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STRIP-MINED LANDS OF THE WESTERN INTERIOR COAL PROVINCE

Nelson F. Rogers

A Contribution of the
CENTRAL STATES FOREST EXPERIMENT STATION,
FOREST SERVICE, U. S. DEPARTMENT OF AGRICULTURE

FOREWORD

There is much interest at this time in restoring to productivity those areas of land which for various reasons have lost their productive capacities. One of many ways in which land is taken out of production is by strip mining for coal. In removing the overburden from the coal to be mined, the soil is destroyed.

The heterogeneous mixture which results when the overburden is broken up, removed, and thrown into the spoil bank is material from which soil eventually will be formed. The transformation of this mixture to productive soil will require many years, depending on the nature of the mixture and the possibility of modifying it by applying practices and treatments that research has shown to be effective. The Agricultural Experiment Station is interested in conducting research which will discover the answers to the problems of restoring these areas to some degree of production.

These areas once were covered with soil which supported trees, grasses, or cultivated crops. Grasses and cultivated crops have relatively shallow roots, and fairly high concentrations of plant food must be available in the upper layer of soil to support their growth. The acidity or alkalinity of soils affects the availability of the mineral plant foods, and, when either is excessive, plant growth may be inhibited. Reference in this bulletin to sick and healthy patches of plant growth in some of these areas indicates plant food deficiencies of some kind. Trees have much deeper and more extensive roots than herbaceous plants, and can grow with a much lower level of plant food. But a deficiency of one or more plant foods may also inhibit the growth of trees.

This bulletin surveys the situation and outlines some of the problems involved in rehabilitating strip-mine areas. Further studies are needed to add to the present rather meager knowledge. The research programs of the Departments of Soils and Forestry will include studies of these problems in the years ahead.

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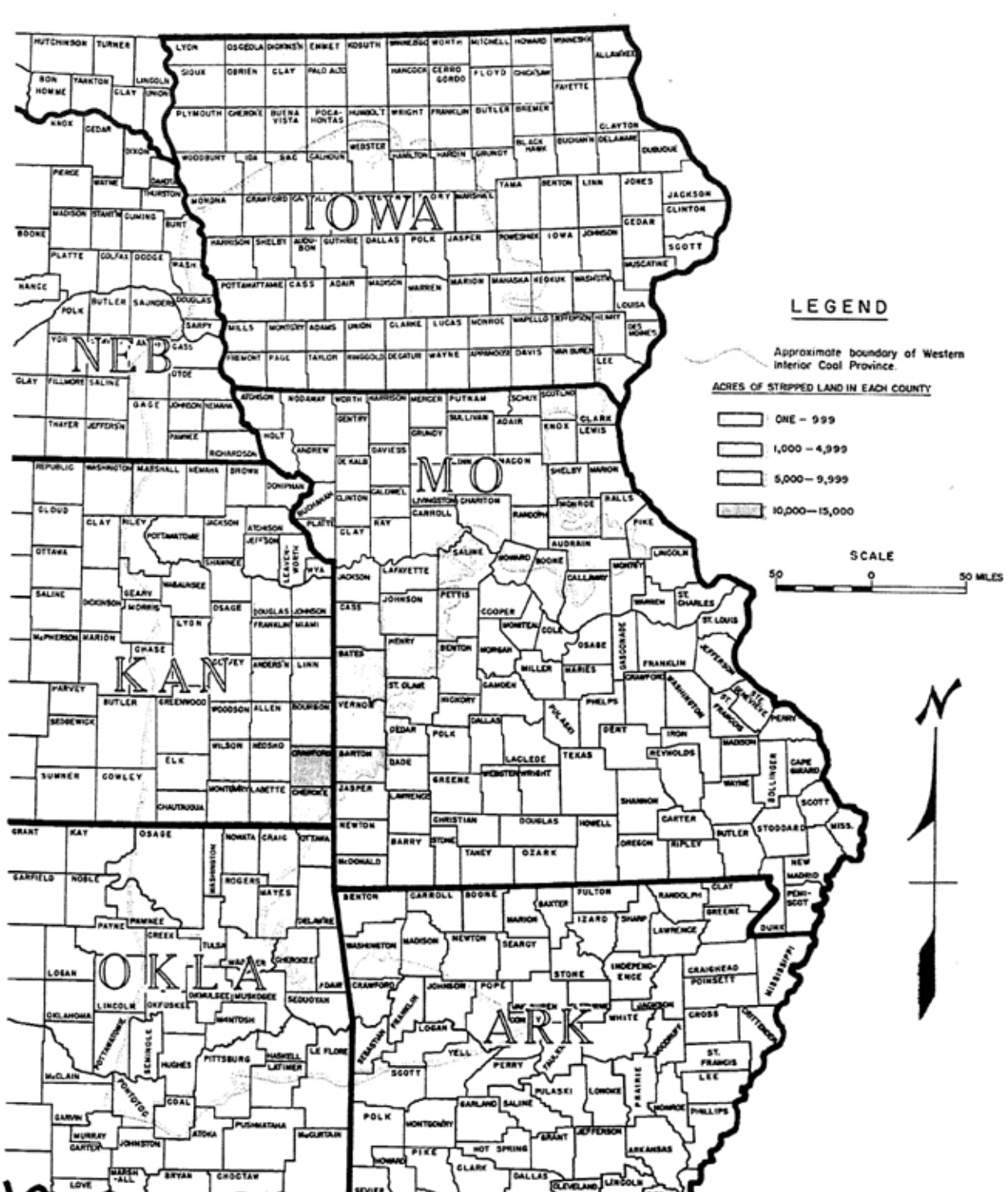

The Western Interior Coal Province. (Boundaries of the Province from "The Coal Fields of the United States," by Marius R. Campbell. U.S.G.S. Professional Paper 100 A, 1922.)

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STRIP-MINED LANDS OF THE WESTERN INTERIOR COAL PROVINCE

NELSON F. ROGERS

INTRODUCTION

About 65,000 acres of land have been strip mined for coal in Arkansas, Oklahoma, Kansas, Missouri, and Iowa. Most of these lands are located in 46 counties along the eastern boundary of a region known as the Western Interior Coal Province (3)[1]. The total area affected by mining operations in each of these counties ranges from only a few acres to more than 12,000 acres; the highest concentration of stripping for coal in the Province is in southeastern Kansas and southwestern Missouri (frontispiece).

Strip-mined land, increasing in the area by about 3,000 acres annually during the past 10 years, presents a problem in planned land use. The local economy, once exclusively agricultural, has now been changed by mining to an agricultural and industrial economy. After mining, the affected area should be restored to some kind of productivity.

The surfaces of land altered by strip mining are a mixture of diverse rocks and soils, piled in a series of narrow, sometimes irregular ridges up to 40 feet high and 100 feet between crests. The surface is essentially a new medium for plant growth, and its potentialities are not well enough known. Recreational facilities, pastures, forest plantations, fruit orchards, and fish and wildlife refuges have been developed on these banks with varying success.

The Central States Forest Experiment Station made a survey in 1946 to find out the location, area, and condition of strip-mined land in the Province. In this survey each strip-mined area five acres and larger was examined to determine ownership of land, method of mining, date of mining, coal seam mined, name of producer, and current use. A record of the topography, texture, acidity, degree of erosion, and density of plant cover was made. Maps of each area, prepared from aerial photographs and records of coal producers, were verified by actual field checks. More than

[1]Numbers in parenthesis refer to Literature Cited, listed on page 42.

600 samples of strata over the coal seams and more than 200 samples of surface bank materials were collected and analyzed for acidity and the amount of available phosphorus, potash, calcium, and organic matter. The results of this survey and other descriptive information on the rehabilitation of these areas are summarized in this paper.

HISTORY OF STRIP MINING

Coal was first mined by stripping in the Western Interior Coal Province some time before 1850, and the development of the industry has kept pace with the progress of mechanization during the past century. Early diggings were made by primitive pick-and-shovel methods. Later, animal-drawn scrapers were used. The steam shovel appeared on the scene in 1877, and by 1905 revolving shovels with dipper capacities of 2 yards were in use. During the past quarter-century some of the largest earth-moving

Photograph, Courtesy U. S. Soil Conservation Service

Figure 1.—Shovel and dragline stripping operation for the No. 6, Weir-Pittsburg, coal; Missouri-Kansas State Line, 4 miles north of Mulberry, Kansas. The equipment visible in this figure from foreground to the rear includes: rotary pump used to pump surface water out of pit, road grader, trucks for hauling coal to tipple, coal-loading shovel, bulldozer used to clean off coal seam, stripping shovel with capacity of 25 cubic yards, and dragline with a 200-foot boom and 9-cubic-yard bucket. The "high-wall" on the right is about 48 feet high. Newly formed banks are on the left. This is a typical operation with a shovel and dragline working in tandem.

machines in the world have been used to remove the overburden. Those used in this Province include electric and diesel-powered shovels with dipper capacities of 35 cubic yards, draglines with 200-foot booms and 15-yard scoops, and trucks with capacities of 80 tons for transporting coal from pit to tipple.

By 1946, about 80 per cent of the land strip mined was mined using power shovels, singly or with the dragline and other equipment (Fig. 1). Bulldozers, carryalls, and several kinds of scrapers pulled with tractors are used on some small operations. On large operations the coal seams are uncovered by removing successive strips of overburden 40 to 100 feet wide and 20 to 50 feet thick. The first cut (called the box cut) is made at the coal seam outcrop in hilly country, or at the property line on level terrain. The overburden from this first cut is piled on the ground next to the area to be strip mined. The exposed coal is then loaded into trucks and carried to a processing plant or a shipping point. When the second and subsequent cuts are made, the overburden is piled into the previously-made cuts. The operation of stripping equipment is rather methodical, so for any given locality, coal seam, and method of mining, the resulting surfaces usually have similar characteristics.

Two hundred and seventeen known operators have mined about 86 per cent of the total land stripped. Thirty-three companies, 28 of which are still operating, have stripped 400 or more acres each. These 33 companies have mined 61 per cent of the total strip-mined land in the Province. In other words, as shown in Table 1, about 15 per cent of the known coal producers have stripped 61 per cent of the total strip-mined area.

Table 1.--Number of known strip-mine operators in the Western Interior Coal Province by states, size of operation, and proportion of total area mined, 1946.

State	Total number known operators	Proportion of total area stripped by known operators (percent)	Number of known operators who have stripped more than 400 acres	Proportion of total area stripped by operators who have stripped more than 400 acres (percent)
Arkansas	16	80	6	40
Iowa	14	73	5	50
Kansas	112	85	8	60
Missouri	55	89	9	63
Oklahoma	20	84	5	67
Total	217	86	33	61

COAL-BEARING FORMATIONS

The following description of the coal-bearing formations in the Western Interior Coal Province is not presumed to be complete. Its purpose is simply to show the close relationship between the character of these formations and the problems to consider in reclaiming strip-mined land.

Stratigraphy

The coal-bearing rocks of the Western Interior Coal Province were formed largely by sedimentation during the great coal-forming age known as the Pennsylvanian period. The Pennsylvanian system of rock lies unconformably over Mississippian, Devonian, Silurian, Ordivician, Cambrian, and Precambrian rocks, and in general dips 20 to 25 feet per mile to the west-northwest (5) (6) (8). The rock and coal outcrops are in a general north and south direction on the eastern edge of the Province.

The sedimentation of the Pennsylvanian formations in this Province is considered cyclic (1). In each complete cycle, called a cyclothem, eight different strata are recognized. From bottom to top, these are sandstone (which rests unconformably on lower beds and in some places occupies channels cut beneath horizons of other cyclothems), sandy shales, underclay, coal, black shale, gray shale, limestone, and calcareous shale. Each of these strata is discontinuous and varies greatly in thickness. Therefore, with rare exceptions, cyclothems are incomplete in that they lack one or several of the members. The shales are usually the thickest members. The limestones are thicker and more widely distributed in Upper Pennsylvanian formations. Most of the coal deposits in the Province are in the Lower Pennsylvanian.

The Coal Seams Strip Mined

More than 30 different coal seams have been recognized in the Western Interior Coal Province. The oldest seam, No. 1, is near the bottom of the Pennsylvanian system. Coal seams are usually the thinnest members of cyclothems and no single seam is present in all parts of the region. Each seam varies considerably in thickness and distance below the earth's surface, so it may be commercially important in some places, of use only for local fuel in others, and of no economic value elsewhere. In general, seams 18 inches thick at depths of less than 40 to 50 feet are considered minable. As shown in Table 2, coal has been commercially recovered by strip mining at least three different seams in Arkansas, seven in Oklahoma, nine in Kansas, seven in Missouri, and three in Iowa.

Although coal-bearing formations in the Province extend beyond state boundaries, the coal seams have been named more or less independently in each state. In some states, three or more local names apply to the same coal. The names of the coal seams given in Table 2 are, on the basis of the best information available, those most commonly used in each state (1), (3), (5), (6), (8).

Seventy-nine per cent of the strip-mined area in the Province has been created by the mining of five coal seams (Table 3): Weir, No. 6; Mineral, No. 9; Croweburg, No. 12; Bevier, No. 14; and Mulberry, No. 18.

Ideal strip-mining conditions in the Province require (a) a large area of level terrain, (b) a uniform thickness of good quality coal within 50 feet of the surface, and (c) a good market for the coal. These conditions occurred over the largest areas in Cherokee and Crawford Counties, Kansas, and in Barton County, Missouri, where the Weir, No. 6, Mineral, No. 9,

Table 2.--Coal seams strip-mined in the Western Interior Province by number of seam and local name.

Coal seam No.	State				
	Arkansas	Oklahoma	Kansas	Missouri	Iowa
	Coal seam name of greatest local usage				
28	----------	----------	Nodaway	----------	----------
22	----------	----------	Thayer	----------	----------
19	----------	Dawson	----------	----------	----------
18	----------	----------	Mulberry	Mulberry	----------
17	----------	----------	----------	----------	Mystic
16	----------	----------	----------	----------	Summit
15	----------	Ft. Scott	Mulky	Mulky	----------
14	----------	----------	Bevier	Bevier	----------
12	----------	Broken Arrow	Croweburg	Croweburg	Whitebreast
10	----------	Fleming	----------	Fleming	----------
9	----------	Henryetta	Mineral	Tebo[1/]	----------
6	----------	Secor	Weir-Pittsburg	Weir-Pittsburg[2/]	----------
4	Paris	----------	Rowe	----------	----------
3	Charleston	McAlester	Columbus	----------	----------
2	----------	Upper Hartshorne	----------	----------	----------
1	Lower Hartshorne	Lower Hartshorne	Riverton	----------	----------

1/ "The Missouri Geological Survey no longer correlates the Mineral Coal (No. 9), of Kansas with the Tebo Coal of Henry County, Missouri. Work now in progress by the Survey appears to be leading toward correct correlation of these two seams," according to Dr. Walter V. Searight of the Missouri Geological Survey.

2/ In the ensuing discussions, this seam is called the "Weir."

Table 3.--Area of strip-mined land in the Western Interior Coal Province by coal seam and state, 1946.

State	Weir No. 6 (acres)	Mineral No. 9 (acres)	Croweburg No. 12 (acres)	Bevier No. 14 (acres)	Mulberry No. 18 (acres)	All others (acres)	Total (acres)
Kansas	5,519	9,435	487	6,225	1,011	2,505	25,182
Missouri	8,790	4,466	2,497	3,856	4,353	1,534	25,496
Oklahoma	254	352	4,114	1	0	3,595	8,316
Arkansas	0	0	0	0	0	3,170	3,170
Iowa	0	0	0	0	0	2,499	2,499
Total	14,563	14,253	7,098	10,082	5,364	13,303	64,663
% of total	22	22	11	16	8	21	100

and Bevier, No. 14, coals were mined extensively. As a result, 13,784 acres, or 3.6 per cent of the land area in Crawford County; 7,480 acres, or 2.0 per cent of land area in Cherokee County, and 9,039 acres, or 2.4 per cent of land area in Barton County, have been strip mined. Other areas that have met these requirements but to a lesser extent are in Bates, Macon and Randolph Counties, Missouri, and Wagoner, Tulsa, and Rogers Counties in Oklahoma. Relatively large areas strip mined in Missouri and Oklahoma in recent years have been in rough and hilly country not generally suited to agriculture.

Overburden Analyses

Whether or not coal mining by stripping is feasible depends upon the thickness, quality, and uniformity of the coal seam, the thickness and physical character of the overburden, and the topography of the land. The reclamation of strip-mined lands is also influenced by these conditions. The chemical properties of the overburden also have an important bearing on the development of these lands for some productive use.

The strata overlying coal seams differ widely in thickness and in chemical and physical composition (Fig. 2 and Table 4)[2]. Because mine banks are a mixture of the materials in these strata, a knowledge of their relative thickness, composition, and structure is useful in considering the uses of strip-mined land. These strata are a series of shales, sandstones, limestones, clays, and the weathered derivities—soil and subsoil. A preponderance of sand, sandstone, and sandy shales in the overburden usually results in banks with coarse texture, good aeration, and relatively low fertility. Banks derived mainly from silty shales, loess, and loamy soils usually have good aeration and high fertility. Glacial till, being of variable composition, produces sandy, loamy, or clayey banks with varying proportions of boulders.

The strata over a given coal seam also vary in thickness and in chemical and physical composition. For example, as shown in Tables 5 and 6, the strata overlying the Mineral, No. 9, coal in one section of Vernon Coun-

[2]The analyses given in Tables 4, 5, and 6 are of sample high-walls and should not be considered as representative of all banks in the region; variations are so great, and data so voluminous that separate publications giving detailed overburden analyses are planned for each state in the Province.

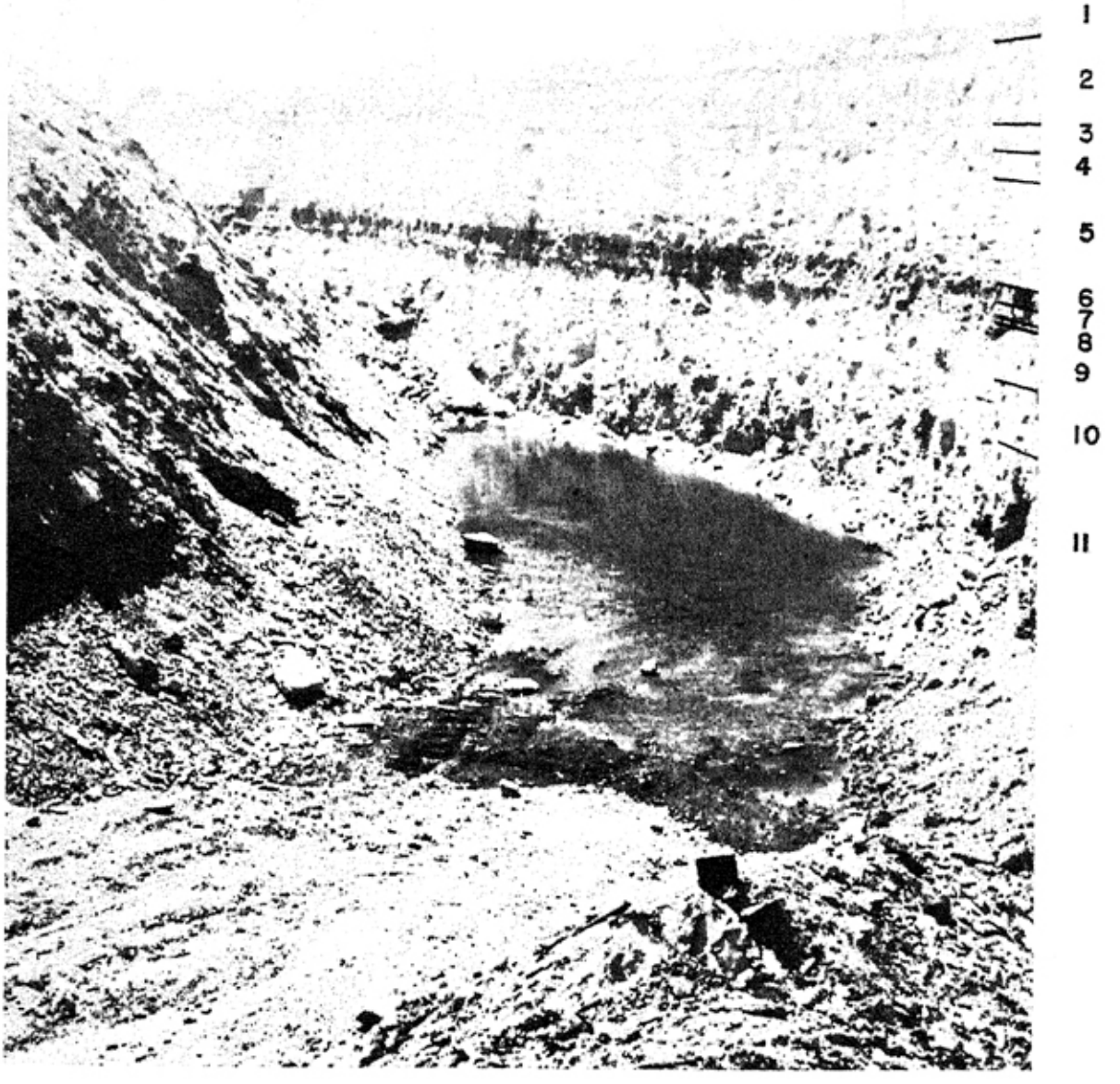

Figure 2.—Sample "high-wall" which shows about 60 feet of overburden over Weir, No. 6, coal, Barton County, Missouri. The description and chemical analyses of strata shown in this photograph are listed in Table 4.

ty, Missouri, were remarkably different from those found over the same coal in a Henry County location. Three distinct seams of thin, unminable coal and associated underclays, occurred in the section sampled in Henry County, whereas in Vernon County only one coal seam appeared in the high-wall over the No. 9 coal. In Henry County a distinct limestone stratum was present in the high-wall, but was absent in the high-wall sampled in Vernon County. Marked differences in acidity, available phosphorus and potassium, percentage of organic matter, and exchangeable calcium are also shown in these two tables.

The data in Tables 4, 5, and 6 show that different types of mine banks may result from different methods of mining. For example, if the highly

Table 4.--Descriptions and chemical analyses of the strata over Weir, No. 6, coal in Barton County, Missouri. (Analyses are for samples taken from high-wall shown in Figure 3.)

Strata No.	Description of strata (Top to bottom)	Thickness of strata (feet)	Acidity of strata (pH)	Available Phosphorus (ppm[1])	Available Potassium (ppm)	Organic matter (%)	Exchangeable calcium
1	Soil--Parsons silt loam	1	4.7	16	43	1.9	Very low
2	Subsoil--mottled buff, orange, black, gray streaks, claypan	8 - 10	5.8	4	35	.7	Low
3	Shale--sandy, buff	2 - 3	5.8	81	36	.0	Very low
4	Sandstone--reddish-brown, massive	2 - 4	---	--	---	---	---------
5	Shale--silty, buff to orange with 1/2-in. limestone bands, and thin streaks of gypsum crystals	8 - 12	6.0	81	22	.3	Very low
6	Shale--black, slaty with one limestone band	6 - 8	6.2	81	140	3.5	Very high
7	Shale--black, fossiliferous, massive	1/2 - 1	7.9	16	137	6.9	Very high
8	Coal--No. 7, Pilot, not recovered	3/4 - 1	---	--	---	---	---------
9	Underclay--dark blue-gray to gray	5 - 6	6.9	16	78	.8	Very low
10	Sandstone--calcareous, light gray, micaceous	6 - 8	7.4	48	140	.6	Very low
11	Shale--massive, light gray to dark blue and black below, with 1/2 - 2-in. limestone bands of same color	18 - 22	7.2	81	140	.7	Very low

[1] ppm = parts per million.

acid underclay listed in Table 6 comes to rest on the surface, it will be toxic and nonplantable. If, on the other hand, the calcareous shales and limestones come to rest on the surfaces, it may be highly productive.

CHARACTER OF STRIP-MINED LAND

Almost 93 per cent of the strip-mined land in the Western Interior Coal Province is a series of low, steep, nearly parallel ridges (Fig. 3); the rest is level or nearly level. Water covers an estimated 8 per cent of the

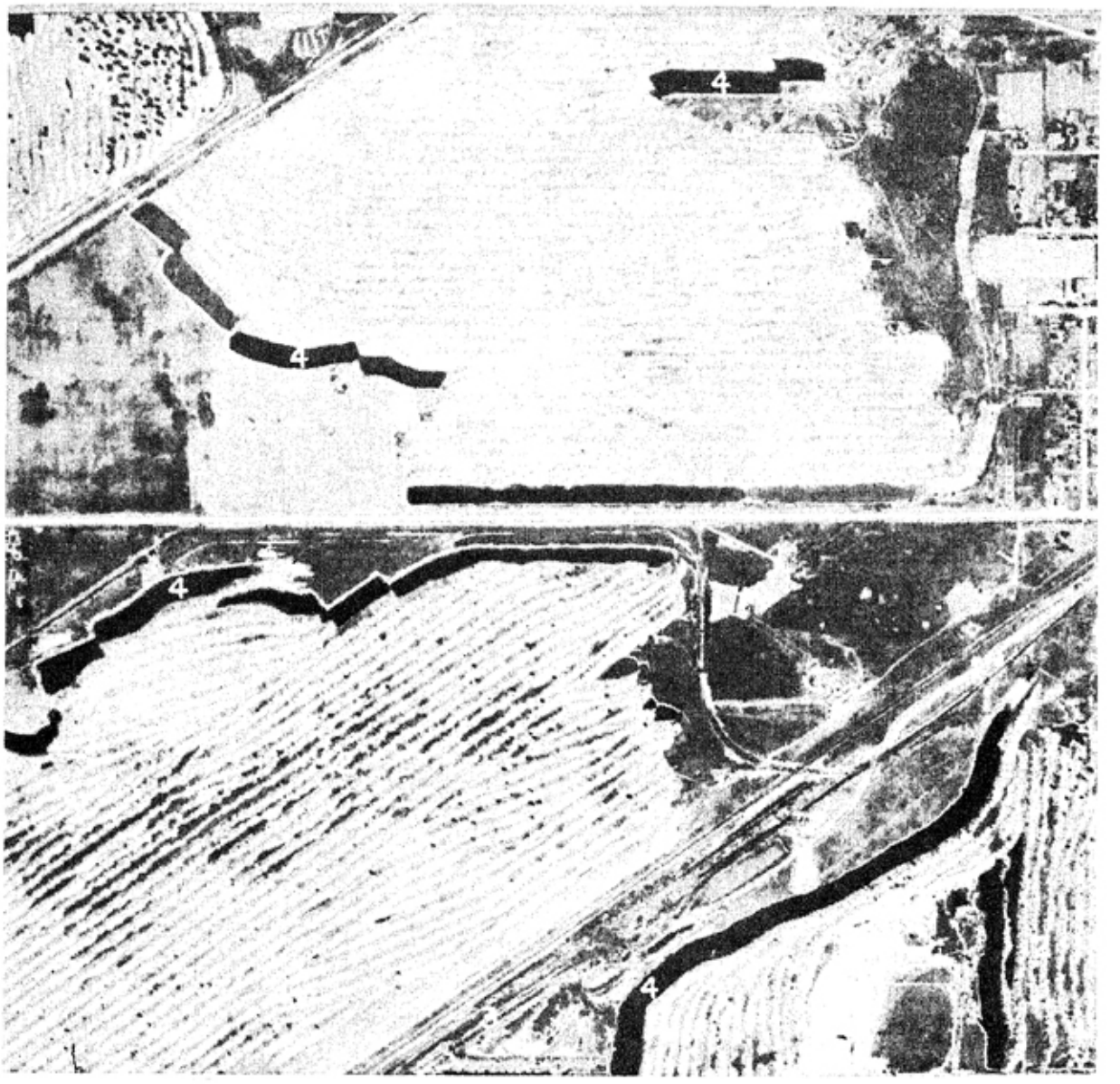

Figure 3.—Aerial photograph taken on August 9, 1938, of a 640-acre tract extensively strip mined in Barton County, Missouri. Part of the town of Mindenmines (1) is shown in the upper right border of the photo. More than 400 acres, or 62 per cent of the area, was stripped (2) for the Weir, No. 6, coal during the period from 1930 to 1934. In addition, more than 40 acres of unmined land are being used as processing plants and tipples (3) railroads, truck-haul roads, refuse dumps, drainage ditches, etc. Unmined lands not needed for industrial or municipal purposes are used largely for the production of hay.

An examination in 1946, of the stripped land shown in this aerial view disclosed the following conditions as to plant cover and land use: About 30 per cent of the land surface was barren; 5 per cent was well stocked with trees, including natural cover of elm, black cherry, pin oak, dogwood, willow, and catalpa, and a 4-acre plantation of black locust, ponderosa pine, and eastern red cedar; 20 per cent of the area was covered with such shrubs as coral-berry, sumac, lead plant, and blackberry; and 45 per cent of the area was covered with grasses and weeds. In addition, the lakes (4) formed in the final cuts of the stripping operation and covering 35 acres, had been stocked with game fish and were yielding good catches.

surface of most areas and as much as 20 per cent of the strip-mined land in some sections.

Banks are a structureless conglomerate of soil, subsoil, and unweathered rocks (Fig. 4). Depending on which are the most predominant, surface texture is described in this paper as stony, shaly, sandy, silty, clayey, or a combination of two of these. The chemical reaction of surface materials is described as toxic (pH below 4.0), acid (pH range of 4.1 to 6.9), or calcareous (pH 7.0 or higher). Most mine banks have enough phosphorus, potash, and calcium to support good plant growth. About 54 per

Table 5.--Descriptions and chemical analyses of strata over Mineral, No. 9, coal at one location in Vernon County, Missouri.

Table 5.--Descriptions and chemical analyses of strata over Mineral, No. 9, coal at one location in Vernon County, Missouri.

Description of strata (Top to bottom)	Thickness of strata (feet)	Acidity of strata (pH)	Available Phosphorus (ppm[1/])	Available Potassium (ppm)	Organic matter (%)	Exchangeable calcium
Soil--grayish-brown, fine sandy clay loam	1/4 - 1 1/2	5.1	5	137	1.0	Low
Subsoil--claypan, gray brown to orange buff, sandy clay with chert in lower one-half, mottled orange, gray, and black	6 - 10	5.9	8	140	.8	High
Shale--light gray, silty, soft	2 - 3	6.2	21	140	6.0	Medium
Shale--olive drab on top, silty, to dark blue with vari-colored streaks of orange, yellow and red; 2 - 3 feet thin black slaty shale on bottom	4 - 8	4.6	13	140	6.0	Medium
Coal--soft and rotten	1 - 1 1/4	4.0	12	124	6.0	Very high
Underclay--mottled gray, orange, and red	2 - 3	3.7	3	140	3.3	Medium
Shale--light blue-gray with tan and yellow streaks, sandy, silty clay	1 - 8	3.6	35	140	1.4	Very low
Shale--blue to dark blue, silty, soft; limestone band on bottom, with reddish and yellow streaks	3 - 10	6.6	23	140	2.8	Very high
Shale--dark blue to black, very hard, fossiliferous below, with phosphatic nodules and pyritic concretions	4 - 8	7.0	36	140	6.0	Very high

[1/] ppm = parts per million--in terms of--"low," "medium," or "high"

	Low	Medium	High
phosphorus	3 - 30	31 - 60	61+
potassium	30 - 60	61 - 100	101+

Table 6.--Descriptions and chemical analyses of strata over Mineral, No. 9, coal at one location in Henry County, Missouri.

Description of strata (Top to bottom)	Thickness of strata (feet)	Acidity of strata (pH)	Available Phosphorus (ppm[1])	Available Potassium (ppm)	Organic matter (%)	Exchangeable calcium
Soil--gray-brown, very fine sandy loam	1 - 1 1/2	5.0	3	140	2.3	Very low
Subsoil--claypan, mottled gray, red with 1 1/2 feet cherty gravel in places	3 - 12	5.8	43	140	.8	Very high
Coal--streak, soft	0 - 1/4	---	--	---	---	---------
Underclay--mottled, mostly reddish	3 - 6	6.9	41	79	.6	Low
Shale--olive drab to olive gray, with dark streaks that have plant fossils, and with reddish iron concretion, silty	4 - 8	6.9	43	134	1.1	Very high
Shale--blue to blue-black, slaty	2 - 4	7.2	43	140	3.3	Very high
Limestone--dark blue, very hard	0 - 2	---	--	---	---	---------
Coal--very hard where present	1 - 1 1/2	---	--	---	---	---------
Underclay--gray	4 - 6	3.2	12	140	2.9	Very low
Shale--hard grayish-stone on top, more shaly below	6 - 12	7.1	45	134	1.2	High
Shale--blue to blue-black, hard, slaty; lime rock on bottom in places	2 - 4	7.4	32	140	4.2	Very high
Coal--streak, very hard	0 - 1/3	---	--	---	---	---------
Shale--black, slaty with several fossiliferous limestone layers	4 - 8	7.0	29	140	6.0	Very high

[1] ppm = parts per million.

cent of the strip-mined land in the Province in 1946 supported some vegetational cover, even though about one-half of the area had been stripped during the previous 10 years.

Topography

Strip-mined lands are usually a series of steep ridges, 5 to 50 feet high with crests 40 to 100 feet apart. The actual width, height, and steepness of ridges vary with the character and thickness of the overburden, the width of the cut, the type of stripping equipment used, and the age of the banks. The first ridge or bank, called the outside bank, usually contains

Figure 4.—Eighteen-month-old bank, Crawford County, Kansas, created by electric shovel mining the Weir, No. 6, coal. The surface is composed of 17 per cent soil-sized particles, 2 mm. or less in diameter; 39 per cent larger particles, 2 mm. to 2 inches in size, and 44 per cent, 2 inches and larger.

a larger proportion of soil-sized particles and since it is piled on unstripped ground, is usually higher than the other ridges. The final cut, generally left unfilled, is a long deep pit with the vertical high-wall on one side and a steep bank on the other side.

The flat or gently sloping banks in Arkansas, Missouri, Oklahoma, and Iowa are generally those resulting from stripping with a bulldozer or scraper. In Kansas, however, 3400 of the 3630 acres of banks in this topographic class are the result of grading performed as the first step in reclaiming the land by the Civilian Conservation Corps during the period from 1933 to 1937.

Water often collects in the low places between the ridges and on the partially graded areas; as a result, small, intermittent, shallow ponds are formed (Fig. 12). The abandoned runways, roadways, and final cuts, all of which may be connected, often become filled with water and form lakes 40 to 80 feet wide, up to 50 feet deep, and 5 miles long.

Texture

The texture of mine bank surfaces varies with the type of overburden, method of mining, and years since stripping. About 3 per cent of the strip-mined lands in the Province were classified as sands, 78 per cent as loams, or silty-shales, and 19 per cent as clays. It was estimated from the data shown in Figure 5 that 30 per cent of the average bank surface was made up of particles less than 2 mm. in diameter, 26 per cent 2 mm. to one-half inch in size, 33 per cent one-half to 4 inches in size, and 11 per cent of stones larger than 4 inches.

These percentages are, of course, only averages, and give a general picture of the texture of this material. Some of the many variations in the texture of strip-mined lands are shown in Figures 4, 5, 6, and 7. For example, Figure 5 shows that No. 6 banks in Oklahoma are composed almost entirely of particles less than one-half inch in size, while the proportion of these size classes on the No. 15 banks in Missouri is less than 50 per cent. On the other hand, the average composition of No. 15 banks in Missouri, Kansas, and Oklahoma are strikingly similar in that each has a much higher proportion of large stones than do other mine banks in the Province. The average proportion of soil-sized particles, an important factor in plant growth, varies from 20 per cent for No. 19 banks in Oklahoma to about 50 per cent for the No. 28 banks in Kansas.

The texture of strip-mined lands has an important bearing on aeration and moisture conditions, both critical factors in plant survival and growth. Areas composed largely of sand have good aeration but are apt to dry out excessively during periods of extreme drought. Clay banks have poor drainage, compact easily, crust over during periods of drought, and are poorly aerated. More shallow ponds are found on clay banks than on those of coarse texture. The loams and silty shales are considered the most productive because they usually contain enough shale to provide good aeration, and enough fine material to offer favorable moisture conditions.

Acidity

Acidity is perhaps the most important of the many site conditions to consider in reclaiming strip-mined land. Some of the strata removed in strip mining contain iron polysulfides, such as pyrite and marcasite, which oxidize to sulfates when exposed to air. These sulfates in turn hydrolyze to sulphuric acid, the cause of most toxicity in bank material.

Little or no plant cover was found on areas with a pH of less than 4.0. For practical purposes, until more research yields accurate acid-tolerance data for different species, banks with a pH value of less than 4.0 have been classified as "toxic" or "lethal" to most plant growth.

In the reconnaissance of strip-mined land in the Province, the mine banks were classified according to the proportion of the banks within given pH ranges (4). The following five classes were used:

1. **Toxic banks.** Areas that have more than 75 per cent of the surface material with a pH of 4.0 or less. Only **2 per cent** of the total area of strip-mined land in the Province were in this class.

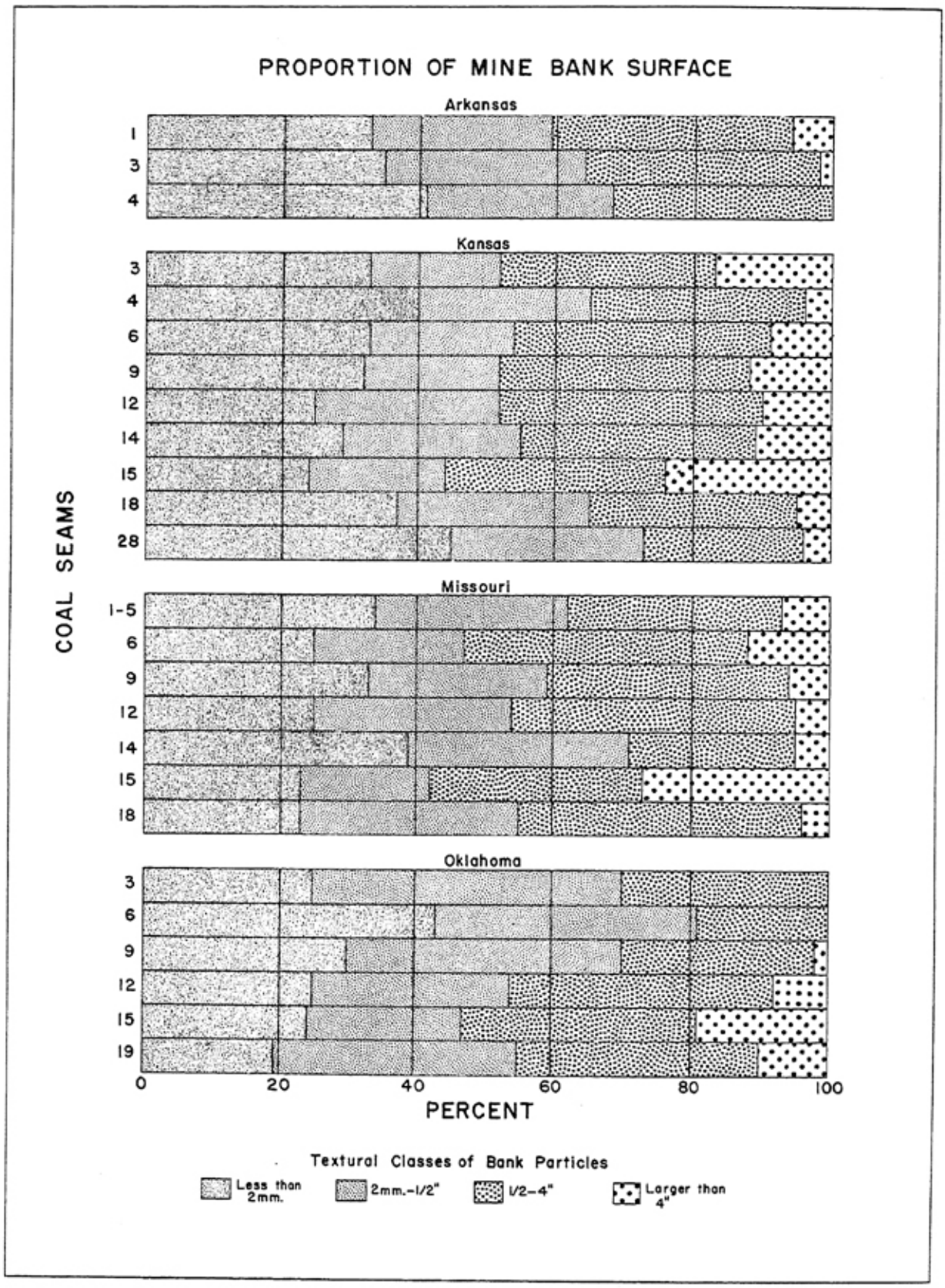

Figure 5.—Relative amount of different sized materials (texture) in the upper 12 inches of mine banks, by state and coal seam.

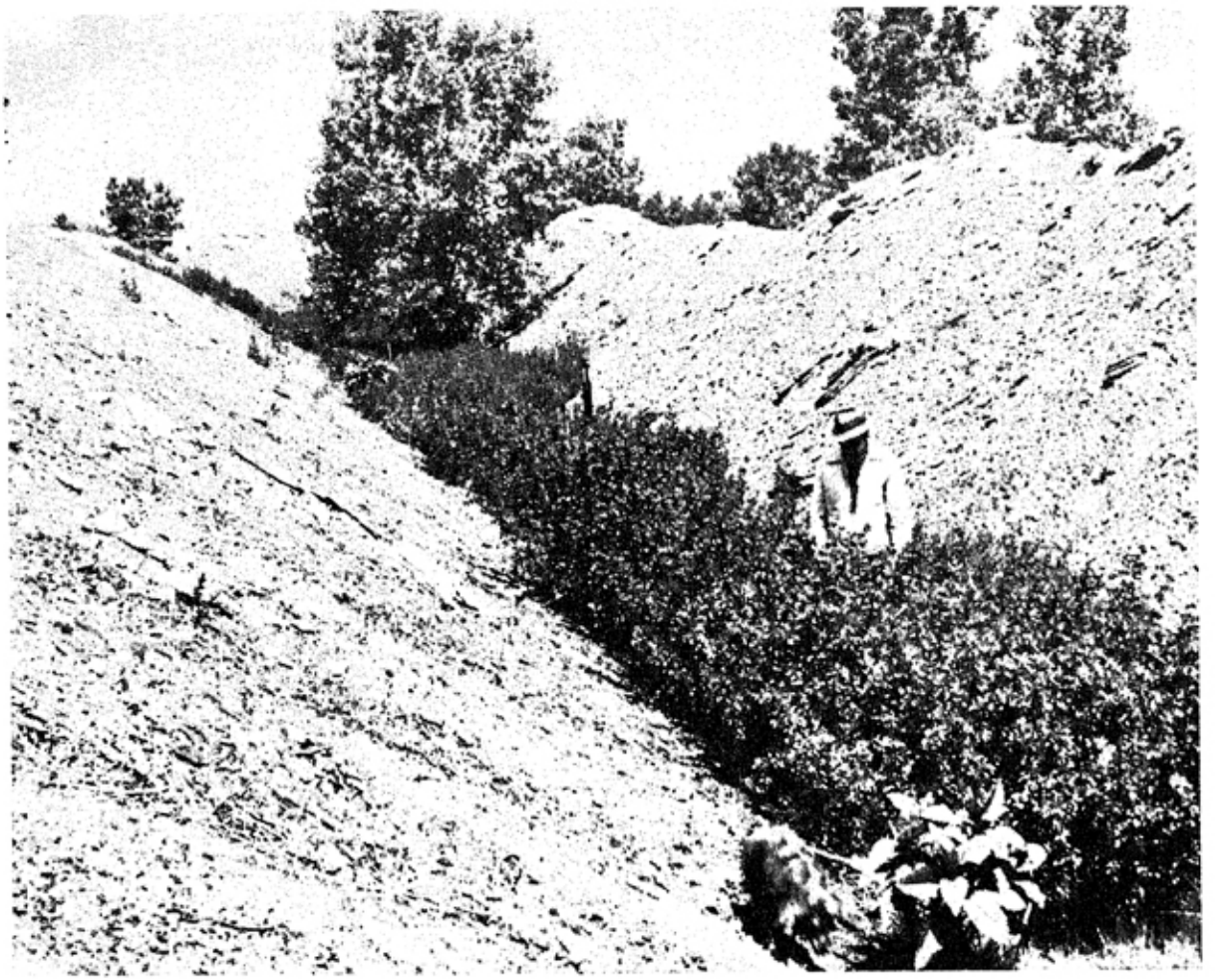

Figure 6.—Fourteen-year-old strip-mined land in Bates County, Missouri. The slopes are covered with a shingle-like layer of hard, thin shale. Very few plants develop on these slopes, although many species grow very well in the bottom. The species most commonly found are: sweet clover, wire grass, pokeweed, bullnettle, cattail, cocklebur, peppergrass, poison ivy, sunflower, blackberry, coralberry, sumac, cottonwood, and willow.

2. **Marginal banks.** Areas that have 51 to 75 per cent of the surface material with pH range of 4.0 or less. Only **2 per cent** of the stripped lands in the Province were in this class.
3. **Acid banks.** Areas that have more than 50 per cent of the surface material with a pH of 4.0 to 6.9. **Seventy per cent** of the stripped lands in the Province were in this class.
4. **Calcareous banks.** Areas that have more than 50 per cent of the surface material with a pH of 7.0 or higher. **Thirteen per cent** of the stripped area in the Province were in this class.
5. **Mixed banks.** Areas that have less than 50 per cent of surface materials toxic, acid, or calcareous. **Thirteen per cent** of the strip-mined lands in the Province were in this class.

Although the toxicity problem is relatively unimportant from a regional standpoint (only 4 per cent of total area is toxic or marginal), it is especially serious in some localities. In Iowa, 19 per cent of the stripped

Figure 7.—Mine banks created by a dragline and a shovel working in tandem, Henry County, Missouri. These new banks, less than 1 year old, are composed of more than 50 per cent soil-sized particles (less than 2 mm. in diameter), and have less than the average amount of stone on the surfaces.

lands were found to be toxic or marginal. In Boone and Callaway Counties, Missouri, 92 and 63 per cent, respectively, were found to be toxic or marginal. It will be a long time, perhaps several decades, before these areas are plantable. In future operations, the proportion of toxic banks may be reduced if feasible methods of stripping can be developed to bury toxic materials deep in the banks.

Nutrient Content

As shown in Tables 4, 5 and 6, the availability of mineral elements essential to plant growth varies considerably in strata overlying coal seams. These strata, randomly mixed in the stripping operation, produce banks which also vary greatly in chemical composition from area to area and from spot to spot within an area (Table 7). Among the samples analyzed, the amount of available phosphorus varied from only a trace to more than 600 parts per million, and potassium varied from little or none to 350 parts per million. The amount of exchangeable calcium was just as variable.

More research on the nutrient requirements of trees and agricultural

Table 7.--Acidity, available phosphorus and potassium, exchangeable calcium, and organic content of 18 random samples taken from surfaces of strip-mined land in the Western Interior Coal Province.

State	County	Coal seam	Sample number	Acidity (pH)	Available phosphorus (ppm[1])	Available potassium (ppm)	Exchangeable calcium	Organic content (%)
Oklahoma	Wagoner	12	1	7.93	106+[2]	103	Very high	1.44
Oklahoma	Wagoner	12	5	4.81	106+	93	Very high	1.54
Oklahoma	Wagoner	12	12	3.67	90	75	Very high	2.38
Kansas	Cherokee	14	3	7.26	106+	85	Medium	1.35
Kansas	Crawford	14	8	5.86	32	91	Very high	1.85
Missouri	Randolph	14	6	3.07	99	104	Low	.80
Kansas	Cherokee	9	4	3.75	106+	53	Medium high	1.67
Kansas	Cherokee	9	9	7.08	106+	85	High	1.18
Kansas	Crawford	9	15	3.27	83	72	Very high	6.00+
Kansas	Crawford	9	50	5.48	56	107	Medium	1.12
Missouri	Henry	9	8	6.25	20	68	Very high	.25
Kansas	Crawford	6	4	4.02	106+	67	Medium	.95
Kansas	Crawford	6	11	3.61	36	49	Medium	1.02
Missouri	Barton	6	6	5.90	40	95	Medium	1.54
Missouri	Barton	6	10	6.40	106+	81	Medium	1.76
Missouri	Bates	18	10	7.55	106+	63	Medium	1.00
Missouri	Bates	18	2	4.59	103	140+	Very high	1.80
Missouri	Bates	18	13	7.83	106+	61	Very high	1.10

[1] ppm = parts per million.

[2] Figures followed by "+" are upper limits of the test.

crops to be grown on mine banks is needed. However, from the analyses of 200 spoil samples made in the Province, it appears that strip-mined land contains enough mineral nutrients for good plant growth. Nitrogen, at first generally lacking, is added by precipitation and by leguminous plants.

Weathering

Bank surfaces weather largely as a result of the interaction of physical, chemical, climatic, and biological factors. Physical disintegration is caused principally by freezing and thawing, by wetting and drying, by the beating of rain drops, by the action of winds, and by the pressures of growing plant roots; it is generally quite rapid. Chemical decomposition, on the other hand, is largely due to the leaching of soluble compounds, and is relatively slow. Because the bonding substances within rocks vary in chemical composition and solubility, rocks decompose at widely varying rates. The soluble compounds and the smaller-sized particles are leached into the earth or deposited in the bottoms between ridges (Fig. 6).

Since these weathering factors and the character of banks differ by

locality, coal seam, and mining method, banks of the same age may show marked differences in weathering. Age alone, then, is not a good criterion for judging the degree of weathering, nor the readiness of an area for planting. Of more importance, perhaps, are the stability and texture of bank surfaces. For example, consider two strip-mined areas in the same locality, resulting from the mining of the same coal seam and overburden. On one of these areas a different method of mining was used; most of the soil, glacial till, loess, and clay came to rest on the tops of the banks. The method used in stripping the other area caused massive limestone and sandstone to come to rest on the tops of banks. This area, even if much older than the first, would no doubt have a much lower proportion of soil-sized particles and weathered material on its surface (Table 8.)

New mine banks are relatively unstable. During the first two or three years they slip and slide until they reach a stable position (Fig. 7). Vertical settling takes considerably longer and erosion continues until the banks are well covered with vegetation. During this settling period the tops of ridges become rounded, valleys between ridges flatten, and the length and gradient of slopes is reduced. Erosion on strip-mined lands is a natural leveling process within the strip-mined areas itself. Except for the outside banks, all of the water-transported materials are deposited in the valleys between ridges. The amount of material moving into streams is of no significance, except in a few, relatively small areas.

Table 8.--Average proportion of soil-sized material[1/] to depth of 12 inches as related to coal seam, age of banks, and method of mining, on 14 strip-mined areas in the Western Interior Coal Province.

Coal seam No.	Age of spoils (years)	Method of mining	Proportion of soil-sized material (percent)	Number of samples analyzed
6	17	Shovel	47	13
6	12	Shovel	43	12
6	2	Shovel	17	13
9	8	Shovel[2/]	39	30
9	8	Shovel	36	27
9	5	Shovel	40	13
9	1	Tandem[3/]	50	13
12	13	Shovel	47	13
14	14	Shovel	50	11
14	6	Shovel	37	13
14	2	Shovel	57[4/]	11
18	15	Shovel	40	13
18	5	Shovel	52	13
18	0[5/]	Shovel	32	7

1/ Less than 2 mm. in diameter.

2/ Graded area created at time of mining with small dragline on top of the stripped area.

3/ Banks created by shovel and dragline working in tandem.

4/ Influence of large amount of glacial till deposited on surface.

5/ Graded with a bulldozer about 3 months before soil samples were collected, about 5 years after the banks were created.

Plant Cover

During the reconnaissance in 1946, more than 70 species of trees and over 200 species of shrubs and herbs were found on strip-mined land.[3] The plant cover varies in amount and species composition with the coal mined (Fig. 8). Only 28 per cent of the banks formed by the mining of the No.

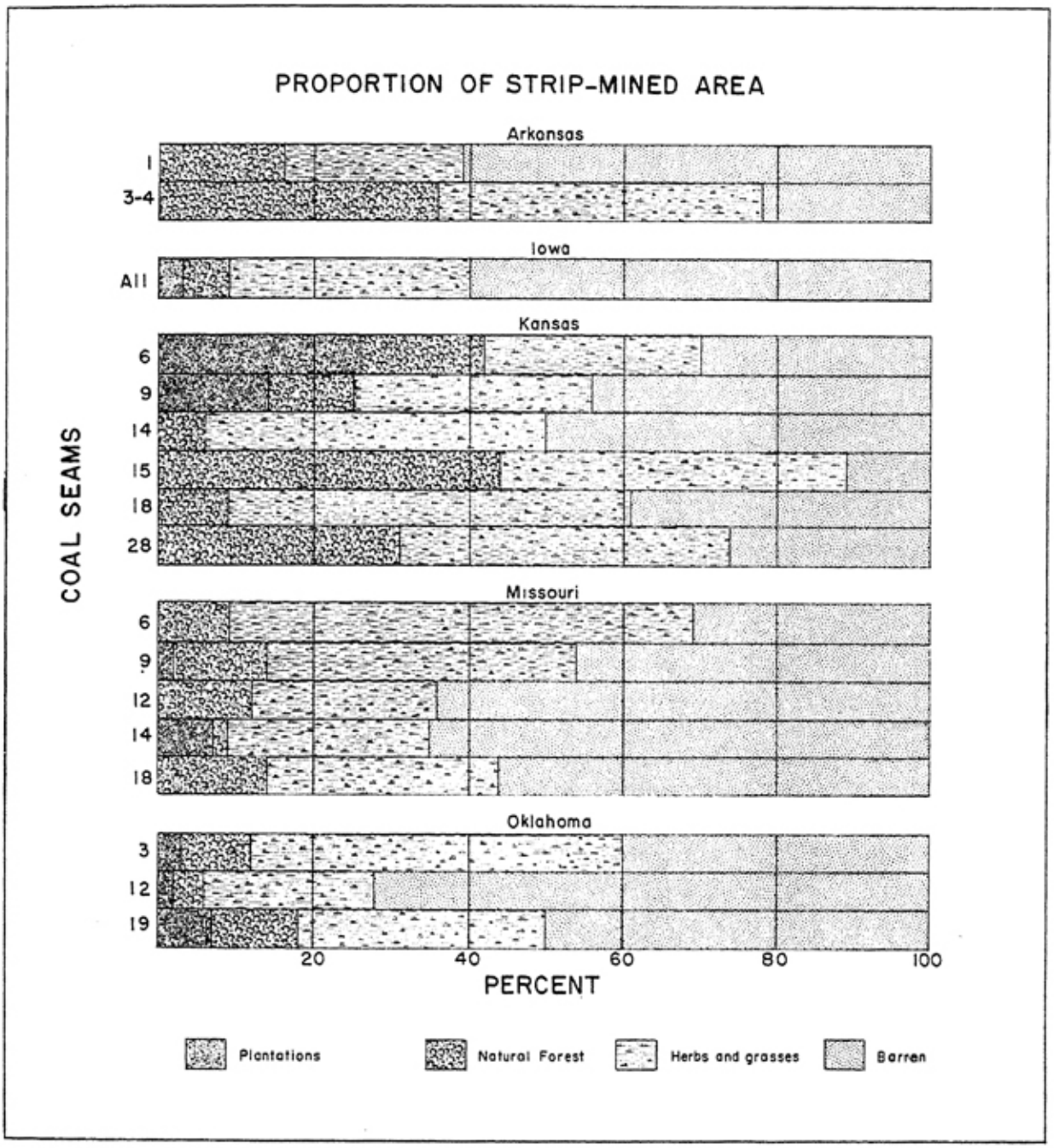

Figure 8.—Proportion of strip-mined land in four main classes of vegetational cover by states, for each of the principal coal seams strip mined in the Western Interior Coal Province, 1946.

[3]For a partial list of these species, see pages 44-45 in the Appendix.

12 coal in Oklahoma were covered with vegetation in 1946, while more than 88 per cent of the banks formed by the mining of the No. 15 coal in Kansas were covered.

About 6 per cent of the strip-mined area has been successfully planted or seeded with forest trees, orchard trees, vines, grasses, and legumes. Most of these plantings are on No. 6, 9, and 14 coal banks in Kansas and Missouri. Approximately 11 per cent of the area was covered with forest trees and about 37 per cent was covered with herbs and shrubs, all of which seeded-in naturally. So in 1946 an estimated 54 per cent of the strip-mined land supported some kind of vegetation.

Most of the strip-mined land with no plant cover was mined relatively recently (Figs. 4 and 6). However, some banks, although nontoxic, become covered with vegetation very slowly because of poor seedbed conditions on their surfaces. For example, the hard, thin, plate-like particles of shale which cover the area shown in Figure 7 create a shingle-like surface and make plant establishment difficult.

No systematic studies of plant succession on strip-mined land in the Province have been made. In general, light-seeded species and those whose seeds are carried by birds and mammals are the first to invade the banks. The density of cover and the rate of plant succession vary considerably with differences in acidity, texture, and stability of surfaces. During the reconnaissance, the most common species found on Weir, No. 6, banks, for example, were broomsedge, little blue-stem, bullnettle, wire grass, peppergrass, and blackberry (Fig. 9). Large areas of No. 9, Mineral, banks were covered with sparse stands of peppergrass, rattlebox, ticklegrass, and blackberry. Mullen was found on No. 15, Mulky, banks and those from higher coals, but not on areas where coal was stripped from seams lower stratigraphically than No. 15.

Heavy stands of lespedeza and sweet clover seeded naturally and artificially were found on the calcareous banks of No. 9, Mineral, No. 12, Croweburg, No. 14, Bevier, and No. 18, Mulberry, coals. These legumes were not found on the acid banks.

Stands of cottonwood developed on all except toxic surfaces. The very light seed of this species has a short period of viability, and seedbed requirements for germination are exacting, but when proper conditions exist, heavy stands of cottonwood do become established as illustrated in Figure 10.

Correlation With Coal Seams and States

The foregoing description of strip-mined areas in the Western Interior Coal Province has emphasized the extreme variations which occur. However, banks resulting from the mining of each coal seam in each state do have certain characteristics in common as shown in Table 9. Color, acidity, and texture are the most distinctive of these. The surfaces resulting from the mining of Weir, No. 6, coal are perhaps the most uniform. In Kansas and Missouri they are generally a tan or gray, silty or sandy shale, containing a small amount of sandstone, and having a pH range from 4.0 to

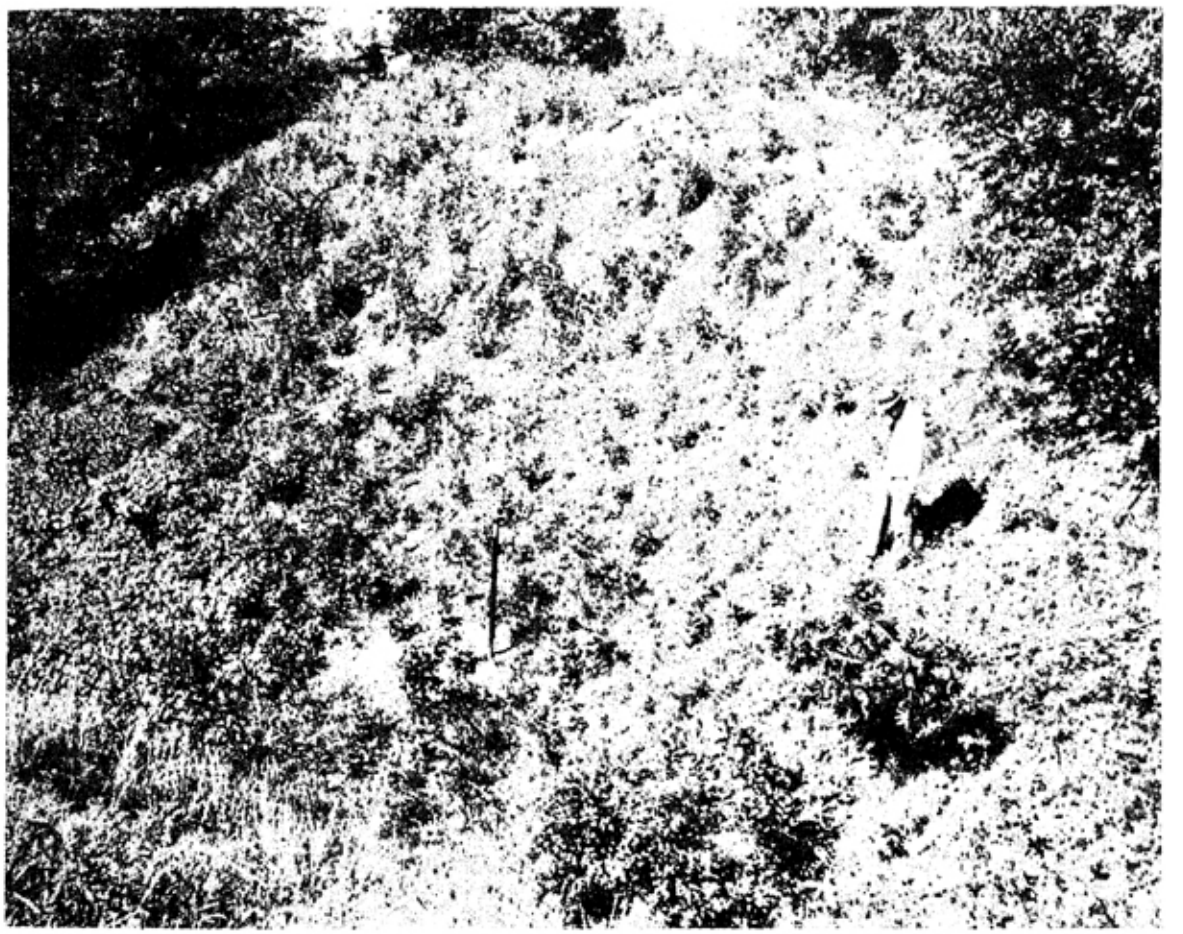

Figure 9.—Thirteen-year-old Weir, No. 6, banks in Barton County, Missouri, with an estimated 95 per cent of the surface covered with plants of the following species: broomsedge, little bluestem, poison ivy, blackberry, wild onion, sumac, wild aster, coralberry, persimmon, black cherry, elm, and silver maple. These species are intermingled at first but in time some of the species develop pure stands over small areas.

6.0. In Oklahoma, where the No. 6 coal seam is known as the Secor, the surface is an olive-green to dark blue, acid, silty shale.

The banks from Mineral, No. 9, coal are the most variable. Some are acid, gray to black, silty and clayey shales, with scattered amounts of massive sandstone and limestone; some are toxic and nonplantable, and still others are black, calcareous, clayey shales.

PRESENT USES OF STRIP-MINED LAND

The 1946 reconnaissance revealed a surprisingly large number of uses of strip-mined lands in the Province (pp. 44-51 in Appendix). Planned use was being made of more than 12,000 acres, about one-fifth of the total area. About 600 acres were improved cattle pastures, 170 acres were in orchards or vineyards, 5,000 acres in well-stocked forests, 750 acres in public parks, and 500 acres in private hunting and fishing grounds. In addition, some

Table 9.--Summary of Bank Characteristics in Part of the Western Interior Coal Province by Coal Seam and State.

Coal seam 1/ Number	Name	Arkansas	Oklahoma	Kansas	Missouri
28	NODAWAY	----	----	NODAWAY: mixed acidity; buff and gray; sandy and silty shales; small amount of massive sandstone	----
22	THAYER	----	----	THAYER: acid; dark blue; sandy and silty shales; 20 percent or more massive sandstone and limestone	----
19	DAWSON	----	DAWSON: acid; dark gray to black silty or clayey shale; calcareous light gray and buff silty and clayey shales; 5 to 8 percent sandstone	----	----
18	MULBERRY	----	----	MULBERRY: mixed acidity; light gray to darker blue gray; silty and clayey shales; weather slowly	MULBERRY: mixed acidity; light gray to darker blue gray; silty and clayey hard shales
15	MULKY	----	FORT SCOTT: acid and calcareous; silty and clayey, gray to blue-black soft to brittle shales; 20 percent large limestone	MULKY: acid; black; hard fissile shale with oval phosphatic concretions; 20 percent or more massive limestone	MULKY: mixed acidity; black and dark gray hard shale with oval phosphatic concretions; 10 percent or more massive limestone
14	BEVIER	----	----	BEVIER: acid and calcareous; gray to bluish; silty and clayey hard shales; weather rapidly	BEVIER: mixed acidity; light gray to bluish, silty shales; (N. of Mo. River sandy and clayey glacial till). Toxic in Boone and Callaway Counties
12	CROWEBURG	----	BROKEN ARROW: acid; light to dark gray; silty to clayey shales; massive limestone in places	CROWEBURG: acid; light to dark gray; silty and clayey shales, some limestone; toxic gray clay in places	CROWEBURG: acid; grayish, silty shales; toxic acid gray clay in places

Table 9.--Summary of Bank Characteristics in Part of the Western Interior Coal Province by Coal Seam and State (cont'd.).

Coal seam 1/ Number	Name	Arkansas	Oklahoma	Kansas	Missouri
10	FLEMING	----	FLEMING: acid and toxic; brownish silty and clayey shales	----	FLEMING: acid; light tan and light gray; silty and sandy shales
9	MINERAL	----	HENRYETTA: acid; grayish silty and clayey shales; small amount of massive sandstone in places	MINERAL: acid; grayish to black silty and clayey shales; massive sandstone and limestone in places; calcareous and mixed acidity in places	TEBO: acid; gray to black silty and clayey shales; massive sandstone and limestone in places (5 percent); some calcareous and toxic areas
6	WEIR	----	SECOR: acid; olive green and dark blue; silty, thin and brittle shales	WEIR: acid; tan and gray sandy and silty shales; 7 percent sandstone	WEIR: acid; tan and gray sandy and silty shales; 3 percent sandstone
4	ROWE	PARIS: mixed acidity; tan and dark blue-black; silty shales and loams	----	ROWE: toxic; orange tan to blue-black; sandy and silty shales	
3	McALESTER	CHARLESTON: acid, calcareous, or mixed acidity; tan and purplish; silty shales and loams; sandstone in western part	McALESTER: acid and calcareous; tan and gray; silty and clayey shales, or clays and loams	COLUMBUS: toxic; orange gray; sandy and silty shales, massive sandstone in places	2/ UNCORRELATED: locally named coal seams; acid; orange, tan and brownish shales; some toxic areas; massive sandstone in places
2	UPPER HARTSHORNE	----	UPPER HARTSHORNE: acid, olive-green and blue-black silty and clayey shales	----	
1	LOWER HARTSHORNE	LOWER HARTSHORNE: acid; tan to dark blue-black silty shales and loams	----	RIVERTON: toxic; light gray and tan; sandy shales	

1/ Listed in relative stratigraphic order; numbering system adopted from "Cyclical sedimentation of the Cherokee" by G. E. Abernathy (1). The most widely used local name of the coal seams are recorded under each state.

2/ These coals in Missouri have not been positively identified nor correlated with those in other states in the Province. Those which are mined in Missouri are given different names in each locality.

Figure 10.—Twelve-year-old natural stand of cottonwood, Bates County, Missouri. Elm seedlings were abundant under this stand in 1946.

strip-mined land was used for barnyards, bee pastures, industrial sites, dumping grounds, and for growing such crops as corn, soybeans, alfalfa, and garden vegetables.

Cattle Pastures

Improved pastures on strip-mined lands in the Province yield good returns. Calcareous areas with a high proportion of soil make particularly good pastures because they will produce luxuriant stands of sweet clover and lespedeza (Fig. 11). To develop pasture, it may be necessary to construct access roads, fence the area, and seed it to grasses or legumes. The many ponds and lakes created by mining afford a year-round supply of water suitable for livestock—an asset in any pasture. Adjoining unmined lands are usually included in pasture developments.

Since 1946, six additional pasture projects have been developed, involving some 5,000 acres of strip-mined land (Fig. 12). Two of these are located in Missouri, three in Kansas, and one in Oklahoma. If these projects prove successful they will demonstrate a good use of large areas of calcareous strip-mined land in the Province.

Figure 11.—Dense patchy natural stand of sweet clover on calcareous portions of Mulberry, No. 18, banks in Bates County, Missouri. The bare areas are acid.

Fruits and Berries

Orchards and vineyards established on strip-mined land in the Province have met with varying success. Like enterprises of this kind on other lands, success depends largely upon the care and maintenance they receive. Before planting, the stripped land must be graded so trucks, spray equipment, and other machinery needed to cultivate and harvest the crop can be used.

One of the outstanding orchards on stripped land in the Province is in Barton County, Missouri. This 11-acre tract has produced good crops of grapes, apples, cherries, peaches, plums, black walnuts, and pecans. Another 45 acres located near Croweburg, Kansas, are no longer productive because they have not received proper care.

An orchard and a vineyard of over 180 varieties were established in 1940 and 1941 on graded strip-mined areas five miles southwest of Pittsburg, Crawford County, Kansas (2). Several varieties of fruits and berries were successfully cultivated. Lack of funds interrupted proper maintenance of the project.[4]

[4]In 1950 this project was transferred to Kansas State Teachers College, Pittsburg, Kansas, for maintenance and further development.

Thousands of quarts of blackberries, dewberries, wild plums, black cherries, and other fruits are harvested annually from stripped lands in the Province. Since the fruits are gathered largely by local people for canning and immediate table use, the economic value of these crops is difficult to estimate.

Forests

The forested strip-mined land in the Province includes about 2000 acres of natural forest (Fig. 13), and over 3000 acres of plantations. Products, such as fence posts, railroad ties, logs for lumber, fruits, edible nuts, and Christmas trees have been harvested from trees growing on these lands. However, up to the present, indirect benefits, largely intangible, exceed the value of the products harvested from trees. The forests have provided good habitats for many species of wildlife and have increased the recreational value of these lands.

Natural stands of cottonwood, elm, and pin oak have developed on many areas of from 1 to 50 acres. Occasionally mixed with these species or growing in relatively pure stands are green ash, black walnut, black cherry, silver maple, pecan hickory, bur oak, eastern red cedar, several

Figure 12.—New pasture project on Mineral, No. 9, coal banks in Cherokee County, Kansas. Access roads have been constructed by striking off the tops of the ridges with a bulldozer. The area will be seeded with lespedeza and sweet clover.

Figure 13.—Thirty-year-old stand of mixed hardwoods, Vernon County, Missouri. A pecan hickory seedling is growing in the opening created by cutting an 18-inch pin oak (note stump). Other species in the stand are elm, black cherry, silver maple, and black walnut.

species of willows, sycamore, catalpa, and black locust. Closed stands of black locust in which the trees have good form and excellent height and diameter growth have developed in a few places (Fig. 14). One 3-acre area in Missouri became stocked with an almost pure stand of black walnut, which at 30 years of age had about 70 trees per acre. These trees were about 13 inches d.b.h. and 50 feet high, had good form, and were growing better than the average rate for the species. With the exception of black locust, osage orange, and catalpa, all of these species are native to the region.

Successful forest plantations had been established before 1946 on 210 acres in Oklahoma, 2575 acres in Kansas, 208 acres in Missouri, 16 acres in Iowa, and 4 acres in Arkansas. Most of the older plantations were made under the sponsorship or supervision of federal or state agencies during the years 1930-1942.

Forest Plantations in Oklahoma

The U. S. Soil Conservation Service has directed most of the planting of strip-mined land in Oklahoma as a part of the individual farm planning

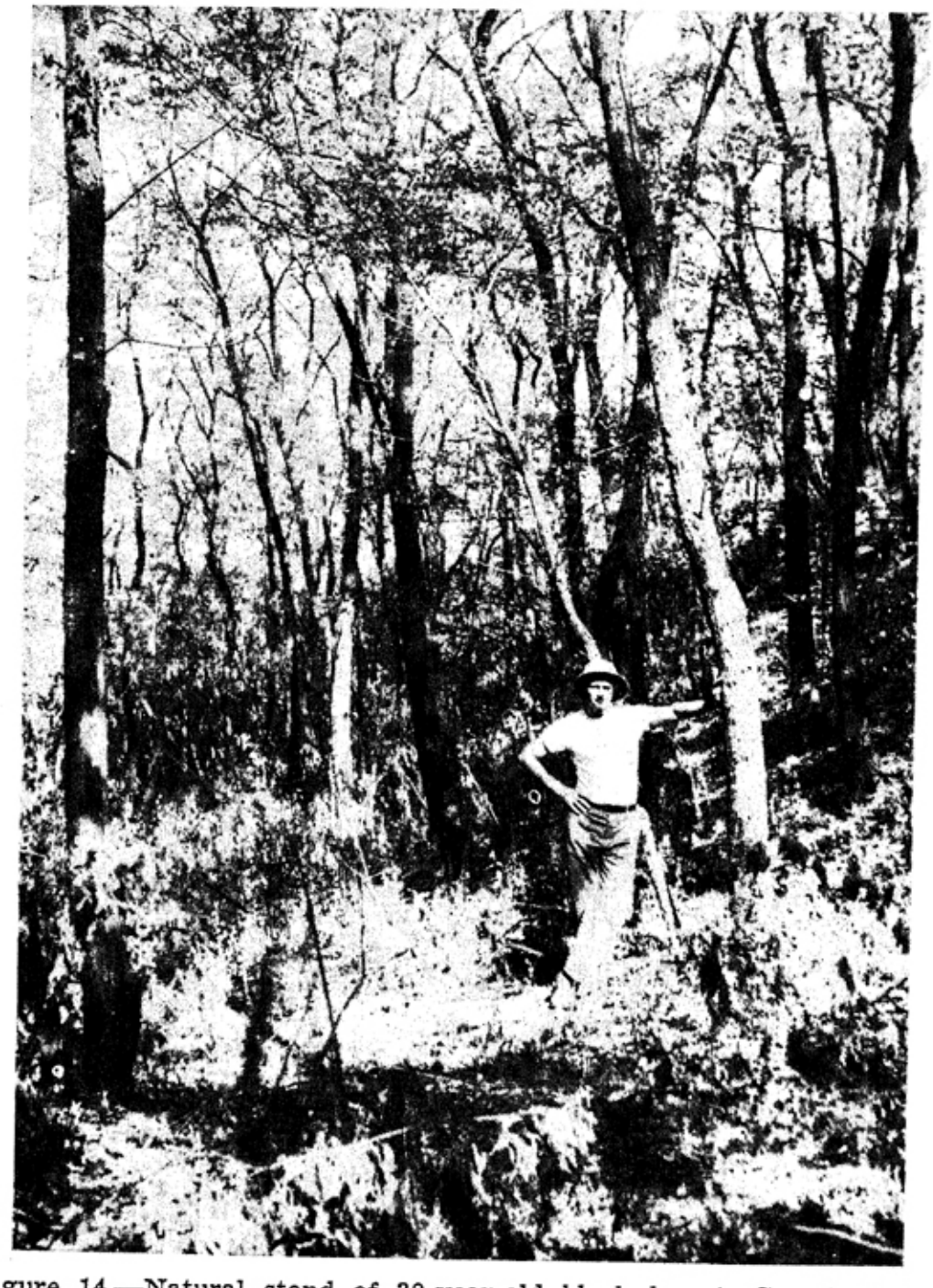

Figure 14.—Natural stand of 30-year-old black locust, Crawford County, Kansas. The trees have good form and diameter and height growth.

programs. Black locust was the principal species planted. Other species used were: mulberry, osage orange, catalpa, red oak, bur oak, honey locust, black walnut, silver maple, hackberry, Chinese elm, and Kentucky coffee tree. Most of these plantations were made to produce fence posts. Black locust had the best survival and growth rate and produced fence posts at an early age.

A thinning of a 7-year-old, 3-acre black locust plantation in Wagoner County, Oklahoma, produced 1000 fence posts which sold for $250. This represents an average growth of 50 posts per acre per year, and an income

of $12.50 per acre per year. Black locust sprouts are rapidly filling the openings created by the thinning. Five years after the thinning, 71 per cent of the stumps had vigorous sprouts which averaged 19.5 feet in height. The average height of the original trees was 27.6 feet. Additional thinnings for fence posts can be made about every 5 years (Fig. 15).

Figure 15.—A 12-year-old black locust plantation, Wagoner County, Oklahoma, which was thinned at the end of the seventh year for fence posts. The stand per acre was composed of 620 original stems, which averaged 3.1 inches in d.b.h. and 27.6 feet in height, and 230 5-year-old sprouts which averaged 1.7 inches in d.b.h. and 19.5 feet in height. Note the stump in the right foreground, made by cutting one stem of a twin tree (no sprout on the stump); and the stump and vigorous sprout in the left edge of the figure. A second thinning for fence posts could be made.

A 7-year-old black locust plantation in Haskell County, Oklahoma, supported more than 1300 trees per acre. The average height of these trees was 23.0 feet, which is an average height growth of 3.3 feet per year. If this stand were thinned for fence posts, it would not only produce cash income but the trees remaining in the stand would benefit. A black locust plantation with a spacing of about 8 x 8 feet on a Wagoner County, Oklahoma, strip-mine area completely shaded the ground in three growing seasons (Fig. 16).

Although black locust borers (**Cyllene robiniae,** Forst.) have caused no serious damage to trees in the plantations described above, they have literally riddled the bole of every black locust tree in some plantations in nearby Tulsa and Mayes Counties. The growth rate of the trees in these plantations was poorer and this may account for the heavy infestation of borers. The borer-damaged trees have been broken by wind and ice and are worthless for posts, but sprouts from these damaged trees and new seedlings provide an effective ground cover.

Forest Plantations in Kansas

During the past 15 years, more than 2500 acres of strip-mined lands in Kansas have been planted. Although most of this area was planted with black walnut, some plantings were made of black locust, cottonwood, bur

Figure 16.—Three-year-old black locust plantation in Wagoner County, Oklahoma. Excellent survival and vigorous growth of these trees, planted about 8 x 8 feet, has caused crowns to close and completely shade the ground.

oak, American elm, Chinese elm, silver maple, hickory, pecan hickory, catalpa, ponderosa pine, jack pine, white pine, Scotch pine, eastern red cedar, and Lombardy poplar. Except for black walnut, the number of trees planted is too small to warrant any general statement as to survival and growth.

Over 2000 acres of graded and partially graded strip-mined land in Cherokee and Crawford Counties, Kansas, are now stocked with 300 or more stems of black walnut per acre (Fig. 17). These plantations were established in 1934-1937 on State-owned land by the Civilian Conservation Corps. The total height and diameter at breast height of over 400 of these black walnut trees were measured in January 1948 (7). The trees averaged 2.5 inches in diameter and 15 feet in height. This represents an annual growth of one-quarter of an inch in diameter, and more than 2 feet in height. Seeds have been produced by some trees in these stands for more than 5 years.

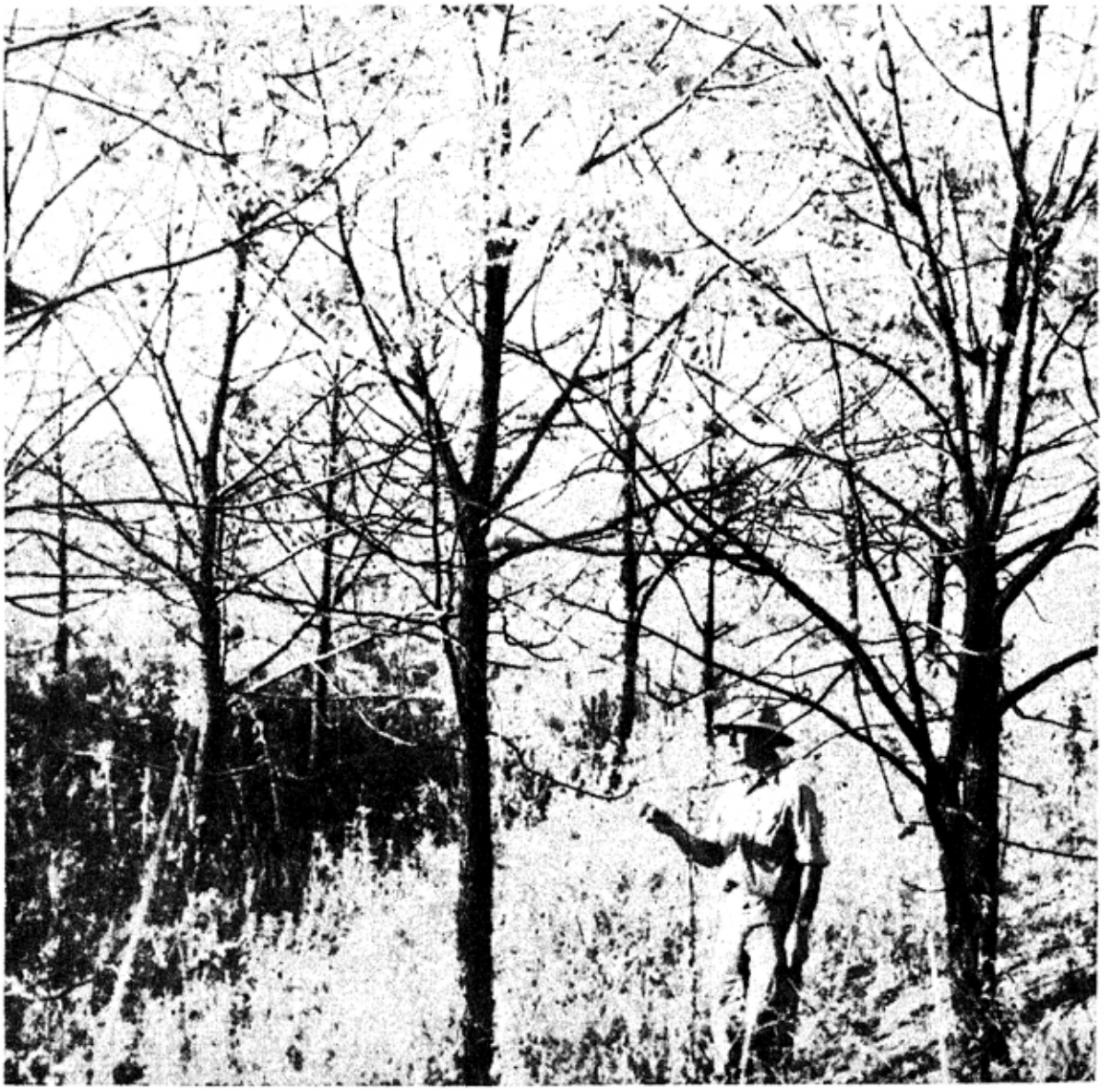

Figure 17.—A 12-year-old black walnut plantation on partially graded strip-mined land, Cherokee County, Kansas. Note the crop of nuts on large crowned tree in the right foreground.

Forest Plantations in Missouri

A little more than 200 acres of strip-mined land in Missouri had been planted with forest trees before 1946. The oldest known plantation, located in Barton County, Missouri, consists of 20 acres which was planted with catalpa in 1933 by a mining company (Fig. 18). A commercial thinning of about 200 fence posts from this plantation would not only produce an income, but would also improve the growth of the remaining trees.

The Soil Conservation Service on their Cedar Creek Project in Callaway County, Missouri, established a 6-acre plantation in 1941 to test the ability of 20 tree species to survive and grow on a specific type of bank (see list of species planted on page 51 in Appendix). Shortleaf pine trees were growing well, and appeared to be vigorous and healthy (Fig. 19). Survival of eastern red cedar was excellent, but growth was very poor.

Twenty additional known plantations have been established since 1936 using black locust, bur oak, white oak, black cherry, yellow poplar, catalpa, ponderosa pine, jack pine, Virginia pine, Scotch pine, and eastern red cedar. Although no general planting recommendations can be made from the observations of these plantings, some, such as Virginia and jack pine (Fig. 20) and yellow poplar (Fig. 21) have shown good survival and growth.

Figure 18.—Thirteen-year-old catalpa plantation, Barton County, Missouri. A thinning of 200 to 300 fence posts per acre could be made from this plantation.

Figure 19.—Six-year-old shortleaf pine plantation in Callaway County, Missouri. The survival and growth of the trees are good.

Serious Diseases and Pests of Planted Trees

Some of the trees planted on stripped lands have been damaged by diseases, insects, and mammals. Only the most common diseases and injuries from pests are described in this paper.

Black locust borers, for example, infest black locust in many areas. They riddle the bole of the tree so that it becomes worthless as post material. Vigorous trees are generally less susceptible to borer damage. Although no practical method of control has been found, spraying or dusting with DDT may be effective. Not to be confused with the locust borer is the caterpillar stage of the locust twig borer, **Ecdytolopha insiticiana,** which causes swelling and some breakage of terminal twigs.

Nantucket Tip Moth, **Rhyacionia Frustrana,** Comst., infestations of planted pines are common. The larvae hollow out and kill the growing tips. Infestation rarely kills the tree, but if attacks continue for a number of consecutive years, the trees become stunted and bushy. Infestations are usually limited to trees less than 15 feet high. No practical method

of control for this insect has been developed although properly timed application of DDT may reduce the severity of infestation.

Ponderosa pines on certain bank plantings have been severely attacked by a needle cast fungus of the genus **Hypoderma.** Needle cast fungi are common on most pines, but in this case the disease has become epidemic and has caused the complete defoliation and death of many trees. No method of control is known.

The fall web worm defoliates some walnut trees in the early fall. Although the colony webs of this insect are conspicuous, no control measures are necessary as little or no damage is caused by defoliation at that time of the year.

Grasshoppers do considerable damage to young trees. By feeding on new branches, they sometimes girdle and kill the ends of the twigs. A small amount of damage is done to some trees every year. Control is normally maintained by birds—natural enemies of the grasshopper.

Rabbits and other rodents damage seeds and seedlings of planted forest trees. By feeding on the bark, they may cut off or girdle the main stem. Mice often destroy planted seeds.

Figure 20.—Four-year-old Virginia and jack pine plantation on Weir, No. 6, banks, Barton County, Missouri. Survival and growth were satisfactory.

Figure 21.—Although far out of its natural range, this 6-year-old yellow poplar planted on banks in Barton County, Missouri, has averaged more than 3 feet of height growth per year.

Wildlife and Recreation

Plant cover on strip-mined areas has created favorable conditions for many species of wildlife. Bank beaver, which have been introduced into lakes and ponds of strip-mined land in southeastern Kansas, are increasing in number. Cottonwood trees growing on the banks are a natural source of food for these animals. Other native and introduced animals found thriving on bank habitats include: muskrat, raccoon, rabbit, mink, fox, squirrel, opossum, skunk, coyote, wolf, ground hog, fish, frog, turtle, quail, song birds, hawks, and water fowl.

More people used the banks for hunting and fishing, than for any other purpose. The Kansas Forestry, Fish, and Game Commission, and the Missouri Conservation Commission have been developing these resources as a public benefit. Charges are made for fishing and hunting privileges on a few private strip-mined areas.

Recreational developments have been made in two places in Missouri. The city of Clinton, Missouri, owns 77 acres of strip-mined land about 3 miles north of the city. Well adapted for recreation, this land has been leased to the local post of the Veterans of Foreign Wars. A caretaker's quarters, several cottages, a recreational hall, boats, and a pond well stocked

with fish are used intensively by Post members and their families (Fig. 22). Near Montrose, Missouri, a park area of about 80 acres of strip-mined land has been fenced and temporary roads have been constructed on the area.

The 329-acre Crawford County State Park, located 5 miles north of Pittsburg, Kansas, is perhaps the best example of an area of strip-mined land managed as a public park. This area is intensively used the year round. The town of Mulberry, Kansas, constructed a baseball field by leveling a small strip-mined area; the conversion is so complete that no traces of the banks are noticeable.

RESEARCH IN STRIP-MINED LAND USES

Investigations on the development and use of strip-mined land in the Province are in the formative stage. Many years of study will be needed to develop a definite program for all bank conditions. Fortunately, state agricultural experiment stations, mining companies, public land use agencies, and many individuals are interested in this problem and are conducting research on the reclamation of spoils. Relatively few studies have been started to date—and these are limited.

The University of Missouri has started tests on seeding legumes and grasses on graded areas. Several mining companies and other owners of

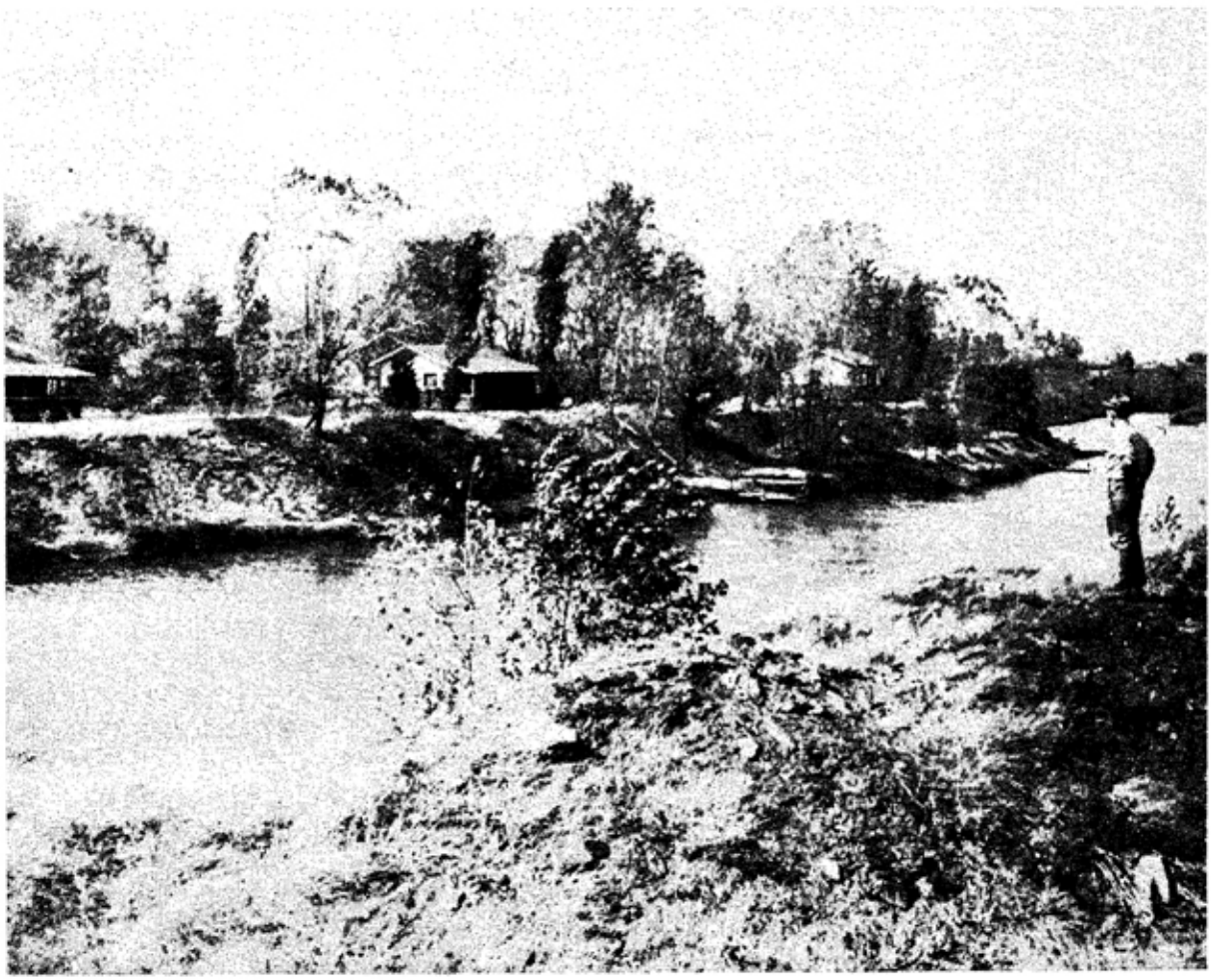

Figure 22.—Recreational development of Veterans of Foreign Wars Post No. 1894, on strip-mined land near Clinton, Missouri.

strip-mined land are making large-scale trials of the possibilities of developing pastures and integrating the use of strip-mined land with neighboring unmined land. These trials are yielding encouraging results. It has already been shown that banks can be seeded with grasses and legumes by airplane and helicopter. The Fleming Strip-Land Reclamation Project in Kansas has shown clearly that it is possible to develop orchards and vineyards on strip-mined land.

The Soil Conservation Service of the U. S. Department of Agriculture has begun a study on planting forest trees on strip coal lands in Missouri. This agency also proposed and supervised several large scale forest plantings in Oklahoma, which are now serving as good demonstration areas. The extensive black walnut plantations on strip-mined land in Kansas, established by the Civilian Conservation Corps, are serving not only as demonstrations but as field laboratories for additional studies on improving the quality and growth of walnut trees. The Department of Forestry at the University of Missouri has made test plantings of forest trees on strip-mined land in the state.

In 1947 several forest-planting experiments were set up by the Central States Forest Experiment Station, U. S. Forest Service, Department of Agriculture, in cooperation with several coal-mining companies. The plantings were made on 12 experimental areas and were designed to test the suitability of species to representative bank types and conditions on strip-mined land in Missouri, Kansas, and Oklahoma. Each area, embracing more than 5 acres, was planted or seeded with trees or seeds of black locust, green ash, bur oak, white oak, black cherry, black walnut, sweet gum, eastern red cedar, jack pine, shortleaf pine, loblolly pine, ponderosa pine, Virginia pine, and pitch pine. In addition, some of the plantings include tests to find the effects of grading stripped land on survival and growth of the planted trees. Differences in survival and growth are present, but the studies have not been established long enough to warrant drawing conclusions and making recommendations for planting.

Since 1947 a number of additional experiments have been started. One of these is designed to test the effects of mixed plantings of hardwoods on survival and growth, particularly of black walnut. Another is to determine the possibilities of improving the quality of black walnut by pruning. Moisture conditions on graded and ungraded banks are also being studied.

A balanced research program in this field should include such diverse studies as the physical and chemical analyses of bank materials, the suitability and the possibility of improving each set of bank conditions for production of forage, fruits, vegetables, forests, fish, game, and recreation; and engineering studies to determine whether site conditions can be economically improved by modifying mining methods.

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APPENDIX

Table 10.--Estimated area of strip-mined land in the Western Interior Coal Province by counties, states, and years since stripping, 1946.

State and county	Years since stripping: 1-10 years (acres)	11-20 years (acres)	20 or more (acres)	Total (acres)
Missouri	9,568	9,927	6,001	25,496
Barton	1,376	3,797	3,866	9,039
Bates	1,895	2,119	992	5,006
Boone	84	86	0	170
Callaway	682	53	137	872
Dade	82	8	0	90
Henry	2,176	2,365	257	4,798
Howard	0	70	0	70
Jasper	84	14	14	112
Johnson	203	33	37	273
Macon	599	201	0	800
Randolph	1,285	654	0	1,939
St. Clair	0	11	228	239
Vernon	1,102	516	470	2,088
Oklahoma	4,394	1,896	2,026	8,316
Atoka	0	81	0	81
Coal	81	109	75	265
Craig	99	161	129	389
Haskell	283	354	287	924
Latimer	0	0	14	14
Mayes	0	94	0	94
Muskogee	314	93	67	474
Okmulgee	25	0	124	149
Pittsburg	0	19	141	160
Rogers	1,231	522	141	1,894
Tulsa	294	0	957	1,251
Wagoner	2,067	463	91	2,621
Kansas	13,331	5,911	5,940	25,182
Bourbon	1,068	167	641	1,876
Cherokee	4,536	1,444	1,502	7,482
Coffey	0	5	100	105
Crawford	6,655	4,072	3,057	13,784
Franklin	0	8	0	8
Labette	76	167	4	247
Linn	893	48	30	971
Osage	73	0	606	679
Wilson	30	0	0	30
Arkansas	1,835	600	735	3,170
Franklin	172	430	470	1,072
Johnson	436	82	154	672
Logan	0	0	22	22
Pope	76	0	0	76
Scott	122	0	0	122
Sebastian	1,029	88	89	1,206
Iowa	1,747	743	9	2,499
Davis	97	53	0	150
Mahaska	795	188	9	992
Marion	685	296	0	981
Monroe	22	0	0	22
Wapello	148	20	0	168
Warren	0	186	0	186
TOTAL REGION	30,875	19,077	14,711	64,663

Partial list of tree species found on strip-mined land in the Western Interior Coal Province.

Acer negundo	Boxelder
Acer saccharinum	Silver maple
Acer saccharaphorum	Sugar maple
Ailanthus altissima	Tree of Heaven
Betula nigra	River birch
Carya alba	Mockernut or Big-bud hickory
Carya cordiformis	Bitternut hickory
Carya glabra	Pignut hickory
Carya lacinosa	Shellbark hickory
Carya ovata	Shagbark hickory
Carya pecan	Pecan hickory
Castanea dentata	Chestnut
Castanea pumila	Chinquapin
Catalpa speciosa	Catalpa
Celtis sp.	Hackberry
Cercis canadensis	Red bud
Cornus sp.	Dogwood
Crataegus sp.	Thorn apple
Diospyros virginiana	Persimmon
Ficus sp.	Fig
Fraxinus americana	White ash
Fraxinus pennsylvanica var. lanceolata	Green ash
Gleditsia triacanthos	Honey locust
Gymnocladus dioicus	Kentucky coffee tree
Juglans nigra	Black walnut
Juglans regia	English walnut
Juniperus virginiana	Eastern Red Cedar
Liriodendron tulipifera	Yellow poplar
Liquidambar styraciflua	Sweet gum
Maclura pomifera	Osage orange
Malus sp.	Apple
Morus alba & rubra	Mulberry
Pinus Banksiana	Jack pine
Pinus densiflora	Japanese red pine
Pinus echinata	Shortleaf pine
Pinus nigra	Austrian pine
Pinus ponderosa	Ponderosa pine
Pinus resinosa	Red pine
Pinus rigida	Pitch pine
Pinus sylvestris	Scotch pine
Pinus Strobus	Eastern white pine
Pinus Taeda	Loblolly pine
Pinus thumbergii	Japanese black pine
Pinus virginiana	Virginia pine
Platanus occidentalis	Sycamore
Populus deltoides	Cottonwood
Prunus americana & augustifolia	Wild plum
Prunus domestida var.	Plum
Prunus persica var.	Peach
Prunus serotina	Black cherry
Pseudotsuga taxifolia	Douglas fir
Pyrus communis var.	Pear
Quercus alba	White oak
Quercus borealis & rubra	Red oak

(Continued)

Partial list of tree species found on strip-mined land in the Western Interior Coal Province (Continued)

Quercus imbricaria	Shingle oak
Quercus macrocarpa	Bur oak
Quercus marilandica	Blackjack oak
Quercus prinus	Swamp chestnut oak
Quercus muehlenbergii	Chinquapin oak
Quercus palustris	Pin oak
Quercus stellata	Post oak
Quercus velutina	Black oak
Quercus suber	Cork oak
Robinia pseudoacacia	Black locust
Salix sp.	Willow
Sassafras albidum	Sassafras
Staphylea trifolia	Bladdernut
Taxodium distichum	Bald cypress
Thuja orientalis	Oriental arborvitae
Ulmus sp.	Elm

Partial list of herbaceous and shrubby species found on strip-mined land in the Western Interior Coal Province.

Herbaceous species	
Amaranth	Poison ivy
Aster	Pokeweed
Bindweed	Prairie mimosa
Bract plantain	Puncture vine
Broomsedge	Ragweed
Bullnettle	Rattlebox
Buttonweed	Rockweed
Cattail	Sage
Cheat grass	Sensitive brier
Cinquefoil	Sheep sorrel dock
Cocklebur	Shepherd's purse
Crabgrass	Small-flowered cranesbill
Curlydock	Smartweed
Daisy	Spanish needles
Dandelion	Spiderwort
Delphinium	Spurge
Dewberry	Sunflower
Dock	Sweet clover
Dogbane	Thistle
Euphorbia	Ticklegrass
Evening primrose	Tickseed
Foxtail grass	Trefoil
Golden rod	Tripleawn grass
Ground cherry	Tumbleweed
Gumweed	Venus'-looking-glass
Hoary cress	Verbenum
Indigo	Violet
Knapweed	Wild alfalfa
Lamb's quarters	Wild carrot
Lespedeza	Wild geranium
Lespedeza bicolor	Wild lettuce
Little blue-stem grass	Wild morning-glory
Milkweed	Wild onion
Mint	Wild senna
Mullen	Woodbine
Partridge pea	Wood sorrel
Peavine	Woolly plantain
Peppergrass	Yarrow
Shrubby species	
Blackberry	Sumac
Coralberry	Wild grape
Leadplant	Wild rose

List of forest plantations on strip-mined land in Kansas, 1946.

Location[1] T	R	S	Acres	Species planted	Remarks
				BOURBON COUNTY	
27	24	13	0	Black walnut	Few trees
				CHEROKEE COUNTY	
32	22	24	1	Bur oak, cork oak	P & M Mining Co.
32	23	4	272	Black walnut, bur oak, green ash	
32	23	8	73	Black walnut, bur oak, green ash, ponderosa pine	
32	23	9	117	Black walnut	
32	23	18	200	Black walnut, black locust, cottonwood	G. Nettle Farm
32	23	24	30	Black walnut	Poor survival
32	23	25	73	Black walnut, black locust	Poor survival
32	24	3	61	Catalpa, black walnut	
32	24	8	73	Catalpa, white ash, black walnut, bur oak	30% survival
32	24	17	250	Black walnut	Fire damage
32	24	18	247	Black walnut	Fire damage
32	24	19	208	Black walnut	Fire damage
32	24	24	1	Jack pine, eastern white pine	About 50 trees
				CRAWFORD COUNTY	
29	25	32	0[2]	Black walnut, eastern red cedar, ponderosa pine, Scotch pine, Lombardy poplar	Crawford County State Park
30	24	22	92	Black walnut	Failed on 20 acres
30	24	23	220	Black walnut, ponderosa pine, jack pine	Site of quail farm
30	24	33	5	Black walnut	98% failure
30	24	34	50	Black walnut	75% failure
30	25	11	60	Black walnut	Survival ok-fire
30	25	12	188	Black walnut, mockernut hickory, pecan hickory	Natural stands mixed with planted trees
30	25	13	236	Black walnut, bur oak, black locust	
31	24	3	2	Catalpa, black walnut, black locust	Fleming Project
				LABETTE COUNTY	
33	21	33	1	Shortleaf pine	Few trees
35	21	17	1	Black walnut, Japanese red pine	Few trees

[1] Location refers to: T = Township South, R = Range East; S = Section

[2] Roadside and recreational site spot plantings

List of natural forest stands on strip-mined land in Kansas, 1946.

Location[1/] T	R	S	Acres	Species planted	Remarks
				BOURBON COUNTY	
27	24	13	21	Boxelder, silver maple, hackberry, dogwood, persimmon, honey locust, sycamore, cottenwood, black cherry, pin oak, osage orange, elm, black walnut	
				CHEROKEE COUNTY	
31	24	20	50	Cottonwood	Mike Reda farm
31	24	22	9	Silver maple, elm, black oak, pin cherry	Scraper spoils
31	24	29	7	Cottonwood, elm, willow, catalpa	Wilkinson farm
31	24	32	2	Cottonwood	
32	23	25	1	Black locust	
32	23	26	21	Silver maple, mulberry, cottonwood, black cherry, osage orange, elm	Closed stand
32	23	35	15	Cottonwood	
32	24	3	61	Catalpa, cottonwood, black locust	Quesnoy farm
32	24	19	50	Silver maple, catalpa, cottonwood	Fire damage
33	24	7	5	Elm, red oak, black cherry, silver maple, cottonwood	1200 trees per acre
				CRAWFORD COUNTY	
27	25	31	15	Cottonwood, elm, ash	10-15 years old
28	24	1	6	Cottonwood, elm	10 years old
28	24	12	25	Cottonwood, red oak, swamp chestnut, oak, pin oak, willow, elm	10-12 years old
28	25	3	5	Cottonwood, pin oak, elm	
28	25	6	50	Cottonwood, elm, sycamore, black cherry	10-17 years old
28	25	7	5	Green ash, black walnut, cottonwood, red oak, bur oak, pin oak, black oak, osage orange, elm	
28	25	36	30	Cottonwood, elm, silver maple, catalpa, black cherry	
29	25	12	20	Silver maple, elm, black cherry, persimmon	Mulberry, Kansas, closed stand
29	25	15	30	Cottonwood	
29	25	27	106	Cottonwood, elm, honey locust, black locust, willow, pin oak, green ash, catalpa	
29	25	32	329	Boxelder, silver maple, catalpa, hackberry, thorn apple, green ash, mulberry, cottonwood, black cherry, pin oak, willow, osage orange, elm	Crawford County State Park

(Continued)

[1/] Location refers to: T = Township South; R = Range East; S = Section

List of natural forest stands on strip-mined land in Kansas, 1946 (Continued).

Location 1/					
T	R	S	Acres	Species planted	Remarks
				CRAWFORD COUNTY (Continued)	
29	25	33	5	Cottonwood	Young stand
30	24	4	25	Cottonwood, elm, pin oak, catalpa, dogwood	
30	24	10	21	Catalpa, green ash, cottonwood, pin oak, elm	40 percent stocking
30	24	23	6	Cottonwood	Site of quail farm
30	24	27	76	Cottonwood, elm	Good stand
30	24	34	15	Cottonwood	
30	24	36	15	Catalpa, white ash, green ash, honey locust, mulberry, cottonwood, black cherry, red oak, willow, osage orange, elm	Good stand
30	25	5	50	Cottonwood, elm, green ash, willow, osage orange, black cherry	
30	25	7	25	Persimmon, sycamore, cottonwood, black cherry, pin oak, willow, osage orange, elm	
30	25	12	30	Boxelder, Tree of Heaven, catalpa, cottonwood, plum, black cherry, bur oak, pin oak, willow, elm	Natural stands mixed with planted trees
30	25	13	40	Silver maple, catalpa, cottonwood, black cherry, pin oak, willow	Mixed with planted trees
30	25	18	15	Silver maple, red birch, catalpa, persimmon, green ash, mockernut, hickory, sycamore, cottonwood, bur oak, pin oak, willow, elm	
30	25	19	2	Pin oak	Excellent stand
31	24	12	34	Cottonwood, pin oak, black locust, elm	Good locust
31	24	14	40	Cottonwood, black cherry, pin oak, elm	Light to fair stocking
31	24	17	5	Cottonwood	
				LABETTE COUNTY	
34	21	21	31	Boxelder, hackberry, persimmon, green ash, honey locust, mockernut hickory, pecan hickory, sycamore, cottonwood, black cherry, red oak, pin oak, black locust, willow, osage orange, elm	Edder Farm

1/ Location refers to: T = Township South; R = Range East; S = Section

List of orchards and pastures on strip-mined land in Kansas, 1946.

Location[1] T	R	S	Acres	Species planted	Remarks
				CHEROKEE COUNTY	
31	24	29	25	Sweet clover	Wilkinson Farm
31	24	32	1	Apples	
32	22	24	6	Plum, peach, apple, grapes	
32	23	8	1	Alfalfa	
32	23	18	249	Sweet clover, lespedeza	G. Nettle Farm
				CRAWFORD COUNTY	
28	25	34	15	Apple, peach, pear	
29	25	13	45	Apple, plum, peach	A Kuren Farm
29	25	23	10	Apple, peach, pear	Mackie-Clemens
29	25	27	17	Chestnut, fig, pecan hickory, black walnut, English walnut, yellow poplar, apple, plum, peach, black cherry	Reickenbach Farm
30	25	30	29	Natural pasture	
31	24	3	1	Peach, apricot, grape	
31	24	4	75	180 varieties	Fleming Stripland Reclamation Proj.
				LINN COUNTY	
21	25	27	50	Lespedeza	Not grazed

[1] Location refers to: T = Township South; R = Range East; S = Section

List of forest plantations on strip-mined land in Missouri, 1946.

Location[1/] T	R	S	Acres	Species planted	Remarks
				BARTON COUNTY	
31	33	6	4	Eastern red cedar, Austrian pine, black locust	U. of Mo. Extension Department
31	33	7	0.2	Jack pine, Virginia pine	U. of Mo. Extension Department
31	32	30	7	Catalpa, green ash, yellow poplar, ponderosa pine, Scotch pine, bur oak, black locust	
33	33	19	20	Catalpa	
33	33	30	1	Eastern red cedar, shortleaf pine, black cherry	
				BATES COUNTY	
38	31	4	1	Catalpa	
				VERNON COUNTY	
36	30	11	10	Black walnut, ponderosa pine, red pine	Pioneer Coal Co.
				CALLAWAY COUNTY	
47	10	28	6	Eastern red cedar, mulberry, jack pine, Japanese red pine, shortleaf pine, Austrian pine, ponderosa pine, red pine, pitch pine, Scotch pine, eastern white pine, loblolly pine, Japanese black pine, Virginia pine, douglas fir, black locust, Oriental arborvitae, osage orange	Soil Conservation Service Cedar Creek Project
47	10	34	6	Shortleaf pine, black locust	Chas. Guerrant Farm
48	11	11	1	Shortleaf pine	
				HENRY COUNTY	
40	26	25	2	Black walnut, black locust	
				RANDOLPH COUNTY	
54	14	8	3	Black locust	FFA planting
54	14	9	6	Black locust	FFA planting
54	14	18	2	Black locust	FFA planting
54	14	19	1	Black locust	FFA planting
54	15	2	15	Green ash, shortleaf pine, black locust	Sinclair Coal Co.
54	15	11	60	Green ash, shortleaf pine, black locust	Sinclair Coal Co.
54	15	14	37	Shortleaf pine, Virginia pine, black locust	Sinclair Coal Co.
54	15	15	17	Shortleaf pine	Sinclair Coal Co.
55	15	23	6	Black locust, shortleaf pine	Sinclair Coal Co.
				ST. CLAIR COUNTY	
39	26	2	1	Shortleaf pine	Neuenschwander Farm

[1/] Location refers to: T = Township North; R = Range West; S = Section

List of natural forest stands on strip-mined land in Missouri, 1946.

Location[1/] T	R	S	Acres	Species
				BARTON COUNTY
31	31	13	3	Red birch, red bud, persimmon, green ash, mockernut hickory, black cherry, bur oak, pin oak, post oak, black locust
31	33	13	5	Red birch, red bud, persimmon, honey locust, shagbark hickory, black walnut, black cherry, laurel oak, pin oak, bladdernut, elm
32	33	29	28	Cottonwood
32	33	30	8	Elm
33	33	18	2	Cottonwood
33	33	19	5	Cottonwood, black cherry, elm
33	33	29	8	Elm, cottonwood
33	33	30	7	Cottonwood
33	33	31	20	Cottonwood
				BATES COUNTY
38	31	4	100	Silver maple, catalpa, thorn apple, persimmon, pecan hickory, black walnut, apple, sycamore, cottonwood, black cherry, pin oak, willow, osage orange, elm
38	33	17	112	Boxelder, silver maple, catalpa, dogwood, black walnut, cottonwood, wild plum, black cherry, black locust, willow, osage orange, elm
39	33	12	12	Chinquapin, dogwood, black cherry, pin oak, osage orange, elm
39	33	14	10	Persimmon, black walnut, eastern red cedar, sycamore, cottonwood, black cherry, willow, osage orange, elm
39	33	16	13	Boxelder, sycamore, cottonwood, chinquapin oak, pin oak, post oak, willow, osage orange, elm
39	33	20	17	Silver maple, dogwood, cottonwood, peach, willow, osage orange, elm
39	33	28	13	Boxelder, honey locust, black walnut, sycamore, cottonwood, willow, osage orange, elm
39	33	29	35	Dogwood, cottonwood, black cherry, pin oak, willow, osage orange, elm
39	33	30	33	Dogwood, cottonwood, black cherry, pin oak, willow, osage orange, elm
39	33	6	6	Thorn apple, persimmon, honey locust, pecan hickory, cottonwood, black cherry, red oak, bur oak, pin oak, post oak, black oak, willow, elm
				VERNON COUNTY
35	33	17	6	Dogwood, cottonwood, willow, elm
37	31	4	77	Boxelder, silver maple, dogwood, thorn apple, green ash, honey locust, shagbark hickory, pecan hickory, black walnut, apple, sycamore, cottonwood, black cherry, pin oak, willow, osage orange, elm
38	31	28	58	Silver maple, persimmon, cottonwood, black cherry, blackjack oak, pin oak, willow, osage orange, elm
38	31	34	8	Thorn apple, persimmon, honey locust, pecan hickory, cottonwood, willow, pin oak, osage orange, elm
				CALLAWAY COUNTY
47	10	28	12	Red birch, persimmon, eastern red cedar, sycamore, laurel oak, willow, sassafras, osage orange, elm

(Continued)

[1/] Location refers to: T = Township North; R = Range West; S = Section

List of natural forest stands on strip-mined land in Missouri, 1946 (Continued).

Location[1] T	R	S	Acres	Species
				HENRY COUNTY
40	26	26	1	Silver maple
40	28	13	11	Silver maple, Tree of Heaven, catalpa, thorn apple, green ash, honey locust, cottonwood, willow, osage orange, elm
42	26	23	8	Red birch, hackberry, dogwood, thorn apple, honey locust, mockernut hickory, black walnut, mulberry, sycamore, cottonwood, black cherry, chinquapin oak, black oak, osage orange, elm
42	26	29	12	Silver maple, Tree of Heaven, green ash, eastern red cedar, sycamore, cottonwood, wild plum, black cherry, pin oak, black locust, willow, elm
42	26	32	20	Honey locust, cottonwood, black cherry, willow, osage orange, elm
43	24	8	12	Elm
43	24	9	12	Black locust, elm, willow, osage orange, hackberry
				ST. CLAIR COUNTY
39	25	6	5	Silver maple, red birch, sycamore, cottonwood, black cherry, willow, elm

[1] Location refers to: T = Township North; R = Range West; S = Section

List of orchards and pastures on strip-mined land in Missouri, 1946.

Location[1] T	R	S	Acres	Species planted	Remarks
				BARTON COUNTY	
32	33	6	11	Pecan hickory, black walnut, apple, peach, grapes	Toni Panizzi
				BATES COUNTY	
38	31	4	1	Apple, peach	
				VERNON COUNTY	
36	30	11	30	Lespedeza	Pioneer Coal Co.
				HENRY COUNTY	
40	26	26	1	Peach	
40	26	35	1	Peach	
43	24	8	3	Peach	
43	24	9	1	Peach	
43	25	35	12	Heavy growth of sweet clover	Not grazed, leveled
				RANDOLPH COUNTY	
54	14	17	1	Peach	
54	15	10	172	Sweet clover, lespedeza	

[1] Location refers to: T = Township North; R = Range West; S = Section

List of forest plantations on strip-mined land in Oklahoma, 1946.

Location[1/]					
T	R	S	Acres	Species planted	Remarks
				HASKELL COUNTY	
9	21	8	5	Black locust, bald cypress, osage orange, mulberry, black cherry	
10	21	13	3.5	Black locust	
				MAYES COUNTY	
23	18	7	35	Eastern red cedar, mulberry, shortleaf pine, cottonwood, black cherry, red oak, black locust, osage orange, elm, plum	
				ROGERS COUNTY	
23	15	5	5	Black locust	Sooner Coal Co.
				TULSA COUNTY	
20	13	21	4	Black locust	Screen planting
20	13	27	19	Black locust, mulberry, catalpa, plum, osage orange	
20	13	34	115	Catalpa, mulberry, plum, black locust, osage orange, elm	
				WAGONER COUNTY	
18	15	17	30	Hackberry, honey locust, Kentucky coffee tree, black walnut, mulberry, black locust, osage orange, elm	Rhinie Wagner Farm
18	15	19	10	Black locust, pear, catalpa, eastern red cedar, shortleaf pine	Boy Scouts of America
18	15	30	3	Black locust, bald cypress	Repschlager Farm

[1/] Location refers to: T = Township North; R = Range East; S = Section

List of natural forest stands on strip-mined land in Oklahoma, 1946.

Location 1/					
T	R	S	Acres	Species planted	Remarks
				HASKELL COUNTY	
9	21	5	15	Sycamore, cottonwood, black cherry	
9	21	8	15	Sycamore, cottonwood, black cherry	
				TULSA COUNTY	
20	13	27	30	Cottonwood	North edge of Tulsa
22	14	20	20	Cottonwood	
				WAGONER COUNTY	
17	18	27	21	Cottonwood, willow, elm	Excellent stand

1/ Location refers to: T = Township North; R = Range East; S = Section

List of orchards and pastures on strip-mined land in Oklahoma, 1946.

Location 1/					
T	R	S	Acres	Species planted	Remarks
				MUSKOGEE COUNTY	
11	20	31	1	Kudzu pasture	Leavell Coal Co.
				ROGERS COUNTY	
21	15	26	1	Peach	King Farm

1/ Location refers to: T = Township North; R = Range East; S = Section