COW-CALF PRODUCTION ON RECLAIMED SURFACE MINED PASTURES IN APPALACHIA [1]

C.D. Teutsch, M. Collins, and D.C. Ditsch[2]

Abstract: Reclaimed surface mined land in Appalachia could provide grazing for livestock. Research is needed to determine optimal stocking densities (SD) and the sustainability of grazing reclaimed land. In 1997, a grazing study was initiated near Chavies, KY. A 151 ha mountain-top-removal site was divided into two replicates of 12, 24, and 36 ha pastures and adjacent ungrazed areas. Each pasture was stocked with 10 cow-calf units resulting in stocking densities of 0, 0.28, 0.41, or 0.83 cow-calf units per hectare. In October, cows at the highest SD were lighter (476 kg) than cows at the medium (509 kg) and low (505 kg) SD ($P<0.01$). Pregnancy rates in October were 100% at the high SD compared with 88% at the medium SD and 85% at the low SD ($P<0.05$). Calf weights were greater on the highest SD in June and August of 1997, but not different in October ($P<0.10$). In 1998, calf weights on the medium SD were greater throughout the grazing season ($P<0.10$) and averaged 268, 255, and 247 kg at the medium, low, and high SD respectively ($P<0.10$). Calves at the high SD were lighter than calves at the low SD for all weigh dates in 1999 after the initial weighing in April. Calf weight per ha was greatest at the high SD in all three years ($P<0.05$). Grazing intensity was high in all years at the high SD ($P<0.01$) and groundcover was lower, indicating that this SD may not be sustainable. These data indicate that the medium and low SD may be sustainable for reclaimed mined land pasture ecosystems.

Additional Key Words: mountain-top removal, beef cattle, reclamation, grazing

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Introduction

Agricultural production in Appalachia is limited by a lack of suitable land. The primary limitation is the sloping topography associated with this region's landscape (Absher, 1983). Mountaintop removal is a common method of surface mining in Appalachia that exposes the coal seam by removing overburden above the seam and placing it in valley-fills. Slopes are greatly reduced and these areas can be utilized for residential, industrial or agricultural purposes, but the remoteness of the mine site often limits its development potential (Gerken and Eller, 1982). However, this land represents a significant resource for grazing livestock (Gill, 1983; Gill et al., 1983). In Kentucky alone, more than 400,000 ha of surface mines have been reclaimed as hay and pastureland (Personal communication, Kentucky Department of Surface Mining Reclamation and Enforcement, 1999).

Previous research in the western United States has demonstrated that reclaimed surface mined land can be grazed sustainably. A study conducted in North Dakota evaluated steer performance at light, medium, and heavy grazing intensities on pastures on reclaimed lignite mine land. Over a five-year period, average daily gains for steers at the low, moderate, and high grazing intensities were 1.2, 1.0, and 0.3 kg d^{-1}, respectively (Hoffman and Ries, 1988). Animal gain on an area basis was maximized at the medium grazing intensity. The high intensity treatment resulted in poor animal performance and rapid deterioration of the reclaimed pastures. After five-years of grazing, ground cover at the high intensity treatment was 62% compared with 87% for the low intensity. With 50% vegetation removal in early summer, reclaimed mined land remained productive with no signs of degeneration (Hoffman and Ries, 1988). Mine-land reclaimed to introduced pasture species in Colorado was grazed successfully in short duration and summer-long grazing systems for two years (Laycock and Layden, 1985). Average daily gains in this study ranged from 1.1 to 1.4 kg d^{-1}. All gains were better than those on adjacent undisturbed areas with native vegetation.

Schuman et al. (1990) found that reclaimed mined land in Wyoming supported grazing without deterioration and produced livestock gains similar to those of adjacent undisturbed rangeland. In this study, reclaimed pastures were grazed at stocking densities of 0.25 and 0.50 steers ha^{-1}. Steer gains averaged 0.94 kg d^{-1} and 0.81 kg d^{-1} for the lower and higher stocking densities, respectively. At the end of the five-year grazing study, basal ground cover increased and bare ground decreased for both stocking densities (Schuman et al., 1990). Because basal ground cover increased, bare ground decreased, there was a trend toward increasing native grass species proportion, and animal performance was similar to that on adjacent undisturbed land. The authors conclude that this ecosystem was not harmed by grazing and may have benefited (Schuman et al., 1990).

There has been no replicated research evaluating the sustainability of reclaimed mine-land grazing systems for the eastern U.S. An extension publication from the University of Kentucky states that reclaimed land can economically support beef cattle when planted to introduced forage species that are well managed (Thom et al., 1990). In general, reclaimed mined land in Appalachia tends to be low in phosphate and may require annual applications (Thom et al., 1990). In contrast, potash tends to be adequate since weathering spoil material releases significant quantities of this mineral (Thom et al., 1990). Lime may be needed to neutralize acidity released from the oxidation of pyrite and to maximize nutrient availability on reclaimed soils having a pH less than 6.0 (Thom, 1990). Available soil N is low in spoil material and swards dominated by grasses require annual N applications (Thom et al., 1990). Maintenance of adequate legume proportion decreases the need for N fertilization and increases forage quality and animal gains (Ditsch and Collins, 2000; Thom et al., 1990). Cow-calf enterprises with spring calving are well suited for reclaimed mined land. A stocking density of 1.2 ha cow-calf^{-1} has been recommended (Thom et al., 1990). However, an additional 0.8 to 1.2 ha cow-calf^{-1} should be added for fall and winter grazing (Thom et al., 1990). Additional land area may be required for conserved forage needs of the herd. Stocking densities recommended for reclaimed mine-land by Thom and coworkers (1990) are based solely on observational data.

A demonstration study evaluated beef cow production on reclaimed mine-land in Virginia (Gerken and Eller, 1982). Twenty-five mature Angus-Hereford cross cows and calves were placed on approximately 20 ha of reclaimed mine-land seeded to a mixture of sericea lespedeza [*Lespedeza cuneata* (Dum. Cours.) G. Don] and tall fescue [*Schedonorus phoenix* (Scop.) Holub]. Average daily gains (ADG) for the calves in this study were 0.78 kg d^{-1} for 1980 and 0.90 kg d^{-1} for 1981. The increased weaning weights and ADG observed in the second year of this study were attributed to high gains during the summer months, but further explanation was not provided. All cows were rebred by the time calves were weaned. Weaning weights of calves averaged 229 kg in 1980 and 261 kg in 1981. This demonstration trial indicated that beef cows could successfully utilize mine-land pastures to maintain weight, reproduce, and wean satisfactory calves (Gerken and Eller, 1982), but did not evaluate different stocking densities or plant community responses.

In April of 1997, a long term grazing study was established near Chavies, KY. This study was designed to determine sustainable stocking densities for beef cow-calf enterprises on reclaimed mine-land pastures. This paper presents the results from the livestock phase of the project.

Methods

The experimental site was located on reclaimed surface mined land near Chavies, KY (37^0 20'22.41" N, $83^0$18'18.97" W). The 151 ha mountain-top-removal site was randomly divided into two replicates of 12, 24, and 36 ha pastures and adjacent ungrazed areas (Fig. 1). Each pasture was grazed by 10 cow-calf pairs blocked according to cow weight, calf birth date, and calf sex and randomly assigned to each treatment x replicate combination resulting in stocking densities of 0.28, 0.41, and 0.82 cow-calf ha^{-1} (Table 1). Remaining animals were grazed on similar pastures outside of the experimental area at a stocking density of approximately 0.41 cow-calf ha^{-1}. The middle stocking density of 0.41 cow-calf ha^{-1} was based on limited producer experience grazing reclaimed pastureland in southeastern Kentucky. The low and high stocking densities of 0.28 and 0.82 cow-calf ha^{-1} were established to provide a range in which the optimal density was most likely contained.

Table 1. Pasture size and stocking densities.

Treatment	Pasture area (ha)	Stocking density (cow-calf ha^{-1})
Heavy	12 ha	0.83
Moderate	24 ha	0.41
Light	36 ha	0.28
Ungrazed	adjacent areas	0.0

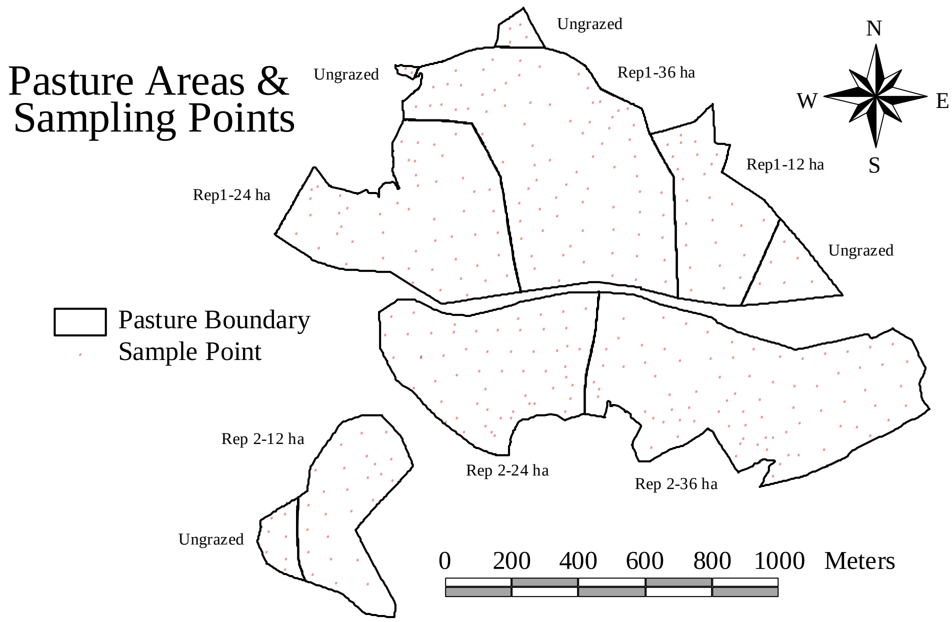

Figure 1. Pasture boundaries and sampling points.

First-calf Angus cross heifers were purchased at an elite heifer sale in Paris, KY in the fall of 1996. Heifers were over-wintered on similar pastures in the vicinity of the study area. Hay and ground corn were supplemented as needed. Heifers were assigned to their respective stocking density treatment x replicate combinations in April, 1997 after calving was complete. Herd health was managed according to current recommendations for the Commonwealth of Kentucky (Burris and Scharko, 1997).

The breeding season began in June and extended to early August in 1997. Seven closely related Angus bulls were used, one for each treatment x replication combination plus the extra group. In 1998, cows were artificially inseminated. Cows were synchronized using a two-injection prostaglandin system and bred using semen from Hereford bulls with performance data similar to the Angus cleanup bulls. In 1998, the breeding season was extended to the middle of August due to the use of artificial insemination. In 1999, the breeding season extended from the second week in June to the end of August.

The grazing season extended from May to October. Cows and calves were weighed at two-month intervals throughout the grazing season. Open cows were replaced with bred cows from the extra group after calves were weaned in October. Cow body condition score was rated at the start and end of the grazing season using a scale from 1 to 9, with 1 being emaciated and 9 being extremely fat (Burris and Johns, 1997). Cows overwintered on their respective pastures with supplemental hay fed as needed.

The site used in this study was revegetated between 1991 and 1993 by hydroseeding. The reclamation mixture included orchardgrass (Dactylis glomerata L.), tall fescue, redtop (Agrostis alba L.), red clover (Trifolium pratense L.), white clover (Trifolium repens L.), birdsfoot trefoil (Lotus corniculatus L.), sericea lespedeza, and annual lespedeza [Kummerowia striata (Thunb.) Schindler]. The majority of the experimental pasture areas were grazed prior to the initiation of this study. Pastures were clipped biannually with a rotary mower to control weeds and received no fertilizer.

The site was mapped and pasture boundaries established using GPS/GIS (Fig. 1). Permanent sampling points (334) were systematically located using GPS, resulting in a sampling density of 1 point per 0.4 ha (Fig. 1). Soil and vegetation samples were collected during May of each grazing season. Percent ground covered by living vegetation was visually estimated within a 5 m radius of each point. Grazing activity was determined by visually estimating the percentage of tillers within the same area showing signs of being severed by grazing. The following scale was used to rate grazing activity: 1=none, 2=light (<20% of tillers defoliated), 3=light + (21-40% of tillers defoliated), 4=moderate (41-60% of tillers defoliated), 5= moderate + (61-80% of tillers defoliated), and 6=heavy (>81% of tillers defoliated).

Analysis of variance using General Linear Models (GLM) from SAS was used to assess treatment differences for the animal and plant variables (SAS Institute, Cary, NC). Birth date was used as a covariate in the analysis of the 1999 calf data, since the calving season was extended compared to other years. Unless otherwise stated, differences are considered significant at $P \leq 0.10$.

Results and Discussion

Statistical analysis indicated no significant treatment x year interactions ($P \leq 0.05$) for the cow data; therefore, cow data are averaged over years. Significant treatment x year interactions ($P \leq 0.05$) were observed for calf data; therefore, these data are presented by year.

Cow Performance

Cows at the highest SD weighed less than those at the medium and low SD at the start of the grazing season. This trend continued at the June weigh date (Fig. 2). When weighed in August SD differences for cow weight were absent, however, by October, cows at the highest SD weighed less than those at the medium and low SD (Fig. 2). Observations indicate that this difference resulted from decreased forage availability later in the grazing season at the highest SD.

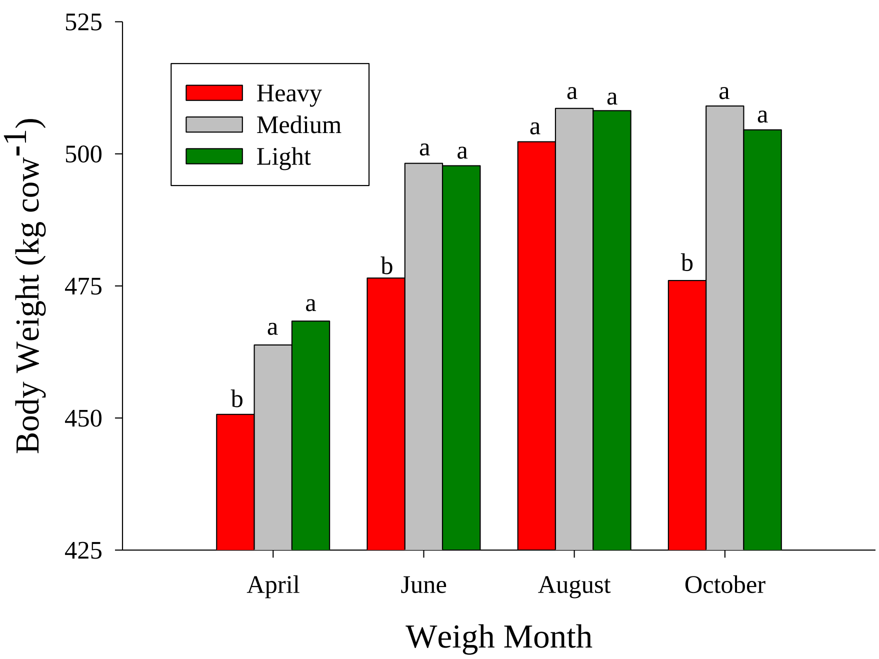

Figure 2. Stocking density effects on cow body weight averaged over years. Bars within a weigh month followed by the same letter are not significantly different according to LSD (P<0.10).

Based on BCS, cows at the low SD were in better condition in October than those at the medium or high SD (Fig. 3). However, BCS of cows on all SD treatments were within the acceptable range for rebreeding (Burris and Johns, 1997). The differences for BCS reflect the decreased forage availability later in the grazing season for the highest SD.

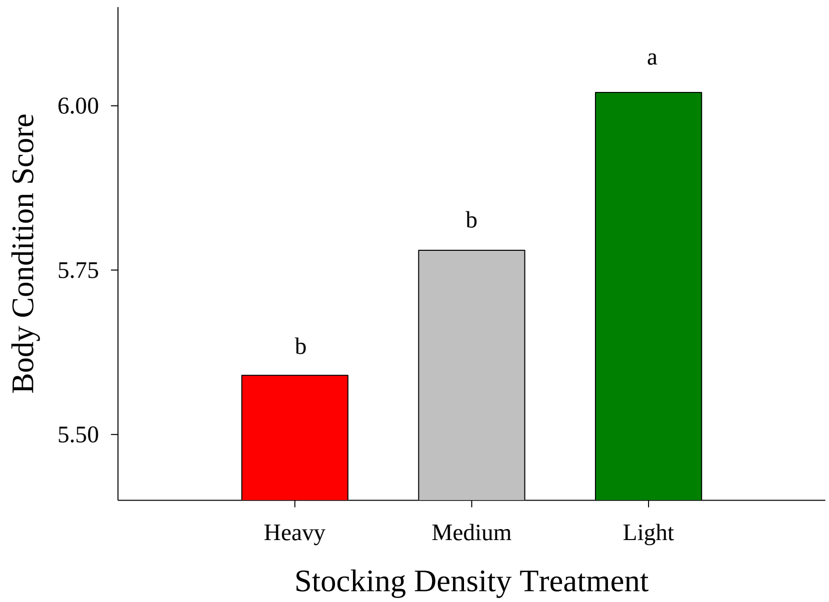

Figure 3. Stocking density effects on cow body condition score averaged over years. Bars followed by the same letter are not significantly different according to LSD (P<0.10).

Pregnancy rates of cows at the time calves were weaned were significantly higher for the highest SD (Fig. 4). This response was unexpected because it appeared that forage availability was restricted on this treatment and BCS were at the lower end of the optimal range. A possible explanation may be that some cows at the medium and low SD were approaching an obese state that may have negatively impacted conception.

Cow weights, body condition, and breeding data from the current study are consistent with results from the grazing demonstration on reclaimed surface mined land pastures in Virginia (Gerken and Elker, 1982). Both studies indicate that mine-land pastures in Appalachia supply adequate forage for beef cows to maintain weight and to reproduce. Our findings suggest that the highest SD may not support maintenance cow weight and condition, especially when pasture growth is limited.

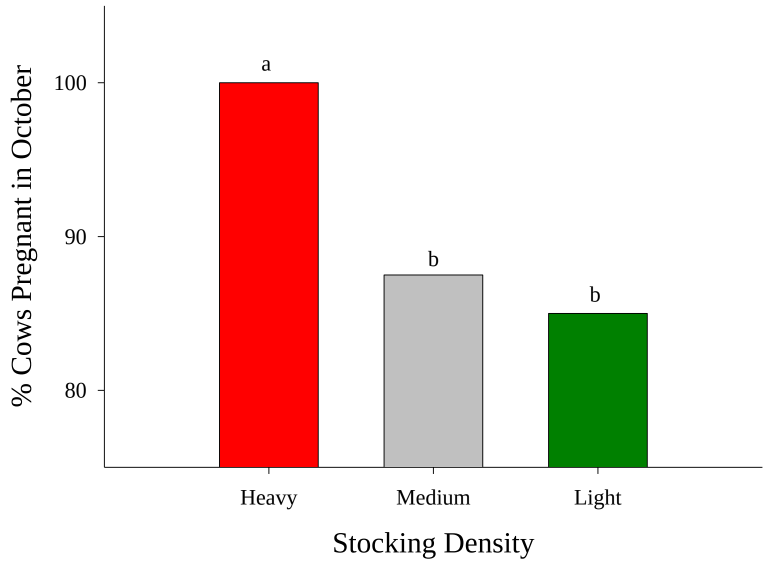

Figure 4. Stocking density treatment effects on cows pregnant in October averaged over years. Bars followed by the same letter are not significantly different according to LSD ($P<0.10$).

Calf Performance

In 1997, calves at the highest SD were heavier in June and August, but not in October (Table 2). Higher initial calf weights were most likely due to increased forage quality at the highest SD resulting from more complete defoliation on those pasture areas early in the season. Declining forage availability appeared to limit calf growth later in the season on this treatment. Average daily gains in 1997 were highest for the medium SD between June and August (Table 3). However, as the grazing progressed and forage growth was limited by hot dry conditions, calves on the high and medium SD had lower ADG than calves at the low SD (Table 3). Over the entire grazing season, calves gained 0.86, 1.1, and 1.1 kg d^{-1} for the high, medium and low SD respectively (Table 3).

In 1998, calves from the medium SD treatment were heavier throughout the grazing season (Table 2). The difference in calf weight between the medium and high SD can be accounted for by differences in forage availability. Calf growth at the highest SD was limited by reduced forage availability. The difference between the medium and low SD might be due to maintenance of higher forage quality at the medium SD. The greater utilization of pasture at the medium SD may have reduced flowering stems and older tissue thereby increasing forage quality in the late season. Stocking density effects on calf ADG were absent for the first two weigh periods in 1998 (Table 3). In fact, all SD had ADG near of 1.2 kg d^{-1} for the period of June to August. The lack of SD differences for the first two weigh periods were due to pasture growth sustained by ample and well distributed rainfall early in the grazing season. However, a hot dry period later in the grazing season resulted in decreased ADG regardless of SD (Table 3). Calves at the medium SD had the highest ADG during the last weigh period. This SD probably provided the best combination of forage availability and quality during this period. Seasonal ADG for the 1998 grazing season were approximately 1.0 kg d^{-1} for all treatments.

Table 2. Calf weights for 1997, 1998, and 1999 grazing seasons.

Stocking density	Calf weight			
	---kg---			
1997	April	June	August	October
High	-	159a†	196a	243a
Medium	-	147ab	188ab	252a
Light	-	144b	181b	249a
1998	April	June	August	October
High	73b	127b	208b	247b
Medium	84a	140a	223a	268a
Light	74b	129b	214ab	255b
1999	May	July	September	October
High	88a	159b	230b	241b
Medium	91a	167ab	234ab	251b
Light	93a	173a	245a	262a

†Means followed by the same letter within a year and month are not significantly different according to LSD (P<0.10).

In 1999, calves at the light SD were heavier than those at the high SD except for the first weigh date (Table 2). At weaning, calves at the high SD weighed 241 kg compared with 262 kg at the light SD (Table 2). In 1999, forage availability appeared to limit gains throughout the grazing season at the high SD. Calf ADG was higher at the low SD compared to the high SD for all weigh periods except July to September (Table 3).

Table 3. Calf average daily gains for 1997, 1998, and 1999 grazing seasons.

Stocking density	Average daily gain			
	----------------------------------kg d^{-1}------------------------------------			
<u>1997</u>	<u>April to June</u>	<u>June to August</u>	<u>August to October</u>	<u>Seasonal</u>
High	-	1.06b[†]	0.75c	0.86b
Medium	-	1.18a	1.02b	1.08a
Light	-	1.06b	1.11a	1.08a
<u>1998</u>	<u>April to June</u>	<u>June to August</u>	<u>August to October</u>	<u>Seasonal</u>
High	0.94a	1.19a	0.71b	0.96b
Medium	1.01a	1.18a	0.80a	1.01a
Light	0.97a	1.22a	0.74ab	1.00ab
<u>1999</u>	<u>May to July</u>	<u>July to Sept.</u>	<u>Sept. to Oct.</u>	<u>Seasonal</u>
High	1.13b	1.27a	0.38b	1.04b
Medium	1.19ab	1.22a	0.55a	1.08b
Light	1.26a	1.29a	0.60a	1.14a

[†]Means followed by the same letter within a year and time period are not significantly different according to LSD (P<0.10).

Weaning weights and calf ADG values in the current study are similar to those reported by Gerken and Elker (1982) in a Virginia demonstration trial. In both cases, cows grazing reclaimed mine-land produced calves that gained about 1.0 kg d^{-1} and had weaning weights near 250 kg. Studies from the western United States also confirm the results of the current study in that all studies produced adequate gains on reclaimed mine-land. However, direct comparison of animal data from the humid eastern United States and the arid western United States may not be valid because of large differences in climate and plant species.

<u>Ground Cover and Grazing Activity</u>

Individual animal performance is important, but it is also important to consider performance on an area basis. Total calf weight ha^{-1} was consistently highest on the high SD (P<0.10) (Fig. 5). However, the high SD may not be sustainable. Groundcover is a good indicator of sustainability. In May, 1998 and 1999, ground cover was lower at the highest SD (P<0.10) (Fig. 6). While groundcover at the highest SD did not vary greatly between years, this treatment did not exhibit the increasing trend in groundcover observed for the medium and low SD pastures (Fig. 6). This indicates that the high SD treatment was slowing the development of the plant communities in these pasture areas. It is critical that a >90% groundcover be maintained in reclaimed pastures in order to qualify for bond release.

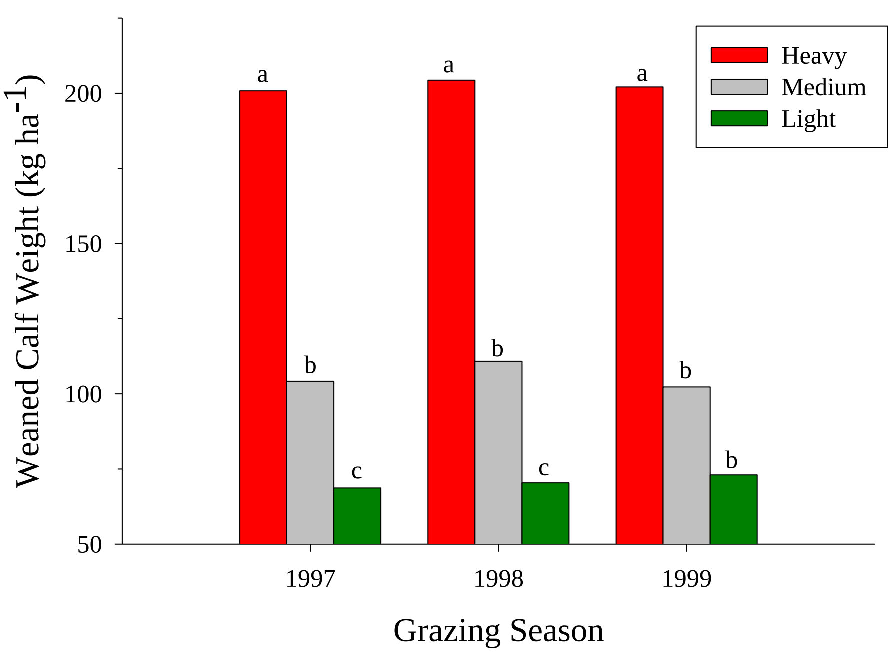

Figure 5. Stocking density treatment effects on weaned calf weight ha^{-1}. Bars within a year followed by the same letter are not significantly different according to LSD (P<0.10).

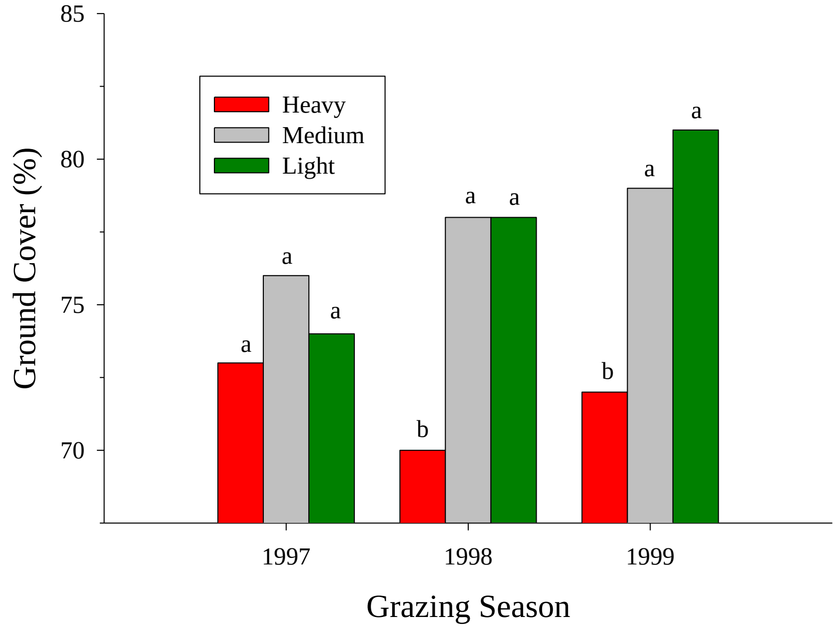

Figure 6. Stocking density treatment effects on groundcover in May. Bars within a year followed by the same letter are not significantly different according to LSD (P<0.10).

The level of grazing activity is another indicator of sustainability of the system. Grazing activity was higher at the high SD early in the grazing season (Fig. 7). This indicates that, near peak forage growth, the entire pasture area was already being heavily utilized. Combined with lower groundcover at the highest SD, this indicates that the highest SD may not be sustainable.

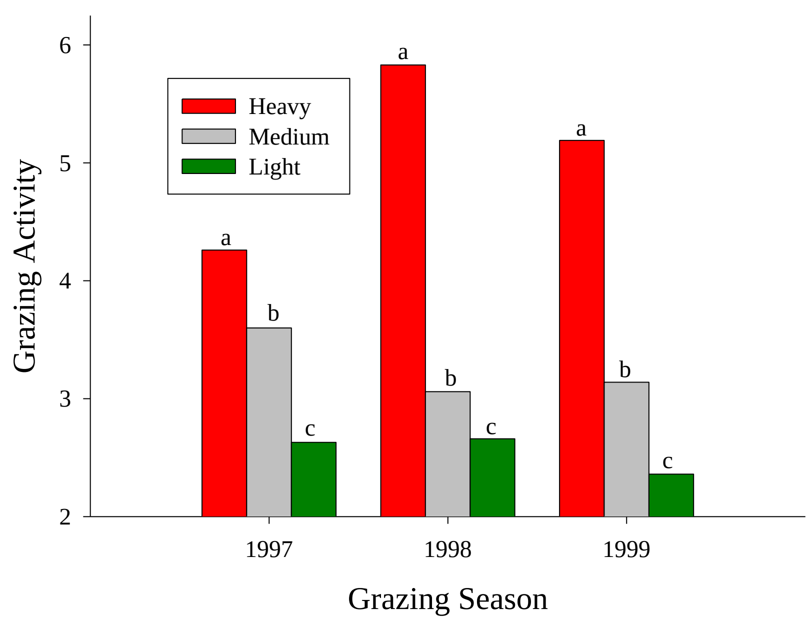

Figure 7. Stocking density treatment effects on grazing activity in May. Bars within a year followed by the same letter are not significantly different according to LSD ($P<0.10$).

Hoffman and Ries (1988) found that, over a five-year period, a high SD reduced groundcover. The high SD also resulted in rapid deterioration of pastures in that study. In the current study, the high SD treatment has not yet reached the point of rapid groundcover loss and increased soil erosion. However, failure to increase groundcover under this treatment and the high degree of pasture utilization suggest that pasture productivity will likely decrease. Hoffman and Ries (1988) found that animal performance on an area basis was maximized at the medium SD. In contrast, in the current study, animal performance on an area basis was maximized at the high SD, but as pasture productivity decreases, animal performance will likely be negatively impacted.

Conclusions

In Kentucky more than 400,000 ha of surface mines have been permitted with a post-mine land use of hay and pastureland. This land represents a significant resource for grazing livestock, especially in the Appalachian region where agricultural production is limited by a lack of suitable land. Results of this study confirm other work from the western United States, where reclaimed mined land has been grazed sustainably. In the current study, cows at the highest SD had lower body weights and were in poorer condition than cows at the medium and low SD. Calves at the highest SD weighed less at weaning in 1998 and 1999 and had lower ADG in all years. In addition, groundcover did not increase at the highest SD and grazing activity was elevated. These data indicated that the highest SD may not be sustainable in the long-term.

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