SPATIAL AND TEMPORAL VARIATION IN MINED LAND PASTURES

by

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Abstract. Kentucky has large areas of reclaimed surface mined land that could provide grazing for livestock. Research is needed to define optimum stocking densities and to determine the sustainability of such grazing systems for this region. A long-term field study was initiated in 1997 on 151 ha of reclaimed land near Chavies, KY to assess spatial and temporal variation under grazing with stocking densities of 0, 0.28, 0.42, or 0.83 beef cow/calf pairs ha^{-1}. Global Positioning System and GIS technologies were employed to interpolate surface maps of the site using 11,000 points. Herbage and soil samples were collected around permanent markers systematically placed over the entire area at a density of 1 per 0.4 ha. Elevation ranged from 295 to 371 m and pasture slope ranged from 0 to 57° with a mean of 13° . Biomass density in late April ranged from 0 to 2500 kg ha^{-1} and was lowest at the highest stocking density, where grazing activity was highest. Spring-born calves averaged 240 kg at weaning. Cow weight and body condition score at the end of the grazing season was reduced at the highest stocking density and suggests that the highest stocking density may be excessive for mined land pastures in this region.

Additional Key Words: cattle, livestock, forage, herbage.

Introduction

In the Appalachian region, where agricultural production is limited by a lack of suitable land, surface mined land reclaimed as hay/pasture represents a significant potential resource for livestock production. Kentucky alone has more than 130,000 ha reclaimed to hay and pasture species (Personal communication, Kentucky Department of Surface Mining Reclamation and Enforcement, 1991). Research outside this region suggests that reclaimed land can support sustained grazing by livestock (Hofmann and Ries, 1988; Schuman et al., 1985).

Spatial variation in topography and spoil composition of mined land are large and should be considered in managing these sites. Global positioning systems (GPS) and geographic information systems (GIS) allow accurate measurement and mapping of landscape-scale sites and could lead to a better understanding of relationships among topographic, edaphic and biotic ecosystem components. The long-term objectives of this research were to document spatial and temporal variation in the amount and botanical composition of vegetative cover on reclaimed surface mined land using GPS and GIS technologies. Information gained in this research will be used to establish guidelines for producers managing beef cattle on reclaimed land pastures in southeastern Kentucky.

Materials and Methods

The experimental site is located on reclaimed surface mined land near Chavies, KY (37° 20'22.41" N, 83°18'18.97" W). The 151 ha mountain-top-removal reclamation site was divided into two replicates of pastures of 12, 24, and 36 ha and adjacent ungrazed areas (Fig. 1). Each pasture was grazed by 10 cow-calf pairs blocked according to cow weight and calf birth date and randomly assigned to treatment x replicate combinations (0.83, 0.42, and 0.28 cow-calf ha^{-1}

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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	0.42
Light	36 ha	0.28

stocking density) (Table 1). Limited producer experience had established the middle stocking density of 0.48 cow-calf ha^{-1} to be adequate for sustained grazing of reclaimed pastureland land in the Appalachian region of S.E. Kentucky, however there were no experimental data to confirm this stocking density. The higher and lower stocking densities of 0.83 and 0.28 cow-calf ha^{-1} provided a range of stocking densities in which the optimal stocking density was most likely contained. First-calf Angus cross heifers, calved between February and April, were allocated to pastures in mid-April. Data collection continued between April and September. Cattle were weighed at 2-month intervals throughout the grazing season. Calves were weaned on 2 October.

The site used in this study was revegetated between 1991 and 1993 by hydroseeding. The reclamation mixture included orchardgrass (*Dactylis glomerata* L.), tall fescue (*Festuca arundinacea* Schreb.), redtop (*Agrostis alba* L.), red clover (*Trifolium pratense* L.), white clover (*Trifolium repens* L.), birdsfoot trefoil (*Lotus corniculatus* L.), sericea lespedeza [*Lespedeza cuneata* (Dunmont) G. Don], and common lespedeza [*Kummerowia striata* (Thunb.) Schindler]. The majority of the experimental pasture areas were grazed prior to the initiation of this study.

The site was mapped and pasture boundaries established using GPS/GIS (Fig. 1). Sampling points (334) were systematically located using GPS (Fig. 1). Soil and vegetation samples were collected during May, approximately one month after the initiation of the experiment. Yield and botanical composition were determined from clipped samples. Two 0.09 m^2 samples were clipped approximately 2.5 cm from the soil surface at two randomly chosen points within a 5 m radius of each permanently established sampling point. Percent ground cover by living vegetation was visually estimated within the same area. Grazing activity was determined visually by estimating the percentage of tillers showing signs of being severed during grazing. Grazing activity was rated using the following scale: 1=none, 2=light (<20% of tillers defoliated), 3=light + (20-40% of tillers defoliated), 3=moderate (40-60% of tillers defoliated), 4= moderate + (60-80% of tillers defoliated), and 5=heavy (>80% of tillers defoliated). Predominant forage and weed species were recorded for the 5 m radius surrounding each sample point. Soil samples were taken within a 5 m radius of each permanently established sampling point and are being analyzed for P, K, Mg, Ca, Zn, Pb, Bo, Cd, Mo, Ni, Cr, Cu, organic matter, water holding capacity, buffered pH, and pH. Surface maps for elevation, slope, and aspect were created from approximately 11,000 GPS points using Arcview GIS software (ESRI, Redlands, CA). Aspect and slope values for permanent sampling points were derived from the interpolated surfaces. Maps of yield, ground cover, and grazing pressure were also created using Arcview. General linear models (GLM) was used to analyze stocking density effects on cow and calf weight changes and to assess pasture differences in topology. Linear regression was used to study relationships among physical and forage variables.

Results and Discussion

Site Physical Characteristics

Elevations within the pastures ranged from 295 to 371 m with a mean of 342 m (Fig 2; Table 2). Stocking density treatments were different with respect to elevation (P=0.0003). Pasture slopes ranged from nearly flat on plateaus and benches to 57° grade on the out-slopes (Table 2). The average slope for all pastures was 12.6°. Slope did not differ between stocking density treatments. All aspects were represented within the pastures. There was no difference in average aspect between stocking density treatments (P=0.05)(data not shown).

Herbage Biomass and Botanical Composition

Within the study area, herbage biomass ranged from zero on washes and hot-spots to nearly 2500 kg ha^{-1} in pasture areas with a dense cover of sericea lespedeza (Fig 3, Table 2). Sericea lespedeza is well adapted to the low pH, droughty conditions prevalent in surface mine spoil (Windham et al., 1988) and this species often dominates on ungrazed reclamation sites in Kentucky.

Table 2. Elevation, slope, biomass, grazing activity, and ground cover.

Parameter	Minimum	Maximum	Mean
Elevation (m)	295	371	342
Slope (°)	<1	57	13
Biomass (kg ha^{-1})	0	2465	573
Grazing activity rating	None	Heavy	Moderate
Ground cover (%)	10	100	74

After omitting sample points on areas considered flat (<4° slope), west-facing slopes had the greatest forage yields ($P<0.10$). Slope and aspect effects on the amount and botanical composition of vegetative cover have been noted in other reclamation research. Dyer and Sencindiver (1985) found mulching to be very beneficial on south and west-facing slopes initially after seeding whereas north-facing slopes had nearly complete cover even without mulch. Nine years later, forage growth was densest on south-facing and west-facing slopes where sericea lespedeza and other legumes were more prevalent.

One month after the start of the experiment, grazed pastures had lower biomass densities than the ungrazed controls. Biomass density for the heavy stocking density was significantly lower than that of the moderate and light stocking densities (Table 3). The moderate and light stocking densities did not differ in biomass (Table 3). Legumes made up a smaller proportion of the total sward at the higher stocking density. Grasses predominated at the moderate and high stocking densities. A month after the initiation of the study, ground cover ranged from 10% to 100%, with an average of 74% (Fig. 4; Table 2) and was not affected by stocking density (Table 3).

Animal Grazing Activity and Weight Gain

Grazing activity on the 36 ha pastures was light to moderate and moderately heavy on the 12 ha pastures (Fig. 5). Grazing activity differed for stocking densities (Table 3). Cattle tended to graze less on the steep slopes than on level areas ($r=-0.28$, $P=0.0001$). However, even the steepest slopes were grazed by animals at the highest stocking density, illustrating that while cattle prefer to graze flat areas, slopes will be grazed when biomass becomes limiting.

Cow weights were similar initially and stocking density effects were minimal during the first 4 months of the grazing season. Poor animal utilization of sericea lespedeza frequently results under grazing due to high tannin levels accumulated in mature forage. In this study beef cows and calves appeared to utilize sericea lespedeza well during early stages of growth. Observations indicate that maturation of the forage in sericea-dominated areas reduced grazing activity later in the season. This was especially a problem at the lowest stocking density. It appeared that more intensive early utilization at the highest stocking density maintained sericea in a vegetative stage and helped to maintain its palatability. By 2 October, cow

Table 3. Biomass, grazing activity, ground cover, grass, and legume.

Stocking density	Biomass (kg ha^{-1})	Grazing activity ‡	Ground cover (%)	Legume (%)	Grass (%)
None	925a†	1.00d	79a	12a	54a
Heavy	406c	4.32a	71a	6b	41b
Moderate	553b	3.55b	76a	13a	37bc
Light	599b	2.63c	73a	16a	33c

† Values followed by the same letter within a column are not significantly different ($P=0.05$) according to LSD.
‡ The following scale was used to rate grazing activity: 1=none, 2=light, 3=light to moderate, 4=moderate, 5=moderate to heavy, and 6=heavy.

Table 4. Livestock performance on reclaimed pastures.

	Stocking density (cow-calf ha^{-1})		
	0.83	0.42	0.28
Cow			
Weight, 4/17 (kg)	394a†	393a	391a
Weight, 10/2 (kg)	433b	465a	460a
Body Cond. Score, 10/2	5.1b	5.5a	5.7a
Calf			
Weight, 6/27 (kg)	160a	148ab	145b
Weight, 10/2 (kg)	244a	253a	250a
Aug-Sept. Gains (kg)	47a	64b	68c

†Value followed by the same letter within a row are not significantly different (p=0.05) according to LSD.

weights were lower at the higher stocking density (Table 4) likely due to insufficient dry matter (DM) availability on that treatment. Body condition scores for cows at the highest stocking density were significantly lower than scores for cows stocked at the low and moderate rates (Table 4). Early season calf weights were significantly greater for the high stocking density (27 June), but as the grazing season progressed these differences declined (2 October). Calf weight gains (Aug-Sept) were highest for the low stocking density, followed by the moderate stocking density, and high stocking density.

In the present study water sources included ponds and springs. Location of the water had little effect on animal distribution even in the largest pastures. This most likely because the furthest point from water in any pasture was 900 m (Fig. 1). Hart et al. (1993) found that pasture utilization of continuously grazed 207 ha pastures declined significantly at distances greater than 3000 m from a water source. In the present study evidence of cattle activity was observed in almost all areas of the pastures with no apparent spatial relationship to the water source. Placement of mineral supplements also had no effect on the grazing distribution. The maximum distance from mineral in any pasture was less than 700 m.

Conclusions

Reclaimed mine land pastures varied widely in physical characteristics such as elevation, slope, aspect, plant growth medium, and vegetation. The amount and botanical composition of vegetative cover also differed widely within and between the stocking density treatments. The availability of GPS and GIS technologies will aid in the understanding of relationships and changes taking place over time within this complex grassland ecosystem. First year data suggest that a cow/calf stocking density of 0.83 ha^{-1} may not be sustainable on reclaimed land in Southeastern Kentucky. This grazing study will be continued for at least four additional grazing seasons providing information on the temporal effects of grazing reclaimed mined land pastures.

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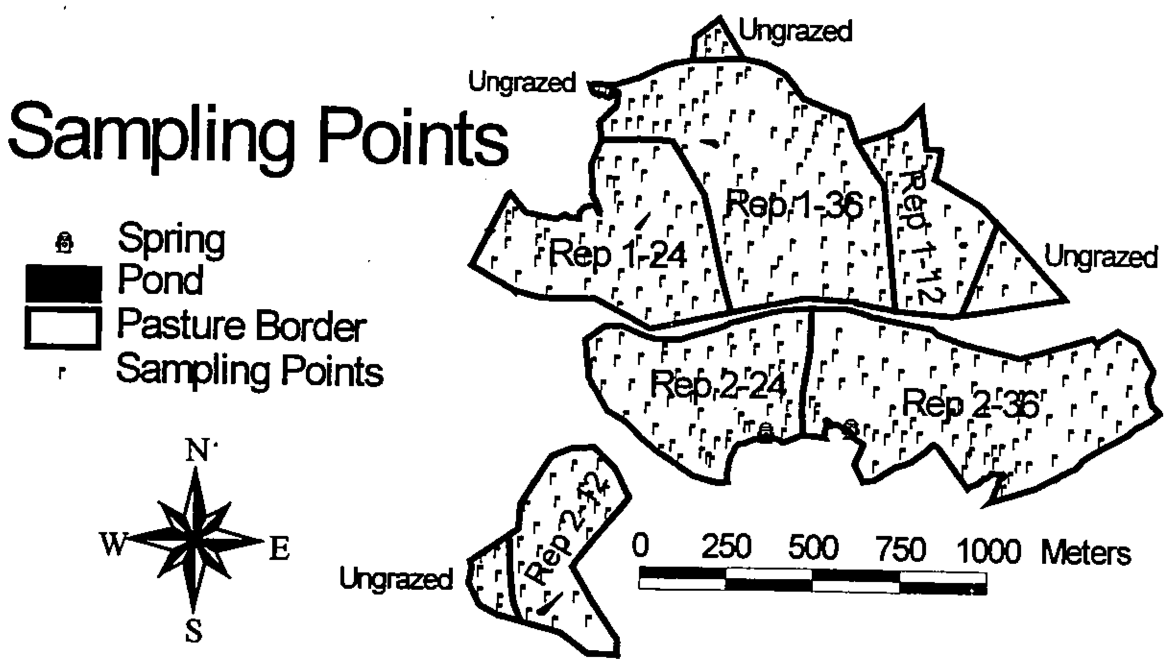

Figure 1. Pasture boundaries, permanent sampling points, and water sources.

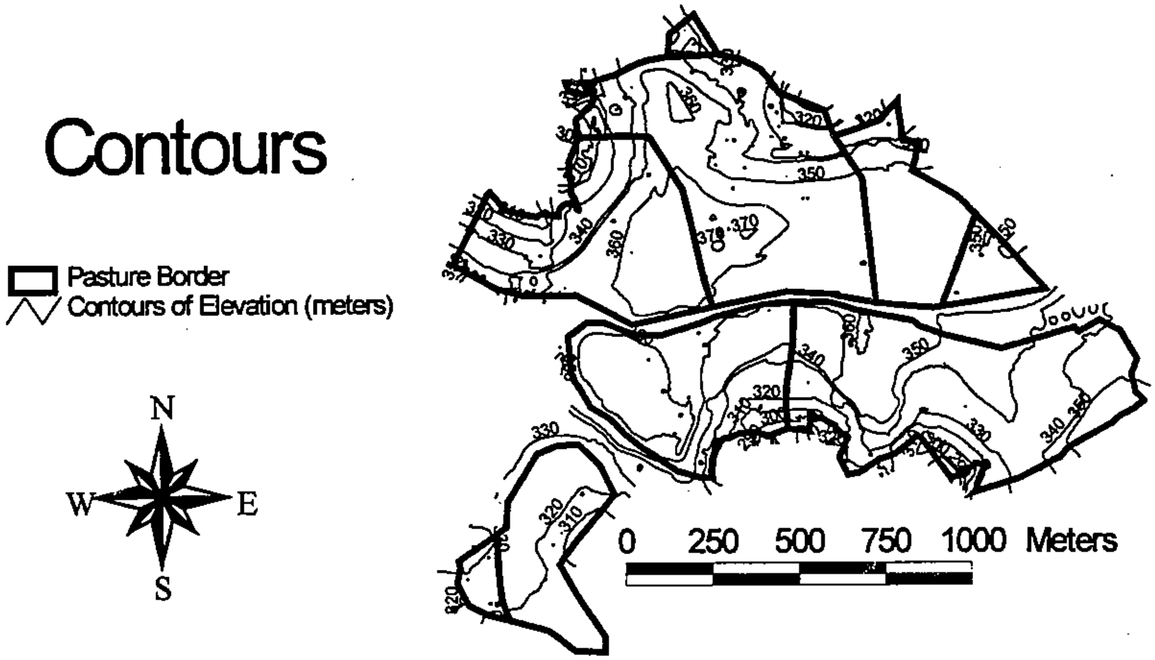

Figure 2. Interpolated surface for elevation.

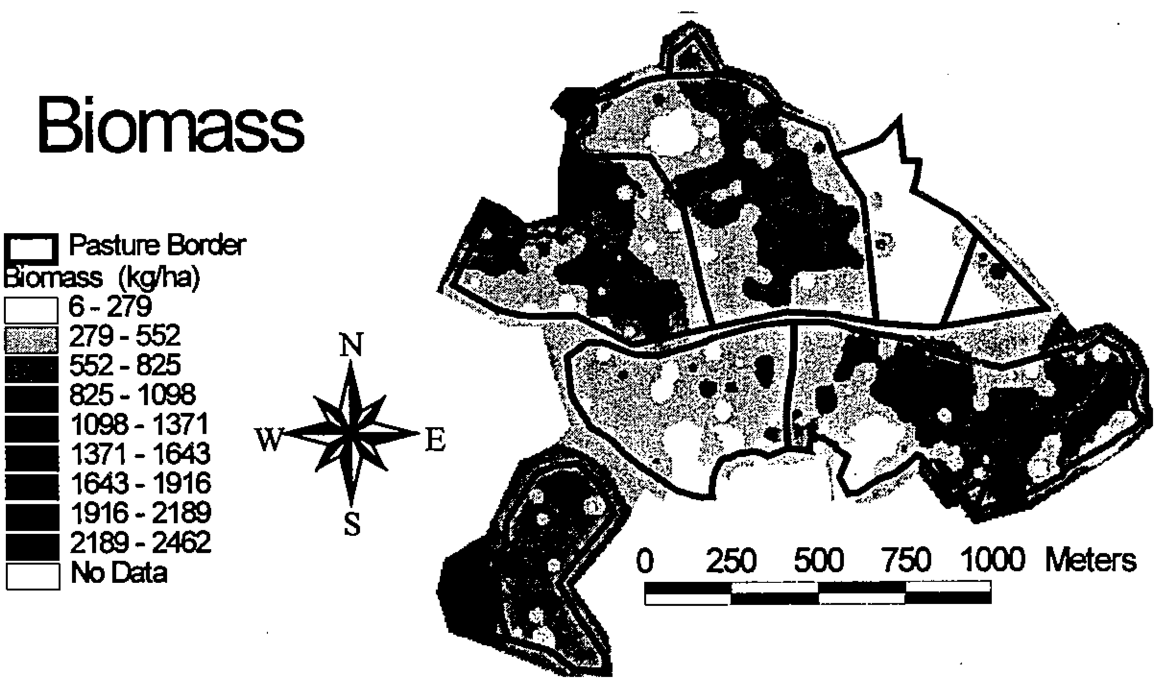

Figure 3. Interpolated surface for biomass.

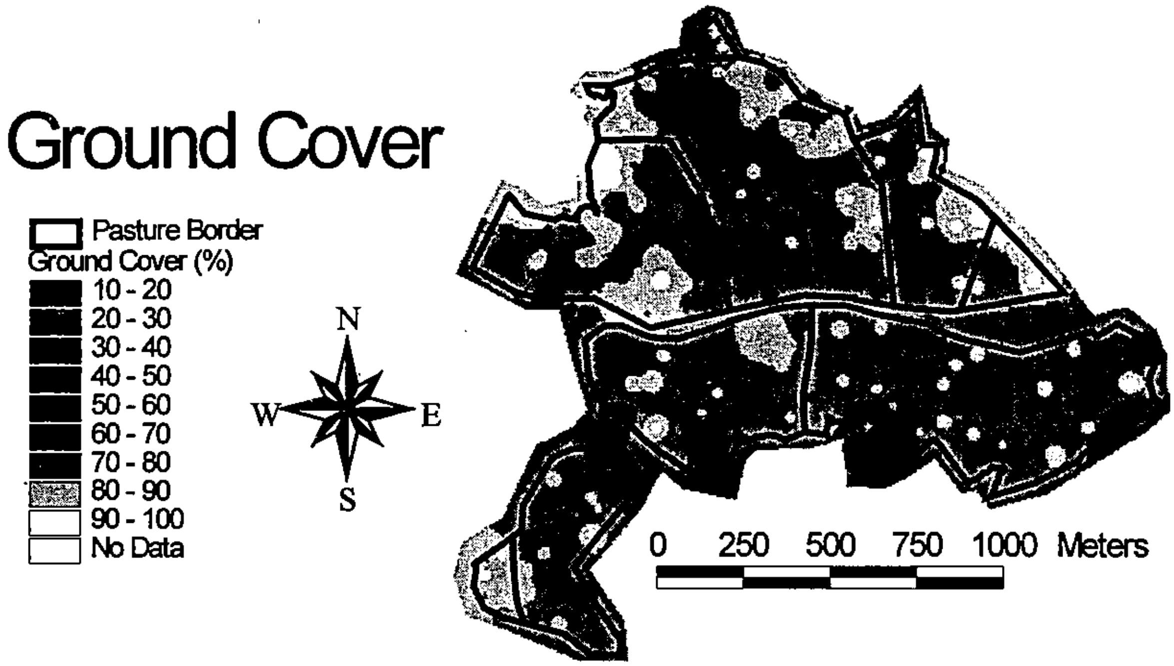

Figure 4. Interpolated surface for ground cover.

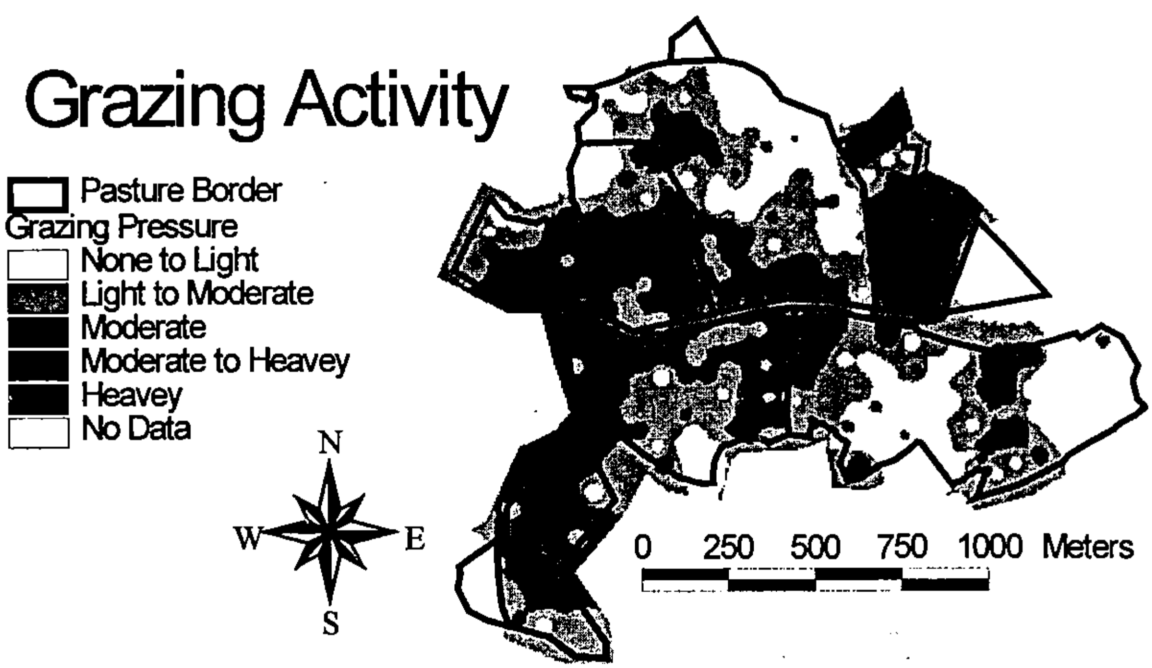

Figure 5. Interpolated surface for grazing activity.