing together on a perennial ryegrass pasture, there was, however, some indication that as the sward was grazed down through the day, cows selected a diet of slightly lower quality than that obtained by the other cattle.

CONCLUSIONS

Nutritive value and digestibility are difficult to determine because animals select their diet from various combinations of plant species and plant parts (Allison 1985). Pinchak et al. (1991) concluded that seasonal cattle use of extant foothill complexes can be predicted reasonably well from intrinsic forage characteristics. There are inconsistencies in grazing effects on rangelands, specifically, riparian areas as well as foraging behavior of cattle in these areas. Researches have revealed that light to moderate grazing would not adversely affect vegetation, but under heavy grazing

alteration in species composition may occur with some decrease in grasses and increase in forbs. Generally, graminoids comprise the majority of cattle diets, but consumption of forbs and shrubs can be erratic depending upon season and year. Lastly, the key to cattle management for increased production is, as Vavra (1983) stated, to take advantage of the nutrients available on various plant communities when they are in excess of the grazing animal's requirements so the declines in gain during the last half of the grazing season are minimized. The study discussed in the next two chapters is designed to evaluate changes in the quantity, quality of forage, and shrub utilization by cattle and the diet botanical composition of first calf heifers and mature cows on mountain riparian pastures of northeastern Oregon. It is intended to aid in the understanding of natural factors influencing livestock behavior on rangelands.

LITERATURE CITED

Allison, C.D. 1985. Factors affecting forage intake by range ruminants: A review. J. Range Manage. 38:305-311.

Bai, Y., Z. Abouguendia, and R.E. Redmann. 2001. Relationship between plant species diversity and grassland condition. J. Range Manage. 54:177-183.

Bailey, D.W. 1995. Daily selection of feeding areas by cattle in homogeneous and heterogeneous environments. Appl. Anim. Behav. Sci. 45:183-200.

Bailey, D.W., and P.L. Sims. 1998. Association of food quality and locations by cattle. J. Range Manage. 51:2-8.

Bailey, D.W., D.D. Kress, D.C. Anderson, D.L. Boss, and E.T. Miller. 2001. Relationship between terrain use and performance of beef cows grazing foothill rangeland. J. Anim. Sci. 79:1883-1891.

Beck, R.F. 1975. Steer diets in Southeastern Colorado. J. Range Manage. 28:48-51.

Bedell, T.E. 1968. Seasonal forage preferences of grazing cattle and sheep in Western Oregon. J. Range Manage. 21:291-297.

Bedell, T.E. 1970. Nutritive value of forage and diets of sheep and cattle from Oregon subclover-grass mixtures. *In*: Sheep and cattle diets. Ore. Agr. Exp. Sta. Corvallis. Ore. p. 125-133.

Binnie, R.C., and D.M.B. Chestnutt. 1991. Effect of regrowth interval on the productivity of swards defoliated by cutting and grazing. Grass and Forage Science. 46:343-350.

Bryant, L.D. 1982. Response of livestock to riparian zone exclusion. J. Range Manage. 35:780-785.

Bryant, L.D. 1985. Livestock management in the riparian ecosystem. *In*: Riparian ecosystems and their management reconciling conflicting uses. Tucson. Ariz. p.285-289.

Buckhouse, J.C., and G.F. Gifford. 1976. Water quality implications of cattle grazing on a semiarid watershed in southeastern Utah. J. Range Manage. 29:109-113.

Buckhouse, J.C., J.M. Skovlin, and R.W. Knight. 1981. Streambank erosion and ungulate grazing relationships. J. Range Manage. 34:339-340.

Cook, C.W., and L.E. Harris. 1968. The nutritive value of seasonal ranges. Utah State Univ. Agr. Exp. Sta. Bull. No. 472. p. 55.

Cruz, R., and D. Ganskopp. 1998. Seasonal preferences of steers for prominent northern Great Basin grasses. J. Range Manage. 51:557-565.

DelCurto, T., M. Porath, M. McInnis, P. Momont, C. Parsons. 1999. Management strategies for optimal beef cattle distribution and use of mountain riparian meadows. p.119-129. *In*: K.L. Launchbaugh, K.D. Sanders, and J.C. Mosley (Eds.), Grazing behavior of livestock and wildlife. Idaho For. Wildlife and Range Exp. Sta. Bull. # 70, Univ. of Idaho, Moscow, Ida.

Eneboe, E.J., B.F. Sowell, R.K. Heitschmidt, M.G. Karl, and M.R. Haferkamp. 2002. Drought and grazing: IV. Blue grama and western wheatgrass. J. Range Manage. 55:73-79.

Everitt, J.H., C.L. Gonzalez, G. Scott, and B.E. Dahl. 1981. Seasonal food preferences of cattle on native range in the South Texas Plains. J. Range Manage. 34:384-388.

Gillen, R., W. Krueger, and R. Miller. 1985. Cattle use of riparian meadows in the Blue Mountains of Northeastern Oregon. J. Range Manage. 38:205-209.

Grings, E.E., R.E. Short, M.R. Haferkamp, and R.K. Heitschmidt. 2001. Animal age and sex effects on diets of grazing cattle. J. Range Manage. 54:77-81.

Heady, H.F. 1964. Palatability of herbage and animal preference. J. Range Manage. 17:76-82.

Hercus, B.H. 1960. Plant cuticle as an aid to determining the diet of grazing animals. Proc. 8th Int. Grassl. Congr. 8:443-447.

Hirschfeld, D.J., D.R. Kirby, J.S. Caton, S.S. Silcox, and K.C. Olson. 1996. Influence of grazing management on intake and composition of cattle diets. J. Range Manage. 49:257-263.

Hodgson, J., and W.S. Jamieson. 1981. Variations in herbage mass and digestibility, and the grazing behaviour and herbage intake of adult cattle and weaned calves. Grass and Forage Science. 36:39-48.

Holechek, J., M. Vavra, J. Skovlin, and W. Krueger. 1982. Cattle diets in the Blue Mountains of Oregon. II. Forests. J. Range Manage. 35:239-242.

Howery, L.D., F.D. Provenza, R.E. Banner, and C.B. Scott. 1998. Social and environmental factors influence cattle distribution on rangeland. Appl. Anim. Behav. Sci. 55:231-244.

Huber, S.A., M.B. Judkins, L.J. Krysl, T.J. Svejcar, B.W. Hess, and D.W. Holcombe. 1995. Cattle grazing a riparian mountain meadow: Effects of low and moderate stocking density on nutrition, behavior, diet selection, and plant growth response. J. Anim. Sci. 73:3752-3765.

Hurd, R.M., and F.W. Pond. 1958. Relative preference and productivity of species on summer cattle ranges, big horn mountains, Wyoming. J. Range Manage. 3:109-114.

Hyder, D.N., R.E. Bement, E.E. Remmenga, and C. Terwilliger, Jr. 1966. Vegetation-soils and vegetation-grazing relations from frequency data. J. Range Manage. 19:12-17.

Kauffman, J.B., and W.C. Krueger. 1984. Livestock impacts on riparian ecosystems and streamside management implications... A review. J. Range Manage. 37:430-438.

Kauffman, J.B., W.C. Krueger, and M. Vavra. 1983a. Effects of late season cattle grazing on riparian plant communities. J. Range Manage. 36:685-691.

Kauffman, J.B., W.C. Krueger, and M. Vavra. 1983b. Impacts of cattle on streambanks in Northeastern Oregon. J. Range Manage. 36:683-685.

Kie, J.G., and B.B. Boroski. 1996. Cattle distribution, habitats, and diets in the Sierra Nevada of California. J. Range Manage. 49:482-488.

Le Du, Y.L.P., and R.D. Baker. 1981. The digestibility of herbage selected by oesophageally fistulated cows, steer calves and wether sheep when strip-grazing together. Grass and Forage Science. 36:237-239.

Leege, T.A., D.J. Herman, and B. Zamora. 1981. Effects of cattle grazing on mountain meadows in Idaho. J. Range Manage. 34:324-328.

Manley, W.A., R.H. Hart, M.J. Samuel, J.W. Waggoner, JR., and J.T. Manley. 1997. Vegetation, cattle, and economic responses to grazing strategies and pressures. J. Range Manage. 50:638-646.

Marlow, C.B., D. Allen, and K. Olson-Rutz. 1991. Making riparian zone protection a workable part of grazing management. Proc. Int. Beef Symp. Great Falls. TNT. p. 256-266.

McCollum, F.T., M.L. Galyean, L.J. Krysl, and J.D. Wallace. 1985. Cattle grazing blue grama rangeland. I. Seasonal diets and rumen fermentation. J. Range Manage. 38:539-543.

Milne, J.A. 1991. Diet selection by grazing animals. Proc. Nutr. Soc. 50:77-85.

Minson, D.J. 1982. Effects of chemical and physical composition of herbage eaten upon intake. *In*: J.B. Hacker (Ed.). Nutritional Limits to Animal Production from Pastures. p.167-182.

Mitchell, J.E., and R.T. Rodgers. 1985. Food habits and distribution of cattle on a forest and pasture range in Northern Idaho. J. Range Manage. 38:214-220.

Mohammad, A.G., C.A. Ferrando, L.W. Murray, R.D. Pieper, and J.D. Wallace. 1996. Season and sex influences on botanical composition of cattle diets in southern New Mexico. J. Range Manage. 49:204-208.

Morrison, J.A. 2002. The influence of cow age on grazing distribution and utilization of mountain riparian areas and adjacent uplands. M.S. Thesis. Ore. State Univ. Corvallis.

Morrison, J.A., T. DelCurto, C.T. Parsons, G.D. Pulsipher, and E.S. Vanzant. 2002. The influence of cow age on grazing distribution and utilization of mountain riparian areas and adjacent uplands. Proc. West. Sec. Amer. Soc. Anim. Sci. 53:21-24.

NRC. 1996. Nutritional Requirements of Beef Cattle, 7th ed. National Academy Press. Washington D.C.

Olsen, F.W. and R.M. Hansen. 1977. Food relations of wild free-roaming horses to livestock and big game, Red Desert, Wyoming. J. Range Manage. 30:17-20.

Orodho, A.B., M.J. Trlica, and C.D. Bonham. 1990. Long-term heavy-grazing effects on soil and vegetation in the Four Corners Region. The Southwestern Naturalist. 35:9-14.

Parsons, C.T., P.A. Momont, T. DelCurto, M. McInnis, and M.L. Porath. 2003. Cattle distribution patterns and vegetation use in mountain riparian areas. J. Range Manage. 56: 334-341.

Pickford, G.D., and E.H. Reid. 1948. Forage utilization on summer cattle ranges in Eastern Oregon. *In*: U.S. Dept. of Agr. Circular No. 796. Washington, D.C. p. 1-27.

Pinchak, W.E., M.A. Smith, R.H. Hart, and J.W. Waggoner, Jr. 1991. Beef cattle distribution patterns on foothill range. J. Range Manage. 44:267-275.

Poppi, D.P., D.J. Minson, and J.H. Ternouth. 1980. Studies of cattle and sheep eating leaf and stem fractions of grasses. The voluntary intake, digestibility and retention time in the reticulo-rumen. Aust. J. Agric. Res., 32:99-108.

Provenza, F.D., and D.F. Balph. 1987. Diet learning by domestic ruminants: theory, evidence and practical implications. Appl. Anim. Behav. Sci. 18:211-232.

Roath, L.R., and W.C. Krueger. 1982. Cattle grazing and behavior on a forested range. J. Range Manage. 35:332-338.

Rosiere, R.E., R.F. Beck, and J.D. Wallace. 1975. Cattle diets on semidesert grassland: Botanical composition. J. Range Manage. 28:89-93.

Scarnecchia, D.L., A.S. Nastis, and J.C. Malechek. 1985. Effects of forage availability on grazing behavior of heifers. J. Range Manage. 38:177-180.

Sheehy, D.P. 1987. Grazing relationships of elk, deer, and cattle on seasonal rangelands in Northeastern Oregon. Ph. D. Dissertation. Ore. State Univ. Corvallis. p.15.

Skinner, R.H., J.D. Hanson, G.L. Hutchinson, and G.E. Schuman. 2002. Response of C3 and C4 grasses to supplemental summer precipitation. J. Range Manage. 55:517-522.

Skovlin, J.M. 1967. Fluctuations in forage quality on summer range in the Blue Mountains. Pacific Northwest Forest and Range Exp. Sta., USDA, Pacific Northwest 44.

Sneva, F.A. 1970. Behavior of yearling cattle on Eastern Oregon range. J. Range Manage. 23:155-158.

Svejcar, T., and M. Vavra. 1985. The influence of several range improvements on estimated carrying capacity and potential beef production. J. Range Manage. 38:395-399.

Vavra, M. 1983. Managing grazing animal response to forestland vegetation. Proc. Symp. Forestland Grazing. Spokane. Washington. p. 43-51.

Vavra, M., and R. J. Raleigh. 1976. Coordinating beef cattle management with the range forage resource. J. Range Manage. 29:449-452.

Vavra, M., R.W. Rice, R.M. Hansen, and P.L. Sims. 1977. Food habits of cattle on shortgrass range in Northeastern Colorado. J. Range Manage. 30:261-263.

Volesky, J.D., and S.W. Coleman. 1996. Estimation of botanical composition of esophageal extrusa samples using near infrared reflectance spectroscopy. J. Range Manage. 49:163-166.

Westoby, M. 1974. An analysis of diet selection by large generalist herbivores. Amer. Natur. 108:290-304.

Willard, E.E., and J.L. Schuster. 1973. Chemical composition of six Southern Great Plains grasses as related to season and precipitation. J. Range Manage. 26:37-38.

Willms, W.D., and L.M. Rode. 1998. Forage selection by cattle on fescue prairie in summer or winter. J. Range Manage. 51:496-500.

Winder, J.A., D.A. Walker, and C.C. Bailey. 1996. Effect of breed on botanical composition of cattle diets on Chihuahuan desert range. J. Range Manage. 49:209-214.

CHAPTER 2

CHANGES IN FORAGE QUANTITY AND QUALITY WITH CONTINUED LATE – SUMMER CATTLE GRAZING IN A MOUNTAIN RIPARIAN PASTURE

E. Darambazar, T. DelCurto, C. Ackerman, D. Damiran, and G. Pulsipher

Authors are Graduate Research Assistant, Department of Animal Sciences, Oregon State University, Corvallis, Oregon 97331; Associate Professor, Department of Animal Sciences, Eastern Oregon Agricultural Research Center, Oregon State University, Union, Oregon 97883; Former Assistant Professor, Department of Animal Sciences, Oregon State University, Corvallis, Oregon 97331; and Graduate Research Assistant, Department of Animal Sciences, Oregon State University, Corvallis, Oregon 97331; Assistant Professor, Department of Animal Sciences, Eastern Oregon Agricultural Research Center, Oregon State University, Union, Oregon 97883.

ABSTRACT

The objective of this study was to evaluate changes in the quantity, quality, and moisture of available forage in a riparian pasture, and shrub utilization by cattle during a 30-d late summer grazing period. A riparian pasture (44.7 ha) in northeastern Oregon was grazed with 30 yearlings (419 kg, BCS = 5.05) and 30 mature cows with calves (499 kg, BCS = 4.65) from early August to early September in 2001, and from late July to late August in 2002. Sampling dates were d 0, d 10, d 20, and d 30. The forage availability before grazing was 1058 kg/ha and declined to 323 kg/ha at the end of the grazing period ($P < 0.10$). Grasses dominated the pasture (44.5%), followed by forbs (30.7%), grass-likes (sedges and/or rushes) (15.9%), and shrubs (8.9%). Kentucky bluegrass was the most prevalent forage species followed by timothy, sedges, and common snowberry. The highest percent disappearances of forage species was (83.7 - 92.7%) observed with quackgrass, western fescue, California brome, redtop, and heartleaf arnica, though their initial contributions to the available forage were less than 5%. Timothy, elk sedge, red clover, and common snowberry were also preferred species and major components of the available vegetation. High levels of shrub utilization were observed from d 20 to the end of the grazing period (45 to 63 % for willow and 59 to 81% for alder). Shrubs did not vary in moisture content over the 30 d grazing period and across the years averaging 61% ($P > 0.10$), while forbs decreased from the initial value in the later dates ($P < 0.10$) and averaged 59%. In contrast, the moisture content of available grasses was over 50% at the beginning of the grazing period and declined to 34% between d 10 and d 20. Likewise, forbs and shrubs were higher ($P < 0.05$) than grasses in CP (11, 14, and 6%, respectively) and IVDMD (58, 49, and 42%, respectively). In summary, our results suggest that cattle grazing late summer riparian pastures will switch to intensive shrub utilization when grasses decline in quantity and quality, and forbs decline in quantity.

Keywords: riparian areas, cattle, utilization.

INTRODUCTION

Grazing animals have long been associated with alteration of productivity, cover, and species composition of plant communities (Stoddart et al.1975, Leege et al. 1981). Researchers have implied that a period of senescence or dormancy will provide a range of forage quality and strongly display the influence of forage quality in driving animal distribution and consequently diet selection. Changes in forage nutritional quality are related to advancing plant phenology. Therefore, optimizing livestock production means coordinating it to the forage resources so that the most efficient use is made of the short periods when forages are at their highest quality (Vavra and Raleigh 1976). One of the grazing strategies to utilize the riparian forage resource while preserving the integrity of the riparian/stream ecosystem is a late season grazing strategy (Kauffman et al.1983a). Late season distribution problems would likely be related to dormant, senesced upslope vegetation being of lower nutritional value than moist green vegetation available in riparian areas (DelCurto et al. 1990). Information on herbivore food habits is essential for optimal food allocation to different types of herbivores, selecting types of grazing animals compatible with the forage resource, identifying new species on which to base management, and determining the suitability of animals for a particular range type (Holechek et al. 1982a). A knowledge of dietary shifts in response to seasonal advance and precipitation induced forage regrowth should help managers optimize use of specific range types for improved grazing management and livestock production (Holechek et al. 1982b). Information on variations in the quality and quantity of available herbage, as well as a better understanding of what drives cattle grazing in riparian zones to shift their diets from grass dominated to shrub dominated will be important to sustainable and productive uses of riparian areas. The objectives of this study were to determine changes in herbage quantity, quality, species composition, and utilization in riparian areas grazed by cattle during the late summer.

MATERIALS AND METHODS

Study Site

The study was conducted at the Oregon State University's Hall Ranch, about 19 km southeast of Union, Oregon. Elevation ranges from 1,050 to 1,250 m. Mean annual precipitation is 35 cm, with majority coming between October and June. This makes for very dry summers that allow for very limited vegetative regrowth during the months of July through September. Average July and August rainfall totals 3.94 cm (in Porath et al. 2002). Hall Ranch includes two distinct riparian zones: the larger on Milk Creek, and smaller on Catherine Creek. The study area utilized in the study is the 2.5 km long area along Catherine Creek, consisting of the stream and riparian area and is confined by steep hills on the east side and a state highway on the west (Figure 2.1). Before 1978, this area was grazed under a season long grazing regime, but it was separated into exclosures and grazed areas in 1978 (Laliberte et al. 2001). The grazed areas comprise 44.7 ha along Catherine Creek. Since 1977, the area has been grazed for 3-4 weeks in August to a utilization level of 70%, and a stubble height of 5 cm on Kentucky bluegrass (Laliberte et al. 2001). The downstream portion of the study area consisted of an open grassland, while the upper portion contained more shrubs and trees (Laliberte et al. 2001). The 10 most prevalent and widely occurring communities in the riparian zone were dry meadow (*Poa pratensis*-mixed forbs); moist meadow (*Poa pratensis-Phleum pratense-Carex spp.* and forbs); Kentucky bluegrass-cheatgrass (*Poa pratensis-Bromus tectorum*); Douglas hawthorne/Kentucky bluegrass (*Crataegus douglasii/Poa pratensis*); snowberry-Wood's rose (*Symphoricarpos albus-Rosa woodsii*); gravel bars (*Salix spp.-Populus trichocarpa* sapling-mixed graminoids-mixed forbs); thin leaf alder/Kentucky bluegrass (*Alnus incana/Poa pratensis*); ponderosa pine/Kentucky bluegrass (*Pinus ponderosa/Poa pratensis*); and black cottonwood-mixed conifer (*Populus trichocarpa*-mixed conifer) (Kauffman et al. 1983a).

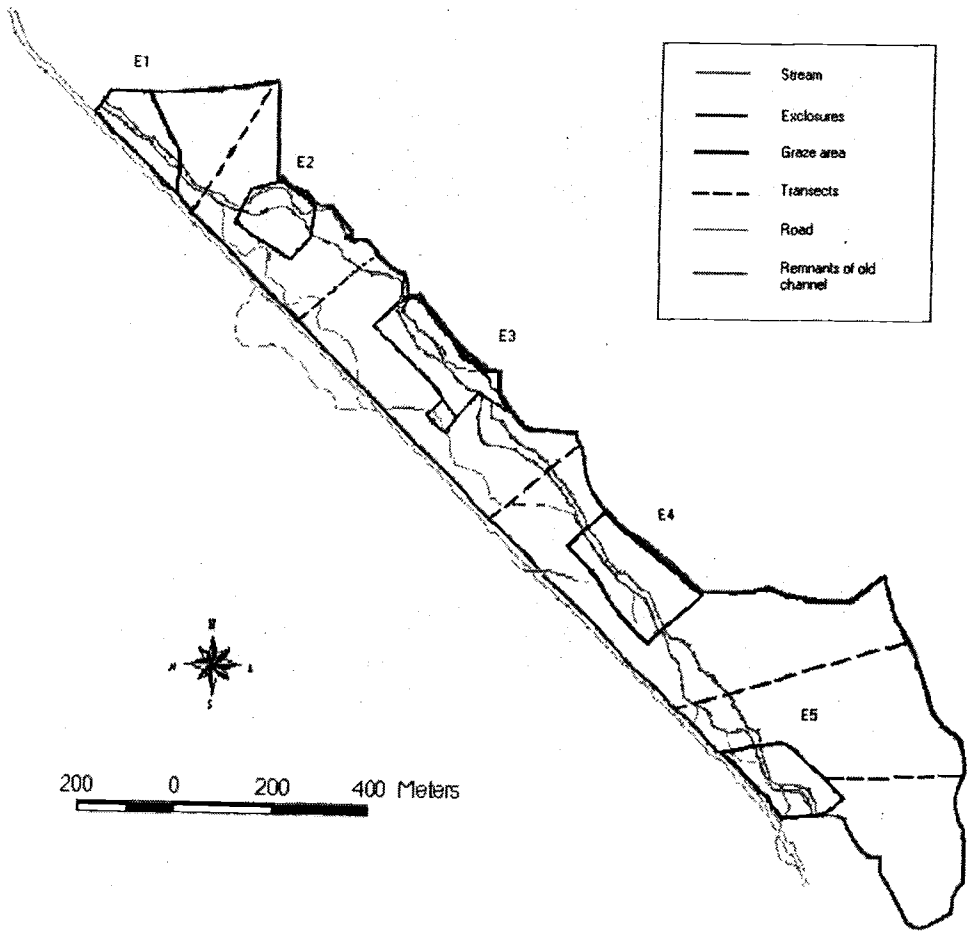

Figure 2.1. Catherine Creek study area located within the Hall Ranch. The grazed areas are 45 ha in size through which runs Catherine Creek for a length of 2.5 km, with a mean stream width of 13 m (Laliberte et al. 2001). Five exclosures alternate with grazed areas, so that the stream is divided equally into exclosed and grazed sites. The grazed site was utilized in a completely random design to evaluate the changes in forage quantity and quality with continued cattle grazing relative to mountain riparian areas. The pasture contains riparian meadow and shrub and tree dominated vegetation communities.

The study was conducted as a completely random design with repeated measures. The pasture was grazed by sixty head of cattle consisting of thirty yearling heifers (419 kg, BCS = 5.05) and thirty mature cows (499 kg, BCS = 4.65) with calves. The grazing was initiated 7 August and ended 7 September in Year 1, but it started a week earlier, 31 July and ended 31 August in Year 2, due to drought conditions. In Year 2, mature cows from Year 1 that were still in the herd and within the age requirements were used again. A new group of yearling heifers were used each year. Data collected at 10 d intervals during the grazing period (d 0, d 10, d 20, and d 30), included herbage production by species, moisture content and nutritive quality of the major forage species, and shrub utilization. Measurements taken before and after grazing in the study were cattle body weight (BW) and body condition scores (BCS). The trials lasted 30 days for two consecutive years.

Herbage Production of Forage

Standing crop of total herbage at a 10-d interval (d 0, d 10, d 20, and d 30) was estimated to evaluate the changes in forage quantity during the 30-d grazing period. To determine the required sample size (number of plots) a 0.25 m^2 circular plot was placed randomly across the area and each plot was hand-clipped for total production of forage. Sample size required to detect 10% of the mean with 90% confidence was calculated using the equation of Stein (1945). The formula is as follows:

$$n = (t^2)\,(s^2) / d^2$$

In this formula n is the computed sample size, t is the tabulated t value for the desired confidence level and the degrees of freedom of the initial sample, d is the half-width of the desired confidence interval, and s^2 is the variance of the initial sample. At least 50 plots are needed to adequately sample forage quantity of the range studied. A 0.25 m^2 plot was placed in every 30 m along five permanent transects across the pasture at each sampling date. Current years forage growth was clipped to ground level, separated by species, dried in a forced air oven at 50° C, and weighed. Total standing crop was

calculated by weighing each plot and adding species together. Utilization (herbage disappearance) was estimated by subtracting residual forage from herbage standing crop before grazing.

Sampling for Nutritive Analysis

Fourteen major forage species which included seven grasses and grasslikes, four forbs, and three shrub species commonly occurring in the study area were chosen for sampling to evaluate forage nutritive quality. For each plant species, a composite sample of approximately 40 g (dry weight) was collected at random throughout their respective distributions in the study area at each sampling date through hand plucking to simulate grazing.

Moisture Content and Nutritive Analysis

The hand plucked samples of the major forage species were weighed, oven-dried at 50°C, and reweighed to determine moisture content. Then the samples were analyzed for crude protein (CP) using a Kjeldahl technique (AOAC, 1990), neutral detergent fiber (NDF) using a Filter Bag Method developed by ANKOM Technology Corporation (Fairport, NY, 1997), and in vitro dry matter and/or organic matter digestibility (IVDMD and IVOMD) by Tilley and Terry (1963) technique. All data on nutritive quality are reported on dry matter basis.

Shrub Utilization

Shrub utilization was evaluated by the photographic technique (Reynolds 1999, Damiran et al. 2003) at each sampling date. Sixteen individual shrubs of two shrub species (8 willows and 8 alders) were selected randomly across the study site. The photos of the shrubs were taken with a digital camera "Nikon" and images were

evaluated using image-processing software. Shrub utilization was estimated by calculating reduction in green leaf area. Utilization estimated by green leaf area size was calculated as follows: Utilization (%) = (Before browsing leaf area size, pixel or cm^2 - After browsing leaf area, pixel or cm^2)/(Before browsing leaf area size, pixel or cm^2) x (100) (Damiran et al. 2003).

Cattle Performance

The cattle performance variables measured were cow body weight change, body condition score change and calf average daily gains (ADG). Cow body weights were obtained after an overnight shrink (16 h). Condition scores were assigned on a scale of 1 to 9 (1 = extremely emaciated, and 9 = very obese; Wagner et al. 1988). Condition score was an average of the scores assigned from two independent observers to each cow.

Statistical Analysis

Data were analyzed using GLM procedures of SAS (1996). Time series data were analyzed as a repeated measures design. Means were separated using least square means procedure of SAS (1996) and were considered different at the ($P < 0.10$) level.

RESULTS AND DISCUSSION

Precipitation

Total annual precipitation for the study years were 27.2 cm in 2001 and 30.6 cm in 2002, which was 22.3% and 12.6% below average, respectively (Figure 2.2). During both study years, the August period was dryer than typical for the northeastern part of Oregon. The amount of precipitation received for the period of the trials (around the

month of August), was 1.0 cm in Year 1 and 1.3 cm in Year 2, which was 50 and 35% less than average for the month, respectively. Average daily temperatures for this time were recorded at 20.1° C in Year 1 and 19.6° C in Year 2.

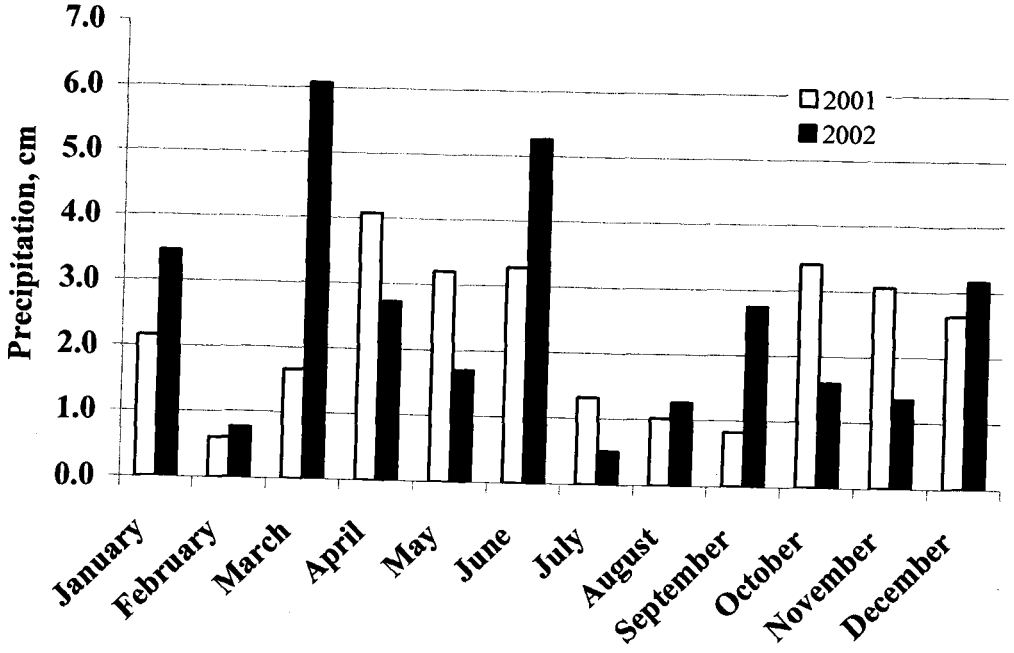

Figure 2.2. Annual monthly precipitation during the study years measured at the EOARC, Union, Oregon.

Herbage Production of Forage

Total number of plant species registered on the pasture during the study period was 82 in Year 1 and 77 in Year 2. It was visually observed that the number of species or species richness varied among the lower and upper portions of the study area and among plots it ranged between 0 to 17 plant species 0.25 m^{-2}, averaging 7 species per plot. The average number of species per plot decreased to 6 from d 20 ($P < 0.10$) till the end of the grazing period as compared to d 0 ($P < 0.05$). Herbage standing crop in the pasture was not different ($P > 0.05$) between years and averaged 1057.8 kg ha^{-1} before grazing, but declined ($P < 0.10$) continuously throughout the grazing period averaging 323 kg ha^{-1} after grazing (Figure 2.3).

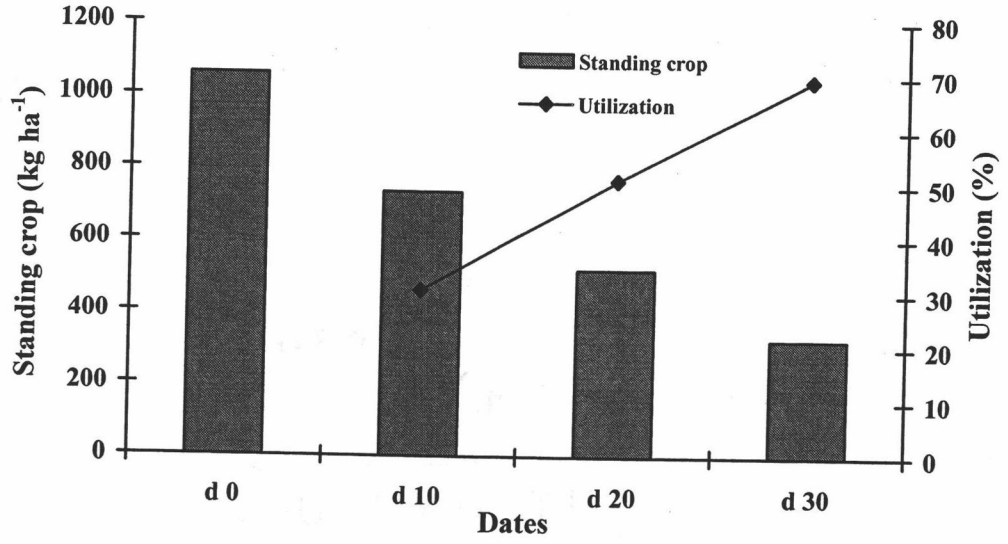

Figure 2.3. Standing crop of total herbage (kg ha^{-1}) and utilization (%) during late summer grazing season in Catherine Creek riparian area, Hall Ranch.

The similar weather conditions during the trials may have contributed to the similar results in quantity of available forage between the study years. The standing crop of herbage in August on continuously grazed plots in north-central Oregon was determined to be 1200 kg ha^{-1} by Gillen et al. (1985), while Parsons et al. (2003) estimated forage availability in northeast Oregon during late season grazing (mid August - mid September) to be 1726 kg ha^{-1}. The estimated value of standing crop of total herbage in our study was below these values, which could be attributed to the drought conditions experienced in the summers. Standing crop of herbage mass was declining at a similar rate over a 10 d interval averaging 32.5%. Cattle seem to have used the pasture vigorously from the onset of the grazing of which indicated that 30.7% of herbage was removed by d 10. Intensive utilization of available forage was observed from d 20 (51%) to the end of grazing period (69.4%). The level of utilization between d 0 and d 10 obtained in the study (31%) is probably a target in grazing public lands, but our data showed that cattle grazing a riparian pasture during a late summer could become progressively heavier. These results generally were in agreement with those found by Buckhouse et al. (1981), where utilization of streamside vegetation was 65 to 70%, and

by Kauffman et al. (1983b) who estimated that streambanks dominated by grasses and/or grasslikes were utilized 59% ranging from 35 to 85% in the areas grazed by cattle in northeastern Oregon. At the initiation of grazing, grasses comprised 44.5%, forbs 30.7%, grasslikes 15.9%, and shrubs 8.9% of the available herbage (Table 2.1). As the season progressed grasses and forbs decreased in herbage mass over the dates ($P < 0.10$). Although no differences were detected between the 10 d intervals in removal of herbage for grasslikes and shrubs ($P > 0.10$), the decreases from the initial herbage mass during the latter half of the trial were significant ($P < 0.10$). Overall, the highest herbage disappearance at the end of the grazing season was found for forbs, shrubs were the next greatest, with grasses and grasslikes being at about similar utilization levels and accounting for the least disappearing forages. Kentucky bluegrass comprised almost 11% of the total herbage and was the major portion of the available forage, timothy and sedges were the next greater forage components making up for 9.4 and 7.8%, respectively (Table 2.2). The highest percent disappearances (84 to 93%), however,

Table 2.1. Standing crop of forages (kg ha^{-1}) and utilization (%) during late summer grazing season in Catherine Creek riparian area, Hall Ranch.

Forages		Dates			
		d 0	d 10	d 20	d 30
Grasses	**Standing crop**	470.5^{a}	353.5^{b}	266.5^{c}	176.9^{d}
	Utilization		24.9	43.4	62.4
Grasslikes	**Standing crop**	168.4^{a}	115.5^{ab}	83.9^{b}	69.9^{b}
	Utilization		31.4	50.2	58.5
Forbs	**Standing crop**	325.2^{a}	168.4^{b}	89.3^{c}	51.0^{c}
	Utilization		48.2	72.5	84.3
Shrubs	**Standing crop**	93.6^{a}	96.2^{a}	78.1^{ab}	25.6^{b}
	Utilization		-2.7	16.6	72.6

^{abcd}Row values with different superscripts differ ($P < 0.10$; SE = 28.67; n = 100)

Table 2.2. Standing crop of the major forage species (kg ha^{-1}) and utilization (%) during late summer grazing season in Catherine Creek riparian area, Hall Ranch.

Forage Species	Standing Crop (kg ha^{-1})					Utilization (%)		
	d 0	d 10	d 20	d 30	SE[1]	d 10	d 20	d 30
Grasses & Grasslikes								
Kentucky Bluegrass	115.6^{a}	103.0^{a}	89.3^{ab}	55.2^{b}	16.23	10.9	22.8	52.2
Timothy	99.2^{a}	59.9^{ab}	50.6^{b}	27.1^{b}	19.41	39.6	49.0	72.7
Redtop	48.8^{a}	21.4^{b}	18.2^{b}	8.0^{b}	8.44	56.0	62.6	83.7
Quackgrass	36.6^{a}	12.4^{b}	4.8^{b}	2.7^{b}	9.92	66.1	86.9	92.7
Western Fescue	33.0^{a}	41.4^{a}	19.9^{a}	3.4^{a}	17.64	-25.5	39.6	89.8
California Brome	12.5^{a}	3.2^{b}	1.6^{b}	2.0^{b}	3.67	74.0	87.3	84.3
Sedges	82.6^{a}	51.8^{ab}	43.3^{ab}	30.7^{b}	20.63	37.4	47.7	62.8
Forbs								
Red Clover	61.1^{a}	14.5^{b}	13.8^{b}	6.3^{b}	13.82	76.2	77.4	89.7
Western Yarrow	34.3^{a}	28.0^{ab}	17.9^{ab}	14.3^{b}	3.84	18.3	47.6	58.3
Heartleaf Arnica	13.4^{a}	7.1^{ab}	2.9^{a}	2.0^{b}	8.12	47.1	78.2	85.1
Strawberries[2]	7.3^{a}	9.0^{b}	5.5^{ab}	2.1^{b}	1.76	-23.6	24.1	70.8
Shrubs & Trees								
Common Snowberry	81.5^{a}	93.7^{a}	73.4^{a}	23.2^{b}	15.18	-14.9	10.0	71.5

[ab]Row values within each species with different superscripts differ ($P < 0.10$, n = 100).

[1]Standard error of mean.

[2]Strawberries included blueleaf strawberry and woods strawberry.

were found for quackgrass (*Agropyron repens* (L.) Beauv.), western fescue (*Festuca occidentalis* Hook.), California brome (*Bromus carinatus* Hook.) and redtop (Agrostis alba L), although their availability on d 0 did not exceed 5%.

In addition to herbage removal by cattle, advancing maturity and (or) senescence due to drought may have contributed to the extensive disappearing of these species. In our study, Kentucky bluegrass – the most abundant forage, was only utilized at 52%, which was the lowest among forages. Hurd and Pond (1958) have implied that utilization of a species did not appear to be influenced by frequency, abundance, or amount of herbage produced. Timothy and sedges were utilized at 63 and 73%, respectively. Our findings were lower or within the range of those estimated by Kauffman et al. (1983a), where Kentucky bluegrass utilization in moist meadow community was 67 to 80%, timothy was utilized at 60 to 76% and sedges were utilized at 65 to 81%. Red clover (*Trifolium pratense* L.) and western yarrow were the primary forb components in the herbage mass. The most utilized forb species were red clover and heartleaf arnica (85.1 and 89.7%, respectively), while utilization of western yarrow was 58.3% at the end of the grazing period. Holechek et al. (1982b) noted that western yarrow and heartleaf arnica were utilized throughout the grazing period because both species remained green and succulent until October in most years. In our study, common snowberry was one of the important shrub components making up 7.7% of the total forage and its utilization reached 72% at the end of the grazing season. Similarly, Holechek et al. (1982b) observed that cattle grazed certain shrubs, particularly common snowberry, probably because the leaves were still green and succulent.

Moisture Content of Forages

As the season advanced and forages mature and senesce, they would be expected to be declining in water content. In our study, all forages declined in moisture content but the rate of decline was strongly influenced by forage type (Table 2.3).

Table 2.3. Moisture content (%) of forages during late summer grazing season in Catherine Creek riparian area, Hall Ranch.

Forages	Dates				
	d 0	d 10	d 20	d 30	SE[1]
Grasses & Grasslikes	52.2[a]	48.5[a]	33.5[b]	33.8[b]	2.52
Forbs	72.0[a]	70.8[a]	63.5[ab]	59.5[b]	3.33
Shrubs	65.4	63.2	61.1	60.9	3.81

[ab]Row values within each forage class with different superscripts differ ($P < 0.10$; n = 14)
[1]Standard error of mean

Specifically, forbs declined in the moisture rather gradually throughout the grazing period with significant decreases from the initial level being noted later in the season or by d 20 and d 30 ($P < 0.10$). In contrast, a sharper decline in moisture was observed for grasses and grasslikes, when they dropped from 48.5% to 33.5% between d 10 and d 20 ($P < 0.05$) during the trial. Shrubs, however, did not change in the moisture content throughout the grazing period containing an average of 62.7% moisture ($P > 0.10$). In a study in the Big Horn Basin of northcentral Wyoming, Smith et al. (1992) determined the proportion of dry matter (succulence) of forages in channel/floodplain community being 44.7 to 49.3% from late July to mid-August. Our findings generally confirm those of Parsons et al. (2000) where dry matter of the forages increases from 43% in early season to 68% in late season. Svejcar and Vavra (1985) had found forbs on the unimproved site of Oregon senesced during mid to late summer and after senescence provided essentially no forage for herbivores. As to the moisture of the individual forage species, they generally followed the same trend as the forage types did in the rate of senescence (Table 2.4). Redtop had a relatively high initial moisture (58%) among grasses and declined toward the end of the grazing period (to 44%), while moisture contents of California brome (51.2%) decreased quite dramatically by the end of the season reaching below 30%.

Table 2.4. Moisture content (%) of the major forage species during late summer grazing season in Catherine Creek riparian area, Hall Ranch (Data is average of 2001 and 2002 years).

Forage Species	Dates			
	d 0	d 10	d 20	d 30
Grasses & Grasslikes				
California Brome	51.2	40.6	23.0	24.3
Kentucky Bluegrass	54.8	53.8	38.7	36.6
Quackgrass	52.1	51.1	32.7	37.4
Redtop	58.2	60.4	45.4	44.0
Elk Sedge	51.1	50.4	35.6	34.9
Timothy	55.9	46.4	33.8	33.2
Western Fescue	42.2	36.8	25.5	26.5
Forbs				
Heartleaf Arnica	78.7	77.1	75.3	74.6
Red Clover	73.9	74.9	69.9	70.0
Strawberries[1]	69.2	65.3	56.7	56.6
Western Yarrow	66.4	65.8	52.1	36.9
Shrubs & Trees				
Alder	68.5	63.6	61.5	60.2
Common Snowberry	63.3	62.2	60.1	61.7
Firmleaf Willow	64.4	63.7	61.8	60.9

[1]Strawberries included two species: blueleaf strawberry and woods strawberry.

In our study, western fescue was the lowest in moisture among grass species even before the grazing event (42.2%) and it reached below 30% at the end of the

grazing season. The most succulent forage species were red clover and heartleaf arnica, the latter of which possessed initially 79% moisture, and only 4% of it was lost at the end of the grazing season, whereas western yarrow has shown a strong sign of senescence among forbs, dropping by almost 30% from its initial moisture. Pickford and Reid (1948) have noted that heartleaf arnica and pinegrass are better forage plants in the denser timber perhaps because they retain moisture longer and do not toughen as quickly as in the less wooded pine-bunchgrass areas. Although shrub species had similar moisture contents from the beginning of the trial, the highest was observed in alder on d 0 (68.5%).

Forage Quality

Forbs contained an average 11% CP, and shrubs contained 14% CP (Table 2.7). In contrast, grasses were lower in CP and differed between the study years ($P < 0.10$), averaging 4.5% in Year 1 and 7.3% in Year 2 (Table 2.5). There were interactions on CP content of grasses by sampling dates and by year ($P < 0.01$). Thus, CP in grasses did not vary between the dates in Year 1 ($P > 0.10$), but did change in Year 2 decreasing from d 0 to d 20 ($P < 0.10$) and slightly increased from d 20 to d 30 ($P > 0.10$). Our data confirm those found elsewhere in that crude protein levels rapidly decline in the dominant grasses of the interior Pacific Northwest and northern Great Basin as they enter reproductive phenological stages, and by July drops below 7.5% and continues to decline through summer and fall (Ganskopp and Bohnert 2001, Clark 2003). The difference in protein content for grasses between the study years was most likely related to relatively more June and August precipitation and cooler temperature for the August period in Year 2, and consequent regrowth observed later in the season. Western fescue, quackgrass, and California brome seem to have declined in CP earlier, between d 0 to d 10, from the initial values of 8.4, 9.8, and 9.9 %, respectively to 5.4, 4.6, and 3.5%, respectively (Table 2.6). The CP content in other grasses ranged 3.8 to 6.5% on d 0 and 5.3 to 9.1% on d 30. Regrowth was observed in Kentucky bluegrass and timothy

Table 2.5. Chemical composition and digestibility of grasses during late summer grazing season in Catherine Creek riparian area, Hall Ranch for 2001 and 2002.

	2001				2002				
	d 0	d 10	d 20	d 30	d 0	d 10	d 20	d 30	SE[1]
Chemical Composition (% DM basis)									
CP	5.3[a]	4.9[a]	3.9[a]	4.0[a]	9.7[a]	5.7[b]	6.1[b]	7.8[ab]	0.79
NDF	63.9[a]	68.0[a]	70.0[ab]	70.8[ab]	68.4[a]	64.7[a]	61.4[ab]	62.7[ab]	2.12
Digestibility (%)									
IVDMD	43.2[a]	40.2[a]	38.6[a]	37.8[a]	39.3[a]	43.0[a]	46.2[ab]	47.5[ab]	2.14
IVOMD	43.3[a]	40.3[a]	38.6[a]	37.8[a]	39.7[a]	43.0[a]	46.6[a]	47.6[ab]	2.13

[ab]Row values within each year with different superscripts differ ($P < 0.10$)
[1]Standard error of mean

Table 2.6. Chemical composition and digestibility of the major grass species during late summer grazing season in Catherine Creek riparian area, Hall Ranch (Data is average of 2001 and 2002 years).

Forage Species	Dates	Chemical Composition (% DM basis)		Digestibility (%)	
		CP	NDF	IVDMD	IVOMD
Redtop	**d 0**	6.5	60.5	43.9	44.6
	d 10	4.8	60.7	41.6	42.1
	d 20	4.6	60.2	42.7	43.1
	d 30	5.3	64.1	41.8	41.7
Quackgrass	**d 0**	9.8	65.9	39.4	40.0
	d 10	4.6	66.3	39.3	39.6
	d 20	4.4	65.4	38.8	39.3
	d 30	4.9	67.4	40.2	40.5
California Brome	**d 0**	9.9	76.1	37.0	36.2
	d 10	3.5	76.8	35.3	33.9
	d 20	3.9	74.6	39.0	38.0
	d 30	4.8	72.5	40.4	39.4
Elk Sedge	**d 0**	7.4	63.4	46.4	47.0
	d 10	7.5	62.9	48.0	48.7
	d 20	6.9	61.1	47.7	48.8
	d 30	7.3	60.7	49.6	50.8
Western Fescue	**d 0**	8.4	69.5	32.2	32.6
	d 10	5.4	68.3	35.7	36.1
	d 20	5.0	71.0	36.2	36.6
	d 30	4.6	72.1	34.6	34.9
Timothy	**d 0**	3.8	64.0	43.9	43.7
	d 10	4.2	64.0	42.9	42.7
	d 20	3.8	62.7	44.7	44.4
	d 30	5.4	64.5	44.8	44.4
Kentucky Bluegrass	**d 0**	6.5	64.1	45.9	46.5
	d 10	7.0	65.5	48.5	48.6
	d 20	6.2	65.1	47.6	48.4
	d 30	9.1	66.2	47.4	47.7

later in the grazing season, which likely resulted in the increases in CP for these species by d 30. In contrast to the grasses, elk sedge was characterized by a relatively stable CP level, averaging at around 7.3% throughout the grazing season. Skovlin (1967) noted that elk sedge maintained its crude protein content later in the grazing season and showed less seasonal and annual variation as compared to grasses. Clark (2003) concluded that while CP in dominant grasses typically drops below 7.5% and continues to decline through summer and fall, crude protein in elk sedge from the Blue Mountains of Oregon remains above this level at least through mid July, providing a maintenance diet later into the season. The study indicated that forbs and shrubs in the pasture did not vary much in nutritive quality throughout the grazing season ($P > 0.10$). Forbs were

Table 2.7. Chemical composition and digestibility of forbs and shrubs during late summer grazing season in Catherine Creek riparian area, Hall Ranch.

	Chemical Composition (% DM basis)		Digestibility (%)	
Dates[1]	CP	NDF	IVDMD	IVOMD
		Forbs		
d 0	11.0	36.6	57.1	54.8
d 10	11.1	33.2	59.9	57.7
d 20	10.7	36.1	56.9	54.7
d 30	10.3	34.9	60.0	57.4
SE[2]	1.24	2.66	2.73	2.82
		Shrubs		
d 0	13.9	29.6	51.7	48.9
d 10	14.2	27.9	51.6	49.0
d 20	13.6	31.7	47.4	44.7
d 30	13.0	30.3	47.2	44.3
SE[2]	1.31	3.12	3.14	3.34

[1]Column values within each forage class with different superscripts differ ($P < 0.10$)
[2]Standard error of mean

higher in NDF and digestibility, but lower in CP than shrubs during the study (Table 2.7). Holechek and Vavra (1983) have reported the higher crude protein content and less total fiber of forbs and shrubs compared to grasses. In our study, the highest CP content among forbs was determined in red clover (16.8% CP), which was pretty close to that of a shrub species in the study (Table 2.8). Other forbs ranged from 8.1 to 9.6% CP. Patterns of NDF content and in vitro digestibility of forages were similar to that of CP, in that they did not differ ($P > 0.10$) between dates and across years, except for grasses. In grasses, NDF was greater ($P < 0.05$), and digestibility lower ($P < 0.05$) in

Table 2.8. Chemical composition and digestibility of the major forb species during late summer grazing season in Catherine Creek riparian area, Hall Ranch (Data is average of 2001 and 2002 years).

		Chemical Composition (% DM basis)		Digestibility (%)	
Forage Species	**Dates**	**CP**	**NDF**	**IVDMD**	**IVOMD**
Western Yarrow	**d 0**	7.6	52.9	45.0	42.6
	d 10	8.6	44.9	53.9	51.9
	d 20	8.1	43.5	54.9	53.4
	d 30	8.0	47.8	54.4	51.7
Heartleaf Arnica	**d 0**	9.0	25.4	72.0	70.2
	d 10	8.7	25.1	74.0	72.5
	d 20	9.1	26.8	69.4	67.8
	d 30	8.2	24.8	73.8	72.1
Strawberries[1]	**d 0**	10.2	28.8	50.9	48.5
	d 10	8.8	28.1	50.3	48.0
	d 20	9.8	31.9	48.0	45.5
	d 30	9.5	25.6	52.3	49.6
Red Clover	**d 0**	17.2	39.3	60.4	57.8
	d 10	18.5	34.6	61.4	58.6
	d 20	15.8	42.3	55.4	52.4
	d 30	15.5	41.2	59.4	56.3

[1]Strawberries included two species: blueleaf strawberry and woods strawberry.

Year 1 as compared to Year 2 (Table 2.5). Overall, NDF content was highest in grasses (66.2%), intermediate in forbs (35.2%) and lowest in shrubs (29.9%) (Table 2.5 and Table 2.6). Conversely, forbs had the greatest IVDMD (58.4%), shrubs were intermediate (49.5%), and grasses had the lowest IVDMD (42.0%) during the trials. Our data were generally in agreement with the findings of Parsons et al. (2003) on a riparian pasture during late season (mid August to mid September) in northeastern Oregon, where a higher NDF (68.4%), and lower CP (4.5%) compared with early season forage was observed. In our study, heartleaf arnica was distinguished by having the highest digestibility among forage species (72.3% IVDMD). With shrubs, alder was higher in CP (17.4%), but lower in digestibility (42.9% IVDMD) as compared to willow and snowberry, which had similar digestibility, averaging 52.8 and 52.9% IVDMD, respectively (Table 2.9).

Table 2.9. Chemical composition and digestibility of the major shrub species during late summer grazing season in Catherine Creek riparian area, Hall Ranch (Data is average of 2001 and 2002 years).

Forage Species	Dates	Chemical Composition (% DM basis)		Digestibility (%)	
		CP	NDF	IVDMD	IVOMD
Alder	**d 0**	18.3	34.3	43.1	40.5
	d 10	17.9	32.4	46.9	44.6
	d 20	17.0	38.0	39.3	36.7
	d 30	16.3	35.5	42.3	39.6
Firmleaf Willow	**d 0**	13.2	28.5	57.6	54.9
	d 10	14.3	23.1	53.7	51.0
	d 20	14.3	27.4	51.4	48.9
	d 30	13.1	26.4	48.5	45.5
Common Snowberry	**d 0**	10.3	26.2	54.4	51.2
	d 10	10.3	28.2	54.4	51.3
	d 20	9.5	29.8	51.7	48.4
	d 30	9.7	29.1	51.0	47.8

Data on forage quality in the study revealed that during the late summer grazing period nutritive quality of grasses were below animal requirements as opposed to other forages. These findings basically agree with Vavra (1983), who indicated that forage quality on the pastures at EOARC's Hall Ranch deteriorates below required levels by late August, while shrubs contain higher levels of crude protein later in the grazing season than herbaceous species.

Shrub Utilization

Shrub utilization measured on two common shrubs (alder and willow) in the area indicated that it intensifies as grazing progresses and this utilization pattern was consistent during both study years (Table 2.10).

Table 2.10. Shrub utilization (%) during late summer grazing season in Catherine Creek riparian area, Hall Ranch for 2001 and 2002.

	2001			2002		
Shrubs	**d 10**	**d 20**	**d 30**	**d 10**	**d 20**	**d 30**
Alder	24.6^{a1}	56.1^{b}	81.1^{c}	8.7^{a2}	59.0^{b}	67.1^{b}
Firmleaf Willow	26.1^{a1}	53.3^{b}	63.0^{b}	3.2^{a2}	44.9^{b}	51.0^{b}
P^3	0.87	0.76	0.05	0.55	0.13	0.08

[abc]Row values within each year with different superscripts differ ($P < 0.05$; SE = 6.45; n = 16)

[12]Row values within each date with different superscripts differ ($P < 0.05$)

[3]Probability of F-test contrasts alder vs firmleaf willow

Alder use by cattle increased ($P < 0.10$) through all dates but one date in Year 2, where the change was not significant ($P > 0.10$) from d 20 to d 30. Willow demonstrated similar utilization patterns to that of alder in that utilization increased ($P < 0.05$) throughout the grazing season, except between d 20 and d 30 in both years ($P > 0.05$). The data revealed that in a riparian pasture cattle browsing activity was increased

starting from d 20 (mid August), where it ranged 45-53% for willow and 56-59% for alder and remained higher to the end of the trial, accounting for 51-63% and 67.1-81.1%, respectively ($P < 0.05$). Willow utilization as estimated by Kauffman et al. (1983a) in the same area ranged from 27-48%, whereas it has received 57% use in a study of Smith et al. (1992). The increase in shrub use by cattle observed in our study is likely to have dictated by the diminishing quality and availability of other forages. This would indicate that cows must shift to a browse dominated diet in order to satisfy their protein and/or energy needs. Our findings agree with Vavra (1983) who reported shrub use increases in riparian community as the grazing season progressed, which was in response to herbaceous vegetation maturing and becoming less palatable and/or declining in availability. Pickford and Reid (1948) implied that shrubs add desired variety to the cattle diet and because of their scarcity are rather heavily utilized by game and livestock. In addition, Holechek et.al. (1982b) observed that on the forested rangelands, in the latter half of the grazing season, cattle responded to weather conditions by shifting their diets away from grasses to browse when green regrowth, due to summer precipitation, was not available.

Shrub utilization on d 10 was lower in Year 2, than it was in Year 1 ($P <0.05$), to which higher quality of grasses in Year 2, than in Year 1 (average 7.3% vs. 4.5% CP) could have been contributed.

Overall, there was heavier use on alder than willow ($P < 0.10$) by the end of the season in the study years, averaging 17% higher, which may be related to alder being higher in CP (17.4% vs. 13.7%), and more abundant and evenly distributed in the area. Previous researches in the same area have found that density of willow species was greater in exclosures compared to grazed areas (Kauffman et al. 1983a, Green and Kauffman 1995).

The Catherine Creek site used in this study has been evaluated extensively by other researchers and reflects 25 years of late summer grazing. This grazing approach has not significantly impacted riparian vegetation when evaluated across plant communities, although some influences within plant communities have occurred with

structural diversity of woody plant communities being affected (Kauffman et al. 1983a, Kauffman et al. 1983b, and Green and Kauffman 1995). Our findings demonstrated that cattle grazing the riparian pasture in the summer could result in significant removal of herbaceous as well as intensive use of woody vegetation.

Cattle Performance

Cattle performance varied by age classes across the years. Yearling heifers gained more ($P < 0.05$) BW than mature cows in both years of the study (Table 2.11). In Year 1, yearling heifers and mature cows had similar initial BCS ($P > 0.10$), but in Year 2, yearling heifers had greater initial BCS than mature cows ($P < 0.05$). After grazing, changes in BCS were significant ($P > 0.10$) for only mature cows, when they dropped ($P < 0.05$) in the body condition in Year 1. Overall, heifers seemed to have performed better than mature cows gaining more weight and having higher BCS during

Table 2.11. Cattle performance during late summer grazing season in Catherine Creek riparian area, Hall Ranch for 2001 and 2002.

		2001		2002	
	Time	**Heifer**	**Mature Cow**	**Heifer**	**Mature Cow**
BW (kg)	**before**	391.7	502.6	446.3	496.1
	after	416.5	518.7	460.4	501.8
ADG (kg)		0.83[a]	0.57[b]	0.47[a]	0.19[b]
	SE[3]	0.08	0.08	0.07	0.07
BCS	**before**	5.0[a]	4.9[a1]	5.1[a]	4.4[b]
	SE[3]	0.09	0.09	0.07	0.07
	after	4.9[a]	4.6[b2]	5.2[a]	4.3[b]
	SE[3]	0.09	0.09	0.07	0.07

[ab]Column values with different superscripts differ ($P < 0.10$, n = 30)
[12]Row values within animal age classes each year with different superscripts differ ($P < 0.05$)
[3]Standard error of mean

the study years. Average daily gain of calves was similar ($P > 0.10$) across years and averaged 0.96 kg/d. Average daily gain is dependent on nutrient levels in the forage. Holechek and Vavra (1983) concluded that ranges supporting a high component of palatable forbs and shrubs will improve weight gains during drought years compared to grassland ranges because of the higher forage intake rates, higher CP, and lower fiber concentrations associated with the leafy material of forbs and shrubs compared to grasses. Svejcar and Vavra (1985) implied that growing heifers would be expected to gain weight only during the first grazing period (July) on moist meadows. The cattle performance data from our study indicate cows were able to obtain diets of such quality that met or was above their maintenance requirements despite the low quality of grasses and scarcity of forbs.

IMPLICATIONS

Our data revealed that maturation and drying of grasses and consequent decline in the quality can occur as early as in the first half of the late summer grazing, while forbs and shrubs remain higher in quality, although forb abundance declines in late summer. This would suggest that in response to changes in the quantity and quality of grasses and availability of forbs, cattle grazing late summer riparian pastures will switch to intensive shrub utilization. Sustainable management of riparian pastures needs to balance uniform use of forage resources with optimal production. If a managers goal is to increase the abundance and diversity of woody vegetation, our data suggest that late summer grazing should be light, or avoided if grasses have senesced. In addition, further investigation on foraging habits of cattle grazing riparian pastures in relation to forage availability and quality is needed.

LITERATURE CITED

AOAC. 1990. Official Methods of Analysis. 15th ed. Assoc. Offic. Anal. Chem., Arlington, VA.

Buckhouse, J.C., J.M. Skovlin, and R.W. Knight. 1981. Streambank erosion and ungulate grazing relationships. J. Range Manage. 34:339-340.

Clark, P.E. 2003. Date and plant community effects on elk sedge forage quality. J. Range Manage. 56:21-26.

Damiran, D., D. Johnson, T. DelCurto, and S. Findholt. 2003. Estimating shrub forage yield and utilization using a photographic technique. *In*: Abstr. of Soc. for Range Manage. 56th Annu. Meeting. #54.

DelCurto, T., R.C. Cochran, L.R. Corah, A.A. Beharka, E.S. Vanzant, and D. Johnson. 1990. Supplementation of dormant, tallgrass-prairie forage. II. Performance and forage utilization characteristics in grazing beef cattle receiving supplements of different protein concentrations. J. Anim. Sci. 68:532.

Ganskopp, D. and D. Bohnert. 2001. Nutritional dynamics of 7 northern Great Basin grasses. J. Range Manage. 54:640-647.

Gillen, R., W. Krueger, and R. Miller. 1985. Cattle use of riparian meadows in the Blue Mountains of Northeastern Oregon. J. Range Manage. 38:205-209.

Green, D.M., and J.B. Kauffman. 1995. Succession and livestock grazing in a northeastern Oregon riparian ecosystem. J. Range Manage. 48:307-313.

Holechek, J.L., M. Vavra, and R.D. Pieper. 1982a. Botanical composition determination of range herbivore diets: A review. J. Range Manage. 35:309-315.

Holechek, J., M. Vavra, J. Skovlin, and W. Krueger. 1982b. Cattle diets in the Blue Mountains of Oregon II. Forests. J. Range Manage. 35:239-242.

Holechek, J.L., and M. Vavra. 1983. Drought effects on diet and weight gains of yearling heifers in Northeastern Oregon. J. Range Manage. 36:227-231.

Hurd, R.M., and F.W. Pond. 1958. Relative preference and productivity of species on summer cattle ranges, big horn mountains. Wyoming. J. Range Manage. 3:109-114.

Kauffman, J.B., W.C. Krueger, and M. Vavra. 1983a. Effects of late season cattle grazing on riparian plant communities. J. Range Manage. 36:685-691.

Kauffman, J.B., W.C. Krueger, and M. Vavra. 1983b. Impacts of cattle on streambanks in Northeastern Oregon. J. Range Manage. 36:683-685.

Laliberte, A., D. Johnson, N. Harris, and G. Casady. 2001. Stream change analysis using remote sensing and Geographic Information Systems (GIS). J. Range Manage. 54:22-50.

Leege, T.A., D.J. Herman, and B. Zamora. 1981. Effects of cattle grazing on mountain meadows in Idaho. J. Range Manage. 34:324-328.

Parsons, C.T., P.A. Momont, T. DelCurto, M. McInnis, and M.L. Porath. 2003. Cattle distribution patterns and vegetation use in mountain riparian areas. J. Range Manage. 56: 334-341.

Pickford, G.D., and E.H. Reid. 1948. Forage utilization on summer cattle ranges in Eastern Oregon. *In*: U.S. Dept. of Agr. Circular No. 796. Washington, D.C. p.1-27.

Porath, M.L., P.A. Momont, T. DelCurto, N.R. Rimbey, J.A. Tanaka, and M. McInnis. 2002. Offstream water and trace mineral salt as management strategies for improved cattle distribution. J. Anim. Sci. 80:346-356.

Reynolds, M. P. 1999. Residual leaf area as a measure of shrub use. M.S. Thesis, Ore. State Univ. Corvallis. Ore.

SAS. 1996. SAS/STAT guide for personal computer. Version 6.12. SAS Institute, Cary, North Caroline.

Skovlin, J.M. 1967. Fluctuations in forage quality on summer range in the Blue Mountains. Pacific Northwest Forest and Range Exp. Sta., USDA, Pacific Northwest. 44.

Smith, M.A., J.D. Rodgers, J.L. Dodd, and Q.D. Skinner. 1992. Declining forage availability effects on utilization and community selection by cattle. J. Range Manage. 45:391-395.

Stoddart, L., A. Smith, and T. Box. 1975. Range management. Third ed. McGraw-Hill Book Company, New York.

Svejcar, T., and M. Vavra. 1985. The influence of several range improvements on estimated carrying capacity and potential beef production. J. Range Manage. 38:395-399.

Tilley, J. M. A. and R. A. Terry. 1963. A two-stage technique for the *in vitro* digestion of forage crops. J. Br. Grassl. Soc.18:104-111.

Vavra, M. 1983. Managing grazing animal response to forestland vegetation. *In*: Proc. Symp. Forestland Grazing. Spokane. Washington. p.43-51.

Vavra, M., and R. J. Raleigh. 1976. Coordinating beef cattle management with the range forage resource. J. Range Manage. 29:449-452.

Wagner, J.J., K.S. Lusby, J.W. Oltjen, J. Rakestraw, R.P. Wettemann, and L.E. Walters. 1988. Carcass composition in mature Hereford cows: estimation and effect on daily metabolizable energy requirement during winter. J. Anim. Sci. 66:603-612.

CHAPTER 3

THE INFLUENCE OF COW AGE ON BOTANICAL COMPOSITION OF DIETS IN MIXED CONIFER MOUNTAIN RIPARIAN AREAS AND ADJACENT UPLANDS

E. Darambazar, T. DelCurto, C. Ackerman, D. Damiran, and J.A. Morrison

Authors are Graduate Research Assistant, Department of Animal Sciences, Oregon State University, Corvallis, Oregon 97331; Associate Professor, Department of Animal Sciences, Eastern Oregon Agricultural Research Center, Oregon State University, Union, Oregon 97883; Former Assistant Professor, Department of Animal Sciences, Oregon State University, Corvallis, Oregon 97331; Graduate Research Assistant, Department of Animal Sciences, Oregon State University, Corvallis, Oregon 97331; and Goose Lake Watershed Coordinator, Alturas, California 96101.

ABSTRACT

The objective of this study was to evaluate the effect of cow age on botanical composition of diets in mountain riparian areas. Treatments consisted of 30 first calf heifers, and 30 mature cows randomly assigned to four pastures (2 pastures/treatment, average 21.5 ha) in a two-year study with a cross over design. Botanical composition of diets was determined in fecal samples obtained from 10 animals in each treatment (5 per pasture) on fourth week of 35 to 42-day grazing periods using microhistological technique. The crude protein (CP) content and *in vitro* dry matter digestibility (IVDMD) were determined, and correction factors were calculated for 22 major plant species. In digested samples, grasses were overestimated, whereas, all forbs but northern bedstraw (*Galium boreale*), were underestimated, and all shrub species were overestimated except common snowberry (*Symphoricarpos albus*). Ponderosa pine (*Pinus ponderosa*) was highly overestimated after digestion. There was no between age class differences in the total number of plant species in the diets ($P > 0.10$). Most grass and grasslike species comprised more than 5% of the diets, while all forb species were minor components, not exceeding 5%. Western wheatgrass (Agropyron smithii) and tufted hairgrass (Deschampsia caespitosa) accounted for over 10% of the diets. Only one tree species from shrubs and trees (i.e. ponderosa pine) made up more than 5% of the diets. Heifers consumed more ($P < 0.05$) grasses and fewer ($P < 0.10$) shrubs and trees than mature cows. The diet of heifers contained more western wheatgrass, Baltic rush (Juncus balticus), and pinegrass (*Calamagrostis rubescens*) ($P < 0.10$), but less Kentucky bluegrass (*Poa pratensis*) ($P < 0.01$), than mature cows. The proportion of ponderosa pine needles was higher in the diet of mature cows ($P < 0.10$), than in the diet of first calf heifers. In summary, mature cows appeared to have selected a diet that contained less grasses and more shrubs and trees compared to younger cows.

Keywords: botanical composition, microhistological analysis, cow age

INTRODUCTION

Information regarding diet selection of herbivores has become an increasingly important tool in resource management. Free et al. (1969) stated that knowing what plants an animal eats is essential in determining "when" and "how much" of each plant is consumed, and in evaluating the availability and the digestibility of the plant. Knowledge of species consumed by grazing animals tells what the key species are and helps explain changes in diet quality and animal performance (Holechek et al. 1981). Milne et al. (1982) noted that grazing animals have the opportunity to select their diet and in many cases the composition of the diet selected simply reflects the species and plant parts present in the horizon of the canopy being grazed. There have been studies in which differences were observed in diet selection between young ruminants and older animals (Grings et al. 1995, Mohammad et al. 1996, Winder et al. 1996). Grings et al. (1995) concluded that suckling calves selected diets of higher quality than did mature steers early in the summer when calves were receiving much of their nutrient intake from milk, but not at later times. In a later study, Grings et al. (2001) reported that diets of calves and heifers generally had greater crude protein concentrations than cows and steers, but differences decreased as the season progressed. They further noted that although dietary crude protein did not differ between heifers and cows in first year, it was higher for heifers than for cows in second year and digestibility did not differ among these age classes for August of a 2 yr study. Winder et al. (1996) observed differences that can be attributed to distances traveled from water during grazing activities. Calves were often observed grazing substantial distances from their dams, increasing dietary variation and reducing the relationship between the diets of cows and their calves (Winder et al. 1996). But still few studies have directly addressed cattle diet selection of different age classes in riparian areas. The overall study, of which this research comprised a part, was designed to evaluate the influence of cow age on grazing distribution relative to mountain riparian areas and was carried out by other researchers (Morrison et al. 2002). The objective of this study was to evaluate the effect of cow age

on botanical composition of diets with cattle grazing mixed conifer mountain riparian areas and adjacent uplands.

MATERIALS AND METHODS

Study Site

The pastures used in the study comprised 86 ha along Milk Creek. The area was divided with electric fence into four pastures, each containing roughly 22 ha and a 560 m stretch of Milk Creek (Figure 3.1). The study was conducted from late July through early September of 2000 and 2001. Dominant grasses in riparian grass communities included timothy (*Phleum pratensis* L.), Kentucky bluegrass (*Poa pratensis* L.), meadow foxtail (*Alopecurus pratensis* L.), wheatgrasses (*Agropyron* spp.) and bromes (*Bromus* spp.). Sedges (*Carex* spp.) and rushes (*Juncus* spp.) were also present. Numerous forbs, including cinquefoil (*Potentilla* spp.), asters (*Aster* spp.), western yarrow (*Achillea millefolium lanulosa* L.), and lupines (*Lupinus* spp.) occurred in these communities. The overstory typically consisted of hawthorn (*Crataegus douglasii* Lindl.), ponderosa pine (*Pinus ponderosa* Dougl.), snowberry (*Symphoricarpus albus* L.), wild rose (*Rosa gymnocarpa* Nutt.), alders (*Alnus* spp.) and willows (*Salix* spp.) (Porath et al. 2002). The herbaceous species dominating the uplands included timothy, brome spp., Kentucky bluegrass, orchardgrass (*Dactylis glomerata* L.), needlegrasses (*Stipa* spp.), blue wildrye (*Elymus glaucus* Buckl.), Idaho fescue (*Festuca idahoensis* Elmer), bluebunch wheatgrass (*Agropyron spicatum* Scribn.&Smith), pinegrass (*Calamagrostis rubescens* Buckl.), and elk sedge (*Carex geyeri* Boott) (Porath et al. 2002). Several forb species occurred in the uplands, including lupine, cinquefoil and wild iris (*Iris* spp.). Snowberry, wild rose, and maple (*Acer* spp.) comprised the majority of the shrub component in the uplands. Ponderosa pine was the dominant tree species. Nomenclature for the species listed were in accordance with Hitchcock et al. (1969).

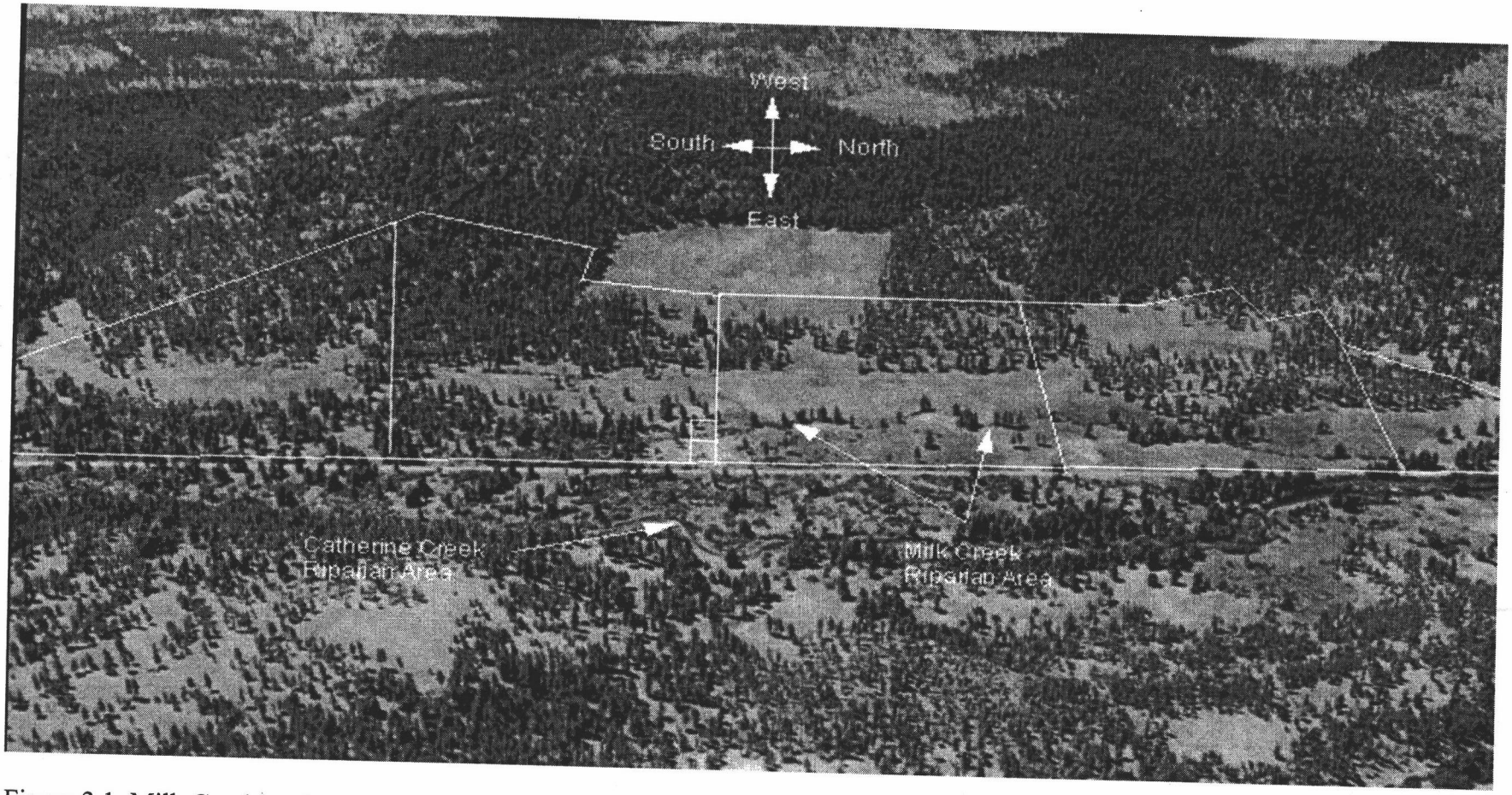

Figure 3.1. Milk Creek study area located within the Hall Ranch. Four pastures (with averages of 22 ha in size and a 560 m stretch of Milk Creek) were utilized in a replicated design to evaluate the influence of cow age on grazing distribution and diet botanical composition relative to mountain riparian areas. Each pasture contains riparian meadow and upland vegetation types.

The overall study, of which this research comprised a part, was conducted as a randomized complete block design. Sixty cow/calf pairs each year were stratified by age into the following treatments: 1) thirty first calf heifers (2 years of age; 442 kg, BCS = 4.4), and 2) thirty mature cows (5, 6, and 7 years of age; 569 kg, BCS = 4.9). Each treatment group was then randomly divided to create a total of four groups of 15 pairs each. In Year 1, treatments were randomly assigned to the four pastures. For Year 2, treatment assignments from the previous year were reversed. Thus, every pasture was grazed by each age class during the two-year study. In Year 2, mature cows from Year 1 that were still in the herd and within the age requirements were used again. A new group of 2-year old first calf heifers were used each year (Morrison et al. 2002).

The pastures were stocked at 1.5 ha per animal unit month (AUM) to achieve light to moderate utilization. The trial lasted 42 days in Year 1 but was reduced to 35 days in Year 2 due to drought conditions (Morrison et al. 2002).

Sampling for Diet Analysis

Ten animals per age class were selected randomly for sampling for fecal analysis. Fresh fecal samples were collected immediately after defecation by following the sampling animals in the pasture. A composite sample was taken from four fecal samples for 4 days obtained during fourth week of the trial. Samples were dried in a forced air oven at 50°C for at least 72 hours and stored.

Botanical Composition of Diets

Botanical composition of cow diets was determined analyzing the fecal samples through the microhistological technique, described by Sparks and Malechek (1968). Each sample was prepared by soaking it in 50% ethanol for overnight, blending, washing under running water over a 200 mesh screen and a small portion of the washed material was used to make a microscopic slide. Five slides were prepared for each

animal and examined in 20 systematically located microscopic fields per slide. Identification was based on epidermal tissue characteristics, such as guard cells, stomata, cell shape, and trichomes. Diet percent by weight was obtained by following steps: the total number of frequency observations for all species is added, and the number of frequency observations of each species is divided by the total number of frequency observations for all species. This number multiplied by 100 is used as the percent by weight composition of the diet (Holechek et al. 1982a).

Correction Factors

To improve the accuracy of fecal analysis it is recommended to develop correction factors specific to forage species, study areas, and season (Dearden et al. 1975; Vavra and Holechek 1980; Leslie et al. 1983; Holechek et al. 1982a). Correction factors were determined following the approach of Dearden et.al. (1975) modified by Leslie et al. (1983). Each plant species was part of 5 hand-mixed diets and occurred in known relative densities (i.e. percentages by weight) in those mixtures. A known percentage of elk sedge was included in each mix as a standard. Each mix was digested in vitro (Tilley and Terry 1963) for 48 hours using inoculum from steers, and analyzed microscopically (Vavra and Holechek 1980). The observed density of each plant species (X) was calculated from frequency of identifiable epidermis (Sparks and Malechek 1968). The actual density (Y) was calculated from relative weights and the observed density of the standard (Table A.3.3), assuming the latter equaled its relative weight in the hand-mixed diet.

Nutritive Quality Analysis

Crude protein, ash (AOAC, 1990), and digestibility (Tilley and Terry, 1968) of available forage was evaluated in the samples of over 50 individual forage species, commonly occurred in the Milk Creek area. The samples were collected by hand clipping around late August and were oven dried at 50°C.

Statistical Analysis

Data were analyzed using the GLM procedures of SAS (1996) as two treatment, replicated, cross-over design with pasture being experimental unit and cow age being treatment. Treatment means were separated using least squares means procedures and were considered significant at the ($P < 0.10$) level.

RESULTS AND DISCUSSION

Chemical Composition and Digestibility of Forage

Crude protein levels of forage species in the study pasture ranged from 2.1 to 6.8% for grasses and grasslikes, 3.7 to 11.8% for forbs and 5.4 to 16.4% for shrubs and trees during the grazing period (Table 3.1 and Table A.3.4). It was determined that among grasses and grasslikes elk sedge, pinegrass, Sandberg bluegrass, Baltic rush, and redtop contained over 5% CP. Among forbs the highest in protein was fleabane, while among shrubs alder and willow were of higher quality. In vitro organic matter digestibility of forages was 33.9 to 65.8% for grasses and grasslikes, 42.1 to 78.1% for forbs, and 34.9 to 65.2% for shrubs and trees. Heartleaf arnica was the highest in digestibility (79%), whereas blue wildrye and western fescue were the lowest (34 and 35%, respectively).

Correction Factors

Correction factors were developed in 22 common forages, which included 10 grass, 2 grasslike, 5 forb, and 4 shrub and 1 tree species that occur in the study area, to adjust for the effects of differential digestibility of ingested forages (Tables 3.1 and Table A.3.3.). All grasses, except orchardgrass, were overestimated, while all forbs, but northern bedstraw, were underestimated. Orchardgrass was slightly underestimated, while northern bedstraw was neither over- or underestimated. Most shrubs were

Table 3.1. Chemical composition and digestibility of the major forage species, and correction factors during late summer grazing season in Milk Creek riparian area, Hall Ranch.

Forage Species	Chemical Composition (% DM basis)			Correction Factor (b)[1]
	Ash	CP	IVDMD	
Grasses & Grasslikes				
Blue Wildrye	8.6	3.5	34.4	0.657
Kentucky Bluegrass	8.6	3.2	45.6	0.639
Meadow Foxtail	8.5	2.3	35.6	0.779
Orchardgrass	10.0	3.2	42.5	1.213
Pinegrass	15.4	6.7	46.2	0.433
Redtop	8.8	5.6	57.1	0.469
Timothy	5.7	2.9	48.7	0.759
Tufted Hairgrass	8.0	4.0	42.4	0.411
Western Needlegrass	_	2.8	_	0.640
Western Wheatgrass	8.8	2.9	43.7	0.838
Elk Sedge	9.4	7.0	51.6	1.001
Baltic Rush	4.3	6.0	45.9	1.133
Forbs				
Western Yarrow	8.5	7.2	45.8	2.613
Fleabane	7.9	9.2	59.9	1.443
Heartleaf Arnica	10.1	7.7	79.4	1.838
Yellow Salsify	_	4.8	_	2.482
Northern Bedstraw	_	6.6	_	1.001
Shrubs & Trees				
Common Snowberry	12.3	9.3	62.4	2.613
Firmleaf Willow	7.8	15.2	67.3	0.656
Alder	5.4	16.4	56.9	0.838
Low Oregongrape	3.4	9.7	59.3	0.635
Ponderosa Pine	2.7	7.9	35.8	0.495

[1] b = Degree of underestimation (b > 1.0) or overestimation (b < 1.0).

overestimated, except that common snowberry was highly underestimated in digested diets. Similar findings have reported Vavra and Holechek (1980), that common snowberry was identified in only small amounts in some digested samples and was totally absent in others. Ponderosa pine was highly overestimated after digestion. The correction factors were then used to adjust the diet composition data from the study.

Diet Botanical Composition

Composition of the cow diets was dominated by grasses, accounting for up to 75% in the diets, the next greater diet constituents were shrubs and trees (9 to 13%), and grasslikes made up lesser portion (to 12%) with forbs occurring only in minor amounts (to 5%) (Table 3.2). This pattern in the rankings of forage classes in diet composition remained similar over the study years ($P > 0.10$). Holechek and Vavra (1983) found that in the early summer (July 19 to August 15) the cattle diet was dominated by shrubs, while grasses dominated the diet in late summer (August 16 to September 12) in the Blue Mountains of northeastern Oregon. They further reported that during the drought year in their study forbs were lower in cattle diets because most forb species had reached maturity and dried by early July.

Table 3.2. Diet botanical composition by forages (% dry weight) of cows during late summer grazing season in Milk Creek riparian area, Hall Ranch.

Forages	Heifers	Mature Cows	SE[1]	P-Value
Grasses	74.7	70.8	0.17	0.01
Grasslikes	11.8	11.0	1.74	0.79
Forbs	4.3	4.8	0.44	0.47
Shrubs & Trees	9.2	13.4	0.69	0.05

[1]Standard error of mean (Pooled) (n = 20).

The diet of heifers comprised significantly more grasses and less shrubs and trees than that of mature cows ($P < 0.10$). In contrast, no differences between age classes were found in percentages of grasslikes and forbs ($P > 0.10$).

Morrison et al. (2002), who studied distribution and utilization patterns of these cows, reported that the mature cows had utilized more forage in the riparian grass communities than did first calf heifers at the end of the trial. Their findings indicated also, that early in the grazing bout the mature cows did appear to select upland areas, while the first calf heifers appeared to prefer riparian vegetation type, though as the grazing bout continued the distribution and utilization patterns of the different age classes converged. Considering that the first calf heifers spent more time in riparian vegetation, it is possible that differences in diet composition reflect differences in distribution and forage utilization patterns.

A total of 41 species was found in the composition of the cow diets (39 identified and 2 unidentified) (Table A.3.1 and Table A.3.2). No differences were found between age classes in number of species in the diets across the study years ($P > 0.10$). The most consistently occurring species throughout examining the diets were 8 grass, 2 grasslike, 5 forb, and 4 shrub and 1 tree species, and data presented in Table 3.3 demonstrate the percentages of these species by weight composition of the diet and correction factors developed for them.

The dietary proportions of western wheatgrass and tufted hairgrass accounted for more than 10% of the diets, and the other grass and grasslike species made up between 5 to 10% with an exception of few species (Table 3.3). In a study on forested ranges in northeastern Oregon, Holechek et al. (1982b) reported that only six of a total 29 graminoids occurred in greater than trace amounts (i.e. 5% or more to the overall diet), which comprised Idaho fescue, bluebunch wheatgrass, pinegrass, elk sedge, western fescue, and Kentucky bluegrass. Our findings were higher in terms of number of grass species occurred in the amounts more than 5% of the diet than those reported by these researchers, but were partly similar in terms of individual species found among them. Forb species have occurred in the amounts near or less than 2%, while shrub and

Table 3.3. Diet botanical composition by the major forage species (% dry weight) of cows during late summer grazing season in Milk Creek riparian area, Hall Ranch.

Forage Species	Heifer	Mature Cow	SE[1]	P - Value
Grasses & Grasslikes				
Baltic Rush	6.5	5.2	0.13	0.02
Blue Wildrye	10.0	8.4	0.54	0.17
Elk Sedge	5.3	5.9	1.67	0.82
Kentucky Bluegrass	6.3	7.5	0.03	0.002
Meadow Foxtail	4.0	6.0	1.19	0.35
Orchardgrass	7.3	7.6	0.47	0.67
Pinegrass	8.0	6.4	0.34	0.08
Redtop	5.2	4.8	0.40	0.44
Timothy	1.8	1.9	0.39	0.89
Tufted Hairgrass	11.1	10.2	0.37	0.21
Western Needlegrass	8.7	7.6	0.80	0.45
Western Wheatgrass	12.6	11.2	0.25	0.06
Forbs				
Heartleaf Arnica	0.3	0.5	0.12	0.27
Northern Bedstraw	0.2	0.2	0.07	0.51
Western Yarrow	1.6	1.8	0.41	0.71
Yellow Salsify	2.1	1.8	0.37	0.71
Shrubs & Trees				
Common Snowberry	2.4	2.5	0.33	0.84
Low Oregongrape	0.2	0.3	0.09	0.82
Ponderosa Pine	5.8	9.5	0.76	0.07
Firmleaf Willow	0.6	0.8	0.12	0.33

[1]Standard error of mean (Pooled) (n=20).

tree species were under 5% except ponderosa pine. Apparently, the reason for the two grass species being found in the diets more often than other grasses may not be the quality, since their CP contents determined in the study were very low (2.9% for western wheatgrass and 4.0% for tufted hairgrass). Perhaps it was their palatability and /or availability, but no speculations could be made because of limited information. Cattle selections for the grass and grasslike species such as western wheatgrass, Kentucky bluegrass, pinegrass, and Baltic rush were different between age classes ($P < 0.10$) with mature cows consuming more Kentucky bluegrass, but less western wheatgrass, Baltic rush, and pinegrass than first calf heifers. Higher portion of Kentucky bluegrass, but lesser portion of Baltic rush in the diet of mature cows may have related to the distribution and utilization patterns of these cows, in that they spent more time in the uplands than their counterparts (Morrison et al. 2002). Among shrubs and trees cattle diets differed between age classes in the percentages for only one species. The proportion of ponderosa pine in the diet of mature cows was higher ($P < 0.10$) as compared to that of first calf heifers. Consequently, the observed amounts of this species in the diets contributed to the differences in consumption of shrubs and trees between age classes found in the study.

Forbs comprised a minor component of diets with the amounts not exceeding 2.1% of the diet. Similarly, Holechek et al. (1982b) reported that forb consumption declined as the grazing season advanced. Although the number of forb species found in diets by Holechek et al. (1982b) was more than it was in our study, only western yarrow, heartleaf arnica, and lupine comprised 1% or more of the overall diet, which was partly, in agreement with our findings. Holechek and Vavra (1983) also, determined that western yarrow in cattle diets declined from 4% in early summer to 1% in late summer. Researchers report smaller number of forb species identified and/or forbs being found in very little amounts in the feces which may be accounted for the almost complete digestion of some forbs, by the low abundance in the diet, or some forbs do not survive the grinding of slide preparation (Free et al. 1969, Rees 1982, Samuel and Howard 1983). On the other hand, Hirschfeld et al. (1996) who

investigated cattle diets in central North Dakota, reported a higher portion of forbs in diets ranging from 1.1% in fall to 27% in late summer, although this study was done in a different climatic and ecological zone.

The greater proportion of ponderosa pine found in the diets of mature cows may have been related in part to that as Morrison et al. (2002) indicated the mature cows spent a great deal of time (much of it foraging) in the uplands early in the trial. This is likely to have happened under the canopy of ponderosa pine, which increases the chances of incidental consumption of pine needles. Sources indicate that diet investigators have observed pine needles being ingested by cattle. Thus, Karl and Doescher (1998) in determining cattle removal of terminal tissue of ponderosa pine seedlings in May and August found that August tissue removal was severe, as both current-year needles and stem tissue were consumed. Estimates similar to ours were found by Mitchell and Rodgers (1985) on summer forest and pasture ranges in northern Idaho, where up to 8% of ponderosa pine needles was recovered in cattle diets, which they explained by possible inadvertent ingestion and by the morphological characteristics of pine needles in the diet.

CONCLUSIONS

The diets of first calf heifers and mature cows grazing in a mixed conifer mountain riparian area differ in that mature cows consumed less in the amount of grasses and more in the amount of shrubs and trees as compared to younger cows. These differences could be explained by the distribution patterns of the cows. Our data support the statement made by Morrison et al. (2002) in that by stocking public lands that have key riparian areas with mature cows, it may be possible to achieve more uniform utilization of available forage resources. Diet species composition varied between age classes in that mature cows had more Kentucky bluegrass and ponderosa pine, but fewer Baltic rush, western wheatgrass, and pinegrass in their diet than first calf heifers. Our research suggest that cow age/experience does relate to modest changes in diet composition of beef cattle grazing mountain riparian areas.

LITERATURE CITED

AOAC. 1990. Official Methods of Analysis. 15th ed. Assoc. Offic. Anal. Chem., Arlington, VA.

Dearden, B.L., R.E. Pegau, and R.M. Hansen. 1975. Precision of microhistological estimates of ruminant food habits. J. Wildl. Manage. 39:402-406.

DelCurto, T., R.C. Cochran, L.R. Corah, A.A. Beharka, E.S. Vanzant, and D. Johnson. 1990. Supplementation of dormant, tallgrass-prairie forage. II. Performance and forage utilization characteristics in grazing beef cattle receiving supplements of different protein concentrations. J. Anim. Sci. 68:532.

Free, J.C., R.M. Hansen, and P.L. Sims. 1969. Estimating dryweights of foodplants in feces of herbivores. J. Range Manage. 23:300-302.

Grings, E.E., D.C. Adams, and R.E. Short. 1995. Diet quality of suckling calves and mature steers on Northern Great Plains rangelands. J. Range Manage. 48:438-441.

Grings, E.E., R.E. Short, M.R. Haferkamp, and R.K. Heitschmidt. 2001. Animal age and sex effects on diets of grazing cattle. J. Range Manage. 54:77-81.

Hirschfeld, D.J., D.R. Kirby, J.S. Caton, S.S. Silcox, and K.C. Olson. 1996. Influence of grazing management on intake and composition of cattle diets. J. Range Manage. 49:257-263.

Hitchcock, C.L., A. Cronquist, M. Owenbey, and J.W. Thompson. 1969. Vascular plants of the Pacific Northwest. University of Washington Press, Seattle, Wash.

Holechek, J.L., and M. Vavra. 1983. Drought effects on diet and weight gains of yearling heifers in Northeastern Oregon. J. Range Manage. 36:227-231.

Holechek, J.L., M. Vavra, and R.D. Pieper. 1982a. Botanical composition determination of range herbivore diets: A review. J. Range Manage. 35:309-315.

Holechek, J., M. Vavra, J. Skovlin, and W. Krueger. 1982b. Cattle diets in the Blue Mountains of Oregon II. Forests. J. Range Manage. 35:239-242.

Holechek, J.L., M. Vavra, and J. Skovlin. 1981. Diet quality and performance of cattle on forest and grassland range. J. Anim. Sci. 53:291-298.

Karl, M.G. "Sherm" and P.S. Doescher. Ponderosa pine aboveground growth after cattle removal of terminal tissue. J. Range Manage. 51:147-151.

Leslie, D.M, Jr., M. Vavra, E.E. Starkey, and R.C. Slater. 1983. Correcting for differential digestibility in microhistological analyses involving common coastal forages of the Pacific Northwest. J. Range Manage. 36:730-732.

Milne, J.A. 1991. Diet selection by grazing animals. *In*: Proc. Nutr. Soc. 50:77-85.

Mitchell, J.E., and R.T. Rodgers. 1985. Food habits and distribution of cattle on a forest and pasture range in Northern Idaho. J. Range Manage. 38:214-220.

Mohammad, A.G., C.A. Ferrando, L.W. Murray, R.D. Pieper, and J.D. Wallace. 1996. Season and sex influences on botanical composition of cattle diets in southern New Mexico. J. Range Manage. 49:204-208.

Morrison, J.A. 2002. The influence of cow age on grazing distribution and utilization of mountain riparian areas and adjacent uplands. M.S. Thesis. Ore. State Univ. Corvallis.

Morrison, J.A., T. DelCurto, C.T. Parsons, G.D. Pulsipher, and E.S. Vanzant. 2002. The influence of cow age on grazing distribution and utilization of mountain riparian areas and adjacent uplands. Proc., West. Sec. Amer. Soc. Anim. Sci. 53: 21-24.

NRC. 1996. Nutritional Requirements of Beef Cattle, 7th ed. National Academy Press, Washington D.C.

Porath, M.L., P.A. Momont, T. DelCurto, N.R. Rimbey, J.A. Tanaka, and M. McInnis. 2002. Offstream water and trace mineral salt as management strategies for improved cattle distribution. J. Anim. Sci. 80:346-356.

Rees, H. 1982. The diet of free-ranging cattle on the Bogong High Plains. Victoria. Austr. Rangel. J. 4:29-33.

Samuel, M.J., and G.S. Howard. 1983. Disappearing forbs in microhistological analysis of diets. J. Range Manage. 36:132-133.

SAS. 1996. SAS/STAT guide for personal computer. Version 6.12. SAS Institute, Cary, North Caroline.

Sparks, D.R., and J.C. Malechek. 1968. Estimating percentage dry weight in diets using a microscopic technique. J. Range Manage. 21:264-265.

Tilley, J. M. A. and R. A. Terry. 1963. A two-stage technique for the *in vitro* digestion of forage crops. J. Br. Grassl. Soc. 18:104 -111.

Vavra, M. and J.L. Holechek. 1980. Factors influencing microhistological analysis of herbivore diets. J. Range Manage. 33:371-374.

Winder, J.A., D.A. Walker, and C.C. Bailey. 1996. Effect of breed on botanical composition of cattle diets on Chihuahuan desert range. J. Range Manage. 49:209-214.

CHAPTER 4

SUMMARY

Our data indicated that forage in a riparian pasture during late summer will decrease significantly both in availability and in quality with cattle grazing and advancing season. Forage dry matter increases are especially dramatic in grasses. Utilization of shrubs could reach higher levels because of progressively diminishing availability and quality of grasses and scarcity of forbs. These factors, in turn, lead to increased riparian area vegetation utilization and woody browse, and potentially, increased bank trampling. Grasses make up majority of cattle diet with shrubs and trees being the next greater diet component, and forbs accounting for only minor portions. It appears that even with the depletion of this type of forage, cattle mostly, are able to select the nutritionally advantageous species. Though mature cows selected less in the amount of grasses and more in the amount of shrubs and trees as compared to younger cows. On the untimbered summer ranges of eastern Oregon, Pickford and Reid (1948) determined that 5 from 25 grass species produced less than half the grass herbage, yet nearly three-fourths of all the grass forage taken by cattle was obtained from them. They implied that cattle are naturally attracted to the more palatable grasses. Efficient utilization is judged not by the consumption of the vegetation as a whole but by the degree to which the better grasses are grazed (Pickford and Reid 1948).

Certainly grazing pattern and diet selection are seldom uniform and can be influenced by such factors as species associations, grazing system, topography, climate, etc (Svejcar and Vavra 1985). Our research suggests that cattle grazing behavior and diet selection could have been influenced by both forage availability and quality. It also suggests that with cattle grazing riparian pastures in late summer over utilization of riparian vegetation, especially, woody vegetation can occur, which could lead to decreased production and cover.

Measurements of the grazing season trend in forage quantity and quality were made only on major forage species in this study; however, in diverse communities there

may be periods when minor species make important contributions to diet quality (Holechek et al. 1982b). A comparison among the forage classes we sampled indicates the importance of riparian woody vegetation for filling the late summer gap in nutritionally adequate forage. Kauffman and Krueger (1984) noted that effect of herbivory on shrub and tree production is a critical impact in riparian ecosystems, because of the importance of the woody vegetation to wildlife habitat and its dominant influence in altering the riparian microclimate. Late summer nutritional deficiencies in pastures are common in regions where summer drought is a normal part of the climatic region (Svejcar and Vavra 1985). Results from this study were undoubtedly influenced by seasonal growing conditions and most importantly, by the low precipitation patterns during the study years.

Pickford and Reid (1948) suggest that the effectiveness of measures taken to keep cattle well distributed can be determined by noting the intensity to which the better grasses are grazed on the scattered grassland types. If these are generally overgrazed in one sector and undergrazed in another, there is good evidence that the distribution of cattle is unbalanced (Pickford and Reid 1948). Parsons et al. (2003) imply that early summer grazing of riparian areas may be less detrimental to riparian areas than late summer grazing because of improved livestock distribution and more uniform vegetation use. Morrison et al. (2002) suggest that better cattle distribution could be achieved by stocking pastures with older, mature cows as long as desirable forage in the uplands is not limiting.

Riparian areas are very diverse ecosystems and respond differently to various land and livestock management activities (Kauffman et al. 1983). Gillen et al. (1985) stated that some flexibility in managing riparian meadow use is available by changing the cattle turn-in point for a pasture. They suggest that the start of grazing on a particular meadow may be changed by as much as 2 weeks in these relatively large range pastures depending on where cattle enter the pasture. While the final intensity of use would not differ the timing of use of a particular meadow could be modified (Gillen et al.1985).

Much attention should be paid to coordinating specific management practices with changes in forage quality. Once seasonal changes in forage quality are identified, the rancher can manipulate grazing time so the cattle can make the most of the period of peak forage quality (Vavra and Raleigh 1976). They conclude that the rancher, then, should evaluate his total forage resource and incorporate management that best utilizes that resource to maximize red meat production. Extending the period during which meadows are nutritionally adequate would help considerably in completing the summer forage cycle in this region (Svejcar and Vavra 1985). Cattle continued to use the riparian meadows even as the herbage levels decreased to the physical limits of grazing (Gillen et al. 1985). The nature of cattle grazing emphasizes the need for paying close attention to the utilization and general condition of good forage grasses on the untimbered range (Pickford and Reid 1948). Though no single management approach is best for all riparian grazing situations, ranchers may use some of those discussed or develop specific programs that fit their situation.

In general, research aimed at determining forage availability and species composition on the range along with thorough investigation of the diets cattle obtained from the range is warranted. Also, we need more information at filling the late summer gap in forage quality in riparian areas. To better understand the nutritional needs and preferences of different age classes of cattle, we need to continue the evaluation of dietary selection as the forage composition of the range changes with use and season.

BIBLIOGRAPHY

Allison, C.D. 1985. Factors affecting forage intake by range ruminants: A review. J. Range Manage. 38:305-311.

AOAC. 1990. Official Methods of Analysis. 15th ed. Assoc. Offic. Anal. Chem. Arlington, VA.

Bai, Y., Z. Abouguendia, and R.E. Redmann. 2001. Relationship between plant species diversity and grassland condition. J. Range Manage. 54:177-183.

Bailey, D.W. 1995. Daily selection of feeding areas by cattle in homogeneous and heterogeneous environments. Appl. Anim. Behav. Sci. 45:183-200.

Bailey, D.W., and P.L. Sims. 1998. Association of food quality and locations by cattle. J. Range Manage. 51:2-8.

Bailey, D.W., D.D. Kress, D.C. Anderson, D.L. Boss, and E.T. Miller. 2001. Relationship between terrain use and performance of beef cows grazing foothill rangeland. J. Anim. Sci. 79:1883-1891.

Beck, R.F. 1975. Steer diets in Southeastern Colorado. J. Range Manage. 28:48-51.

Bedell, T.E. 1968. Seasonal forage preferences of grazing cattle and sheep in Western Oregon. J. Range Manage. 21:291-297.

Bedell, T.E. 1970. Nutritive value of forage and diets of sheep and cattle from Oregon subclover-grass mixtures. *In*: Sheep and cattle diets. Ore. Agr. Exp. Sta. Corvallis. Ore. p. 125-133.

Binnie, R.C., and D.M.B. Chestnutt. 1991. Effect of regrowth interval on the productivity of swards defoliated by cutting and grazing. Grass and Forage Science. 46:343-350.

Bryant, L.D. 1985. Livestock management in the riparian ecosystem. *In*: Riparian ecosystems and their management reconciling conflicting uses. Tucson. Ariz. p.285-289.

Bryant, L.D. 1982. Response of livestock to riparian zone exclusion. J. Range Manage. 35:780-785.

Buckhouse, J.C., and G.F. Gifford. 1976. Water quality implications of cattle grazing on a semiarid watershed in southeastern Utah. J. Range Manage. 29:109-113.

Buckhouse, J.C., J.M. Skovlin, and R.W. Knight. 1981. Streambank erosion and ungulate grazing relationships. J. Range Manage. 34:339-340.

Clark, P.E. 2003. Date and plant community effects on elk sedge forage quality. J. Range Manage. 56:21-26.

Cook, C.W., and L.E. Harris. 1968. The nutritive value of seasonal ranges. Utah State Univ. Agr. Exp. Sta. Bull. No. 472. p. 55.

Cruz, R., and D. Ganskopp. 1998. Seasonal preferences of steers for prominent northern Great Basin grasses. J. Range Manage. 51:557-565.

Damiran, D., D. Johnson, T. DelCurto, and S. Findholt. 2003. Estimating shrub forage yield and utilization using a photographic technique. *In*: Abstr. Soc. Range Manage. 56th Annu. Meeting. #54.

Dearden, B.L., R.E. Pegau, and R.M. Hansen. 1975. Precision of microhistological estimates of ruminant food habits. J. Wildl. Manage. 39:402-406.

DelCurto, T., M. Porath, M. McInnis, P. Momont, C. Parsons. 1999. Management strategies for optimal beef cattle distribution and use of mountain riparian meadows. p.119-129. *In*: K.L. Launchbaugh, K.D. Sanders, and J.C. Mosley (eds.), Grazing behavior of livestock and wildlife. Idaho For., Wildlife and Range Exp. Sta. Bull. #70, Univ. of Idaho, Moscow, Ida.

DelCurto, T., R.C. Cochran, L.R. Corah, A.A. Beharka, E.S. Vanzant, and D. Johnson. 1990. Supplementation of dormant, tallgrass-prairie forage. II. Performance and forage utilization characteristics in grazing beef cattle receiving supplements of different protein concentrations. J. Anim. Sci. 68:532.

Eneboe, E.J., B.F. Sowell, R.K. Heitschmidt, M.G. Karl, and M.R. Haferkamp. 2002. Drought and grazing: IV. Blue grama and western wheatgrass. J. Range Manage. 55:73-79.

Everitt, J.H., C.L. Gonzalez, G. Scott, and B.E. Dahl. 1981. Seasonal food Preferences of cattle on native range in the South Texas Plains. J. Range Manage. 34:384-388.

Free, J.C., R.M. Hansen, and P.L. Sims. 1969. Estimating dryweights of foodplants in feces of herbivores. J. Range Manage. 23:300-302.

Ganskopp, D. and D. Bohnert. 2001. Nutritional dynamics of 7 northern Great Basin grasses. J. Range Manage. 54:640-647.

Gillen, R., W. Krueger, and R. Miller. 1985. Cattle use of riparian meadows in the Blue Mountains of Northeastern Oregon. J. Range Manage. 38:205-209.

Green, D.M., and J.B. Kauffman. 1995. Succession and livestock grazing in a northeastern Oregon riparian ecosystem. J. Range Manage. 48:307-313.

Grings, E.E., D.C. Adams, and R.E. Short. 1995. Diet quality of suckling calves and mature steers on Northern Great Plains rangelands. J. Range Manage. 48:438-441.

Grings, E.E., R.E. Short, M.R. Haferkamp, and R.K. Heitschmidt. 2001. Animal age and sex effects on diets of grazing cattle. J. Range Manage. 54:77-81.

Harris, R.W. 1954. Fluctuations in forage utilization on ponderosa pine ranges in Eastern Oregon. J. Range Manage. 7:250-255.

Heady, H.F. 1964. Palatability of herbage and animal preference. J. Range Manage. 17:76-82.

Hercus, B.H. 1960. Plant cuticle as an aid to determining the diet of grazing animals. Proc. 8th Int. Grassl. Congr. 8:443-447.

Hirschfeld, D.J., D.R. Kirby, J.S. Caton, S.S. Silcox, and K.C. Olson. 1996. Influence of grazing management on intake and composition of cattle diets. J. Range Manage. 49:257-263.

Hitchcock, C.L., A. Cronquist, M. Owenbey, and J.W. Thompson. 1969. Vascular plants of the Pacific Northwest. University of Washington Press, Seattle, Wash.

Hodgson, J., and W.S. Jamieson. 1981. Variations in herbage mass and digestibility, and the grazing behaviour and herbage intake of adult cattle and weaned calves. Grass and Forage Science. 36:39-48.

Hofmann, L., and R.E. Ries. 1989. Animal performance and plant production from continuously grazed cool-season reclaimed and native pastures. J. Range Manage. 42:248-251.

Holechek, J.L., M. Vavra, and R.D. Pieper. 1982a. Botanical composition determination of range herbivore diets: A review. J. Range Manage. 35:309-315.

Holechek, J., M. Vavra, J. Skovlin, and W. Krueger. 1982b. Cattle diets in the Blue Mountains of Oregon II. Forests. J. Range Manage. 35:239-242.

Holechek, J.L., and M. Vavra. 1982. Forage intake by cattle on forest and grassland ranges. J. Range Manage. 35:737-741.

Holechek, J.L., and M. Vavra. 1983. Drought effects on diet and weight gains of yearling heifers in Northeastern Oregon. J. Range Manage. 36:227-231.

Holechek, J.L., M. Vavra, and J. Skovlin. 1981. Diet quality and performance of cattle on forest and grassland range. J. Anim. Sci. 53:291-298.

Howery, L.D., F.D. Provenza, R.E. Banner, and C.B. Scott. 1998. Social and environmental factors influence cattle distribution on rangeland. Appl. Anim. Behav. Sci. 55:231-244.

Huber, S.A., M.B. Judkins, L.J. Krysl, T.J. Svejcar, B.W. Hess, and D.W. Holcombe. 1995. Cattle grazing a riparian mountain meadow: Effects of low and moderate stocking density on nutrition, behavior, diet selection, and plant growth response. J. Anim. Sci. 73:3752-3765.

Hurd, R.M., and F.W. Pond. 1958. Relative preference and productivity of species on summer cattle ranges, big horn mountains, Wyoming. J. Range Manage. 3:109-114.

Hyder, D.N., R.E. Bement, E.E. Remmenga, and C. Terwilliger, Jr. 1966. Vegetation-soils and vegetation-grazing relations from frequency data. J. Range Manage. 19:12-17.

Kamstra, L.D. 1973. Seasonal changes in quality of some important range grasses. J. Range Manage. 26:289-291.

Karl, M.G."Sherm", and P.S. Doescher. 1998. Ponderosa pine aboveground growth after cattle removal of terminal tissue. J. Range Manage. 51:147-151.

Kauffman, J.B., and W.C. Krueger. 1984. Livestock impacts on riparian ecosystems and streamside management implications... A review. J. Range Manage. 37:430-438.

Kauffman, J.B., W.C. Krueger, and M. Vavra. 1983a. Effects of late season cattle grazing on riparian plant communities. J. Range Manage. 36:685-691.

Kauffman, J.B., W.C. Krueger, and M. Vavra. 1983b. Impacts of cattle on streambanks in Northeastern Oregon. J. Range Manage. 36:683-685.

Kie, J.G., and B.B. Boroski. 1996. Cattle distribution, habitats, and diets in the Sierra Nevada of California. J. Range Manage. 49:482-488.

Laliberte, A., D. Johnson, N. Harris, and G. Casady. 2001. Stream change analysis using remote sensing and Geographic Information Systems (GIS). J. Range Manage. 54:22-50.

Le Du, Y.L.P., and R.D. Baker. 1981. The digestibility of herbage selected by oesophageally fistulated cows, steer calves and wether sheep when strip-grazing together. Grass and Forage Science. 36:237-239.

Leege, T.A., D.J. Herman, and B. Zamora. 1981. Effects of cattle grazing on mountain meadows in Idaho. J. Range Manage. 34:324-328.

Leslie, D.M, Jr., M. Vavra, E.E. Starkey, and R.C. Slater. 1983. Correcting for differential digestibility in microhistological analyses involving common coastal forages of the Pacific Northwest. J. Range Manage. 36:730-732.

Lesperance, A.L., P.T. Tueller, and V.R. Bonham. 1970. Competitive use of the range forage resource. J. Anim. Sci. 30:1-115.

Manley, W.A., R.H. Hart, M.J. Samuel, J.W. Waggoner, Jr., and J.T. Manley. 1997. Vegetation, cattle, and economic responses to grazing strategies and pressures. J. Range Manage. 50:638-646.

Marlow, C.B., D. Allen, and K. Olson-Rutz. 1991. Making riparian zone protection a workable part of grazing management. *In*: Proc. Int. Beef Symp. Great Falls. TNT. p. 256-266.

McCollum, F.T., M.L. Galyean, L.J. Krysl, and J.D. Wallace. 1985. Cattle grazing blue grama rangeland. I. Seasonal diets and rumen fermentation. J. Range Manage. 38:539-543.

Milne, J.A. 1991. Diet selection by grazing animals. *In*: Proc. Nutr. Soc. 50:77-85.

Minson, D.J. 1982. Effects of chemical and physical composition of herbage eaten upon intake. *In*: J.B. Hacker (ed.). Nutritional limits to animal production from pastures. p.167-182.

Mitchell, J.E., and R.T. Rodgers. 1985. Food habits and distribution of cattle on a forest and pasture range in Northern Idaho. J. Range Manage. 38:214-220.

Mohammad, A.G., C.A. Ferrando, L.W. Murray, R.D. Pieper, and J.D. Wallace. 1996. Season and sex influences on botanical composition of cattle diets in southern New Mexico. J. Range Manage. 49:204-208.

Morrison, J.A. 2002. The influence of cow age on grazing distribution and utilization of mountain riparian areas and adjacent uplands. M.S. Thesis. Ore. State Univ. Corvallis.

Morrison, J.A., T. DelCurto, C.T. Parsons, G.D. Pulsipher, and E.S. Vanzant. 2002. The influence of cow age on grazing distribution and utilization of mountain riparian areas and adjacent uplands. Proc., West. Sec. Amer. Soc. Anim. Sci. 53: 21-24.

NRC. 1996. Nutritional Requirements of Beef Cattle, 7th ed. National Academy Press, Washington D.C.

Olsen, W. and R.M. Hansen. 1977. Food relations of wild free-roaming horses livestock and big game, Red Desert, Wyoming. J. Range Manage. 30:17-20.

Orodho, A.B., M.J. Trlica, and C.D. Bonham. 1990. Long-term heavy-grazing effects on soil and vegetation in the Four Corners Region. The Southwestern Naturalist 35:9-14.

Parsons, C.T., P.A. Momont, T. DelCurto, M. McInnis, and M.L. Porath. 2003. Cattle distribution patterns and vegetation use in mountain riparian areas. J. Range Manage. 56: 334-341.

Pearson, H.A. 1975. Herbage disappearance and grazing capacity determinations of Southern Pine Bluestem range. J. Range Manage. 28:71-73.

Pickford, G.D., and E.H. Reid. 1948. Forage utilization on summer cattle ranges in Eastern Oregon. *In*: U.S. Dept. of Agr. Circular No. 796. Washington, D.C. p.1-27.

Pinchak, W.E., M.A. Smith, R.H. Hart, and J.W. Waggoner, Jr. 1991. Beef cattle distribution patterns on foothill range. J. Range Manage. 44:267-275.

Poppi, D.P., D.J. Minson, and J.H. Ternouth. 1980. Studies of cattle and sheep eating leaf and stem fractions of grasses. The voluntary intake, digestibility and retention time in the reticulo-rumen. Aust. J. Agric. Res. 32:99-108.

Porath, M.L., P.A. Momont, T. DelCurto, N.R. Rimbey, J.A. Tanaka, and M. McInnis. 2002. Offstream water and trace mineral salt as management strategies for improved cattle distribution. J. Anim. Sci. 80:346-356.

Provenza, F.D., and D.F. Balph. 1987. Diet learning by domestic ruminants: theory, evidence and practical implications. Appl. Anim. Behav. Sci. 18:211-232.

Rees, H. 1982. The diet of free-ranging cattle on the Bogong High Plains. Victoria. Austr. Rangel. J. 4:29-33.

Reynolds, M. P. 1999. Residual leaf area as a measure of shrub use. M.S. Thesis. Ore. State Univ. Corvallis. Ore.

Roath, L.R., and W.C. Krueger. 1982. Cattle grazing and behavior on a forested range. J. Range Manage. 35:332-338.

Rosiere, R.E., R.F. Beck, and J.D. Wallace. 1975. Cattle diets on semidesert grassland: Botanical composition. J. Range Manage. 28:89-93.

Samuel, M.J., and G.S. Howard. 1983. Disappearing forbs in microhistological analysis of diets. J. Range Manage. 36:132-133.

SAS. 1997. SAS/STAT guide for personal computer. Version 6.12. SAS Institute, Cary, North Caroline.

Scarnecchia, D.L., A.S. Nastis, and J.C. Malechek. 1985. Effects of forage availability on grazing behavior of heifers. J. Range Manage. 38:177-180.

Sheehy, D.P. 1987. Grazing relationships of elk, deer, and cattle on seasonal rangelands in Northeastern Oregon. Ph. D. Dissertation. Ore. State Univ. Corvallis. p. 15.

Skinner, R.H., J.D. Hanson, G.L. Hutchinson, and G.E. Schuman. 2002. Response of C3 and C4 grasses to supplemental summer precipitation. J. Range Manage. 55:517-522.

Skovlin, J.M. 1967. Fluctuations in forage quality on summer range in the Blue Mountains. Pacific Northwest Forest and Range Exp. Sta. USDA. Pacific Northwest 44.

Smith, M.A., J.D. Rodgers, J.L. Dodd, and Q.D. Skinner. 1992. Declining forage availability effects on utilization and community selection by cattle. J. Range Manage. 45:391-395.

Sneva, F.A. 1970. Behavior of yearling cattle on Eastern Oregon range. J. Range Manage. 23:155-158.

Sparks, D.R., and J.C. Malechek. 1968. Estimating percentage dry weight in diets using a microscopic technique. J. Range Manage. 21:264-265.

Stoddart, L., A. Smith, and T. Box. 1975. Range management. Third ed. McGraw-Hill Book Company, New York.

Svejcar, T., and M. Vavra. 1985. The influence of several range improvements on estimated carrying capacity and potential beef production. J. Range Manage. 38:395-399.

Tilley, J.M.A., and R.A. Terry. 1963. A two-stage technique for the *in vitro* digestion of forage crops. J. Br. Grassl. Soc.18:104 -111.

Uresk, D.W., and W.W. Paintner. 1985. Cattle diets in a ponderosa pine forest in the Northern Black Hills. J. Range Manage. 38:440-442.

Vavra, M. 1983. Managing grazing animal response to forestland vegetation. *In*: Proc. Symp. Forestland Grazing. Spokane. Wash. p. 43-51.

Vavra, M. and J.L. Holechek. 1980. Factors influencing microhistological analysis of herbivore diets. J. Range Manage. 33:371-374.

Vavra, M., and R.J. Raleigh. 1976. Coordinating beef cattle management with the range forage resource. J. Range Manage. 29:449-452.

Vavra, M., R.W. Rice, R.M. Hansen, and P.L. Sims. 1977. Food habits of cattle on shortgrass range in Northeastern Colorado. J. Range Manage. 30:261-263.

Volesky, J.D., and S.W. Coleman. 1996. Estimation of botanical composition of esophageal extrusa samples using near infrared reflectance spectroscopy. J. Range Manage. 49:163-166.

Wagner, J.J., K.S. Lusby, J.W. Oltjen, J. Rakestraw, R.P. Wettemann, and L.E. Walters. 1988. Carcass composition in mature Hereford cows: estimation and effect on daily metabolizable energy requirement during winter. J. Anim. Sci. 66:603-612.

Westoby, M. 1974. An analysis of diet selection by large generalist herbivores. Amer. Natur. 108:290-304.

Willard, E.E., and J.L. Schuster. 1973. Chemical composition of six Southern Great Plains grasses as related to season and precipitation. J. Range Manage. 26:37-38.

Willms, W.D., and L.M. Rode. 1998. Forage selection by cattle on fescue prairie in summer or winter. J. Range Manage. 51:496-500.

Winder, J.A., D.A. Walker, and C.C. Bailey. 1996. Effect of breed on botanical composition of cattle diets on Chihuahuan desert range. J. Range Manage. 49:209-214.

APPENDIX

Table A.2.1. Standing crop of forages during late summer grazing season in Catherine Creek riparian area, Hall Ranch of Eastern Oregon for 2001 (Year 1) and 2002 (Year 2).

Year[1]	Date[2]	Plot#	Standing Crop (kg ha^{-1})				
			Grasses	Grasslikes	Forbs	Shrubs	Total
1	d 0	1	936	-	66	-	1002
1	d 0	2	680	1164	1386	-	3230
1	d 0	3	544	1172	452	50	2218
1	d 0	4	1052	192	378	-	1622
1	d 0	5	74	-	326	-	400
1	d 0	6	1762	-	-	-	1762
1	d 0	7	260	48	502	640	1450
1	d 0	8	98	-	8	620	726
1	d 0	9	-	-	-	-	-
1	d 0	10	32	434	4	396	866
1	d 0	11	344	786	-	16	1146
1	d 0	12	584	304	-	624	1512
1	d 0	13	6	-	50	-	56
1	d 0	14	30	-	258	40	328
1	d 0	15	1144	1094	436	-	2674
1	d 0	16	1020	6	12	16	1054
1	d 0	17	284	-	-	284	568
1	d 0	18	-	-	162	36	198
1	d 0	19	892	60	1056	-	2008
1	d 0	20	286	-	318	78	682
1	d 0	21	160	266	78	262	766
1	d 0	22	36	16	90	72	214
1	d 0	23	440	16	224	250	930
1	d 0	24	6	-	34	444	484
1	d 0	25	-	-	36	28	64
1	d 0	26	394	-	216	-	610
1	d 0	27	314	-	76	84	474
1	d 0	28	2	-	348	92	442
1	d 0	29	26	-	54	76	156
1	d 0	30	324	450	38	38	850
1	d 0	31	88	56	92	46	282

[1]Study years: 1 - Year 1; 2 - Year 2.

[2]Sampling dates: 1 - d 0; 2 - d 10; 3 - d 20; 4 - d 30.

Table A.2.1. (Continued). Standing crop of forages during late summer grazing season in Catherine Creek riparian area, Hall Ranch of Eastern Oregon for 2001 (Year 1) and 2002 (Year 2).

Year[1]	Date[2]	Plot#	Standing Crop (kg ha^{-1})				
			Grasses	Grasslikes	Forbs	Shrubs	Total
1	d 0	32	550	66	2088	72	2776
1	d 0	33	1126	-	-	6	1132
1	d 0	34	2034	-	492	-	2526
1	d 0	35	1498	-	714	-	2212
1	d 0	36	272	-	-	392	664
1	d 0	37	-	-	56	-	56
1	d 0	38	276	-	94	-	370
1	d 0	39	284	-	524	-	808
1	d 0	40	1154	-	380	-	1534
1	d 0	41	160	36	102	-	298
1	d 0	42	1194	618	60	112	1984
1	d 0	43	1398	704	1094	-	3196
1	d 0	44	956	1240	1456	-	3652
1	d 0	45	716	62	768	-	1546
1	d 0	46	248	1210	38	-	1496
1	d 0	47	120	-	-	10	130
1	d 0	48	494	-	200	-	694
1	d 0	49	386	32	-	2	420
1	d 10	1	304	-	6	-	310
1	d 10	2	394	1656	160	10	2220
1	d 10	3	432	664	88	96	1280
1	d 10	4	538	-	422	50	1010
1	d 10	5	146	-	360	-	506
1	d 10	6	1936	-	32	-	1968
1	d 10	7	274	-	208	476	958
1	d 10	8	328	36	128	908	1400
1	d 10	9	148	-	-	-	148
1	d 10	10	448	82	-	50	580
1	d 10	11	-	370	60	-	430
1	d 10	12	-	732	-	8	740
1	d 10	13	402	-	14	1020	1436

[1]Study years: 1 - Year 1; 2 - Year 2.

[2]Sampling dates: 1 - d 0; 2 - d 10; 3 - d 20; 4 - d 30.

Table A.2.1. (Continued). Standing crop of forages during late summer grazing season in Catherine Creek riparian area, Hall Ranch of Eastern Oregon for 2001 (Year 1) and 2002 (Year 2).

Year[1]	Date[2]	Plot#	Standing Crop (kg ha^{-1})				
			Grasses	Grasslikes	Forbs	Shrubs	Total
1	d 10	14	224	304	56	-	584
1	d 10	15	-	-	108	-	108
1	d 10	16	52	8	214	-	274
1	d 10	17	4	8	6	132	150
1	d 10	18	92	12	14	294	412
1	d 10	19	16	-	50	184	250
1	d 10	20	66	-	36	-	102
1	d 10	21	324	-	228	-	552
1	d 10	22	244	-	82	-	326
1	d 10	23	38	108	72	316	534
1	d 10	24	10	-	26	120	156
1	d 10	25	168	-	-	196	364
1	d 10	26	124	30	22	-	176
1	d 10	27	92	-	40	176	308
1	d 10	28	24	-	18	24	66
1	d 10	29	38	-	20	136	194
1	d 10	30	170	-	180	-	350
1	d 10	31	62	136	30	-	228
1	d 10	32	-	-	24	102	126
1	d 10	33	140	8	38	0	186
1	d 10	34	494	574	760	12	1840
1	d 10	35	858	-	-	-	858
1	d 10	36	2288	-	110	-	2398
1	d 10	37	650	-	46	36	732
1	d 10	38	222	-	378	94	694
1	d 10	39	96	112	30	8	246
1	d 10	40	-	-	-	-	-
1	d 10	41	288	-	356	108	752
1	d 10	42	568	72	4	-	644
1	d 10	43	376	-	2	-	378
1	d 10	44	574	284	128	2	988
1	d 10	45	752	464	644	-	1860

[1]Study years: 1 - Year 1; 2 - Year 2.

[2]Sampling dates: 1 - d 0; 2 - d 10; 3 - d 20; 4 - d 30.

Table A.2.1. (Continued). Standing crop of forages during late summer grazing season in Catherine Creek riparian area, Hall Ranch of Eastern Oregon for 2001 (Year 1) and 2002 (Year 2).

Year[1]	Date[2]	Plot#	Standing Crop (kg ha^{-1})				
			Grasses	Grasslikes	Forbs	Shrubs	Total
1	d 10	46	956	342	434	-	1732
1	d 10	47	770	186	842	-	1798
1	d 10	48	98	1152	24	-	1274
1	d 10	49	572	-	-	-	572
1	d 10	50	480	-	256	-	736
1	d 10	51	590	8	10	-	608
1	d 20	1	454	-	518	-	972
1	d 20	2	410	438	238	46	1132
1	d 20	3	476	772	338	324	1910
1	d 20	4	484	-	358	-	842
1	d 20	5	60	-	34	-	94
1	d 20	6	864	-	-	-	864
1	d 20	7	484	8	120	172	784
1	d 20	8	332	24	100	-	456
1	d 20	9	124	-	76	-	200
1	d 20	10	-	-	-	-	-
1	d 20	11	-	840	-	80	920
1	d 20	12	-	604	-	-	604
1	d 20	13	530	-	252	68	850
1	d 20	14	-	508	-	-	508
1	d 20	15	24	8	76	-	108
1	d 20	16	38	6	178	-	222
1	d 20	17	8	-	28	34	70
1	d 20	18	60	6	20	74	160
1	d 20	19	10	-	-	84	94
1	d 20	20	260	-	126	10	396
1	d 20	21	572	-	128	-	700
1	d 20	22	166	10	12	10	198
1	d 20	23	176	116	-	10	302
1	d 20	24	200	10	166	92	468
1	d 20	25	-	-	30	352	382
1	d 20	26	-	-	-	68	68

[1]Study years: 1 - Year 1; 2 - Year 2.

[2]Sampling dates: 1 - d 0; 2 - d 10; 3 - d 20; 4 - d 30.

Table A.2.1. (Continued). Standing crop of forages during late summer grazing season in Catherine Creek riparian area, Hall Ranch of Eastern Oregon for 2001 (Year 1) and 2002 (Year 2).

Year[1]	Date[2]	Plot#	Standing Crop (kg ha^{-1})				
			Grasses	Grasslikes	Forbs	Shrubs	Total
1	d 20	27	96	-	-	74	170
1	d 20	28	34	-	-	72	106
1	d 20	29	-	-	-	28	28
1	d 20	30	38	26	8	160	232
1	d 20	31	116	-	140	260	516
1	d 20	32	162	-	96	96	354
1	d 20	33	14	56	72	-	142
1	d 20	34	160	220	458	-	838
1	d 20	35	646	-	56	22	724
1	d 20	36	434	-	-	-	434
1	d 20	37	828	-	80	-	908
1	d 20	38	304	76	14	48	442
1	d 20	39	212	-	32	34	278
1	d 20	40	8	-	116	-	124
1	d 20	41	176	6	80	208	470
1	d 20	42	162	-	40	-	202
1	d 20	43	182	30	-	52	264
1	d 20	44	314	72	178	-	564
1	d 20	45	622	20	60	-	702
1	d 20	46	914	44	148	-	1106
1	d 20	47	556	36	168	-	760
1	d 20	48	842	-	-	-	842
1	d 20	49	356	256	-	-	612
1	d 20	50	550	-	16	-	566
1	d 20	51	90	932	24	-	1046
1	d 30	1	1116	-	34	-	1150
1	d 30	2	14	150	84	-	248
1	d 30	3	256	1004	62	-	1322
1	d 30	4	24	-	32	-	56
1	d 30	5	50	-	116	-	166
1	d 30	6	210	-	-	-	210
1	d 30	7	180	-	64	52	296

[1]Study years: 1 - Year 1; 2 - Year 2.

[2]Sampling dates: 1 - d 0; 2 - d 10; 3 - d 20; 4 - d 30.

Table A.2.1. (Continued). Standing crop of forages during late summer grazing season in Catherine Creek riparian area, Hall Ranch of Eastern Oregon for 2001 (Year 1) and 2002 (Year 2).

Year[1]	Date[2]	Plot#	Standing Crop (kg ha^{-1})				
			Grasses	Grasslikes	Forbs	Shrubs	Total
1	d 30	8	144	-	70	-	214
1	d 30	9	42	-	8	-	50
1	d 30	10	-	-	-	-	-
1	d 30	11	40	-	-	-	40
1	d 30	12	4	632	-	8	644
1	d 30	13	168	-	44	144	356
1	d 30	14	110	-	-	-	110
1	d 30	15	302	-	26	-	328
1	d 30	16	1114	-	58	-	1172
1	d 30	17	50	32	50	32	164
1	d 30	18	54	20	8	20	102
1	d 30	19	158	-	42	76	276
1	d 30	20	334	-	142	-	476
1	d 30	21	526	28	86	-	640
1	d 30	22	48	-	8	-	56
1	d 30	23	-	100	-	40	140
1	d 30	24	130	-	8	140	278
1	d 30	25	16	-	32	80	128
1	d 30	26	-	-	8	112	120
1	d 30	27	134	-	-	120	254
1	d 30	28	164	-	-	156	320
1	d 30	29	-	26	-	250	276
1	d 30	30	30	-	86	16	132
1	d 30	31	56	-	18	-	74
1	d 30	32	30	10	80	10	130
1	d 30	33	114	-	88	-	202
1	d 30	34	124	244	332	-	700
1	d 30	35	314	-	40	-	354
1	d 30	36	244	-	-	-	244
1	d 30	37	456	-	-	-	456
1	d 30	38	234	10	160	12	416
1	d 30	39	258	54	154	16	482

[1]Study years: 1 - Year 1; 2 - Year 2.

[2]Sampling dates: 1 - d 0; 2 - d 10; 3 - d 20; 4 - d 30.

Table A.2.1. (Continued). Standing crop of forages during late summer grazing season in Catherine Creek riparian area, Hall Ranch of Eastern Oregon for 2001 (Year 1) and 2002 (Year 2).

Year[1]	Date[2]	Plot#	Standing Crop (kg ha^{-1})				
			Grasses	Grasslikes	Forbs	Shrubs	Total
1	d 30	40	-	-	-	-	-
1	d 30	41	78	52	26	12	168
1	d 30	42	40	-	60	-	100
1	d 30	43	452	10	12	12	486
1	d 30	44	354	48	62	-	464
1	d 30	45	246	168	70	-	484
1	d 30	46	328	12	22	-	362
1	d 30	47	380	64	58	-	502
1	d 30	48	216	44	-	-	260
1	d 30	49	364	-	-	-	364
1	d 30	50	196	-	100	-	296
1	d 30	51	610	-	-	-	610
2	d 0	1	461	226	242	506	1435
2	d 0	2	401	1634	2224	52	4311
2	d 0	3	573	976	2376	80	4005
2	d 0	4	1186	8	244	-	1438
2	d 0	5	133	-	223	-	356
2	d 0	6	2128	-	-	-	2128
2	d 0	7	171	110	681	441	1403
2	d 0	8	1071	224	528	-	1822
2	d 0	9	116	-	12	-	128
2	d 0	10	-	-	-	-	-
2	d 0	11	-	1472	-	-	1472
2	d 0	12	-	552	-	220	772
2	d 0	13	2026	-	30	736	2792
2	d 0	14	24	76	-	72	172
2	d 0	15	248	-	140	-	388
2	d 0	16	61	10	812	-	883
2	d 0	17	104	-	126	10	240
2	d 0	18	38	24	46	52	160
2	d 0	19	14	-	94	-	108
2	d 0	20	565	-	416	-	981

[1]Study years: 1 - Year 1; 2 - Year 2.

[2]Sampling dates: 1 - d 0; 2 - d 10; 3 - d 20; 4 - d 30.

Table A.2.1. (Continued). Standing crop of forages during late summer grazing season in Catherine Creek riparian area, Hall Ranch of Eastern Oregon for 2001 (Year 1) and 2002 (Year 2).

Year[1]	Date[2]	Plot#	Standing Crop (kg ha^{-1})				
			Grasses	Grasslikes	Forbs	Shrubs	Total
2	d 0	21	532	-	294	6	832
2	d 0	22	62	-	142	110	314
2	d 0	23	8	1	4	362	375
2	d 0	24	50	-	34	278	362
2	d 0	25	23	-	68	-	91
2	d 0	26	259	-	104	176	539
2	d 0	27	-	-	199	192	391
2	d 0	28	313	-	234	96	643
2	d 0	29	-	-	100	76	176
2	d 0	30	77	74	212	232	595
2	d 0	31	236	-	250	-	486
2	d 0	32	4	2	30	-	36
2	d 0	33	368	354	1517	12	2251
2	d 0	34	486	-	112	-	598
2	d 0	35	730	-	150	-	880
2	d 0	36	672	-	48	176	896
2	d 0	37	312	16	66	56	450
2	d 0	38	259	36	670	72	1037
2	d 0	39	328	3	180	-	511
2	d 0	40	173	-	22	-	195
2	d 0	41	162	2	800	242	1205
2	d 0	42	44	-	445	-	488
2	d 0	43	350	-	32	230	612
2	d 0	44	462	363	792	-	1616
2	d 0	45	1386	144	650	-	2180
2	d 0	46	2088	134	1258	-	3480
2	d 0	47	2144	204	814	-	3162
2	d 0	48	360	-	-	-	360
2	d 0	49	374	-	-	-	374
2	d 0	50	321	-	10	-	331
2	d 10	1	1265	-	576	336	2177
2	d 10	2	560	542	568	308	1978

[1]Study years: 1 - Year 1; 2 - Year 2.

[2]Sampling dates: 1 - d 0; 2 - d 10; 3 - d 20; 4 - d 30.

Table A.2.1. (Continued). Standing crop of forages during late summer grazing season in Catherine Creek riparian area, Hall Ranch of Eastern Oregon for 2001 (Year 1) and 2002 (Year 2).

Year[1]	Date[2]	Plot#	Standing Crop (kg ha^{-1})				
			Grasses	Grasslikes	Forbs	Shrubs	Total
2	d 10	3	583	828	389	-	1800
2	d 10	4	328	-	110	609	1047
2	d 10	5	255	0	354	-	609
2	d 10	6	1664	-	-	-	1664
2	d 10	7	456	-	744	540	1740
2	d 10	8	574	8	262	-	844
2	d 10	9	40	-	46	-	86
2	d 10	10	-	-	-	-	-
2	d 10	11	10	1512	8	-	1530
2	d 10	12	893	-	60	486	1439
2	d 10	13	28	-	0	-	28
2	d 10	14	26	-	526	-	552
2	d 10	15	648	-	895	-	1543
2	d 10	16	24	-	92	36	152
2	d 10	17	108	18	271	6	403
2	d 10	18	170	-	47	388	605
2	d 10	19	242	-	400	-	642
2	d 10	20	338	-	370	-	708
2	d 10	21	426	100	48	14	588
2	d 10	22	8	-	66	206	280
2	d 10	23	4	30	54	136	224
2	d 10	24	-	-	152	-	152
2	d 10	25	401	12	188	178	779
2	d 10	26	10	-	64	214	288
2	d 10	27	-	-	64	456	520
2	d 10	28	224	-	14	10	248
2	d 10	29	466	-	44	132	642
2	d 10	30	10	50	46	278	384
2	d 10	31	86	39	366	-	491
2	d 10	32	104	86	479	28	697
2	d 10	33	216	-	-	-	216
2	d 10	34	128	-	44	-	172

[1]Study years: 1 - Year 1; 2 - Year 2.

[2]Sampling dates: 1 - d 0; 2 - d 10; 3 - d 20; 4 - d 30.

Table A.2.1. (Continued). Standing crop of forages during late summer grazing season in Catherine Creek riparian area, Hall Ranch of Eastern Oregon for 2001 (Year 1) and 2002 (Year 2).

Year[1]	Date[2]	Plot#	Standing Crop (kg ha^{-1})				
			Grasses	Grasslikes	Forbs	Shrubs	Total
2	d 10	35	1048	-	129	-	1177
2	d 10	36	102	-	4	312	418
2	d 10	37	104	278	138	132	652
2	d 10	38	162	104	268	-	534
2	d 10	39	213	16	388	148	765
2	d 10	40	194	-	198	-	392
2	d 10	41	225	50	108	98	481
2	d 10	42	1138	-	286	-	1424
2	d 10	43	316	236	298	-	850
2	d 10	44	804	100	171	-	1075
2	d 10	45	928	106	182	-	1216
2	d 10	46	1094	86	210	-	1390
2	d 10	47	210	-	-	-	210
2	d 10	48	468	-	328	-	796
2	d 10	49	180	-	16	8	204
2	d 20	1	732	-	114	138	984
2	d 20	2	586	486	423	14	1509
2	d 20	3	440	627	180	212	1459
2	d 20	4	159	-	318	-	477
2	d 20	5	252	-	186	-	438
2	d 20	6	885	-	32	-	917
2	d 20	7	180	-	151	276	607
2	d 20	8	172	-	96	-	268
2	d 20	9	152	-	12	-	164
2	d 20	10	-	-	-	-	0
2	d 20	11	-	712	-	-	712
2	d 20	12	654	-	-	706	1360
2	d 20	13	48	26	20	20	114
2	d 20	14	404	-	112	-	517
2	d 20	15	662	-	326	-	988
2	d 20	16	78	8	16	80	182
2	d 20	17	40	10	228	364	642

[1]Study years: 1 - Year 1; 2 - Year 2.

[2]Sampling dates: 1 - d 0; 2 - d 10; 3 - d 20; 4 - d 30.

Table A.2.1. (Continued). Standing crop of forages during late summer grazing season in Catherine Creek riparian area, Hall Ranch of Eastern Oregon for 2001 (Year 1) and 2002 (Year 2).

Year[1]	Date[2]	Plot#	Standing Crop (kg ha^{-1})				
			Grasses	Grasslikes	Forbs	Shrubs	Total
2	d 20	18	154	-	136	122	412
2	d 20	19	46	-	86	-	132
2	d 20	20	78	-	96	-	174
2	d 20	21	68	292	-	210	570
2	d 20	22	-	6	16	1084	1106
2	d 20	23	-	-	44	14	58
2	d 20	24	80	14	37	-	131
2	d 20	25	96	24	10	212	342
2	d 20	26	10	-	14	272	296
2	d 20	27	-	-	-	174	174
2	d 20	28	-	8	-	64	72
2	d 20	29	-	-	6	16	22
2	d 20	30	48	-	-	1064	1112
2	d 20	31	160	53	73	26	312
2	d 20	32	367	450	568	4	1389
2	d 20	33	160	-	28	-	188
2	d 20	34	163	-	-	-	163
2	d 20	35	724	-	-	16	740
2	d 20	36	278	-	4	88	370
2	d 20	37	174	-	6	40	220
2	d 20	38	140	70	49	30	289
2	d 20	39	61	100	92	84	337
2	d 20	40	214	-	84	-	298
2	d 20	41	152	-	10	-	162
2	d 20	42	550	98	146	-	794
2	d 20	43	238	26	106	-	370
2	d 20	44	1034	12	237	-	1283
2	d 20	45	1549	204	140	-	1892
2	d 20	46	428	-	-	-	428
2	d 20	47	423	-	17	-	440
2	d 20	48	154	-	130	-	284
2	d 20	49	112	44	-	-	156

[1]Study years: 1 - Year 1; 2 - Year 2.

[2]Sampling dates: 1 - d 0; 2 - d 10; 3 - d 20; 4 - d 30.

Table A.2.1. (Continued). Standing crop of forages during late summer grazing season in Catherine Creek riparian area, Hall Ranch of Eastern Oregon for 2001 (Year 1) and 2002 (Year 2).

Year[1]	Date[2]	Plot#	Standing Crop (kg ha^{-1})				
			Grasses	Grasslikes	Forbs	Shrubs	Total
2	d 30	1	528	-	60	54	642
2	d 30	2	952	812	112	-	1876
2	d 30	3	453	904	230	6	1593
2	d 30	4	66	-	338	-	404
2	d 30	5	40	-	45	-	85
2	d 30	6	250	-	-	-	250
2	d 30	7	84	34	65	114	297
2	d 30	8	194	9	137	-	340
2	d 30	9	14	-	30	-	44
2	d 30	10	-	-	-	-	-
2	d 30	11	48	1820	-	-	1868
2	d 30	12	226	-	2	16	244
2	d 30	13	-	-	-	18	18
2	d 30	14	94	-	30	-	124
2	d 30	15	68	-	16	-	84
2	d 30	16	36	38	28	-	102
2	d 30	17	12	-	-	-	12
2	d 30	18	148	6	64	-	218
2	d 30	19	68	-	111	-	179
2	d 30	20	41	16	96	28	181
2	d 30	21	15	212	110	2	339
2	d 30	22	8	16	26	24	74
2	d 30	23	-	-	4	28	32
2	d 30	24	22	62	-	112	196
2	d 30	25	22	58	11	160	251
2	d 30	26	-	-	-	18	18
2	d 30	27	36	-	-	-	36
2	d 30	28	346	-	-	100	446
2	d 30	29	60	10	10	188	268
2	d 30	30	132	-	-	206	338
2	d 30	31	42	6	87	-	135
2	d 30	32	233	86	310	-	629

[1]Study years: 1 - Year 1; 2 - Year 2.

[2]Sampling dates: 1 - d 0; 2 - d 10; 3 - d 20; 4 - d 30.

Table A.2.1. (Continued). Standing crop of forages during late summer grazing season in Catherine Creek riparian area, Hall Ranch of Eastern Oregon for 2001 (Year 1) and 2002 (Year 2).

Year[1]	Date[2]	Plot#	Standing Crop (kg ha^{-1})				
			Grasses	Grasslikes	Forbs	Shrubs	Total
2	d 30	33	162	-	8	-	170
2	d 30	34	170	-	-	-	170
2	d 30	35	16	-	108	-	124
2	d 30	36	389	-	16	10	415
2	d 30	37	56	-	74	36	166
2	d 30	38	114	16	47	-	177
2	d 30	39	72	-	44	124	240
2	d 30	40	194	-	1	-	195
2	d 30	41	258	16	6	10	290
2	d 30	42	154	64	181	-	399
2	d 30	43	80	25	70	-	175
2	d 30	44	410	10	42	-	462
2	d 30	45	500	62	122	-	684
2	d 30	46	58	-	-	-	58
2	d 30	47	122	-	-	-	122
2	d 30	48	24	-	109	-	133
2	d 30	49	159	-	-	-	159

[1]Study years: 1 - Years 1; 2 - Year 2.

[2]Sampling dates: 1 - d 0; 2 - d 10; 3 - d 20; 4 - d 30.

Table A.2.2. Chemical composition and digestibility of the major forage species during late summer grazing season in Catherine Creek riparian area, Hall Ranch of Eastern Oregon for 2001 (year 1) and 2002 (year 2).

Sample#	Year[1]	Date[2]	Plant#	Plant Species	Moisture (%)	Composition (% DM basis)				
						OM	CP	NDF	IVDMD	IVOMD
1	1	1	1	*Agrostis alba*	58.1	91.9	4.5	57.5	46.4	47.1
2	1	1	2	*Agropyron repens*	52.1	91.5	5.0	61.2	43.9	44.4
3	1	1	3	*Bromus carinatus*	44.4	92.2	5.1	72.6	41.1	40.8
4	1	1	4	*Festuca occidentalis*	41.8	90.6	5.5	69.3	31.9	32.2
5	1	1	5	*Phleum pratensis*	53.5	94.0	4.5	59.7	48.0	47.6
6	1	1	6	*Poa pratensis*	51.5	93.2	4.8	64.5	45.1	45.1
7	1	1	7	*Carex geyeri*	56.0	92.1	7.6	62.8	46.0	46.1
8	1	1	8	*Achillea millefolium lanulosa*	63.7	90.7	9.1	43.0	53.1	51.4
9	1	1	9	*Arnica cordifolia*	80.1	90.5	8.5	24.2	72.6	70.7
10	1	1	10	*Fragaria* spp.	73.8	92.5	10.9	24.7	50.6	48.1
11	1	1	11	*Trifolium pratense*	74.4	91.4	15.9	34.2	64.1	61.4
12	1	1	12	*Alnus incana*	68.6	95.4	20.5	36.6	42.4	40.1
13	1	1	13	*Salix rigida*	62.7	93.3	12.2	27.9	58.8	56.6
14	1	1	14	*Symphoricarpos albus*	64.1	91.7	12.2	23.7	59.8	57.5
15	1	2	1	*Agrostis alba*	50.6	92.2	5.2	62.1	40.1	40.6
16	1	2	2	*Agropyron repens*	45.3	91.8	4.9	64.7	42.1	42.6
17	1	2	3	*Bromus carinatus*	22.4	93.4	3.3	79.0	35.6	34.9

[1]Study years: 1 - Year 1; 2 - Year 2.

[2]Sampling dates: 1 - d 0; 2 - d 10; 3 - d 20; 4 - d 30.

Table A.2.2. (Continued). Chemical composition and digestibility of the major forage species during late summer grazing season in Catherine Creek riparian area, Hall Ranch of Eastern Oregon for 2001 (year 1) and 2002 (year 2).

Sample#	Year[1]	Period[2]	Plant#	Plant Species	Moisture (%)	Composition (% DM basis)				
						OM	CP	NDF	IVDMD	IVOMD
18	1	2	4	*Festuca occidentalis*	26.4	91.8	4.2	74.3	29.1	28.8
19	1	2	5	*Phleum pratensis*	37.3	94.0	4.6	63.3	45.4	45.4
20	1	2	6	*Poa pratensis*	36.1	93.2	5.3	69.0	44.3	44.3
21	1	2	7	*Carex geyeri*	43.3	90.7	6.8	63.6	45.0	45.4
22	1	2	8	*Achillea millefolium lanulosa*	66.9	86.8	9.2	38.7	60.3	59.1
23	1	2	9	*Arnica cordifolia*	74.8	90.5	8.7	25.3	72.6	70.8
24	1	2	10	*Fragaria spp.*	57.1	93.1	9.1	25.2	50.9	48.5
25	1	2	11	*Trifolium pratense*	73.1	90.6	20.1	32.0	61.4	58.4
26	1	2	12	*Alnus incana*	63.8	94.7	18.1	32.9	44.5	41.9
27	1	2	13	*Salix rigida*	64.0	93.1	14.5	21.7	55.8	53.3
28	1	2	14	*Symphoricarpos albus*	62.6	91.1	11.3	25.3	55.7	52.8
29	1	3	1	*Agrostis alba*	41.8	93.2	3.7	62.5	40.1	40.5
30	1	3	2	*Agropyron repens*	27.9	92.3	3.7	71.3	34.2	34.3
31	1	3	3	*Bromus carinatus*	13.2	93.2	2.4	79.4	34.1	33.6
32	1	3	4	*Festuca occidentalis*	17.3	94.0	3.2	78.9	30.0	29.7
33	1	3	5	*Phleum pratensis*	27.9	94.7	3.7	67.8	42.2	41.6
34	1	3	6	*Poa pratensis*	31.3	91.9	4.7	68.8	43.4	43.7
35	1	3	7	*Carex geyeri*	34.7	89.3	5.9	61.4	45.9	47.1

[1]Study years: 1 - Year 1; 2 - Year 2.

[2]Sampling dates: 1 - d 0; 2 - d 10; 3 - d 20; 4 - d 30.

Table A.2.2. (Continued). Chemical composition and digestibility of the major forage species during late summer grazing season in Catherine Creek Riparian area, Hall Ranch of Eastern Oregon for 2001 (year 1) and 2002 (year 2).

Sample#	Year[1]	Period[2]	Plant#	Plant Species	Moisture (%)	Composition (% DM basis)				
						OM	CP	NDF	IVDMD	IVOMD
36	1	3	8	*Achillea millefolium lanulosa*	50.9	87.5	7.7	42.3	55.3	54.1
37	1	3	9	*Arnica cordifolia*	74.5	90.3	9.4	29.9	65.2	63.1
38	1	3	10	*Fragaria spp.*	53.5	92.6	9.1	28.7	46.4	43.7
39	1	3	11	*Trifolium pratense*	68.9	91.5	15.6	46.9	51.2	47.6
40	1	3	12	*Alnus incana*	64.2	94.5	16.4	45.2	34.0	30.8
41	1	3	13	*Salix rigida*	62.8	92.2	14.7	28.8	55.3	51.6
42	1	3	14	*Symphoricarpos albus*	61.0	91.6	9.5	34.9	49.3	45.3
43	1	4	1	*Agrostis alba*	43.1	92.5	4.2	66.0	40.6	40.9
44	1	4	2	*Agropyron repens*	35.3	92.8	2.8	73.0	36.4	36.7
45	1	4	3	*Bromus carinatus*	18.4	93.3	2.7	77.5	35.6	34.8
46	1	4	4	*Festuca occidentalis*	17.3	94.4	2.1	81.8	26.0	25.3
47	1	4	5	*Phleum pratensis*	26.7	94.9	5.1	68.8	38.2	37.3
48	1	4	6	*Poa pratensis*	28.9	91.3	5.3	68.0	40.7	41.4
49	1	4	7	*Carex geyeri*	28.3	90.0	6.0	60.8	47.1	48.5
50	1	4	8	*Achillea millefolium lanulosa*	33.5	89.3	5.8	52.1	48.2	45.7
51	1	4	9	*Arnica cordifolia*	72.9	90.6	8.4	25.0	72.0	70.5
52	1	4	10	*Fragaria spp.*	54.2	93.0	8.6	22.8	53.9	51.9
53	1	4	11	*Trifolium pratense*	68.7	91.7	14.1	43.5	56.8	53.7

[1]Study years: 1 - Years 1; 2 - Year 2.

[2]Sampling dates: 1 - d 0; 2 - d 10; 3 - d 20; 4 - d 30.

Table A.2.2. (Continued). Chemical composition and digestibility of the major forage species during late summer grazing season in Catherine Creek Riparian area, Hall Ranch of Eastern Oregon for 2001 (year 1) and 2002 (year 2).

Sample#	Year[1]	Period[2]	Plant#	Plant Species	Moisture (%)	Composition (% DM basis)				
						OM	CP	NDF	IVDMD	IVOMD
54	1	4	12	*Alnus incana*	62.5	94.1	14.0	37.0	42.3	39.4
55	1	4	13	*Salix rigida*	60.0	93.0	11.9	31.2	51.6	48.6
56	1	4	14	*Symphoricarpos albus*	61.4	92.0	8.4	32.4	51.0	48.0
57	2	1	1	*Agrostis alba*	58.3	92.3	8.6	63.4	41.3	42.1
58	2	1	2	*Agropyron repens*	52.0	91.9	14.6	70.5	34.9	35.6
59	2	1	3	*Bromus carinatus*	58.0	94.0	14.7	79.5	32.9	31.6
60	2	1	4	*Festuca occidentalis*	42.5	91.8	11.3	69.6	32.5	33.0
61	2	1	5	*Phleum pratensis*	58.3	94.6	3.0	68.2	39.8	39.7
62	2	1	6	*Poa pratensis*	58.2	90.7	8.3	63.6	46.7	47.8
63	2	1	7	*Carex geyeri*	46.2	92.8	7.2	64.0	46.8	47.8
64	2	1	8	*Achillea millefolium lanulosa*	69.0	93.1	6.1	62.8	36.8	33.7
65	2	1	9	*Arnica cordifolia*	77.2	89.9	9.6	26.5	71.3	69.7
66	2	1	10	*Fragaria spp.*	64.6	92.8	9.6	32.9	51.2	48.9
67	2	1	11	*Trifolium pratense*	73.4	91.4	18.6	44.4	56.7	54.1
68	2	1	12	*Alnus incana*	68.4	93.9	16.1	31.9	43.7	40.8
69	2	1	13	*Salix rigida*	66.1	91.8	14.3	29.0	56.4	53.2
70	2	1	14	*Symphoricarpos albus*	62.4	91.9	8.4	28.6	49.0	44.9
71	2	2	1	*Agrostis alba*	70.2	92.0	4.4	59.2	43.1	43.5

[1]Study years: 1 - Years 1; 2 - Year 2.

[2]Sampling dates: 1 - d 0; 2 - d 10; 3 - d 20; 4 - d 30.

Table A.2.2. (Continued). Chemical composition and digestibility of the major forage species during late summer grazing season in Catherine Creek riparian area, Hall Ranch of Eastern Oregon for 2001 (year 1) and 2002 (year 2).

Sample#	Year[1]	Period[2]	Plant#	Plant Species	Moisture (%)	Composition (% DM basis)				
						OM	CP	NDF	IVDMD	IVOMD
72	2	2	2	*Agropyron repens*	56.9	91.8	4.3	67.8	36.5	36.6
73	2	2	3	*Bromus carinatus*	58.9	92.3	3.7	74.5	34.9	32.8
74	2	2	4	*Festuca occidentalis*	47.2	90.3	6.6	62.2	42.3	43.3
75	2	2	5	*Phleum pratensis*	55.6	94.1	3.8	64.7	40.3	39.9
76	2	2	6	*Poa pratensis*	71.4	91.1	8.6	62.0	52.7	52.9
77	2	2	7	*Carex geyeri*	57.4	92.7	8.2	62.2	50.9	52.0
78	2	2	8	*Achillea millefolium lanulosa*	64.8	90.5	7.9	51.1	47.5	44.6
79	2	2	9	*Arnica cordifolia*	79.4	90.2	8.6	24.8	75.3	74.1
80	2	2	10	*Fragaria* spp.	73.6	91.6	8.6	30.9	49.6	47.4
81	2	2	11	*Trifolium pratense*	76.7	90.2	16.8	37.2	61.4	58.7
82	2	2	12	*Alnus incana*	63.4	94.7	17.8	31.9	49.2	47.2
83	2	2	13	*Salix rigida*	63.4	92.5	14.1	24.4	51.6	48.7
84	2	2	14	*Symphoricarpos albus*	61.8	91.4	9.2	31.0	53.0	49.8
85	2	3	1	*Agrostis alba*	48.9	91.6	5.4	57.9	45.2	45.6
86	2	3	2	*Agropyron repens*	37.4	90.6	5.0	59.4	43.3	44.3
87	2	3	3	*Bromus carinatus*	32.9	92.2	5.5	69.8	43.8	42.3
88	2	3	4	*Festuca occidentalis*	33.6	90.1	6.9	63.1	42.4	43.4
89	2	3	5	*Phleum pratensis*	39.7	94.7	4.0	57.5	47.1	47.2

[1]Study years: 1 - Years 1; 2 - Year 2.

[2]Sampling dates: 1 - d 0; 2 - d 10; 3 - d 20; 4 - d 30.

Table A.2.2. (Continued). Chemical composition and digestibility of the major forage species during late summer grazing season in Catherine Creek riparian area, Hall Ranch of Eastern Oregon for 2001 (year 1) and 2002 (year 2).

Sample#	Year[1]	Period[2]	Plant#	Plant Species	Moisture (%)	Composition (% DM basis)				
						OM	CP	NDF	IVDMD	IVOMD
90	2	3	6	*Poa pratensis*	46.0	90.6	7.7	61.4	51.8	53.0
91	2	3	7	*Carex geyeri*	36.6	92.3	8.0	60.8	49.5	50.5
92	2	3	8	*Achillea millefolium lanulosa*	53.3	90.0	8.5	44.7	54.4	52.6
93	2	3	9	*Arnica cordifolia*	76.0	90.5	8.8	23.7	73.5	72.5
94	2	3	10	*Fragaria spp.*	59.8	92.5	10.4	35.0	49.6	47.2
95	2	3	11	*Trifolium pratense*	70.9	91.4	16.1	37.6	59.5	57.1
96	2	3	12	*Alnus incana*	58.7	95.4	17.6	30.8	44.5	42.6
97	2	3	13	*Salix rigida*	60.8	93.1	13.8	26.0	47.5	46.1
98	2	3	14	*Symphoricarpos albus*	59.1	92.2	9.6	24.7	54.0	51.5
99	2	4	1	*Agrostis alba*	45.0	91.9	6.5	62.2	42.9	42.4
100	2	4	2	*Agropyron repens*	39.5	91.7	7.0	61.7	44.0	44.2
101	2	4	3	*Bromus carinatus*	30.1	89.9	7.0	67.4	45.1	43.9
102	2	4	4	*Festuca occidentalis*	35.8	89.2	7.1	62.4	43.1	44.4
103	2	4	5	*Phleum pratensis*	39.7	93.4	5.6	60.1	51.3	51.4
104	2	4	6	*Poa pratensis*	44.3	91.5	12.9	64.4	54.0	54.0
105	2	4	7	*Carex geyeri*	41.5	91.4	8.6	60.5	52.1	53.1
106	2	4	8	*Achillea millefolium lanulosa*	40.2	89.8	10.2	43.5	60.6	57.6
107	2	4	9	*Arnica cordifolia*	76.3	90.5	8.0	24.6	75.5	73.7

[1]Study years: 1 - Years 1; 2 - Year 2.

[2]Sampling dates: 1 - d 0; 2 - d 10; 3 - d 20; 4 - d 30.

Table A.2.2. (Continued). Chemical composition and digestibility of the major forage species during late summer grazing season in Catherine Creek riparian area, Hall Ranch of Eastern Oregon for 2001 (year 1) and 2002 (year 2).

Sample#	Year[1]	Period[2]	Plant#	Plant Species	Moisture (%)	Composition (% DM basis)				
						OM	CP	NDF	IVDMD	IVOMD
108	2	4	10	*Fragaria* spp.	59.1	92.1	10.4	28.4	50.7	47.3
109	2	4	11	*Trifolium pratense*	71.3	91.2	17.0	38.9	61.9	58.8
110	2	4	12	*Alnus incana*	57.9	95.5	18.7	34.0	42.2	39.8
111	2	4	13	*Salix rigida*	61.8	93.9	14.3	21.5	45.3	42.4
112	2	4	14	*Symphoricarpos albus*	62.1	92.1	11.0	25.8	50.9	47.5

[1]Study years: 1 - Years 1; 2 - Year 2.

[2]Sampling dates: 1 - d 0; 2 - d 10; 3 - d 20; 4 - d 30.

Table A.2.3. Shrub utilization during late summer grazing season in Catherine Creek riparian area, Hall Ranch, Eastern Oregon for 2001 (Year 1).

Shrub#	Shrub Species	Green Leaf Area (pixel)				Utilization (%)		
		d 0[1]	d 10	d 20	d 30	d 10	d 20	d 30
1	*Salix rigida*	188284	150658	101189	98686	20.0	46.3	47.6
2	*Salix rigida*	182040	174609	140864	108254	4.1	22.6	40.5
3	*Salix rigida*	67953	42627	23139	19762	37.3	65.9	70.9
4	*Alnus incana*	97986	60861	21661	22968	37.9	77.9	76.6
5	*Alnus incana*	82016	73018	66738	19431	11.0	18.6	76.3
6	*Alnus incana*	44659	36393	21348	9145	18.5	52.2	79.5
7	*Salix rigida*	24720	24202	17859	11070	2.1	27.8	55.2
8	*Alnus incana*	34439	23026	16539	9837	33.1	52.0	71.4
9	*Salix rigida*	15269	13720	6960	3928	10.1	54.4	74.3
10	*Alnus incana*	85772	64962	51063	13502	24.3	40.5	84.3
11	*Alnus incana*	32612	29249	21063	7560	10.3	35.4	76.8
12	*Salix rigida*	61172	45728	25936	25422	25.2	57.6	58.4
13	*Salix rigida*	129409	54747	23755	22492	57.7	81.6	82.6
14	*Salix rigida*	58961	28027	17685	14874	52.5	70.0	74.8
15	*Alnus incana*	46372	19964	4140	1415	56.9	91.1	96.9
16	*Alnus incana*	104799	99797	19595	13814	4.8	81.3	86.8

[1]Sampling dates: 1 - d 0; 2 - d 10; 3 - d 20; 4 - d 30.

Table A.2.4. Cow and calf performance during late summer grazing season in Catherine Creek riparian area, Hall Ranch for 2001 (Year 1) and 2002 (Year 2).

			Condition Score[1]		Cow Weight (kg)		Calf Weight (kg)	
Cow #	Calf#	Year[2]	Pre	Post	Pre	Post	Pre	Post
8218	8218	1	4.5	4.3	404.2	416.6	147.6	165.3
8178	8178	1	4.0	4.3	427.1	435.9	210.9	234.1
5249	5249	1	5.5	5.5	601.2	591.5	188.5	214.1
8141	8141	1	4.5	4.3	508.7	529.1	210.0	239.7
5160	5160	1	5.3		566.5		212.7	
3151	3151	1	5.3	5.3	522.5	545.5	207.5	237.7
8010	8010	1	4.0	3.5	332.7	354.9	206.4	231.3
2107	2107	1	5.8	5.5	483.3	489.0	160.1	189.2
8211	8211	1	4.5	4.0	418.4	438.6	194.4	223.2
1176	1176	1	5.5		555.9		202.8	
8037	8037	1	4.5	4.3	449.1	475.4	262.4	262.0
3110	3110	1	4.8	4.3	615.3	632.5	213.2	245.9
8226	8226	1	4.8	4.3	545.0	565.9	205.5	234.1
9132	9132	1	5.5	4.5	580.2	588.8	171.7	212.1
9223	9223	1	5.3	5.0	444.8	449.7	192.6	222.3
9255	9255	1	5.0	4.5	454.1	482.6	198.7	232.0
8101	8101	1	4.5	4.5	459.7	485.4	215.9	243.8
5204	5204	1	5.3	5.0	585.6	606.2	192.8	229.1
8125	8125	1	5.5	5.0	501.5	531.8	211.4	233.4
4029	4029	1	4.8	4.3	600.3	613.9	224.5	260.6
6124	6124	1	4.8	4.5	530.0	531.6	234.7	264.4
8017	8017	1	4.5	4.5	470.4	484.7	259.7	291.7
5162	5162	1	6.5	6.3	682.4	704.4	190.7	219.3
9168	9168	1	5.0	4.5	431.1	434.5	221.4	252.7
1075	1075	1	5.0	4.8	560.2	554.3	246.8	290.3
4150	4150	1	5.3	5.0	622.8	643.2	206.4	242.9
9046	9046	1	4.8	4.3	469.2	498.7	226.1	252.0
9121	9121	1	5.5	4.8	455.0	484.7	220.7	245.4
9209	9209	1	5.5		482.0		242.7	267.4
8031	8031	1	4.5	4.5	388.3	406.7	205.3	233.8
7106	7106	2	5.0	4.3	572.9	557.2	264.7	295.1
7140	7140	2	4.8	5.0	548.6	565.2	222.3	262.0
9209	9209	2	4.8	4.3	543.4	565.6	167.4	191.6
8141	8141	2	4.0	4.8	587.0	590.6		
188	188	2	4.8	4.5	450.7	460.2	182.3	206.6
126	126	2	4.0	4.3	451.3	496.5		

[1]Body condition scores pre- and post- grazing.
[2]Study years: 1 - Year 1; 2 - Year 2.

Table A.2.4. (Continued). Cow and calf performance during late summer grazing season in Catherine Creek riparian area, Hall Ranch for 2001 (Year 1) and 2002 (Year 2).

			Condition Score[1]		Cow Weight (kg)		Calf Weight (kg)	
Cow #	Calf#	Year[2]	Pre	Post	Pre	Post	Pre	Post
7113	7113	2	4.5	4.0	496.9	493.5	258.8	290.3
9215	9215	2	4.3	4.0	496.5	506.9	185.1	210.2
9255	9255	2	4.5	4.0	495.6	496.5	196.9	220.2
145	145	2	3.8	3.5	434.3	443.6	186.7	213.6
9173	9173	2	4.8	4.5	578.6	594.2	167.6	199.4
7124	7124	2	5.0	5.0	557.0	551.6	196.6	238.8
155	155	2	4.5	4.3	537.7	540.5	202.5	228.6
8246	8246	2	5.3	5.0	591.3	605.6	217.7	249.7
222	222	2	4.3	4.3	488.8	513.5		
228	228	2	4.8	4.5	550.2	552.7	216.4	252.0
7128	7128	2	5.0	5.5	553.4	541.4	176.9	211.6
54	54	2	3.8	3.8	414.6	406.0	186.4	213.6
229	229	2	4.0	3.8	390.5	393.7	137.9	161.5
9121	9121	2	4.5	4.5	494.0	504.4		
131	131	2	4.0	4.3	396.9	413.9	207.5	231.6
16	16	2	4.0	3.5	451.1	448.4	189.6	208.2
8010	8010	2	4.0	4.0	375.8	400.1		
9102	9102	2	4.5	4.3	460.4	469.9	166.2	181.0
143	143	2	4.5	4.0	501.0	483.5	198.0	231.3
8017	8017	2	4.0	4.0	517.3	522.3	233.4	269.9
8243	8243	2	4.3	4.0	506.9	494.9	205.7	234.5
8130	8130	2	4.3	4.0	449.3	456.8	226.3	261.5
8188	8188	2	4.5	4.8	511.2	535.9		
12	12	2	4.3	3.8	479.0	449.1	176.9	214.6

[1]Body condition scores pre- and post- grazing.

[2]Study years: 1 - Year 1; 2 - Year 2.

Table A.2.5. Heifer performance during late summer grazing season in Catherine Creek riparian area, Hall Ranch for 2001 (Year 1) and 2002 (Year 2).

		Condition Score[1]		Cow Weight (kg)	
Cow #	Year[2]	Pre	Post	Pre	Post
0229	1	4.3	4.5	338.2	356.5
0165	1	5.5	5.0	359.7	391.0
0228	1	5.5	5.0	449.5	485.4
0143	1	4.8	5.0	418.2	440.0
0210	1	5.3	5.0	406.2	416.6
0110	1	5.5	5.3	413.2	435.5
0216	1	5.3	5.0	423.0	432.3
0202	1	4.8	5.0	362.4	390.3
0009	1	5.8	5.0	393.3	416.4
0211	1	5.0	4.8	422.3	454.1
0222	1	4.5	4.8	411.2	430.0
0233	1	4.3	4.8	370.1	427.1
0160	1	4.3	4.3	417.5	463.1
0145	1	4.3	4.0	369.9	389.2
0224	1	4.5	4.5	380.6	400.8
0033	1	5.0	5.0	360.6	389.0
0101	1	5.5	5.0	401.0	428.4
0188	1	5.5	5.0	368.3	400.3
0155	1	4.8	4.5	446.1	464.7
0007	1	5.5	4.8	399.2	424.6
0102	1	5.3		395.8	
0217	1	5.3	5.0	401.0	417.3
0025	1	5.0	5.0	372.2	381.9
0127	1	4.8	4.5	350.2	386.7
0034	1	4.8	5.0	348.4	362.4
0103	1	5.3	5.0	423.7	442.0
0020	1	5.5	5.3	400.5	425.0
0018	1	5.0	5.0	394.2	417.1
0053	1	4.5	4.8	330.9	349.0

[1]Body condition scores pre- and post- grazing.
[2]Study years: 1 - Year 1; 2 - Year 2.

Table A.2.5. (Continued). Heifer performance during late summer grazing in Catherine Creek riparian area, Hall Ranch for 2001 (Year 1) and 2002 (Year 2).

		Condition Score[1]		Cow Weight (kg)	
Cow #	Year[2]	Pre	Post	Pre	Post
0213	1	5.3	5.5	403.5	436.1
1189	2	4.8	5.0	440.0	455.4
1213	2	5.3	5.5	428.2	430.7
1196	2	5.3	5.0	432.7	453.6
1024	2	5.5	5.5	488.8	499.6
1282	2	5.3	5.3	451.8	450.7
1116	2	5.5	5.5	467.4	494.2
1046	2	4.8	5.3	430.2	442.7
1186	2	5.0	5.0	427.5	428.7
1190	2	5.0	4.8	420.7	410.3
1102	2	5.3	4.8	434.3	444.5
1141	2	5.0	4.8	477.0	490.8
1132	2	4.8	5.0	431.8	444.8
1206	2	5.3	5.5	513.0	526.6
1123	2	5.0	5.0	506.7	544.3
1241	2	5.5	5.0	454.7	463.4
1154	2	5.5	5.5	434.5	453.1
1228	2	5.3	5.0	411.9	437.3
1020	2	5.0	5.3	507.6	496.5
1145	2	5.0	5.3	447.2	467.0
1018	2	4.8	5.5	450.4	468.6
1139	2	5.0	5.3	435.5	452.7
1242	2	4.8	5.3	418.0	452.5
1110	2	5.0	4.5	446.1	465.4
1004	2	5.5	5.8	461.3	466.5
1129	2	5.3	5.3	429.6	438.6
1144	2	5.0	5.5	474.2	477.2
1238	2	4.8	5.3	409.8	437.5
1112	2	4.5	4.8	420.9	442.9
1100	2	5.0	5.3	409.8	436.8
1134	2	5.3	5.5	426.6	439.3

[1]Body condition scores pre- and post- grazing.
[2]Study years: 1 - Year 1; 2 - Year 2.

Table A.3.1. Diet species composition of mature cows during late summer grazing season in Milk Creek riparian area, Hall Ranch of Eastern Oregon for 2000 (Year 1) and 2001 (Year 2).

Year[1]	Forage[2]	Plant Species	Composition (%)
1	1	AGAL	4.919
1	1	AGRE	0.079
1	1	AGSM	6.419
1	1	ALPR	6.247
1	1	AREL	9.494
1	1	BRCA	0.141
1	1	CARU	8.558
1	1	DAGL	3.016
1	1	DECA	15.148
1	1	ELGL	6.138
1	1	FEID	0.044
1	1	FEOC	0.37
1	1	MEBU	0.443
1	1	PHPR	0.115
1	1	POPR	7.317
1	1	POSA	0.138
1	1	STOC	7.365
1	1	TRCA	2.116
1	2	CAGE	4.854
1	2	JUBA	1.876
1	3	ACMIL	0.371
1	3	ARCO	0.067
1	3	GABO	0.103
1	4	ABGR	1.319
1	4	BERE	0.189
1	4	HODI	0.18
1	4	PIPO	11.553
1	4	PSME	0.234
1	4	RICE	0.016

[1]Study years: 1 - Year 1; 2 - Year 2.
[2]Forage classes: 1-grasses; 2-grasslikes; 3-forbs; 4-shrubs and trees; 5-mosses.

Table A.3.1. (Continued). Diet species composition of mature cows during late summer grazing season in Milk Creek riparian area, Hall Ranch of Eastern Oregon for 2000 (Year 1) and 2001 (Year 2).

Year[1]	Forage[2]	Plant Species	Composition (%)
1	4	SARI	0.215
1	4	SYAL	0.176
1	5	Moss	0.782
2	1	AGAL	6.807
2	1	AGRE	0.022
2	1	AGSM	9.281
2	1	AGSP	2.12
2	1	ALPR	2.848
2	1	AREL	1.302
2	1	BRCA	0.138
2	1	CARU	8.729
2	1	DAGL	4.355
2	1	DECA	13.912
2	1	ELGL	8.914
2	1	FEOC	0.017
2	1	MEBU	0.318
2	1	PHPR	2.792
2	1	POPR	6.516
2	1	STOC	6.689
2	1	TRCA	1.941
2	2	CAGE	2.102
2	2	JUBA	3.498
2	3	ACMIL	0.451
2	3	ARCO	0.272
2	3	ERPH	0.339
2	3	GABO	0.176
2	3	TRDU	0.875
2	4	ABGR	0.177
2	4	ALIN	0.499
2	4	AMAL	0.587
2	4	BERE	0.315

[1]Study years: 1 - Year 1; 2 - Year 2.
[2]Forage classes: 1-grasses; 2-grasslikes; 3-forbs; 4-shrubs and trees; 5-mosses.

Table A.3.1. (Continued). Diet species composition of mature cows during late summer grazing season in Milk Creek riparian area, Hall Ranch of Eastern Oregon for 2000 (Year 1) and 2001 (Year 2).

Year[1]	Forage[2]	Plant Species	Composition (%)
2	4	HODI	0.156
2	4	PIPO	11.042
2	4	RICE	0.34
2	4	ROGY	0.097
2	4	SARI	1.175
2	4	SYAL	0.97
2	4	Unknown shrub1	0.011
2	5	Moss	0.224

[1]Study years: 1 - Year 1; 2 - Year 2.
[2]Forage classes: 1-grasses; 2-grasslikes; 3-forbs; 4-shrubs and trees; 5-mosses.

Table A.3.2. Diet species composition of heifers during late summer grazing season in Milk Creek riparian area, Hall Ranch of Eastern Oregon for 2000 (Year 1) and 2001 (Year 2).

Year[1]	Forage[2]	Plant Species	Composition (%)
1	1	AGAL	6.536
1	1	AGRE	0.128
1	1	AGSM	9.245
1	1	AGSP	0.272
1	1	ALPR	3.177
1	1	AREL	4.109
1	1	BRCA	0.202
1	1	CARU	11.596
1	1	DAGL	2.721
1	1	DECA	17.71
1	1	ELGL	8.686
1	1	FEID	0.161
1	1	FEOC	0.35
1	1	MEBU	0.409
1	1	PHPR	0.049
1	1	POPR	4.52
1	1	POSA	0.48
1	1	STOC	7.373
1	1	TRCA	5.118
1	2	CAGE	3.907
1	2	Carex sp.	0.803
1	2	JUBA	3.101
1	3	ACMIL	0.306
1	3	GABO	0.109
1	3	TRDU	0.183
1	4	ABGR	1.273
1	4	BERE	0.366
1	4	HODI	0.204
1	4	PIPO	6.034
1	4	SARI	0.181

[1]Study years: 1 - Year 1; 2 - Year 2.
[2]Forage classes: 1-grasses; 2-grasslikes; 3-forbs; 4-shrubs and trees; 5-mosses.

Table A.3.2. (Continued). Diet species composition of heifers during late summer grazing season in Milk Creek riparian area, Hall Ranch of Eastern Oregon for 2000 (Year 1) and 2001 (Year 2).

Year[1]	Forage[2]	Plant Species	Composition (%)
1	4	SYAL	0.281
1	5	Moss	0.41
2	1	AGAL	6.548
2	1	AGRE	0.104
2	1	AGSM	8.367
2	1	AGSP	2.408
2	1	ALPR	2.837
2	1	AREL	2.338
2	1	BRCA	0.139
2	1	CARU	10.003
2	1	DAGL	4.329
2	1	DECA	14.102
2	1	ELGL	9.246
2	1	FEOC	0.015
2	1	MEBU	0.513
2	1	PHPR	2.686
2	1	POPR	7.13
2	1	STOC	8.625
2	1	TRCA	1.739
2	2	CAGE	2.346
2	2	JUBA	3.655
2	3	ACMIL	0.402
2	3	ARCO	0.178
2	3	ERPH	0.186
2	3	GABO	0.127
2	3	TRDU	0.797
2	3	Unknown forb1	0.041
2	4	ABGR	0.077
2	4	ALIN	0.379
2	4	AMAL	0.186
2	4	BERE	0.075

[1]Study years: 1 - Year 1; 2 - Year 2.
[2]Forage classes: 1-grasses; 2-grasslikes; 3-forbs; 4-shrubs and trees; 5-mosses.

Table A.3.2. (Continued). Diet species composition of heifers during late summer grazing season in Milk Creek riparian area, Hall Ranch of Eastern Oregon for 2000 (Year 1) and 2001 (Year 2).

Year[1]	Forage[2]	Plant Species	Composition (%)
2	4	HODI	0.082
2	4	PIPO	7.613
2	4	PSME	0.018
2	4	RICE	0.279
2	4	ROGY	0.032
2	4	SARI	0.818
2	4	SYAL	0.816
2	4	Unknown shrub1	0.014
2	5	Moss	0.744

[1]Study years: 1 - Year 1; 2 - Year 2.
[2]Forage classes: 1-grasses; 2-grasslikes; 3-forbs; 4-shrubs and trees; 5-mosses.

Table A.3.3. Correction factors for common forage species at Hall Ranch of Eastern Oregon to improve estimates of relative density in fecal analysis.

Hand mixed diets	Composition (%) Actual	Composition (%) Estimated	Density (%) Relative	Density (%) Actual	Frequency (%)	Correction factor (b)	Adjustment
Mixture 1							
Poa pratensis	20	34.5	34.6	22.1	85	0.639	Y=0.639X
Agropyron smithii	20	26.3	26.4	22.1	70	0.838	Y=0.837X
Carex geyeri	20	22.4	22.1	22.1	68	0.998	Y=1X
Achillea millifolium lanulosa	20	8.4	8.5	22.1	29	2.613	Y=2.6X
Symphoricarpos albus	20	8.4	8.5	22.1	31	2.613	Y=2.6X
Mixture 2							
Phleum pratensis	20	20.3	19.8	15	72	0.759	Y=0.761X
Agrostis alba	20	32.2	32.0	15	82	0.469	Y=0.469X
Carex geyeri	20	14.6	15.0	15	56	1.002	Y=1X
Erigeron sp.	20	10.3	10.4	15	43	1.443	Y=1.442X
Salix rigida	20	22.4	22.9	15	64	0.656	Y=0.655X
Mixture 3							
Deschampsia caespitosa	20	38.1	37.7	15.5	85	0.411	Y=0.411X
Alopecurus pratensis	20	19.9	19.9	15.5	63	0.779	Y=0.779X
Carex geyeri	20	15.7	15.5	15.5	51	1.003	Y=1X
Arnica cordifolia	20	7.9	8.4	15.5	33	1.838	Y=1.845X
Alnus incana	20	17.4	18.5	15.5	51	0.838	Y=0.838X

Y - Relative density of each species, X - Observed density of species, b - Degree of overestimation ($b < 1.0$) or underestimation ($b > 1.0$).

Table A.3.3. (Continued). Correction factors for common forage species at Hall Ranch of Eastern Oregon to improve estimates of relative density in fecal analysis.

Hand mixed diets	Composition (%) Actual	Composition (%) Estimated	Density (%) Relative	Density (%) Actual	Frequency (%)	Correction factor (b)	Adjustment
Mixture 4							
Calamagrostis rubescens	20	34.2	33.7	14.6	93	0.433	Y=0.433X
Stipa occidentalis	20	22.9	22.8	14.6	77	0.640	Y=0.64X
Carex geyeri	20	14.4	14.6	14.6	56	0.999	Y=1X
Tragopogon dubius	20	5.9	5.9	14.6	32	2.482	Y=2.475X
Berberis repens	20	22.7	23.0	14.6	75	0.635	Y=0.635X
Mixture 5							
Elymus glaucus	16.7	21	21.0	13.8	80	0.657	Y=0.657X
Dactylus glomerata	16.7	11.5	11.4	13.8	59	1.213	Y=1.211X
Carex geyeri	16.7	13.6	13.8	13.8	60	1.001	Y=1X
Juncus balticus	16.7	12.1	12.2	13.8	55	1.133	Y=1.131X
Galium boreale	16.7	13.9	13.8	13.8	66	1.001	Y=1X
Pinus ponderosa	16.7	28	27.9	13.8	94	0.495	Y=0.495X

Y = Relative density of each species, X = Observed density of species, b = Degree of overestimation ($b < 1.0$) or underestimation ($b > 1.0$).

Table A.3.4. Chemical composition and digestibility of the major forage species during late summer grazing season in Milk Creek riparian area, Hall Ranch[1].

			Composition (% DM basis)			
Sample#	**Forage[2]**	**Plant Species**	**Ash**	**CP**	**IVDMD**	**IVOMD**
1	1	*Elymus glaucus*	8.6	3.5	34.4	33.9
2	1	*Poa pratensis*	8.6	3.2	45.6	46.3
3	1	*Phleum pratensis*	5.7	2.9	48.7	48.8
4	1	*Alopecurus pratensis*	8.5	2.3	35.6	35.1
5	1	*Stipa occidentalis*		2.8		
6	1	*Calamagrostis rubescens*	13.2	9.1		
7	1	*Deschampsia caespitosa*		4.3		
8	1	*Festuca occidentalis*	6.9	3.4	34.8	34.8
9	1	*Agropyron smithii*	8.8	2.9	43.7	45.6
10	1	*Agrostis alba*	8.8	5.6	57.1	58.7
11	1	*Festuca idahoensis*	15.0	4.7	47.0	50.9
12	1	*Agropyron spicatum*	12.0	4.6	47.3	50.3
13	1	*Dactylis glomerata*	10.0	3.2	42.5	41.6
14	1	*Trisetum canescens*	7.4	3.8	46.4	45.6
15	1	*Melica bulbosa*		6.2	47.4	54.1
16	1	*Agropyron intermedium*	8.0	3.4	46.8	48.3
17	1	*Arrhenatherum elatius*	6.5	4.3	45.7	45.6
18	2	*Carex geyeri*		5.8		
19	2	*Carex nebraskensis*		5.3		
20	2	*Juncus balticus*	4.3	6.0	45.9	44.5
21	1	*Bromus carinatus*	9.3	2.7	42.1	41.6
22	1	*Koeleria cristata*		2.6		
23	1	*Poa secunda*	4.0	6.1	65.1	65.8
24	1	*Deschampsia elongata*		5.3		
25	1	*Bromus mollis*		2.1		
26	1	*Agropyron repens*		3.5		
27	2	*Carex rossi*		4.6		
28	2	*Carex stipata*		6.5		
29	3	*Galium boreale*		6.6		
30	3	*Arnica cordifolia*	10.1	7.7	79.4	78.1

[1]Plant species' samples were collected Aug. 22 - Aug. 31 of 2000 and 2001.
[2]Forage classes: 1- grasses, 2 - grasslikes, 3 - forbs, 4 - shrubs and trees.

Table A.3.4. (Continued). Chemical composition and digestibility of the major forage species during late summer grazing season in Milk Creek riparian area, Hall Ranch[1].

Sample#	Forage[2]	Plant Species	Composition (% DM basis)			
			Ash	CP	IVDMD	IVOMD
31	3	*Achillea millefolium lanulosa*	8.5	7.2	45.8	42.1
32	4	*Salix exigua*		16.3		
33	4	*Salix rigida*	7.8	15.2	67.3	65.2
34	4	*Ribes cereum*	8.0	8.7	49.8	47.3
35	4	*Berberis repens*	3.4	9.7	59.3	58.6
36	4	*Alnus incana*	5.4	16.4	56.9	55.4
37	4	*Pinus ponderosa*	2.7	7.9	35.8	34.9
38	4	*Abies grandis*		5.4		
39	4	*Pseudotsuga menziesii*		5.5		
40	4	*Holodiscus discolor*		6.1		
42	3	*Erigeron philadelphicus*	7.9	9.2	59.9	59.0
43	3	*Epilobium paniculatum*		9.1		
44	3	*Dipsacus sylvestris*		8.1		
45	3	*Heracleum lanatum*		6.1		
46	3	*Tragopogon dubius*		4.8		
47	3	*Vicia americana*		11.8		
48	3	*Equisetum arvense*		6.1		
49	3	*Potentilla gracilis*		3.7		
50	3	*Geum macrophyllum*		6.7		
51	3	*Microseris nutans*		12.6		
55	1	*Bromus tectorum*	5.5	3.1		
56	1	*Deschampsia caespitosa*	8.0	4.0	42.4	41.3
57	2	*Carex geyeri*	9.4	7.0	51.6	54.2
58	4	*Symphoricarpos albus*	12.3	9.3	62.4	59.5
60	3	*Lupinus sericeus*	8.0	8.7	63.5	60.9
61	4	*Amelanchier alnifolia*	8.2	11.6	56.1	54.0
486	1	*Calamagrostis rubescens*	15.4	6.7	46.2	49.6

[1]Plant species' samples were collected Aug. 22 - Aug. 31 of 2000 and 2001.

[2]Forage classes: 1 - grasses, 2 - grasslikes, 3 - forbs, 4 - shrubs and trees.

Table A.3.5. List of plant species occurred at Hall Ranch of Eastern Oregon during the study years.

#	Alpha Code Name	Forage[1]	Plant Species Scientific Name	Plant Species Common Name
			Grasses	
1	AGAL	1	*Agrostis alba*	Redtop
2	AGDI	1	*Agrostis diegoensis*	Thin Bentgrass
3	AGRE	1	*Agropyron repens*	Quackgrass
4	AGSM	1	*Agropyron smithii*	Bluestem Wheatgrass
5	AGSP	1	*Agropyron spicatum*	Bluebunch Wheatgrass
6	AREL	1	*Arrhenatherum elatius*	Tall Oatgrass
7	BRBR	1	*Bromus brizaeformis*	Rattle Brome
8	BRCA	1	*Bromus carinatus*	California Brome
9	BRMO	1	*Bromus mollis*	Soft Brome
10	BRTE	1	*Bromus tectorum*	Cheatgrass Brome
11	CARU	1	*Calamagrostis rubescens*	Pinegrass
12	DAGL	1	*Dactylis glomerate*	Orchardgrass
13	DECA	1	*Deschampsia caespitosa*	Tufted Hairgrass
14	ELGL	1	*Elymus glaucus*	Blue Wildrye
15	FEEL	1	*Festuca elatior*	Meadow Fescue
16	FEID	1	*Festuca idahoensis*	Idaho Fescue
17	FEOC	1	*Festuca occidentalis*	Western Fescue
18	FEOV	1	*Festuca ovina*	Sheep Fescue
19	GLST	1	*Glyceria striata*	Fowl Mannagrass
20	HOLA	1	*Holcus lanatus*	Common Velvetgrass
21	KOCR	1	*Koeleria cristata*	Junegrass
22	MEBU	1	*Melica bulbosa*	Oniongrass
23	PHPR	1	*Phleum pratensis*	Timothy
24	POBU	1	*Poa bulbosa*	Bulbous Bluegrass
25	POCO	1	*Poa compressa*	Canada Bluegrass
26	POPR	1	*Poa pratensis*	Kentucky Bluegrass
27	POSE	1	*Poa secunda*	Sandberg Bluegrass
28	TRCA	1	*Trisetum canescens*	Tall Trisetum
			Grasslikes	
29	CAGE	2	*Carex geyeri*	Elk Sedge

[1]Forage classes: 1 - grasses, 2 - grasslikes, 3 - forbs, 4 - shrubs and trees.

Table A.3.5. (Continued). List of plant species occurred at Hall Ranch of Eastern Oregon during the study years.

#	Alpha Code Name	Forage[1]	Plant Species Scientific Name	Plant Species Common Name
			Grasslikes	
30	CARO	2	*Carex rossii*	Ross Sedge
31	JUBA	2	*Juncus balticus*	Baltic Rush
32	JUEN	2	*Juncus ensifolius*	Swordleaf Rush
			Forbs	
33	ACMIL	3	*Achillea millefolium lanulosa*	Western Yarrow
34	ANPI	3	*Anemone piperi*	Piper Anemone
35	ANRO	3	*Antennaria rosea*	Rose Pussytoes
36	ARCO	3	*Arnica cordifolia*	Heartleaf Arnica
37	ARMA	3	*Arenaria macrophylla*	Bigleaf Sandwort
38	CACU	3	*Castilleja cusickii*	Cusick Paintbrush
39	CEVI	3	*Cerastium viscosum*	Sticky Cerastium
40	CIVU	3	*Cirsium vulgare*	Bull Thistle
41	COGR	3	*Collomia grandiflora*	Largeflower Collomia
42	COLI	3	*Collomia linears*	Narrowleaf Collomia
43	DESO	3	*Descurainia sophia*	Flixweed Tansymustard
44	EPGL	3	*Epilobium glaberrimum*	Smooth Willowweed
45	EPPA	3	*Epilobium paniculatum*	Autumn Willowweed
46	EQAR	3	*Equisetum arvense*	Field Horsetail
47	ERCI	3	*Erodium cicutarium*	Filaree
48	ERCH	3	*Eriogonum chrysocephalum*	Goldball Buckwheat
49	ERHE	3	*Eriogonum heracleoides*	Wyeth Buckwheat
50	ERPU	3	*Erigeron pumilus*	Shaggy Fleabane
51	ERPH	3	*Erigeron philadelphicus*	Philadelphia Fleabane
52	FRVE	3	*Fragaria vesca*	Woods Strawberry
53	FRVI	3	*Fragaria virginiana*	Blueleaf Strawberry
54	GAAS	3	*Galium asperrimum*	Rough Bedstraw

[1]Forage classes: 1 - grasses, 2 - grasslikes, 3 - forbs, 4 - shrubs and trees.

Table A.3.5. (Continued). List of plant species occurred at Hall Ranch of Eastern Oregon during the study years.

#	Alpha Code Name	Forage[1]	Plant Species Scientific Name	Plant Species Common Name
			Forbs	
55	GABO	3	*Galium boreale*	Northern Bedstraw
56	GEMA	3	*Geum macrophyllum*	Largeleaf Avens
57	HELA	3	*Heracleum lanatum*	Common Cowparsnip
58	HIAL	3	*Hieracium albertinum*	Western Hawkweed
59	IRMI	3	*Iris missouriensis*	Rockymountain Iris
60	LASE	3	*Lactuca serriola*	Prickly Lettuce
61	LEPE	3	*Lepidium perfoliatum*	Clasping Pepperweed
62	LUSE	3	*Lupinus sericeus*	Silky Lupine
63	MAEX	3	*Madia exigua*	Little Tarweed
64	MELU	3	*Medicago lupulina*	Black Medic
65	MIGU	3	*Mimulus guttatus*	Common Monkeyflower
66	MINU	3	*Microseris nutans*	Nodding Microseris
67	MYOSO	3	*Myosotis spp.*	Forgetmenot
68	PERY	3	*Penstemon rydbergii*	Rydberg Penstemon
69	PLLA	3	*Plantago lanceolata*	Buckhorn Plantain
70	PLMA	3	*Plantago major*	Rippleseed Plantain
71	PODO	3	*Polygonum douglasii*	Douglas Knotweed
72	POGR	3	*Potentilla gracilis*	Beauty Cinquefoil
73	PRVU	3	*Prunella vulgaris*	Common Selfheal
74	RAAC	3	*Ranunculus acris*	Buttercup
75	RAUN	3	*Ranunculus uncinatus*	Buttercup
76	RUAC	3	*Rumex acetosella*	Sheep Sorrel
77	SEIN	3	*Senecio integerrimus*	Western Groundsel
78	SEST	3	*Sedum stenopetalum*	Wormleaf Stonecrop
79	SMST	3	*Smilacina stellata*	Starry Solomonplume
80	STNI	3	*Stellaria nitens*	Shining Starwort
81	TAOF	3	*Taraxacum officinale*	Common Dandelion
82	THOC	3	*Thalictrum occidentale*	Western Meadowrue

[1]Forage classes: 1 - grasses, 2 - grasslikes, 3 - forbs, 4 - shrubs and trees.

Table A.3.5. (Continued). List of plant species occurred at Hall Ranch of Eastern Oregon during the study years.

#	Alpha Code Name	Forage[1]	Plant Species Scientific Name	Plant Species Common Name
			Forbs	
83	TRDU	3	*Tragopogon dubius*	Yellow Salsify
84	TRPR	3	*Trifolium pratense*	Red Clover
85	TRRE	3	*Trifolium repens*	White Clover
86	URGR	3	*Urtica gracilis*	Slim Nettle
87	VIAD	3	*Viola adunca*	Hook Violet
88	VIAM	3	*Vicia americana*	American Vetch
89	VINU	3	*Viola nuttalli*	Nuttall Violet
			Shrubs and Trees	
90	AMAL	4	*Amelanchier alnifolia*	Saskatoon Serviceberry
91	BERE	4	*Berberis repens*	Low Oregongrape
92	ALIN	4	*Alnus incana*	Alder
93	LIBO	4	*Linnaea borealis*	Twinflower
94	RICE	4	*Ribes cereum*	Wax Currant
95	ROGY	4	*Rosa gymnocarpa*	Baldhip Rose
96	ROWO	4	*Rosa woodsii*	Woods Rose
97	SARI	4	*Salix rigida*	Firmleaf Willow
98	SPBEL	4	*Spiraea betulifolia*	Shinyleaf Spirea
99	SYAL	4	*Symphoricarpos albus*	Common Snowberry
100	PIPO	4	*Pinus ponderosa*	Ponderosa Pine

[1]Forage classes: 1 - grasses, 2 - grasslikes, 3 - forbs, 4 - shrubs and trees.