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Seasonal preferences of steers for prominent northern Great Basin grasses

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Abstract

The objective of this research was to determine, on a seasonal basis, the relative preferences of cattle for 7 native grasses and crested wheatgrass (*Agropyron desertorum* (Fischer ex Link)Schultes), a long-used introduction in the Pacific Northwest. Methods involved observing forage selection processes of 3 steers in paddocks, where plants existed in equal densities and in rangeland pastures with variable forage composition. Design of paddock and pasture studies was a randomized-complete-block with 3 replications, 3 stages of phenology (vegetative, anthesis, and quiescent), and 8–11 forages. Dietary proportions as indexed by bite-counts changed ($P < 0.01$) with phenology and varied among species. Diets were more similar ($P < 0.05$) than forage composition between the 2 study areas (paddocks and native pastures), and became less similar ($p < 0.05$) as phenology of the grasses advanced from vegetative growth through anthesis and quiescence. Steers were selective grazers during vegetative and anthesis stages of phenology, and despite variations in herbage availability, 'Nordan' crested wheatgrass was the most prominent dietary component in paddocks and pastures. Variation in proportions of grasses in the diet was associated ($P < 0.05$) with measures of available forage in the paddocks ($r = 0.46–0.89$, $\bar{x} = 0.72$) but poorly associated with herbage composition in pastures ($r = 0.41-0.02$, $\bar{x} = 0.12$). Inconsistencies in rankings of relative preference indices and dietary proportions of grasses suggested that measures of herbage availability may confound the predictive utility of relative preference indices. More grasses were acceptable to cattle at quiescence, with crested wheatgrass ranging from 8–26% of the diet. We suggest that with proper management, interseedings of crested wheatgrass on native range may be used to lessen grazing demands previously borne by native perennials early in the grazing season.

Key Words: relative preference index, bluebunch wheatgrass, giant wildrye, Idaho fescue, Sandberg's bluegrass, bottlebrush squirreltail, Thurber needlegrass, needle-and-threadgrass, crested wheatgrass

Resumen

El objetivo de esta investigación fue determinar, por temporada, las preferencias relativas de ganado de carne para 7 pastos nativos y "crested wheatgrass" (*Agropyron desertorum* (Fischer ex Link) Schultes), introducido y usado por mucho tiempo en el Noroeste del Pacifico. Los métodos usados incluyeron la observación de 3 novillos pastoreando parcelas experimentales con densidades iguales para cada especie y en praderas naturales con diferente composición de forrajes. El diseño usado en las parcelas y praderas fue de bloques al azar con 3 repeticiones, 3 etapas fenológicas (vegetativa, floración, y dormancia), y de 8 a 11 forrajes. La proporción en la dieta, estimada usando número de mordidas, cambio ($P < 0.01$) con etapa fenológica y vario entre especies. Las dietas fueron mas similares ($P < 0.05$) que la composición botánica entre las dos areas estudiadas (parcelas y praderas), y la diferencia fue mayor ($P < 0.05$) conforme avanzo la fenología de vegetativa a floración y a dormancia. Los novillos pastorearon selectivamente en las etapas vegetativa y de floración, y a pesar de variaciones en la disponibilidad de forrajes, 'Nordan' "crested wheatgrass" fue el componente principal en la dieta tanto en las parcelas como en las praderas. La variación de la proporción de pastos en la dieta estuvo asociada ($P < 0.05$) con las medidas de disponibilidad de los forrajes en las praderas ($r = 0.46–0.89$, $\bar{x}=0.72$) pero poco correlacionada con la composición botánica de las praderas ($r = 0.41–0.02$, $\bar{x} = 0.12$). Las incosistencias observadas en las categorías de los indices de preferencia relativa y las proporciones de pastos en las dietas sugirieron que las medidas de disponibilidad de forrajes pueden confundir la capacidad de predicción de los indices de preferencia relativa. Un mayor número de pastos fueron aceptables al ganado durante la etapa de dormancia, con "crested wheatgrass" entre 8 y 26% de la dieta. Nosotros sugerimos que con un manejo adecuado, crested wheatgrass" puede ser sembrado en praderas nativas para disminuir las demandas previamente soportadas por los pastos nativos perennes al inicio de la temporada de pastoreo.

Over the long-run, selective grazing can affect the structure and composition of rangelands (McNaughton and Geordiadis 1986, Taylor et al. 1993). Efficient range management demands that those responsible for grazing programs have knowledge of seasonal palatability, utilization levels, and nutritional value of the various forages (Malechek and Leinweber 1972, Holechek et al. 1982). Such information can aid in identifying key species, explain shifts in diet quality and animal performance (Holechek et al. 1981), and assist in developing grazing programs designed to retard or stimulate specific components of the vegetation (Anderson and Scherzinger 1975, Reiner and Urness 1982, Gordon 1988).

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Effective means of predicting selective grazing among forages by livestock have not yet been devised (Jones et al. 1994), and managers must rely on demonstrated preferences of animals to predict how specific forages or mixes of forages might be grazed (Hart and Hanson 1990). A substantial volume of literature has addressed quantitative aspects of grazing and defoliation on the subsequent vigor of many range grasses (e.g. Mueggler, 1950, and 1975, Olson et al. 1989, Busso 1990), but little effort has been directed toward documenting relative preferences of grazers for these same forages in many regions. The objective of this research was to determine on a phenological basis (vegetative, anthesis, and quiescent stages of phenology), the relative preferences of cattle for 8 grasses (in paddock studies) and 11 grasses (on native rangeland pastures) that characterize northern Great Basin and Pacific Northwest rangelands. This was accomplished by monitoring forage selection of steers in experimental paddocks, where forages were available in equal density, and in native pastures where levels of forage availability were variable.

Materials and Methods

Experimental Paddocks

Nine experimental paddocks were established on the Northern Great Basin Experimental Range near Burns, Ore. in March and April 1989 (119°42'W, 43°29'N, elevation 1,370 m). Mean annual precipitation is 282 mm, and mean annual temperature is 7.6° C with extremes of –29 and 42° C. Plants of 8 different forages were excavated from native and improved pastures on the station and replanted in the paddocks. All transplants originated from areas characterized by an overstory of Wyoming big sagebrush (*Artemisia tridentata* subsp. *wyomingensis* Beetle). Each paddock contained a grid of 29 rows and 29 columns with 0.61 m between plant centers. One hundred plants of each forage were randomly positioned in each paddock for a total of 800 plants and 41 empty positions in each row:column matrix. This randomized arrangement prevented animals from settling in a given area or row and focusing their grazing activities on a single forage.

The 8 grasses intensively studied were: bluebunch wheatgrass (*Agropyron spicatum* (Pursh) Scribn. & Smith), Idaho fescue (*Festuca idahoensis* Elmer), bottlebrush squirreltail (*Sitanion hystrix* (Nutt.) Smith), needle-and-thread grass (*Stipa comata* Trin. & Rupr.), Sandberg's bluegrass (*Poa sandbergii* Vasey), Thurber's needlegrass (*Stipa thurberiana* Piper), giant wildrye (*Elymus cinereus* Scribn. & Merr.), and 'Nordan' crested wheatgrass (*Agropyron desertorum* (Fischer ex Link)Schultes), a successful and long-used introduction to region. These grasses have wide ecological amplitudes, and one or another typically dominates the herbaceous layer of sagebrush/steppe communities in the region (Daubenmire 1970, Hironaka et al. 1983). Paddocks were rested for 4 growing seasons to facilitate plant establishment. Weeds were controlled throughout the project by tillage or hoeing, and cured standing forage was mowed each fall to a 5-cm stubble.

Experimental Rangeland Pastures

Nine 1-ha pastures were established with electric fencing on native-rangeland having a 60-year history of growing season deferment. The pastures supported an overstory of Wyoming big sagebrush, and in addition to the grasses previously listed, prairie Junegrass (*Koeleria cristata* Pers.), and trace amounts of cheatgrass (*Bromus tectorum* L.) and Indian ricegrass (*Oryzopsis hymenoides* (R. and S.)Ricker). Several forbs were also present, with the most prominent being tapertip hawksbeard (*Crepis acuminata* Nutt.). Soil of the pastures and paddocks was a complex of loam and loamy fine sands (Milican coarse-loamy, mixed, frigid Orthidic Durixerolls and Holtle coarse-loamy, mixed, frigid Aridic Duric Haploxerolls, respectively) (Lentz and Simonson 1986) with depth to bedrock or hardpan ranging between 90 and 150 cm.

Vegetation Sampling

Trials were conducted at vegetative, anthesis, and quiescent stages of phenology as indexed by bluebunch wheatgrass. When compared to bluebunch wheatgrass, the phenology of Sandberg's bluegrass was more advanced, development of giant wildrye lagged well behind, and the remaining grasses closely tracked bluebunch wheatgrass. Readers are reminded, however, that all subsequent mentions of phenology in text and tables relate specifically to development of bluebunch wheatgrass.

Three paddocks and 3 pastures were grazed at each stage of phenology. One to 3 days before paddocks were grazed, the basal area of 5 randomly selected plants of each species was measured. Basal area was derived from a plant's maximum diameter, a second diameter perpendicular to the first, and solving for the area of an ellipse (Jones et al. 1994). Measured plants were clipped to a 2.5-cm stubble to obtain oven-dry (40° C) biomass. Herbage was composited by species within a paddock and retained for subsequent grinding (1 mm screen) and chemical analyses.

Descriptive data gathered from each rangeland pasture focused primarily on grasses and included measures of plant density, biomass, and foliage cover. Density was sampled by counting the number of plants of each species rooted within fifty 1-m^2 plots randomly distributed about the pasture. Foliage cover in each pasture was obtained with the line intercept method (Canfield 1941) from 4 randomly positioned 50-m line transects. Herbage production of each grass and a composited sample of the forbs were sampled from 25, 1-m^2 plots by clipping foliage to ground level. Samples were oven dried at 40° C for 48 hours, weighed, and subsamples of each grass retained for later grinding and lab analysis. Forage quality was indexed by crude protein content (CP = Kjeldahl nitrogen X 6.25) (AOAC 1984) and neutral detergent fiber (NDF) (Goering and Van Soest 1970).

Grazing Trials

One week before each grazing trial, five 2-year old esophageal-fistulated steers were released in an adjoining shrub-steppe pasture to assure their familiarity with our forages. Before steers grazed the paddocks, numbered cards were placed on the ground outside of an enclosing electric fence to expedite rapid identification of each row and column in the paddock. In each trial, 3 steers, equipped with esophageal sample bags (Van Dyne and Torell 1964), were allowed to graze each paddock or pasture. Animals foraged alone to avoid any influence from social facilitation.

At each stage of phenology, the 3 paddock and 3 pasture trials were conducted over 6 successive days. Sampling in the paddocks began with entry of a steer and a computer equipped technician. The technician tallied each bite and noted when the animal abandoned a feeding station and began walking in search of another. Steers were tame and tolerated observers within 2 to 5

m. Because some of the forages could not be rapidly identified from cursory examination, 2 additional observers moved along the X and Y axes of the enclosing fence and simultaneously recorded row/column coordinates of each grazed plant. A steer was allowed to forage until it had grazed on 84 plants with repeat visits to previously grazed stations included in the talley. The steer was led out of the paddock, relieved of its esophageal sample, and the remaining animals given their turns. This protocol generated a total of 252 observations (3 steers × 84 plants), full esophageal sample bags, and assured that none of the forages were completely depleted in a paddock. Esophageal samples were oven dried (40°C), ground, and analyzed for CP and NDF. The same procedures were used for grazing trials in the pastures.

All data were tallied by species across steers within a paddock or pasture. Feeding station coordinates, maps of plant positions, and bite-count data were integrated for each paddock to yield 4 variables: 1) the number of plants grazed (excluding regrazing events), 2) the number of plants regrazed 1 or more times, 3) the total number of bites harvested from each of the 8 forages, and 4) the total amount of time expended grazing each forage. For the pastures the bite count data and sequential species lists were integrated to yield the total number of bites removed from each species and the total amount of time expended grazing each forage.

We employed a modification of Van Dyne and Heady's (1965) relative preference index (RPI = the percentage of a forage in diet divided by its relative contribution to available forage in the pasture) to rank the preferences of steers. For the diet component, our modification involved an integration of the relative numbers of bites harvested, plus the relative numbers of plants grazed, plus the relative amounts of time expended on each forage. Bite counts were intended to reflect dietary proportions. Inclusion of the number of plants grazed increases the contribution of small stature species that might be easily harvested at high frequencies but with very few bites. The addition of the time factor increases the contribution of species that might be more difficult for an animal to harvest (i.e. cattle stripping individual leaves from stems of giant wildrye). In the denominator herbage production, herbage cover, and plant density (which was equal for all species in our paddocks) were integrated. In mathematic form the equation was:

$$RPI = \frac{(\%\text{ bites} + \%\text{ of total plants grazed} + \%\text{ time expended on a forage})}{(\%\text{ herbage production} + \%\text{ herbage cover} + \%\text{ plant density})} \quad (1)$$

Interpretations are identical to Van Dyne and Heady's (1965) index. Indices > 1.0 denote a preference, a score of 1.0 suggests a species is acceptable and taken in proportion to its abundance, indices < 1.0 imply a species was avoided, and a score of zero occurs when a species is not grazed at all.

Statistical Design and Analyses

Project layout was a randomized complete-block design with 3 replicates, 3 stages of phenology, and either 8 (in paddocks) or 11 (in pastures) species of grasses. Because stages of phenology cannot be randomized in a field trial, a split-plot analysis of variance was used with 3 replicates, 3 stages of phenology as whole-plots, and either 8 or 11 species of forage as sub-plots. Phenology effects (2 df) were tested with the block × phenology error term (4 df), while species (7 df for paddocks or 10 df for pastures) and the phenology × species interaction effects (14 df for paddocks and 20 df for pastures) were tested with the phenology × block × species error term (42 df for paddocks and 60 df for pastures). Mean separations were accomplished with Fisher's Protected Least Square Difference ($P = 0.05$) procedures (LSD).

Analysises of variance was used to determine whether relative preference indices differed among forages. If the species effect was significant ($P < 0.05$), a single sample t-test with 2 degrees of freedom tested the null hypothesis that each RPI was not equal to 1.0.

To further explore the degree of selectivity exhibited by the steers, the diets selected in paddock and pasture settings were compared with the relative levels of forage available in each environment. We hypothesized that if the steers were selective in their grazing, diets in the 2 environments would exhibit a higher degree of similarity than one would expect from comparisons of available herbage. We further hypothesized the steers would become less selective as phenology advanced, and that diets in paddocks and pastures would become less similar as the growing season advanced.

To test these hypotheses, bite-count and herbage availability data in corresponding paddocks and pastures were expressed as relative proportions, and Kulczynski's mathematical expression (Oosting 1956) was used to index degree of similarity (S) between steer diets and available herbage. When data are converted to relative values (percentages), S will range between 0 and 100. A value of 0 indicates no common components were shared between the 2 entities, and a value of 100 indicates a complete overlap or duplication of conditions. Because an animal's opportunity to encounter a particular forage may be affected by several characteristics of the vegetation, similarities of available herbage in paddocks and pastures were based on 3 criteria: herbage biomass (kg/ha), plant density per m^2, and percent cover. Because values spanned a wide range, an arcsin transformation was applied. A split-plot analysis of variance with 3 replicates, 3 stages of phenology as main plots, and the 4 different types of similarity indices (diet, biomass, density, and cover) as sub-plots was conducted to test for differences ($P < 0.05$) among means. Mean separations were accomplished with LSD procedures. While analyses and mean separations employed arcsin transformed data, means and standard errors presented in the text are in the original format to maintain continuity with other components of the manuscript.

Lastly, relationships among the several variables employed in this study were investigated with Pearson correlation matrices at each stage of phenology. The objectives of this endeavor were: 1) to quantitatively express the degree of association (r) among the variables, and 2) explore relationships that might provide predictive potential.

Results

In both paddock and pasture analyses, main effects of phenology, species, and their interactions were significant ($P < 0.05$) for all but one variable. Basal areas of plants in the paddocks did not change ($P > 0.05$) over the growing season. Data, therefore, are presented in 2-way tables depicting means for each species at each stage of phenology.

Experimental Paddocks

When grasses were in vegetative and anthesis stages of phenology, steers were selective and focused the majority of their grazing on the introduced crested wheatgrass (Table 1). They grazed from 68 to 74% of the crested wheatgrass plants available, returned to regraze 33 to 50% of those, obtained from 72 to 90% of their total bites from crested wheatgrass, and spent from 76 to 92% of their time foraging on crested wheatgrass. Based on the number of plants grazed during vegetative trials, giant wildrye and bluebunch wheatgrass received a second place ranking, and giant wildrye, bluebunch wheatgrass, and squirreltail were equally ranked below crested wheatgrass at anthesis. Using the number of plants grazed and regrazing efforts during vegetative and anthesis trials, the least preferred species were Sandberg's bluegrass, needle-and-thread-grass, and Idaho fescue. Bite-counts and measures of grazing time provided no mean separations ($P > 0.05$) among the 7 lesser ranked grasses at anthesis.

In an abbreviated effort to obtain more resolution among species in our anthesis trials, all crested wheatgrass plants were clipped to ground-level in 1 paddock and the steers reintroduced to graze among the remaining 7 grasses. In response, the steers simply shifted to giant wildrye. As indexed by total-bites, 51% were taken from giant wildrye, 17% from bluebunch wheatgrass, 16% from Thurber's needlegrass, and the balance was distributed among the remaining 4 taxa (data not shown).

Steers were less focused grazers after grasses entered quiescence. Based on the number of plants grazed, their selection was more equitably distributed among all forages. Numbers of plants grazed and regrazing efforts suggested giant wildrye was preferred, while bite-counts and grazing times implied that crested wheatgrass and giant wildrye were equally preferred.

While equal numbers of each species were present in paddocks, measures of herbage production and basal area suggested that crested wheatgrass was the most available forage during all trials. Giant wildrye was second and Thurber's needlegrass was the third most productive species. Sandberg's bluegrass had the smallest basal area and produced the least herbage during vegetative and quiescent trials.

Rangeland Pastures

During vegetative trials, steers were extremely selective grazers, spending 80% of their time and harvesting 81% of their bites from crested wheatgrass (Table 2). This focus on a single species required a concerted effort, since crested wheatgrass contributed about 6% to total herbage production and constituted roughly 3% of foliage cover and total plant density. With the exception of crested wheatgrass being a preferred forage, no differences occurred ($P > 0.05$) among the remaining 10 grasses in the pastures.

Steers were slightly less selective when bluebunch was in anthesis. Based on total bites, roughly 50% of their diet was derived collectively from crested wheatgrass (27%) and prairie junegrass (23%). Bluebunch wheatgrass (16%) and Idaho fescue (16%) ranked third and fourth in importance (Table 2). Again, the proportion of crested wheatgrass in the diet was quite high given that it was not detected in biomass samples, and it contributed only trace amounts (>1%) to foliage cover and total plant density.

When grasses were quiescent, steers shifted their grazing to bluebunch wheatgrass (37%) and giant wildrye (31%) for a total of 68% of their bites. No differences ($P > .0.05$) were observed among the remaining 9 grasses in the pastures. Crested wheatgrass, which contributed prominently to diets in the earlier trials, accounted for only 8% of the total bites and occupied 13% of the steers' grazing time.

Table 1. The number of plants grazed, percent of grazed plants that were regrazed, total number of bites removed, total grazing time, and characteristics of 8 grasses (herbage available and basal area) during 3 seasonal trials with steers in experimental paddocks on the Northern Great Basin Experimental Range near Burns, Ore. Means in rows sharing a common letter are not significantly different (P > 0.05).

	Species							
	Bluebunch Wheatgrass	Idaho fescue	Squirreltail	Needle and Thread	Sandberg's bluegrass	Thurber's needlegrass	Crested wheatgrass	Giant wildrye
Phenology	Number of plants grazed (#)							
Veg[1].	24.3bc	7.0d	18.7c	6.3d	4.3d	19.3c	74.3a	32.0b
Anth[2].	11.0bc	7.0c	10.3bc	4.7c	7.7c	7.3c	68.0a	16.7b
Quies[3].	29.7ab	24.7bc	24.3bc	14.3d	19.3cd	21.3cd	19.7cd	35.3a
	Percent of grazed plants that were regrazed							
Veg.	3.0c	0.3c	20.c	0.0c	0.0c	4.0c	33.0a	8.3b
Anth.	3.3bc	0.0c	2.0c	1.7c	0.0c	1.0c	50.0a	60.b
Quies.	6.0b	3.7bc	3.0bc	1.3c	1.7c	5.3bc	6.3b	14.7a
	Total number of bites (#)							
Veg.	80bc	12c	62bc	17c	7c	64bc	1232a	237b
Anth.	47b	19b	40b	24b	32b	27b	2936a	122b
Quies.	125b	79b	64b	41b	54b	129b	342a	493a
	Total grazing time (s)							
Veg	68bc	9c	52bc	18bc	6c	51bc	1418a	230b
Anth	39b	13b	34b	30b	40b	23b	3929a	149b
Quies	286b	92bc	88bc	64c	54c	163bc	760a	717a
	Herbage available (g/plants)							
Veg.	39d	90c	75c	44d	24d	164b	521a	511a
Anth.	73g	200d	102ef	118e	80fg	282c	1457a	1096b
Quies.	55g	116f	165e	435c	61g	411d	4877a	1667b
—	Basal area/plant (cm^2)							
x	66bc	30cd	27cd	36cd	22d	85b	289a	83b

[1]Vegetative
[2]Anthesis
[3]Quiescence

Table 2. Foraging behavior of steers (total number of bites harvested and grazing time) and characteristics of vegetation (herbage available, foliage cover, and plant density of grasses) in grazing trials conducted at 3 stages of phenology (vegetative, anthesis, and quiescence) in sagebrush/steppe pastures on the Northern Great Basin Experimental Range near Burns, Ore. Means in rows sharing a common letter are not significantly different (P > 0.05).

	Species										
	Bluebunch wheatgrass	Idaho fescue	Squirreltail	Needle and thread	Sandberg's bluegrass	Thurber's needlegrass	Crested wheatgrass	Giant wildrye	Prairie Junegrass	Indian ricegrass	Cheatgrass
Phenology	Total number of bites (#)										
Vegetative	36b	17b	0b	0b	66b	3b	674a	20b	12b	0b	0b
Anthesis	178ab	136ab	8c	11c	17c	4c	235a	80bc	197a	1c	1c
Quiescent	247a	74b	2b	0b	3b	4b	57b	210a	68b	6b	0b
	Total grazing time (s)										
Vegetative	39b	23b	0b	0b	59b	1b	658a	31b	12b	0b	0b
Anthesis	197ab	102bc	4c	23b	17c	6c	302a	101bc	217a	0c	23c
Quiescent	280a	86b	2b	0b	9b	6b	102b	237a	66b	7b	0b
	Herbade available (kg/ha)										
Vegetative	102b	67bc	4c	0c	261a	8c	37b	28c	64b	1c	2c
Anthesis	260a	106cd	11e	0e	298a	18e	0e	36de	187b	0e	1e
Quiescent	244a	53cd	4d	0d	126b	21d	0d	15d	101bc	6d	1d
	Foliage cover (%)										
Vegetative	5.7b	2.6bcd	0.0d	0.0d	21.9a	0.7c	1.1c	0.3d	3.6bc	0.0d	0.2d
Anthesis	5.1b	4.5b	0.5c	0.0c	29.9a	0.9c	0.5c	0.5c	6.2b	0.1c	0.3c
Quiescent	7.1b	6.3b	0.2c	0.1c	19.8a	0.6c	0.1c	0.6c	5.9b	0.0c	0.1c
	Plant density (#/m^2)										
Vegetative	2.4b	1.3bc	0.2c	0.0c	13.0a	0.7b	0.6c	0.2c	1.4bc	0.0c	24.b
Anthesis	3.3b	1.4c	0.2c	0.0c	10.1a	0.5c	0.2c	0.3c	3.8b	0.0c	1.2c
Quiescent	3.6b	1.9bc	0.1c	0.0c	7.8a	0.5c	0.1c	0.1c	3.6b	0.0c	0.4c

Diet and Forage Similarities Between Paddocks and Pastures

Of the various diet/forage-composition similarity indices, only diets exhibited a significant change as phenology advanced (Table 3). Pasture:paddock comparisons for vegetative trials revealed a 78% level of similarity between steer diets in the 2 environments, which was significantly higher than any of the 3 indices depicting comparisons in available herbage. Diet similarity dropped to 33% during the anthesis trials. A large portion of this decrease was attributed to prairie junegrass which made up 23% of the steers' diets in the pastures, but it was not a component of our paddocks. During the dormant stage of phenology, diet similarity increased slightly to 46%. For both the anthesis and dormant periods, diet similarity was greater (P < 0.05) than indices of herbage availability based on production or cover, but about equal to similarity indices based on relative population densities.

Pasture: Paddock Forage and Diet Quality

As phenology advanced individual grasses and esophageal samples declined in nutritive value, a pattern typical of Mediterranean climates (Table 4). In paddocks, CP content of the grasses averaged 18, 11, and 6%, respectively, during vegetative, anthesis, and quiescent periods. Corresponding esophageal samples contained about 23, 16, and 8% crude protein, respectively, suggesting the steers effectively harvested a higher quality forage than means of the standing crop would suggest. CP of the grasses and esophageal samples from the paddocks was consistently higher than similar samples from pastures. Measures of NDF generally reflected the same patterns in forage and diet quality. Among the grasses, NDF's in the paddocks were approximately 1 to 4 percentage points lower than in the pastures. During 4 of 6 instances, NDF's of esophageal samples were 2 to 5 percentage points lower than means of standing crop samples. The 2 exceptions included our quiescent trial in the paddocks where the mean NDF value of the grasses was 68%, and the esophageal samples averaged 69%. During anthesis trials in the pastures, esophageal samples averaged 69% NDF, and the forages averaged 66%.

Relative Preference Indices

Significant shifts among the rankings of the grasses occurred as the growing season advanced (Table 5), and no grass was universally preferred at all 3 stages of phenology. Four consistent patterns, however, were evident in the data. First, only 1 of the 8 grasses received a preferred ranking at each stage of phenology. Crested wheatgrass was preferred in vegetative and anthesis stages of phenology, and giant wildrye was preferred after grasses entered quiescence. Second, needle-and-thread grass was always avoided. Third, all significant changes in relative preference indices within a species occurred with the advance from

Table 3. Kulczynski's indices (± SE) expressing the degree of similarity of steer diets and forage availability as indexed by herbage biomass, plant density, and cover in experimental paddocks and sagebrush/steppe pastures at 3 stages of phenology on the Northern Great Basin Experimental Range near Burns, Oregon. Means in rows or columns sharing a common letter are not significantly different (P > 0.05).

	Paddock: pasture similarity indices			
Stage of Phenology	Steer diets	Herbage biomass	Plant density	Herbage cover
Vegetative	78±0.9c	21±1.0a	36±5.3b	19±3.0a
Anthesis	33±13.9b	14±1.0a	36±2.1b	18±1.9a
Quiescence	46±3.8b	9±2.0a	38±2.6b	23±4.2a

Table 4. Crude protein and neutral detergent fiber (%) of available grasses and esophageal samples from grazing trials in experimental paddocks and sagebrush/steppe pastures at 3 stages of phenology on the Northern Great Basin Experimental Range near Burns, Ore. Means in rows sharing a common letter are not significantly different (P > 0.05).

	Source of sample									
Phenology and Location	Bluebunch wheatgrass	Idaho fescue	Squirreltail	Needle and thread	Sandberg's bluegrass	Thurber's needlegrass	Crested wheatgrass	Giant wildrye	Prairie Junegrass	Esophageal samples
	Crude protein (%)									
Paddocks										
Vegetative	18.0cd	12.7e	21.6ab	17.7cd	12.9e	16.2d	23.7a	19.6bc	—	22.9a
Anthesis.	9.5cd	7.8d	12.0bc	11.0bc	11.9bc	9.2cd	11.0bc	13.7ab	—	16.2a
Quiescent.	6.9abc	5.2bc	8.3a	4.2c	5.4bc	6.7abc	6.1abc	5.3bc	—	7.5c
Pastures										
Vegetative	13.5bcd	11.0d	14.2b	—	11.4cd	14.1bc	14.7b	17.9a	13.4bcd	14.7b
Anthesis	7.5ab	6.3ab	7.5ab	—	5.6b	8.4a	7.5ab	8.8a	7.9ab	7.9ab
Quiescent	3.3bc	2.2c	3.4abc	—	1.8c	2.3c	3.3bc	6.2a	2.5c	5.5ab
Paddocks	Neutral detergent fiber (%)									
Vegetative	58.8bc	62.4a	50.1e	57.9c	60.2b	60.1b	50.8e	54.9d	—	54.2d
Anthesis	66.6b	67.1b	59.9d	67.3b	57.7e	71.7a	62.5c	61.9c	—	60.3cd
Quiescent	64.9d	69.6c	64.5d	75.9a	70.5c	73.7b	61.3e	65.5d	—	69.4c
Pastures										
Vegetative	61.2abc	61.3ab	58.2bcd	—	63.2a	63.3a	51.8e	57.7bcd	58.6bcd	54.1de
Anthesis	67.2bc	67.7bc	66.1bcd	—	65.3bcde	72.0a	61.8e	62.5de	64.2cde	68.8ab
Quiescent	69.2cd	76.0ab	70.6c	—	79.2ab	79.6a	65.7de	63.1e	75.4b	70.0c

anthesis to the quiescent stage of phenology. And lastly, although it was always scored as simply acceptable, bluebunch wheatgrass received the second highest ranking at each stage of phenology.

Crested wheatgrass was the only forage to receive both preferred and avoided classifications in these trials. When it was green and growing (vegetative and anthesis), it was preferred, but after the grass had ceased growth and cured, it was avoided. In the paddocks, roughly 26% of the steers' total bites were taken from crested wheatgrass during the quiescent stage of phenology, but its prominence in the stand (about 63% of total herbage production and 45% of total basal area) partially explained its avoided classification.

The numbers of grasses seasonally occurring in the preferred, accepted, and avoided classes clearly illustrated that steers were less selective after grasses entered quiescence. Only 3 to 4 grasses were preferred or acceptable in vegetative and anthesis trials compared to 6 grasses at the quiescent stage of phenology. Reciprocally, more grasses were rejected or avoided (4-5) during vegetative and anthesis stages of phenology than during quiescent sessions.

Discussion and Conclusions

Forage Selection and Preference

In a dictionary context "select" is defined as an action of choosing in preference to others. In the context of foraging theory and resource partitioning, cattle are frequently described as being incapable of a fine degree of selectivity (Hormay 1943, Hanley 1982). Inferences in these instances relate specifically to the ability of cattle to harvest the most nutritious portions from structurally complicated forages. Less thorough readers, however, often conclude from such phrases that cattle systematically devour whatever herbage they encounter. In this discussion, "selective" refers to the animals ability to discern and choose from among a collection of different forages. In that light, we found that cattle are very discriminating.

If the first and second most frequently grazed forages were combined in our vegetative and anthesis trials, about 79% of total bites were from 2 forages. Others have noted that a small proportion of the plant community occasionally bears the brunt of the grazing load (Hurd and Pond 1958, Galt et al. 1982), and we agree this is a distinct possibility when cattle are allowed to be selective. In such instances, managers are faced with the dilemma of choosing appropriate key species for condition and trend monitoring. That discussion is beyond the scope of this effort, because each decision ultimately depends on the nature of the plant communities in question and the manager's specific objectives.

Herbage availability often affects preference and grazing behavior (Allison et al. 1982); and the diversity of environments in this project furnish some opportunity for comment. In well-controlled trials where choice was limited to a single species, Laca et al. (1992) and Distel et al (1995) established that cattle graze most efficiently and prefer areas where forage density or bulk density allows the most rapid intake. This efficient behavior would seem to be intuitive, and there is almost universal agreement, this manuscript not withstanding, that some measure of herbage availability be included in quantitative assessments of forage value or relative preference by animals (Ivlev 1961, Heady 1964, Krueger 1972, Jacobs 1974, Loehle and Rittenhouse 1982). Data from our paddock studies lend some support to these contentions, but other aspects of the paddock and pasture trials suggest a realignment of thinking might be in order. In the paddocks, total number of bites among forages were associated ($P < 0.01$) with levels of available herbage. Correlation coefficients (r) were 0.72, 0.73, and 0.65 (data not shown) during vegetative, anthesis, and quiescent trials, respectively. When total bites were related to basal areas of plants, correlation coefficients were 0.85, 0.89, and 0.46, respectively, with the latter value being significant at $P \leq 0.05$. While these relationships imply a significant statistical association occurs between available herbage and dietary proportions, the coefficients of determination (r^2) averaged 0.53 and ranged from 0.21 to 0.79. This suggested that forage availability, as expressed by biomass or cover, can account for approximately 50% of the variation in selection among the grasses.

Table 5. Ranked relative preference indices (RPI) for 8 grasses grazed by steers during forage selection trials at 3 stages of phenology in experimental paddocks on the Northern Great Basin Experimental Range near Burns, Ore. An RPI of less than 1 indicates an avoided forage, greater than 1 suggests a forage was preferred, and a value of 1.0 implies a forage was passively accepted or grazed roughly in proportion to its level of availability.

Stage of phenology					
Vegetative		Anthesis		Quiescent	
Forage	RPI	Forage	RPI	Forage	RPI
crested wheatgrass[1]	2.18*	crested wheatgrass[1]	2.28*	giant wildrye[2]	2.02*
bluebunch wheatgrass[1]	0.79	bluebunch wheatgrass[1]	0.57	bluebunch wheatgrass[2]	1.67
bottlebrush squirreltail[1]	0.76	bottlebrush squirreltail[1]	0.51*	Idaho fescue[2]	1.22
giant wildrye[1]	0.69	giant wildrye[1]	0.44	bottlebrush squirreltail[2]	1.03
Thurber's needlegrass[1]	0.45*	Sandberg's bluegrass[1]	0.41*	Thurber's needlegrass[2]	1.03
needle-and-thread[1]	0.27*	Idaho fescue[1]	0.28	Sandberg's bluegrass[2]	0.94
Idaho fescue[1]	0.21*	needle-and-thread[1]	0.22*	needle-and-thread[2]	0.59*
Sandberg's bluegrass[1]	0.20*	Thurber's needlegrass[1]	0.19*	crested wheatgrass[2]	0.58*

*indicates a significant departure from 1.0 ($P < 0.05$)

[1] RPI's of a species sharing a common superscript across the 3 stages of phenology are not significantly different ($P > 0.05$).

When steers were moved to pastures during vegetative and anthesis stages of phenology, respectively, 81 and 27% of their total bites were selected from crested wheatgrass. In vegetative trials crested wheatgrass constituted about 6% of total biomass, and was roughly 3% of total foliage cover and relative plant density. At the anthesis stage of phenology crested wheatgrass was not detected in herbage production samples but did make up about 1% of total foliage cover and relative plant density. Our perception in the pastures while observing the steers, was that they were seeking out crested wheatgrass. This searching behavior typically involved traveling 15 to 50 m between feeding stations and literally rejecting hundreds of opportunities to graze on alternative forages along the way.

The crested wheatgrass in our pastures was established over the last 40+ years by seed from adjacent areas (south and west) and was not an intentional component of our pasture study. Plant densities and distribution patterns suggested the plants established in abandoned ant-hills or areas disturbed by burrowing activity. Because our data structure allowed derivation of travel time by the steers between successive feeding stations, we speculated mean search time per plant might indicate a greater time commitment for locating individual crested wheatgrass plants than for other forages. Analyses revealed, however, that while the plants were widely dispersed about the pastures, they in fact existed in clusters. As a result there was extreme variability in the data, as steers made extended searches to locate a cluster but were able to quickly move to an adjacent plant for their next feeding bout. Consequently, we could not support our "search time" contention without arbitrarily ignoring certain portions of the data.

Correlation coefficients between available herbage (biomass or cover) in the pastures and total bites harvested from each forage were remarkably poor. Correlation coefficients relating herbage biomass with total bites were –0.08, 0.09, and 0.41, respectively for the vegetative, anthesis, and quiescent stages of phenology, and only the last value was statistically significant ($P < 0.05$). For herbage cover, correlation coefficients were 0.02, 0.04, and 0.08, respectively. Inconsistencies in the rankings of forages using our own relative preference indices in paddocks also occurred. Most notable was the fourth place ranking of giant wildrye's relative preference index at anthesis when all our measures of plant use by the steers indicated it deserved a higher second place ranking. Also supporting this argument was the immediate shift of the steers to giant wildrye for 51% of total bites when we harvested all of the crested wheatgrass from a paddock.

Other researchers (Hurd and Pond 1958, Galt et al. 1982,) have suggested that herbage availability has little to no influence on selection or preferences of cattle in rangeland settings. When overall nutritive value of the environment is high, ungulates focus their grazing on relatively few, but highly profitable, forages (Coleman et al.1989). Others observe that as phenologies of plant communities become mixed, animals reduce species selectivity and graze more in accordance with levels of available herbage (Stuth 1991). Restricted amounts of forage that accompany drought or intensive cropping by animals also reduces selective grazing (Coates 1996, Guevara et al. 1996). We support these contentions, but suggest further research is needed to accurately define the influence of relative availability of forages on an animal's diet and preference

A recent, well-controlled study with sheep demonstrated that dietary proportions of preferred foods were not linearly related to variation in availability (Edwards et al. 1996). When cattle are foraging in a nutritionally rich and diverse environment, we agree that 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. Intensive grazing programs can suppress selective foraging (Allison et al. 1982), and some argue that arid land management should be based solely on control of grazing intensity (Guevara et al. 1996). Many public rangelands are conservatively grazed, however, and selective pressures can stimulate change in community composition (Pacala and Crawley 1992). In these settings we need to develop tools truly capable of predicting effects of extensive grazing programs, and a more thorough understanding of the forage and availability factors affecting animal preference and selection is certainly required.

From a nutritional standpoint, selective grazing by steers facilitated harvest of a higher quality diet than standing crop estimates. With the exception of giant wildrye, CP of forages and esophageal samples tended to be greater in our paddocks than the pastures, and NDF's of the forages were generally lower in the paddocks than in the pastures. The pastures were not grazed in the year preceding our trials, and their lower nutritive value was probably due to contamination of forages by standing-dead plant material. Only current year's growth was available in the paddocks, because they were mowed the previous fall.

Lastly, we want to stress that cattle do graze all of the grasses evaluated in these trials, and one should not reject or accept a potential candidate in a reclamation effort based solely on our findings. With minimal searching, references can be found where 1 or more of these grasses figured prominently in livestock diets, and the animals performed well. The mixture of associated species plays a prominent role in shaping livestock preference and selection (Heady 1964), and there can be significant differences in palatability even among selections within a single species (Murray 1984, Truscott and Currie 1987). Astute managers, however, can soon recognize the inherent tendencies of their livestock and exploit those behaviors to accomplish specific goals.

Conclusions

With the majority of their diet derived from only 1 to 2 grasses, steers were very selective grazers in both paddock and pasture settings during vegetative and anthesis stages of plant phenology. In paddocks steers grazed preferred species more frequently, took more bites from them, and returned to regraze preferred plants before any of the grasses were entirely depleted. This behavior suggests that competitive relationships within plant communities can be altered if 1 or 2 species are repeatedly defoliated over time. In extensive grazing programs where cattle have selective opportunity, we suggest managers can rapidly identify key species if they briefly observe their animals on a representative area. Seasonal adjustments in management programs, however, ultimately depend on the objectives of the landowner and selective patterns of the cattle. We found no consistent associations among measures of forage availability and the preferences of steers in these trials. Our measures of diet similarity in paddock and pasture settings were typically greater than similarities in herbage composition. We suggest that further research is needed to accurately appraise the relationships between levels of forage availability and the seasonally dynamic selective patterns of cattle and the utility of relative preference indices in predictive applications.

Although our steers grazed selectively at the end of the growing season, a broader array of forages received acceptable rankings after grasses entered quiescence. We suggest cattle will graze a mix of forages more uniformly at this stage of phenology, and that managers can more effectively use cattle to clean-up standing litter if the area is pastured after grasses enter dormancy. Nutritional value of the forages will most likely be marginal at that time, and if an extended stay is anticipated, supplementation may be required to sustain animal performance.

Crested wheatgrass has a long history of reclamation use in the Pacific Northwest and Great Basin regions, and its high palatability relative to prominent native grasses suggests its selection was an excellent choice. Most crested wheatgrass seedings were, however, established as near monocultures on historically degraded areas. We suggest that interseedings of crested wheatgrass on native rangeland might be used to lessen grazing demands previously born by native perennial grasses early in the grazing season. Local experiences have shown that such pastures must be intensively managed, however, to prevent a build up of standing litter in the crested wheatgrass. Cattle will reject crested wheatgrass if the plants contain a preponderance of dead stems, and out of necessity, they will again focus on the native grasses. Similar seedings might also be used to encourage livestock use of more distant or less frequented regions of larger pastures. Again though, those areas should not be allowed to accumulate standing litter.

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