VEGETATION TRENDS IN RECLAIMED AREAS AT GIBBONS CREEK LIGNITE MINE, GRIMES COUNTY, TEXAS[1]

by

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Abstract: Vegetation productivity and cover studies have been conducted annually at the Gibbons Creek Lignite Mine since 1989, and multiple annual clippings have been collected since 1991. The primary purpose of these studies was to examine revegetation success, in terms of herbaceous productivity, for various post-mine soil types. However, the studies also contain detailed information on species composition. For the years in which multiple annual clippings have been collected (1991 through 1996), total vegetation cover increased, with the mean proportion of bare ground dropping from 12% in 1991 to 1% in 1996. Relative proportions of most introduced and native grasses were virtually static from 1991 through 1994; in 1995, however, herbicide applications to reduce clover cover resulted in a dramatic increase in total grass cover, especially in bahiagrass (*Paspalum notatum*) and Indiangrass (*Sorgastrum nutans*). In contrast to the trends of other introduced and native grasses, bahiagrass increased in cover throughout the study period, increasing from 7% in 1991 to 21% in 1996. Annual and weedy grass species decreased in cover throughout the study period, falling from 12% cover in 1991 to 2% in 1996. This trend of displacement of annuals by perennials is typically observed during ecological succession in natural vegetation communities, and appears to have been accelerated by the herbicide application.

Additional Key Words: revegetation, species composition, herbicide, bahiagrass, *Paspalum notatum*.

Introduction

The 1977 Surface Mining Control and Reclamation Act (SMCRA) requires that all mines be reclaimed to a vegetation cover and productivity equal to or better than the pre-mining condition. The Gibbons Creek Lignite Mine, located in Grimes County, Texas, has conducted annual vegetation cover and productivity studies since 1989. The primary purpose of these studies was to examine revegetation success for various post-mine soil types; for example, ranges of pH, texture, and the effects of different liming treatments. In the course of this data collection, several years' worth of species composition data have also been gathered. This paper details the species composition trends observed through analysis of species composition data and examines reasons for some of these trends.

Study Site

The Gibbons Creek Lignite Mine is a surface lignite mine located in Grimes County, Texas, approximately 26 km (16 miles) east of Bryan/College Station. The area typically receives 99 cm (39 inches) of precipitation per year, with peak rainfall in spring and fall. The climate is humid subtropical, with an average frost-free period of 270 days per year (Griffiths 1993).

Until its closure in 1996, the mine provided lignite to the nearby Gibbons Creek Steam Electric Station. The permit area examined in this study is 4,400 ha (11,000 acres), of which 1,680 ha (4,200 acres) were mined from 1978 to 1996. The study covers the first two proposed bond release areas, comprising a total area of 350 ha (876 acres). Soils at the mine were reclaimed from mixed overburden until 1985; after 1985 topsoil was salvaged and replaced to a depth of at least 6 inches. Pre-mine soils were predominantly claypans; post-mine soil textures were generally clay loam to sandy loam. Before lime treatment, post-mine soils ranged in reaction from extremely acid to neutral; after treatment, soils ranged from medium acid to neutral.

Reclaimed mined areas were revegetated with both native and introduced grasses; a list of permitted revegetation species and planting rates is provided in Table 1. In 1990, 39% of the study area was overseeded

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following agricultural lime treatment. Revegetation species and rates for overseeded areas are provided in Table 2.

Table 1. Revegetation Species - Original Planting Gibbons Creek Lignite Mine

Common Name	Scientific Name	Rate (lbs/acre)[3]
Bermudagrass (Common and NK-37)	*Cynodon dactylon*	2 PLS[4]
Bahiagrass (Pensacola)	*Paspalum notatum*	3 PLS
Kleingrass (Selection 75)	*Panicum coloratum*	2 PLS
K.R. Bluestem	*Bothriochloa ischaemum*	2 PLS
Indiangrass (Lometa)	*Sorgastrum nutans*	2 PLS
Sideoats grama (Haskell)	*Bouteloua curtipendula*	3 PLS
Switchgrass (Alamo)	*Panicum virgatum*	1 PLS
White sweetclover (Hubam)	*Melilotus albus*	4 PLS

Table 2. Revegetation Species - Reseeded Areas Gibbons Creek Lignite Mine

Common Name	Scientific Name	Rate (lbs/acre)
Bermudagrass (Common and NK-37)	*Cynodon dactylon*	2 PLS
Bahiagrass (Pensacola)	*Paspalum notatum*	2 PLS
Kleingrass (Selection 75)	*Panicum coloratum*	2 PLS
Illinois bundleflower	*Desmanthus illinoensis*	0.5 PLS
Native sunflower	*Helianthus annuus*	0.5 PLS

[3]1 lb/acre = 1.125 kg/ha.
[4]PLS = pure live seed.

Nomenclature after Gould 1975 for grasses and Correll and Johnston 1979 for forbs.

Methods

When vegetation studies were initiated in 1989, one-time spring clipping and cover determinations were performed, primarily to observe the effects of soil pH and texture on these parameters. A spring clipping was repeated in 1990. In 1991, Soil Conservation Service (SCS, now known as Natural Resources Conservation Service) standards developed for the mine were accepted by the Railroad Commission of Texas, the state regulatory agency, to be used as the performance standard against which vegetation productivity data would be compared. Based on recommendations from the SCS, permanent plots were established in randomly selected areas to be monitored two to three times over the growing season.

This sampling procedure was used until 1995, when the Railroad Commission of Texas field staff began using randomly located plots along random transects for cover and productivity determinations. Our sampling procedure was revised at this time to match that used by the Railroad Commission.

Field Procedures

Reclaimed areas at the Gibbons Creek Lignite Mine have been divided into 150 x 150m (500 x 500') grids (each grid approximately 2.3 ha or 5.7 acres). Grid corners are marked and labeled in the field with PVC pipe. For the 1991 through 1994 studies, grids were randomly selected (by drawing "out of a hat") and checked in the field to determine that vegetation was sufficiently established to begin field studies. On each grid selected for study, five permanent 1 x 1m plots were set up and marked with fence posts and rebar.

Plots were normally sampled two to three times per year; however, sampling schedules were adjusted depending on precipitation patterns. For each sampling, foliar cover of each species was visually estimated to the nearest 5%. The entire plot was then clipped, and the biomass bagged and sent to a commercial laboratory for oven-drying (60°C) and weighing. No more than five days elapsed between clipping and delivery to the laboratory. Mean cover and productivity data values were calculated for each grid, and for each management area.

For areas sampled in 1995 and 1996, a base line was plotted across each area to be sampled. At random distances along this base line, transects were generated perpendicular to the base line. Square 1/2 x 1/2 m plots were sampled at random distances along each transect (in paces from a random number table), using the same procedures as for previous years' data collection. Plots were sampled twice in 1995; only one sampling was

performed in 1996 due to a severe drought. After each sampling, the entire transect was shredded to ensure that the subsequent clipping would represent only new growth. As for previous years, the biomass was oven-dried and weighed by a commercial laboratory.

Data Analysis

For consistency, only data collected from the same geographic areas over the study period were used for calculations.

Mean cover values were calculated for each species from the raw data collected each year. A standard deviation (sd) was calculated for each population mean (Ott 1984). Standard error (se) was calculated as follows:

$$se = \frac{sd}{\sqrt{n}}$$

A one-way analysis of variance (ANOVA) was used to determine if significant differences in percent species composition occurred between years. Duncan's Multiple Range test was used to perform means separations on data identified through ANOVA as having significant differences (Ott 1984). Results were considered significant at the level of $\alpha = 0.05$.

Results and Discussion

Cover data are summarized in Figure 1, while Table 3 provides detailed results of the species composition calculations. Total vegetation cover increased over the years studied, with bare ground dropping from 12% in 1991 to less than 1% in 1996. The category "other grasses" also showed a decline over the study period. This category mainly includes annual grasses, such as annual rye grass, winter wheat, and oats, previously planted as temporary cover to prevent erosion until a suitable time for planting permanent vegetation. The relative proportion of these annual grasses has decreased as perennial species have become established.

Although data collected through the years showed most of the reclaimed area had good grass cover, by 1994 portions had developed such thick stands of white sweetclover that grass growth was negatively affected (the forb cover shown in Table 3 is primarily composed of clover). Clover had been included in the permanent revegetation planting mix and occasionally in planting mixes for temporary cover as well. We hypothesized that clover took over in areas where the permanent grasses never became well established.

Herbicide spraying (Ally brand of metsulfuron methyl) was conducted in May of 1995 to reduce cover of clover in the reclaimed areas. The herbicide appears to have had a marked effect on the cover of several species.

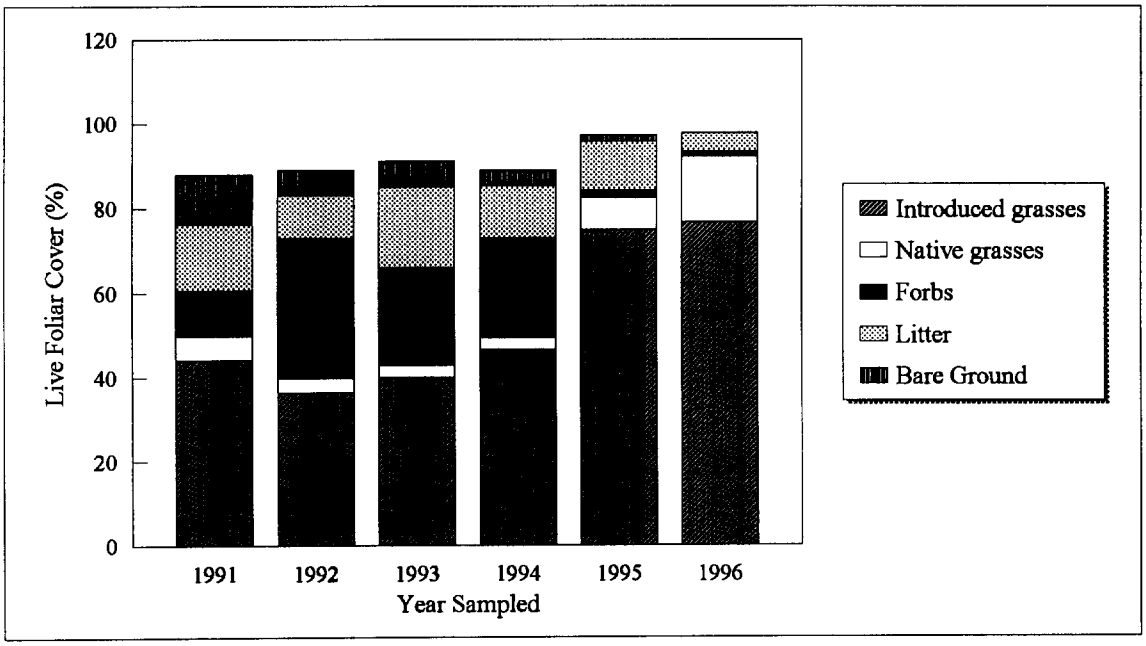

Figure 1. Gibbons Creek Lignite Mine Reclaimed Vegetation Cover

Table 3. Gibbons Creek Lignite Mine
Vegetation Species Composition 1991 through 1996

		Live Cover (%)										
		Introduced				Native						
		Bermuda grass	Bahia grass	Klein grass	K.R. Bluestem	Indian grass	Switch grass	Sideoats grama	Other grasses	Forbs	Litter	Bare ground
1991	Mean:	26a	7a	11a	0a	2abc	2a	2a	12b	11b	16c	12d
	sd:	21.0	9.9	9.5	0.0	3.8	5.0	2.7	17.4	5.9	6.9	9.5
	se:	4.0	2.1	2.0	0.0	0.8	1.1	0.6	3.6	1.2	1.4	2.0
1992	Mean:	22a	8a	6a	0a	1ab	2a	1a	11b	33d	10b	6cb
	sd:	13.8	7.8	4.6	0.0	2.2	2.5	1.5	9.7	9.1	3.8	3.6
	se:	2.9	1.6	1.0	0.0	0.5	0.5	0.3	2.0	1.9	0.8	0.7
1993	Mean:	21a	9a	10a	0a	0a	1a	1a	9b	23c	19d	6cb
	sd:	15.4	9.1	7.8	0.7	0.7	3.0	2.2	6.3	5.0	6.0	3.6
	se:	3.2	1.9	1.6	0.1	0.1	0.6	0.5	1.3	1.0	1.3	0.7
1994	Mean:	24a	15ab	8a	1a	1a	1a	1a	11b	24c	12bc	4ab
	sd:	16.2	13.8	7.0	1.8	2.0	2.1	1.6	8.2	7.3	4.2	3.1
	se:	3.5	3.0	1.5	0.4	0.4	0.5	0.3	1.7	1.6	0.9	0.7
1995	Mean:	38a	25c	10a	1a	3bc	3a	2a	3a	2a	11b	2a
	sd:	17.8	16.3	12.4	3.3	4.8	4.9	4.0	4.3	1.8	4.7	1.0
	se:	4.3	4.0	3.0	0.8	1.2	1.2	1.0	1.0	0.4	1.1	0.3
1996	Mean:	28a	21bc	20b	7b	4c	9a	3a	2a	2a	4a	0a
	sd:	20.7	20.6	21.9	12.0	7.1	20.5	6.4	5.0	2.0	3.8	0.9
	se:	5.0	5.0	5.3	2.9	1.7	5.0	1.5	1.2	0.5	0.9	0.2

Values (within columns) followed by the same letter are not significantly different from one another.
n = 23 for 1991 through 1994; n = 17 for 1995 through 1996.

Forbs, dominated by clover, were significantly reduced in cover from 24% in 1994 to 2% in 1995. Bahiagrass and Indiangrass also increased in cover from 1994 to 1995, and overall grass cover increased from 1994 to 1995.

A severe drought in 1996 appears to have differentially affected the cover of several grass species. For example, bermudagrass cover did not show any significant change from 1995 to 1996, while kleingrass and bluestem showed a substantial increase. Bahiagrass, which increased over the study period, did not show an increase in 1996. None of the native grasses appeared to decline in the drought year, indicating they may be able to withstand climatic fluctuations better than some of the introduced species. In fact, when looked at as a group, cover of native grasses doubled from 1995 to 1996. The 1996 data may also indicate a continuing positive response of the native grasses to the herbicide treatment.

Conclusions

Vegetation studies conducted over a period of several years at the Gibbons Creek Lignite Mine have yielded a great deal of information on species composition. Analysis of these data showed that total vegetation cover has increased throughout the study period, and annual grasses have been gradually replaced by perennial species.

Cover of most perennial species did not vary greatly throughout the study period, until an herbicide application was conducted in 1995 to control clover. The herbicide application substantially reduced forb cover in reclaimed areas, and appeared to result in increased warm season perennial grass cover.

A severe drought in 1996 was not detrimental to grass species in the reclaimed areas. Cover of kleingrass and introduced bluestem significantly increased in the drought year, and no negative impact was observed on switchgrass, Indiangrass, or sideoats grama cover.

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