GRAZING DEMONSTRATION ON RECLAIMED LANDS AT THE BLACK THUNDER MINE, CAMPBELL COUNTY, WYOMING [1]

by

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Abstract. One of the standards of reclamation success is demonstrating the ability of the reclaimed plant community to sustain grazing pressure by domestic livestock and native wildlife that is at least equal to premining grazing pressure. Five to seven-year old reclaimed areas at the Black Thunder Mine were utilized in designing and constructing a two pasture rotational grazing system that encompasses a total of 74 hectares. The study design includes vegetation monitoring to document forage utilization and determine changes in vegetation due to grazing, and livestock weighing to determine animal performance while grazing mined land vegetation. In 1988, the first year of the study, Black Angus-Hereford cross (black-baldy) yearling steers were introduced to the west pasture in mid-May. The cattle were moved into the east pasture in mid-July where they remained until mid-September. Vegetation data were collected in mid-July and again in mid-September to provide baseline pasture vegetation characteristics and forage utilization data. First season results indicated excellent animal performance under 60-70% forage utilization, with average daily gains of 1.03 and 0.6D kilograms/animal/day during early and late rotations, respectively, and an average gain of D.83 kilograms/animal/day season-long. Vegetation responses to grazing will be determined after post-grazing sampling in 1989 and 1990.

Additional Key Words: Revegetation, Cattle, Plant Response

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Introduction

Land use goals for most reclaimed surface-mined lands in Wyoming include establishment of stable self-perpetuating rangeland vegetation for support of wildlife and domestic livestock (Boles 1984). In terms of livestock grazing, revegetated lands must prove capable of both withstanding proper grazing pressure and meeting animal forage requirements (DePuit 1988, Laycock 1989).

Although protection of revegetated coal mined lands from grazing is legally mandated for at least the first two to three years of plant growth, grazing may be allowed in subsequent years to enhance certain aspects of the reclamation process (Boles 1984). For example, past research in the northern plains region has suggested a potential role of controlled grazing for improving vegetation productivity, changing plant species composition, increasing diversity, and/or accelerating carbon-nutrient cycling and pedogenesis (DePuit and Coenenberg 1989, Young and Rennick 1983). Furthermore, animal performance while grazing revegetated mined lands may provide one important indication of reclamation success from the standpoint of grazing utility (Sindelar and Murdock 1985, Ries and Hofmann 1984). For these reasons, incorporation of livestock grazing within operational reclamation programs is becoming more common at mines within the northern great plains region (e.g., Kleinman et al. 1984, Williamson 1981, Coenenberg 1982). Results of most demonstrations and research efforts have been positive, indicating that, with proper management, livestock can be successfully grazed on reclaimed lands with no adverse effects on vegetation or other site characteristics (Laycock 1989).

Although livestock grazing programs have been conducted at several Wyoming mines, most of the published information on mined land grazing in the region has been generated by studies in the surrounding states of Montana (e.g., Kleinman et al. 1984, DePuit and Coenenberg 1989, Young and Rennick 1983), North Dakota (e.g., Ries and Hofmann 1984, Hofmann and Ries 1988, Williamson 1981) and Colorado (e.g., Laycock and McGinnies 1985). An exception was the research of Schuman et al. (1986), which reported positive vegetation and animal responses under a three year season-long grazing regime on central Wyoming uranium mined lands. The fact remains, however, that a paucity of published information exists on mined land grazing within the Powder River Basin coalfields of northeastern Wyoming--the leading coal producing area of the northern great plains.

Objectives

A three year, two pasture rotational grazing demonstration was initiated in early 1988 on northeastern Wyoming coal mined lands revegetated primarily to a mixture of cool-season perennial grasses. The broad goals of this project are two-fold:

1. To determine the influence of the applied cattle grazing regime on productivity, structure and composition of vegetation, and

2. To evaluate the capability of established vegetation to support cattle under season-long rotational grazing, as determined by animal growth responses.

These two goals focus on key issues related to post-mining land use and management of this and similarly revegetated minesites in the area. If vegetation is demonstrated to adequately support livestock while either withstanding or benefiting from grazing use, it will be possible to state with a greater degree of certainty that reclamation objectives related to livestock production can be met with current technology. Conversely, if certain results prove negative, the need for and possible approaches toward improvements in reclamation methods will be clarified.

Methods and Procedures

Study Area Description

This study was conducted on a revegetated site at the Black Thunder Mine (Thunder Basin Coal Company) approximately 65 kilometers south of Gillette, Campbell County, Wyoming. Elevation of the mine ranges from 1408 to 1477 meters, and the climate is semiarid and continental. Annual precipitation averages 33 centimeters, most of which occurs as rain from April through July. Pre-mining vegetation is characterized by a mosaic of native rangeland plant communities, containing elements of both shortgrass and northern mixed prairie plant associations (Fisser et al. 1975). Specific plant communities are variously co-dominated by cool-season perennial grasses [e.g., western wheatgrass,(*Agropyron smithii*) and needle-and-thread grass, (*Stipa comata*)], warm-season perennial grasses [e.g., blue grama, (*Bouteloua gracilis*)] and shrubs [e.g., Wyoming big sagebrush, (*Artemisia tridentata ssp. wyomingensis*)]. The primary pre-mining uses of area rangelands involve support of wildlife (most conspicuously pronghorn antelope and mule deer) and grazing by cattle and sheep.

The specific study site occupies a previously mined and reclaimed area at the northeast corner of the mine (in Sections 9 and 16, T43N, R70W). After mining, spoils were graded to a varied topography (level uplands/lowlands, steeper slopes and drainages) and covered with 61 centimeters of topsoil. The site was drill seeded in the fall and spring of 1981, 1982 and 1983 with a mixture of native and introduced cool and warm season perennial grasses and fourwing saltbush (*Atriplex canescens*), at a rate of 22.4 kilograms PLS/hectare; the site was subsequently mulched with hay at 4484 kilograms/hectare. The site was fertilized with phosphorus (at 56 kilograms available P/hectare) in 1982 and nitrogen (at 56 kilograms available N/hectare) in 1983. By 1988, the site had become dominated (approximately 71% composition) by the seeded cool-season native grasses thickspike (*Agropyron dasystachyum*), western (*A. smithii*) and, secondarily, slender (*A. trachycaulum*) wheatgrasses. Crested wheatgrass (*Agropyron cristatum*), the only introduced species, was a co-dominant species (approximately 23% composition).

Grazing System Design/Implementation

Pastures. Two fenced pastures, one approximately 40 hectares and the other approximately 34 hectares, were constructed on the oldest reclaimed areas in the north pit (Figure 1). The fenced pastures include areas that were reclaimed in 1981, 1982 and 1983, as well as some drainage areas that were interseeded via hydroseeding in 1985. A livestock watering source was centrally located on the fence line that divides the two pastures. Water was pumped from a permanent impoundment to a 2000 gallon tank trailer which gravity fed a 1250 gallon livestock tank.

Livestock. In 1988, the pastures were grazed from mid-May to late September with 25 head of first generation cross Hereford-Black Angus (black baldy) steers. These steers were purchased in the spring and were sold in late September after removal from the second pasture. The initial weights for the steers ranged from 170 to 256 kilograms. The project design calls for the same breed of cattle to be used in subsequent years. Stocking rates may vary depending on the results of the earlier years of the study and current year plant production.

Grazing Schedule. The study design calls for livestock to be placed in one of the pastures on or about May 15th. Grazing in this pasture will continue until approximately July 15th or until a level of approximately fifty percent (50%) utilization of the forage has occurred. If 50 percent utilization has not been attained by July 15th, the cattle will still be moved to the other pasture on July 15th, where they will remain until approximately October 1st. After the first of October, the cattle will be removed from the second pasture and will be sold. The sequence of early and late season use will be alternated between the two pastures among successive years of grazing. This schedule will be followed for the first three years of the study. Depending on the results of the study, it is possible that both pastures will be rested the fourth year.

During the first year of the study (1988 growing season), the cattle were placed in the west pasture (34 hectares in size) on May 17th and were kept there until July 25th (69 days). On July 26th, they were released into the east pasture (40 hectares in size) and were allowed to graze until September 26th (62 days). It should be noted that the recorded annual precipitation for the first year of the study (1988) was 13.6 centimeters, only 41 percent of normal.

Dietary Supplements. No dietary supplements other than salt blocks will be provided. Salt blocks were strategically placed to enhance livestock utilization of all portions of the pasture.

Livestock Treatments. During the first year of the study, the cattle were inoculated with Ivomec, a parasiticide for the control of internal and external parasites of cattle, prior to being turned into the first pasture. The cattle were also ear-tagged with a fly tag in one ear and a numbered tag in the other, and were branded with the official Company insignia. To help control flies, a commercial oiler was placed in one pasture and a homemade backrubber was placed in the other. The cattle were also sprayed when they were moved from one pasture to the other. Permectrin II/10% EC was the chemical used on all three treatments mixed with the appropriate solution.

Measurements

Vegetation

The vegetation data collection program consists of obtaining information about productivity, forage utilization, species composition, shrub density, and vegetation canopy cover in each of the pastures.

Production/Utilization Data. Plant biomass data were collected using a harvest method and were measured using three separate, but complementary approaches. The first consisted of collecting biomass data at each of four 0.2 hectare exclosures located within the two pastures (Figure 1). Eight 1.0 square meter quadrats were clipped within each of the fenced exclosures. Data from these plots will provide information regarding long-term vegetation development in the absence of grazing. Associated with each of these control plots is a set of eight range production cages located near the control plots but not immediately adjacent to the fences (Figure 1). The data from these cages represent annual growth from sites that have been protected from grazing only during the current growing season. Comparison of data from these cages with the data from inside the control plots will provide the means for evaluating the long-term effects of grazing and grazing exclusion.

An additional 20 range utilization cages were located in each of the two pastures (Figure 1). The purpose of these cages was to obtain data on annual production throughout the pasture, and also to determine forage utilization at each of these sites. Biomass data were obtained by clipping the vegetation within a one-square meter quadrat inside the cages, and forage utilization was estimated by comparing biomass inside the cages with that from clipped 1.0 square meter quadrats located in the immediate vicinity outside of the cages. These sampling locations were scattered throughout the pasture so that all parts of the pastures were included in the sample. Some restrictions were placed on cage locations. Three of the cages were located in the vicinity of each of the control plots, thereby allowing evaluation of utilization in the areas close to the control plots. An additional three cages were located in the ephemeral drainages that occur in each of the pastures. This made it possible to examine whether the cattle tend to utilize the vegetation in the drainages to a greater extent than that on the uplands. The remaining eleven cages in each pasture were scattered so that all of the upland portions were represented in the sample. Biomass data were summarized by computing total biomass as well as the percent of biomass provided by each species.

Species Composition Data. Species composition data were collected in conjunction with biomass data. As each plot was clipped, the vegetation was sorted on the basis of species. Clipped samples were oven dried at 100° C for 24 hours and weighed to the

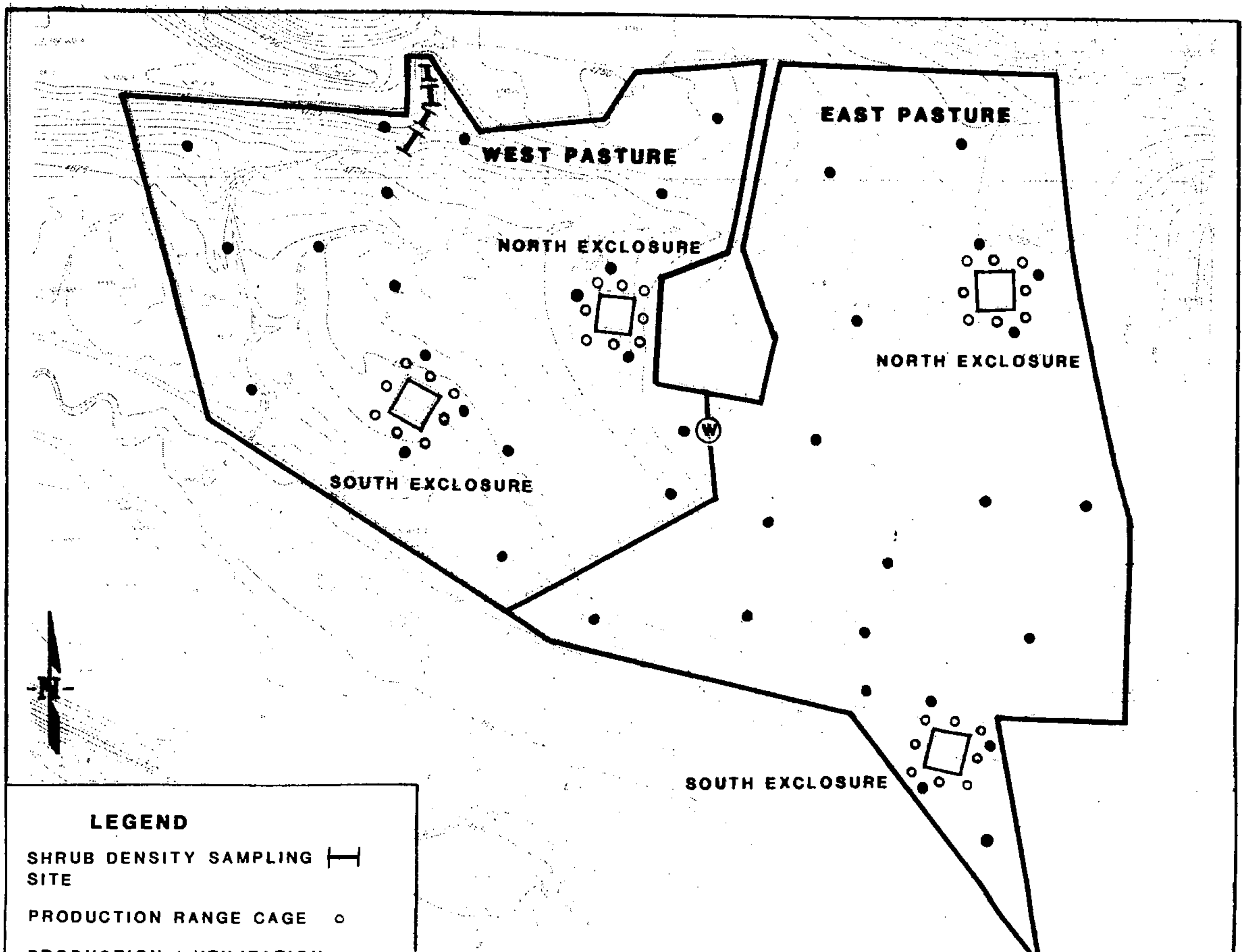

FIGURE 1

Scale 1cm=64m

nearest 0.01 gm. Species were then evaluated on the basis of both percentage of total biomass (composition) and the number of species per square meter (richness).

Shrub Density Data. Shrub density was determined using a line strip transect. All of the shrubs occurring within one meter on either side of a 25 meter transect were counted and measured for height. Shrub density data were collected at each of the pasture-wide range cage production/ utilization plots and at several other selected sites where numerous shrubs had become established (Figure 1). By sampling these sites over time, it will be possible to evaluate grazing impacts on shrub density. All transects were permanently marked with steel fence posts and concrete reinforcing rods. Sampling permanently marked transects over time will improve the quality of the data for detecting increasing or decreasing trends in shrub density.

Cover Data. Prior to clipping, estimates were made of total vegetation canopy cover, cover by bare soil and cover by litter in each of the production and utilization quadrats. Cover data were summarized by computing mean values for each of the above parameters.

Sampling Schedule. The vegetation sampling schedule focused on two critical dates. The first was at the time when the livestock were moved from one pasture to another in July, and the second was in early October after the cattle were removed from the second pasture. In July, all of the large exclosures and their associated range cages were sampled. Additionally, all of the range cages and utilization plots in the pasture where the livestock had been removed were also sampled. In October, all of the range cages and utilization plots in the second pasture were sampled.

Livestock Performance.

Livestock performance was measured by the weight gain of the cattle. Each of the steers was individually weighed after being deprived of water and feed for eighteen (18) hours before release into the first pasture (May 17th). After completion of early season grazing (July 25th), the steers were trailed to a neighboring ranch where they were again deprived of water and feed for eighteen (18) hours and individually weighed on July 26th before being transferred to the second pasture. Final weights were obtained when the steers were removed from the second pasture on September 26th and weighed on September 27th, using the same methods. These data were used to determine total weight gains in each pasture and mean daily weight gains for each grazing period.

First Year Results and Discussion

Vegetation Characteristics

Since 1988 was the first year of the study, much of the data presented in this section simply characterizes the vegetation at the beginning of the project. In later years, these data will be used to evaluate any changes and trends which may occur. These data also provide insight into the homogeneity of the individual pastures as well as the comparability of the two pastures.

West Pasture. Reclaimed areas in the west pasture were sampled in 1987, thus providing preliminary information about structure and composition of these areas prior to the initiation of the grazing study. Of the three different sampling approaches employed in 1988 (exclosures, range cages associated with the exclosures, and the pasture-wide range cages), the data from the pasture-wide range cages provide the most useful data for overall characterization of west pasture vegetation. Therefore, only pasture-wide range cage data are presented here. It should be noted, however, that exclosure data in most cases yielded similar results.

The major species in the west pasture included thickspike wheatgrass, western wheatgrass and crested wheatgrass. Total production for these three species in 1988 was 430 kilograms/hectare, which was 94 percent of the total biomass in the pasture (Table 1). The remaining 6 percent of the biomass was distributed among 10 other species. Native cool season perennial grasses accounted for 71 percent of the biomass, and introduced perennial grasses accounted for 29 percent of the biomass. Total vegetation canopy cover was 11.4 percent; cover by litter and rock was 79.0 percent; and cover by bare soil was 9.6 percent (Table 2). Species richness averaged 2.95 species per square meter.

After early season grazing, total biomass in the grazed areas adjacent to the pasture-wide range cages was 138 kilograms/hectare, with thickspike wheatgrass, western wheatgrass and crested wheatgrass again accounting for 94 percent of the total biomass (Table 1). Total vegetation canopy cover was reduced to 4.9 percent, while cover by litter and rock remained high at 85.9 percent and cover by bare soil remained low at 9.2 percent (Table 2). Species richness was 2.85 species per square meter. The difference in biomass within the range cages (458 kilograms/hectare) and from adjacent open areas (138 kilograms/hectare) was statistically significant, clearly demonstrating the influence of the livestock. These data indicate that forage utilization by livestock during May-July was 69.9 percent, considerably higher than the project design level of 50 percent utilization.

Shrubs were small and scattered in the west pasture. Mean shrub density at the pasture-wide range cages was 49 individuals per hectare. Most of the shrubs did not exceed 10 centimeters in height (Table 3).

The differences in biomass and cover between 1987 and 1988 were quite striking (Tables 1 and 2). The 1987 season was much more favorable relative to available moisture, resulting in 240% higher total production than in 1988 (Table 1). Vegetation cover values show comparable differences (Table 2).

East Pasture. Based on the biomass data from the pasture-wide range cages, the major species in the east pasture include western wheatgrass, thickspike wheatgrass and crested wheatgrass. Total biomass

Table 1. Above-Ground Plant Biomass Summary for East and West Pastures, 1987-1988. 1988 Values Derived From Pasture-Wide Range Cage Locations.

Species	1987 Pre-Grazing		1988 Non-Grazed (Range Cages)		1988 Grazed (Open Areas)	
	East Pasture	West Pasture	East Pasture	West Pasture	East Pasture	West Pasture
COOL SEASON PERENNIAL GRASSES	kilograms/hectare					
Agropyron dasystachyum	484	286	111	172	50	62
Agropyron smithii	571	430	126	139	43	45
Agropyron cristatum/desertorum	213	147	74	119	45	22
Agropyron trachycaulum	126	132	53	<1	13	1
Other Species	33	89	25	27	2	8
Sub-Total	1427	1084	389	457	153	138
WARM SEASON PERENNIAL GRASSES	0	2	0	0	0	0
ANNUAL GRASSES	7	34	1	<1	<1	<1
PERENNIAL FORBS	0	0	0	0	0	0
ANNUAL/BIENNIAL FORBS	13	<1	0	<1	0	0
TOTAL HERBACEOUS SPECIES BIOMASS	1447	1120	390	458	153	138

Table 2. **Cover Summary for East and West Pastures, 1987-1988. Values in Percent.**

Species	1987 Pre-Grazing		1988 Non-Grazed (Range Cages)		1988 Grazed (Open Areas)	
	East Pasture	West Pasture	East Pasture	West Pasture	East Pasture	West Pasture
	%					
TOTAL VEGETATION COVER	23	22	9	11	4	5
LITTER ANO ROCK	61	64	83	79	86	86
BARE SOIL	16	14	8	10	10	9
TOTAL COVER	84	86	92	90	90	91

Table 3. Shrub, Semi-Shrub and Cactus Density (number per hectare) and Height (cm) Summary for East and West Pastures, 1987-1988.

Species	1987 Pre-Grazing				1988 First Year Grazing (Range Cage Sites)			
	East Pasture		West Pasture		East Pasture		West Pasture	
Artemisia cana	17*	(13)**	5	(9)				
Artemisia tridentata	12	(14)	114	(12)	20	(10)		
Atriplex canescens	230	(35)	5	(40)	170	(32)	10	(10)
Atriplex gardneri			10	(11)				
Ceratoides lanata	5	(40)	245	(17)			40	(10)
Gutierrezia sarothrae			10	(10)				
Opuntia polyacantha	35	(8)			40	(7)		
Total	299		369		250		50	

* Density Values
** Height Values

Table 4. Percent utilization among different species and in different topographic settings in the East and West Pastures.

	East Pasture	West Pasture
Species		
COOL SEASON PERENNIAL GRASSES	- - - - - - % Utilization	- - - - - -
Agropyron dasystachyum	55	64
Agropyron cristatum/desertorum	39	82
Agropyron smithii	65	68
Agropyron trachycaulum	75	-
Other species	91	72
TOTAL BIOMASS	60	70
Topographic Setting (Based on Total Biomass)		
Entire Pasture	60	70
Drainages	79	84
Uplands	56	64

production for these three species was 311 kilograms/hectare, which was 80 percent of total production by all species (Table 1). These are the same three species that occurred as dominants in the west pasture. Slender wheatgrass was more prevalent in the east pasture, however, accounting for approximately 14 percent of the total biomass. While slender wheatgrass had the fourth highest production value, it was mostly restricted to ephemeral drainage sites.

Total biomass in the grazed areas adjacent to the pasture-wide range cages averaged 155 kilograms/hectare compared to 399 kilograms/hectare within the cages. This difference was statistically significant, and was a measure of forage utilization by livestock during the late season grazing period. Overall utilization in the east pasture was 61.4 percent, which was less than the utilization in the west pasture but still more than the targeted level of 50 percent. The major species in the open areas were the same as those encountered in the range cages (Table 1).

Species richness values for the sampling sites in the east pasture were comparable to those measured in the west pasture averaging 3.25 species per square meter at the pasture-wide range cage sites.

Total vegetation cover within the pasture-wide range cages was 8.6 percent; cover by litter and rock was 82.8 percent; and cover by bare soil was 8.6 percent (Table 2).

Shrub density in the east pasture was somewhat higher than that measured in the west pasture, although still relatively low. Total density (including semi-shrubs and cacti) was 249 individuals per hectare (Table 3). The shrubs in the east pasture tended to be taller than those in the west pasture. Mean height values for most species were more than 10 centimeters, with fourwing saltbush being the tallest (24-43 centimeters; Table 3).

Over the past two growing seasons, total production in the east pasture has varied in much the same manner as in the west pasture. In 1988, total production values were less than one-third of the value recorded for 1987. Total vegetation cover values reflected similar yearly variations (Table 2).

<u>Forage Utilization.</u> As mentioned above, overall utilization in the two pastures was 60 percent in the east pasture and 70 percent in the west pasture. Both of these values were higher than the target of 50 percent. At the beginning of the study, there was a considerable amount of standing dead plant litter in the pastures. It was decided to allow the livestock to remain in the pastures somewhat longer than originally planned to reduce the amount of the standing dead biomass.

Utilization of thickspike and western wheatgrasses was approximately the same in the two pastures. However, utilization of crested wheatgrass was approximately two times greater in the west pasture (Table 4). This difference may have been due to the fact that the west pasture was grazed early in the season, when palatability of the early-maturing crested wheatgrass was highest.

The estimates of overall utilization may be somewhat misleading since the degree of utilization was not consistent throughout the pastures (Table 4). Utilization of the vegetation in the ephemeral drainages was about 14 to 19 percent higher than on the uplands.

<u>Livestock Responses.</u>

Weight gain responses for the yearling steers are presented in Table 5. Total weight gain for the entire length of the grazing period was 108 kilograms per steer, which is equivalent to 0.83 kilograms per day. When evaluated with a t-test, livestock daily gains were found to be significantly greater during the first grazing period (1.03 +/- 0.11 kilograms/day) than they were during the second [0.60 +/- 0.12 kilograms/day (+/- values equal the standard deviation)]. This weight gain difference probably relates to factors other than vegetational differences between the two pastures, since the two pastures proved quite floristically similar. Lower gains later in the seson are characteristic as rangeland vegetation declines in forage quality following maturity, coupled with lower inherent growth rates of yearling livestock.

<u>Preliminary Conclusions and Future Activities</u>

From the standpoint of cattle performance, the first year of this grazing study must be considered a success. Season-long steer gains were judged excellent, comparing very favorably with gains reported in preceding grazing trials on both mined lands (e.g., DePuit and Coenenberg 1989, Hofmann and Ries (1988) and non-mined rangelands (e.g., Smoliak 1960, Hart et al. 1983) in the region. The fact that such gains were achieved in an abnormally dry year and under somewhat heavier grazing intensity than originally planned casts an even more favorable light on the capability of mined land vegetation to support season-long, rotational grazing. Results from succeeding years will indicate whether such forage value can be maintained after repeated animal use.

Conclusions on the influence of grazing on vegetation must necessarily be deferred, since first year sampling largely established only vegetation baselines from which to make future comparisons. Forage utilization (60-70 percent) in 1988 was higher than originally planned, but still was not considered excessive and did help to achieve a concurrent goal of plant litter reduction. Whether this and subsequent, more moderate levels of forage use in 1989 and 1990 have positive, neutral or negative impact on vegetation productivity or composition should become clear based upon future, post-grazing sampling. In short, the vegetation data base developed in 1987-1988 will be used in concert with future data to determine any changes in herbaceous species productivity/composition and shrub density attributable to grazing, thereby allowing an evaluation of the capability of vegetation to withstand the given rotational grazing regime.

Table. 5 **Livestock Weight Responses During Early and Late Season Grazing, and Over Entire Grazing Period, 1988**

Grazing Period/Dates-Durations	Beginning Weight	Ending Weight	Total Gain/ Animal	Average Gain/ Animal/Day
I. Early Season Grazing (5/17-7/25, 69 Days)	231 kg (510 lb)	302 kg (666 lb)	71 kg (156 lb)	1.03 kg (2.26 lb)
II. Late Season Grazing (7/26-9/26, 62 Days)	302 kg (666 lb)	339 kg (748 lb)	37 kg (82 lb)	.60 kg (1.33 lb)
III. Entire Grazing Season (5/17-7/25, 7/26-9/26, 131 Days)	231 kg (510 lb)	339 kg (748 lb)	108 kg (238 lb)	.83 kg (1.82 lb)

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