WOODY PLANT SEEDLING SURVIVAL AS RELATED TO SITE CONDITIONS ON SOUTHEASTERN KENTUCKY ORPHAN LANDS

by

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Chapter 1

INTRODUCTION

Statement of Purpose

Reclamation of lands mined for coal has had limited success in the United States to date. This thesis research attempts to prove that successful reclamation is possible even on the old, abandoned or orphan mines, where little preplanning was used to assist the reclamation. The author also attempts to show, through analysis of site data collected on southeastern Kentucky orphan mine lands, that available woody plant seedlings can be used for revegetation. Additionally the author attempts to prove that by knowing the major site characteristics of a mine the reclamation planner can choose particular plants to best survive on and adapt to those particular site conditions encountered.

Background

Kentucky has been a large producer of coal throughout this century. It has produced more tons of coal than any other state in our nation every year since 1973 according to U.S. Department of Energy statistics. The Kentucky Energy Center has forecast United States' coal production will double between 1973 and 1990 at the current rate of increase. President Carter has made a plea for production to double by 1985.

One has but to drive through Kentucky's coal producing regions, the gently rolling hills of western Kentucky and the mountains of

eastern Kentucky, to see the many scars left by mining. Figure 1 shows the approximate location of both Kentucky coal regions. Eastern Kentucky, lying on the western edge of the Appalachian Mountains, has been a coal producing area since eastern United States manufacturing companies bought mineral rights to large acreages in the late 1800's and early 1900's. The first surface mining in eastern Kentucky occurred in 1905 at Lilly in Laurel County. Surface mining became extensive during the World War II years.

Coal production and its consequences have affected every family in eastern Kentucky. Coal mining has been, and still is, ingrained in the lives of the local populace. Before 1966 mining companies did not have a legal obligation to extensively repair the damage caused by their mining operations. Particularly with contour mining (see Appendix A for definitions of terms), where extra soil and rock was pushed over the edge of the hill, operators seldom felt the necessity to change, since production meant income and reclamation meant expenses. The steep terrain, illustrated in Figure 2, has magnified the damages from mining operations.

These factors have resulted in a large number of improperly reclaimed mines in both the Eastern and Western Kentucky Coal Regions. In 1966, Kentucky passed a tougher version of its mining and reclamation laws. However, the law itself was not a solution for the reclamation of current mined land nor orphan land.

Thousands of acres of orphan lands exist in Kentucky today. Orphan land, for the purposes of this thesis, is land that was mined prior to the 1966 mining and reclamation legislation of Kentucky. Some of these acres were reclaimed by the mining companies and some were

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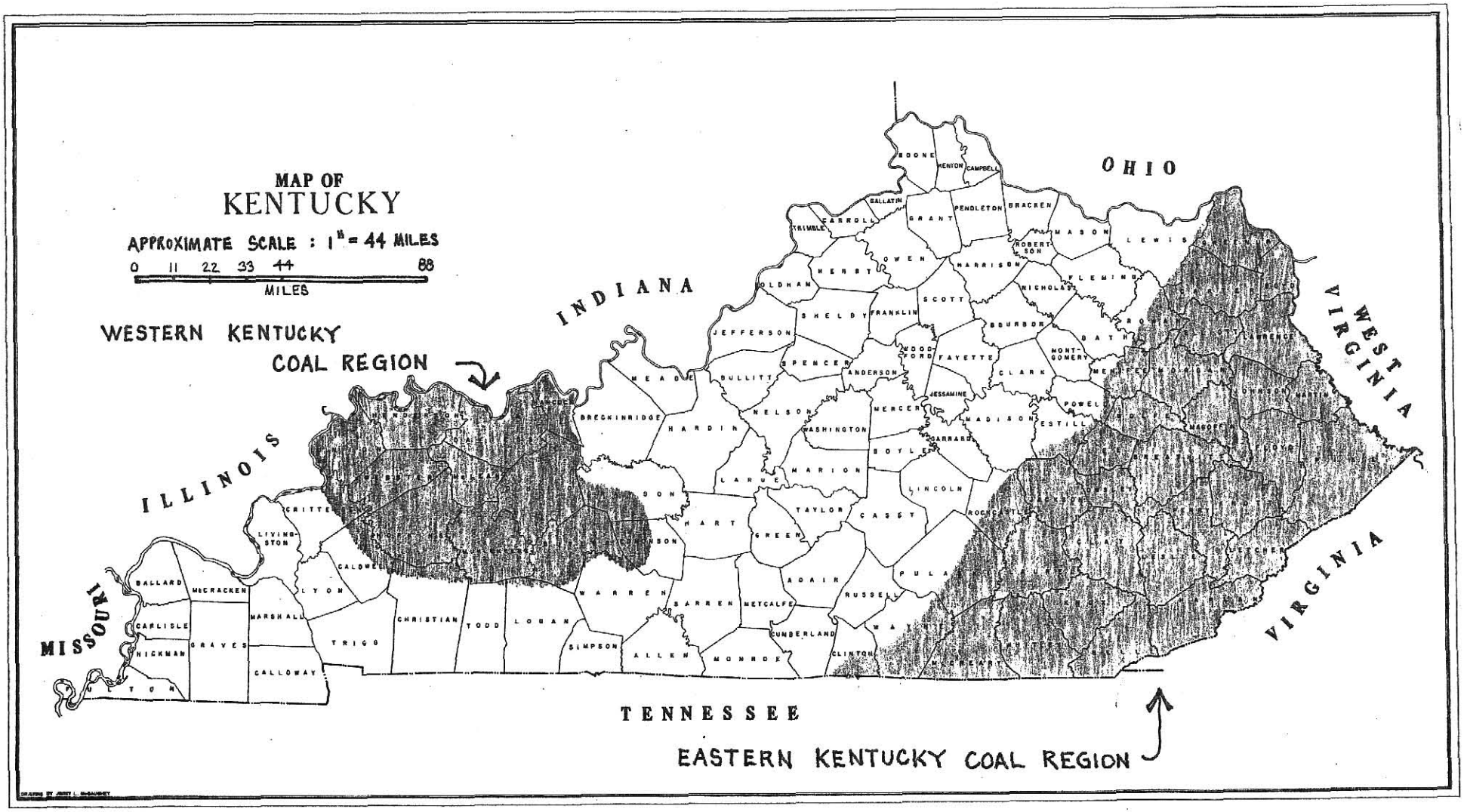

Figure 1

Kentucky Coal Regions

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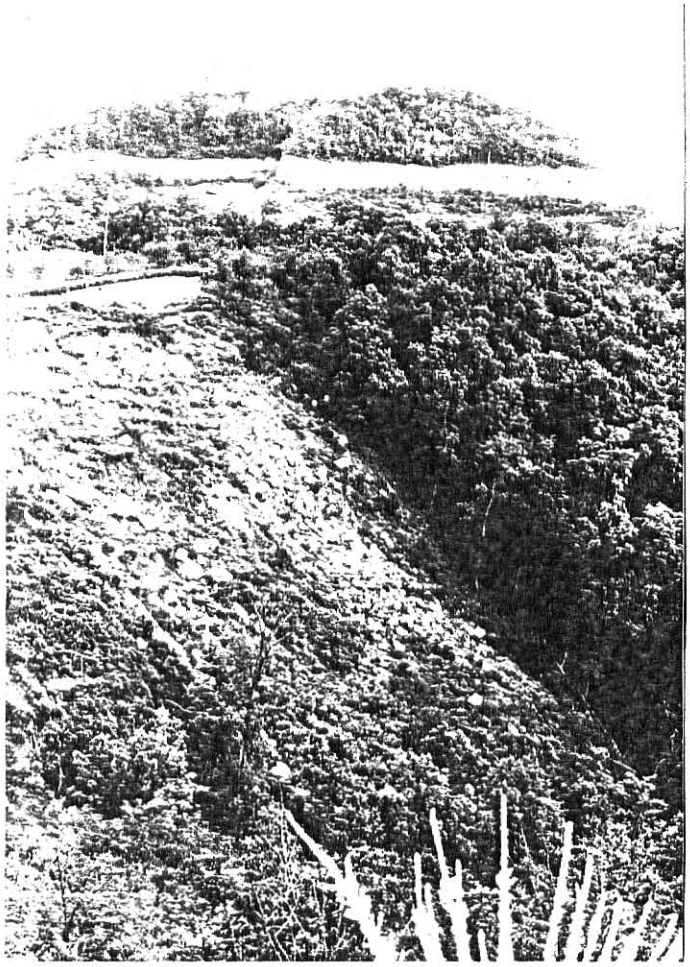


Figure 2

Unhealed Outslope

reclaimed by nature. Many still have not healed. There is not a long history of efforts to heal orphan land. Until the Surface Mining Control and Reclamation Act of 1977 was passed by Congress, Kentucky had minimal provisions for reclaiming orphan lands within the state. Very little research has been undertaken on orphan land in eastern Kentucky and, for lack of interest on the part of the government and the people, only a portion of that research has been published.

In 1976 the Tennessee Valley Authority established a four state demonstration project for the reclamation of abandoned mine lands. The demonstration area involved parts of Kentucky, Tennessee, Virginia, and Alabama. In Kentucky, the project was administered by the Bureau of Surface Mining Reclamation and Enforcement. It was labeled Project Orphan Land (P.O.L.). It was through cooperation with Project Orphan Land that this thesis research was done.

With an average per acre cost of $200-$250 set by T.V.A., only basic reclamation was envisioned for the orphan lands. The extensive use of hand planted tree seedlings was proposed as the main method of reclamation, to be supplemented by the use of many small silt dams and occasional grading by bulldozers followed by seeding of herbaceous vegetation.

The use of tree seedlings had many advantages. Most of the orphan land sites were small in size, were partially revegetated, normally adjacent to existing woodland, and difficult to reach because of poor access roads. T.V.A. set the policies of (1) not adding spoil amendments for tree seedlings and (2) adding spoil amendments for the seeding of herbaceous vegetation. Use of herbaceous vegetation required the site to be redisturbed by earth moving equipment. This temporarily increased erosion, exposed acidic spoil to runoff by rainwater, and eliminated all but black locust tree seeds from being used in the seed mixture. Use of herbaceous vegetation was limited to benches and other flat areas because of the steep terrain, seen in Figure 3, which makes spoil amending much more difficult and expensive. Liming, a necessary spoil amending activity, is very expensive in eastern Kentucky. It is used to neutralize acidic material to an acceptable pH needed for

Figure 3

Plot on Outslope

vegetation establishment. Steep outslopes also make spoil amending ineffective since much of the lime, fertilizer, seed, and mulch is washed away as the slope is eroded.

Although seedlings are not tremendously expensive, labor, management costs, and other fixed expenses increase the cost per plant tremendously. Therefore, it is to everyone's economic advantage to get the best plant survival possible. Repeated failures tend to give landowners more excuses for not trying to improve upon nature's reclamation, which can be very slow where extreme conditions have been established. Seedlings selected for southeastern Kentucky orphan lands should be tolerant of poor spoil conditions - low pH, high rates of aluminum and

manganese, low fertility, and low organic matter content. In addition spoils often have a high rock content or high percentage of large soil particles on outslopes, are droughty, and reach extremely high temperatures during the growing season.

The Kentucky Project Orphan Land staff was limited by state government policy to use the plant materials grown and sold by the Department for Natural Resources, Division of Forestry. Plants used by the staff were autumn olive, bicolor lespedeza, black locust, Chinese chestnut, European black alder, loblolly pine, Scotch pine, shortleaf pine, tulip poplar, Virginia pine, and white pine. These trees are normally used for wildlife habitat, woodland, and aesthetic improvement throughout the state. None of these plants were introduced or developed specifically for reclamation of surface mined lands, where conditions are normally very different from the woodland or home grounds. A data base for survival of these plants on eastern Kentucky orphan lands was not available.

Hypothesis for Solution

It is possible to reclaim surface mined lands in eastern Kentucky, including those with extreme site conditions, with little additional effort to that historically shown by mine owners and operators. Specifically, it is possible to revegetate orphan lands by choosing the correct plant to fit the site specifics. By taking data, specifically aspect, position on the mine, slope, degree of erosion, occurrence of rock fragments, percent of existing plant cover, type of plant invaders, spoil color, water pH and buffer pH at many test plots and comparing the data with seedling survival on those plots, enough

information can be generated so that reliable revegetation recommendations can be made for the great variety of conditions found on orphan lands in eastern Kentucky.

Chapter 2

REVIEW OF LITERATURE

Introduction

Much research has been published on numerous aspects of surface mine reclamation. However, the vast majority of revegetation research is done on newly mined land which has been disturbed less than two years. During the author's library search, no publications were found describing vegetative efforts on old surface mines or orphan lands in eastern Kentucky of the age investigated (12 to 24 years old).

The Soil Conservation Service or S.C.S. (33) based much of its recommendations on spoils planted less than one year after mining. Plass (41) investigated trees planted two years after mining in Ky. 31 tall fescue, sampled spoils six months after mining in West Virginia (42), and planted spoils less than one year old in eastern Kentucky (34).

Regardless of the spoil's age, it has specific characteristics that are critical predictors of revegetation success. The most useful data for prediction purposes are pH and slope. Texture, spoil color, aspect, parent material, and existing vegetation growing on the spoil may also be useful in predicting success of revegetative efforts. Climate must be considered also.

Site Characteristics

pH

Most important among spoil characteristics is the pH, or numerical measure of the hydrogen ion concentration. This characteristic has received a great deal of attention from researchers. Berg (2) thoroughly described spoil sampling for pH measurement on strip-mined land and indicated (4) that concentrations of soluble iron, copper, zinc, and nickel could be toxic to plants in extremely acid spoils. Toxic concentrations of aluminum were found in spoils with a pH of 5.5 or lower (4) and manganese toxicity to legumes was found at pH 5.4 or lower. Figure 4 shows how the University of Kentucky (30) illustrated the potential for occurrence of these toxicity problems. In Figure 4 the availability of the elements, at pH levels between 4.5 and 8.0, is shown by the width of the element band; the wider the band, the more available the element to plant uptake. For example, at pH 8.0 manganese is almost totally unavailable. As the spoil pH becomes lower, the manganese band becomes wider, indicating that the manganese is much more available at pH 4.5 than at 8.0. Figure 5 shows toxic precipitate near the top of spoil containers being used for greenhouse experiments on eastern Kentucky spoils. These toxicities would indicate low survival rates for plants in spoils with low pH. Czapowskyj (16) stated that toxic conditions primarily were due to high concentrations of sulfur present in pyritic shales and rejected coal. Boyce (6) found that toxic conditions in Illinois spoils persisted for many years as evidenced by tree kill five to ten years after planting when plant roots extended into buried toxic material.

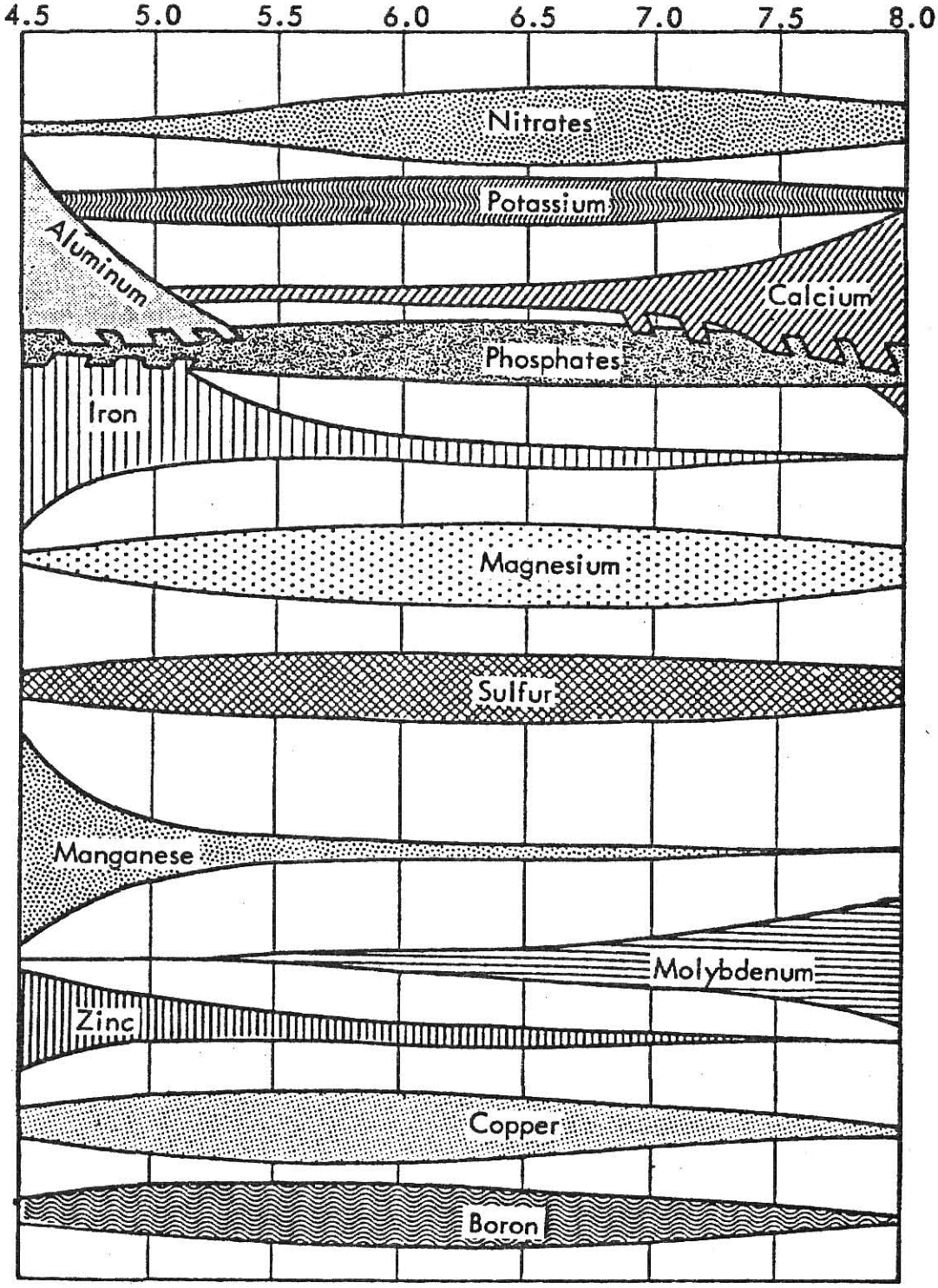


Figure 4

Relationship of Plant Nutrient Availability to Soil pH (30)

Plass (40) found that in southern West Virginia nutrient deficiencies were a more frequent problem than the acidity. Cummins (11) found that some essential nutrients became less available at pH values below 4.5. Plass (42) found that phosphorous, in particular, is deficient in spoils with low pH values because insoluable compounds are formed with iron and aluminum.

Figure 5

U.S. Forest Service Experiments With Spoils

Spoil composition ranges widely because of the different types of parent material found at different locations in eastern Kentucky and the different mining methods used. Vogel (57) found pH ranges of 3.8 to 7.5 on eastern Kentucky spoils in 1967 and 1968. As an example, overburden pH ranging from 2.8 to 6.6 is noted in Figure 6, illustrating geologic strata associated with the Horse Creek coal seam,

extensively mined in Clay County, Kentucky. Plass (34) found a pH distribution in southern West Virginia spoils of 5% for pH less than 4.0; 27% for 4.1 to 5.0; 48% for 5.1 to 6.0; 20% for 6.1 or greater.

The S.C.S. (29) found that in Kentucky autumn olive grows in spoils with pH of 4.0 to 7.5; black locust 4.0 to 8.0; European black alder 3.5 to 7.5; loblolly pine 4.0 to 7.5; Virginia pine 4.0 to 7.5; white pine 4.0 to 7.5; Chinese chestnut 4.5 to 7.5; yellow poplar 4.5 to 7.5. S.C.S. (33) also reported that black locust had been grown on spoils as low as 3.0; Virginia pine as low as 3.5; bicolor lespedeza 4.5. The Appalachian Regional Commission or A.R.C. reported shortleaf pine could grow on spoils as low as 4.5, as did Boyce (6) in southern Illinois.

Slope

Slope has a major influence on revegetation success because of its effect on water movement over the spoil surface. Length of slope and degree of slope angle determine the velocity of rainfall runoff, other factors being equal, and therefore are a major influence on the degree of erosion. The A.R.C. (45) discussed the difficulty of establishing vegetation on long or steep slopes, especially on the lower portions of steep outslopes.

Riley (46) in southeastern Ohio discovered the length of the slope was directly related to the rate of erosion. On a constant 12% slope 36.3 feet long, 72.4 tons of spoil per acre eroded; on a 72.6 foot slope, 76.9 tons per acre eroded; on a 145.2 foot slope, 91.6 tons per acre eroded. Curtis (12) found on eastern Kentucky surface mines that erosion and sediment yield have a half life of six months. The sediment

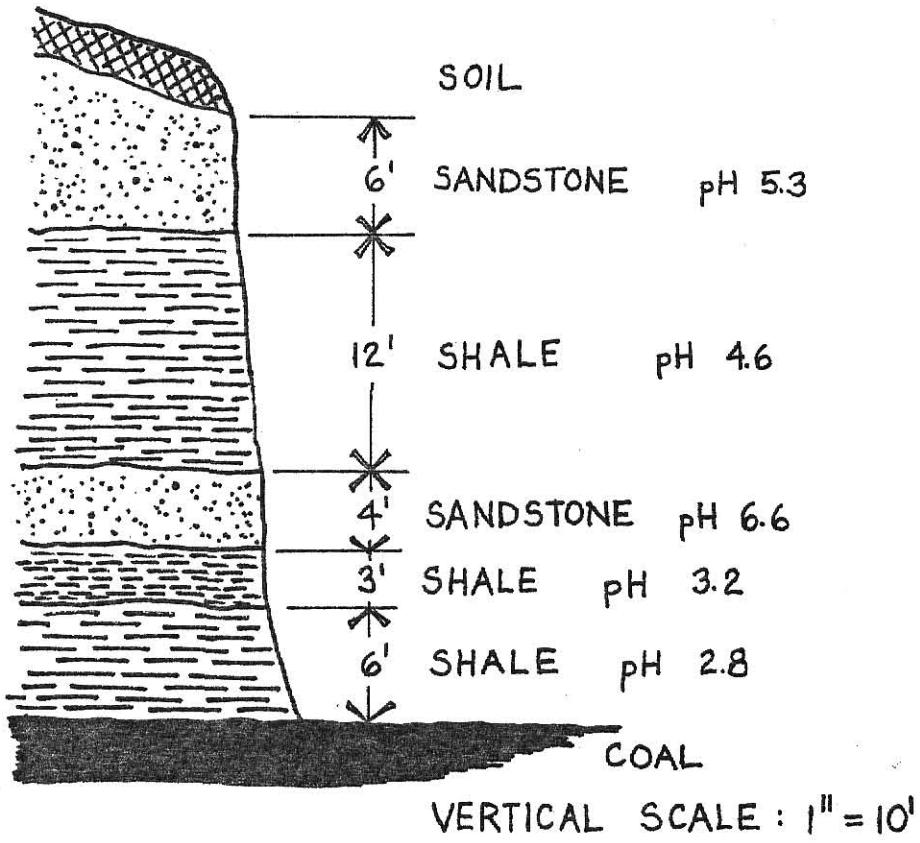


Figure 6

Horse Creek Coal Seam Highwall Section

produced during the second six months of erosion is about one-half the yield during the first six months, and so on, provided spoil stabilization progresses at an acceptable rate. Because of the erosion factor vigorous seedlings are needed for long or steep slopes.

The S.C.S. (29) reported that white, Virginia, and loblolly pine could be used on all slopes, along with black locust, European black alder, and Chinese chestnut. Yellow poplar was proposed for the better sites, meaning the less erosive slopes. Boyce (5) found from his western Kentucky studies pines could be established on upper slopes and ridges but best growth was on the lower slopes and well drained bottoms.

Spoil Texture

Van Lear (41) discussed the importance of spoil texture, finding toxic ion concentration greater on fine-textured spoil than on coarse-textured material. Clay loam spoils are created from the weathering of shales, seen in Figure 7, and sandy loam spoils from sandstones. Vogel (52) found shales and some sandstones weather rapidly to produce spoil with 15 to 45% soil size particles. Plass (34) concluded the greater the percentage of soil size particles, the more vulnerable become the spoils to erosion. Shale spoil normally has a higher percentage of soil size particles than sandstone. Curtis (13) found in southeastern Kentucky that sediment yield on shale spoils was always greater than yield on sandstone spoils for all storms during his two year study.

Clay spoils may compact too tightly from heavy machinery and thereby affect plant growth for as much as ten years according to Boyce (6). The spoil texture, if too high in clay content, may crust over and prevent rainwater infiltration or, if too sandy, permit too much percolation and create a dry spoil environment.

Figure 7

Shale Spoils

Parent Material

Knowledge of the parent material for which a spoil is derived can be a tremendous tool for the reclamation planner. Berg (3) stated that most toxic material in eastern Kentucky is caused by a relatively thin strata, known as a rider seam, which usually is found directly over the coal seam. Before Kentucky had strict reclamation laws acid material was often spread throughout the overburden with little regard given to the implications to revegetation. Being directly over the coal seam, the acid material was often cast on the top of the spoil pile. Despard (22) found that when acid strata was left at the surface, spoil was difficult or impossible to revegetate.

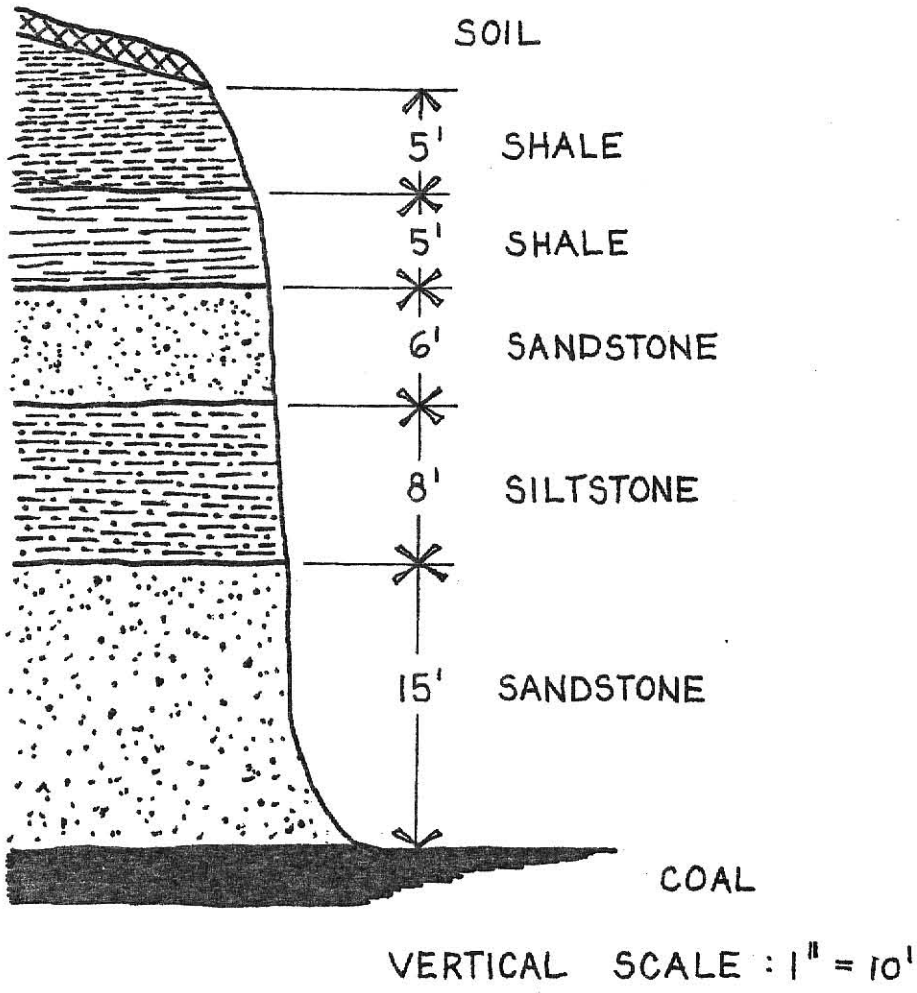


Figure 8

Lily Coal Seam Highwall Section

Figure 8 shows overburden representative of the Lily coal seam. The Lily seam, according to the Kentucky Geological Survey, is the same as the Horse Creek coal seam. Elevation of the two seams varies somewhat as does the composition of the overburden. Plass (37) found spoil samples from the Lily coal seam, found in Laurel County, ranged in pH from 2.9 to 4.2. About 70% of the samples had pH values of 3.5 or less. From this information alone, the planner will know he has only a few trees from which to choose. The A.R.C. (45) found spoil material from the Horse Creek coal seam, found in Clay County, was among the most acid and toxic encountered. Spoils were found with pH down to 2.2.

Existing Vegetation

Boyce (6) determined from his Illinois research that sparse and scattered vegetation helped survival of planted trees by lowering surface temperatures during the summer and increasing organic matter. The species found on orphan lands, extent of survival, and vigor of growth can be extremely good indicators of revegetation possibilities. Both invaders and planted species offer information to the planner. However, the author found almost no references to these possibilities in his literature search.

Climate

The landscape architect, horticulturalist, or reclamation planner knows climate influences plant survival. Plant hardiness zones have been established to indicate macroclimate. Southeastern Kentucky, which lies within the Cumberland Plateau and Mountains, is characterized by an average annual precipitation of about 46 inches, 21 inches occurring during the growing season. Snowfall averages about 20 inches per

year (33). Precipitation is nearly uniformly distributed among the 12 months (56). Monthly precipitation at Mullins Fork in Breathitt County (eastern Kentucky) during the five year period 1969 to 1973 averaged as follows: January, 3.61 inches; February, 3.87; March, 3.53; April, 5.88; May, 4.48; June, 3.66; July, 3.97; August, 2.89; September, 4.31; October, 3.16; November, 3.22; December, 4.58 (12). The average annual temperature is about 55 degrees Fahrenheit, varying from an average low of -.4 to an average high of +100.4 degrees Fahrenheit. The average annual freeze-free period is about 175 days.

Information on microclimate is much more difficult to find. Boyce (6) summarized that conifers were better suited for planting on ridges and upper slopes, hardwoods on lower slopes and valleys. Pines did not tolerate flooding, however pines and black locust did well on hot west and south facing slopes. Extremely steep and erosive slopes were difficult for all plants.

Aspect

High temperatures on spoils may prevent or limit seedling growth according to Vogel (55). Vogel also found that exchangeable aluminum greatly increased with increased temperature. Ruffner (47) projected that it is not as difficult to establish vegetation on cool north or east slopes. The A.R.C. (45) found that high surface temperatures occurred on south and southwesterly slopes due to solar radiation. Figure 9 shows how the microclimate provided by a pine tree, in this case shade and surface mulch, can provide a suitable environment for vegetative growth while the surrounding area remains barren.

Spoil Color

The Commission also found that dark color spoils absorb more heat from the sun than do light color spoils. Moisture loss and stress occur more quickly on dark spoils. During summer and particularly on south and southwesterly slopes black spoils can reach temperature levels lethal to seedlings.

Figure 9

Microclimate Created by Pine Tree

Woody Plant Species Available For Testing

Kentucky surface mine regulations (49) between 1966 and 1978 required no less than 800 seedlings planted per acre on all disturbed areas in eastern Kentucky except those approved for grasses and legumes only. Bond release standards for revegetation required a minimum of 600 live woody plants per acre at the end of two growing seasons.

The U.S. Environmental Protection Agency or E.P.A. (24) included wildlife cover and food production, erosion control, aesthetics, and timber production as uses for reclamation trees. S.C.S. (33) generalized from their research pines survived as well as the hardwoods excepting black locust and European black alder. However, they felt pines also needed herbaceous cover for eight to ten years to provide suitable erosion control. A.R.C. (45) found that, in general, pine trees perform better than hardwoods, and nitrogen fixers perform better than non-nitrogen fixers. Plass (39) found evidence that woody species capable of fixing atmospheric nitrogen may contribute to the increased growth of other species planted nearby. He also stated that fast growing species are desirable for their ability to curb extremes of wind and temperature, as well as erosion.

Autumn Olive

The S.C.S. (29) found that autumn olive was useful for erosion control and wildlife food, while A.R.C. (45) recommended it for wildlife cover and nitrogen fixation. S.C.S. (33) found autumn olive outstanding for its early and vigorous growth and exceptional cover-producing qualities surpassed only by black locust. Plass (34) reported a survival rate of 48% after four years of growth on eastern Kentucky spoils.

Black Locust

Geyer (26) found black locust a good erosion control plant while Vogel (56) discovered it to be tolerant of a wide range of site conditions and an aid to adjacent plants since it fixed nitrogen in the soil. S.C.S. (29) reported black locust as a rapid grower but a plant with insect problems. S.C.S. (33) went on to report that black locust reproduced by root suckers and also produced seed at an early age. Its leaf litter and light shade created an environment that encouraged the invasion of herbaceous cover. A.R.C. (45) recommended black locust be planted in pure stands on steep slopes for erosion control. E.P.A. (24) recommended using it in mixed plantings as a nurse plant. Boyce (5) found in western Kentucky studies the black locust canopy plus litter accumulation on the spoil surface insulated the spoil against rapid temperature changes and slowed evaporation and runoff. Further, Boyce (6) reported that when used with timber producing species black locust should be less than 25% of the total plant population. All hardwoods except cottonwood and sycamore were suitable for interplanting; no conifers were suitable. Geyer's Kansas study (26) showed a 32% survival rate after 22 years of growth; Boyce's western Kentucky study (5) showed a 50% survival rate after 10 years; S.C.S. (33) showed survival of 80% or better 10 to 20 years after planting and considered black locust to be the best tree species available for the eastern United States coal region for quick cover and stabilizing a wide variety of sites.

European Black Alder

European black alder also has a wide adaptation according to E.P.A. (24). Good qualities recorded were rapid growth and the ability

to fix nitrogen in the spoil. S.C.S. (33) reported alder had the same advantageous qualities as black locust but to a slightly lower extent with the exception of being more tolerant to very acid spoil.

Loblolly Pine

A.R.C. (45) and E.P.A. (24) reported loblolly pine to be a fast growing tree and a desirable timber species. S.C.S. (29) recommended planting loblolly pine in bands or blocks to promote species growth. Boyce (6) recorded loblolly as the fastest growing pine used in the southern Illinois experiments, further noting that loblolly grew better on the ridges and upper slopes than most hardwoods. Plass (35) found loblolly adapted to a wide range of spoils in eastern Kentucky. S.C.S. (33) reported 54% survival in southern Illinois after 10 years; Boyce (5) reported 28% after 10 years in western Kentucky; Boyce (6) found 29% survival in southern Illinois after 10 years; Vogel (53) found 36% survival in eastern Kentucky after three years for trees planted in 1968 and 93% survival for trees, of similar size and in similar conditions to that shown in Figure 10, planted in 1969 where no spoil treatment was used. S.C.S. (29), A.R.C. (45), and E.P.A. (24) all reported loblolly pine susceptible to snow and ice damage in Kentucky.

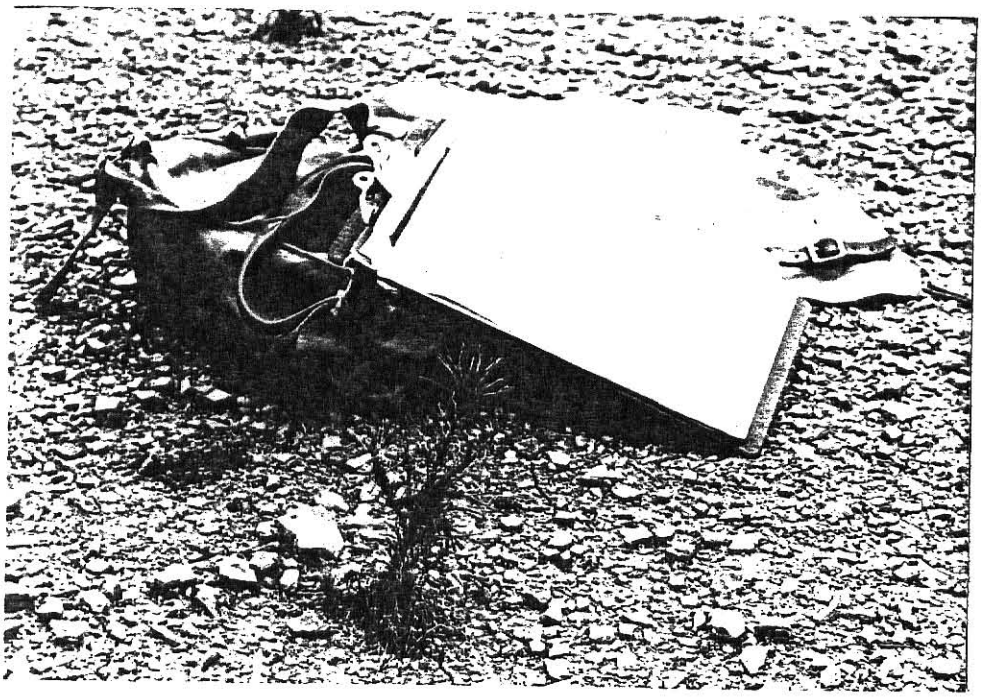


Figure 10

Pine Seedling

Scotch Pine

Although S.C.S. (29) reported scotch pine to have as wide a range of acceptable spoil conditions as shortleaf, loblolly, white, and Virginia pines, very little information was found by the author about its use as a reclamation plant. S.C.S. (33) cited a study by Brown which rated scotch pine as the best conifer for spoils in West Virginia and a Pennsylvania study by Hart and Byrnes where survival was 80% after 10 years.

Shortleaf Pine

E.P.A. (24) reported shortleaf pine as a good marketable timber that sprouted freely if cut or fire killed when young. Boyce (6) found

shortleaf as the best pine for use on southern Illinois spoils. He cited its best growth on acid spoils, pH 4.5 to 6.9, and greater resistance to winter damage than loblolly pine. However, Plass (35) found shortleaf pine growth reduced on extremely acid spoils and S.C.S. (33) noted severe winter snow damage. E.P.A. (24) also found shortleaf had some insect problems. Survival has been reported as 20 to 30% on acid spoil to 60% on slightly acid spoil by S.C.S. (33) and 25% by Boyce (5) after 10 years in western Kentucky.

Virginia Pine

Virginia pine was recognized by S.C.S. (29), E.P.A. (24), and Boyce (6) as good wildlife cover. Boyce (6) noted that Virginia pine branches extended to the ground and persisted. E.P.A. (24) also noted its use for aesthetics. E.P.A. (24) reported Virginia pine being slow to develop and S.C.S. (29) found it had tipmoth problems. Boyce (6) found the highest survival on slopes, ridges, and acid areas. Plass (37) found survival ranged from 47 to 91% after the second growing season in southeastern Kentucky and (35) 60% after direct seeded pines had been emerged four months. S.C.S. (33) found the survival rate usually more than 50%; Boyce (5) found 27% after 10 years in western Kentucky; Vogel (53) reported 74% for 1968 - 1972 tests and 91% survival for 1969 - 1972 tests in southeastern Kentucky.

White Pine

E.P.A. recommended white pine for use as Christmas trees rather than erosion control, wildlife cover, or timber production (24). It has poor initial growth but does improve with time. S.C.S. (33) found adequate soil protection could not be provided by white pine for the first

eight to ten years. E.P.A. (24) and S.C.S. (29) recommended planting white pine in bands or blocks. S.C.S. (33) did find white pine ideal for mixed plantings because it was shade tolerant. Although white pine had 90% survival in Plass's eastern Kentucky study (35), growth was very slow on all spoils. In northern Illinois (6) Boyce found survival of 22 to 54%, while in southern Illinois it had only 12% survival and made the slowest growth of all the conifers.

Chinese Chestnut

Wildlife food and cover was the major use recommended for Chinese chestnut by S.C.S. (29). S.C.S. (33) found Chinese chestnut needed moderately good sites for spoil quality, pH 5.0 to 7.0, and exposure for good survival. Survival rates varied from 50 to 80% for plantings up to 15 years old.

Bicolor Lespedeza

E.P.A. (24) reported bicolor lespedeza ineffective as a ground cover for erosion control. S.C.S. (33) went on to recommend it for wildlife food only, as it provided only fair to poor cover for erosion control.

Tulip Poplar

Yellow poplar or tulip poplar were found to grow best on slightly acid spoils and on the lower parts of slopes and in cove-like areas by S.C.S. (33). Boyce (5) also found yellow poplar grew best only on the good sites, such as well-drained bottoms. S.C.S. (29) recommended the yellow poplars be planted in mixtures with other hardwoods; Boyce (6) also stated they were not suitable for pure stands since

survival under these conditions ranged from 0 to 37%. Boyce (5) found 24% survival after 10 years in western Kentucky.

Tables 1-A and 1-B summarize the survival data compiled by Boyce (5) and (6), Davidson (17), Davis (19), Geyer (26), Plass (34), S.C.S. (33), and Vogel (53) for species common to their research and this study.

Table 1-A

Plant Survival Results for Research by Other Authors

Research Author	Species Tested	Average Plot Age	Average % Seedling Survival
Boyce (5)	black locust	10 years	50
	loblolly pine	10 years	28
	shortleaf pine	10 years	25
	Virginia pine	10 years	27
	yellow poplar	10 years	24
	Average =	22 years	26.0
Boyce (6)	black locust	10 years	38
	loblolly pine	10 years	29
	shortleaf pine	10 years	9
	Virginia pine	10 years	16
	white pine	10 years	12
	yellow poplar	10 years	7
	Average =	10 years	18.5
Davidson (17)	Scotch pine	5 years	50.0
Davis (19)	autumn olive	1 year	44.5
	white pine	1 year	43.5
	Average =	1 year	44.0

Table 1-B

Plant Survival Results for Research by Other Authors

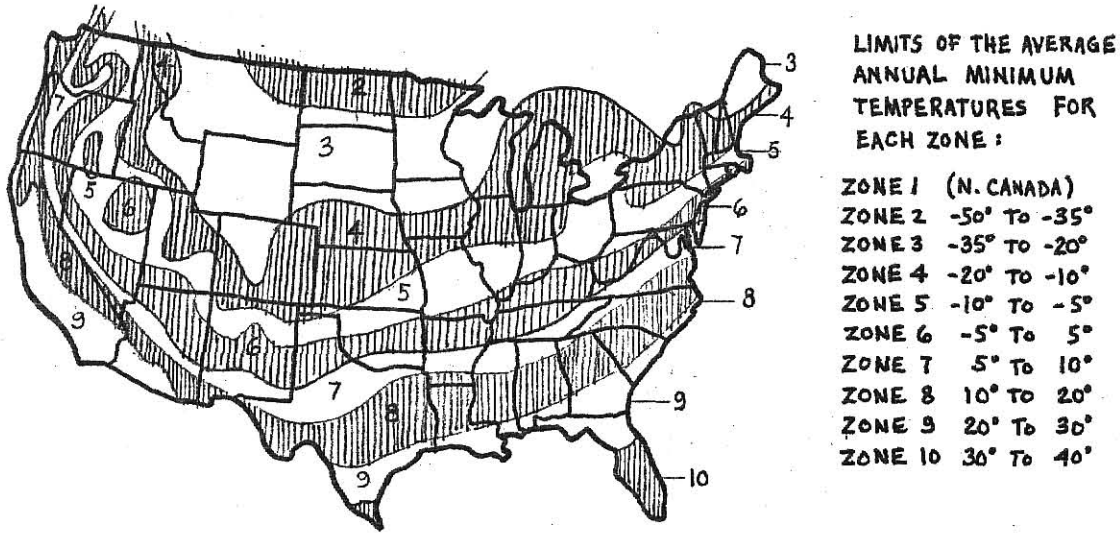
Research Author	Species Tested	Average Plot Age	Average % Seedling Survival
Geyer (26)	black locust	22 years	32
	loblolly pine	22 years	22
	shortleaf pine	22 years	29
	Virginia pine	22 years	21
		Average = 22 years	26.0
Plass (34)	autumn olive	4 years	48.0
S.C.S. (33)	black locust	8 years	80
	Chinese chestnut	7 years	50
	loblolly pine	7 years	54
	shortleaf pine	7 years	45
	Virginia pine	7 years	50
		Average = 7.2 years	55.8
Vogel (53)	loblolly pine	4 years	36
	Virginia pine	4 years	77
		Average = 4 years	56.5

Chapter 3

GENERAL DESCRIPTION OF PLANT SPECIES STUDIED

The following general plant descriptions are included to provide the reader with information which may be useful in 1) identifying the plants studied, 2) interpreting the data summaries and conclusions drawn from the summaries, and 3) helping the reader visualize other reclamation possibilities for the plants studied on orphan or abandoned mine lands.

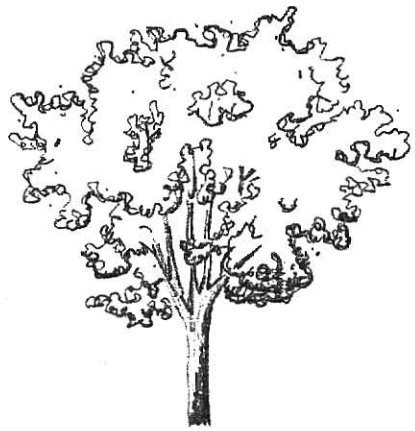
The hardiness zone system included was created by Alfred Rehder and used as early as 1927 in the Manual of Cultivated Trees and Shrubs. This hardiness system has become standard among horticulturalists in the United States.



HARDINESS ZONES OF THE UNITED STATES

General Description of *Alnus glutinosa*, European black alder

Growth Habit	:	tree; single or multistemmed; slender at youth, ovoid to oblong head at maturity; to 75 feet high with a trunk diameter of one to two feet
Foliage	:	deciduous; dark green leaves, two to five inches long, blunt-tipped and usually double-toothed
Fruit	:	pine cone-like catkins, to three-fourths inch long or slender stalks
Bark	:	dark with numerous short warty stripes; twigs are reddish or tinged with red
Native Habitat	:	Europe to Siberia
Hardiness Zone	:	three
Limitations	:	no serious problems
Special Features	:	withstands very acid spoil, pH 4.0 to 7.0; has vigorous early growth; not a legume but fixes nitrogen; adaptable to wet conditions



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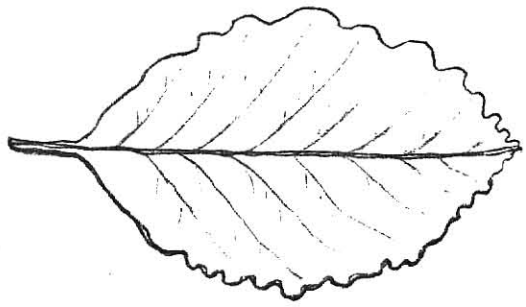
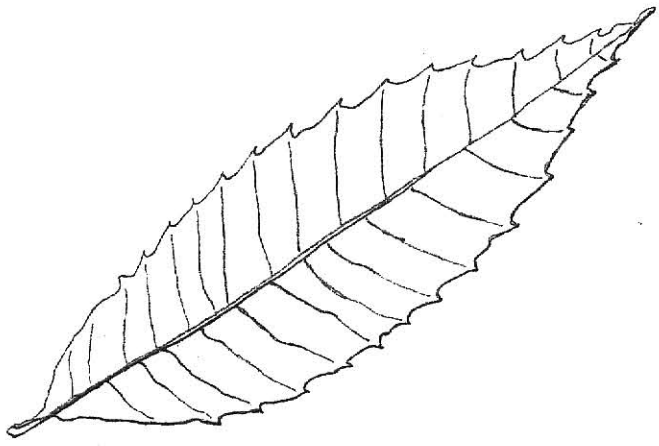


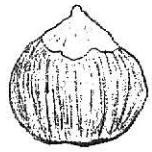
Foliage

General Description of *Castanea mollisima*, Chinese Chestnut

Growth Habit	:	tree; to 60 feet high with an equal spread; dense, round headed
Foliage	:	deciduous; coarse lustrous leaves, alternate simple, three and one-half to eight inches long and one to two inches wide, oval to oblong
Fruit	:	one to three nuts to one inch diameter enclosed within a spiny bur, light to dark brown in color
Bark	:	olive-brown; bark on second and third year stems is cherry-like in appearance; mature trunk is strongly ridged and furrowed
Native Habitat	:	China and Korea
Hardiness Zone	:	four
Limitations	:	requires moderately good spoil quality and slight acidity, pH 5.0 to 7.0; prefers well drained sites
Special Features	:	excellent nut production possible for wildlife food



Foliage



Fruit

General Description of *Elaeagnus umbellata*, Autumn Olive

Growth Habit : shrub; spreading and upright, 12 to 18 feet high with a width to 20 or 30 feet; branches often extending to the ground

Foliage : deciduous; alternate leaves, olive-green above and silvery below, elliptic or oval, one and one-half to three inches long

Fruit : produces dependable crops of abundant berries in three to four years; berries approximately one-fourth inch diameter with one-third to one-half inch stalks, starting as silver and turning to red

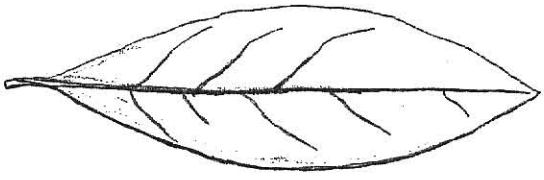
Bark : yellow-brown branchlets, often partially silver; spines profuse; bark smooth except on very old stems where it is scaly

Native Habitat : China, Korea, Japan

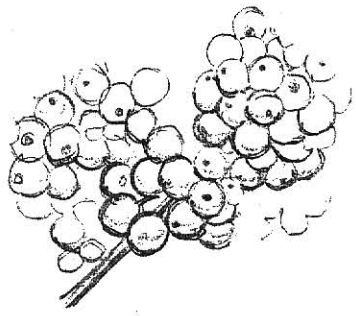
Hardiness Zone : four

Limitations : does not grow well on very dry sites or sites with shallow root medium

Special Features: although not a legume, a good nitrogen fixer; can be used as a barrier or screen; has a tendency to spread; provides excellent wildlife cover; prefers acid soil, pH 4.5 to 7.0



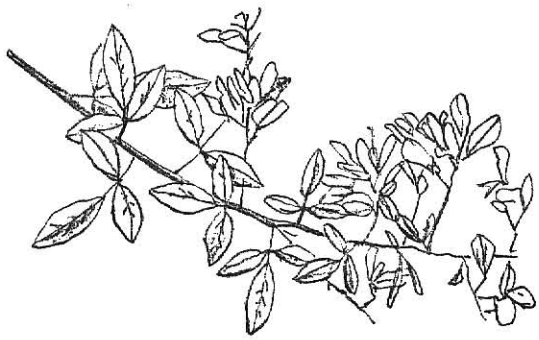
Foliage



Fruit

General Description of *Lespedeza bicolor*, Bicolor Lespedeza

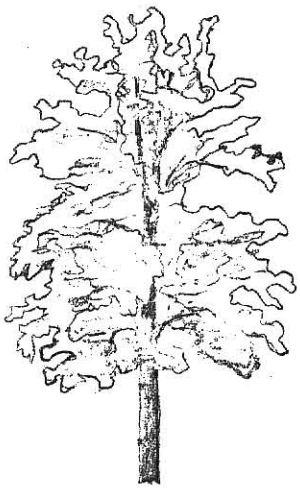
Growth Habit	:	shrub; upright to 12 feet high and slightly less in spread; somewhat open and loosely branched; weak stemmed when young but becoming woody with age; twigs slender
Foliage	:	deciduous; leaves one to three inches long, compound, three-parted with leaflets blunt-tipped; middle leaflet longer stalked than the two side ones; undersides of leaves are gray-green
Fruit	:	one-fourth inch long single seeded pods; found in clusters two to four inches long on the current year's growth; seed crops in three to four years
Bark	:	brown
Native Habitat	:	northern China, Manchuria, Japan
Hardiness Zone	:	five
Limitations	:	requires well drained soils; dies back in severe winters; does not provide good erosion control
Special Features:		excellent wildlife cover and food; grows in slightly acid, pH 5.0 to 7.0, spoils with low fertility; can be direct seeded



Foliage

General Description of *Liriodendron tulipifera*, Tulip Poplar

Growth Habit	:	tree; broadly pyramidal with massive branches; to 150 feet high with a straight clear trunk to six feet in diameter; dense crown
Foliage	:	deciduous; leaves uniquely squarish in form, bright green above and paler below
Fruit	:	pyramidal conelike dry pod two to three inches long composed of single-winged samaras
Bark	:	on young trees, whitened within small grooves but nearly smooth; on mature trees bark is gray-brown with regular ridges and furrows
Native Habitat	:	eastern United States
Hardiness Zone	:	four
Limitations	:	requires best site conditions available, such as lower slopes and coves; prefers slightly acid spoils, pH 5.0 to 7.0
Special Features:		tree is commercially valuable for many wood products



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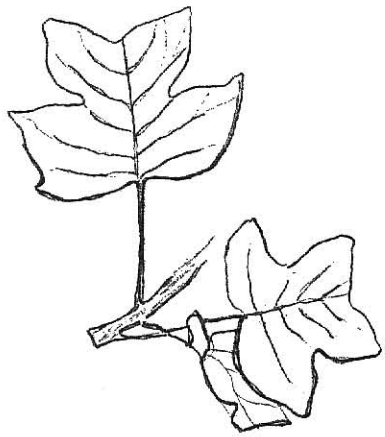
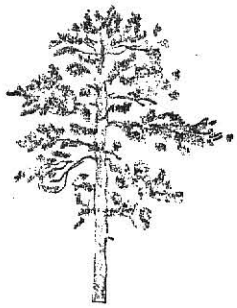


Foliage

General Description of *Pinus echinata*, Shortleaf Pine

Growth Habit	:	tree; normally grows with a straight trunk and slender branches; at maturity has a narrow pyramidal crown; 80 to 100 feet high with a trunk diameter of two to three feet
Foliage	:	evergreen; needles mostly in bundles of two, three to five inches long, dark yellow-green, slender, flexible
Fruit	:	small cones, one and one-half to two and one-half inches long, each scale tipped with a weak prickle
Bark	:	dark brown; dark furrows between irregular shaped smooth plates; twigs whitened with a powdery covering
Native Habitat	:	southeastern United States
Hardiness Zone	:	six
Limitations	:	subject to winter injury from heavy snow or ice; survival rates lower than for other pines; subject to tipmoth injury
Special Features:		can be used for screening and wildlife cover; grows well in light dry spoils; prefers acid spoil, pH 4.5 to 6.0

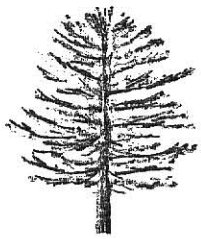


Form

Foliage

General Description of *Pinus strobus*, White Pine

Growth Habit	:	tree; pyramidal when young, flat topped when old; to 100 feet high when a two to four foot diameter trunk
Foliage	:	evergreen; needles five in a bundle, two and one-half to five and one-half inches long, soft and flexible
Fruit	:	cones four to eight inches long; scales lack spines
Bark	:	on mature trees bark is gray and broken into small rectangular blocks; smooth on young trees
Native Habitat	:	eastern North America
Hardiness Zone	:	three
Limitations	:	white pine weevil injury; does not do well on exposed ridges or severely eroded sites
Special Features	:	shade tolerant, therefore can be used in mixed plantings with hardwoods; grows best in acid spoil, pH 4.5 to 6.0



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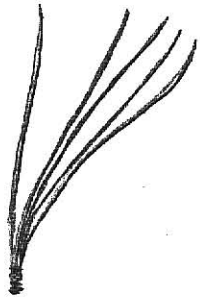
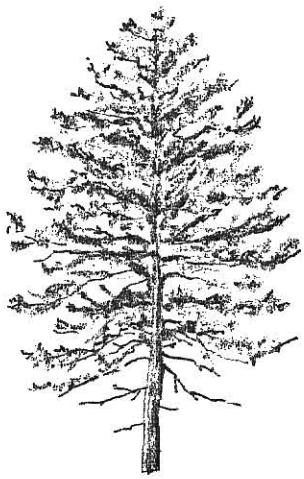


Foliage

General Description of *Pinus sylvestris*, Scotch Pine

Growth Habit	:	tree; open, pyramidal while young but round-topped and irregular when old; to 75 feet high; trunk to one and one-half feet in diameter, often crooked
Foliage	:	evergreen; blue-green needles are twisted, two in a bundle, three-fourths inch to three inches long, stiff and sharp-pointed
Fruit	:	brown cone near same length as needles, oblong in shape
Bark	:	red to orange on older branches; trunk becomes dark and furrowed at maturity
Native Habitat	:	Europe to Siberia
Hardiness Zone	:	two
Limitations	:	no serious problems
Special Features	:	tolerant to dry sites; can be used for screening and wildlife cover; prefers acid spoils, pH 4.5 to 6.0



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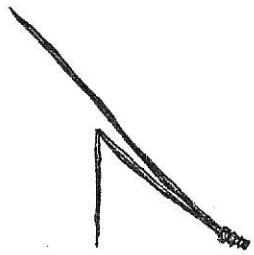
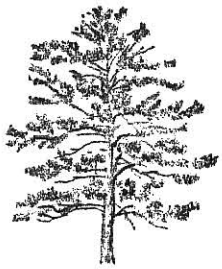


Foliage

General Description of *Pinus taeda*, Loblolly Pine

Growth Habit	:	tree; to 100 feet high with a trunk diameter of two to three feet; normally develops a tall, straight trunk with short, thick branches; relatively dense crown is usually compact and round-topped
Foliage	:	evergreen; needles usually in bundles of three but sometimes two, six to nine inches long, slender, stiff, yellow-green
Fruit	:	oval to conical stout cones, two to six inches long, each scale tipped with a prickle
Bark	:	red-brown with scaly plates on mature trees
Native Habitat	:	southeastern United States
Hardiness Zone	:	six
Limitations	:	subject to severe winter damage from cold and snow in northernmost range
Special Features	:	does best in acid spoils, pH 4.5 to 6.0; can be used for screening and wildlife cover; can withstand a wide range of conditions including root flooding for several months at a time

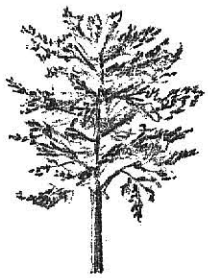


Form

Foliage

General Description of *Pinus virginiana*, Virginia Pine

Growth Habit	:	tree; open, branching sparse; variable form when young; to 45 feet high with a trunk diameter of one to two feet at maturity, when it also may have a very wide top and stiff appearance
Foliage	:	evergreen; needles in bundles of two, one and one-fourth to three inches long, twisted
Fruit	:	cones, somewhat egg-shaped, one and one-half to two and one-half inches long with a prickle on each scale; remain on the tree for many years
Bark	:	red-brown and scaly with age; twigs are somewhat yellow or purple
Native Habitat	:	eastern United States
Hardiness Zone	:	four
Limitations	:	tipmoth injury
Special Features	:	prefers acid spoil, pH 4.5 to 6.0; can be used for screening; low branches provide excellent wildlife cover; can be direct seeded



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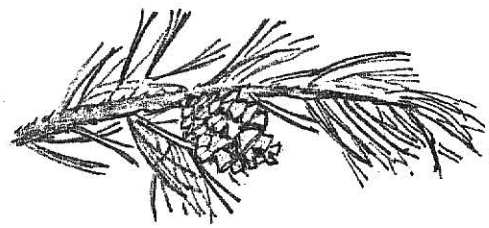
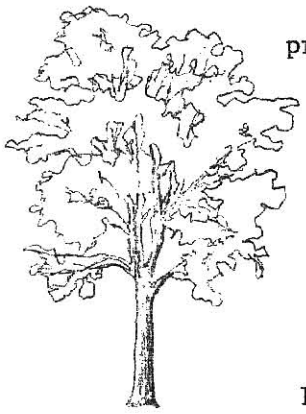


Foliage & Fruit

General Description of *Robinia pseudoacacia*, Black Locust

Growth Habit	:	tree; to 80 feet high with a trunk diameter of two to four feet; normally open with few branches
Foliage	:	deciduous; pinnately compound leaves, eight to fourteen inches long with seven to nineteen smooth-margined egg-shaped leaflets one to two inches long and one-half to three-fourths inch wide
Fruit	:	flat, brown to black pods, two to six inches long and one-half inch wide, containing four to eight kidney-shaped orange-brown seeds
Bark	:	dark on old trunks, nearly black; deeply ridged and crosshatched
Native Habitat	:	eastern United States
Hardiness Zone	:	three
Limitations	:	subject to injury from locust borer and locust leaf miner
Special Features:		a legume; can be direct seeded; provides good shade and spoil surface litter, encouraging plant invaders; excellent for erosion control; vigorous early growth; prefers acid spoil, pH 4.5 to 7.5



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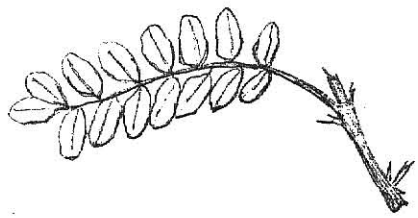

Foliage

Chapter 4

METHODS AND PROCEDURES

Only those Project Orphan Land mines which had been completed or were completed except for remedial work were used for research plots. Of these, only mines where the woody plant materials had been planted on the sites for two months or more were chosen.

The author attempted to do all the research within Clay and adjacent Laurel County but was forced to establish plots in Harlan County also in an attempt to get a larger data base. The general research location is shown in Figure 11.

A significant problem encountered in choosing mines was the unequal number of plantings for the different species. For example, almost every mine used black locust in large enough quantities so that a black locust plot could be established there. However, autumn olive and Chinese chestnut were available in such small quantities that normally only a few could be used on each mine making a plot difficult to establish. Loblolly pine was not available in quantities equal to that for the other pines. Bicolor lespedeza, tulip poplar, white pine, and scotch pine were used in small quantities because the P.O.L. staff thought they required better spoil conditions than normally found on the Clay and Laurel County orphan mines.

An adequate data sheet evolved from early attempts at gathering site information that were only partially successful. The final data sheet, as seen in Appendix D, represents a refinement, encompassing sufficient information to describe each site's characteristics. The

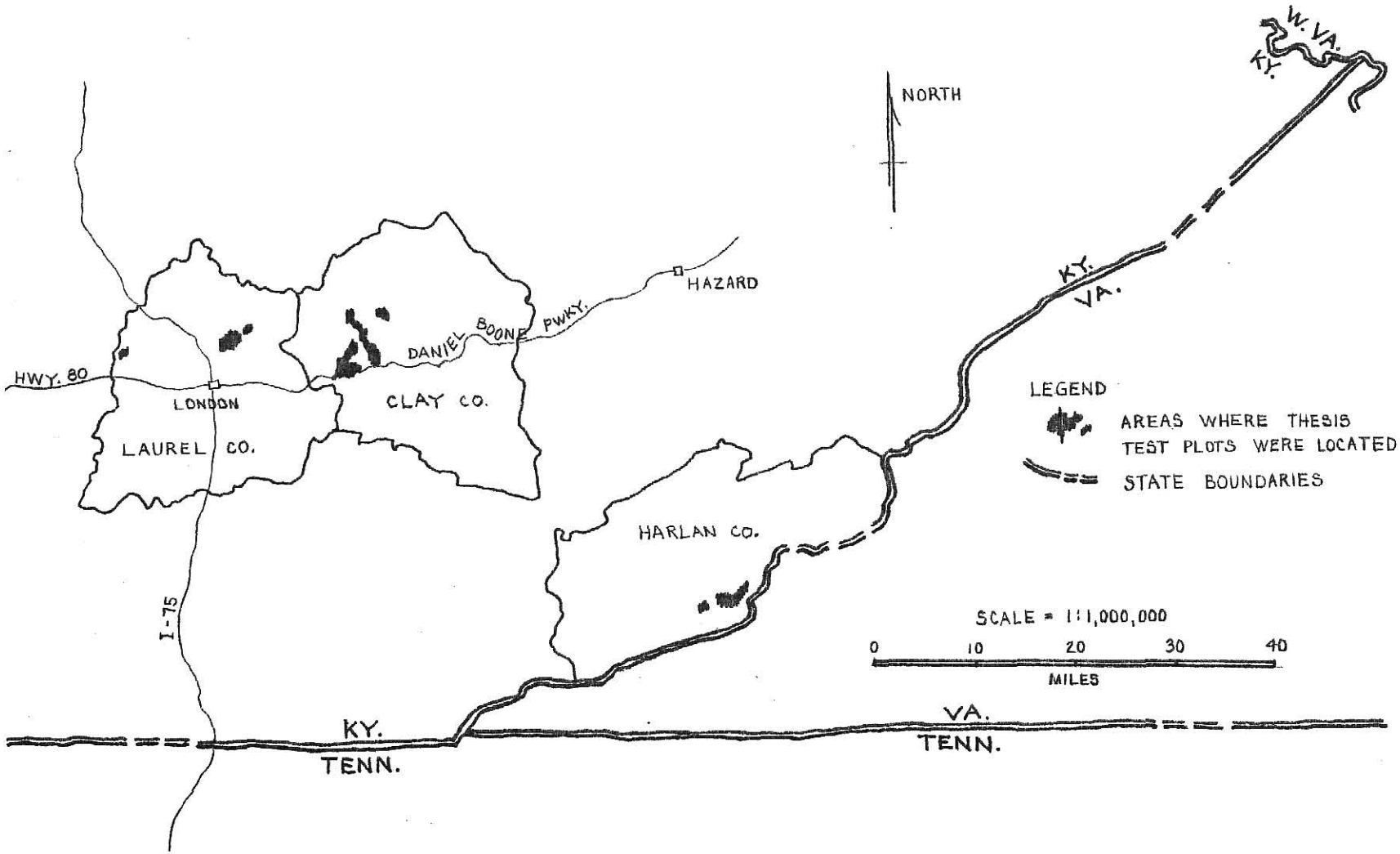

Figure 11

Regional Location Map

mine number, site reconnaissance number, subwatershed, coal seam name, approximate elevation, last known mining disturbance, and original planting date were obtained from the Project Orphan Land files and staff interviews.

The author attempted to establish plots with a size of 40' x 40' or larger, however, the plot size varied considerably because of terrain, mining pattern, invading vegetation, and area of the mine operation. Plots ranged from 75' x 10' or .02 acre to 95' x 45' or .10 acre. Sixty-three different variations in plot area were used. Dimensions for the plots were approximate, established by pacing.

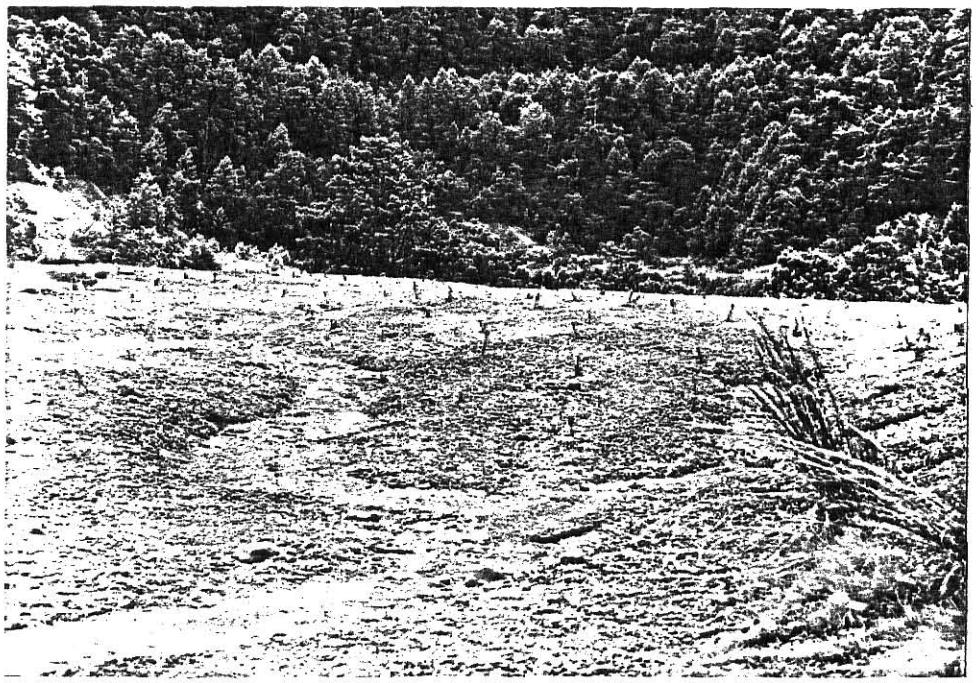

Figure 12

Seedling Test Plot Site

The major consideration in locating a plot was establishing it within an area of homogeneous site conditions. Figure 12, shows a site

that had a large enough area of homogeneous site conditions so that the author could establish a test plot. From the foreground to the center of the photo, where this plot was located, is a relatively flat area where pine seedlings were planted as part of the reclamation of the orphan mine. When a continuous planting of the same species had different aspects or positions on the mine within that continuous planting, it was broken into separate plots.

Plot location was used to describe, in a general sense, the plot. References to the plot location indicate that the plot was relatively flat or steep, wet or dry, slightly or severely eroded, and so forth.

Most plots were located on the bench, berm, or outslope. Figure 13 illustrates these general locations. Other locations on the mine where plots were established were on a hollow fill, highwall toe, adjacent to the highwall, gully side, haul road, berm side, and filled gully. Plots adjacent to the highwall were located on areas where the highwall had ended, resulting in a steep, scalped area subject to severe erosion and sliding. Plots on gully sides were located on the steep side walls of the gullies as opposed to the flatter bottom areas. Plots on filled gullies were established on the new surface resulting from sediment filling a gully to a near level area. Several plots were located on berm sides where slopes were steep in comparison to the gently sloping areas of the berm top.

Plot aspect, or the directional orientation of the plot, was determined in the field by compass. Plot slope was determined by use of an Abney hand level.

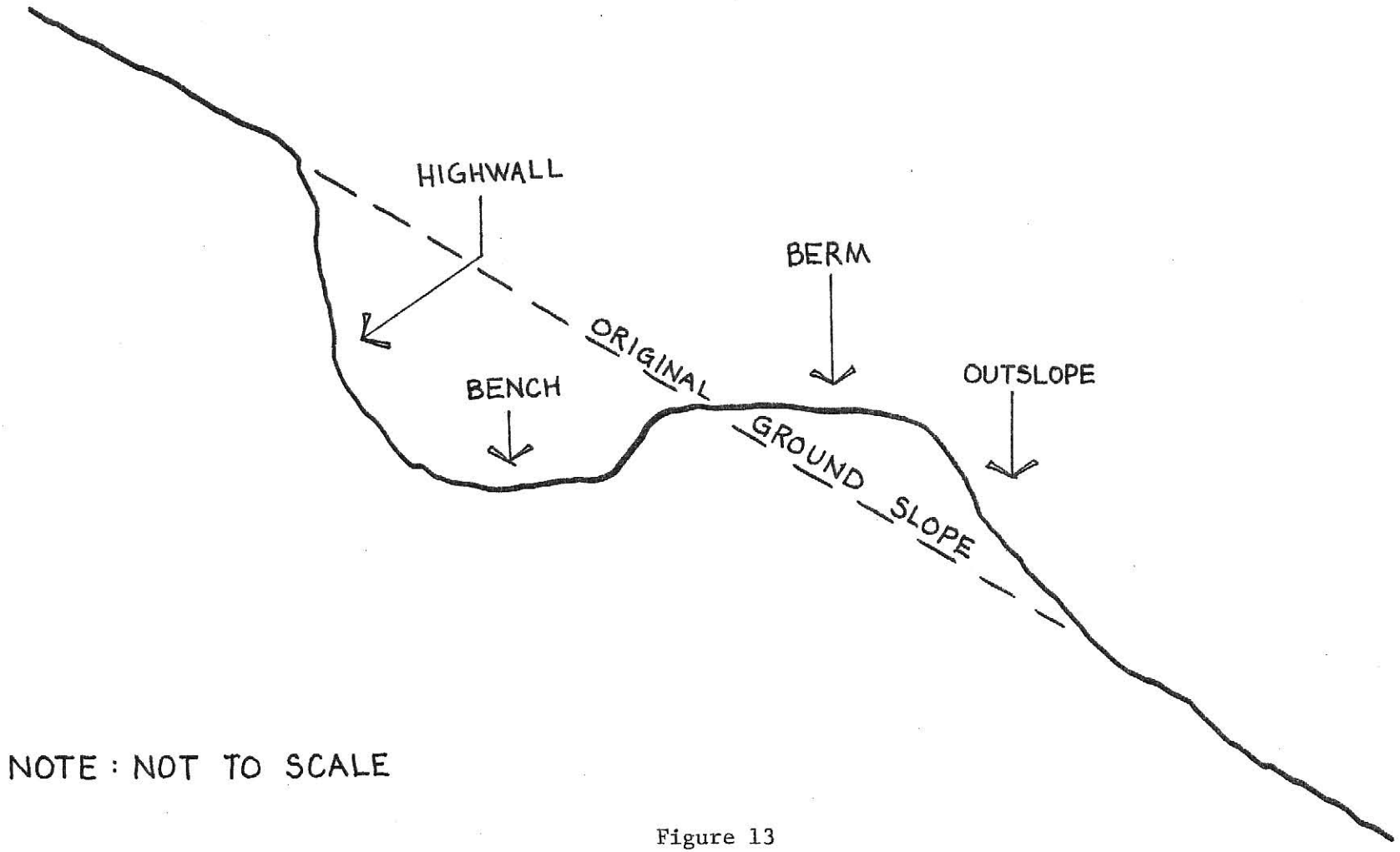

Figure 13

Typical Contour Mine Section for Southeastern Kentucky Orphan Lands

The number of living seedlings within the plot was obtained by visually checking for leaf growth and stem viability. Since the amount of growth was not a consideration, every live plant was counted, regardless of its condition. The spacing, or distance between plants, was determined visually or by pacing. The sum of the dead seedlings found plus those thought to be missing because of known spacing added to the number of live seedlings resulted in the number of original seedlings within the plot boundaries.

Seedling age and size information was obtained from the Kentucky Division of Forestry price list for available seedlings. This information was dependable except for a few situations when the Project Orphan Land staff was notified of changes. For example, if a shipment of loblolly pine was going to be two year old seedlings instead of the normal one year old seedlings, then officials of the state nursery would inform the Project Orphan Land staff of this fact.

The percent of existing vegetative cover was determined by a visual analysis of crown or stem cover provided by the invading plants plus any additional plants that may have been seeded or planted during earlier reclamation attempts by the mining company or landowner. Figure 15 illustrates existing vegetative cover. Broomsedge, seen in the foreground, comprises part of the existing vegetation in this test plot. Identification was made by the author or Project Orphan Land staff members. Several plants which could not be identified in the field were keyed by state plant biologists. Abbreviations for common names were made by the author and used on the plot data sheets because of space limitations only.

Spoil samples were collected with a small shovel or a hand trowel. Spoil material was taken at a depth of 2-6" beneath the surface. Approximately one-half pint of spoil was collected and placed in a small plastic bag with an identification number enclosed. Rock fragments of ½" diameter or greater were discarded.

The first six spoil samples were taken from one location each, which appeared to be representative of the majority of the plot. Thereafter, subsamples were taken, as seen in Figure 14, from four different locations within each plot and mixed in the plastic bag to form a composite sample of the same size. Spoil samples were turned over to the Project Orphan Land staff who had them tested at the University of Kentucky Laboratory.

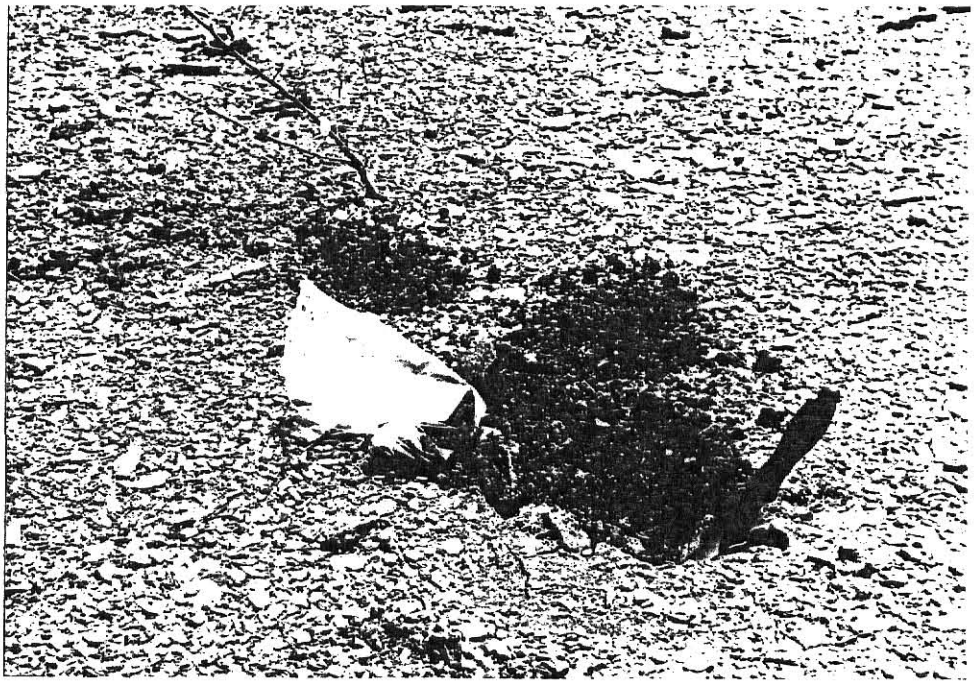

Figure 14

Taking a Spoil Sample

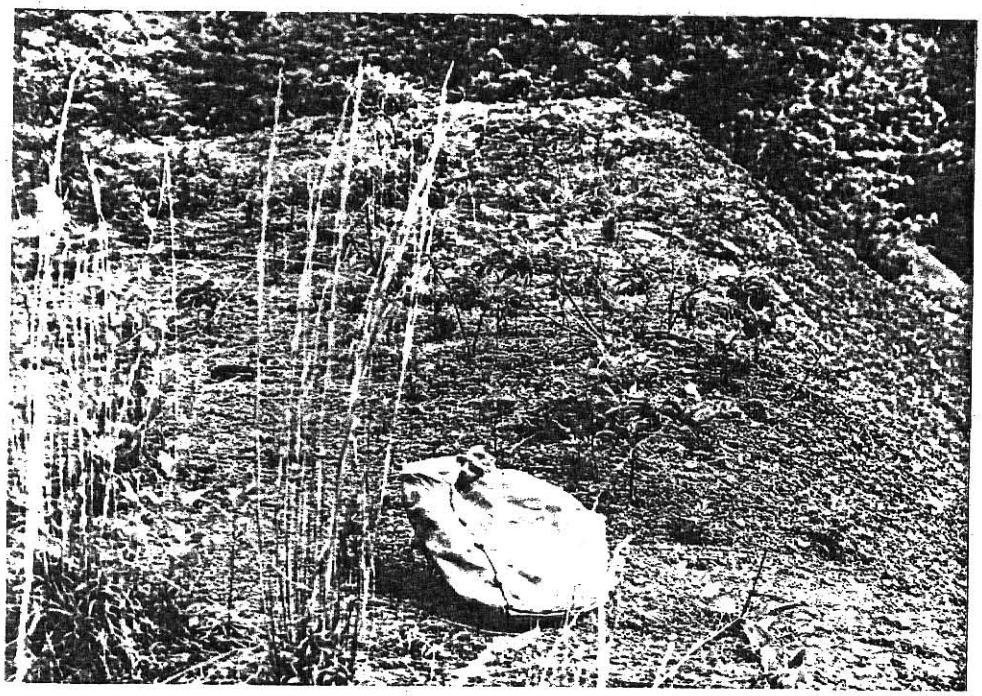

Figure 15

Broomsedge, A Common Invader

Vegetation of adjacent areas included plants that were located within approximately 300 feet of the plot. These plants were identified in the same manner as those within the plots and included plants on mined and unmined areas. This section of the data was collected in an attempt to see if the mined areas were supporting the same types of vegetation that were growing near the disturbed areas.

Spoil color was visually identified in the field without the use of color wheels or charts. The decision to not use charts was made after consultation with an eastern Kentucky soil scientist employed by the U.S. Soil Conservation Service. All spoil colors were noted in the

field, from black to all shades of gray and brown to tan. They were then grouped into grays, browns, and mixtures of the two for analysis.

The degree of rock fragment occurrence on the test plots was determined by visual analysis. This analysis was subdivided into three categories: few, several, and many in an attempt to find some correlations with seedling survival. The degree of erosion was also determined visually. It was categorized as slight, moderate, or severe. Spoil parent material was determined by looking at the spoil color and texture in addition to rock fragment shape and hardness. Figure 16 shows angular rock fragments on the surface of this spoil indicating that the upper portion was dominated by sandstone parent material. A complicating factor for this data analysis was the fact that when these mines were in operation good spoil handling practices had not been developed, resulting in a haphazard placement rather than uniform placement of spoil. As a result, a great deal of variation occurred from mine to mine, within the mine, and even within the test plots.

Seedling survival results were obtained by summarizing numerical data obtained from the thesis data sheets. Summaries of data for each plant species studied are presented in Chapter 5. Summaries of seedling survival as a function of each site factor are presented in Chapter 6.

Figure 16

Sandstone Spoil

Chapter 5

PRESENTATION OF DATA

Each table in this chapter displays the data compiled from all the data sheets for each individual plant species studied. Each table also summarizes the data into averages, where possible, and categories to be used for further analysis. For example, Table 3, the Autumn Olive Summary, shows the average slope of the 15 test plots was 16.5 degrees. It further categorizes the slope into the number of plots with slopes between zero and 10 degrees; the number of plots with slopes between 11 and 20 degrees; and number of plots with slopes greater than 20 degrees. In Chapter 6 each of these three slope categories will be compared with the average seedling survival for each species and for all species to see if a direct relationship exists between plot slope and seedling survival. Each category of predetermined site conditions will be analyzed in this manner, the relationship indicating the reliability of each particular site condition as a predictor of seedling survival.

Table 2

AUTUMN OLIVE SUMMARY

	Mine No.	Plot Location	Slope (degrees)	Aspect	% Existing Cover	Major Invader	pH Water/Buffer	Spoil Age (years)	Spoil Color	Degree of Erosion	Rock Fragments	Planting Age (months)	% Survival
1.	0002 - A	outslope	35	S.E.	20	blackberry	4.5 / 5.9	20	light gray	slight	few	14	65
2.	0009 - A	bench	0 - 2	N.	0 - 5	wire grass	3.3 / 4.7	20	dark gray-black	slight	several	3	17
3.	0014 - A	berm	2 - 10	S.	50	wire grass	4.6 / 5.7	19	light gray & light brown	moderate	few	6	93
4.	0014 - A	berm	3	W.	30	wire grass	3.7 / 4.7	19	medium brown	moderate	many	6	75
5.	0016 - A	berm side	32	N.E.	20	broomsedge	3.8 / 4.6	19	medium gray	moderate	several	6	89
6.	0033 - A	mid outslope	29	E.	0	none	3.5 / 5.1	22	dark gray	severe	many	6	68
7.	0034 - A	berm	0 - 3	S.	0 - 5	deertongue	3.8 / 5.1	22	light-medium gray	moderate	few	13	51
8.	0036 - A	outslope	25	S.	10	none	4.5 / 6.1	18	light-dark gray & light brown	severe	several	3	28
9.	0036 - A	outslope	37	S.W.	10	shining sumac	2.5 / 4.7	18	medium gray	severe	few	3	93
10.	0037 - A	bottom highwall	0 - 30	S.E.	0 - 5	black gum	5.2 / 5.8	19	light brown	severe	several	4	89
11.	0039 - A	top outslope	30	S.W.	0	none	3.4 / 5.0	22	dark gray	moderate	few	12	45
12.	0040 - B	bench	0 - 2	N.	0 - 5	wire grass	3.6 / 4.9	19	light gray	slight	several	4	28
13.	0104 - A	berm	0 - 2	N.E.	80	wire grass	3.8 / 5.1	19	light brown	slight	many	3	95
14.	0104 - A	berm	2	S.E.	15	broomsedge	3.7 / 4.4	19	light-medium gray & light brown	slight	many	3	52
15.	0104 - A	berm	0 - 5	S.	0 - 5	wire grass	4.1 / 5.4	19	medium gray	moderate	few	3	35
		1 highwall 2 bench 6 berm 1 berm side 5 outslope	Ave. = 16.5 8: 0-10 0:11-20 7>20	4 S. 2 S.W. 3 S.E. 2 N. 2 N.E. 1 W. 1 E.	Ave. = 17.3 13: 0-30 1:31-60 1>60	6 wire grass 3 none 2 broomsedge 1 blackberry 1 deertongue 1 shining sumac 1 black gum	Ave. = 3.9 / 5.1	Ave. = 19.6	2 light gray 1 light-medium gray 1 light-medium gray & light brown 1 light gray & light brown 1 light-dark gray & light brown 3 medium gray 2 dark gray 1 dark gray-black 2 light brown 1 medium brown	5:slight 6:moderate 4:severe	6:few 5:several 4:many	Ave. = 5.9	Ave. = 61.5

Table 3

BICOLOR LESPEDEZA SUMMARY

	Mine No.	Plot Location	Slope (degrees)	Aspect	% Existing Cover	Major Invader	pH Water/Buffer	Spoil Age (years)	Spoil Color	Degree of Erosion	Rock Fragments	Planting Age (months)	% Survival
1.	0006 - C	bench	1	W.	5	broomsedge	4.0 / 5.8	22	light gray	slight	few	3	85
	1 bench		Ave. = 1.0 1: 0-10 0:11-20 0 >20	1 W.	Ave. = 5.0 1: 0-30 0:31-60 0>60	1 broomsedge	Ave. = 4.0 / 5.8	Ave. = 22.0	1 light gray	1:slight 0:moderate 0:severe	1:few 0:several 0:many	Ave. = 3.0	Ave. = 85.0

Table 4

BLACK LOCUST SUMMARY

	Mine No.	Plot Location	Slope (degrees)	Aspect	% Existing Cover	Major Invader	pH Water/Buffer	Spoil Age (years)	Spoil Color	Degree of Erosion	Rock Fragments	Planting Age (months)	% Survival
1.	0002 - A	bench	0 - 6	S.E.	0 - 5	wire grass	3.1 / 4.6	20	dark gray	slight	many	6	57
2.	0003 - B	outslope	0 - 3	S.	10	green brier	4.3 / 5.0	20	dark gray	severe	several	3	80
3.	0003 - C	bench	4	N.	0 - 5	blackberry	3.9 / 5.3	20	light-dark gray	slight	several	3	67
4.	0006 - A	top outslope	27	N.E.	0 - 5	blackberry	4.1 / 5.4	23	light gray	severe	many	2	48
5.	0006 - C	top outslope	32	S.W.	10	blackberry	4.1 / 5.1	22	dark gray	severe	several	2	100
6.	0021 - D	top outslope	31	N.W.	50	wire grass	4.2 / 5.5	19	light brown	severe	many	5	98
7.	0021 - D	top outslope	38	N.	20	blackberry	4.0 / 4.9	19	light brown-medium gray	severe	several	5	9
8.	0032 - A	top outslope	10 - 26	N.	25	shining sumac	4.4 / 5.4	22	light gray	slight	few	13	93
9.	0033 - A	above highwall	26	S.	0 - 5	blackberry	5.2 / 6.3	22	tan-light brown	severe	several	7	100
10.	0034 - A	mid outslope	39	N.E.	5	wire grass	3.7 / 5.1	22	light brown & light gray	severe	few	13	93
11.	0037 - A	bottom highwall	22	S.	40	goldenrod	5.5 / 6.7	19	light gray-tan	moderate	many	4	100
12.	0040 - A	short outslope	31	N.	10	green brier	4.0 / 5.1	19	medium gray	severe	several	4	100
13.	0040 - B	short outslope	32	S.W.	0 - 5	broomsedge	3.8 / 5.2	19	light gray	severe	few	4	97
14.	0058 - A	highwall	25	W.	0	none	5.1 / 5.7	15	light-medium brown	severe	many	5	88
15.	0104 - A	mid outslope	33	W.	0	none	3.8 / 5.0	19	light gray-light brown	severe	many	3	50
	1 above highwall 2 highwall 2 bench 10 outslope		Ave. = 25.0 3: 0-10 0:11-20 12> 20	1 S.E. 3 S. 4 N. 2 N.E. 2 S.W. 1 N.W. 2 W.	Ave. = 13.0 13: 0-30 2:31-60 0>60	5 blackberry 3 wire grass 2 green brier 2 none 1 shining sumac 1 goldenrod 1 broomsedge	Ave. = 4.2 / 5.4	Ave. = 20.0	3 dark gray 1 medium gray 3 light gray 1 light-dark gray 1 light gray & light brown 1 light gray-tan 1 light gray-light brown 1 medium gray-light brown 1 tan-light brown 1 light brown 1 light-medium brown	3:slight 1:moderate 11:severe	3:few 6:several 6:many	Ave. = 5.3	Ave. = 78.7

Table 5

CHINESE CHESTNUT SUMMARY

	Mine No.	Plot Location	Slope (degrees)	Aspect	% Existing Cover	Major Invader	pH Water/Buffer	Spoil Age (years)	Spoil Color	Degree of Erosion	Rock Fragments	Planting Age (months)	% Survival
1.	0036 - A	berm	7	N.E.	25	wire grass	4.2 / 5.2	18	dark gray	slight	many	3	96
	1 berm		Ave. = 7.0	1 N.E.	Ave. = 25.0	1 wire grass	Ave. = 4.2 / 5.2	Ave. = 18.0	1 dark gray	1:slight 0:moderate 0:severe	0:few 0:several 1:many	Ave. = 3.0	Ave. = 96.0
			1: 0-10 0:11-20 0:>20		1: 0-30 0:31-60 0:>60								

Table 6

EUROPEAN BLACK ALDER SUMMARY

	Mine No.	Plot Location	Slope (degrees)	Aspect	% Existing Cover	Major Invader	pH Water/Buffer	Spoil Age (years)	Spoil Color	Degree of Erosion	Rock Fragments	Planting Age (months)	% Survival
1.	0002 - A	bench	0 - 6	S.E.	0 - 5	wire grass	2.7 / 4.4	20	dark gray	slight	many	5	80
2.	0014 - A	berm	5	S.	0 - 5	blackberry	4.1 / 5.4	19	light gray	severe	many	6	86
3.	0019 - A	bench	0 - 18	E.	25	tall sedge	3.9 / 5.3	19	light gray & light brown	slight	several	4	94
4.	0019 - A	gully side	28	N.E.	30	wire grass	4.1 / 5.3	19	light brown	moderate	many	4	98
5.	0021 - B	bench	2	S.E.	60	wire grass	4.0 / 5.3	19	light brown	slight	many	4	100
6.	0021 - C	filled gully	2	N.	0	none	3.5 / 4.9	19	light gray	slight	few	5	92
7.	0021 - C	bench	0 - 4	N.	0 - 5	saw grass	3.4 / 4.9	19	light gray	severe	many	5	89
8.	0022 - A	berm	0 - 6	N.W.	5	none	3.4 / 4.8	20	light gray	moderate	few	14	91
9.	0034 - C	bench	0 - 4	N.W.	35	wire grass	4.0 / 5.8	19	light-dark gray & light brown	slight	few	5	100
10.	0036 - A	berm	1	S.E.	20	tall sedge	3.7 / 5.4	18	light-dark gray & light brown	slight	few	3	90
11.	0057 - C	bench	3	N.E.	65	wire grass	4.7 / 5.8	15	medium-dark gray & light-medium brown	slight	few	5	98
12.	0057 - C	bottom highwall	0 - 5	N.E.	50	small sedge	5.1 / 6.6	15	medium brown	slight	few	5	100
13.	0076 - B	bench	3	W.	60	broomsedge	5.6 / 6.8	14	tan-light brown	slight	several	5	88
14.	0076 - B	bench	1	N.W.	50	wire grass	4.9 / 5.7	14	light gray & light brown	slight	many	5	86
15.	0104 - A	bench	0 - 5	S.	25	black gum	4.2 / 5.2	19	medium gray	slight	few	3	90
	1 highwall 9 bench 3 berm 2 gully		Ave. = 6.2 14: 0-10 0:11-20 1>20	3 S.E. 2 S. 2 N. 3 N.E. 3 N.W. 1 W. 1 E.	Ave. = 29.3 9: 0-30 5:31-60 1 >60	6 wire grass 2 tall sedge 2 none 1 blackberry 1 small sedge 1 saw grass 1 broomsedge 1 black gum	Ave. = 4.1 / 5.4	Ave. = 17.9	4 light gray 2 light gray & light brown 2 light-dark gray & light brown 1 medium gray 1 medium-dark gray & light-medium brown 1 dark gray 1 tan-light brown 2 light brown 1 medium brown	11:slight 2:moderate 2:severe	7:few 2:several 6:many	Ave. = 5.2	Ave. = 92.1

Table 7

LOBLOLLY PINE SUMMARY

	Mine No.	Plot Location	Slope (degrees)	Aspect	% Existing Cover	Major Invader	pH Water/Buffer	Spoil Age (years)	Spoil Color	Degree of Erosion	Rock Fragments	Planting Age (months)	% Survival
1.	0006 - A	haul road	0 - 8	W.	0 - 5	wire grass	4.9 / 6.1	22	medium gray	slight	few	5	89
2.	0006 - A	hollow fill	6	N.E.	5	broomsedge	3.7 / 5.2	22	light brown	slight	several	5	0
3.	0025 - A	berm	0 - 5	N.	15	steeple bush	3.9 / 4.9	22	medium brown	slight	few	14	70
4.	0026 - A	bench	2	S.E.	40	wire grass	4.9 / 6.0	22	medium brown	moderate	many	7	82
5.	0033 - B	above highwall	20	S.	10	sourwood	5.3 / 6.3	22	light brown	moderate	many	7	89
6.	0033 - C	berm	12	S.W.	5	broomsedge	3.8 / 4.9	22	light gray & light brown	moderate	many	7	68
	1 above highwall 1 bench 1 hollow fill 2 berm 1 haul road		Ave. = 8.8 4: 0-10 2:11-20 0>20	1 S. 1 S.E. 1 S.W. 1 N. 1 N.E. 1 W.	Ave. = 13.3 5: 0-30 1:31-60 0>60	2 wire grass 2 broomsedge 1 steeple bush 1 sourwood	Ave. = 4.4 / 5.6	Ave. = 22.0	1 light gray & light brown 1 medium gray 2 light brown 2 medium brown	3:slight 3:moderate 0:severe	2:few 1:several 3:many	Ave. = 7.5	Ave. = 66.3

Table 8

SCOTCH PINE SUMMARY

	Mine No.	Plot Location	Slope (degrees)	Aspect	% Existing Cover	Major Invader	pH Water/Buffer	Spoil Age (years)	Spoil Color	Degree of Erosion	Rock Fragments	Planting Age (months)	% Survival
1.	0049 - A	bottom highwall	24	W.	90	blackberry	5.2 / 5.8	14	medium brown	slight	several	6	100
2.	0095 - A	highwall	33	N.	25	ground moss	5.1 / 6.0	12	light-medium brown	severe	many	8	100
3.	0095 - A	bottom highwall	34	N.W.	10	blackberry	5.3 / 6.4	12	light brown	severe	many	7	100
	3 highwall		Ave. = 30.3 0: 0-10 0:11-20 3>20	1 N. 1 N.W. 1 W.	Ave. = 41.7 2: 0-30 0:31-60 1>60	2 blackberry 1 ground moss	Ave. = 5.2 / 6.1	Ave. = 12.7	1 light brown 1 light-medium brown 1 medium brown	1:slight 0:moderate 2:severe	0:few 1:several 2:many	Ave. = 7.0	Ave. = 100

Table 9

SHORTLEAF PINE SUMMARY

	Mine No.	Plot Location	Slope (degrees)	Aspect	% Existing Cover	Major Invader	pH Water/Buffer	Spoil Age (years)	Spoil Color	Degree of Erosion	Rock Fragments	Planting Age (months)	% Survival
1.	0014 - A	bench	1 - 5	S.E.	50	wire grass	4.5 / 6.1	19	light brown	moderate	many	6	86
2.	0021 - B	bench	4	N.W.	0 - 5	tall sedge	3.3 / 4.7	19	light-medium gray & light brown	severe	many	5	86
3.	0021 - B	berm	1	E.	0	none	3.6 / 4.9	19	light gray & light brown	moderate	many	3	60
4.	0021 - C	berm	0 - 4	N.	0	none	3.4 / 4.7	19	light gray	moderate	many	5	88
5.	0021 - C	berm	1	N.	0 - 5	wire grass	3.7 / 4.9	19	light brown	moderate	many	5	96
6.	0021 - C	berm	3	N.	0 - 5	tall sedge	3.5 / 4.7	19	light gray & light brown	slight	many	5	100
7.	0034 - C	berm	2 - 16	N.W.	40	wire grass	4.1 / 5.3	19	light brown	moderate	many	5	91
8.	0037 - B	berm	8	S.E.	50	broomsedge	4.4 / 5.4	19	light gray	slight	few	4	98
9.	0049 - A	highwall	46	N.E.	20	red oak	5.1 / 6.3	24	tan	severe	many	6	96
10.	0049 - A	bench	4	N.	70	pokeberry	5.0 / 5.5	14	light-medium gray & light brown	slight	many	6	100
11.	0049 - A	bench	3	S.E.	65	pokeberry	5.3 / 6.4	14	light brown	slight	many	6	83
12.	0058 - A	bench	0 - 2	W.	60	wire grass	4.7 / 6.3	15	light brown	slight	many	5	54
13.	0058 - A	bench	1	W.	60	wire grass	5.0 / 6.2	15	medium brown	slight	many	5	65
		1 highwall 6 bench 6 berm	Ave. = 7.5 11: 0-10 1:11-20 1>20	3 S.E. 4 N. 2 N.W. 1 N.E. 2 W. 1 E.	Ave. = 33.1 6: 0-30 5:31-60 2>60	5 wire grass 2 tall sedge 2 pokeberry 2 none 1 broomsedge 1 red oak	Ave. = 4.3 / 5.5	Ave. = 18.0	2 light gray 2 light gray & light brown 2 light-medium gray & light brown 1 tan 5 light brown 1 medium brown	6:slight 5:moderate 2:severe	1:few 0:several 12:many	Ave. = 5.1	Ave. = 84.8

Table 10

TULIP POPLAR SUMMARY

	Mine No.	Plot Location	Slope (degrees)	Aspect	% Existing Cover	Major Invader	pH Water/Buffer	Spoil Age (years)	Spoil Color	Degree of Erosion	Rock Fragments	Planting Age (months)	% Survival
1.	0004 - A	bottom outslope	8	N.E.	20	wire grass	4.9 / 6.1	19	light gray & light brown	slight	few	17	93
	1 outslope		Ave. = 8.0	1 N.E.	Ave. = 20.0	1 wire grass	Ave. = 4.9 / 6.1	Ave. = 19.0	1 light gray & light brown	1:slight 0:moderate 0:severe	1:few 0:several 0:many	Ave. = 17.0	Ave. = 93.0
			1: 0-10 0:11-20 0 -20		1: 0-30 0:31-60 0>60								

Table 11

VIRGINIA PINE SUMMARY

	Mine No.	Plot Location	Slope (degrees)	Aspect	% Existing Cover	Major Invader	pH Water/Buffer	Spoil Age (years)	Spoil Color	Degree of Erosion	Rock Fragments	Planting Age (months)	% Survival
1.	0004 - A	outslope	20	N.E.	10	green brier	4.7 / 6.1	20	light gray	moderate	several	14	94
2.	0004 - A	berm	0 - 5	N.E.	30	broomsedge	4.4 / 5.5	20	light gray	slight	several	14	86
3.	0004 - A	outslope	30	N.E.	35	blackberry	4.8 / 6.2	20	light gray	severe	several	2	90
4.	0022 - A	hollow fill	8	S.W.	0 - 5	blackberry	3.3 / 4.9	21	light gray	moderate	few	3	56
5.	0022 - A	berm	7	W.	20	none	3.3 / 4.9	21	light gray & light brown	moderate	many	3	55
6.	0032 - A	berm	10	N.	30	wire grass	4.0 / 5.2	22	light gray	moderate	many	14	78
7.	0033 - A	bench	1	S.	10	small sedge	4.5 / 5.9	22	light brown-black	slight	few	7	77
8.	0034 - C	berm side	22	N.W.	0	none	3.7 / 5.0	19	light-medium gray & light brown	severe	many	5	78
9.	0037 - A	bench	4	S.	25	broomsedge	3.6 / 4.9	19	light gray	slight	few	4	96
10.	0039 - A	berm	7	S.W.	25	broomsedge	3.8 / 5.1	20	medium brown	moderate	few	13	85
11.	0056 - A	berm	0 - 2	N.E.	0 - 5	Virginia pine	4.1 / 4.9	15	light gray & light brown	slight	several	5	88
12.	0056 - A	berm	9	S.W.	10	blackberry	3.8 / 4.7	15	light-medium gray	severe	many	5	93
13.	0098 - A	beside highwall	19	S.E.	30	wire grass	5.4 / 6.4	19	light brown	severe	many	5	75
14.	0104 - A	outslope	30	E.	0 - 5	blackberry	3.6 / 5.2	19	light brown	severe	many	3	15
15.	0104 - A	berm	0 - 1	E.	25	broomsedge	3.8 / 5.1	19	medium gray	slight	many	3	25
		1 beside highwall 2 bench 7 berm 1 berm side 1 hollow fill 3 outslope	Ave. = 11.7 10: 0-10 2:11-20 3>20	2 S. 3 S.W. 1 S.E. 1 N. 4 N.E. 1 N.W. 1 W. 2 E.	Ave. = 17.7 14: 0-30 1:31-60 0>60	4 broomsedge 4 blackberry 2 wire grass 2 none 1 green brier 1 small sedge 1 Virginia pine	Ave. = 4.1 / 5.3	Ave. = 19.4	6 light gray 2 light gray & light brown 1 light-medium gray 1 light-medium gray & light brown 1 medium gray 2 light brown 1 light brown-black 1 medium brown	5:slight 5:moderate 5:severe	4:few 4:several 7:many	Ave. = 6.7	Ave. = 72.7

Table 12

WHITE PINE SUMMARY

	Mine No.	Plot Location	Slope (degrees)	Aspect	% Existing Cover	Major Invader	pH Water/Buffer	Spoil Age (years)	Spoil Color	Degree of Erosion	Rock Fragments	Planting Age (months)	% Survival
1.	0049 - A	highwall	35	S.	30	broomsedge	4.9 / 6.1	24	tan-light brown	severe	many	7	92
2.	0049 - A	bottom highwall	13	S.	70	none	5.3 / 6.1	14	light gray & light brown	slight	many	7	89
	2 highwall		Ave. = 24.0	2 S.	Ave. = 50.0	1 broomsedge 1 none	Ave. = 5.1 / 6.1	Ave. = 19.0	1 light gray & light brown 1 tan-light brown	1:slight 0:moderate 1:severe	0:few 0:several 2:many	Ave. = 7.0	Ave. = 90.5
			0: 0-10 1:11-20 1>20		1: 0-30 0:31-60 1>60								

Chapter 6

SUMMARY AND CONCLUSIONS

The first portion of this chapter deals with results found for the six species studied with six or more experimental plots tested. Results for each of these six species is broken down into an analysis of each site condition studied. Five additional species had three or fewer plots tested. Results for these five were not considered fully valid because of the much smaller number of seedlings tested. Therefore, only highlights of these results are presented.

The second and last portion of the chapter presents data based on information gained from all eleven woody plant species tested.

Correlations between invaders and seedling survival was done on an individual basis only. For example, seedling survival was averaged for all Virginia pine plots with blackberry as the major invader. No other invaders were lumped with blackberry. However, group relationships were investigated for the degree of existing vegetative cover.

Each category of predetermined site conditions was compared to the percent of seedling survival to see what, if any, relationship existed. Straight line relationships were considered to be reliable, this being a situation where the percent of seedling survival continued in the same direction on a graph with each increment change of a site condition. Although some type of relationship was established for each set of site specific results, a reversal of direction for the graph line was termed an unreliable relationship for purposes of seedling survival prediction on orphan mine lands in southeastern Kentucky.

Results for Individual Species

Autumn Olive Summary

Fifteen autumn olive plots were selected for testing. A total of 1,334 seedlings were planted on those plots. Survival averaged 61%, the lowest of all species tested. Autumn olive survival ranged from 17% to 95% on individual plots. Seedlings had been planted an average of six months, ranging from three to fourteen months.

As can be seen in Table 2, autumn olive plots were located so that all aspects were represented except northwest, with 63% survival on the warm aspects versus 59% survival on the cool aspects.

Survival was higher for plots located on mine positions with steeper slopes, with the exception of those located on outslopes. Survival on the berm side was 89%, on the highwall, 89%; on the berm, 67%; on the outslope, 60%; and on the bench, 23%.

The average slope for all plots was 17 degrees, ranging from 0 to 37 degrees. On the eight plots that ranged from 0-10 degrees slope, 56% of the seedlings survived; no plots were established with slopes between 11 and 20 degrees; on the seven plots with slopes greater than 20 degrees, there was 68% survival.

On the five plots with slight erosion, 51% of the seedlings survived; on the six plots with moderate erosion, survival averaged 65%; on the three plots with severe erosion, survival averaged 69%.

There appeared to be no direct relationship between the amount of rock fragments on the spoil surface and the seedling survival. On the six plots with few rock fragments, survival was 64%; on the five plots with several rock fragments, survival was 50%; on the four plots with many rock fragments, survival averaged 73%.

There appeared to be a direct relationship between the percentage of existing plant cover on the plots and the seedling survival. On the thirteen plots with 0-30% existing cover, seedling survival was 57%; on the one plot with 31-60% cover, survival was 93%; on the one plot with more than 60% cover, seedling survival was 95%. From the data collected it appears the greater the percentage of existing plant cover on the orphan land, the higher the autumn olive survival.

Six invading plant species on the autumn olive plots were identified. Two plots with broomsedge as the major invader averaged 71%. Six plots with wire grass as the major invader averaged 57% seedling survival; three plots with no major invaders averaged 47%. Four additional major invaders were found on only one plot each. They were blackberry, deertongue, shining sumac, and black gum; seedling survival for those plots was 65%, 51%, 93%, and 89% respectively.

Ten variations of spoil color were found on the autumn olive plots including shades of gray, brown, and mixtures of the two. Brown spoils had an average seedling survival of 86%. Spoils with mixtures of brown and gray coloration had an average seedling survival of 58%. Gray spoils had survival of 55%.

Water pH averaged 3.9, ranging from 2.5 to 4.6; buffer pH averaged 5.1, ranging from 4.4 to 6.1. When water pH was less than 4.0, survival averaged 61%; with water pH from 4.0 to 5.0, survival was 55%; with water pH greater than 5.0, survival was 89%. When the buffer pH was less than 5.0, seedling survival was 59%; between 5.0 and 6.0 survival was 67%; with the buffer pH greater than 6.0, seedling survival was 28%.

Black Locust Summary

A total of fifteen plots were chosen for black locust testing. On those fifteen plots 1,430 seedlings were planted. Survival averaged 79%, ranging from 9% to 100%. Seedlings had been planted an average of five months, ranging from two to thirteen months.

Black locust plots were located on all aspects except east facing slopes, with 84% survival on the warm aspects versus 73% on the cool aspects.

When the plots were evaluated according to position on the mine, survival was better on the steeper locations. Survival on outslopes averaged 77%, on the highwall, 94%; above the highwall, 100%; and on the bench, 62%.

The average slope for all plots was 25 degrees, ranging from 0 degrees to 39 degrees. On the three plots that ranged from 0-10 degrees, 68% of the seedlings survived; no plots were established on slopes of 11-20 degrees; on the twelve plots with slopes greater than 20 degrees, survival averaged 81%.

On the three plots with slight erosion, 72% of the seedlings survived; on the one plot with moderate erosion, survival was 100%; on the eleven plots with severe erosion, survival was 88%.

The amount of rock fragments on the plot surface was originally thought to relate directly to the degree of erosion; however, the black locust studies did not bear this out. There appeared to be a direct relationship between the number of rock fragments on the plot and the plant survival. On the three plots with few rock fragments, seedling survival was 94%; on the six plots with several rock fragments, survival was 76%, on the six plots with many rock fragments, survival was 74%.

There appeared to be a direct relationship between the percentage of existing cover and the seedling survival. On the thirteen plots with 0-30% existing plant cover, seedling survival was 75%; on the two plots with 31-60% existing cover, survival was 99%; no black locust plots were established with existing cover of greater than 60%.

Six different invaders, which made up the majority of the existing plant material on their respective plots at the time of testing, were identified. Two plots with green brier as the major invader averaged 90% seedling survival; three plots with wire grass as the major invader averaged 83% seedling survival; two plots with no invaders averaged 69% survival; five plots with blackberry as the major invader averaged 65% seedling survival. Three additional invaders were found to be a majority of the existing vegetation on only one plot. They were shining sumac, goldenrod, and broomsedge. Seedling survival on those plots was 93%, 100%, and 97% respectively.

When local geologic conditions are known, spoil color can be an indicator of parent material and therefore plant survival. Eleven variations of spoil color were recorded on the black locust plots including shades of gray, brown, and mixtures of the two. Seedling survival on brown spoils averaged 95%; on gray spoils, 80%; on spoils with mixed gray and brown coloration, 63%.

Water pH averaged 4.2, ranging from 3.1 to 5.5; buffer pH averaged 5.2, ranging from 4.6 to 6.7. There appeared to be a direct relationship between pH and plant survival, which increased as the pH range increased. When water pH was less than 4.0, survival was 73%; when 4.0 to 5.0, survival was 75%; when greater than 5.0, survival was

96%. When the buffer pH was less than 5.0, survival was 33%; at buffer pH 5.0 to 6.0, survival was 83%; with buffer pH greater than 6.0, survival was 100%.

European Black Alder Summary

Fifteen plots were established for European black alder testing. On those fifteen plots 1,087 seedlings were planted. Survival averaged 92%, ranging from 80% to 100%. Seedlings had been planted an average of five months, ranging from three to fourteen months.

European black alder plots were located on all aspects except southwest facing slopes, with 89% survival on the warm aspects versus 94% survival on the cool aspects.

Survival was better for plots located on steeper mine positions. Survival on the highwall was 100%, 98% on a gullyside, 93% on the bench, 92% on a filled gully, 89% on the berm, and 80% on a hollow fill.

The average slope for all plots was 6 degrees, ranging from 0 to 28 degrees. On the thirteen plots that ranged from 0-10 degrees, 91% of the seedlings survived; on the one plot within the range of 11-20 degrees slope, 94% of the seedlings survived; on the one plot with a slope greater than 20 degrees, survival was 98%.

On the eleven plots with slight erosion, 93% of the seedlings survived; on the two plots with moderate erosion, survival was 95%; on the two plots with severe erosion, survival was 87%.

The amount of rock fragments on the plot surfaces appeared to have a direct relationship to the seedling survival. On the seven plots with few rock fragments, survival was 94%; on the two plots with several rock fragments, seedling survival was 91%; on the six plots with many rock fragments, survival was 90%.

There appeared to be no direct relationship between European black alder seedling survival and the degree of existing plant cover. On the nine plots with 0-30% existing plant cover, seedling survival was 90%; on the five plots with 31-60% existing cover, survival was 95%; on the one plot established with existing plant cover greater than 60%, survival was 65%.

Seven invading plant species, which made up the majority of the existing plant material on their respective plots at the time of testing, were identified. Six plots with wire grass as the major invader averaged 94% seedling survival; two plots with tall sedge as the major invader averaged 92% seedling survival; two plots with no invaders averaged 91% seedling survival. Five additional major invaders were recorded on one plot each. They were blackberry, short sedge, orchard grass, saw grass, and broomsedge; their survival was 86%, 100%, 90%, 89%, and 88% respectively.

Nine variations of spoil color were recorded on the European black alder plots including shades of gray, brown, and mixtures of the two. Survival on brown spoils averaged 97%; on gray spoils 88%; on spoils with mixed gray and brown coloration 78%.

Water pH averaged 4.1, ranging from 2.7 to 5.6; buffer pH averaged 5.4, ranging from 4.4 to 6.8. As the pH increased, European black alder survival also increased for both water and buffer pH. When water pH was less than 4.0, survival was 89%; when water pH was 4.0 to 5.0, survival was 94%; when water pH was greater than 5.0, survival was 94%. When the buffer pH was less than 5.0, survival averaged 88%; when buffer pH was 5.0 to 6.0, survival was 94%; and when the buffer pH was greater than 6.0, survival was again 94%.

Virginia Pine Summary

Fifteen Virginia pine plots were established for testing with a total of 1,049 seedlings planted on them. Seedling survival averaged 73%, ranging from 15% to 96%. Seedlings had been planted an average of seven months, ranging from two to fourteen months.

Virginia pine plots were located on all aspects, with 77% survival on the warm aspects versus 69% on the cool aspects.

Results from the analysis of plots on various mine positions were so varied that no conclusions could be drawn from them. Survival on the two bench plots averaged 87%; on the berm side, 78%; on the slope adjacent to the highwall, 75%; on the berm, 73%; on the outslope, 66%; on the hollow fill, 56%.

The average slope for all plots was 12 degrees, ranging from 0 to 30 degrees. On the ten plots located on slopes 0-10 degrees, seedling survival averaged 74%; on the two plots with slopes of 11-20 degrees, seedling survival was 85%; on the three plots with slopes greater than 20 degrees, survival was 61%.

On the five plots with slight erosion, 74% of the seedlings survived; on the five plots with moderate erosion, survival also averaged 74%; on the five plots with severe erosion, seedling survival averaged 70%.

There was no apparent correlation between the number of rock fragments on the spoil surface and the percentage of seedling survival for the Virginia pine plots. On the four plots with few rock fragments, survival was 79%; on the four plots with several rock fragments, survival was 89%; on the seven plots with many rock fragments, survival was 60%.

Again there did not appear to be a direct relationship between the percentage of existing plant cover on the plots and the seedling survival. On the fourteen plots with 0-30% existing cover, seedling survival was 71%; on the one plot with 31-60% cover, survival was 90%; no plots were established with cover greater than 60%.

Six plant species were identified as being a majority of the invading plants on their respective plots. Two plots with wire grass as the major invader had 67% seedling survival; four plots with blackberry as the major invader had 63% survival. Three additional existing plant species were found to be the major invader on only one Virginia pine plot each. They were short sedge, Virginia pine, and green brier; seedling survival on these plots was 77%, 88%, and 94% respectively.

Eight variations of spoil color were found on the Virginia pine plots including shades of gray and brown along with mixtures of the two. Gray spoils had an average seedling survival of 77%. Spoils with mixtures of gray and brown coloration had seedling survival of 75%. Brown spoils had 50% survival.

Water pH averaged 4.1, ranging from 3.3 to 5.4; buffer pH averaged 5.3, ranging from 4.7 to 6.4. When water pH was less than 4.0, survival was 63%, when water pH was 4.0 to 5.0, survival was 85%, with water pH greater than 5.0, survival was 75%. When buffer pH was less than 5.0, survival was 78%; when between 5.0 and 6.0, seedling survival averaged 63%; with buffer pH greater than 6.0, survival of Virginia pine seedlings averaged 86%.

Shortleaf Pine Summary

Thirteen shortleaf pine plots were established for testing. A total of 1,046 seedlings were planted on those plots. Survival averaged

85%, ranging from 54 to 100%. Seedlings had been planted an average of five months, ranging from three to six months.

Shortleaf pine plots were established on all aspects except south and southwest. Seedling survival averaged 77% on warm aspects and 90% on cool aspects.

Survival of seedlings was better on the plot locations with steeper slopes. Survival on the highwall was 96%; on the berm, 89%; and on the bench, 79%.

The average slope for all shortleaf pine plots was seven degrees, ranging from 0 to 46 degrees. On the eleven plots that ranged from 0-10 degrees slope, 83% of the seedlings survived; on the one plot with a slope of 11-20 degrees, survival was 91%; on the one plot with slope greater than 20 degrees, survival was 96%.

On the six plots with slight erosion, 83% of the seedlings survived; on the five plots with moderate erosion, 84% of the seedlings survived; on the two plots with severe erosion, 91% survival was noted.

On the one plot with few rock fragments, survival was 98%; there were no shortleaf pine plots with several rock fragments; on the twelve plots with many rock fragments, survival averaged 84%.

There did not appear to be a direct relationship between seedling survival and the percentage of existing vegetative cover on the plots at the time of testing. On the six plots with 0-30% existing cover, 88% of the seedlings survived; on the five plots with 31-60% cover, 79% of the seedlings survived; on the two plots with greater than 60% cover, survival was 91%.

Five major invading plant species were identified. Two plots with tall sedge as the major invader averaged 93% seedling survival; two

plots with pokeberry as the major invader had 91% survival; five plots with wire grass as the major invader averaged 78% seedling survival; two plots with no invaders averaged 74% survival. Two additional invaders were a majority on only one plot each. They were broomsedge and red oak; seedling survival on these plots was 98 and 96% respectively.

Six variations of spoil color were found on the shortleaf pine plots. Gray spoils had an average seedling survival of 93%. Spoils with mixtures of gray and brown colors had 87% survival. Brown spoils averaged 82% seedling survival.

Water pH for all shortleaf pine plots averaged 4.3, ranging from 3.3 to 5.3; buffer pH averaged 5.5, ranging from 4.7 to 6.4. When water pH was less than 4.0, survival averaged 86%; with water pH at 4.0 to 5.0, survival averaged 82%; with water pH greater than 5.0, seedling survival was 89%. When the buffer pH was less than 5.0, survival was 86%; with pH at 5.0 to 6.0, seedling survival was 96%; with buffer pH greater than 6.0, shortleaf pine survival was 77%.

Loblolly Pine Summary

Six loblolly pine plots were chosen for testing with a total of 338 seedlings planted on them. Seedling survival averaged 66%, ranging from 0 to 89% on individual plots. Seedlings had been planted an average of seven months, ranging from five to fourteen months.

Loblolly pine plots were located on all aspects except east and northwest, with plots on warm aspects having 82% seedling survival versus 35% survival on cool aspects.

Results with regard to plot locations on the mine were varied. That is, no direct relationship was evident. Survival on the slope adjacent to the highwall was 89%; 84% on the haul road; 82% on the bench;

69% on the berm; 0% on the hollow fill. Total failure on the hollow fill can best be attributed to seedling injury at some point between the nursery and the mine site.

The average slope for all plots was 9 degrees, ranging from 0 to 20 degrees. On the four plots with slopes of 0-10 degrees, survival was 60%; on the two plots with slopes of 11-20 degrees, survival was 79%; no plots were located on slopes greater than 20 degrees.

On the three plots with slight erosion, seedling survival averaged 53%; on the three plots with moderate erosion, survival was 80%; there were no plots with severe erosion.

On the two plots with few rock fragments, seedling survival averaged 79%; on the one plot with several rock fragments, survival was 0%; on the three plots with many rock fragments, loblolly pine seedling survival averaged 80%. These results indicate no apparent relationship between the presence of rock fragments on the spoil surface and the survival rate of loblolly pine.

There appeared to be a direct relationship between the percentage of existing plant cover on the plots and the seedling survival. On the five plots with 0-30% existing plant cover, seedling survival was 63%; on the one plot with 31-60% cover, survival was 82%; no plots were established with more than 60% existing plant cover.

Four invading plant species were identified. Two plots with wire grass as the major invader averaged 85% seedling survival; two plots with broomsedge as the major invader had 34% survival. Two additional plants which made up the majority of the plant invaders were found on only one plot each. They were steeplebush and sourwood with 70 and 89% seedling survival respectively.

Four variations of spoil color were found on the loblolly pine plots. Gray spoils had an average seedling survival of 89%. Spoils with mixtures of gray and brown colors had 68% survival. Plots with brown surface spoils had 60% seedling survival.

Water pH averaged 4.4, ranging from 3.7 to 5.3; buffer pH averaged 5.6, ranging from 4.9 to 6.3. When water pH was less than 4.0, survival of loblolly pine seedlings was 46%; with pH 4.0 to 5.0, survival was 85%; with water pH greater than 5.0, seedling survival was 89%. These results show a strong correlation between water pH and loblolly pine seedling survival. When buffer pH was less than 5.0, seedling survival averaged 69%; with buffer pH at 5.0 to 6.0, survival was 41%; with buffer pH greater than 6.0, loblolly pine seedlings survival averaged 89%. These results do not show a straight line relationship between buffer pH and seedling survival. However, seedling tests for other species usually did show similar results for water and buffer pH. That situation did not occur here because of the low survival occurring with buffer pH between 5.0 and 6.0 where one plot had 0% survival.

Summary for Scotch Pine, White Pine, Bicolor Lespedeza, Chinese Chestnut, and Tulip Poplar

Three Scotch pine plots were chosen for testing with a total of 134 seedlings planted on them. Seedling survival averaged 100%, the highest of any plant species tested. Seedlings had been planted an average of seven months, ranging from six to eight months. No conclusions were drawn from the data base because of the small number of Scotch pine plots.

Two white pine plots were established for testing with a total of 253 seedlings. Seedling survival averaged 91%, ranging only from 89 to 92%. Both plots had been planted seven months at the time of testing. Again, because of the small number of plots, no relationships between site conditions and seedling survival were examined.

One bicolor lespedeza plot was established with 49 seedlings planted. Eighty-five percent of these seedlings had survived at the time of testing, which was three months after the planting date. No further conclusions regarding relationships of site conditions and seedling survival were made from this small data sample.

One Chinese chestnut plot was established with 80 seedlings originally planted on it. Seedling survival was 96% after three months. No conclusions were drawn from this Chinese chestnut plot data.

One tulip poplar plot was established with 33 seedlings planted on it. Seedling survival was 93% seventeen months after planting. No relationships between site conditions and seedling survival were examined nor conclusions drawn from the tulip poplar plot data because of the small sample.

Summary and Conclusions for All Species

Average seedling survival figures, as related to particular site conditions, include plot data from all eleven plant species tested, even though the averages for species with less than six plots are not displayed in the tables.

Water pH

Water pH was the most reliable predictor of seedling survival. This does not mean that the planner could always predict seedling survival results but that he could predict a range of results and be correct most of the time. As seen in Table 13, when water pH was less than 4.0, for all species tested, the average seedling survival was 70%; when the water pH ranged from 4.0 to 5.0, survival averaged 82%; when

Table 13

Percentage of Seedling Survival for Water pH and Buffer pH for All Spoils

Species	pH					
	Water pH			Buffer pH		
	<4.0	4.0-5.0	>5.0	<5.0	5.0-6.0	>6.0
autumn olive	61	55	89	59	67	28
black locust	73	75	96	33	83	100
European black alder	89	94	94	88	94	94
loblolly pine	46	85	89	69	41	89
shortleaf pine	86	82	84	86	96	77
Virginia pine	63	85	75	78	63	86

the water pH was greater than 5.0, seedling survival averaged 93%. These results show a definite improvement in the survival rate as the water pH increases. Using the autumn olive plot with a slope of 0-3 degrees on mine number 0034 - A as an example, where the water pH was 3.8, the planner could predict that seedling survival would be relatively low. While 70% survival was the average for all plots with a water pH of less than 4.0, survival on this plot was 51%. The water pH results were similar to findings of Boyce (6), S.C.S. (33), and Plass (39).

Buffer pH

Buffer pH results were similar to water pH results. When the buffer pH was less than 5.0, seedling survival for all species averaged 72%; when buffer pH was 5.0 to 6.0, survival averaged 79%; when the buffer pH was greater than 6.0, survival was 85%.

Thus both water and buffer pH results appear to have direct relationships to seedling survival and should be good predictors of seedling survival. However, pH is a chemical characteristic of spoil and therefore cannot be noted visually. The author's research results indicate with laboratory pH results in hand the planner could predict, on the average, how many seedlings of a certain species would need to be planted to meet certain vegetation standards.

Existing Plant Cover

The percentage of existing plant cover on the plots was also a good indicator of seedling survival. Table 14 summarizes the data collected for existing plant cover: when the plots had 0-30% existing cover, seedling survival for all species averaged 75%; when the plots

Table 14

Percentage of Seedling Survival for Existing Plant Cover

Species	Existing Plant Cover		
	0-30%	31-60%	>60%
autumn olive	57	93	95
black locust	75	99	none
European black alder	90	95	65
loblolly pine	63	82	none
shortleaf pine	88	79	91
Virginia pine	71	90	none

had 31-60% cover, survival averaged 89%; when the plots had existing cover greater than 60%, survival also averaged 89%. The greater the plant cover, the better the seedling survival in most cases. Competition with the seedlings from existing plant cover did not become a factor since a large percentage of the invaders did not produce a dense shade nor a dense leaf litter. The implication is that if the percentage of existing plant cover is small at the time the seedlings are planted, for orphan mines at least twelve years old, site conditions are sufficiently severe to limit seedling survival. A further observation suggests the establishment of any vegetation will aid in the survival of seedlings for areas where site conditions indicate physiological stresses. This nurse vegetation proved to assist survival to a certain point, at which the survival rate decreased again. The author's results show that point may be near 60% existing vegetative cover.

Spoil Color

Results of the spoil color summary, displayed in Table 15, show that spoil color may be an indicator of seedling survival but it will be less reliable than pH or the percentage of existing plant cover. Plots with gray spoils only, for all species, had an average seedling survival of 75%; brown spoils had an average survival of 83%; spoils with mixtures of the two colors had an average seedling survival of 81%. Planners could expect to get slightly higher seedling survival rates on brown spoils as compared to gray spoils for orphan lands where the same coal seams were present as in this research. The survival rates, however, did not show enough variation between the different colors to make spoil color a reliable indicator of seedling survival. The theory

that dark spoils absorb more solar radiation, increasing surface temperatures to the point of seedling kill is probably correct but could only be proved via the use of spoil temperature recording equipment over an extended period of time.

Table 15

Percentage of Seedling Survival for All Spoil Colors

Species	Spoil Color		
	Grays	Mixtures	Browns
autumn olive	55	58	86
black locust	80	63	95
European black alder	88	78	97
loblolly pine	89	68	60
shortleaf pine	93	87	82
Virginia pine	77	75	50

Plant Invaders

Plant invaders also may be indicators of seedling survival. This is assuming that the different invaders prefer different sets of site conditions and therefore will dominate on those plots where their preferred conditions exist. It is also assuming that seeds from many plants somehow have been transported to each plot and had the opportunity to germinate and grow.

The most common invaders found were wire grass, seen in Figure 17, the major invader on 26 plots; blackberry, seen in Figure 18, the

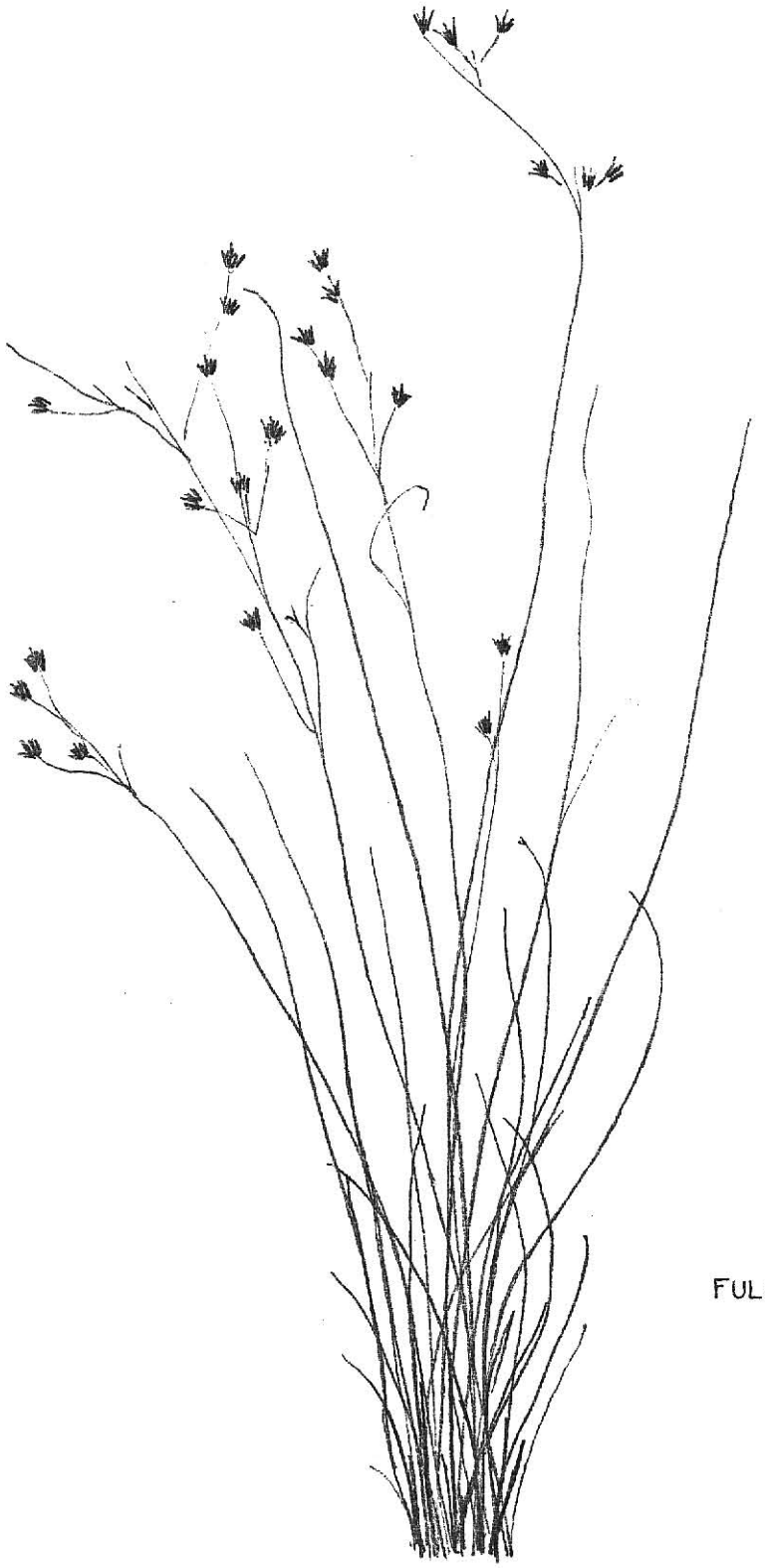

Figure 17

Wire Grass Sketch

major invader on 13 plots; and broomsedge, seen in Figure 15, the major invader on 12 plots. No invaders were found on 12 plots.

Although a wide range of survival rates was found for seedlings planted on plots with invaders, 51% to 100%, only one plant invader was associated with an unacceptable average seedling survival rate, that being 51%. This particular survival rate was for one plot only, where deertongue was the major invader on the plot. The average seedling survival rate associated with deertongue might have been higher with a larger sample, meaning more plots where deertongue was the major invader, since the next lowest seedling survival rate was 70%.

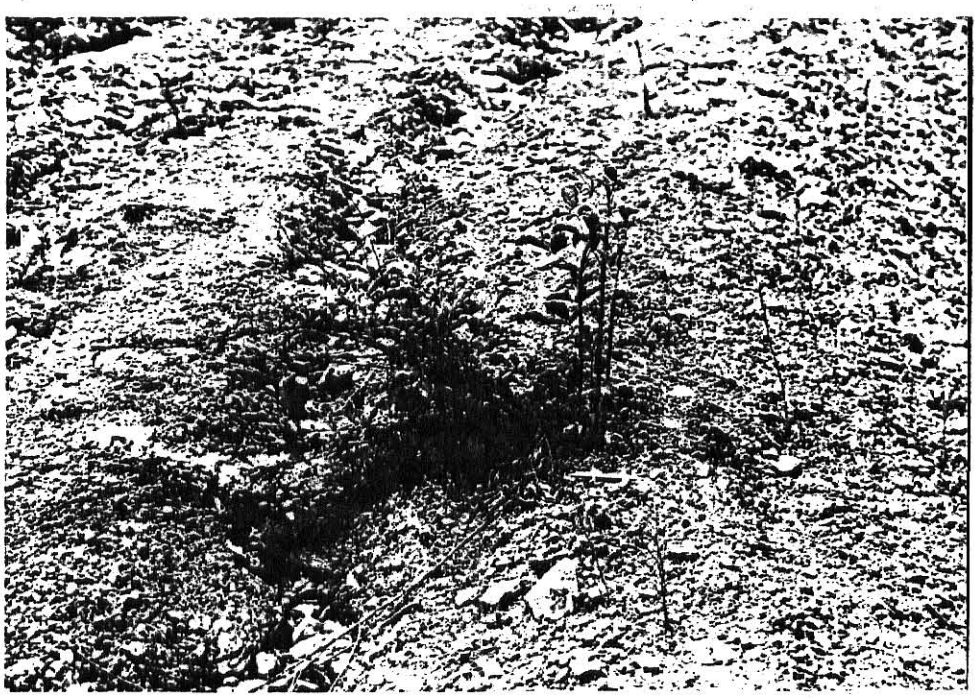

Figure 18

Blackberry, An Invader

Table 16

Percentage of Seedling Survival for
Plots With Plant Invaders

Species	Major Plant Invader*				
	wire grass	blackberry	broomsedge	Others	No Invader
autumn olive	57	65	71	80	47
black locust	83	65	97	93	69
European black alder	94	86	88	93	91
loblolly pine	85	none	34	79	none
shortleaf pine	78	none	98	93	74
Virginia pine	77	63	73	86	67

*Invaders listed were observed to be a majority of all the invaders identified on the plot.

Of the invaders with a sample of three plots or more, tall sedge and green brier results of 93% and 91% seedling survival respectively were most unexpected. The most common invaders recorded, wire grass, broomsedge, and blackberry were associated with similar average seedling survival rates of 79%, 73%, and 71% respectively for all plots where they were a majority. Survival rates for autumn olive, black locust, European black alder, loblolly pine, shortleaf pine, and Virginia pine plots with these invaders are shown in Table 16.

Without larger samples for most of the invaders the planner could make few predictions about seedling survival based on invader occurrence alone. Multiple relationships between plant invaders and combinations of other site conditions such as pH, slope, aspect, etc., should reveal much more information about predicting seedling survival, as there appears to be a strong interdependence between the site conditions.

Survival for seedlings on plots with no plant invaders averaged 69%, which is on the low end of the survival results recorded in this research. This was probably due to extreme, adverse conditions. The planner can predict relatively low survival when the plot has no invaders growing. This coincides with the results of percentage of existing plant cover, see Table 14, which showed relatively low seedling survival can be predicted when the percentage of existing plant cover found on the plot is 0-30%, again probably due to very adverse conditions at those sites.

Aspect

Results of the author's aspect summaries show this site condition to have only limited value in predicting seedling survival. The

average survival for all plots with warm south and west aspects was 78%; the average survival for plots with cool north and east aspects was 79%. As shown in Table 17, species which did best on warm aspects were black locust, 11% better than on cool aspects; autumn olive, 4% better; Virginia pine, 8% better; and loblolly pine, 47% better. Species that did best on cool aspects were European black alder, 5% better than on warm aspects; and shortleaf pine, 13% better. If the planner used a 10% survival difference as significant, then only three of the species showed a significant preference for warm or cool aspects. Black locust preferred warm south and east aspects by an 11% margin; loblolly pine preferred warm aspects by a 47% margin; and shortleaf pine preferred cool north and east aspects by a 13% margin.

Table 17

Percentage of Seedling Survival for Warm and Cool Aspects

Species	Aspects	
	warm	cool
autumn olive	63	59
black locust	84	73
European black alder	89	94
loblolly pine	82	35
shortleaf pine	77	90
Virginia pine	77	69

Slope

From the data collected, slope could not be used as a reliable predictor of seedling survival. On all plots with slopes of 0-10 degrees, seeding survival averaged 77%; on plots with slopes of 11-20 degrees, survival averaged 86%; on plots with slopes greater than 20 degrees, survival averaged 79%. Results were even more unexpected when each species was studied individually. Black locust did best on slopes greater than 20 degrees, as did European black alder, autumn olive, and shortleaf pine. Virginia pine and loblolly pine did best on slopes of 11-20 degrees. None of the species studied, encompassing six test plots or more, did best on slopes of 0-10 degrees. This was totally unexpected since it was thought that the steep slopes would be a great disadvantage to plant survival and growth. No statistical explanation was apparent. Table 18 illustrates the unexpected results and, in particular, the surprising results for European black alder and shortleaf pine, which both showed excellent adaptation to steep slopes.

Table 18

Percentage of Seedling Survival for
All Slopes

Species	Slope		
	0-10°	11-20°	>20°
autumn olive	56	none	68
black locust	68	none	81
European black alder	91	94	98
loblolly pine	60	79	none
shortleaf pine	83	91	96
Virginia pine	74	85	61

Plot Position on the Mine

Figure 19 shows the relationship of the three major mine positions: the nearly vertical highwall, in the upper portion of the photo; the relatively flat bench, in the center; and the steep outslope, in the lower center of the photo. Table 19 shows that the author's research was only partially successful in gaining data related to plot position, due in large part to T.V.A.'s policy of using particular species in a limited manner. For example, black locust was used almost exclusively on the steeper slopes when a range of slopes was available for planting, resulting in a data void for some relationships. Table 19 shows survival on the steeper mine positions was higher than on those relatively flat positions, the opposite of what had been expected. The statistical results do not illustrate a straight line relationship, making plot position on the mine an unreliable predictor of seedling survival for all of the seedlings tested as a whole.

Table 19

Percentage of Seedling Survival for
All Plot Positions on the Mine

Species	Plot Position On the Mine								
	Bench	Berm	Hollow Fill	Outslope	Highwall Toe	Adjacent to Highwall	Gully Side	Haul Road	Other
autumn olive	23	67	--	60	89	--	--	--	89
black locust	62	--	--	77	94	100	--	--	--
European black alder	93	89	80	--	100	--	98	--	92
loblolly pine	82	69	0	--	--	89	--	89	--
shortleaf pine	79	89	--	--	96	--	--	--	--
Virginia pine	87	73	56	66	--	75	--	--	78

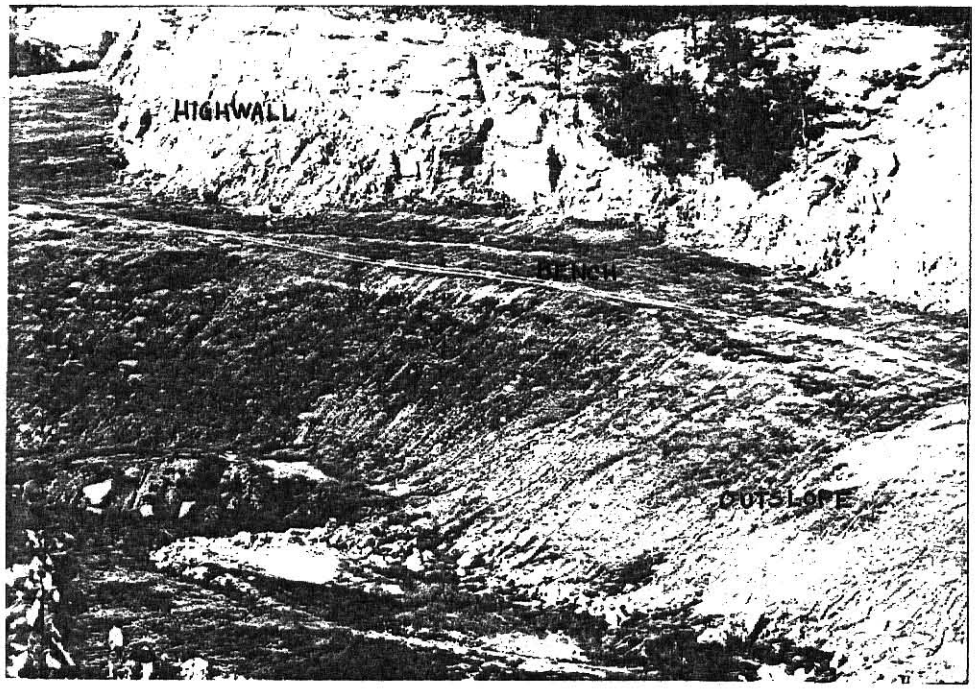

Figure 19

Landscape After Contour Mining

Degree of Erosion

Other site conditions that did not show expected results included the degree of erosion and occurrence of rock fragments. It was originally expected that severe erosion would reduce the survival rate of the planted seedlings. Results did not bear this out. Table 20 shows the degree of erosion relationships with the seedlings that had six or more test plots. Figure 20 shows that on all test plots with slight erosion, seedling survival averaged 79% and on all plots with moderate erosion, survival was 77%. However, on plots with severe erosion, seedling survival was 83%. Expectations were that the degree of erosion results would parallel the degree of slope results. In

essence the data gathered indicates the degree of erosion, as well as the degree of slope could not be used as reliable predictors of seedling survival. Because erosion is an ongoing process its effect upon seedling survival may not be apparent over the short time period of this study; however, a study completed over five to ten years would probably provide results more in line with the author's expectations.

Table 20

Percentage of Seedling Survival for All Degrees of Erosion

Species	Degree of Erosion		
	slight	moderate	severe
autumn olive	51	65	69
black locust	72	100	88
European black alder	93	95	87
loblolly pine	53	80	none
shortleaf pine	83	84	91
Virginia pine	74	74	70

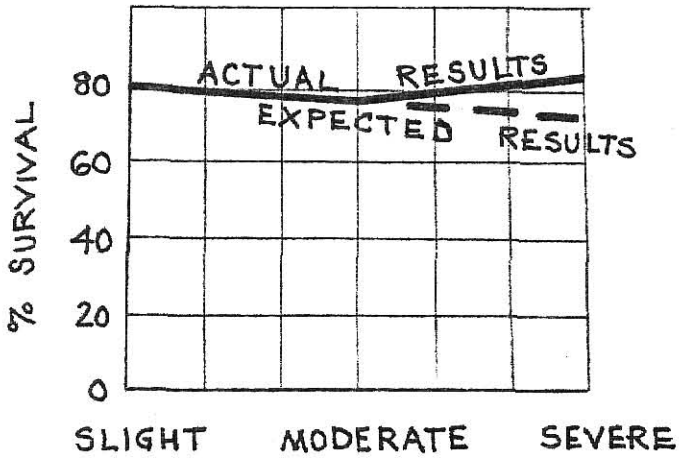

Figure 20

Degree of Erosion Results for All Plots

Rock Fragments

The summary of rock fragment occurrence, Figure 21, showed 83% seedling survival on all plots with few rock fragments and 75% survival on plots with several fragments. However, on plots with many fragments, survival averaged 79%. It was originally expected that a direct relationship would exist between seedling survival and the occurrence of rock fragments; in other words, the greater the occurrence of rock fragments the less the rate of seedling survival. Table 21 shows the relationship between the major species tested and the occurrence of rock fragments. The occurrence of rock fragments is apparently not a factor in seedling survival for the coal seams investigated in this research. This site factor obviously does play a more important role in the establishment of herbaceous vegetation where the more spoil surface covered by rock fragments, the less the percent vegetative cover that can be achieved.

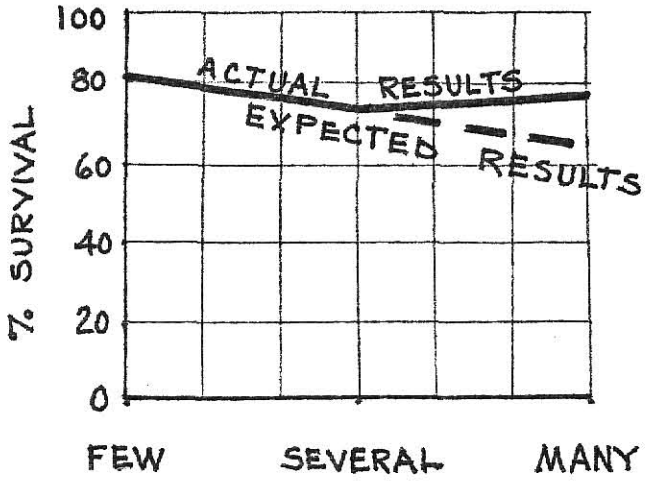

Figure 21

Occurrence of Rock Fragments for All Plots

Table 21

Percentage of Seedling Survival for
Rock Fragment Occurrence

Species	Rock Fragments		
	few	several	many
autumn olive	64	50	73
black locust	94	76	74
European black alder	94	91	90
loblolly pine	79	0	80
shortleaf pine	98	none	84
Virginia pine	79	89	60

Table 22 shows a summary of the average seedling survival for the species that were tested. Figure 22 shows a best approximation of the plant survival results obtained from this study and the studies of other authors. The curve can be used to predict approximate survival results for extended periods for the group of plants tested, as a whole. The information, from sources other than the author's research, is listed in detail in Tables 1-A and 1-B.

Table 22

Average Seedling Survival for All Tested Species

Species	Number of Seedlings Planted	Average Plot Age	Average % Seedling Survival
autumn olive	1,334	6 months	61.5
bicolor lespedeza	49	3 months	85.0
black locust	1,430	5 months	78.7
Chinese chestnut	80	3 months	96.0
European black alder	1,087	5 months	92.1
loblolly pine	338	7 months	66.3
Scotch pine	134	7 months	100
shortleaf pine	1,046	5 months	84.8
tulip poplar	33	17 months	93.0
Virginia pine	1,049	7 months	72.7
white pine	253	7 months	90.5
		Average = 5.7 months	83.7

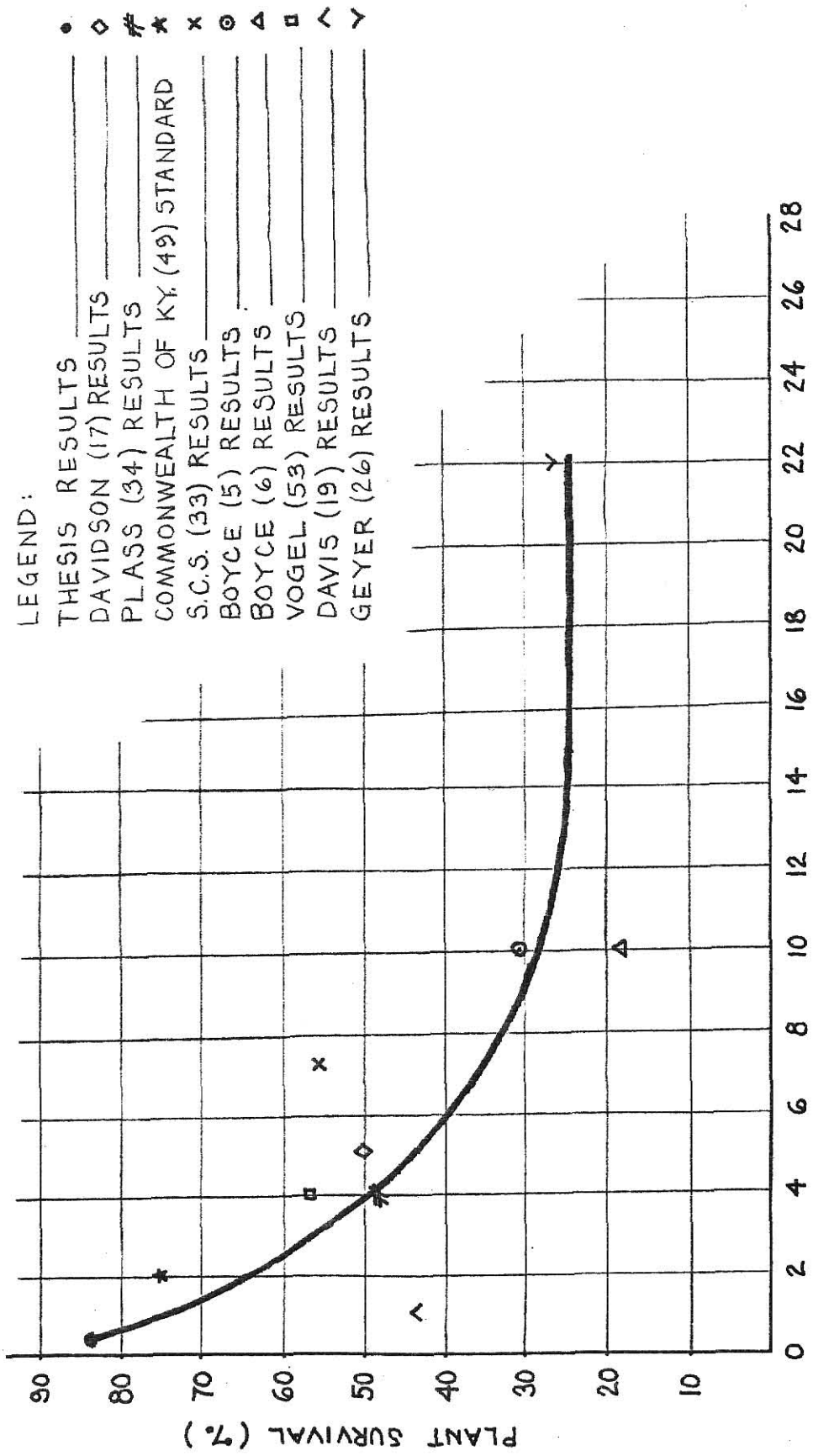

Figure 22

Plant Survival Curve for Tested Species

In order to compare the species tested against each other, in a manner related to site conditions, an arbitrary seedling survival standard of 70% was chosen as being desirable for each site condition. Using the 70% figure, each species summary was reviewed for survival on warm aspect, cool aspect, each position on the mine, slope of 0-10 degrees, slope of 11-20 degrees, slope of greater than 20 degrees, slight erosion, moderate erosion, severe erosion, few rock fragments, several rock fragments, many rock fragments, 0-30% existing plant cover, 31-60% existing plant cover, greater than 60% existing plant cover, each plant invader, plots with no invaders, gray spoils, brown spoils, mixtures of gray and brown spoils, water pH less than 4.0, water pH of 4.0-5.0, water pH greater than 5.0, buffer pH less than 5.0, buffer pH of 5.0-6.0, and buffer pH greater than 6.0.

Table 23

Seedling Tolerance to All Site Conditions

Species	Survival Standard Achieved Per Number Site Conditions Examined	Tolerance
shortleaf pine	31/31	100
European black alder	36/37	97
black locust	26/32	81
Virginia pine	25/36	69
loblolly pine	16/29	55
autumn olive	10/34	29

*Using a scale of 100, with 100 being the most tolerant

As seen in Table 23, not all the plant species were used with an equal number of site conditions. However, shortleaf pine achieved the desired standard for 31 of 31 site conditions examined; European black alder, 36 of 37; black locust, 26 of 32; Virginia pine, 25 of 36; loblolly pine, 16 of 29; and autumn olive, 10 of 34. This indicates some unexpected results. For example, autumn olive has been highly recommended in the past, yet it ranked sixth best here, and black locust, also highly recommended, ranked only third. These unexpected results may indicate that seedling survival results are somewhat altered for orphan mine lands as opposed to what has been experienced on recently mined lands.

While water pH, buffer pH, and the extent of existing vegetation on the orphan mines proved, individually, to be the most reliable indicators of seedling survival, it is obvious one factor alone cannot be used to predict seedling survival rates. Computer analysis would be most useful in determining various multiple relationships of site factors needed for more reliable predictions.

Figure 23, from the 1978 U.S.D.A. Soil Conservation Service's Environmental Impact Statement for the Rural Abandoned Mine Program, shows all counties in the United States where abandoned mine lands are located. Results of the thesis research are most applicable to those areas where contour mining has occurred, principally the Appalachian area of the eastern United States.

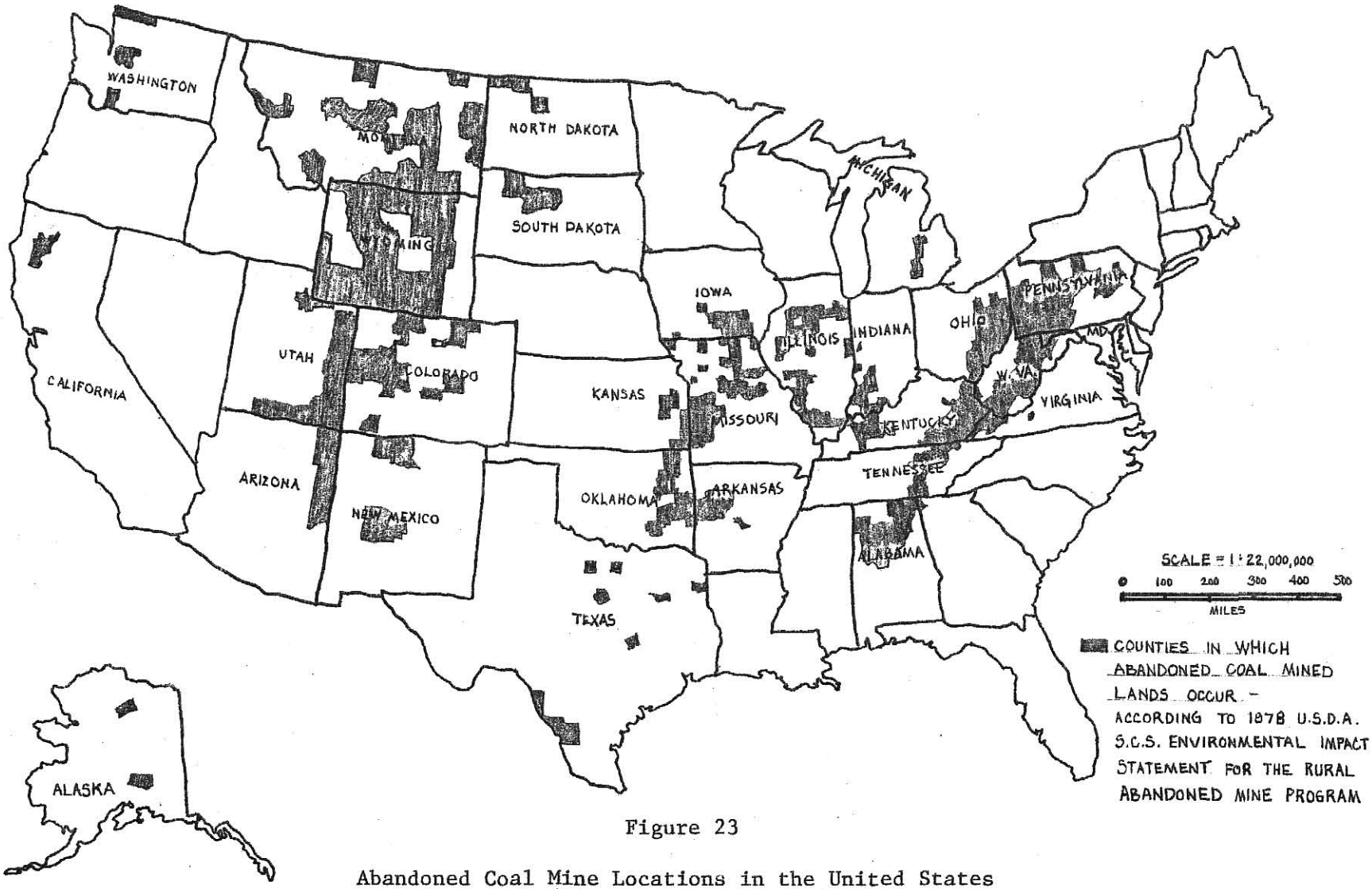

Figure 23

Abandoned Coal Mine Locations in the United States

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APPENDIX A

DEFINITIONS

1. auger bench - A horizontal bench that is wide enough to accomodate auger equipment. It is narrower than the traditional bench resulting from contour strip mining.
2. auger mining - The type of mining where a machine drills, in a closely spaced single horizontal row, into a coal seam to extract the coal. Auger mining is practiced when law prohibits normal contour strip mining because of excessive slope, because the depth of overburden is economically undesirable for mountaintop removal, or, in the past, because large enough machinery was not available to contour strip mine.
3. bench - The horizontal surface that is left after the existing earth and rock have been removed to extract the mineral. The width of the bench, regulated by state law, is determined by the slope of the premining land surface.
4. berm - A mound of spoil which has been placed on the bench after the coal has been removed. On most contour orphan mines the berm parallels the highwall and is broken occasionally by a drainageway.
5. buffer pH - A measure of the hydrogen ion concentration in relation to the cation exchange capacity. This test is run in order to get a recommendation for liming the soil or spoil to achieve a more desirable pH for a specific type of vegetation.
6. colluvium - material which has been eroded and accumulated downhill from its origin.
7. contour mining - That type of mining, predominant in mountainous terrain, where the extracting process is carried on horizontally around the hill or mountain on the same contour or elevation. There may be several separate coal seams mined at different

elevations on the same mountain, which may run continuously for several miles.

8. erosion - The natural process by which soil and rock is moved from its landform to another site. The most common cause of erosion on eastern Kentucky strip mines is the force of the raindrop striking and dislodging soil from its landform, whereupon the soil particles continue downhill, often entering a stream.
9. grasses - Plants which may be annual, biennial, or perennial in growth cycle; members of the Gramineae plant family, typically with long, narrow leaves, jointed stems, flowers in spikelets and seed-like fruit.
10. gully - The area of spoil which has been voided by erosion activity. The size of the gully is dependent upon slope, length of slope, spoil texture, intensity and duration of local rainfalls, and length of time active erosion has continued.
11. highwall - The vertical portion of the hill or mountain that is exposed above the mineral seam when the overburden is removed and not replaced.
12. hollow fill - A valley area adjacent to a hill or mountain that is filled by layers of dumped rock and earth. This process is normally used as permanent storage for excess materials from mountain-top removal.
13. invading species - Of the total plant population in a disturbed area, those which have become established naturally rather than by being planted by humans. An orphan mine may have only a few invaders, such as path rush, blackberry, or broomsedge, after many years.

14. legumes - Members of the Leguminosae plant family, which have the unique ability to fix nitrogen from soil air by action of bacteria in root nodules.

15. mountaintop removal - That type of mining, as opposed to contour mining, where the entire top of the hill or mountain is removed in order to extract the mineral to the lowest elevation economically feasible. Normally, more than one mineral seam is removed. The topographic result of this type of mining is a large, nearly level area.

16. orphan mine - For the purposes of the thesis study, any area that was strip mined for coal before 1966.

17. outslope - The slope below the bench that is a result of the mining process, whereby the overburden that was removed has been pushed downhill on top of the original ground surface.

18. overburden - The soil and rock which lies above the mineral seam. A part of this material may have been disturbed previously when a seam closer to the original soil surface was mined.

19. parent material - The type of rock from which a subsoil and soil are developed through natural climatic and geological processes. Sandstone, limestone, and shale are the major types of parent material in eastern Kentucky.

20. pH - The measure of potential chemical reaction of a soil or spoil ranging from 0 to 14, 0 being the most acidic possible and 14 the most basic possible. Every plant has a pH range within which it can grow. Knowing the pH will give the reclamationist a good idea of which plants may be successful for a particular spoil area.

21. reclamation - The act of restabilizing the land surface which has been disturbed by a mining process. This may require the installation of structures to control water, in addition to establishing vegetation which will hold the soil surface in place under normal climatic conditions.

22. regrowth timber - Woodland which has regrown after it has been cut or burned. In eastern Kentucky nearly all woodland is regrowth rather than virgin.

23. ridges - The areas of spoil between gullies which have not been completely eroded. The ridges may be as barren of vegetation as the gullies.

24. rock fragments - During the strip mining process many pieces of rock parent material, varying considerably in size, are mixed into the spoil. Some of these pieces are left on the spoil surface where they are weathered by climatic forces.

25. sediment - The soil or spoil material which has been transported as a result of erosion, usually by water action.

26. spoil - The heterogeneous mixture of topsoil, subsoil, and rock that results from upheaval and mixing during the mining process as opposed to the homogeneous soil horizons that develop in place by weathering over a long period of time.

27. subsoil - That layer or total of layers of soil found below the layer of topsoil and above the bedrock or parent material. Subsoil seldom contains significant organic matter. It does not provide a medium for plant growth equal to that of topsoil.

28. surface mining - The removal of rock, mineral, soil, earth, etc., from the earth's surface for the purpose of extracting a specific

material to process and sell. Surface mining for coal is often called strip mining.

29. undisturbed area - The area of land adjacent to the mined area that was neither removed nor filled.

30. water pH - The standard pH reading of a soil or spoil obtained by mixing the sample material at a 1:1 ratio with water; a measure of the negative log of the hydrogen ion concentration.

31. watershed - A geographical area, the boundaries of which are determined by topography which in turn determines the flow of water into a particular drainage body, such as a creek or river.

32. weathering - The breakdown of spoil material by the climatic processes of rain, wind, freeze, and thaw.

APPENDIX B

MINE LOCATIONS ON TOPOGRAPHIC MAPS

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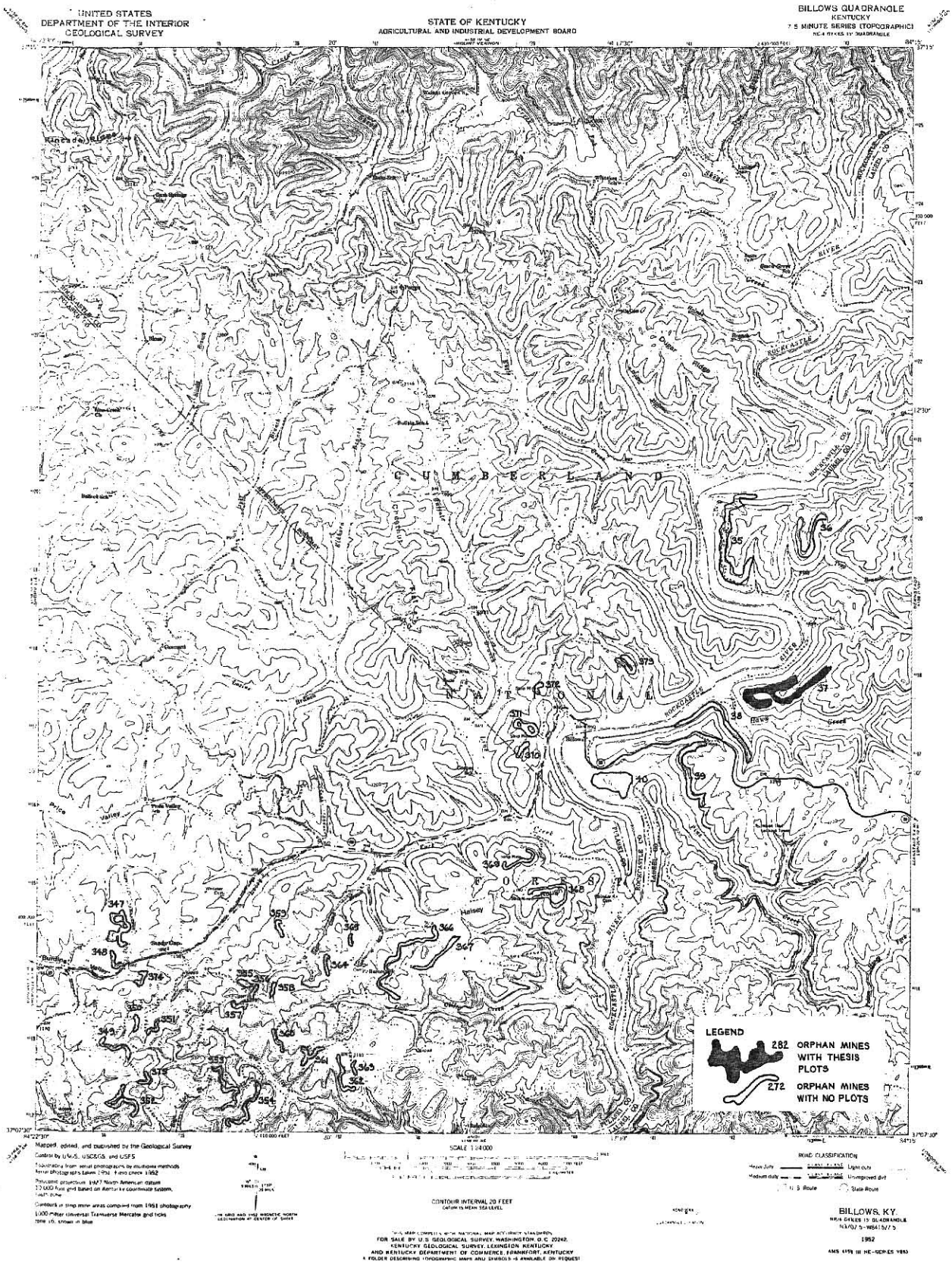
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STATE OF KENTUCKY
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BILLOWS QUADRANGLE
KENTUCKY
7.5 MINUTE SERIES (TOPOGRAPHIC)
CUMBERLAND
NATIONAL
LEGEND
282 ORPHAN MINES WITH THESIS PLOTS
272 ORPHAN MINES WITH NO PLOTS
SCALE 1:24000
CONTOUR INTERVAL 20 FEET
BILLOWS, KY.
1952

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STATE OF KENTUCKY
AGRICULTURAL AND INDUSTRIAL DEVELOPMENT BOARD
EVARTS QUADRANGLE
KENTUCKY—VIRGINIA
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LEGEND
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272 ORPHAN MINES WITH NO PLOTS
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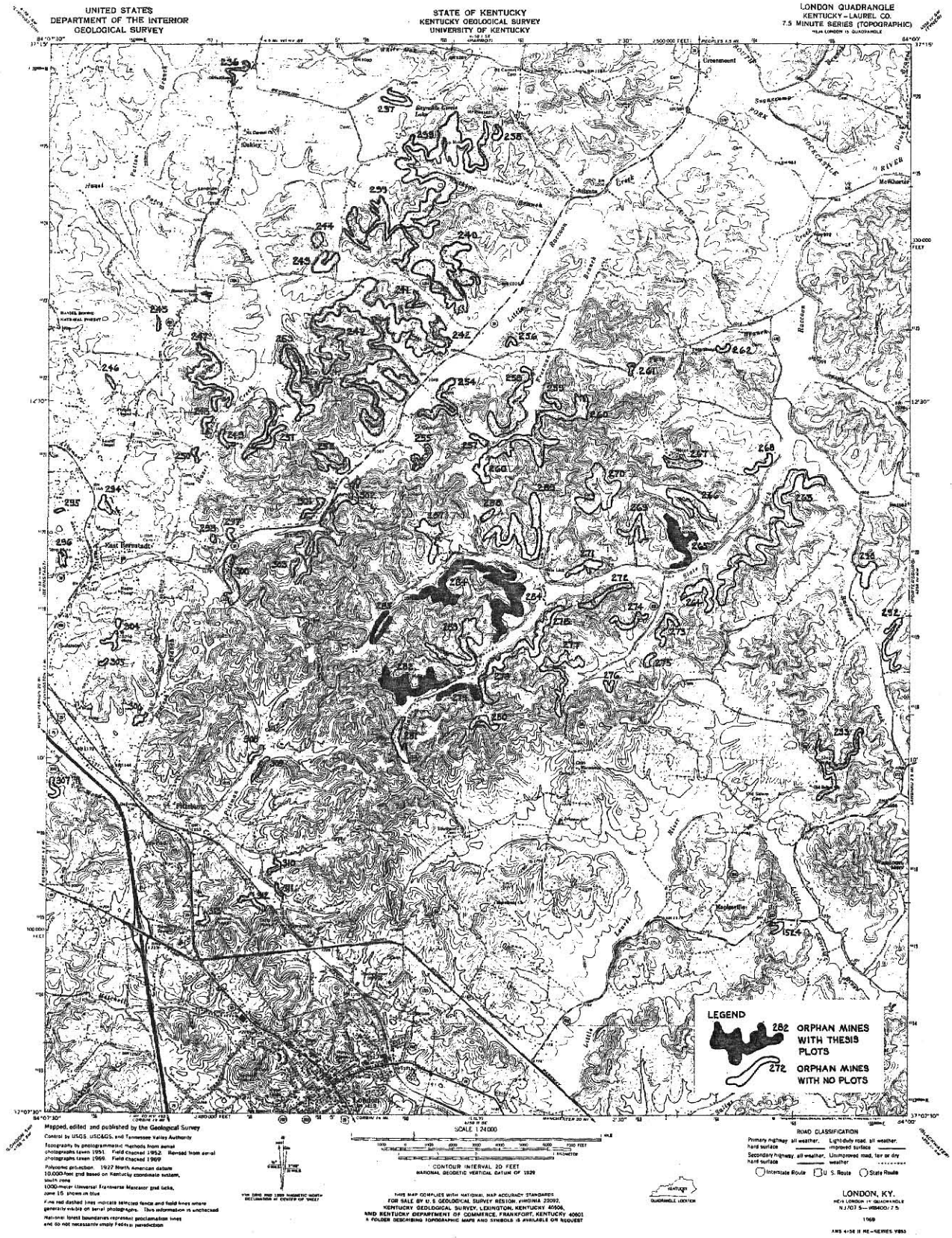
SCALE 1:24 000
CONTOUR INTERVAL 40 FEET
ROAD CLASSIFICATION
EVARTS, KY.—VA.
1954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272 ORPHAN MINES WITH NO PLOTS
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NATIONAL GEODETIC VERTICAL DATUM OF 1929
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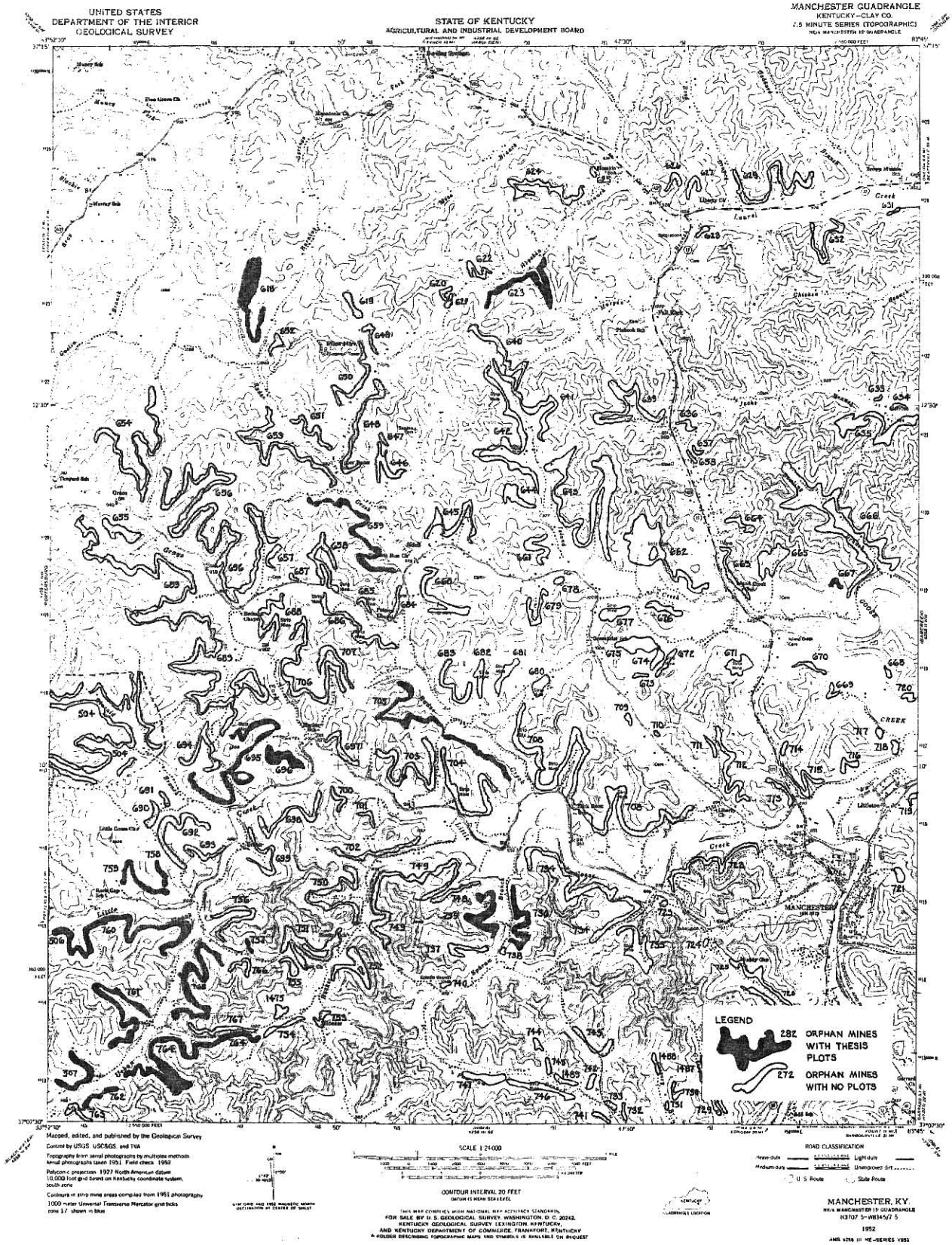
ROAD CLASSIFICATION
LONDON, KY.
1969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282 ORPHAN MINES WITH THESIS PLOTS
272 ORPHAN MINES WITH NO PLOTS
MANCHESTER
Littleton
Mapped, edited, and published by the Geological Survey
SCALE 1:24000
CONTOUR INTERVAL 20 FEET
ROAD CLASSIFICATION
MANCHESTER, KY.
1952

APPENDIX C

PLANT NAMES

	Scientific Name	Common Name	Abbreviation
A.	Evergreen Trees		
1.	*Ilex opaca*	American holly	A. holly
2.	*Juniperus virginians*	Eastern red cedar	E. r. cedar
3.	*Pinus echinata*	shortleaf pine	sh. pine
4.	*Pinus rigida*	pitch pine	p. pine
5.	*Pinus strobus*	white pine	w. pine
6.	*Pinus sylvestris*	Scotch pine	Sc. pine
7.	*Pinus taeda*	loblolly pine	l. pine
8.	*Pinus virginiana*	Virginia pine	V. pine
B.	Deciduous Trees		
1.	*Acer rubrum*	red maple	r. maple
2.	*Acer saccharum*	sugar maple	s. maple
3.	*Aesculus octandra*	yellow buckeye	y. buckeye
4.	*Ailanthus altissima*	tree of heaven	---
5.	*Alnus glutinosa*	Eureopean black alder	E. b. alder
6.	*Alnus serrulata*	native alder	n. alder
7.	*Betula lenta*	sweet birch	s. birch
8.	*Betula nigra*	river birch	r. birch
9.	*Carya cordiformis*	bitternut hickory	b. hickory
10.	*Carya glabra*	pignut hickory	p. hickory
11.	*Carya lacinosa*	shellbark hickory	sh. hickory
12.	*Carya ovata*	shagbark hickory	sg. hickory
13.	*Carya tomentosa*	mockernut hickory	m. hickory
14.	*Castanea mollissima*	Chinese chestnut	C. chestnut
15.	*Cercis canadensis*	Eastern redbud	E. redbud

16.	*Cornus florida*	flowering dogwood	f. dogwood
17.	*Fagus grandifolia*	American beech	A. beech
18.	*Fraxinus americana*	white ash	w. ash
19.	*Fraxinus pennsylvanica*	green ash	g. ash
20.	*Liquidambar styraciflua*	sweet gum	s. gum
21.	*Liriodendron tulipifera*	tulip poplar	t. poplar
22.	*Magnolia tripetala*	umbrella magnolia	u. magnolia
23.	*Malus pumila*	native apple	n. apple
24.	*Nyssa sylvatica*	black gum	b. gum
25.	*Oxydendrum arboreum*	sourwood	---
26.	*Paulownia tomentosa*	royal paulownia	r. paulownia
27.	*Platanus occidentalis*	sycamore	---
28.	*Populus deltoides*	cottonwood	---
29.	*Populus species x*	hybrid poplar	h. poplar
30.	*Prunus serotina*	black cherry	b. cherry
31.	*Quercus alba*	white oak	w. oak
32.	*Quercus coccinea*	scarlet oak	s. oak
33.	*Quercus muehlenbergii*	chinkapin oak	ck. oak
34.	*Quercus palustris*	pin oak	pn. oak
35.	*Quercus prinus*	chestnut oak	cs. oak
36.	*Quercus rubra*	Northern red oak	N. r. oak
37.	*Quercus stellata*	post oak	pt. oak
38.	*Quercus velutina*	black oak	b. oak
39.	*Robinia pseudoacacia*	black locust	b. locust
40.	*Salix nigra*	black willow	b. willow
41.	*Sassafras albidum*	sassafras	---
42.	*Tilia americana*	American linden	A. linden

43.	Ulmus americana	American elm	A. elm
44.	Ulmus rubra	slippery elm	s. elm

C. Deciduous Shrubs and Vines

1.	Elaeagnus umbellata	autumn olive	a. olive
2.	Kalmia latifolia	mountain laurel	m. laurel
3.	Lespedeza bicolor	bicolor lespedeza	b. lespedeza
4.	Lonicera japonica	honeysuckle	---
5.	Rhus copallina	shining sumac	sh. sumac
6.	Rhus typhina	staghorn sumac	st. sumac
7.	Rosa multiflora	multiflora rose	m. rose
8.	Rubus allegheniensis	blackberry	---
9.	Rubus hispidus	dewberry	---
10.	Smilax species	green brier	g. brier

D. Grasses and Legumes

1.	Andropogon virginicus	broomsedge	---
2.	Coronilla varia	crownvetch	---
3.	Dactylis glomerata	orchard grass	o. grass
4.	Digitaria species	crabgrass	---
5.	Eragrostis curvula	weeping lovegrass	w. lovegrass
6.	Erianthus species	plume grass	p. grass
7.	Festuca arundinacea "Ky. 31"	Kentucky 31 tall fescue	K. 31 t. fescue
8.	Lespedeza cuneata	sericea lespedeza	s. lespedeza
9.	Lespedeza stipulacea	Korean lespedeza	Kr. lespedeza
10.	Lespedeza striata	kobe lespedeza	kb. lespedeza
11.	Panicum clandestinum	deertongue	---

E. Other Herbaceous Species

1.	Bryophyte - unidentified	ground moss	g. moss
2.	*Calonida rangifera*	lichens	---
3.	*Cirsium arvense*	Canadian thistle	C. thistle
4.	*Cyperus esculentus*	saw grass	s. grass
5.	*Dipsacus sylvestris*	teasel	---
6.	*Fragaria virginiana*	wild strawberry	w. strawberry
7.	*Juncus tenuis*	wire grass or path rush	w. grass
8.	*Phytolacco americana*	pokeberry	---
9.	*Polystichum ocrostichoides*	Christmas fern	C. fern
10.	*Rhus radicans*	poison ivy	p. ivy
11.	*Rumex acetosella*	sheep sorrel	s. sorrel
12.	*Scirpus pedicellatus*	tall sedge or wool grass	t. sedge
13.	*Scirpus polyphyllus*	short sedge or bulrush	s. sedge
14.	*Solidago species*	goldenrod	---
15.	*Spirea tomentosa*	steeplebush	---
16.	*Typha latifolia*	cattail	---
17.	*Veronia altissima*	ironweed	---

APPENDIX D

PLOT DATA SHEETS

THESIS PLOT DATA

Plant name, common autumn olive

Plant name, scientific *Elaeagnus umbellata*

Mine no. 0002 - A Site recon. no. 282

State: Ky. County: Laurel Subwatershed: Slate Lick Creek

Coal seam name Lily Approx. elevation MSL 1200

Last known mining disturbance 1955 - 1958

Plot aspect southeast Plot slope in degrees 35

Plot size 50' x 30'

Original planting date 3/16/77

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 55

Number of plants living at 5/30/78 was 36 = 65 %

Spoil pH from lab test: water 4.5 buffer 5.9

Plot location outslope

Spoil color light gray

Rock fragments few to 3" D.

Parent material of surface spoil majority is shale

Degree of erosion no gullies visible within plot

Existing vegetation: % cover 20 description blackberry, V. pine

Vegetation of adjacent areas b. gum, g. ash, b. cherry, n.r. oak, sycamore, r. maple, t. poplar, V. pine, cattails, sh. sumac

THESIS PLOT DATA

Plant name, common black locust

Plant name, scientific *Robinia pseudoacacia*

Mine no. 0002 - A Site recon. no. 282

State: Ky. County: Laurel Subwatershed: Slate Lick Creek

Coal seam name Lily Approx. elevation MSL 1200

Last known mining disturbance 1955 - 1958

Plot aspect southeast Plot slope in degrees 0 - 6

Plot size 55' x 25'

Original planting date 12/5/77

Seedlings at time of planting: size 8 - 16" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 52

Number of plants living at 5/30/78 was 30 = 57 %

Spoil pH from lab test: water 3.1 buffer 4.6

Plot location top of fill located between county road and creek

Spoil color dark gray

Rock fragments many small fragments to 4" D.

Parent material of surface spoil majority is shale

Degree of erosion no current gullying seen

Existing vegetation: % cover 0 - 5 description small grasses only

Vegetation of adjacent areas n.r. oak, sycamore, g. ash, r. maple, t. poplar, V. pine, cattails, sh. sumac

THESIS PLOT DATA

Plant name, common European black alder

Plant name, scientific *Alnus glutinosa*

Mine no. 0002 - A Site recon. no. 282

State: Ky. County: Laurel Subwatershed: Slate Lick Creek

Coal seam name Lily Approx. elevation MSL 1200

Last known mining disturbance 1955 - 1958

Plot aspect southeast Plot slope in degrees 0 - 6

Plot size 55' x 25'

Original planting date 12/16/77

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 57

Number of plants living at 5/30/78 was 46 = 80 %

Spoil pH from lab test: water 2.7 buffer 4.4

Plot location top of fill located between county road and creek

Spoil color dark gray

Rock fragments many small fragments to 4" D.

Parent material of surface spoil majority is shale, some reject coal

Degree of erosion no gullies seen

Existing vegetation: % cover 0 - 5 description w. grass

Vegetation of adjacent areas n.r. oak, sycamore, r. maple, t. poplar, w. ash, V. pine, cattails, sh. sumac

THESIS PLOT DATA

Plant name, common black locust

Plant name, scientific *Robinia pseudoacacia*

Mine no. 0003 - B Site recon. no. 284

State: Ky. County: Laurel Subwatershed: Slate Lick Creek

Coal seam name Lily Approx. elevation MSL 1200

Last known mining disturbance 1955 - 1958

Plot aspect south Plot slope in degrees 0 - 3

Plot size 40' x 30'

Original planting date 3/17/77

Seedlings at time of planting: size 8 - 16" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 56

Number of plants living at 6/30/77 was 45 = 80 %

Spoil pH from lab test: water 4.3 buffer 5.0

Plot location flat section on outslope

Spoil color dark gray

Rock fragments several fragments to 3" D.

Parent material of surface spoil majority is shale

Degree of erosion severely eroded

Existing vegetation: % cover 10 description few V. pine and green brier

Vegetation of adjacent areas V. pine, t. poplar, blackberry, goldenrod

THESIS PLOT DATA

Plant name, common black locust

Plant name, scientific *Robinia pseudoacacia*

Mine no. 0003 - C Site recon. no. 284

State: Ky. County: Laurel Subwatershed: Slate Lick Creek

Coal seam name Lily Approx. elevation MSL 1200

Last known mining disturbance 1955 - 1958

Plot aspect north Plot slope in degrees 4

Plot size 40' x 20'

Original planting date 4/5/77

Seedlings at time of planting: size 8 - 16" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 52

Number of plants living at 6/30/77 was 35 = 67 %

Spoil pH from lab test: water 3.9 buffer 5.3

Plot location bench

Spoil color varies from light to dark gray

Rock fragments several to 4" D.

Parent material of surface spoil majority is shale

Degree of erosion no current gullies visible

Existing vegetation: % cover 0 - 5 description blackberry

Vegetation of adjacent areas V. pine, deertongue, blackberry, r. maple

THESIS PLOT DATA

Plant name, common tulip poplar

Plant name, scientific *Liriodendron tulipifera*

Mine no. 0004 - A Site recon. no. 265

State: Ky. County: Laurel Subwatershed: Slate Lick Creek

Coal seam name Lily Approx. elevation MSL 1200

Last known mining disturbance 1955 - 1958

Plot aspect northeast Plot slope in degrees 8

Plot size 40' x 40'

Original planting date 12/28/76

Seedlings at time of planting: size 6 - 16" age in years 1

Approximate spacing 8' x 8'

Original number of plants within plot 33

Number of plants living at 5/30/78 was 31 = 93 %

Spoil pH from lab test: water 4.9 buffer 6.1

Plot location base of outslope

Spoil color light gray to light brown

Rock fragments few fragments to 4" D.

Parent material of surface spoil majority is shale

Degree of erosion slight; no current gullies seen

Existing vegetation: % cover 20 description w. grass

Vegetation of adjacent areas sycamore, n.r. oak, b. willow, t. poplar, e. redbud

THESIS PLOT DATA

Plant name, common Virginia pine

Plant name, scientific *Pinus virginiana*

Mine no. 0004 - A Site recon. no. 265

State: Ky. County: Laurel Subwatershed: Slate Lick Creek

Coal seam name Lily Approx. elevation MSL 1200

Last known mining disturbance 1955 - 1958

Plot aspect northeast Plot slope in degrees 0 - 5

Plot size 70' x 20'

Original planting date 4/1/77

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 66

Number of plants living at 5/30/78 was 57 = 86 %

Spoil pH from lab test: water 4.4 buffer 5.5

Plot location berm

Spoil color light gray

Rock fragments several fragments to 3" D.

Parent material of surface spoil majority is shale

Degree of erosion no gullies seen

Existing vegetation: % cover 30 description sh. sumac, greenbrier, broomsedge, V. pine, f. dogwood, b. cherry

Vegetation of adjacent areas t. poplar, r. maple, sycamore, blackberry

THESIS PLOT DATA

Plant name, common Virginia pine

Plant name, scientific *Pinus virginiana*

Mine no. 0004 - A Site recon. no. 265

State: Ky. County: Laurel Subwatershed: Slate Lick Creek

Coal seam name Lily Approx. elevation MSL 1200

Last known mining disturbance 1955 - 1958

Plot aspect northeast Plot slope in degrees 20

Plot size 55' x 25'

Original planting date 3/24/77

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 68

Number of plants living at 5/30/78 was 64 = 94 %

Spoil pH from lab test: water 4.7 buffer 6.1

Plot location outslope

Spoil color light gray

Rock fragments several light brown fragments to 4" D.

Parent material of surface spoil majority is shale; some sandstone

Degree of erosion moderate; several gullies to 1' deep and 3' wide through entire length of plot

Existing vegetation: % cover 10 description V. pine to 6', green briers, blackberry, broomsedge

Vegetation of adjacent areas sycamore, b. willow, r. maple, f. dogwood, V. pine, blackberry

THESIS PLOT DATA

Plant name, common Virginia pine

Plant name, scientific *Pinus virginiana*

Mine no. 0004 - A Site recon. no. 265

State: Ky. County: Laurel Subwatershed: Slate Lick Creek

Coal seam name Lily Approx. elevation MSL 1200

Last known mining disturbance 1955 - 1958

Plot aspect northeast Plot slope in degrees 30

Plot size 40' x 40'

Original planting date 4/1/77

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 32

Number of plants living at 6/1/77 was 29 = 90 %

Spoil pH from lab test: water 4.8 buffer 6.2

Plot location outslope

Spoil color light gray

Rock fragments several fragments to 5" D.

Parent material of surface spoil majority is shale

Degree of erosion severe erosion

Existing vegetation: % cover 35 description blackberry, goldenrod, sh. sumac

Vegetation of adjacent areas blackberry, goldenrod, t. poplar, V. pine, sh. sumac, t. poplar, sycamore, s. lespedeza

THESIS PLOT DATA

Plant name, common black locust

Plant name, scientific *Robinia pseudoacacia*

Mine no. 0006 - A Site recon. no. 765

State: Ky. County: Clay Subwatershed: Urban Fork

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1953 - 1958

Plot aspect northeast Plot slope in degrees 27

Plot size 40' x 30'

Original planting date 3/28/78

Seedlings at time of planting: size 8 - 16" age in years 1

Approximate spacing 3' x 3'

Original number of plants within plot 95

Number of plants living at 5/26/78 was 46 = 48 %

Spoil pH from lab test: water 4.1 buffer 5.4

Plot location top of outslope

Spoil color light gray

Rock fragments many fragments to 12" D.

Parent material of surface spoil majority is shale

Degree of erosion severely eroded with 2 gullies 1' deep & 3' wide;

plot bordered on 1 side by a gully to 4' deep

Existing vegetation: % cover 0 - 5 description blackberry, w. grass

Vegetation of adjacent areas 1. pine to 75', broomsedge, w. grass

THESIS PLOT DATA

Plant name, common loblolly pine

Plant name, scientific *Pinus taeda*

Mine no. 0006 - A Site recon. no. 765

State: Ky. County: Clay Subwatershed: Urban Fork

Coal seam name Horse Creek Approx. elevation MSL 1100-1150

Last known mining disturbance 1953 - 1958

Plot aspect northeast Plot slope in degrees 6

Plot size 60' x 20'

Original planting date 12/9/77

Seedlings at time of planting: size 6 - 14" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 50

Number of plants living at 5/26/78 was 0 = 0 %

Spoil pH from lab test: water 3.7 buffer 5.2

Plot location hollow fill

Spoil color light brown

Rock fragments several fragments to 4" D.

Parent material of surface spoil majority is shale, some sandstone

Degree of erosion slight, no gullies within plot

Existing vegetation: % cover 5 description broomsedge, s. sedge

Vegetation of adjacent areas t. poplar, w. oak to 30', b. oak, sg. hickory

THESIS PLOT DATA

Plant name, common loblolly pine

Plant name, scientific *Pinus taeda*

Mine no. 0006 - A Site recon. no. 765

State: Ky. County: Clay Subwatershed: Urban Fork

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1953 - 1958

Plot aspect west Plot slope in degrees 0 - 8

Plot size 80' x 25'

Original planting date 12/9/77

Seedlings at time of planting: size 6 - 14" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 64

Number of plants living at 5/26/78 was 57 = 89 %

Spoil pH from lab test: water 4.9 buffer 6.1

Plot location haul road between 2 mines

Spoil color medium gray

Rock fragments few fragments to 4" D.

Parent material of surface spoil majority is shale

Degree of erosion slight; no gullies visible

Existing vegetation: % cover 0 - 5 description w. grass

Vegetation of adjacent areas sassafras, r. maple to 20', st. sumac, b. cherry, w. oak to 30', s. oak, p. hickory, b. oak

THESIS PLOT DATA

Plant name, common bicolor lespedeza

Plant name, scientific *Lespedeza bicolor*

Mine no. 0006 - C Site recon. no. 765

State: Ky. County: Clay Subwatershed: Urban Fork

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1953 - 1958

Plot aspect west Plot slope in degrees 1

Plot size 40' x 25'

Original planting date 4/15/77

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 49

Number of plants living at 6/30/77 was 42 = 85 %

Spoil pH from lab test: water 4.0 buffer 5.8

Plot location bench

Spoil color light gray

Rock fragments none

Parent material of surface spoil shale

Degree of *erosion* no current gullies visible

Existing vegetation: % cover 5 description broomsedge, blackberry

Vegetation of adjacent areas V. pine, sh. pine, blackberry, m. hickory, n.r. oak, t. poplar

THESIS PLOT DATA

Plant name, common black locust

Plant name, scientific *Robinia pseudoacacia*

Mine no. 0006 - C Site recon. no. 765

State: Ky. County: Clay Subwatershed: Urban Fork

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1953 - 1958

Plot aspect southwest Plot slope in degrees 32

Plot size 40' x 40'

Original planting date 4/22/77

Seedlings at time of planting: size 8 - 16" age in years 1

Approximate spacing 3' x 3'

Original number of plants within plot 143

Number of plants living at 6/30/77 was 143 = 100 %

Spoil pH from lab test: water 4.1 buffer 5.1

Plot location top of outslope

Spoil color dark gray

Rock fragments several fragments 1 to 24" D.

Parent material of surface spoil majority is shale

Degree of erosion severely eroded with gullies to 3' deep formed approximately every 10' across plot

Existing vegetation: % cover 10 description broomsedge, w. grass, blackberry

Vegetation of adjacent areas w. oak, s. oak, b. oak, t. poplar, r. maple, p. hickory, l. pine, V. pine, broomsedge, blackberry

THESIS PLOT DATA

Plant name, common autumn olive

Plant name, scientific *Elaeagnus umbellata*

Mine no. 0009 - A Site recon. no. 279

State: Ky. County: Laurel Subwatershed: Slate Lick Creek

Coal seam name Lily Approx. elevation MSL 1200

Last known mining disturbance 1955 - 1958

Plot aspect north Plot slope in degrees 0 - 2

Plot size 40' x 30'

Original planting date 3/14/77

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 39

Number of plants living at 6/1/77 was 7 = 17 %

Spoil pH from lab test: water 3.3 buffer 4.7

Plot location fill area between road and mine

Spoil color dark gray to black

Rock fragments several fragments to 6" D.

Parent material of surface spoil majority is shale

Degree of erosion no current gullying visible

Existing vegetation: % cover 0 - 5 description small grasses only

Vegetation of adjacent areas V. pine, t. poplar, r. maple, cattails, sycamore

THESIS PLOT DATA

Plant name, common autumn olive

Plant name, scientific *Elaeagnus umbellata*

Mine no. 0014 - A Site recon. no. 736

State: Ky. County: Clay Subwatershed: Little Goose below Urban

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1955 - 1962

Plot aspect south Plot slope in degrees 2 - 10

Plot size 75' x 35'

Original planting date 4/21/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 91

Number of plants living at 10/18/78 was 85 = 93 %

Spoil pH from lab test: water 4.6 buffer 5.7

Plot location berm

Spoil color light gray and light brown

Rock fragments few to 4" D.

Parent material of surface spoil shale majority

Degree of erosion moderate; several old gullies to 3' deep and 10' wide stabilizing now

Existing vegetation: % cover 50 description sourwood to 4', g. brier, w. grass majority, broomsedge, steeplebush, blackberry to 3'

Vegetation of adjacent areas V. pine to 15', sassafras to 15', b. oak to 15', n.r. oak to 50', f. dogwood to 10', r. maple to 20', sycamore to 20', s. birch to 3', p. hickory to 60', e. redbud to 6', broomsedge, cattails, steeplebush, goldenrod, g. brier, ironweed

THESIS PLOT DATA

Plant name, common autumn olive

Plant name, scientific *Elaeagnus umbellata*

Mine no. 0014 - A Site recon. no. 736

State: Ky. County: Clay Subwatershed: Little Goose below Urban

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1955 - 1962

Plot aspect west Plot slope in degrees 3

Plot size 70' x 25'

Original planting date 4/21/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 8' x 8'

Original number of plants within plot 49

Number of plants living at 10/18/78 was 37 = 75 %

Spoil pH from lab test: water 3.7 buffer 4.7

Plot location berm

Spoil color medium brown

Rock fragments many to 6" D.

Parent material of surface spoil shale majority; some sandstone

Degree of erosion moderate; no gullies present but much unevenness to the surface

Existing vegetation: % cover 30 description 1 b. oak to 4', blackberry, broomsedge, w. grass majority

Vegetation of adjacent areas n.r. oak to 60', sourwood to 20', sycamore to 50', A. beech to 30', w. oak to 30', b. cherry to 25', V. pine to 5', r. maple to 5', E. r. cedar to 1', f. dogwood to 5', blackberry, ironweed, pokeberry, t. sedge

THESIS PLOT DATA

Plant name, common European black alder

Plant name, scientific *Alnus glutinosa*

Mine no. 0014 - A Site recon. no. 736

State: Ky. County: Clay Subwatershed: Little Goose below Urban

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1955 - 1962

Plot aspect south Plot slope in degrees 5

Plot size 90' x 20'

Original planting date 4/21/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 80

Number of plants living at 10/18/78 was 69 = 86 %

Spoil pH from lab test: water 4.1 buffer 5.4

Plot location berm

Spoil color light gray

Rock fragments many to 4" D.

Parent material of surface spoil shale majority

Degree of erosion severe; 2 gullies run through the plot to 3' deep & 6' wide

Existing vegetation: % cover 0 - 5 description blackberry majority, broomsedge

Vegetation of adjacent areas sassafras to 15', V. pine to 15', b. oak to 15', n.r. oak to 50', f. dogwood to 10', r. maple to 20', sycamore to 20', r. birch to 3', broomsedge to 3', cattails, steeplebush, goldenrod, g. brier, ironweed to 6'

THESIS PLOT DATA

Plant name, common shortleaf pine

Plant name, scientific *Pinus echinata*

Mine no. 0014 - A Site recon. no. 736

State: Ky. County: Clay Subwatershed: Little Goose below Urban

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1955 - 1962

Plot aspect southeast Plot slope in degrees 1 - 5

Plot size 60' x 35'

Original planting date 4/21/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 69

Number of plants living at 10/18/78 was 60 = 86 %

Spoil pH from lab test: water 4.5 buffer 6.1

Plot location bench

Spoil color light brown

Rock fragments many to 4" D.

Parent material of surface spoil shale majority

Degree of erosion moderate; no gullies present

Existing vegetation: % cover 50 description goldenrod to 3', blackberry to 3', broomsedge to 3', w. grass majority, sourwood to 1', V. pine to 4'

Vegetation of adjacent areas V. pine to 15', sassafras to 15', b. oak to 15', n.r. oak to 50', f. dogwood to 10', r. maple to 20', sycamore to 20', s. birch to 3', p. hickory to 60', e. redbud to 6', broomsedge, cattails, steeplebush, goldenrod, g. brier, ironweed

THESIS PLOT DATA

Plant name, common autumn olive

Plant name, scientific *Elaeagnus umbellata*

Mine no. 0016 - A Site recon. no. 739

State: Ky. County: Clay Subwatershed: Little Goose

Coal seam name Horse Creek Approx. elevation MSL 1100-1150

Last known mining disturbance 1955 - 1962

Plot aspect northeast Plot slope in degrees 32

Plot size 85' x 20'

Original planting date 4/25/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 5' x 5'

Original number of plants within plot 98

Number of plants living at 10/18/78 was 88 = 89 %

Spoil pH from lab test: water 3.8 buffer 4.6

Plot location side of berm (next to highwall)

Spoil color medium gray

Rock fragments several to 3" D.

Parent material of surface spoil shale majority

Degree of erosion moderate; several gullies formed to 6" deep & 2' wide

Existing vegetation: % cover 20 description b. oak to 10', deertongue to 2', blackberry, w. grass, broomsedge majority

Vegetation of adjacent areas n.r. oak to 60', V. pine to 30', s. oak to 40', w. oak to 30', b. gum to 15', sh. pine to 20', t. sedge to 3', blackberry to 3', broomsedge, pokeberry

THESIS PLOT DATA

Plant name, common European black alder

Plant name, scientific *Alnus glutinosa*

Mine no. 0019 - A Site recon. no. 758

State: Ky. County: Clay Subwatershed: Little Goose

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1955 - 1962

Plot aspect east Plot slope in degrees 0 - 18

Plot size 60' x 30'

Original planting date 4/14/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 3' x 3'

Original number of plants within plot 192

Number of plants living at 8/10/78 was 181 = 94 %

Spoil pH from lab test: water 3.9 buffer 5.3

Plot location bench

Spoil color light gray to light brown

Rock fragments varies from 1 - 12" D. coal

Parent material of surface spoil shale and sandstone

Degree of erosion No gullies visible. All surface material is sediment eroded from highwall and fill bench into pit.

Existing vegetation: % cover 25 description t. sedge to 3' are majority; few s. sedge to 12"; many blackberry to 4' on highwall side out of water

Vegetation of adjacent areas *a few ironweed and* s. lespedeza, sh. and V. pine to 25', r. maple to 15', b. gum to 10', m. hickory to 40', w. oak to 35', t. poplar to 5', b. locust to 20'

THESIS PLOT DATA

Plant name, common European black alder

Plant name, scientific *Alnus glutinosa*

Mine no. 0019 - A Site recon. no. 758

State: Ky. County: Clay Subwatershed: Little Goose

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1955 - 1962

Plot aspect northeast Plot slope in degrees 28

Plot size 70' x 15'

Original planting date 4/14/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 3' x 3'

Original number of plants within plot 83

Number of plants living at 8/10/78 was 82 = 98 %

Spoil pH from lab test: water 4.1 buffer 5.3

Plot location side of gully eroded through fill bench

Spoil color light brown with black fragments

Rock fragments many fragments 1 - 12" D, both coal and brown shale

Parent material of surface spoil shale

Degree of erosion plot has several small gullies currently eroding from 3 - 12" deep and 6 - 24" wide; much material eroding from above

Existing vegetation: % cover 30 description short 3" w. grass majority; also g. brier to 2', pokeberry to 3', 1 multiflora rose to 1'.

Vegetation of adjacent areas ironweed, s. lespedeza, sh. pine, V. pine to 25', r. maple to 15', b. gum to 10', m. hickory to 40', w. oak to 35', t. poplar to 5', b. locust to 20'

THESIS PLOT DATA

Plant name, common European black alder

Plant name, scientific *Alnus glutinosa*

Mine no. 0021 - B Site recon. no. 506

State: Ky. County: Clay Subwatershed: Little Goose

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1955 - 1962

Plot aspect southeast Plot slope in degrees 2

Plot size 100' x 20'

Original planting date 4/7/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 50

Number of plants living at 8/25/78 was 50 = 100 %

Spoil pH from lab test: water 4.0 buffer 5.3

Plot location bench

Spoil color light brown

Rock fragments many small 1 - 4" D.; some coal fragments

Parent material of surface spoil shale majority

Degree of erosion only slightly eroded; bench has been filled with sediment to 3' deep; 1 gully to 1' deep and 3' wide

Existing vegetation: % cover 60 description w. strawberry, deertongue to 1', sh. sumac to 5', t. sedge to 4', ironweed to 5', majority is w. grass to 8", blackberry to 3', t. poplar to 3'

Vegetation of adjacent areas g. brier, blackberry, l., sh., V. pine to 35', deertongue, goldenrod, sassafras to 6', f. dogwood to 10', p. hickory to 35', n.r. oak to 50', r. maple to 25', sycamore to 40'

THESIS PLOT DATA

Plant name, common shortleaf pine

Plant name, scientific *Pinus echinata*

Mine no. 0021 - B Site recon. no. 506

State: Ky. County: Clay Subwatershed: Little Goose

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1955 - 1962

Plot aspect east Plot slope in degrees 1

Plot size 120' x 35'

Original planting date 4/7/78

Seedlings at time of planting: size 6 - 14" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 120

Number of plants living at 8/25/78 was 72 = 60 %

Spoil pH from lab test: water 3.6 buffer 4.9

Plot location top of fill berm

Spoil color mixed - light gray to light brown

Rock fragments many small 1 - 4" D., mostly shale and coal

Parent material of surface spoil mostly shale

Degree of erosion moderate; some gullies formed on slopes of plot from 6" to 3' deep and 1' to 5' wide

Existing vegetation: % cover 0 description

Vegetation of adjacent areas V. pine to 8', ironweed to 5', sycamore to 20', t. sedge to 3', p. hickory to 45', sh. pine to 20', cottonwood to 55', t. poplar to 40', n.r. oak to 60', sassafras to 10', g. brier, blackberry to 5', st. sumac to 10', b. locust to 20'

THESIS PLOT DATA

Plant name, common shortleaf pine

Plant name, scientific *Pinus echinata*

Mine no. 0021 - B Site recon. no. 506

State: Ky. County: Clay Subwatershed: Little Goose

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1955 - 1962

Plot aspect northwest Plot slope in degrees 4

Plot size 60' x 45'

Original planting date 4/7/78

Seedlings at time of planting: size 6 - 14" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 86

Number of plants living at 9/7/78 was 74 = 86 %

Spoil pH from lab test: water 3.3 buffer 4.7

Plot location fill bench

Spoil color mixed - light brown majority to medium gray

Rock fragments many from 1 - 14" D. siltstone and coal

Parent material of surface spoil shale and sandstone

Degree of erosion 1 gully to 4' wide & 2' deep, 2 gullies to 5' wide & 15" deep

Existing vegetation: % cover 0 - 5 description V. pine to 6', 1 t. sedge to 3', 1 clump deertongue to 6", K. 31 t. fescue to 1'

Vegetation of adjacent areas t. sedge to 4', goldenrod to 3', sycamore to 15', n.r. oak to 60', s. birch to 25', t. poplar to 55', sg. hickory to 60', r. maple to 30', sourwood to 10', b. gum to 15', f. dogwood to 20'

THESIS PLOT DATA

Plant name, common European black alder

Plant name, scientific *Alnus glutinosa*

Mine no. 0021 - C Site recon. no. 506

State: Ky. County: Clay Subwatershed: Little Goose

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1955 - 1962

Plot aspect north Plot slope in degrees 2

Plot size 75' x 10'

Original planting date 4/5/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 4' x 4'

Original number of plants within plot 54

Number of plants living at 9/7/78 was 50 = 92 %

Spoil pH from lab test: water 3.5 buffer 4.9

Plot location sediment filled gully on bench

Spoil color light gray

Rock fragments none

Parent material of surface spoil shale (sediment) majority

Degree of erosion gully surface has stabilized; no erosion visible

Existing vegetation: % cover 0 description

Vegetation of adjacent areas r. maple to 20', b. willow to 20', ironweed to 5', cattail to 5', t. poplar to 3', sycamore to 40', sh. & V. pine to 20', p. hickory to 60', m. hickory to 35', f. dogwood to 15', w. oak to 40', blackberry to 4', n.r. oak to 45', st. sumac to 8', s. birch to 12', s. maple to 10', sassafras to 20'

THESIS PLOT DATA

Plant name, common European black alder

Plant name, scientific *Alnus glutinosa*

Mine no. 0021 - C Site recon. no. 506

State: Ky. County: Clay Subwatershed: Little Goose

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1955 - 1962

Plot aspect north Plot slope in degrees 0 - 4

Plot size 35' x 25'

Original planting date 4/5/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 2' x 2'

Original number of plants within plot 100

Number of plants living at 9/7/78 was 89 = 89 %

Spoil pH from lab test: water _____ buffer _____

Plot location bench

Spoil color light gray

Rock fragments many from 1 - 12" D.; mostly sandstone

Parent material of surface spoil shale majority

Degree of erosion erosion has been slowed considerably by check dam at edge of plot; several gullies still exist to 2' deep and 6' wide

Existing vegetation: % cover 0 - 5 description saw grass only

Vegetation of adjacent areas r. maple to 20', b. willow to 20', ironweed to 5', cattail to 5', t. poplar to 30', sycamore to 40', sh. & V. pine to 20', p. hickory to 60', m. hickory to 35', f. dogwood to 15', w. oak to 40'

THESIS PLOT DATA

Plant name, common shortleaf pine

Plant name, scientific *Pinus echinata*

Mine no. 0021 - C Site recon. no. 506

State: Ky. County: Clay Subwatershed: Little Goose

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1955 - 1962

Plot aspect north Plot slope in degrees 1

Plot size 150' x 12'

Original planting date 4/5/78

Seedlings at time of planting: size 6 - 14" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 62

Number of plants living at 9/7/78 was 60 = 96 %

Spoil pH from lab test: water 3.7 buffer 4.9

Plot location top of berm on bench

Spoil color light brown

Rock fragments many coal 1 - 16" D. & few sandstone 1 - 14" D.

Parent material of surface spoil shale majority

Degree of erosion moderate; several gullies eroded to 4' deep and 3' wide

Existing vegetation: % cover 0 - 5 description w. grass

Vegetation of adjacent areas r. maple to 20', b. willow to 20', ironweed to 5', cattail to 5', t. poplar to 30', sycamore to 40', sh. and V. pine to 20', p. hickory to 60', m. hickory to 35', f. dogwood to 15', w. oak to 40', blackberry to 4', n.r. oak to 45', st. sumac to 8', s. birch to 12', s. maple to 10', sassafras to 20'

THESIS PLOT DATA

Plant name, common shortleaf pine

Plant name, scientific *Pinus echinata*

Mine no. 0021 - C Site recon. no. 506

State: Ky. County: Clay Subwatershed: Little Goose

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1955 - 1962

Plot aspect north Plot slope in degrees 0 - 4

Plot size 120' x 15'

Original planting date 4/5/78

Seedlings at time of planting: size 6 - 14" age in years 1

Approximate spacing 8' x 8'

Original number of plants within plot 59

Number of plants living at 9/7/78 was 52 = 88 %

Spoil pH from lab test: water 3.4 buffer 4.7

Plot location berm on bench

Spoil color light gray

Rock fragments many coal fragments 1 - 12" D. & some sandstone 1 - 12" D.

Parent material of surface spoil shale majority

Degree of erosion moderate erosion; several gullies eroded to 3' deep and 6' wide

Existing vegetation: % cover 0 description no vegetation despite good shale from highwall

Vegetation of adjacent areas r. maple to 20', b. willow to 20', ironweed to 5', cattail to 5', t. poplar to 30', sycamore to 40', sh. and V. pine to 20', p. hickory to 60', m. hickory to 35', f. dogwood to 15', w. oak to 40', blackberry to 4', n.r. oak to 45'

THESIS PLOT DATA

Plant name, common shortleaf pine

Plant name, scientific *Pinus echinata*

Mine no. 0021 - C Site recon. no. 506

State: Ky. County: Clay Subwatershed: Little Goose

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1955 - 1962

Plot aspect north Plot slope in degrees 3

Plot size 45' x 20'

Original planting date 4/5/78

Seedlings at time of planting: size 6 - 14" age in years 1

Approximate spacing 8' x 8'

Original number of plants within plot 40

Number of plants living at 9/7/78 was 40 = 100 %

Spoil pH from lab test: water 3.5 buffer 4.7

Plot location berm

Spoil color light brown to light gray

Rock fragments many to 18" D.

Parent material of surface spoil shale majority, some sandstone

Degree of erosion only slight current gullying; 1 gully to 6" deep and 6' wide

Existing vegetation: % cover 0 - 5 description 2 t. sedge to 3', 1 clump deertongue to 6"

Vegetation of adjacent areas r. maple to 20', b. willow to 20', ironweed to 5', cattail to 5', t. poplar to 30', sycamore to 40', sh. & V. pine to 20', p. hickory to 60', m. hickory to 35', f. dogwood to 15', w. oak to 40'

THESIS PLOT DATA

Plant name, common black locust

Plant name, scientific *Robinia pseudoacacia*

Mine no. 0021 - D Site recon. no. 506

State: Ky. County: Clay Subwatershed: Little Goose

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1955 - 1962

Plot aspect north Plot slope in degrees 38

Plot size 40' x 30'

Original planting date 4/6/78

Seedlings at time of planting: size 8 - 16" age in years 1

Approximate spacing 3' x 3'

Original number of plants within plot 75

Number of plants living at 8/25/78 was 7 = 9 %

Spoil pH from lab test: water 4.0 buffer 4.9

Plot location steep outslope

Spoil color mixed; light brown to medium gray

Rock fragments several 1 - 12" D.; several 6 - 10' boulders

Parent material of surface spoil mostly shale with some sandstone

Degree of erosion severe; 1 large gully eroded to 4' deep and 12' wide borders 1 side of plot; 2 small gullies to 6" deep and 3' wide

Existing vegetation: % cover 20 description blackberry to 3', majority, several t. sedge to 4'

Vegetation of adjacent areas V. pine to 12', sycamore to 35', n.r. oak to 45', sassafras to 10', b. locust to 10', p. hickory to 40', A. beech to 40', cattails to 3', t. sedge to 4'

THESIS PLOT DATA

Plant name, common black locust

Plant name, scientific *Robinia pseudoacacia*

Mine no. 0021 - D Site recon. no. 506

State: Ky. County: Clay Subwatershed: Little Goose

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1955 - 1962

Plot aspect northwest Plot slope in degrees 31

Plot size 50' x 25'

Original planting date 4/6/78

Seedlings at time of planting: size 8 - 16" age in years 1

Approximate spacing 4' x 4'

Original number of plants within plot 100

Number of plants living at 8/25/78 was 98 = 98 %

Spoil pH from lab test: water 4.2 buffer 5.5

Plot location steep outslope

Spoil color light brown

Rock fragments many; from 1" D. to 6' D.

Parent material of surface spoil shale majority

Degree of erosion severely eroded slide area; several gullies present to 6" deep and 2' wide

Existing vegetation: % cover 50 description 2 y. buckeye to 8', b. locust to 5', 1 V. pine to 12', ironweed to 6', blackberry to 3', f. dogwood to 5', w. grass.

Vegetation of adjacent areas s. birch to 20', t. poplar to 30', sycamore to 30', cottonwood to 50', sh. sumac to 5', b. locust to 15', V. pine to 10', A. beech to 50', n.r. oak to 50'.

THESIS PLOT DATA

Plant name, common European black alder

Plant name, scientific *Alnus glutinosa*

Mine no. 0022 - A Site recon. no. 285

State: Ky. County: Laurel Subwatershed: Slate Lick Creek

Coal seam name Lily Approx. elevation MSL 1200

Last known mining disturbance 1955 - 1958

Plot aspect northwest Plot slope in degrees 0 - 6

Plot size 30' x 25'

Original planting date 3/31/77

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 4' x 4'

Original number of plants within plot 57

Number of plants living at 5/30/78 was 52 = 91 %

Spoil pH from lab test: water 3.4 buffer 4.8

Plot location berm

Spoil color light gray

Rock fragments few fragments to 3" D.

Parent material of surface spoil majority is shale

Degree of erosion moderate; 3 gullies to 6" deep & 2' wide

Existing vegetation: % cover 5 description V. pine, sh. pine

Vegetation of adjacent areas V. pine to 15', n.r. oak to 30', sh. pine to 15', t. poplar, r. maple

THESIS PLOT DATA

Plant name, common Virginia pine

Plant name, scientific *Pinus virginiana*

Mine no. 0022 - A Site recon. no. 285

State: Ky. County: Laurel Subwatershed: Slate Lick Creek

Coal seam name Lily Approx. elevation MSL 1200

Last known mining disturbance 1955 - 1958

Plot aspect southwest Plot slope in degrees 8

Plot size 60' x 20'

Original planting date 3/17/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 41

Number of plants living at 5/30/78 was 23 = 56 %

Spoil pH from lab test: water 3.3 buffer 4.9

Plot location hollow fill

Spoil color light gray

Rock fragments few fragments to 4" D.

Parent material of surface spoil shale majority

Degree of erosion moderate; 2 gullies to 1' deep & 18" wide run length of plot

Existing vegetation: % cover 0 - 5 description blackberry only

Vegetation of adjacent areas V. pine, sh. pine, n.r. oak, b. oak, cs. oak to 50', r. maple, t. poplar, sh. sumac, sassafras, blackberry

THESIS PLOT DATA

Plant name, common Virginia pine

Plant name, scientific *Pinus virginiana*

Mine no. 0022 - A Site recon. no. 285

State: Ky. County: Laurel Subwatershed: Slate Lick Creek

Coal seam name Lily Approx. elevation MSL 1200

Last known mining disturbance 1955 - 1958

Plot aspect west Plot slope in degrees 7

Plot size 40' x 25'

Original planting date 3/17/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 3' x 3'

Original number of plants within plot 79

Number of plants living at 5/30/78 was 44 = 55 %

Spoil pH from lab test: water 3.3 buffer 4.9

Plot location berm

Spoil color light brown to light gray

Rock fragments many fragments to 6" D.

Parent material of surface spoil sandstone and shale

Degree of erosion moderate; 2 gullies to 18" deep & 18" wide

Existing vegetation: % cover 20 description sh. pine to 6', V. pine to 6'

Vegetation of adjacent areas sh. pine to 20', V. pine to 20', r. maple, t. poplar, n.r. oak to 50', b. oak

THESIS PLOT DATA

Plant name, common loblolly pine

Plant name, scientific *Pinus taeda*

Mine no. 0025 - A Site recon. no. 762

State: Ky. County: Clay Subwatershed: Urban Fork

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1953 - 1958

Plot aspect north Plot slope in degrees 0 - 5

Plot size 60' x 35'

Original planting date 3/14/77

Seedlings at time of planting: size 6 - 14" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 30

Number of plants living at 5/26/78 was 21 = 70 %

Spoil pH from lab test: water 3.9 buffer 4.9

Plot location berm

Spoil color medium brown

Rock fragments very few to 3" D.

Parent material of surface spoil majority is shale

Degree of erosion slight; no gullies visible

Existing vegetation: % cover 15 description steeplebush, w. grass, V. pine to 7', w. pine to 7'

Vegetation of adjacent areas sg. hickory, w. oak to 60', t. poplar to 60', b. locust to 60', V. pine

THESIS PLOT DATA

Plant name, common loblolly pine

Plant name, scientific *Pinus taeda*

Mine no. 0026 - A Site recon. no. 507

State: Ky. County: Clay Subwatershed: Urban Fork

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1953 - 1958

Plot aspect southeast Plot slope in degrees 2

Plot size 50' x 50'

Original planting date 3/15/77

Seedlings at time of planting: size 6 - 14" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 57

Number of plants living at 11/3/77 was 47 = 82 %

Spoil pH from lab test: water 4.9 buffer 6.0

Plot location bench

Spoil color medium brown

Rock fragments many fragments 1 - 6" D.

Parent material of surface spoil majority is shale

Degree of erosion moderate; 1 gully to 3' deep & 7' wide runs diagonally through the plot

Existing vegetation: % cover 40 description w. grass, broomsedge

Vegetation of adjacent areas n. apple, V. pine, g. brier, honeysuckle, f. dogwood, t. poplar

THESIS PLOT DATA

Plant name, common black locust

Plant name, scientific *Robinia pseudoacacia*

Mine no. 0032 - A Site recon. no. 764

State: Ky. County: Clay Subwatershed: Urban Fork

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1953 - 1958

Plot aspect north Plot slope in degrees 10 - 26

Plot size 50' x 30'

Original planting date 4/8/77

Seedlings at time of planting: size 8 - 16" age in years 1

Approximate spacing 4' x 4'

Original number of plants within plot 73

Number of plants living at 5/30/78 was 68 = 93 %

Spoil pH from lab test: water 4.4 buffer 5.4

Plot location top of outslope

Spoil color light gray

Rock fragments few fragments to 4" D.

Parent material of surface spoil shale majority

Degree of erosion slight; no gullies

Existing vegetation: % cover 25 description s. maple, b. gum to 8', r. maple, V. pine, broomsedge, sh. sumac

Vegetation of adjacent areas V. pine to 15', n.r. oak to 50', A. beech to 70', sassafras to 15', m. hickory

THESIS PLOT DATA

Plant name, common Virginia pine

Plant name, scientific *Pinus virginiana*

Mine no. 0032 - A Site recon. no. 764

State: Ky. County: Clay Subwatershed: Urban Fork

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1953 - 1958

Plot aspect north Plot slope in degrees 10

Plot size 30' x 30'

Original planting date 4/8/77

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 33

Number of plants living at 5/30/78 was 26 = 78 %

Spoil pH from lab test: water 4.0 buffer 5.2

Plot location berm

Spoil color light gray

Rock fragments many fragments to 4" D.

Parent material of surface spoil shale and sandstone

Degree of erosion moderate; several gullies to 18" deep and 3' wide

Existing vegetation: % cover 30 description V. pine, blackberry, w. grass

Vegetation of adjacent areas t. poplar to 100', b. locust, r. maple, n.r. oak to 100', e. redbud, b. gum

THESIS PLOT DATA

Plant name, common autumn olive

Plant name, scientific *Elaeagnus umbellata*

Mine no. 0033 - A Site recon. no. 761

State: Ky. County: Clay Subwatershed: Urban Fork

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1953 - 1958

Plot aspect east Plot slope in degrees 29

Plot size 70' x 30'

Original planting date 4/1/77

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 4' x 4'

Original number of plants within plot 101

Number of plants living at 10/12/77 was 69 = 68 %

Spoil pH from lab test: water 3.5 buffer 5.1

Plot location outslope

Spoil color dark gray

Rock fragments many fragments to 2" D.

Parent material of surface spoil shale majority

Degree of erosion severe; gullies irregularly spaced across the plot 12 - 20' apart and to 3' deep

Existing vegetation: % cover 0 description

Vegetation of adjacent areas sh. pine, V. pine, pokeberry, broomsedge, s. maple to 10', blackberry, ironweed, steeplebush

THESIS PLOT DATA

Plant name, common black locust

Plant name, scientific *Robinia pseudoacacia*

Mine no. 0033 - A Site recon. no. 761

State: Ky. County: Clay Subwatershed: Urban Fork

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1953 - 1958

Plot aspect south Plot slope in degrees 26

Plot size 60' x 30'

Original planting date 3/25/77

Seedlings at time of planting: size 8 - 16" age in years 1

Approximate spacing 4' x 4'

Original number of plants within plot 207

Number of plants living at 10/12/77 was 207 = 100 %

Spoil pH from lab test: water 5.2 buffer 6.3

Plot location immediately above highwall

Spoil color tan to light brown

Rock fragments several fragments to 18" D.

Parent material of surface spoil shale majority

Degree of erosion severe; gullies formed every 6 - 12' to a depth of 2 1/2'

Existing vegetation: % cover 0 - 5 description blackberry, 1 b. gum to 6', w. grass

Vegetation of adjacent areas n.r. oak, broomsedge, pokeberry, t. sedge

THESIS PLOT DATA

Plant name, common Virginia pine

Plant name, scientific *Pinus virginiana*

Mine no. 0033 - A Site recon. no. 761

State: Ky. County: Clay Subwatershed: Urban Fork

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1953 - 1958

Plot aspect south Plot slope in degrees 1

Plot size 55' x 35'

Original planting date 4/1/77

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 54

Number of plants living at 10/12/77 was 42 = 77 %

Spoil pH from lab test: water 4.5 buffer 5.9

Plot location bench

Spoil color very variable; light brown to black

Rock fragments few fragments to 6" D.

Parent material of surface spoil shale majority

Degree of erosion slight

Existing vegetation: % cover 10 description s. sedge

Vegetation of adjacent areas n.r. oak, w. oak, l. pine to 20'

THESIS PLOT DATA

Plant name, common loblolly pine

Plant name, scientific *Pinus taeda*

Mine no. 0033 - B Site recon. no. 761

State: Ky. County: Clay Subwatershed: Urban Fork

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1953 - 1958

Plot aspect south Plot slope in degrees 20

Plot size 70' x 25'

Original planting date 3/21/77

Seedlings at time of planting: size 6 - 14" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 57

Number of plants living at 11/3/77 was 51 = 89 %

Spoil pH from lab test: water 5.3 buffer 6.3

Plot location one side of cove just above highwall

Spoil color light brown

Rock fragments many fragments to 8" D.

Parent material of surface spoil shale majority

Degree of erosion moderate; several gullies to 6" deep & 18" wide

Existing vegetation: % cover 10 *description* 1 7' V. *pine, sourwood* to 3', w. grass

Vegetation of adjacent areas n.r. oak to 40', w. oak to 40', t. poplar, V. pine, blackberry, broomsedge

THESIS PLOT DATA

Plant name, common loblolly pine

Plant name, scientific *Pinus taeda*

Mine no. 0033 - C Site recon. no. 761

State: Ky. County: Clay Subwatershed: Urban Fork

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1953 - 1958

Plot aspect southwest Plot slope in degrees 12

Plot size 150' x 25'

Original planting date 3/16/77

Seedlings at time of planting: size 6 - 14" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 80

Number of plants living at 10/12/77 was 55 = 68 %

Spoil pH from lab test: water 3.8 buffer 4.9

Plot location berm

Spoil color light brown and light gray

Rock fragments many fragments to 12" D.

Parent material of surface spoil shale majority; some sandstone

Degree of erosion moderate; 2 gullies to 6" deep & 18" wide

Existing vegetation: % cover 5 description broomsedge only

Vegetation of adjacent areas p. oak, b. gum, sycamore, broomsedge, blackberry, r. maple, V. pine, pokeberry, t. sedge, sh. sumac

THESIS PLOT DATA

Plant name, common autumn olive

Plant name, scientific *Elaeagnus umbellata*

Mine no. 0034 - A Site recon. no. 760

State: Ky. County: Clay Subwatershed: Urban Fork

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1953 - 1958

Plot aspect south Plot slope in degrees 0 - 3

Plot size 55' x 30'

Original planting date 4/29/77

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 4' x 4'

Original number of plants within plot 87

Number of plants living at 5/26/78 was 45 = 51 %

Spoil pH from lab test: water 3.8 buffer 5.1

Plot location berm

Spoil color light to medium gray

Rock fragments few to 6" D.

Parent material of surface spoil shale majority

Degree of erosion moderate; 2 gullies to 6" deep & 3' wide

Existing vegetation: % cover 0 - 5 description V. pine to 4', deertongue to 2'

Vegetation of adjacent areas p. hickory to 50', w. oak, V. pine

THESIS PLOT DATA

Plant name, *common* black locust

Plant name, scientific *Robinia pseudoacacia*

Mine no. 0034 - A Site recon. no. 760

State: Ky. County: Clay Subwatershed: Urban Fork

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1953 - 1958

Plot aspect northeast Plot slope in degrees 39

Plot size 50' x 20'

Original planting date 4/29/77

Seedlings at time of planting: size 8 - 16" age in years 1

Approximate spacing 3' x 3'

Original number of plants within plot 107

Number of plants living at 5/26/78 was 100 = 93 %

Spoil pH from lab test: water 3.7 buffer 5.1

Plot location outslope

Spoil color light gray and light brown

Rock fragments few fragments, but to 3' D.

Parent material of surface spoil shale majority; some sandstone

Degree of erosion severe; several gullies to 18" deep and 3' wide criss-cross the plot

Existing vegetation: % cover 5 description V. pine to 6', w. grass

Vegetation of adjacent areas V. pine to 20', t. poplar to 60', g. ash, w. oak, p. hickory

THESIS PLOT DATA

Plant name, common European black alder

Plant name, scientific *Alnus glutinosa*

Mine no. 0034 - C Site recon. no. 760

State: Ky. County: Clay Subwatershed: Little Goose above Urban

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1955 - 1962

Plot aspect northwest Plot slope in degrees 0 - 4

Plot size 65' x 20'

Original planting date 5/12/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 22

Number of plants living at 10/25/78 was 22 = 100 %

Spoil pH from lab test: water 4.0 buffer 5.8

Plot location bench

Spoil color light brown & light - dark gray

Rock fragments few; most are coal fragments

Parent material of surface spoil shale majority

Degree of erosion slight; one gully to 1' deep & 1' wide

Existing vegetation: % cover 35 description w. grass, blackberry to 2', goldenrod, 2 r. maple to 7', 1 t. sedge, deertongue

Vegetation of adjacent areas pokeberry, ironweed, blackberry, deertongue, goldenrod, b. locust to 15', t. poplar to 60', sourwood to 5', sycamore to 20', sh. pine to 15', f. dogwood to 20', u. magnolia, n.r. oak to 50', A. beech to 30', p. hickory to 60', sh. hickory to 50', s. birch to 6'

THESIS PLOT DATA

Plant name, common shortleaf pine

Plant name, scientific *Pinus echinata*

Mine no. 0034 - C Site recon. no. 760

State: Ky. County: Clay Subwatershed: Little Goose above Urban

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1955 - 1962

Plot aspect northwest Plot slope in degrees 2 - 16

Plot size 80' x 35'

Original planting date 5/12/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 8' x 8'

Original number of plants within plot 82

Number of plants living at 10/25/78 was 75 = 91 %

Spoil pH from lab test: water 4.1 buffer 5.3

Plot location berm

Spoil color light brown

Rock fragments many to 12" D.; shale and sandstone

Parent material of surface spoil shale majority

Degree of erosion moderate; several small gullies to 2' deep & 4' wide on edge of berm

Existing vegetation: % cover 40 description w. grass majority, blackberry, broomsedge, g. brier, t. sedge, deertongue to 6"

Vegetation of adjacent areas pokeberry, ironweed, blackberry, deertongue, goldenrod, sourwood to 5', f. dogwood to 20', s. birch to 6', sycamore to 20', u. magnolia, n.r. oak to 50', p. hickory to 60', sh. hickory to 50', A. beech to 30', sh. pine to 15'

THESIS PLOT DATA

Plant name, common Virginia pine

Plant name, scientific *Pinus virginiana*

Mine no. 0034 - C Site recon. no. 760

State: Ky. County: Clay Subwatershed: Little Goose above Urban

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1955 - 1962

Plot aspect northwest Plot slope in degrees 22

Plot size 55' x 35'

Original planting date 5/12/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 65

Number of plants living at 10/25/78 was 51 = 78 %

Spoil pH from lab test: water 3.7 buffer 5.1

Plot location side of berm

Spoil color light brown & light - medium gray

Rock fragments many to 18" D.

Parent material of surface spoil shale majority

Degree of erosion severe; few gullies present but much previous erosion

Existing vegetation: % cover 0 description

Vegetation of adjacent areas pokeberry, ironweed, blackberry, deertongue, goldenrod, t. poplar to 60', u. magnolia, n.r. oak to 50', p. hickory to 60', sh. hickory to 50', sourwood to 5', sycamore to 20', f. dogwood to 20', A. beech to 30', s. birch to 6', b. locust to 15', sh. pine to 15'

THESIS PLOT DATA

Plant name, common autumn olive

Plant name, scientific *Elaeagnus umbellata*

Mine no. 0036 - A Site recon. no. 37

State: Ky. County: Laurel Subwatershed: Rockcastle

Coal seam name Lily Approx. elevation MSL 1200

Last known mining disturbance 1958 - 1959

Plot aspect south Plot slope in degrees 25

Plot size 45' x 40'

Original planting date 4/15/77

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 52

Number of plants living at 7/21/77 was 15 = 28 %

Spoil pH from lab test: water 4.5 buffer 6.1

Plot location outslope

Spoil color light brown, light gray, and dark gray

Rock fragments several fragments to 12" D.

Parent material of surface spoil shale majority

Degree of erosion severe; several gullies to 7' deep

Existing vegetation: % cover 10 description V. pine

Vegetation of adjacent areas V. pine, n.r. oak, w. oak, t. poplar, p. hickory

THESIS PLOT DATA

Plant name, common autumn olive

Plant name, scientific *Elaeagnus umbellata*

Mine no. 0036 - A Site recon. no. 37

State: Ky. County: Laurel Subwatershed: Rockcastle

Coal seam name Lily Approx. elevation MSL 1200

Last known mining disturbance 1958 - 1959

Plot aspect southwest Plot slope in degrees 37

Plot size 65' x 40'

Original planting date 4/15/77

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 3' x 3'

Original number of plants within plot 108

Number of plants living at 7/21/77 was 101 = 93 %

Spoil pH from lab test: water 2.5 buffer 4.7

Plot location outslope

Spoil color medium gray

Rock fragments few fragments to 10" D.

Parent material of surface spoil shale majority

Degree of erosion severe; several gullies to 3' deep

Existing vegetation: % cover 10 description several sh. sumac

Vegetation of adjacent areas V. pine, n.r. oak, w. oak, t. poplar, p. hickory

THESIS PLOT DATA

Plant name, common Chinese chestnut

Plant name, scientific *Castanea mollis*

Mine no. 0036 - A Site recon. no. 37

State: Ky. County: Laurel Subwatershed: Rockcastle

Coal seam name Lily Approx. elevation MSL 1200

Last known mining disturbance 1958 - 1959

Plot aspect northeast Plot slope in degrees 7

Plot size 100' x 10'

Original planting date 4/15/77

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 4' x 4'

Original number of plants within plot 80

Number of plants living at 7/21/77 was 77 = 96 %

Spoil pH from lab test: water 4.2 buffer 5.2

Plot location berm

Spoil color dark gray, almost black

Rock fragments many fragments to 2" D.

Parent material of surface spoil shale majority

Degree of erosion slight; no gullies visible

Existing vegetation: % cover 25 description sh. pine, V. pine, w. grass

Vegetation of adjacent areas sycamore, sh. sumac, sh. pine, V. pine, s. birch, s. lespedeza, n.r. oak, w. oak, t. poplar, p. hickory

THESIS PLOT DATA

Plant name, common European black alder

Plant name, scientific *Alnus glutinosa*

Mine no. 0036 - A Site recon. no. 37

State: Ky. County: Laurel Subwatershed: Rockcastle

Coal seam name Lily Approx. elevation MSL 1200

Last known mining disturbance 1958 - 1959

Plot aspect southeast Plot slope in degrees 1

Plot size 100' x 10'

Original planting date 4/22/77

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 4' x 4'

Original number of plants within plot 42

Number of plants living at 7/21/77 was 38 = 90 %

Spoil pH from lab test: water 3.7 buffer 5.4

Plot location berm

Spoil color light brown & light gray to dark gray

Rock fragments none

Parent material of surface spoil shale majority

Degree of erosion slight

Existing vegetation: % cover 20 description s. and t. sedges

Vegetation of adjacent areas V. pine, n.r. oak, w. oak, t. poplar.
r. maple, p. hickory, b. gum

THESIS PLOT DATA

Plant name, common autumn olive

Plant name, scientific *Elaeagnus umbellata*

Mine no. 0037 - A Site recon. no. 695

State: Ky. County: Clay Subwatershed: Gray's Fork

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1955 - 1962

Plot aspect southeast Plot slope in degrees 0 - 30

Plot size 55' x 45'

Original planting date 4/14/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 8' x 8'

Original number of plants within plot 113

Number of plants living at 8/10/78 was 101 = 89 %

Spoil pH from lab test: water 5.2 buffer 5.8

Plot location lower highwall and adjacent bench

Spoil color light brown

Rock fragments several to 3" D.

Parent material of surface spoil shale

Degree of erosion well eroded and current gullying; many small gullies to 3' deep and 3' wide.

Existing vegetation: % cover 0 - 5 description several b. gum trees to 4' high, few w. grass

Vegetation of adjacent areas sassafras to 15', n.r. oak to 40', b. oak to 60', broomsedge to 3', blackberry to 3', st. sumac to 8', s. lespedeza to 3'

THESIS PLOT DATA

Plant name, common black locust

Plant name, scientific *Robinia pseudoacacia*

Mine no. 0037 - A Site recon. no. 695

State: Ky. County: Clay Subwatershed: Gray's Fork

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1955 - 1962

Plot aspect south Plot slope in degrees 22

Plot size 70' x 35'

Original planting date 4/14/78

Seedlings at time of planting: size 8 - 16" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 94

Number of plants living at 8/10/78 was 94 = 100 %

Spoil pH from lab test: water 5.5 buffer 6.7

Plot location bottom of highwall

Spoil color varies from light gray to tan

Rock fragments many rock fragments from 1 - 6" D.

Parent material of surface spoil shale

Degree of erosion well eroded, several gullies currently eroded to 18" deep & 24" wide

Existing vegetation: % cover 40 description blackberry to 1', goldenrod to 2', b. lespedeza to 3', s. lespedeza to 4', g. brier to 1', kb. lespedeza to 6"

Vegetation of adjacent areas m. hickory to 60', b. oak to 20', n.r. oak to 40', r. maple to 25', t. poplar to 5', V. pine to 3', sourwood to 15', st. sumac to 3'

THESIS PLOT DATA

Plant name, common shortleaf pine

Plant name, scientific *Pinus echinata*

Mine no. 0037 - B Site recon. no. 695

State: Ky. County: Clay Subwatershed: Little Goose

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1955 - 1962

Plot aspect southeast Plot slope in degrees 8

Plot size 50' x 25'

Original planting date 4/14/78

Seedlings at time of planting: size 6 - 14" age in years 1

Approximate spacing 4' x 4'

Original number of plants within plot 53

Number of plants living at 8/10/78 was 52 = 98 %

Spoil pH from lab test: water 4.4 buffer 5.4

Plot location top of berm on fill bench

Spoil color light gray

Rock fragments few between 2 - 4" D.

Parent material of surface spoil majority shale, some sandstone

Degree of erosion slight; few gullies to 1' wide & 6" deep; some weathered new soil eroded leaving only shale.

Existing vegetation: % cover 50 description s. birch to 3', f. dogwood to 3', V. pine to 5', deertongue to 1', broomsedge to 3', g. brier to 1', blackberry to 1'

Vegetation of adjacent areas s. birch to 25', A. elm to 10', V. pine & sh. pine to 15', w. oak to 60', sycamore to 25', m. hickory to 50', ironweed to 6', f. dogwood to 5'.

THESIS PLOT DATA

Plant name, common autumn olive

Plant name, scientific *Elaeagnus umbellata*

Mine no. 0039 - A Site recon. no. 757

State: Ky. County: Clay Subwatershed: Urban Fork

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1953 - 1958

Plot aspect southwest Plot slope in degrees 30

Plot size 50' x 30'

Original planting date 4/15/77

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 5' x 5'

Original number of plants within plot 70

Number of plants living at 5/26/78 was 32 = 45 %

Spoil pH from lab test: water 3.4 buffer 5.0

Plot location top of outslope

Spoil color dark gray

Rock fragments few fragments to 4" D.

Parent material of surface spoil shale majority; some waste coal

Degree of erosion moderate; several gullies to 1' deep & 2' wide

Existing vegetation: % cover 0 description

Vegetation of adjacent areas w. oak to 40', V. pine, sh. pine, s. lespedeza, K. 31 t. fescue, A. beech

THESIS PLOT DATA

Plant name, common Virginia pine

Plant name, scientific *Pinus virginiana*

Mine no. 0039 - A Site recon. no. 757

State: Ky. County: Clay Subwatershed: Urban Fork

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1953 - 1958

Plot aspect southwest Plot slope in degrees 7

Plot size 55' x 30'

Original planting date 4/15/77

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 40

Number of plants living at 5/26/78 was 34 = 85 %

Spoil pH from lab test: water 3.8 buffer 5.1

Plot location berm

Spoil color medium brown

Rock fragments few to 18" D.

Parent material of surface spoil shale majority; some sandstone

Degree of erosion moderate; several gullies to 18" deep & 6' wide

Existing vegetation: % cover 25 description V. pine to 6', t. poplar to 4', broomsedge

Vegetation of adjacent areas blackberry, cattails, b. willow to 6', t. poplar, r. maple, sg. hickory, b. oak to 60', V. pine, broomsedge, sh. pine

THESIS PLOT DATA

Plant name, common black locust

Plant name, scientific *Robinia pseuoacacia*

Mine no. 0040 - A Site recon. no. 696

State: Ky. County: Clay Subwatershed: Gray's Fork

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1955 - 1962

Plot aspect north Plot slope in degrees 31

Plot size 35' x 30'

Original planting date 4/6/78

Seedlings at time of planting: size 8 - 16" age in years 1

Approximate spacing 5' x 5'

Original number of plants within plot 76

Number of plants living at 8/10/78 was 76 = 100 %

Spoil pH from lab test: water 4.0 buffer 5.1

Plot location outslope (adjacent to existing drag strip)

Spoil color medium gray (some brown mixed)

Rock fragments several to 4" D.

Parent material of surface spoil shale

Degree of erosion severely gullied; plot bordered by gullies on both sides, divided in middle by one gully 3' deep and to 6' wide

Existing vegetation: % cover 10 description few g. brier, few V. pine to 3' high, few K. 31 t. fescue clumps

Vegetation of adjacent areas p. pine to 20', t. poplar to 30', s. maples to 35', w. oak to 45', A. beech to 50', w. grape

THESIS PLOT DATA

Plant name, common black locust

Plant name, scientific *Robinia pseudoacacia*

Mine no. 0040 - B Site recon. no. 696

State: Ky. County: Clay Subwatershed: Little Goose

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1955 - 1962

Plot aspect southwest Plot slope in degrees 32

Plot size 45' x 30'

Original planting date 4/6/78

Seedlings at time of planting: size 8 - 16" age in years 1

Approximate spacing 4' x 4'

Original number of plants within plot 103

Number of plants living at 8/10/78 was 100 = 97 %

Spoil pH from lab test: water 3.8 buffer 5.2

Plot location outslope (adjacent to drag strip)

Spoil color light gray

Rock fragments a few fragments greater than 6" D. on surface

Parent material of surface spoil shale

Degree of erosion severe; many small gullies eroding 6 - 36" deep & 6 - 24" wide

Existing vegetation: % cover 0 - 5 description few sprigs of K. 31 t. fescue, crabgrass, s. sorrel, 1 clump broomsedge

Vegetation of adjacent areas t. poplar to 25', A. elm to 20', r. maple to 20', V. and sh. pine to 15', sh. sumac to 5', deertongue to 2', blackberry

THESIS PLOT DATA

Plant name, *common* scotch pine

Plant name, scientific *Pinus sylvestris*

Mine no. 0049 - A Site recon. no. 1214

State: Ky. County: Harlan Subwatershed: Cranks Creek

Coal seam name Creech Approx. elevation MSL 1900

Last known mining disturbance 1964

Plot aspect west Plot slope in degrees 24

Plot size 130' x 15'

Original planting date 5/8/78

Seedlings at time of planting: size 6 - 12" age in years 2

Approximate spacing 6' x 6'

Original number of plants within plot 45

Number of plants living at 11/1/78 was 45 = 100 %

Spoil pH from lab test: water 5.2 buffer 5.8

Plot location lower edge of highwall

Spoil color medium brown

Rock fragments several to 48" D. (most from highwall collapse)

Parent material of surface spoil shale majority; some sandstone

Degree of erosion slight; no gullies present

Existing vegetation: % cover 90 description Ky. 31 t. fescue, blackberry, pokeberry, s. lespedeza, w. lovegrass, steeplebush

Vegetation of adjacent areas r. maple to 35', ck. oak, n.r. oak to 35', s. maple to 25', sassafras to 35', A. linden, m. laurel to 10'

THESIS PLOT DATA

Plant name, common shortleaf pine

Plant name, scientific *Pinus echinata*

Mine no. 0049 - A Site recon. no. 1214

State: Ky. County: Harlan Subwatershed: Cranks Creek

Coal seam name Creech Approx. elevation MSL 1900

Last known mining disturbance 1964

Plot aspect north Plot slope in degrees 4

Plot size 95' x 45'

Original planting date 4/24/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 97

Number of plants living at 11/1/78 was 97 = 100 %

Spoil pH from lab test: water 5.0 buffer 5.5

Plot location bench

Spoil color light brown & light - medium gray

Rock fragments many to 6" D.

Parent material of surface spoil shale majority

Degree of erosion slight; no gullies present

Existing vegetation: % cover 70 description K. 31 t. fescue, pokeberry

Vegetation of adjacent areas pokeberry, K. 31 t. fescue, w. lovegrass, c. fern, n.r. oak to 60', s. maple to 15', b. gum to 70', b. locust to 10', sg. hickory to 65'

THESIS PLOT DATA

Plant name, common shortleaf pine

Plant name, scientific *Pinus echinata*

Mine no. 0049 - A Site recon. no. 1214

State: Ky. County: Harlan Subwatershed: Cranks Creek

Coal seam name Creech Approx. elevation MSL 1900

Last known mining disturbance 1954

Plot aspect northeast Plot slope in degrees 46

Plot size 125' x 30'

Original planting date 4/24/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 99

Number of plants living at 11/1/78 was 96 = 96 %

Spoil pH from lab test: water 5.1 buffer 6.3

Plot location highwall

Spoil color tan

Rock fragments many to 3" D.

Parent material of surface spoil shale majority

Degree of erosion severe; several gullies to 18" deep & 4' wide; sheet erosion also evident

Existing vegetation: % cover 20 description several b. locust to 25' tall, 1 r. maple to 7', 2 n.r. oak to 20', K. 31 t. fescue, blackberry, g. brier, w. pine to 25'

Vegetation of adjacent areas broomsedge, s. lespedeza, sourwood to 10', r. maple to 15', b. locust to 40', sycamore to 25', t. poplar to 45', b. cherry to 20', l. pine to 25'

THESIS PLOT DATA

Plant name, common shortleaf pine

Plant name, scientific *Pinus echinata*

Mine no. 0049 - A Site recon. no. 1214

State: Ky. County: Harlan Subwatershed: Cranks Creek

Coal seam name Creech Approx. elevation MSL 1900

Last known mining disturbance 1964

Plot aspect southeast Plot slope in degrees 3

Plot size 95' x 25'

Original planting date 4/24/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 86

Number of plants living at 11/1/78 was 72 = 83 %

Spoil pH from lab test: water 5.3 buffer 6.4

Plot location bench

Spoil color light brown

Rock fragments many to 2" D.

Parent material of surface spoil shale and sandstone

Degree of erosion slight; no gullies present

Existing vegetation: % cover 65 description K. 31 t. fescue, pokeberry is majority, w. lovegrass

Vegetation of adjacent areas w. lovegrass, K. 31 t. fescue, pokeberry, blackberry, w. grape, w. oak to 25', n.r. oak to 50', t. poplar to 80', s. maple to 15', w. ash to 30', b. hickory to 30', sg. hickory to 60', b. cherry to 45', b. locust to 40', A. beech to 40', r. paulownia to 65'

THESIS PLOT DATA

Plant name, common Virginia pine

Plant name, scientific *Pinus virginiana*

Mine no. 0056 - A Site recon. no. 705

State: Ky. County: Clay Subwatershed: Rader Creek

Coal seam name Horse Creek Approx. elevation MSL 950 - 1150

Last known mining disturbance 1955 - 1963

Plot aspect northeast Plot slope in degrees 0 - 2

Plot size 125' x 20'

Original planting date 5/12/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 5' x 5'

Original number of plants within plot 101

Number of plants living at 10/18/78 was 89 = 88 %

Spoil pH from lab test: water 4.1 buffer 4.9

Plot location berm

Spoil color light brown & light gray (surface crust)

Rock fragments several to 3" D.

Parent material of surface spoil shale majority

Degree of erosion slight; no gullies present

Existing vegetation: % cover 0 - 5 description broomsedge, w. grass, several V. pine to 4' is majority

Vegetation of adjacent areas sycamore to 30', V. pine to 25', sh. pine to 30', f. dogwood to 10', s. birch to 20', e. redbud to 10', r. maple to 30', t. poplar to 50', honeysuckle, t. sedge to 4', ironweed to 7', s. lespedeza, blackberry to 3', steeplebush, st. sumac, cattails to 4'

THESIS PLOT DATA

Plant name, common Virginia pine

Plant name, scientific *Pinus virginiana*

Mine no. 0056 - A Site recon. no. 705

State: Ky. County: Clay Subwatershed: Rader Creek

Coal seam name Horse Creek Approx. elevation MSL 950 - 1150

Last known mining disturbance 1955 - 1963

Plot aspect southwest Plot slope in degrees 9

Plot size 90' x 40'

Original planting date 5/5/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 105

Number of plants living at 10/18/78 was 98 = 93 %

Spoil pH from lab test: water 3.8 buffer 4.7

Plot location berm

Spoil color light to medium gray

Rock fragments many to 12" D.

Parent material of surface spoil shale majority

Degree of erosion severe; 7 gullies to 3' deep and 8' wide

Existing vegetation: % cover 10 description V. pine to 6', broomsedge to 3', blackberry to 4' is majority, w. grass

Vegetation of adjacent areas sycamore to 30', V. pine to 25', sh. pine to 30', f. dogwood to 10', s. birch to 20', e. redbud to 10', r. maple to 30', t. poplar to 50', honeysuckle, t. sedge to 4', cattails to 4', ironweed to 7', s. lespedeza, blackberry to 3', steeplebush, st. sumac, g. brier to 3', w. grape, n.r. oak to 45', s. gum to 15'

THESIS PLOT DATA

Plant name, common European black alder

Plant name, scientific *Alnus glutinosa*

Mine no. 0057 - C Site recon. no. 659

State: Ky. County: Clay Subwatershed: Rader Creek

Coal seam name Horse Creek Approx. elevation MSL 950 - 1150

Last known mining disturbance 1955 - 1963

Plot aspect northeast Plot slope in degrees 3

Plot size 85' x 15'

Original planting date 5/4/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 5' x 5'

Original number of plants within plot 56

Number of plants living at 10/18/78 was 55 = 98 %

Spoil pH from lab test: water 4.7 buffer 5.8

Plot location bench (slightly filled)

Spoil color medium - dark gray & light - medium brown

Rock fragments few to 8" D.; coal fragments to 3" D.

Parent material of surface spoil shale majority; some sandstone

Degree of erosion slight; no gullies present

Existing vegetation: % cover 65 description w. grass is majority, s. sedge

Vegetation of adjacent areas cattails, broomsedge, steeplebush, honeysuckle, deertongue, t. sedge, r. maple to 3', V. pine to 35', sourwood to 4', b. oak to 20', t. poplar to 40', f. dogwood to 10', sassafras to 15', sycamore to 25'

THESIS PLOT DATA

Plant name, common European black alder

Plant name, scientific *Alnus glutinosa*

Mine no. 0057 - C Site recon. no. 659

State: Ky. County: Clay Subwatershed: Rader Creek

Coal seam name Horse Creek Approx. elevation MSL 950 - 1150

Last known mining disturbance 1955 - 1963

Plot aspect northeast Plot slope in degrees 0 - 5

Plot size 75' x 10'

Original planting date 5/4/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 5' x 5'

Original number of plants within plot 24

Number of plants living at 10/18/78 was 24 = 100 %

Spoil pH from lab test: water 5.1 buffer 6.6

Plot location base of highwall and adjacent edge of bench

Spoil color medium brown

Rock fragments few; coal fragments to 4", sandstone to 8" D.

Parent material of surface spoil shale majority

Degree of erosion slight; no gullies present

Existing vegetation: % cover 50 description s. sedge is majority, t. sedge, steeplebush

Vegetation of adjacent areas steeplebush, honeysuckle, deertongue to 2', p. ivy to 3', t. sedge, r. maple to 3', V. pine to 35', b. oak to 20', t. poplar to 40', f. dogwood to 10', sassafras to 15', sycamore to 25'

THESIS PLOT DATA

Plant name, common black locust

Plant name, scientific *Robinia pseudoacacia*

Mine no. 0058 - A Site recon. no. 618

State: Ky. County: Clay Subwatershed: Rader Creek

Coal seam name Horse Creek Approx. elevation MSL 950 - 1150

Last known mining disturbance 1955 - 1963

Plot aspect west Plot slope in degrees 25

Plot size 55' x 45'

Original planting date 5/19/78

Seedlings at time of planting: size 8 - 16" age in years 1

Approximate spacing 4' x 4'

Original number of plants within plot 127

Number of plants living at 10/18/78 was 112 = 88 %

Spoil pH from lab test: water 5.1 buffer 5.7

Plot location highwall

Spoil color light - medium brown

Rock fragments many to 10" D.

Parent material of surface spoil shale majority

Degree of erosion severe; many gullies to 4' deep & 6' wide

Existing vegetation: % cover 0 description

Vegetation of adjacent areas ironweed to 5', blackberry to 6', sycamore to 30', V. pine to 15', sh. pine to 30', t. poplar to 80', p. hickory to 25', sg. hickory to 50', f. dogwood to 5', sourwood to 10', r. maple to 30'

THESIS PLOT DATA

Plant name, common shortleaf pine

Plant name, scientific *Pinus echinata*

Mine no. 0058 - A Site recon. no. 618

State: Ky. County: Clay Subwatershed: Rader Creek

Coal seam name Horse Creek Approx. elevation MSL 950 - 1150

Last known mining disturbance 1955 - 1963

Plot aspect west Plot slope in degrees 1

Plot size 60' x 40'

Original planting date 5/19/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 5' x 5'

Original number of plants within plot 96

Number of plants living at 10/18/78 was 62 = 65 %

Spoil pH from lab test: water 5.0 buffer 6.2

Plot location fill bench

Spoil color medium brown

Rock fragments many small fragments to 6" D.; some sandstone

Parent material of surface spoil shale majority

Degree of erosion slight; no gullies present

Existing vegetation: % cover 60 description w. grass is majority, blackberry, kb. lespedeza, goldenrod, g. brier

Vegetation of adjacent areas ironweed to 5', blackberry to 6', sycamore to 30', V. pine to 15', sh. pine to 30', p. hickory to 25', sg. hickory to 50', f. dogwood to 5', sourwood to 10', r. maple to 30'

THESIS PLOT DATA

Plant name, common shortleaf pine

Plant name, scientific *Pinus echinata*

Mine no. 0058 - A Site recon. no. 618

State: Ky. County: Clay Subwatershed: Rader Creek

Coal seam name Horse Creek Approx. elevation MSL 950 - 1150

Last known mining disturbance 1955 - 1963

Plot aspect west Plot slope in degrees 0 - 2

Plot size 65' x 35'

Original planting date 5/19/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 97

Number of plants living at 10/18/78 was 52 = 54 %

Spoil pH from lab test: water 4.7 buffer 6.3

Plot location bench

Spoil color light brown

Rock fragments many small fragments to 6" D.

Parent material of surface spoil shale majority; some sandstone

Degree of erosion slight; one gully to 6" deep & 6' wide; plot bordered by gully on one end to 6' deep and 15' wide

Existing vegetation: % cover 60 description kb. lespedeza, w. grass is majority, g. brier, broomsedge, steeplebush, n. apple to 2'

Vegetation of adjacent areas ironweed to 5', blackberry to 6', t. sedge, n. alder, n.r. oak to 80', sycamore to 30', V. pine to 15', t. poplar to 80', p. hickory to 25', sg. hickory to 50', f. dogwood to 5', sourwood to 10', r. maple to 30', sh. pine to 30'

THESIS PLOT DATA

Plant name, common European black alder

Plant name, scientific *Alnus glutinosa*

Mine no. 0076 - B Site recon. no. 623

State: Ky. County: Clay Subwatershed: Laurel Creek

Coal seam name Horse Creek Approx. elevation MSL 950 - 1150

Last known mining disturbance 1962 - 1963

Plot aspect northwest Plot slope in degrees 1

Plot size 90' x 15'

Original planting date 5/19/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 35

Number of plants living at 10/25/78 was 30 = 86 %

Spoil pH from lab test: water 4.9 buffer 5.7

Plot location bench

Spoil color light gray & light brown

Rock fragments many to 4" D.

Parent material of surface spoil shale majority

Degree of erosion slight; no gullies present

Existing vegetation: % cover 50 description lichens, w. grass is majority, steeplebush, broomsedge, goldenrod, V. pine to 5'

Vegetation of adjacent areas goldenrod, sh. sumac to 10', blackberry, pokeberry, E. r. cedar to 4', sh. pine to 30', sycamore to 20', n.r. oak to 30', p. hickory to 60', t. poplar to 70', b. willow to 5'

THESIS PLOT DATA

Plant name, common European black alder

Plant name, scientific *Alnus glutinosa*

Mine no. 0076 - B Site recon. no. 623

State: Ky. County: Clay Subwatershed: Laurel Creek

Coal seam name Horse Creek Approx. elevation MSL 950 - 1150

Last known mining disturbance 1962 - 1963

Plot aspect west Plot slope in degrees 3

Plot size 100' x 20'

Original planting date 5/19/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 113

Number of plants living at 10/25/78 was 100 = 88 %

Spoil pH from lab test: water 5.6 buffer 6.8

Plot location bench

Spoil color tan - light brown

Rock fragments several to 8" D.

Parent material of surface spoil shale majority

Degree of erosion slight; no gullies present

Existing vegetation: % cover 60 description w. strawberry, broomsedge is majority, t. sedge, goldenrod, w. grass, deertongue, Kr. lespedeza, K. 31 t. fescue

Vegetation of adjacent areas s. lespedeza, sh. sumac, goldenrod, blackberry, w. strawberry, ironweed, dewberry, r. maple to 15', n.r. oak to 35', sycamore to 20', A. beech to 70', sh. pine to 25'

THESIS PLOT DATA

Plant name, common scotch pine

Plant name, scientific *Pinus sylvestris*

Mine no. 0095 - A Site recon. no. 1223

State: Ky. County: Harlan Subwatershed: Crummies

Coal seam name Darby Approx. elevation MSL 2000

Last known mining disturbance 1966

Plot aspect north Plot slope in degrees 33

Plot size 80' x 30'

Original planting date 3/27/78

Seedlings at time of planting: size 6 - 12" age in years 2

Approximate spacing 6' x 6'

Original number of plants within plot 55

Number of plants living at 11/1/78 was 55 = 100 %

Spoil pH from lab test: water 5.1 buffer 6.0

Plot location highwall

Spoil color light - medium brown

Rock fragments many to 24" D.

Parent material of surface spoil shale and sandstone

Degree of erosion severe, extensive sheet erosion plus several small gullies to 1' deep & 3' wide

Existing vegetation: % cover 25 description g. moss is majority, blackberry, c. fern, 1 f. dogwood to 7', 1 n.r. oak to 10'

Vegetation of adjacent areas K. 31 t. fescue, cattails, t. sedge, s. lespedeza, c. fern, blackberry, pokeberry, n.r. oak to 65', t. poplar to 75', w. ash to 60', sassafras to 30'

THESIS PLOT DATA

Plant name, common scotch pine

Plant name, scientific *Pinus sylvestris*

Mine no. 0095 - A Site recon. no. 1223

State: Ky. County: Harlan Subwatershed: Crummies

Coal seam name Darby Approx. elevation MSL 2000

Last known mining disturbance 1966

Plot aspect northwest Plot slope in degrees 34

Plot size 100' x 15'

Original planting date 3/27/78

Seedlings at time of planting: size 6 - 12" age in years 2

Approximate spacing 6' x 6'

Original number of plants within plot 34

Number of plants living at 11/1/78 was 34 = 100 %

Spoil pH from lab test: water 5.3 buffer 6.4

Plot location lower edge of highwall

Spoil color light brown

Rock fragments many to 12" D. (many eroded from above)

Parent material of surface spoil shale and sandstone

Degree of erosion severe; much sheet erosion; several gullies to 18" deep & 5' wide

Existing vegetation: % cover 10 description blackberry, ironweed, K. 31 t. fescue

Vegetation of adjacent areas K. 31 t. fescue, blackberry, ironweed, A. beech to 90', t. poplar to 70', w. ash to 70', b. gum to 60', f. dogwood to 6', r. maple to 10', r. paulownia to 45', sg. hickory to 55'

THESIS PLOT DATA

Plant name, common Virginia pine

Plant name, scientific *Pinus virginiana*

Mine no. 0098 - A Site recon. no. 667

State: Ky. County: Clay Subwatershed: Goose Creek

Coal seam name Horse Creek Approx. elevation MSL 950 - 1150

Last known mining disturbance 1955 - 1962

Plot aspect southeast Plot slope in degrees 19

Plot size 55' x 45'

Original planting date 5/19/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 101

Number of plants living at 10/25/78 was 76 = 75 %

Spoil pH from lab test: water 5.4 buffer 6.4

Plot location on slope adjacent to highwall

Spoil color light brown

Rock fragments many to 12" D.

Parent material of surface spoil shale majority

Degree of erosion severe; much sheet erosion leaving very rocky surface; several small gullies to 1' deep

Existing vegetation: % cover 30 description w. grass is majority, kr. lespedeza, blackberry, broomsedge, V. pine to 4'

Vegetation of adjacent areas broomsedge, ironweed, blackberry, t. sedge, g. brier, s. lespedeza, st. sumac to 10', sycamore to 35', n.r. oak to 50', E. r. cedar to 8', f. dogwood to 10', n. alder, r. maple to 10', A. holly to 6', pt. oak to 30', tree of heaven to 25'

THESIS PLOT DATA

Plant name, common autumn olive

Plant name, scientific *Elaegnus umbellata*

Mine no. 0104 - A Site recon. no. 759

State: Ky. County: Clay Subwatershed: Little Goose

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1955 - 1962

Plot aspect northeast Plot slope in degrees 0 - 2

Plot size 60' x 30'

Original planting date 5/12/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 4' x 4'

Original number of plants within plot 70

Number of plants living at 8/25/78 was 67 = 95 %

Spoil pH from lab test: water 3.8 buffer 5.1

Plot location top of berm on fill bench

Spoil color light brown

Rock fragments many small fragments 1" - 12" D., mostly coal

Parent material of surface spoil shale majority, some sandstone

Degree of erosion very little; no gullying but some depressions caused by previous erosion and weathering

Existing vegetation: % cover 80 description broomsedge to 3', w. grass is majority, sourwood to 3', t. sedge to 3', ironweed to 2', blackberry to 1'

Vegetation of adjacent areas V. pine and sh. pine to 20', s. lespedeza, b. locust to 8', n.r., w., b. oaks to 70', t. poplar to 30', r. maple to 30', p. hickory to 55'

THESIS PLOT DATA

Plant name, common autumn olive

Plant name, scientific *Elaeagnus umbellata*

Mine no. 0104 - A Site recon. no. 759

State: Ky. County: Clay Subwatershed: Little Goose

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1955 - 1962

Plot aspect southeast Plot slope in degrees 2

Plot size 90' x 35'

Original planting date 5/12/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 5' x 5'

Original number of plants within plot 130

Number of plants living at 8/25/78 was 68 = 52 %

Spoil pH from lab test: water 3.7 buffer 4.4

Plot location top of berm on fill bench

Spoil color mixed; light brown to medium gray

Rock fragments many, from 1 - 6" D., mostly shale and coal fragments

Parent material of surface spoil shale majority

Degree of erosion slight; 1 gully runs through plot to 6" deep and 3' wide

Existing vegetation: % cover 15 description V. pine to 10', broomsedge to 2'

Vegetation of adjacent areas b. locust to 15', t. poplar to 70', e. redbud to 6', sycamore to 35', ironweed to 4', t. sedge to 5', goldenrod to 3', blackberry to 3', s. lespedeza to 3', V. pine to 30', p. hickory to 45', n.r. oak to 40'

THESIS PLOT DATA

Plant name, common black locust

Plant name, scientific *Robinia pseudoacacia*

Mine no. 0104 - A Site recon. no. 759

State: Ky. County: Clay Subwatershed: Little Goose

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1955 - 1962

Plot aspect west Plot slope in degrees 33

Plot size 50' x 40'

Original planting date 5/12/78

Seedlings at time of planting: size 8 - 16" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 70

Number of plants living at 8/25/78 was 35 = 50 %

Spoil pH from lab test: water 3.8 buffer 5.0

Plot location outslope

Spoil color variable; light brown to light gray

Rock fragments many from 1" D. - 6' D. sandstone and shale

Parent material of surface spoil sandstone and shale

Degree of erosion severely eroded; deeply gullied; gullies range from 18" - 6' deep and 3' - 12' wide

Existing vegetation: % cover 0 description none (extremely hot and rocky)

Vegetation of adjacent areas w. oak to 30', sycamore to 45', t. poplar to 35', b. locust to 8', sh. pine to 20', V. pine to 10', pokeberry to 4', sourwood to 7', s. birch to 15'

THESIS PLOT DATA

Plant name, common Virginia pine

Plant name, scientific *Pinus virginiana*

Mine no. 0104 - A Site recon. no. 759

State: Ky. County: Clay Subwatershed: Little Goose

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1955 - 1962

Plot aspect east Plot slope in degrees 0 - 1

Plot size 60' x 25'

Original planting date 5/12/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 104

Number of plants living at 8/25/78 was 27 = 25 %

Spoil pH from lab test: water 3.8 buffer 5.1

Plot location berm on fill bench

Spoil color medium gray

Rock fragments many small fragments 1 - 5" D.; no large ones

Parent material of surface spoil shale majority

Degree of erosion very slight; plot bordered on one end by gully which drains back onto bench

Existing vegetation: % cover 25 description majority is V. pine to 10', deertongue to 1', broomsedge to 3', w. grass

Vegetation of adjacent areas t. poplar to 45', sycamore to 30', sh. & V. pine to 30', st. sumac to 5', goldenrod to 4', ironweed to 5', t. sedge to 4', deertongue to 2', b. locust to 6', w. oak to 60', n.r. oak to 60', r. maple to 25', b. gum to 8', p. hickory to 60'

THESIS PLOT DATA

Plant name, common Virginia pine

Plant name, scientific *Pinus virginiana*

Mine no. 0104 - A Site recon. no. 759

State: Ky. County: Clay Subwatershed: Little Goose

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1955 - 1962

Plot aspect east Plot slope in degrees 30

Plot size 60' x 50'

Original planting date 5/12/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 4' x 4'

Original number of plants within plot 100

Number of plants living at 8/25/78 was 15 = 15 %

Spoil pH from lab test: water 3.6 buffer 5.2

Plot location steep outslope

Spoil color light brown

Rock fragments many small 1 - 3" D. shale fragments

Parent material of surface spoil shale mostly

Degree of erosion severely gullied across entire plot; gullies from 3 - 6' deep and 2 - 8' wide

Existing vegetation: % cover 0 - 5 description t. sedge to 3', blackberry to 2', sourwood to 5', 1 s. birch to 10'

Vegetation of adjacent areas sourwood to 10', w. oak to 30', sycamore to 35', t. poplar to 25', sh. pine to 10', n.r. oak to 45', b. locust to 10', ironweed to 5'

THESIS PLOT DATA

Plant name, common Virginia pine

Plant name, scientific *Pinus Virginiana*

Mine no. 0037 - A Site recon. no. 695

State: Ky. County: Clay Subwatershed: Gray's Fork

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1955 - 1962

Plot aspect south Plot slope in degrees 4

Plot size 60' x 45'

Original planting date 4/14/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 60

Number of plants living at 8/10/78 was 58 = 96 %

Spoil pH from lab test: water 3.6 buffer 4.9

Plot location fill bench

Spoil color light gray

Rock fragments few between 1" and 4" D. (sandstone)

Parent material of surface spoil shale majority

Degree of erosion slight; no gullies in plot

Existing vegetation: % cover 25 description blackberry to 3' and broomsedge to 3' ***majority***, w. grass, V. pine to 2'

Vegetation of adjacent areas s. oak to 15', V. pine to 20', t. poplar to 45', m. hickory to 40', w. oak to 40', n.r. oak to 75', blackberry to 4', s. lespedeza to 3', sassafras to 6'

THESIS PLOT DATA

Plant name, common autumn olive

Plant name, scientific *Elaeagnus umbellata*

Mine no. 0040 - B Site recon. no. 696

State: Ky. County: Clay Subwatershed: Little Goose

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1955 - 1962

Plot aspect north Plot slope in degrees 0 - 2

Plot size 50' x 45'

Original planting date 4/6/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 6' x 6'

Original number of plants within plot 60

Number of plants living at 8/10/78 was 17 = 28 %

Spoil pH from lab test: water 3.6 buffer 4.9

Plot location bench

Spoil color light gray

Rock fragments several to 4" D.; most less than 1" D.

Parent material of surface spoil shale; spoil very shallow

Degree of erosion very slight; no gullies

Existing vegetation: % cover 0 - 5 description w. grass

Vegetation of adjacent areas sh. pine and V. pine to 15' high, deertongue to 1', goldenrod to 2', sh. sumac to 5', ironweed to 6', c. thistle to 4', sourwood to 15', sassafras to 10', w. and n.r. oak to 40', t. poplar to 25'

THESIS PLOT DATA

Plant name, common white pine

Plant name, scientific *Pinus strobus*

Mine no. 0049 - A Site recon. no. 1214

State: Ky. County: Harlan Subwatershed: Cranks Creek

Coal seam name Creech Approx. elevation MSL 1900

Last known mining disturbance 1964

Plot aspect south Plot slope in degrees 13

Plot size 120' x 30'

Original planting date 4/7/78

Seedlings at time of planting: size 6 - 12" age in years 2

Approximate spacing 6' x 6'

Original number of plants within plot 160

Number of plants living at 11/1/78 was 143 = 89 %

Spoil pH from lab test: water 5.3 buffer 6.1

Plot location lower edge of highwall

Spoil color light brown & light gray

Rock fragments many to 36" D.; larger fragments are sandstone

Parent material of surface spoil shale and sandstone

Degree of erosion slight; only shallow surface erosion has occurred; no gullies present

Existing vegetation: % cover 70 description w. lovegrass, K. 31 t. fescue, kb. lespedeza

Vegetation of adjacent areas pokeberry, w. lovegrass, K. 31 t. fescue, blackberry, w. oak to 25', n.r. oak to 50', t. poplar to 80', s. maple to 15', w. ash to 30', m. hickory to 30', sg. hickory to 60', b. cherry to 45', b. locust to 40', A. beech to 40', r. paulownia to 65', w. grape

THESIS PLOT DATA

Plant name, common white pine

Plant name, scientific *Pinus strobus*

Mine no. 0049 - A Site recon. no. 1214

State: Ky. County: Harlan Subwatershed: Cranks Creek

Coal seam name Creech Approx. elevation MSL 1900

Last known mining disturbance 1954

Plot aspect south Plot slope in degrees 35

Plot size 75' x 25'

Original planting date 4/7/78

Seedlings at time of planting: size 6 - 12" age in years 2

Approximate spacing 8' x 8'

Original number of plants within plot 93

Number of plants living at 11/1/78 was 86 = 92 %

Spoil pH from lab test: water 4.9 buffer 6.1

Plot location highwall

Spoil color tan - light brown

Rock fragments many to 36" D.

Parent material of surface spoil shale majority

Degree of erosion severe; several small gullies to 6" deep; much material on surface has eroded from above

Existing vegetation: % cover 30 description K. 31 t. fescue, broomsedge to 3', 1 tree of heaven to 7', 1 t. sedge, 1 pokeberry

Vegetation of adjacent areas broomsedge, K. 31 t. fescue, t. sedge, goldenrod, p. grass, E. r. cedar, 1. pine to 40', r. paulownia to 25', tree of heaven to 30', b. locust to 35', A. elm to 10', t. poplar to 60', m. hickory to 60'

THESIS PLOT DATA

Plant name, common autumn olive

Plant name, scientific *Elaeagnus umbellata*

Mine no. 0104 - A Site recon. no. 759

State: Ky. County: Clay Subwatershed: Little Goose

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1955 - 1962

Plot aspect south Plot slope in degrees 0 - 5

Plot size 85' x 35'

Original planting date 5/12/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 4' x 4'

Original number of plants within plot 211

Number of plants living at 8/10/78 was 74 = 35 %

Spoil pH from lab test: water 4.1 buffer 5.4

Plot location top of fill bench berm

Spoil color medium gray

Rock fragments few from 1 - 6" D.

Parent material of surface spoil shale, well weathered

Degree of erosion moderate; several small gullies eroding near ends of plot to 18" deep and 6' wide

Existing vegetation: % cover 0 - 5 description s. sorrel to 3", w. grass is majority, 2 b. locust to 3' high, 1 deertongue clump to 1'

Vegetation of adjacent areas b. gum to 5', b. locust to 10', sh. and l. pines to 35', sycamore to 15', t. poplar to 15', b. oak to 45', m. hickory to 70'

THESIS PLOT DATA

Plant name, common European black alder

Plant name, scientific *Alnus glutinosa*

Mine no. 0104 - A Site recon. no. 759

State: Ky. County: Clay Subwatershed: Little Goose

Coal seam name Horse Creek Approx. elevation MSL 1100 - 1150

Last known mining disturbance 1955 - 1962

Plot aspect south Plot slope in degrees 0 - 5

Plot size 115' x 20'

Original planting date 5/12/78

Seedlings at time of planting: size 6 - 12" age in years 1

Approximate spacing 5' x 5'

Original number of plants within plot 122

Number of plants living at 8/10/78 was 111 = 90 %

Spoil pH from lab test: water 4.2 buffer 5.2

Plot location bench

Spoil color medium gray

Rock fragments few black fragments 1 - 4" D.

Parent material of surface spoil shale, eroded from highwall and berm

Degree of erosion slight active gullying through center of bench where water drains

Existing vegetation: % cover 25 description mostly o. grass to 2' high in clumps, 1 sh. pine to 4', 1 b. gum

Vegetation of adjacent areas b. gum to 5', b. locust to 10', sh. and l. pines to 35', sycamore to 15', t. poplar to 15', b. oak to 45', m. hickory to 70'

WOODY PLANT SEEDLING SURVIVAL AS RELATED TO SITE CONDITIONS ON SOUTHEASTERN KENTUCKY ORPHAN LANDS

by

LARRY JOE LEACH

B.S. in Agriculture
University of Kentucky, 1971

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF LANDSCAPE ARCHITECTURE

Department of Landscape Architecture

KANSAS STATE UNIVERSITY
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1980

ABSTRACT

Field research was conducted over a seventeen month period in 1977 and 1978 to collect site condition data on southeastern Kentucky orphan mines that had only partially revegetated twelve to twenty-four years after mining. The mines studied had been planted with woody plant seedlings under a Tennessee Valley Authority funded demonstration project. They were located on the Lily coal seam in Laurel County, the Horse Creek coal seam in Clay County, the Creech and the Darby coal seams in Harlan County.

Eighty-seven test plots were sampled, ranging in size from .02 acre to .10 acre, to collect site data to relate seedling survival results for autumn olive, Elaeagnus umbellata; bicolor lespedeza, Lespedeza bicolor; black locust, Robinia pseudoacacia; Chinese chestnut, Castanea mollissima; European black alder, Alnus glutinosa; loblolly pine, Pinus taeda; Scotch pine, Pinus sylvestris; shortleaf pine, Pinus echinata; tulip poplar, Liriodendron tulipifera; Virginia pine, Pinus virginiana; and white pine, Pinus strobus.

Seedling survival showed considerable variation. Average survival for species with three or more test plots showed European black alder most successful, at 92%; shortleaf pine next, at 85%; black locust, 79%; Virginia pine, 73%; loblolly pine, 66%; autumn olive, 61%.

Research data showed that water pH was the most reliable predictor of seedling survival, of those site conditions measured and considered alone. Buffer pH was the next most reliable predictor, followed by the percentage of existing plant cover found on the plot.

Spoil color was found to be less reliable as were the individual plant invaders. Aspect, plot position on the mine, slope, degree of erosion, and occurrence of rock fragments were found to be unreliable predictors of seedling survival.

Relationships between the site conditions and seedling survival were individually analyzed, except for bicolor lespedeza, Chinese chestnut, Scotch pine, tulip poplar, and white pine, which did not have large enough data samples. When a 70% seedling survival standard was established, a relative comparison of tolerance to all site conditions was obtained. This comparison rated shortleaf pine, at 100, as the best plant species used; European black alder, 97; black locust, 81; Virginia pine, 69; loblolly pine, 55; and autumn olive, 29.