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Vegetative Analysis of the Monahan Reclaimed Mined Land Area

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VEGETATIVE ANALYSIS OF THE MONAHAN RECLAIMED MINED LAND AREA

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By

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ABSTRACT

The Monahan reclaimed mined land area is located in Crawford County, Kansas, and is approximately one mile north and one mile east of Cherokee, Kansas. Strip and shaft mining both occurred at the site. The reclamation project was performed in 1984, with seeding of native grasses comprising the final stage.

This study was designed to evaluate the revegetation portion of the project. Data was collected to determine basal cover and frequency of plant species occurring on the site; soil pH measurements were also included in the study. This information was used to develop a comparative evaluation of the grass species utilized in the reclamation.

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CHAPTER I

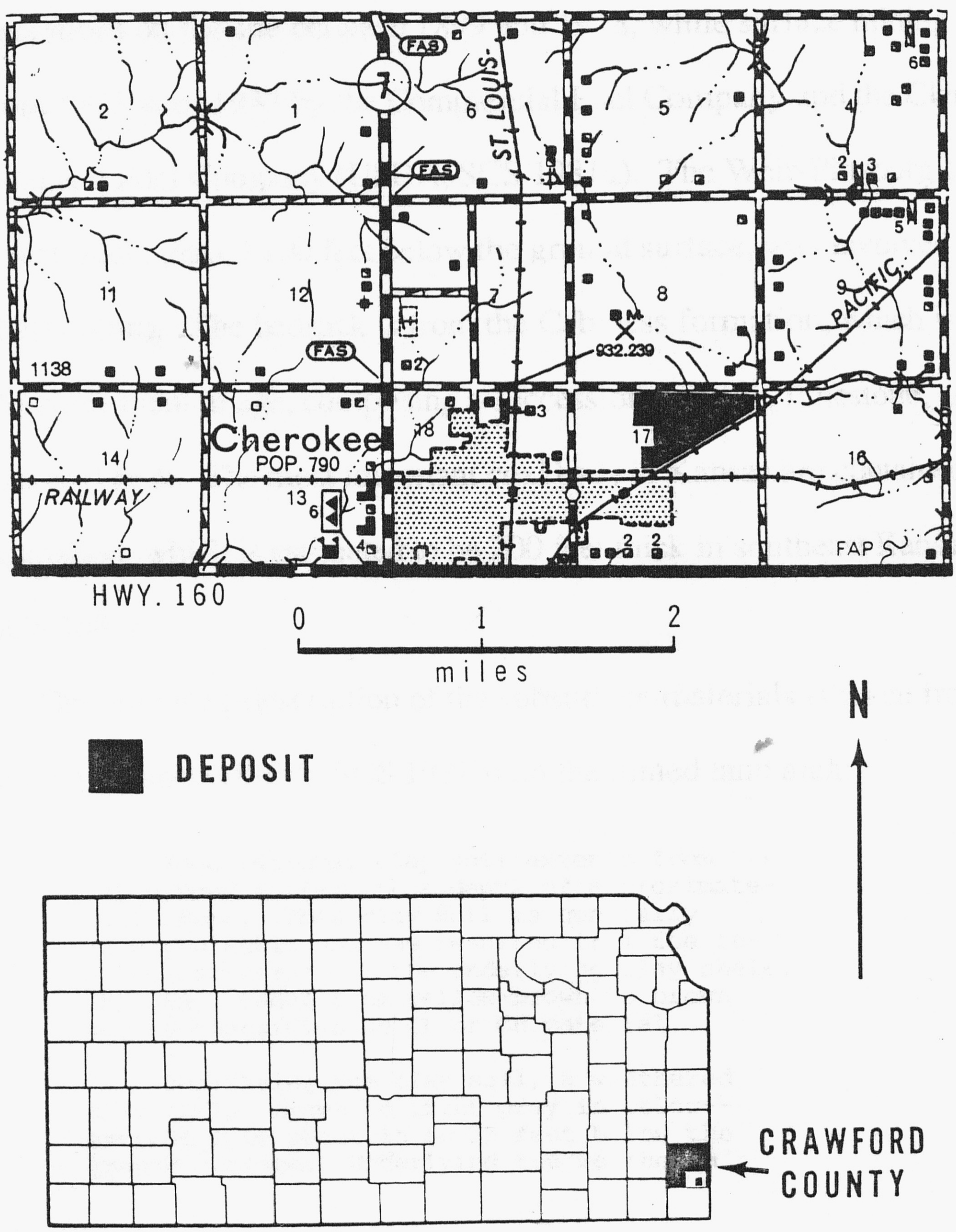
INTRODUCTION

Study area

The Monahan Outdoor Education Center is located 1 mile north and 1.5 miles east of the intersection of US Highway 160 and Kansas State Highway 7. The site lies within the northeastern quarter of section 17, T31S, R24E, of Crawford County (Figure 1). The center was donated to Pittsburg State University by Dr. William Reals of Wichita, Kansas. The Monahan site is approximately 156 acres in area; only an approximate 80 acres were reclaimed. The 80-acre area, before any reclamation work was conducted, consisted of a gob pile of just under 20 acres, spoil banks, water filled cuts, and a coal processing/shipping area (USDA, SCS 1981a).

The area is located in the Parsons-Dennis soil association, which is characterized by deep soils, nearly level to gently sloping terrain. This is the most extensive of the associations in the county, with mine pits and dumps comprising 10 percent of the associations area (Rott et al. 1973). The Monahan site lies at an elevation of 930 to 940 feet, with an average annual

Figure 1. Location of Monahan reclamation site



MAP SOURCE : KANSAS STATE HIGHWAY COMMISSION

rainfall of 40 inches. A tributary of Brush Creek drains the site in a southeasterly direction (USDA, SCS 1981b).

The Western Coal and Mining Company conducted underground mining operations on the site between 1899 and 1918, while surface mining occurred from 1933 until 1937 by the Commercial Fuel Company and the Clemens Coal and Fuel Company (USDA, SCS 1981a). The Weir-Pittsburg coal bed, 3 feet thick, placed 100 feet below the ground surface, was involved in the shaft mining. The bedrock is from the Cabiness formation, which is Middle Pennsylvanian in age, comprising a succession of shale, limestone, sandstone and coal beds. The most important coal beds in Kansas are contained in this formation, which is estimated to be 200 feet thick in southeast Kansas(USDA, SCS 1981b).

The following description of the subsurface materials is taken from the geology report (USDA, SCS 1981b) on the mined land area:

> Deep residual clay soil extends from the ground surface to a depth of approximately 15 feet. This clay soil is generally highly plastic and has resulted from the in-place weathering of the underlying clay shale. The clay ranges from yellow-brown to brown and is classified as CL or CH material.
>
> Underlying the clay soil, a weathered clay shale--brown to light gray in color--extends from about 15 to 25 feet below the ground surface. Underlying the weathered

> shale, a succession of shales, sandstones, and the limestones occurs. This bedrock strata contains a few coal layers at 25- to 30-foot intervals. In one test hole drilled on this site the bedrock strata was penetrated to a depth of 100 feet at which depth the
>
> mined out Weir-Pittsburg coal bed was encountered.

In addition to the mining operations, a coal- processing plant was operated on the site for some time until it was closed in the mid-1940's. Coal mined at the site, along with that brought in from other mines by rail, was washed and screened before it was sent on to its next destination. A pond, located just east of the present gob pile, was used for the disposal of the sediment-laden wash, where the sediment eventually reached a depth of nearly 6 feet over the 30-acre pond. It is estimated the sediment contained a 50 percent coal content. The current gob pile is the result of coarse-grained waste produced by the coal processing plant (USDA, SCS 1981b).

The geology report describes this gob pile as follows:

> The material in this gob was dumped to a depth of about 30 feet over an area of about 17 acres. The gob pile contains an estimated 508,000 cubic yards of dumped waste material. The gob material consists of a heterogenous mixture of ironstone, broken shale, and impure coal fragments of varying sizes. However, less than 10% of the dumped waste material consists of rock fragments greater than 3 inches. About 50% of the gob material (dump-ed waste) is finer than the No. 200 sieve. That is, about 50% of the material is coarse-grained and 50% is fine-grained. The fine-grained material in the gob pile shows very little plasticity and is generally classified

> as ML material. The undisturbed ground surface of the gob pile forms a relatively impervious iron hydroxide crust.

It was found that significant portions of the gob pile consisted of pyrite, iron oxides, and sulfur; along with some traces of burned shale and coal, termed red dog. Production of iron and sulfur compounds from these materials, combined with a lack of any substances to act as buffers, created a condition nearly devoid of any vegetation (USDA, SCS 1981b).

The gob pile, with its considerable erosion problems, was depositing harmful materials into the adjacent creek and upon the surrounding area. No aquatic life, plant or animal, was reported in the two mile tributary of Brush Creek (USDA, SCS 1981a). Water samples were taken on the site, and it was found the gob pile was the primary source of acid water, but no danger to any underground water supply was discovered (USDA, SCS 1981b).

Mining history

Many changes including increased population and industrial and economic growth have placed more of an emphasis on the extraction of U.S. coal reserves (Armiger et al. 1976). Consequently, as much of our electrical

energy is now produced by the burning coal, and we are striving to become less dependent on foreign oil it is expected that coal use will more than double in the next decade, therefore continuing, and most likely expanding, the problem of surface mining operations (Slick and Curtis 1985). Surface mining occurs in all the states of the Union. Although the actual percentage of land disturbed is figured to be quite low, other problems stem from these sites, pollution runoff for example, which can adversely affect a much greater area. A total of 5.7 million acres have been disturbed as of July 1, 1977 in the United States. Disturbed areas are defined as: (1) those areas having materials displaced by surface mining, (2) those regions in which displaced materials have been deposited, (3) the haul roads and holding basins on surface mined sites, and (4) all those lands which have had their natural state altered by surface mining activities. Kansas, as of 1977, had a total of 91,109 acres of disturbed land, coal mines contributing 50 percent of that state total. Cherokee and Crawford counties, having 23,000 and 23,180 acres of disturbed land respectively, together contribute approximately 50 percent of the total acreage disturbed in the state. Coal mines are by far the major disturbing factor in the two southeasterly situated counties (USDA 1977).

Mining has aroused nationwide concern because of its production of

erosion and sedimentation along with the unsightly, drastically altered lands (Armiger et al. 1976). The possible results of mining operations include, the changing of entire ecosystems, eradication of plant communities, production of surface and ground water pollution, topsoil loss, wildlife habitat elimination or reduction, and visual detriment (Slick and Curtis 1985). However, the potential contributions of reclaimed sites should not be overlooked. These sites can be restored to original land use patterns or alternate uses can be developed, such as recreational areas, wildlife habitats, or even industrial and commercial development sites (Armiger et al. 1976).

Reclamation background

The primary goal of revegetation of mined land areas, regardless of its intended use, is to control erosion by runoff and the consequential result of sedimentation. This process also returns the area to some productive use while imparting a more eye-pleasing appearance. Herbaceous species are particularly important for their rapid rate of establishing a cover (Vogel 1981). The mixing of an annual along with a slower developing species is often done to provide an immediate cover, allowing the slower developing

species to come into production (Rafaill and Vogel 1978). At the Monahan site spring oats were planted in the fall of 1984 to provide temporary cover until the native grasses were seeded in the spring of 1985.

Presently much research is being conducted to determine proper mixes of seed and exactly what plant species are determined satisfactory for revegetation. Specific projects have been undertaken by several federal agencies in an attempt to evaluate criteria for measuring success of revegetation projects, and to make success predictions available (Packer et al. 1982). Today there are lists produced by these agencies, usually the Soil Conservation Service, that contain selected species that have been evaluated for use in reclamation of mined land areas (Chironis 1977). Because the characteristics of many of these plant species are known, their natural habitat and specific growth requirements, almost in any area, can successfully be revegetated by proper species selection (Thornburg 1982). Table I illustrates some characteristics of the grass species employed in this reclamation project.

Recent research has shown that the use of native grasses, more so than pasture grasses, can prove to be a valuable revegetation technique. The drought-tolerance, lower fertilization demand and perennial nature of these

Table I. Characteristics of the grasses utilized in the Monahan reclamation project

Common Name: Western Wheatgrass
Scientific Name: Agropyron smithii Rydb.
Life Cycle: Perennial
Season of Growth: Cool
Origin: Native
Lower pH Limit: 4.5
Comments: Rhizomatous, aggressive sod-forming species. Widely used in surface mine reclamation, and critical area stabilization.

Common Name: Indiangrass
Scientific Name: Sorghastrum nutans (L.) Nash
Life Cycle: Perennial
Season of Growth: Warm
Origin: Native
Lower pH Limit: 4.5
Comments: Sod-forming, establishing clumps with short rhizomes. Established stands generally require little or no maintenance.

Common Name: Big Bluestem
Scientific Name: Andropogon gerardii Vitman
Life Cycle: Perennial
Season of Growth: Warm
Origin: Native
Lower pH Limit: 4.5
Comments: Stout nonrhizomatous or short rhizomatous species. May be slow to develop cover, but once established, stands require little maintenance.

Common Name: Little Bluestem
Scientific Name: Andropogon scoparius Michx.
Life Cycle: Perennial
Season of Growth: Warm
Origin: Native
Lower pH Limit: 4.5
Comments: Two to three foot tall bunchgrass, sometimes with short rhizomes. Occasionally slow to establish, but requires little maintenance.

Table I. continued

Common Name: Switchgrass
Scientific Name: Panicum virgatum L.
Life Cycle: Perennial
Season of Growth: Warm
Origin: Native
Lower pH Limit: 4.0 to 4.5
Comments: Strongly rhizomatous, often forming large clumps. Stands usually require two to four years to develop good cover, but once established little or no maintenance is required.

Common Name: Sideoats Grama
Scientific Name: Bouteloua curtipendula (Michx.) Torr.
Life Cycle: Perennial
Season of Growth: Warm
Origin: Native
Lower pH Limit: 4.5
Comments: Stems growing from strong, scaly rootstalks. Establishes fairly quickly.

Common Name: Buffalograss

Scientific Name: Buchloe dactyloides (Nutt.) Engelm.
Life Cycle: Perennial
Season of Growth: Warm
Origin: Native
Lower pH Limit: 4.5
Comments: Dioecious, sod-former, spreading by stolons. Slow to moderate establishment, but well adapted to arid minesoils.

Sources: Great Plains Flora Association. 1986.
Ohlenbusch et al. 1983.
Thornburg 1982.
Vogel 1981.

species frequently warrants a greater success, and when a stand is established, a cover of indefinite longevity results (Bonfert et al. 1986).

Research performed by Russell in 1977, (cited by Ashby et al. 1984) found, by means of greenhouse studies, that excellent plant growth could be supported by very small amounts of soil; more important than the soil volume were the supply of water, nutrients, and other resources. It has become well known that the characteristics of different soils can affect vegetative growth. Rafaill and Vogel (1978) stated "chemical and physical characteristics of spoil such as acidity or alkalinity, nutrient content, stoniness, color, and slope can influence vegetation establishment and growth."

Extensive soil testing is less important when purposes, such as producing wildlife habitat or herbaceous cover, is established for erosion control, than if agricultural uses are intended. The most useful criterion for evaluating the capacity of the reclaimed site to support vegetation appears to be the soil reaction (pH). Soil pH not only affects plant growth, but it can limit the uptake of some important plant nutrients. This is when an understanding of specific plant tolerances to acid conditions is extremely useful in plant selection for revegetating minesoils (Vogel 1981). As of today, the

supplying of the primary plant nutrients - nitrogen, phosphorus, and potassium - has been the most prominent fertilizer application (Wedin 1974).

Reclamation regulations

The Surface Mining Control and Reclamation Act of 1977, Public Law 95-87, which was passed on August 3, 1977 by Congress set forth a fairly comprehensive set of guidelines for surface mining activities. Although the Monahan (Reals) site was not covered by this Act, certain aspects are believed to be important and are briefly discussed in this section.

Congress found that the mining of coal was of upmost importance for our nation's energy needs, but it also agreed that these operations caused disturbances to those areas mined and that there was a need for regulatory standards. Thus, Congress defined as part of its purpose to "establish a nationwide program to protect society and the environment from the adverse effects of surface coal mining operations." These activities were to be carried out through the newly formed Office of Surface Mining Reclamation and Enforcement within the Department of Interior. Also created by the Act was the Abandoned Mine Reclamation Fund to be used for the reclamation of

areas that were mined in the past.

Initial regulatory procedures, Sec. 502(a) states that, "no person shall open or develop any new or previously mined or abandoned site for surface coal mining operations ... unless such person has obtained a permit from the State's regulatory authority." Regulations also require that a reclamation plan, which meets the Act requirements, be submitted as part of the permit application. Public notice must be given of proposed mining activities at the time of application.

Specific environmental protection performance standards were required by mining operators. Standards were written to require, as a minimum, for mining operators to:

> (1) conduct surface coal mining operations so as to maximize the utilization and conservation of the solid fuel resource being recovered so that reaffecting the land in the future through surface coal mining can be minimized.
> (2) restore the land affected to a condition capable of supporting the uses which it was capable of supporting prior to any mining, or higher or better uses of which there is reasonable likelihood...

In addition, other standards demanded that the area be stabilized, thus controlling erosion, and to require attempts to preserve and replace the topsoil or subsoil which was best capable of supporting plant life. Operators

would be required to:

> establish on the regraded areas, and all other lands affected, a diverse, effective, and permanent vegetative cover of the same seasonal variety native to the area of land to be affected and capable of self-regeneration and plant succession at least equal in extent of cover to the natural vegetation of the area; except that introduced species may be used in the revegetation process where desirable and necessary to achieve the approved postmining land use plan.

The Surface Mining Control and Reclamation Act, besides simply setting forth regulations, also outlined penalties to be levied against violators and enforcement procedures to be followed to carry out the legislation.

Site reclamation

The Monahan reclamation project was established through cooperation between the Office of Surface Mining (OSM) and the Soil Conservation Service (SCS) of the U.S. Department of Agriculture, the first such project in Kansas to combine the efforts of these agencies (USDA, SCS 1981a). The money for the reclamation was provided by OSM, while the work was conducted by private firms under the guidance and supervision of the SCS office (telephone conversation 25 January 1989 with Mark M. Sooter, Soil

Conservation Service). The General Counsel for the Kansas Attorney General's Office, Brian Moline, stated August 26, 1980, that there was no legal responsibility on anyone to reclaim the land, thus satisfying requirements under the Surface Mining Control and Reclamation Act of 1977, to be eligible for funds under the Abandoned Mined Land Program. Concurrence with this statement was made by OSM field solicitors. It was determined that state and local support were present for the reclamation project (USDA, SCS 1981a).

The physical reclamation of the site was started in 1984, although numerous preliminary studies were conducted at earlier times, and was completed with the final grass seeding in the spring of 1985. Total costs for the actual construction was approximately $400,000, this figure, however, did not include technical assistance rendered by SCS offices (telephone conservation 25 January 1989 with Mark M. Sooter, Soil Conservation Service). Table II shows the general outline of reclamation procedures followed, while Table III depicts those plants employed in the revegetation process.

Table II. Procedures initiated in Monahan reclamation

1. clearing of trees/shrubs in specific areas
2. leveling and grading of gob pile into acceptable slopes
3. drainage of acidic pits
4. burial of refuse in drained pits
5. development of surface drainage
6. construction of sub-surface drainage
7. top-dressing of crushed limestone, rock & soil
8. development of terraces
9. discing and fertilizing (Nitrogen 50 lbs/acre, Phosphate 60 lbs/acre, Potash 50 lbs/acre)
10. construction of fencing
11. planting of oats 90 lbs/acre (Sept. 1984)
12. planting of grasses*, trees, shrubs (1985)

* grasses drill seeded
Source: Sooter (1989) (personal communication)

Table III. Plants involved in Monahan reclamation

Grasses	Seeding Rates*
Barton Western Wheatgrass	6.0 lbs PLS
El Reno Sideoats Grama	1.8 lbs PLS
Kanlow Switchgrass	0.5 lbs PLS
Blackwell Switchgrass	0.6 lbs PLS
Osage Indiangrass	1.2 lbs PLS
Kaw Big Bluestem	1.2 lbs PLS
Aldrous Little Bluestem	0.8 lbs PLS
Improved Buffalo Grass	0.5 lbs PLS
	12.6 lbs PLS
Forbs	
Maximilian Sunflower	.25 lbs Bulk
Purple Prairie Clover	.50 lbs Bulk
Grayhead Prairie Clover	.25 lbs Bulk
	1.0 lbs Bulk
Trees	Total
Pin Oak	132
Mulberry	132
Hackberry	132
Black Walnut	132
Bur Oak	132
Austrian Pine	132
Loblolly Pine	132
Shrubs	
Fragrant Sumac	200
Autumn Olive	200
American Plum	200
Wild Cherry	200

* Pure live seed per acre
Source: (USDA, SCS 1981c)

CHAPTER II

VEGETATIVE SAMPLING

Recently more emphasis has been placed on quantitative methodology and much less on purely descriptive ones. This has been shown as our knowledge of plant communities has grown, and greater amounts of time have been exerted to develop methods to measure the characteristics of these communities. Those studying these communities are most often concerned with the determination of the kind of plants present and to gain some representation of their numbers (Cottam et al. 1953).

Chambers and Brown (1983) outlined the concept of vegetation sampling as "a means by which an investigator can make inferences about a plant community based on information obtained from intensive examinations of a small proportion or sample of that community." Thus we can infer from a group of representative statistics some supposedly true aspects of the community. Since we are unable to count or measure the entire community, it becomes crucial to determine what exactly comprises an adequate sample (Oosting 1956). The basic idea being the saving of time and labor while still

rendering data that does not significantly stray from that which would be obtained if the complete area had been studied (Gates 1949).

Ecologists have called sample areas quadrats, derived from the fact that early investigators' sample areas were square, although today there exists circles and point samples (Goodall 1952). Because communites are heterogenous, it is necessary to have large enough or numerous enough samples to include all of the variation and to have it properly represented (Oosting 1956). The size of the quadrat is usually determined by community characteristics. The exact number of quadrats will also vary with the characters of the community, but also to be considered are the objectives of the research, and the precision wanted in the study (Smith 1966). Species-area curves have been developed chiefly for the use of indicating minimal quadrat size and the least number of quadrats needed for adequate sampling. It has been suggested that sufficient sampling has been conducted when a 10 percent increase in sample area gives a result of less than a 10 percent increase in the number of species (Rice and Kelting 1955).

Once the size, shape, and numbers of quadrats have been determined there still remains the question of how they are to be positioned within the study area (Oosting 1956). Goodall (1952) states that "the distribution of

quadrats over the area should be such that (a) the mean values for the whole areas of the variables studied are reflected without bias in the means of the samples; and (b) as much information about their variation over the area may be retained as possible." Oosting (1956) gives a much broader view on the situation, simply stating that any method is appropriate if it insures a wide and even distribution of the samples.

Once the data has been obtained for the plant community analysis of this information is the next step. There are any number of analyses which may be applied to the data, however, only a select few will be discussed here.

Frequency, an expression of how often (usually expressed as a percentage) a species occurs in the sample plots is a characteristic tool used in revegetation studies. Frequency, even though it does not give an indication of the space occupied or amount of ground cover a species contributes, does give some inference about the number and distribution of that species (Oosting 1956).

Many people often get the impression, as they look down at the quadrat from above, that the ground is well covered; however, if the plants are clipped at ground level it becomes clear that emerging plants make up only a small amount of the area (Gates 1949). Frequency, while implying numbers

and density, does not always give a true reflection of dominance (Smith 1966). Coverage, more so than numbers of plants or frequency, gives character to the community (Bauer 1943). Thus, area of coverage, for all practical purposes, is used to express dominance (Smith 1966).

CHAPTER III

OBJECTIVES

This research was undertaken to gain information on the revegetation of the Monahan Outdoor Education Center. The objective was to provide both baseline data for the area and obtain information useable in determining species selection for successful revegetation of future reclamation projects.

The study was designed to determine basal cover and frequency of the plants occurring on the reclaimed area. Basal cover provided a foundation for determining dominance of species, and also total ground exposure. Frequency, in turn, determined distribution of each species. A comparative success of plantings was hoped to be shown by basal cover and frequency figures. A select number of soil pH tests were performed to identify any possible correlation of plant distribution to specific site locations.

The data gained from this study will hopefully provide some insight into revegetative reclamation in this immediate geographical region; for example they should indicate which plant species provide best ground cover to diminish erosion and supply substantial habitat for wildlife. It is

recognized that considerable study has been conducted on revegetation processes throughout the United States, however, this work should provide some additional evaluative material for this general area of concern. There is much still to be learned about successful reclaiming of the extensively mined land areas, especially with current mining operations now being required to restore the disturbed area. Secondly, this work should lay a firm foundation of data to build upon in future years. As information is collected over the years, the continual succession of the reclaimed area can be detailed. This work also should prove to be valuable for future projects.

CHAPTER IV

METHODS

Vegetative Sampling

Aerial maps, reclamation reports, and literature sources were reviewed to determine appropriate procedures to be used in surveying the area. Reclamation plans used in the Monahan project were consulted to gather a listing of plants used in the reclamation, how they were seeded, and what seeding rate was administered. These were not the only plants encountered on the site, but they were the ones of particular interest to the study.

The quadrat method was the technique employed for the determination of basal cover and frequency of species occurring on the research site. For this investigation a one-tenth square meter quadrat was chosen as the most useable. Several factors were reviewed in the decision to make this judgement, including size of study area, ease of use, and vegetative type of the site.

Quadrats were evenly distributed throughout the plot along compass and

line measurements; thus, a grid-like pattern of samples were taken on the site. A starting point was randomly selected at the northwest corner of the area and samples were taken at 25-pace intervals (each pace equalling three feet) within each transect line, each successive transect line was placed at 50-pace intervals, all by aid of a compass. Transect lines were established in a north-south orientation.

Sampling was conducted September 1 through October 18 of 1987 and September 10 through September 27 of 1988. This time frame was chosen because of the maximal growth of the majority of plants. This is of extreme importance, especially when sampling is to reflect productivity or vegetative growth (Chambers and Brown 1983).

Within each quadrat all species were identified for purposes of frequency and basal cover. Frequency was calculated for each species by determining how often it occurred in the total number of quadrats. It should be noted that this addressed presence of the plant only, not the amount of growth. Basal cover for each species was obtained by cutting the vegetation at ground level. Cover was then estimated by the use of small squares signifying a defined percentage of the quadrat. Five percent and one percent squares were used for this estimation by placing them on top of the clipped vegetation. Average

ground cover was estimated by averaging the percentage cover encountered for each species in the quadrats; those which had a less than one percent cover were recorded for frequency, but were not included in determining cover, i.e. Melilotus officinalis. The seven grass species selected for the reclamation were collected and can be found in the Sperry Herbarium at Pittsburg State University.

Soil Sampling

Soil samples were taken from the three visually distinct vegetative areas. Two drills, at depths between three and four feet, were randomly taken from each of these regions and combined to make a composite sample for each of the major vegetative areas, as recommended by Vogel (1981). Samples were obtained on October 25, 1988.

The samples were allowed to air dry, after removal of the top few inches of organic matter, and lightly crushed to reduce any large soil clods. Twenty-five grams of the completely dry soil were mixed with 25 milliters of distilled water (1:1 ratio) and the mixture was stirred to adequately saturate all of the soil. The solution was allowed to sit for nearly six hours, letting the soil and

clay to settle. The pH, measured by a pH meter with a glass electrode, was taken from the clear supernatant. Procedures follow those outlined by Askenasy and Severson (1988). For each vegetation area's composite sample three different pH readings were taken to establish the precision of the testing.

CHAPTER V

RESULTS

This chapter sets forth, in tabular and illustrated form, the findings of this investigation. Frequency figures, both for 1987 and 1988 were recorded for all species encountered in the vegetative sampling (Table IV). Those which were intentionally planted or seeded are noted by an asterisk. Amount of ground cover provided by each species is also shown for both study years, including an average for the two years (Table V). All species producing less than one-tenth percent cover for at least one of the years were not included in the listing. The eight species recorded, all grasses, are arranged in order of maximum average cover. All plant nomenclature follows that of The Flora of the Great Plains (Great Plains Flora Association 1986).

Species-area curves, depicting the number of new species found for each new sample quadrat, are illustrated for each study year (Figures 2 and 3). Soil pH measurements of the major vegetative areas are also reported (Table VI). And, finally, statistical analyses have been generated regarding coverage supplied by those grasses used in the reclamation (Table VII).

Table IV. Checklist & frequency figures of all plant species

Species	1987	1988
Agropyron smithii*	0.10	0.07
Amaranthus sp.	0.00	0.01
Ambrosia artemisiifolia	0.49	0.04
Andropogon gerardii*	0.01	0.11
Andropogon scoparius*	0.05	0.10
Aster subulatus	0.36	0.01
Bouteloua curtipendula*	0.66	0.73
Buchloe dactyloides*	0.00	0.03
Conyza canadensis	0.04	0.00
Dalea candida	0.12	0.00
Dalea purpurea*	0.04	0.02
Desmanthus illinoensis	0.00	0.01
Echinochloa crusgalli	0.01	0.01
Elaeagnus umbellata*	0.01	0.00
Elymus	0.02	0.00
Festuca sp.	0.01	0.04
Helianthus annuus	0.05	0.01
Helianthus maximilianii*	0.00	0.02
Iva annua	0.02	0.01
Melilotus officinalis	0.92	0.01
Panicum virgatum*	0.52	0.56
Physalis sp	0.01	0.00
Populus deltoides	0.01	0.00
Setaria geniculata	0.01	0.01
Solanum carolinense	0.00	0.01
Solidago spp.	0.83	0.05
Sorghastrum nutans*	0.05	0.06
Xanthium sp.	0.01	0.00

* Species listed in the reclamation plan

Table V. Estimated ground coverage for plant species

Species	1987	1988	MEAN
Bouteloua curtipendula	4.3	6.7	5.5
Panicum virgatum	2.7	2.4	2.55
Sorghastrum nutans	0.4	0.3	0.35
Andropogon gerardii	0.05	0.4	0.225
Andropogon scoparius	0.2	0.2	0.2
Festuca sp.	0.1	0.2	0.15
Agropyron smithii	0.2	0.03	0.115
Buchloe dactyloides	0.0	0.1	0.05
Total	7.95	10.33	

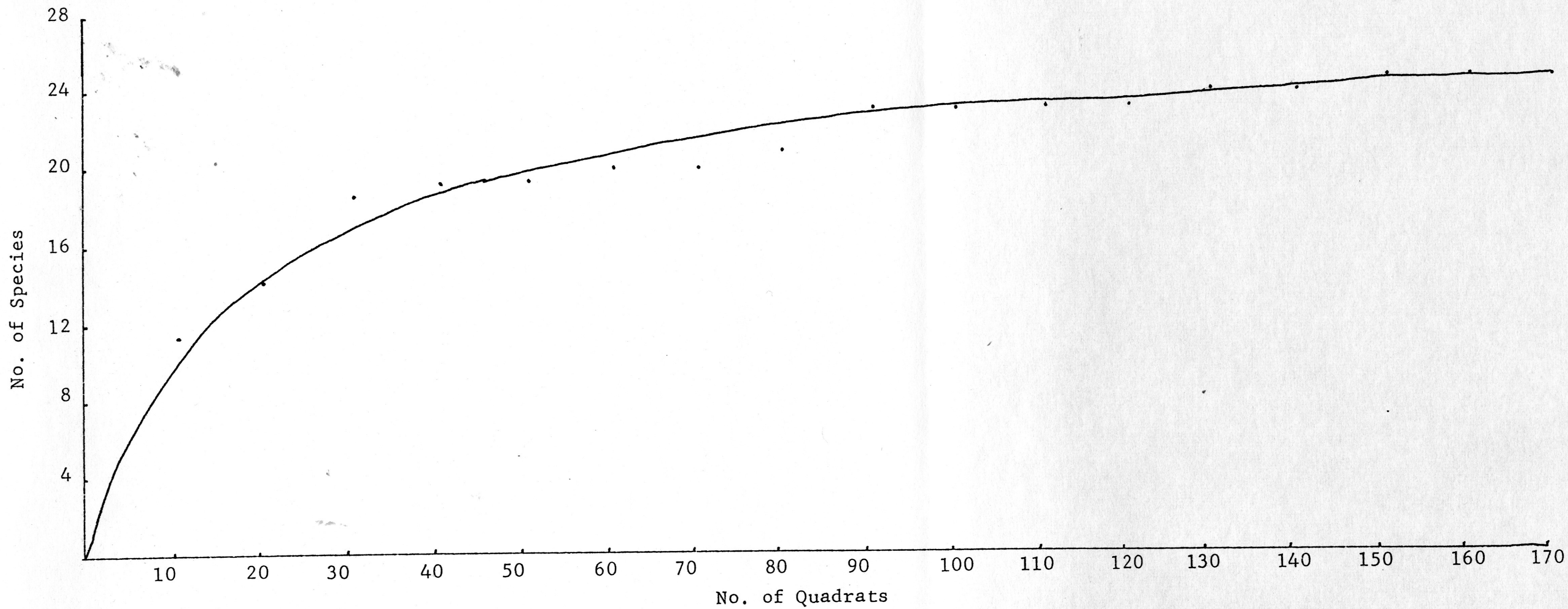


Figure 2. Species-area curve for 1987

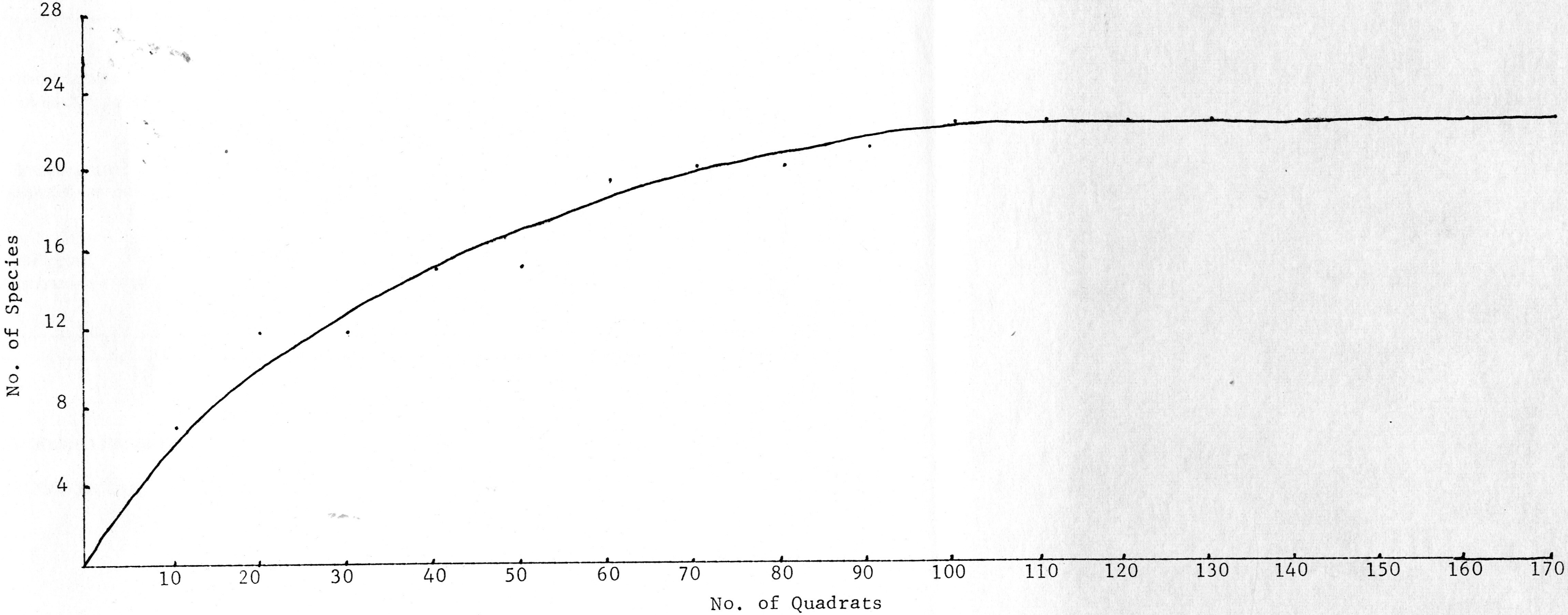


Figure 3. Species-area curve for 1988

Table VI. Soil pH measurements

Vegetative Area	Sample #1	Sample #2	Sample #3
Side-oats grama[1] dominated high area	7.9	7.5	7.7
Side-oats grama dominated low area	7.5	7.6	7.7
Switchgrass[2] dominated low area	6.6	6.7	6.8

1 Bouteloua curtipendula
2 Panicum virgatum

Table VII. Statistical analysis of coverage for grass species

Part A. A X B factorial ANOVA

Source	d.f.	SS	MS	F
Total	2358	34764	-	-
Years	1	63	63	5.8*
Species	6	8638	1440	132.2**
Years X Species	6	426	71	6.5**
Within	2355	25637	10.89	-

* significant to 0.025 level
** significant to 0.001 level

Part B. Duncan's new multiple range test

<u>1 2 3 4 5</u> <u>6</u> <u>7</u>

1-<u>Buchloe</u> <u>dactyloides</u>
2-<u>Agropyron</u> <u>smithii</u>
3-<u>Andropogon</u> <u>scoparius</u>
4-<u>Andropogon</u> <u>gerardii</u>
5-<u>Sorghastrum</u> <u>nutans</u>
6-<u>Panicum</u> <u>virgatum</u>
7-<u>Bouteloua</u> <u>curtipendula</u>

CHAPTER VI

DISCUSSION

Thirty species of plants were identified during this project, including both those species used in the reclamation and various other invaders from the surrounding area. It is believed that an adequate number of samples were taken to provide sufficient data to make some determinations of frequency and basal cover, as indicated by species-area curves constructed for each of the sampling years.

Frequency was quite low for most species, except for some of the grasses and a few other species in 1987. In the following year only grasses had any relatively high frequency figures. This can be explained by a combination of an accidental burning of the study site in early March and the cutting at approximate knee-height, due to the harvesting of the side-oats grama grass (Bouteloua curtipendula) in the second study year. These together could reduce the occurrence of several species. One good example is that of yellow sweet clover (Melilotus officinalis). In 1987 this species had a frequency rate of 92 percent, but in 1988 only a rate of 1 percent.

Ground cover for the site appeared to be quite low for both years,

although there was some increase after the first year. Even though the grasses used in the reclamation were evenly drill-seeded over the entire area, several completely plantless sites did occur where no seed seemed able to germinate, thus greatly influencing coverage figures. Side-oats grama and switchgrass (Panicum virgatum) were the only real contributors to basal coverage, with side-oats grama supplying near twice that of switchgrass. Most of the grasses provided equal or greater amounts of coverage in 1988 than in 1987. Difficulties arise in stating major trends for these results because of their small number size. Because sampling was carried out during the second and third growing years the native grasses had not as yet been given substantial time to develop. Most likely, with favorable conditions, these species will provide increasing cover as they have been given time to establish themselves. It should be pointed out that Anderson (1953), citing Anderson (1951), found that a good stand of bluestem vegetation (Andropogon) only provided an approximate 20 percent ground cover.

Soil tests revealed pH readings higher than most individuals would predict for minesoils; however, this site, as a part of reclamation, had considerable amounts of crushed limestone applied. There are other studies (Bonfert et al.

1986 and SCS 1981) of minesoils that have reported soil pH ranges between 7.0 and 7.8, very near those found in this report; whether limestone or other substances to raise the pH were used on those sites was not reported. These pH measurements are still within the good growing conditions for plants as cited by Askenasy and Severson (1988). The slightly more acidic soil reported for the switchgrass dominated regions could be looked upon as a possible reason for the lack of side-oat grama dominance that appeared in most all other areas. It is also known that side-oats grama will not establish well on moist sites or areas that for periods of time have standing water (Clubine 1989).

Statistical procedures performed on the cover produced by the seven major grasses illuminated the idea that significant differences were present between species, between years, and the interaction of years and species. The A X B factorial ANOVA illustrated the highly significant differences on the figures found for the two study seasons, 1987 and 1988, with the latter possessing the larger amount. The difference between species, with coverage for each species averaged for the two years, was very highly significant, thus signaling at least one statistical difference between the seven species. An interaction, calculated for the coverage of each species for the two years, also

was very highly significant. Duncan's new multiple range test was performed on the average cover provided by each species for both study years to elaborate on findings found by the A X B factorial ANOVA. This test was done to analyze where significant differences occurred between the seven species regarding ground coverage. It was found that no significant difference was present between Buchloe dactyloides (buffalograss), Agropyron smithii (wheatgrass), Andropogon scoparius (little bluestem), Andropogon gerardii (big bluestem), and Sorghastrum nutans (Indiangrass). Panicum virgatum (switchgrass) and Bouteloua curtipendula (side-oats grama), however, showed a significant difference from the other five grasses, as well as between the two respective species. The upcoming years will most certainly show changes in these aspects.

This study set forth to gain a foundation of knowledge concerning the study site. That information is outlined here and hopefully it will be built upon in the future. Trends and significant changes could easily be followed for the site if ongoing studies are continued. Secondly, the project hoped to analyze to some extent performance and evaluate the progress of those species selected for the revegetation. This can be drawn from the results acquired for each species. Continued studies of the stand, as it is allowed time

to establish better, would be required for any exacting conclusions to be drawn. However, it is believed that it is clearly shown that side-oats grama and switchgrass were an excellent choice for reclamation in this area. Together they provided the vast majority of ground coverage and appeared to be well distributed. Differing circumstances and situations will undoubtedly call for other methods, but continued research should prove to be invaluable.

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