Use of Plants in Seasonal Grazing Trials on Chihuahuan Desert Rangeland

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ABSTRACT

Short-term grazing trials were conducted to determine seasonal diet differences and forage plant use patterns on mesa dropseed (*Sporobolus flexuosus* Thurb. ex Vasey) and snakeweed (*Gutierrezia sarothrae* [Pursh] Britt. Rusby) rangelands. Trials were conducted at the Chihuahuan Desert Rangeland Research Center in southern New Mexico during June and September in 1992 and 1993. Each trial lasted 6 days. Stocking rate was 4 cows/ha/trial, except for June 1993 when 2 cows were used.

Objectives of the study were to: measure changes in diets selected by cows as forage availability changed; determine if either moderate grazing or heavy grazing in June (end of the dry season) or September (end of the growing season) caused changes in plant composition, herbage production, and use; compare use techniques for measuring mesa dropseed.

Distinct preference patterns were shown by cows for some species. As preferred species disappeared (e.g., hog potato [*Hoffmanseggia glauca* (Ort) Eifert] and paperflower [*Psilostrophe tagetina* (Nutt.) Rydb.]), other plants became important in the diets, such as fluffgrass [*Dasyochola pulchella* (Kunth) Muell.-Arg.] and desert zinnia (*Zinnia grandiflora* Nutt.). Dropseed, the most abundant grass, comprised large portions of the diets in all seasons. Total above ground biomass was maintained under moderate and heavy stocking in grazed paddocks in September. Total biomass was reduced nearly 50% on the June, heavy-grazed paddocks, with grasses declining 36% and 47% on the moderately and heavily grazed paddocks, respectively. The heavy stocking rate appeared to have more influence on plant biomass present in June 1993, as compared to that present in September 1993. Because paddocks were small, trampling and scuffing caused the disappearance of many individual plants. Use measured on mesa dropseed with the before-and-after grazing technique was considered more representative than using height-weight charts.

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M. Nsinamwa, R. F. Beck, and R. P. McNeely[1]

Forage availability and acceptability are important determinants of diet selection by herbivores. On grazing lands with abundant available forage, cows selectively graze the most desirable plant parts, usually leaves. As percentage of dry material increases, cows are unable to select entirely green diets without decreasing their total intake. Generally the total amount of herbage in a plant community is greater than what cows willingly graze, because of differences in palatability of plants and plant parts (Bailey et al. 1996).

Preferential grazing of leaves and other plant parts affects whether plants survive. Briske and Richards (1994) propose that the importance of grazing on plant growth and plant survival may be more closely related to changes in competitive interactions and abilities among plants than the direct effect of removing photosynthetic material. Grazing animals alter competition among plants by selective plant use resulting from plant characteristics that cause preferences or avoidances (Briske 1991). Evaluating several studies on range grasses, Briske and Richards (1994) reported that plant growth was more dependent on current photosynthesis than on carbohydrate reserves unless soil water and temperature were unfavorable. However, in arid environments like southern New Mexico, it is probable that carbohydrate reserves are important for regrowth and necessary for plants to be effective competitors. Each plant has its own peculiar response to defoliation, and the amount of defoliation affects its ability to survive. For example, the amount of active meristem, root respiration, and nutrient absorption are positively affected by defoliation intensity. But another factor to consider is the age of the photosynthetic material grazed, because young leaf material is more photosynthetically active than older leaves (Briske and Richards 1994). Trampling by grazing herbivores also is a factor that needs to be considered, because it affects the microenvironment and causes physical damage that alters the plants' ability to compete. As a result of vegetation composition changes caused by herbivory, many rotational grazing systems and plans have been developed for different grazing seasons that attempt to counteract the loss of grazing plants (Beck 1980).

The appropriate grazing plan and the correct stocking rates are both important for rangeland perpetuation (Taylor et al. 1997), livestock well-being, and the operator's economic stability. Continuous or seasonal overstocking is certain to result in deteriorated rangeland resources. Low stocking rates may or may not result in improved rangeland conditions, but they generally mean more forage, allowing individual animals to be more selective in their diets and increasing maximum animal production.

The study's purpose was to determine the influence of moderate and heavy grazing before and after the summer rainy season on plant composition changes, and selective use of forage species. It also considered how decreases in forage availability cause changes in cattle diets on mesa dropseed (*Sporobolus flexuosus* Thurb. ex Vasey) and snakeweed (*Gutierrezia sarothrae* [Pursh] Britt. & Rusby) rangelands. A secondary objective was to evaluate use measurements on mesa dropseed with two techniques. Mesa dropseed on this rangeland is a key species.

MATERIALS AND METHODS

Description of the Study Area

The study paddocks were at New Mexico State University's Chihuahuan Desert Rangeland Research

[1]Authors are a former graduate student (currently an instructor in Botswana College of Agriculture, Gaborone, Botswana), professor, and senior research assistant, Department of Animal and Range Sciences, New Mexico State University, Las Cruces, NM 88003-8003. Research was funded through the New Mexico Agricultural Experiment Station.

Center, approximately 38 km north of Las Cruces, New Mexico. The area is a semiarid rangeland characterized by soils (mostly Petroargids and Petrocalcids) ranging from fine sandy to sandy loam texture. Annual average temperature is 16°C, with an average maximum daytime temperature during June of 37°C, and an average maximum daytime temperature during January of 13°C. Spring is the windiest and driest season, with strong winds occurring only in conjunction with storms during the remainder of the year. Annual precipitation during the study was 59% and 12% above the long-term average in 1992 and 1993, respectively (table 1). Summer precipitation was near the average in 1992, and 25% above average in 1991 and 1993. The unusually large amount of rain during the 1991—1992 winter and in May 1992 resulted in a large grass and forb standing crop before the start of the study.

The major grasses found in study paddocks were mesa dropseed, threeawns (*Aristida* spp.), black grama (*Bouteloua eriopoda* [Torrey] Torrey) and fluffgrass (*Dasyochloa pulchella* [Kunth] Steudel). The major half-shrubs were broom snakeweed and desert zinnia (*Zinnia graniflora* Nutt.). Some mesquite (*Prosopis glandulosa* Torrey) grew in the area. A large number of forb species were present.

METHODOLOGY

Paddock Design and Grazing

Two 1-ha paddocks (replicates) were each stocked with 4 cows for 6 days in June 1992 (fig. 1). In September 1992, another replicated pair of 1-ha paddocks were each stocked with 4 cows for 6 days. In 1993, the same paddocks were grazed at the same times as in 1992—for 6 days in June and 6 days in September. Only 2 cows were used for the grazing in each paddock in June 1993, and 4 cows grazed in each paddock during the September trials. Different cows of similar ages were used in each grazing trial. Cows had access to the entire paddock until mesa dropseed (used as a key species) was grazed to near 35% use, which usually took about 4 days. A fence was then put across the paddock, and cows grazed on the remaining 0.5 ha for 2 days to obtain 65% use on mesa dropseed. One cow in each replication was observed for 1 hour each day (generally in the morning) during the trials. The number of bites the cows took of each plant species were recorded for that hour (Mofarreh et al. 1997). Bite count data were summarized by species as a percentage of the total diet eaten that day.

Plant Characteristics and Grazing Use

Five belt transects (0.5 x 10 m) were permanently established in each grazing treatment (a total of 10 transects in each season and replication) for measuring plant attributes. Transects were specifically located in areas with an abundance of herbaceous plants, so there would be a maximum number of each species to follow through the study. Grass, shrub, and forb densities were determined on the 5 transects. Basal area was estimated for all plants growing on the transects. Plant attributes were measured on the transects before and after each grazing trial.

Grazing use estimates were determined by two different methods. A height-weight chart for mesa dropseed was developed for each grazing trial. This technique

Table 1. Monthly and total precipitation (mm) averages of two rain gauges within 1.5 km of study areas.

Month	Years			
	1991	1992	1993	1930—1992*
	(mm)			
January	10	38	35	12
February	11	4	13	11
March	15	8	2	7
April	0	21	2	6
May	3	88	8	8
June	7	15	20	13
July	71	25	88	41
August	63	86	65	45
September	57	8	6	37
October	0	26	10	23
November	24	11	12	12
December	112	46	14	16
Total	372	376	265	236
Seasonal precipitation (July, Aug., Sept.)	191	120	159	127

*Long-term averages are for all gauges on the Chihuahuan Desert Rangeland Research Center.

was used during the grazing trials to determine the use level on mesa dropseed while the cows were grazing. The before-and- after grazing technique was used to estimate percent disappearance (use) by weight for all species (including mesa dropseed). Before and after each grazing trial, different sizes of each plant species were clipped at ground level, put into separate bags, oven dried at 50°C and each plant weighed individually. Only current years' growth was measured. For annual and perennial forbs, generally the entire plant was collected. For grasses and half-shrubs, only green leaves and stems were measured. The basal area of each plant was recorded before clipping. Dry-biomass for each species was calculated in grams per square centimeter of basal area. Dry-biomass/cm^2 was then multiplied by the total basal area (in cm^2) for each species found on the 5 transects. The results were then converted to kilograms per hectare. The difference in weight before and after grazing was expressed as a percent disappearance (use). Before-grazing biomass was used as an estimate of total forage available. Standard errors were calculated for the means for each species in each paddock for each season. No samples were taken from the control paddocks in June 1993.

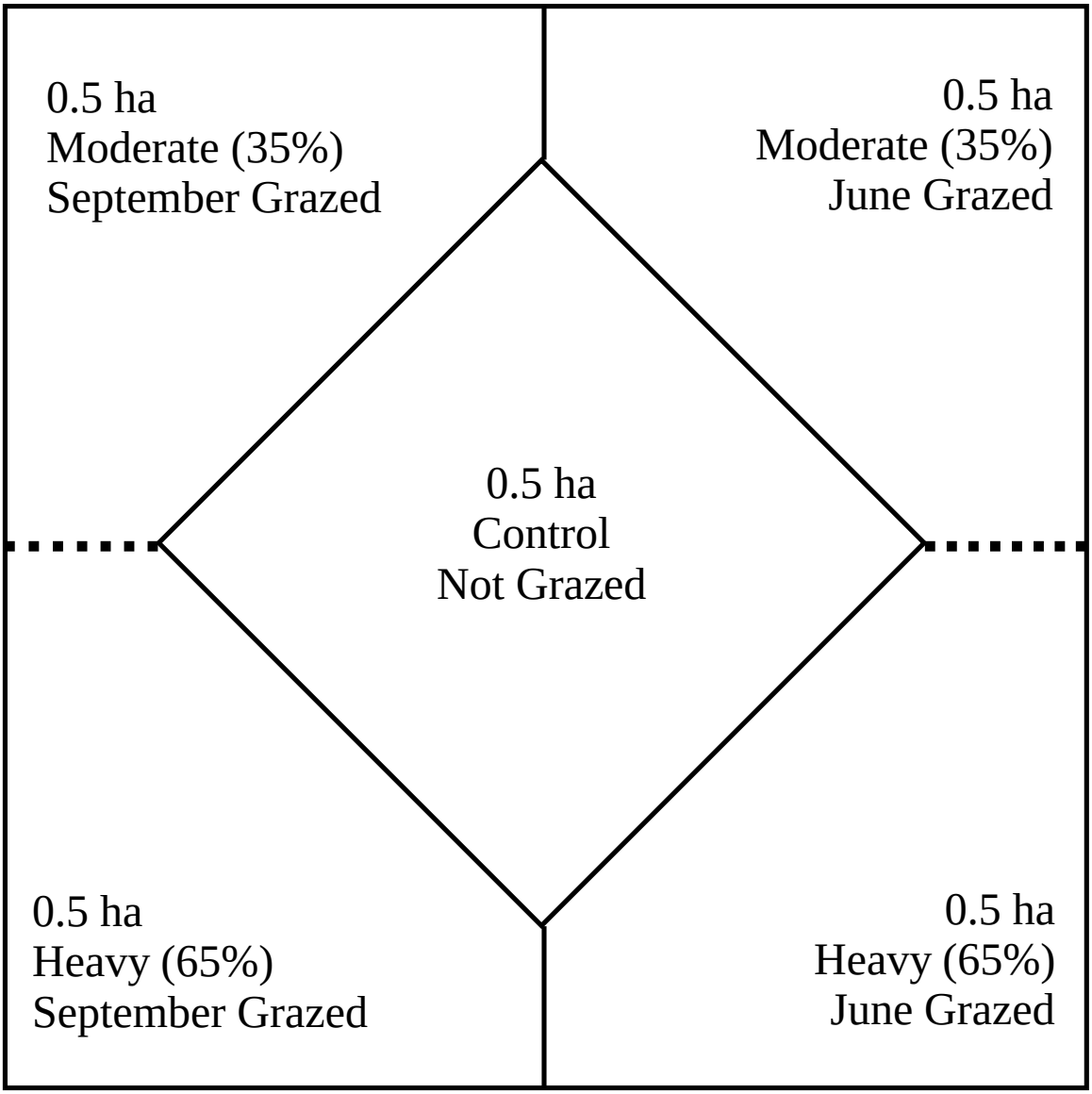

Figure 1. Layout of one replicated paddock. Cows grazed on a side (June or September) until the side was moderately grazed. At that time, a fence was constructed (dotted line) and cows were restricted to one half of the side until it was heavily grazed.

RESULTS AND DISCUSSION

Aboveground biomass available for grazing across the 4 trials was comprised of 4 perennial grasses, 20 to 30 forbs (mostly annuals), and 5 shrubs and half-shrubs, including soaptree yucca (*Yucca elata* Engelm.) (table 2). Aboveground biomass was similar for moderate and heavy grazed paddocks at the study's start in 1992 (table 3). In June 1992, the production of dropseed, threeawn, and snakeweed was unusually high for that early in the summer. This high production occurred because of above-average rainfall in April and May (table 1) which followed above-average rains in mid-winter. In this area, spring months generally are dry, and little herbaceous growth occurs until the start of the summer rains in late June to mid-July. In September 1992, the available forage production was similar in the paddocks prior to grazing and was more typical of production estimates from other studies (Mofarreh et al. 1997; De Alba Becerra et al. 1998). Rainfall in 1993 was approximately equal to the long-term average, and plant biomass availability was again similar to the long-term average production. By June 1993, the effect of grazing and less rainfall during the previous year was noticeable as reduced available biomass (table 3). In September 1993 there was not a clear pattern regarding the availability of grasses and forbs between the moderately and heavily grazed pastures. The lack of a clear pattern can be attributed to there only being one year between sampling dates and also starting the study with a large amount of available plant biomass due to high rainfall. Also, the technique for calculating biomass contributed to the potential variation observed. The estimations of the basal areas of plants growing in the frames were generally consistent. The exceptions were with plants such as snakeweed, that tended to lean over on to the soil surface. Or sometimes the lowest branches were covered by drifting sand and were assigned more basal area than just the area occupied by the single stem. The higher estimates were assigned because of the larger areas dominated (occupied) by the plant.

This same phenomenon was encountered with other plants, such as grasses. During the grazing trial, these plants were often disturbed by the trampling of cows. Therefore, when basal area was measured after the trial, some plants had less basal area covered by soil, and a smaller total basal area was measured.

The other reason for not getting a clear picture of biomass for each species relates to how the multiplier used in conversion was determined. The plants selected to calculate the multipliers were sometimes larger and taller than the average plants growing on the transects. This allowed the numbers used for the multipliers to be larger than what should have been used, considering the size of the plants growing on the transects. These two factors—overestimating the basal areas and using larger than appropriate multipliers—generally resulted in an overestimation of production for snakeweed, dropseeds, and threeawns, but not for other species.

Diets versus Forage Availability

Grasses were the major forage component for cattle in all 4 grazing trials, followed by forbs and then shrubs (table 4). All 4 perennial grasses were eaten in 3 of the 4 trials, while the number of forbs eaten was fewer in trials after June 1992 (table 2). This reduction in forb content was due to lower production available (table 3) and the plants' generally smaller stature. Because of the large amount of rainfall in April and May 1992 there was a relatively large variety of spring and summer forbs available that the cattle sampled (table 2), but did

Table 2. Number of species in each plant class available and eaten by cows in June 1992, 1993, and September 1992, 1993.

Year	Season	Class of plants	Total no. of spp. available	Total no. of spp. eaten
1992	June	Grasses	5	4
		Forbs	22	18
		Shrubs	5	3
1993	June	Grasses	5	5
		Forbs	20	11
		Shrubs	5	3
1992	September	Grasses	5	5
		Forbs	30	14
		Shrubs	5	3
1993	September	Grasses	4	4
		Forbs	22	10
		Shrubs	5	1

not eat in the quantity they did in June 1993 (table 4). Larger percentages of bites eaten for fewer species indicate less abundance of grasses and forbs in June 1993 (table 3) and lower palatability of many forbs because of drier conditions. De Alba Becerra et al. (1998) noted similar findings with heifers grazing in the Chihuahuan Desert, and reported forbs comprised small portions of cattle diets in the nongrowing season.

Generally, more bites were counted per hour in the heavily grazed paddock on days 5 and 6 as compared to the first 4 days when the cattle had access to the entire paddock (both moderate and heavily grazed areas). This could be attributed to a change in bite size, which becomes smaller as forage availability becomes less (Bailey et al. 1996). Or, as species preference changed, the cattle ate smaller-sized plants and took more bites in order to satiate their requirements. Arnold (1964) reported that highest biting rates were observed when forage was limited, especially when there was green growth.

The diets selected by the cows depended to a large degree on a species' abundance. Considering his work with crested wheat grass pastures (*Agropyron* spp), Scarnecchia et al. (1985) suggested that biting rate and grazing time are affected by leaf:stem ratio and forage maturity as well as forage density. Dropseed was the most abundant species (table 3) and no general pattern of preference was seen for it in any of the trials (table 4). In all trials, dropseed plants made up the bulk of the total forage eaten. However, dropseed plants provide green growth earlier and respond more quickly to summer showers than other warm-season grasses growing in this region.

For other species, availability and preference were important factors in the diets selected. The cows had been grazing on a similar vegetation type before being put on the study paddocks. Diet selected on the first day probably represented preferred species. As these species become less abundant other species became more important. Black grama, for example, was not eaten in June 1992, even though it was green and flowering. In June 1993, when there was less forage and most plants were dry, black grama was heavily used (95% use on the black grama on the heavily grazed paddock) (table 6). Black grama was readily eaten in September of both years. Fluffgrass, a species generally considered not important for cattle, was eaten in all trials, with most consumption in the latter part of each trial. Threeawns were eaten in all trials with overall percentage of the diets increasing toward the end of the trials. Shortness of threeawn plants and presence of seedheads caused the animals to take many bites from around the base of the plants without obtaining much material in any individual bite.

Forb consumption showed similar patterns to that of grasses with some being eaten more at the beginning of the trials. As they disappeared, other species became more common in diets. Both paperflower (*Psilostrophe tagetina* [Nutt.] Rybd.) and hog potato (*Hoffmenseggia glauca* [Ort] Eifert) were readily eaten at the beginning of each trial, but the percentage in the diets declined during each trial (table 4). Percent of croton (*Croton potsii* [Klotzsch] Muell.-Ang.) in the diets generally increased from the first to last day in all trials. Desert holly (*Acourtia nana* [Gray] Reveal & King) in diets tended to increase for both trials in 1993, even though biomass was low (table 3).

Generally, average shrub aboveground biomass was greater than forbs' or grasses' biomass (table 3). Broom snakeweed and desert zinnia, both half-shrubs, were the two major shrubs in the study area. Yucca and some mesquite were present in the paddocks, but did not occur in the plots used for measuring biomass. Highest aboveground shrub biomass was in June 1992, with 974 kg/ha and 1,193 kg/ha before grazing on the moderate- and heavily-grazed paddocks, respectively. Shrub biomass was generally lower in the paddocks grazed in September than in June.

Broom snakeweed was abundant in June and September in both years, but the cows were not observed eating it in any of the grazing trials. Desert zinnia biomass fluctuated from season to season even when other forage species became limited. Its production was greater in moderately grazed paddocks than on heavily grazed paddocks. Results indicate that both shrubs responded similarly to seasonal changes, but differently to grazing because one was eaten and the other was not. The highest bite count of desert zinnia was recorded in September, 1993, and the least amount in the diets was recorded in June 1992. Although results showed some fluctuations from season to season, generally the percentage of desert zinnia in diets was higher during the latter part of each grazing trial.

Low rainfall in spring 1993 coupled with grazing effects from 1992 trials might be the cause of low forage availability and, hence, diet changes in the June and September 1993 trials. Changes observed in diets during each trial are most likely related to total available biomass and palatability of available forage. Because of the shortness of each grazing trial there was little time for physiological changes that might affect palatability or plant compositional changes other than plant losses due to hoof action. As preferred species were eaten, the ratio of palatable (green forage material) to unpalatable (old, dry plant material) decreased and other plant species offered better opportunities for foraging. Stature of plants also appeared to be a factor with smaller plants offering less forage material per bite at the end of each trial. Different patterns of preference found for forbs and desert zinna within and between trials were in part due to their response to the available rainfall patterns. Timing of the rain events prior to grazing trials

Table 3. Average aboveground biomass (kg/ha ± SE; mean of two replications) by species before grazing on grazed and control paddocks in June and September, 1992 and 1993. Control paddocks were not sampled in June 1993.

Species	Stocking rate	June 1992 kg/ha	June 1992 SE	June 1993 kg/ha	June 1993 SE	September 1992 kg/ha	September 1992 SE	September 1993 kg/ha	September 1993 SE
Grasses									
Threeawns	control	257	112			243	66	271	74
(*Aristida* spp.)	moderate	171	102	247	133	196	66	155	58
	heavy	53	38	85	27	105	60	49	16
Black grama	control	0	0			2	2	0	0
(*Bouteloua eriopoda*)	moderate	47	47	65	65	28	28	18	18
	heavy	0	0	0	0	10	10	8	8
Fluffgrass	control	47	14			46	24	77	24
(*Dasyochloa*	moderate	14	4	13	4	18	10	7	3
pulchella)	heavy	33	13	26	8	19	8	13	5
Hall's panicum	control	0	0			0	0	0	0
(*Panicum hallii*)	moderate	0	0	0	0	0	0	T	0
	heavy	7	6	2	2	3	3	T	0
Mesa dropseed	control	499	139			247	74	240	105
(*Sporobolus*	moderate	479	140	192	69	356	86	195	55
flexuosus)	heavy	364	144	230	127	140	28	208	76
Subtotal	control	804	97			538	57	588	58
	moderate	710	89	516	49	598	69	375	41
	heavy	458	69	343	43	277	28	280	39
Perennial forbs									
Desert holly	control	67	43			21	14	16	14
(*Acourtia nana*)	moderate	0	0	0	0	0	0	1	1
	heavy	1	1	T	0	2	1	1	1
Twin leaf	control	7	3			11	6	5	2
(*Cassia*	moderate	6	3	3	2	3	2	1	0
bauhinioides)	heavy	5	2	1	1	4	2	1	0
Leatherweed croton	control	516	152			176	62	252	75
(*Croton potsii*)	moderate	250	118	140	52	160	52	34	13
	heavy	146	76	126	51	98	47	246	72
Hog potato	control	23	20			13	8	16	14
(*Hoffmanseggia*	moderate	5	5	6	6	10	8	1	1
glauca)	heavy	7	5	6	3	7	5	1	1
Paperflower	control	31	31			29	28	0	0
(*Psilostrophe*	moderate	23	15	18	11	22	13	42	35
tagetina)	heavy	1	1	1	1	3	3	23	23
Silverleaf nightshade	control	32	19			24	13	11	8
(*Solanum*	moderate	3	3	0	0	21	12	2	1
elaeagnifolium)	heavy	20	16	4	3	7	4	1	0
Tetraclea	control	9	5			7	4	6	4
(*Tetraclea coulteri*)	moderate	3	3	2	1	2	1	1	1
	heavy	37	27	1	0	0	0	0	0
Other	control	19	18			7	7	6	6
	moderate	8	7	21	14	2	1	39	15
	heavy	7	6	14	12	2	1	31	24
Subtotal	control	704	62			288	20	312	31
	moderate	297	30	191	17	220	19	122	7
	heavy	224	17	154	15	122	12	305	30

Table 3. Continued

Species	Stocking rate	June 1992 kg/ha	June 1992 SE	June 1993 kg/ha	June 1993 SE	September 1992 kg/ha	September 1992 SE	September 1993 kg/ha	September 1993 SE
Annual forbs									
Gray goosefoot	control	4	4			0	0	0	0
(*Chenopodium*	moderate	4	4	0	0	1	1	0	0
incanum)	heavy	11	7	0	0	1	1	0	0
Spectaclepod	control	119	79			18	12	2	2
(*Dimorphocarpa*	moderate	0	0	1	0	0	0	0	0
wislizenii)	heavy	2	2	3	3	0	0	7	5
Abert's buckwheat	control	14	10			17	13	6	4
(*Eriogonum*	moderate	1	1	0	0	17	17	1	1
abertianum)	heavy	9	6	0	0	7	5	3	1
Russian thistle	control	4	3			9	9	0	0
(*Salsola tragus*)	moderate	11	11	0	0	185	165	2	2
	heavy	16	7	0	0	6	4	9	7
Other	control	11	9			0	0	4	2
	moderate	3	3	1	1	23	20	3	2
	heavy	1	1	1	1	11	6	5	4
Subtotal	control	151	22			0	4	13	1
	moderate	18	2	2	1	227	35	6	1
	heavy	39	3	4	1	25	2	24	2
Half-shrubs									
Snakeweed	control	589	216			324	138	261	115
(*Gutierrezia*	moderate	934	497	965	407	215	163	472	219
sarothrae)	heavy	1154	563	738	344	391	168	222	119
Plains zinnia	control	49	48			41	32	12	12
(*Zinnia grandiflora*)	moderate	40	38	10	9	12	11	8	7
	heavy	39	36	14	12	2	2	5	5
Subtotal	control	638	270			365	141	273	125
	moderate	974	497	975	477	228	102	480	232
	heavy	1193	563	751	362	393	195	227	108
Herbaceous total	control	1659	203			826	155	913	166
	moderate	1026	201	709	150	1044	125	503	109
	heavy	721	121	500	98	424	74	608	90
TOTAL	control	2297	145			1235	112	1186	118
	moderate	2000	213	1869	213	1272	93	983	110
	heavy	1913	253	1258	162	818	82	835	64

T = > .05 kg/ha aboveground production

influenced composition as well as size of individual plants, and both contributed to differences in diets observed between June and September trials. These observed diet selection patterns were described by Stuth (1991) in discussing animal preference in relation to availability. In his discussion, he categorized one group of plants as having secondary preference, meaning plants that change from being avoided to preferred by the herbivores as herbage biomass declined. Generally, these plants are considered to have some morphological constraints affecting grazing selection. Threeawns and fluffgrass (possibly because of awns), leatherweed croton (possibly because of leaf texture), and paperflower (possibly because of taste) are plants in this study with morphological constraints.

Use

Calculating plant use by before-and-after weight difference includes loss of weight due to the hoof action and trampling of individual plants of the different species. The soils were relatively sandy. As a result of the animals walking across the small paddocks, many plants were broken off or scuffed out of the ground. An example of this (table 5) shows the difference for mesa dropseed use calculated by before-after and height-

Table 4. Average percentage of bites eaten of common plant species. Cows were observed each day for 1 hour in each replication in June and September in 1992 and 1993.

	Percent											
	Days						Days					
Category[3]	1	2	3	4	5	6	1	2	3	4	5	6
	June 1992						June 1993					
Grasses												
Mesa dropseed	55	74	73	90	65	43	54	34	24	27	22	28
Blackgrama	0	0	0	0	0	0	0	2	2	0	1	0
Fluffgrass	0	0	0	0	3	4	1	1	1	7	7	5
Threeawns	0	0	1	1	2	27	0	18	21	24	32	41
Subtotal	55	74	74	91	70	74	55	55	48	58	62	74
Forbs												
Desert holly	0	0	0	0	0	3	0	2	14	0	7	1
Hogpotato	6	2	3	1	0	0	2	1	T	T	0	0
Leatherweed croton	0	2	7	3	19	11	14	26	24	29	23	15
Paperflower	11	5	3	1	T[2]	T	12	3	4	1	T	T
Subtotal	17	9	13	5	19	15	29	33	42	30	31	17
Shrubs												
Broom snakeweed	0	0	0	0	0	0	0	0	0	0	0	0
Desert zinnia	0	1	2	1	3	2	3	4	4	6	4	9
Yucca	1	T	0	1	3	5	8	1	2	T	0	0
Subtotal	1	2	2	2	6	7	11	5	6	7	4	9
Other annuals	18	12	10	3	5	3	2	7	2	2	2	0
Other perennials	9	3	2	1	0	0	3	2	2	1	0	0
Other shrubs	0	0	0	0	0	0	0	0	0	2	2	T
Subtotal	27	15	12	4	5	3	5	9	4	5	4	T
Total	100[4]	100	101	102	100	99	100	102	100	100	101	100

[1]Cows had access to both moderately and heavily grazed paddocks for days 1-4 and were restricted to heavily grazed paddocks on days 5 and 6.

[2] T < .05%

weight techniques. The height-weight technique gives a fairly clear distinction between the percent use on the moderately and the heavily grazed portions of the paddocks for all seasons. The use estimates are generally higher with the before-and-after weight technique, probably because many small plants were trampled and scuffed out or pulled out and grazed. The total density and basal area were less for a species after grazing. In September 1993, use was lower when calculated by weight in both moderate- and heavy-grazed paddocks. This may have been due to less green or new forage compared to the dry, old forage. In calculating use with the before-and-after technique, only differences in green forage weights were used. However, dropseed use with the height-weight charts used total heights that sometimes included old, dry leaves and stems—not just green material. Therefore, measuring grazed heights of dropseeds would include dry stems and leaves that had been grazed, and percent use would be higher than if only green material was considered as in the before-and-after calculation.

Forb and half-shrub use is not well documented in literature. There is no satisfactory technique to determine use over an extended period. The height-weight technique does not appear practical for this group of plants because of their growth forms. The before-and-after weight technique can only be used for short grazing periods as used in this study. The 100% use obtained on some species in some trials indicate that the plants disappeared (eaten or trampled out) during the trial. The 0% use for some plant species on some paddocks may be because the species were not available (annual) or because no bite count was recorded. For example, the animals sometimes ate a species on the heavily grazed paddock and not on the moderately grazed paddock, even though it grew in both paddocks. Aberts buckwheat and silverleaf nightshade are examples of this.

Table 4. Continued

Category	Percent											
	Days						Days					
	1	2	3	4	5	6	1	2	3	4	5	6
	September 1992						September 1993					
Grasses												
Mesa dropseed	76	48	66	65	44	44	50	43	43	40	28	26
Blackgrama	4	27	12	5	3	4	8	9	7	2	0	0
Fluffgrass	1	T	2	1	2	0	T	4	10	12	13	15
Threeawns	1	1	4	10	24	31	0	0	1	11	17	30
Subtotal	82	77	85	81	73	79	59	57	60	65	59	71
Forbs												
Desert holly	0	0	0	0	0	0	0	1	1	3	5	1
Hogpotato	T	2	T	T	0	0	5	2	T	2	T	0
Leatherweed croton	3	4	3	7	14	12	0	5	14	17	20	23
Paperflower	7	5	2	1	T	1	19	8	2	2	0	0
Subtotal	10	11	5	8	14	13	24	16	18	24	26	24
Shrubs												
Broom snakeweed	0	0	0	0	0	0	0	0	0	0	0	0
Desert zinnia	1	5	1	3	2	0	6	14	16	4	15	5
Yucca	0	0	1	1	1	1	0	0	0	0	0	0
Subtotal	1	5	2	4	3	1	6	14	16	4	15	5
Other annuals	6	7	7	5	10	7	10	10	5	6	0	0
Other perennials	1	0	0	0	0	0	2	4	1	1	0	0
Other shrubs	0	0	1	2	0	0	0	0	0	0	0	0
Subtotal	7	7	8	7	10	7	12	13	6	7	0	0
Total	100	100	100	100	100	100	101	100	100	100	100	100

[3] Scientific names for plants listed can be found in table 3.

[4] Subtotals may not add to 100% due to rounding.

Another problem with determining grazing use for forbs is that many disappeared during the trials. It is difficult to determine whether the cows pulled them out of the ground and ate them, or whether they were scuffed out of the ground. By watching the animals graze, it is possible to observe patterns of grazing selection and avoidance. Snakeweed was never observed to be eaten during any trial, yet some use is indicated with the before-and-after technique. This disappearance is most likely due to trampling.

SUMMARY AND CONCLUSIONS

Average biomass of grasses decreased with both levels of stocking after the first year. Forb and shrub biomasses also declined in the June grazed paddocks after one year, while they remained nearly similar or increased in the September grazed paddocks. Cattle

Table 5. Dropseed use determined by differences between weight before and after grazing and by height-weight ratios at two stocking rates.

Year	Season	Level of grazing use	Percent use by	
			Before and after weight	Height-weight ratio
1992	June	moderate	47	38
		heavy	67	68
1993	June	moderate	63	39
		heavy	63	54
1992	September	moderate	66	37
		heavy	74	65
1993	September	moderate	23	40
		heavy	59	70

Use by weight takes into account disappearance as well as amount eaten.

Table 6. Use of grasses, forbs, and shrubs determined by weight differences before and after grazing at two stocking rates.

Species	Stocking Rate	June 1992 Use (%)	June 1993 Use (%)	Sept.1992 Use (%)	Sept. 1993 Use (%)
Grasses					
Dropseeds	moderate	47	63	66	23
	heavy	67	63	74	59
Blackgrama	moderate	-1	50	33	26
	heavy	-1	95	50	56
Fluffgrass	moderate	0	33	0	0
	heavy	-1	50	50	18
Three-awn	moderate	14	25	26	24
	heavy	17	19	36	41
Forbs					
Aberts buckweed	moderate	0	0	50	31
	heavy	70	0	67	68
Desert holly	moderate	0	0	0	0
	heavy	0	100	0	0
Goosefoot	moderate	83	0	80	0
	heavy	83	0	83	0
Hogpotato	moderate	75	100	70	38
	heavy	88	100	67	83
Leatherweed-	moderate	50	0	70	40
croton	heavy	65	0	0	56
Paperflower	moderate	26	77	0	50
	heavy	63	33	0	17
Russian thistle	moderate	33	0	0	0
	heavy	80	0	60	0
Silverleaf nightshade	moderate	0	0	50	44
	heavy	57	100	50	50
Tetraclea	moderate	0	100	33	100
	heavy	0	100	0	0
Twinleaf	moderate	75	50	0	100
	heavy	75	100	0	67
Shrubs					
Broom snakeweed	moderate	5	11	18	7
	heavy	4	9	-0.4	5
Desert zinnia	moderate	80	0	40	30
	heavy	78	67	70	58

*Percent use was calculated from weights before and after.

*Negative numbers indicate increase in weight from before to after grazing (considered as no use).

diets changed throughout each of the 6-day grazing trials. Dropseeds and threeawns were important grass species in all seasons, while black grama and fluffgrass were only important in September diets. Leatherweed croton was the important forb species. Paperflower was a forb species that was preferred and eaten at the beginning of each trial, but very little was eaten during the latter part of each trial. Desert zinnia was eaten during each trial, comprising up to 16% of the diet in September 1993. Yucca blooms were readily eaten when available in June. A small amount of yucca leaves was eaten each September.

The study also showed that more forage production can be maintained under a moderate stocking rate, regardless of the season. The lowered forage production in the heavily grazed paddocks was partially a loss of plants due to direct trampling and physical disturbance of sandy soil. The before-and-after use technique measured disappearance of small plants, seedlings, annual grasses and forbs that were trampled by hoof action. In

contrast, use of height-weight charts on mesa dropseed gave a good indication of use of established plants. However, it did not take into account disappearance of dropseed seedlings. Problems encountered during this study in measuring use are aptly described by Sharp et al. (1994) in their review about use and whether it has value as a management tool. Using the height-weight technique on dropseed to indicate when to close the moderately grazed paddock to grazing and let the cows graze only on the heavy-grazed paddock worked well. But it also is obvious that the height-weight technique (table 5) did not represent the amount of dropseed biomass that disappeared.

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