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Description of Disturbed and Reclaimed Surface-Mined Coal Lands in Eastern Oklahoma

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(Text to accompany Map GM-17)

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Description of Disturbed and Reclaimed Surface-Mined Coal Lands in Eastern Oklahoma

Kenneth S. Johnson[1]

INTRODUCTION

Large reserves of bituminous coal are distributed over an area of 10,000 square miles in eastern Oklahoma (fig. 1), and these deposits have been mined continuously since 1872. Early production in Oklahoma was almost entirely from underground mines, but with the development of large power equipment, surface mining became increasingly important, accounting for about 50 percent of annual production in 1943 and 99 percent or more in 1964-67 (fig. 2). With the temporary closing of Oklahoma's last underground mine in 1972, surface mines became the State's sole coal producers.

The accompanying maps and data deal with lands disturbed by surface mining prior to July 1973 and do not include information on surface features associated with underground mines. Data herein compiled show that about 35,400 acres of coal land in eastern Oklahoma was disturbed by surface mining by mid-1973 and that approximately 8,300 acres of this land has been reclaimed or partly reclaimed for sequential use. Therefore, about 27,000 acres of disturbed land remains unleveled and unreclaimed.

Restoration of newly mined lands is required by Oklahoma's Mining Lands Reclamation Acts of 1968 and 1971, but land mined before 1968 has generally not been leveled and reconditioned for sequential use. To date, no program has been established for reconditioning the acreage disturbed prior to 1968. I hope that this report will be useful as a first step in launching such a program.

Four descriptive terms are used in this report to indicate the condition of mined lands. These terms refer to all lands within a mined area, including spoil banks (whether on mined or unmined land), open cuts, highwalls, spoils cast above highwalls, haul roads on or adjacent to spoil banks, and ponds in open cuts, troughs, or haul roads. The terms are explained as follows.

Disturbed land refers to all land modified by surface-mining activity.

Unreclaimed land refers to disturbed land upon which no reclamation efforts have been made (also called "orphan" mined lands). Virtually all land in this category was mined prior to 1968.

Partly reclaimed land refers to disturbed lands upon which some reclamation efforts have been directed. Most of the land referred to by this term was mined between 1968 and June 1971, when Oklahoma law required leveling only the tops of spoil ridges to a width of 10 feet. Much of the remainder is land that has been partly leveled during use as sanitary-landfill sites.

Reclaimed land refers to disturbed land that has been

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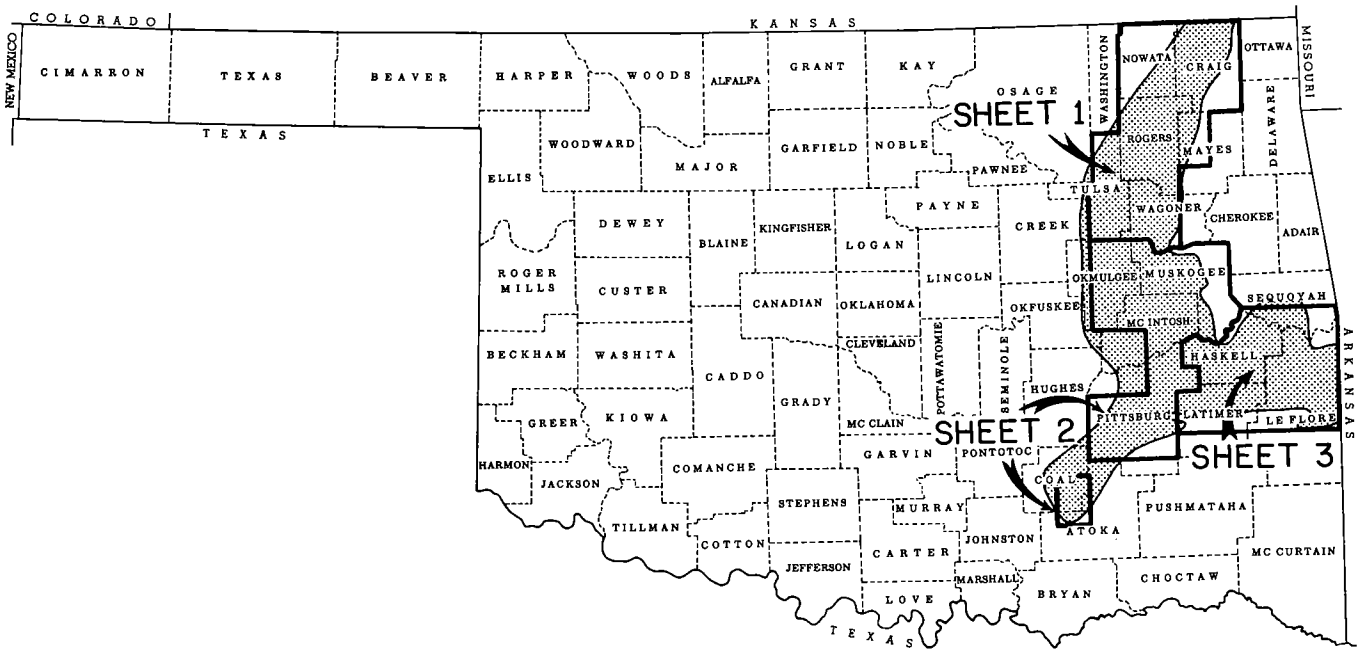

Figure 1. Index map of Oklahoma showing location of coal field (shaded) and coverage of accompanying large-scale map sheets 1, 2, and 3.

leveled to a gently rolling terrain and restored to productive sequential use. Much of this land has had original topsoil set aside and then spread on leveled spoils. Most of this land has been reclaimed since passage of the Mining Lands Reclamation Act of June 1971, and most has been developed as grasslands.

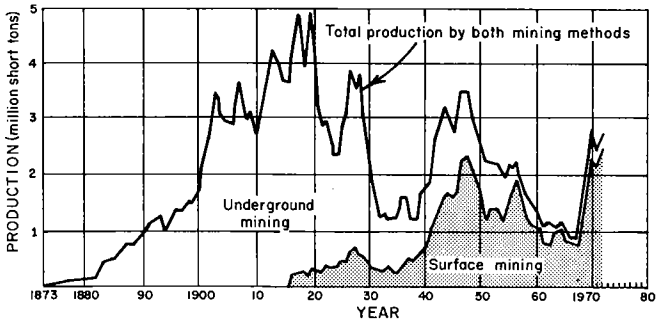

Figure 2. Coal production in Oklahoma, 1873-1972, showing amounts of coal mined by underground and surface methods. Data for 1873-1952 from Trumbull (1957) and for 1953-72 from U.S. Bureau of Mines Minerals Yearbooks and annual reports of Oklahoma Department of Mines.

OKLAHOMA'S CURRENT MINING AND RECLAMATION ACTIVITIES

The methods and economics of mining coal are determined largely by regional and local geology, that is, by factors such as coal thickness, continuity, and quality; by character and thickness of overburden; geologic structure; dip of the strata; and topography. Eleven principal coal beds (of Pennsylvanian age) have been mined in Oklahoma; the mined beds are commonly 1 to 4 feet thick, but beds as thick as 7 feet have been worked locally (Friedman, 1973). Coal beds dip gently in the northern part of the Oklahoma coal field, north of the Canadian River, and are folded broadly and dip more steeply in the south (fig. 3). Surface mining predominates in areas where the coal crops out, particularly where the dip is gentle, whereas underground mining (slope or shaft) is necessary where the dip is steep or where the coal beds are deep underground. Present mining practices of Oklahoma companies are described by Friedman (1973, p. 148-149).

A surface-mining operation involves digging a long, open trench, or "box cut," through the overburden to expose a portion of the coal, which is then removed (fig. 4a). As each succeeding parallel cut is made, the overburden

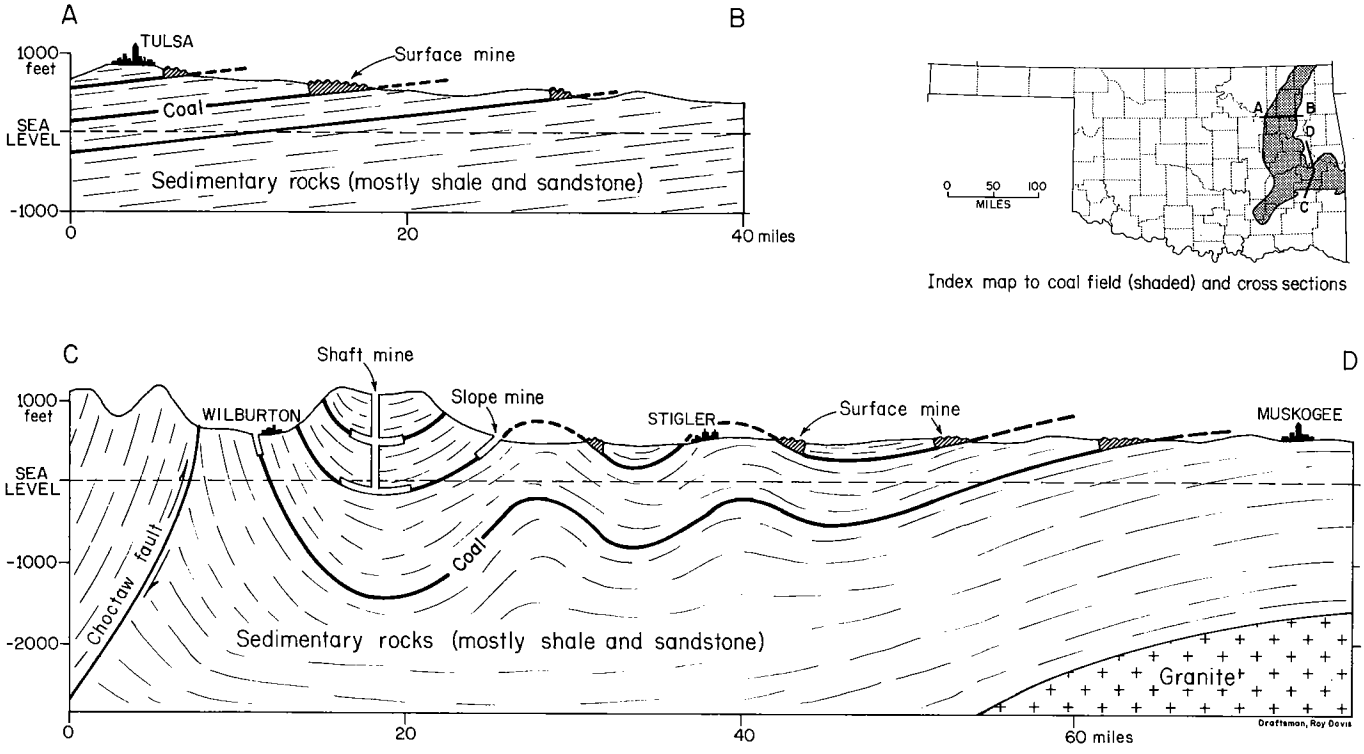

Figure 3. Schematic cross sections showing geologic structure and types of mines in different parts of the Oklahoma coal field. Only a few key coal beds are shown.

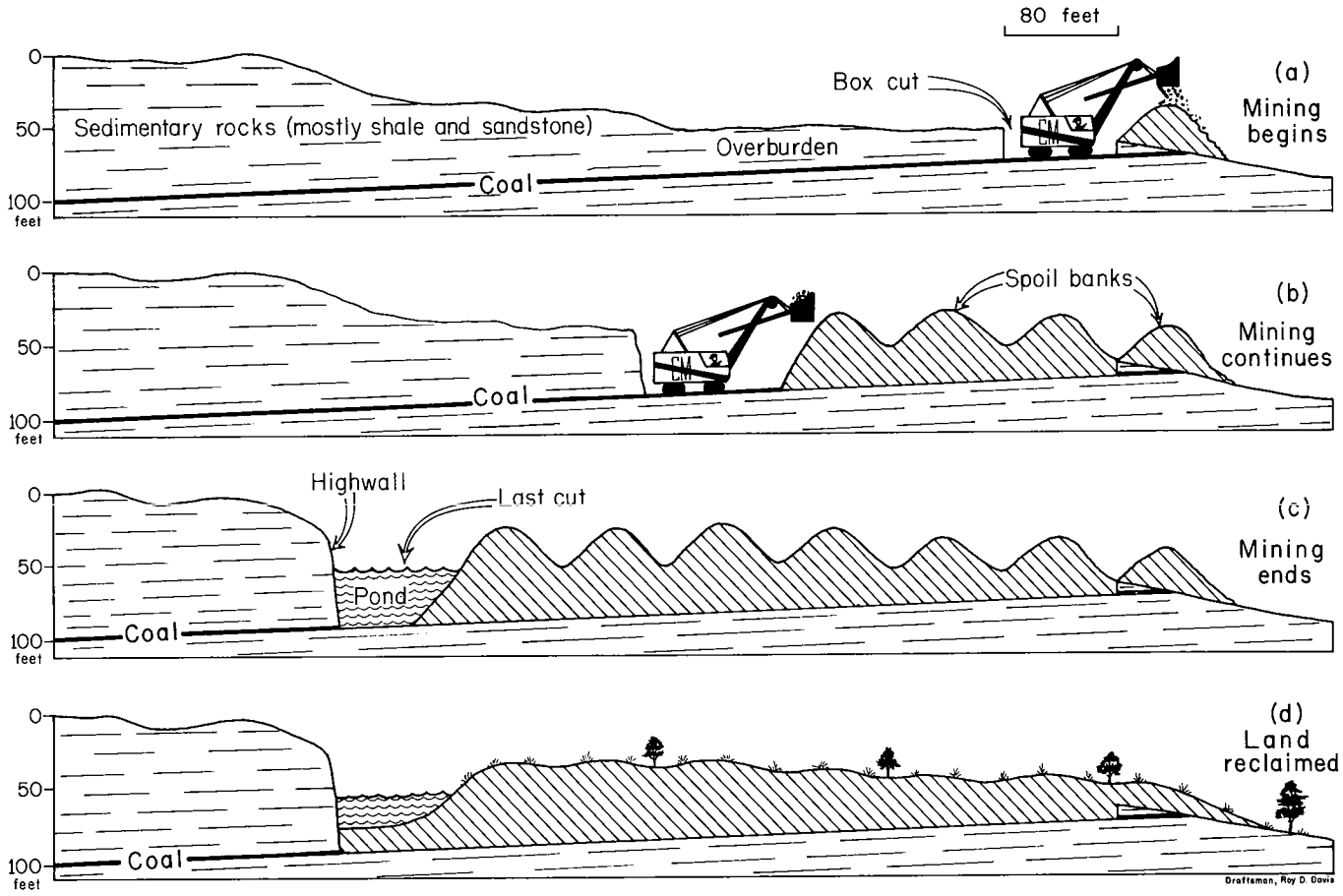

Figure 4. Schematic cross sections showing stages of surface mining for coal. Prior to 1968 most mined lands were left as shown in section *c*, but current Oklahoma law requires leveling and reclaiming land as in section *d*.

is placed as spoil material into the cut previously excavated (fig. 4b). Successive cuts are mined until the overburden thickness becomes so great that the coal can no longer be mined economically. The final cut leaves an open trench bounded by the last spoil bank on one side and the undisturbed highwall on the other (fig. 4c). If the last cut or other major depressions are below the ground-water table in the mined area, they will be partially filled by ground water and precipitation. Unless the ridges of spoil are graded or leveled (as in fig. 4d), the mined area resembles a giant washboard (fig. 5). "Area mining" describes mining of a large area with many successive cuts, whereas "contour mining" or "rim stripping" refers to mining of four cuts or less before the overburden becomes too great (fig. 6).

Oklahoma's first step toward mined-land restoration, taken on January 1, 1968, with passage of the Open Cut Land Reclamation Act, established mining-permit fees, required that a bond be posted for reclamation, and specified minimum restoration requirements. The act applied to surface mines beginning operations after that date or new extensions of preexisting mines. In June 1971 the Oklahoma Legislature passed the Mining Lands Reclamation Act (House Bill 1492), strengthening reclamation requirements. Enforcement of this legislation is carried out through the office of the chief mine inspector, Oklahoma Department of Mines.

Under the new act, companies planning to extract minerals (excluding liquids and gases such as oil and natural gas) by surface or underground mining must obtain a permit, pay an application fee of $50 each year, and post a bond of $350 to $650 for each acre of land affected; coal-mining companies are obliged to post a bond of $500 to $650 per acre, with a minimum bond of $5,000. In addition, each application for a mining permit must be accompanied by a reclamation plan that meets the requirements of the act and furnishes the following information: (1) the proposed use of the land after mining, (2) the grading to be done, (3) the type of vegetation to be planted, and (4) the approximate time of grading and initial revegetation effort. A mining permit will not be issued unless these conditions are met, and any operator engaged in mining without a valid permit is liable for a fine of $50 to $1,000 for each day of operation.

The operator and landowner determine the subsequent use of the land, that is, they determine whether the land will be reclaimed for forest, pasture, crop, homesite, recrea-

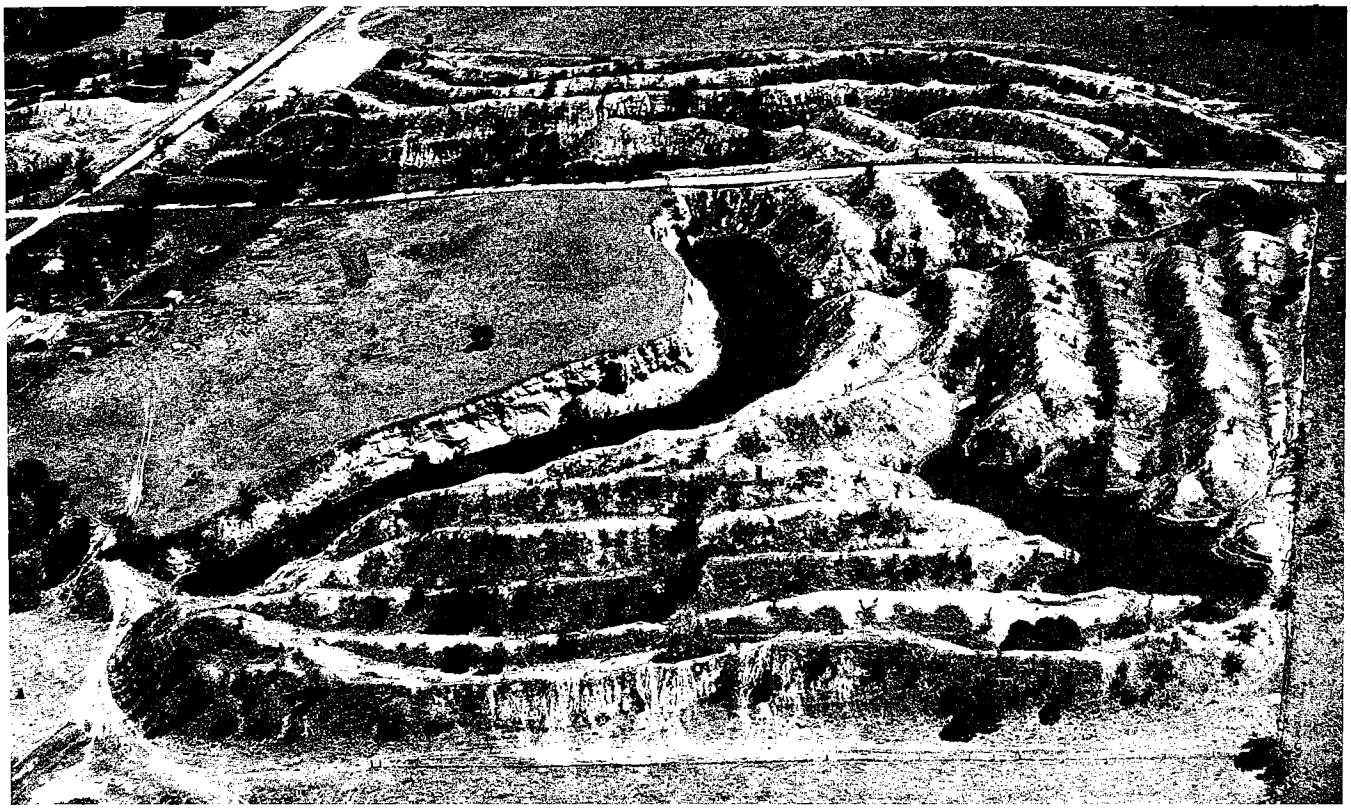

Figure 5. Aerial view of unreclaimed land mined for coal before passage of Oklahoma's reclamation acts. Vegetation is sparse, and water fills last cut (center) and part of abandoned haul road (lower right). Photograph taken in May 1971, looking south in sec. 21, T. 22 N., R. 16 E., Rogers County.

tional, or industrial use. The operator is required to grade all spoil ridges and peaks to "a rolling topography traversable by machines or equipment customarily used in connection with the use to be made of the land after reclamation" (fig. 7). In addition, the operator must cover mineral seams containing significant concentrations of acid-forming materials with 3 feet of earth that will support plant life or cover them with a permanent water impoundment. Grading is to be completed within 1 year after mining, and initial seeding or planting is to be done at the first appropriate time following completion of the grading. Violation of any provision of the act will bring forfeiture of the operator's bond.

Reclamation is not without cost. Oklahoma mineral producers reportedly spend from $300 to $700 per acre in leveling, conditioning, and seeding newly mined lands. Most operators go beyond minimum requirements and voluntarily set aside original topsoil and then spread it over the leveled spoils; this increases the cost of reclamation to $500 to $2,000 per acre, even more at some sites. These costs appear high when considered on a dollars-per-acre basis, but they are relatively small when compared to the quantity and value of coal being mined (table 1). For example, a company that mines a 36-inch-thick coal bed and spends $500 per acre on restoration is actually incurring a reclamation cost of only 12 cents per ton of coal recovered. Most of the coal beds mined in Oklahoma are 12 to 48 inches thick, so reclamation costs on lands now being mined are generally 10 to 70 cents per ton. Oklahoma coal was valued at nearly $7 per ton f.o.b. mine in 1971 and 1972 (U.S. Bureau of Mines), meaning that effective land reclamation increases the value of this coal by about 2 to 10 percent.

Oklahoma coal companies have mined and reclaimed about 1,200 acres of land in each of the past 3 fiscal years (1970-71, 1971-72, and 1972-73), according to Ward Padgett, chief mine inspector of Oklahoma (oral communication, 1973). During this same period, annual coal production from surface mines has averaged nearly 2.3 million tons (fig. 2). Thus, for the past 3 years Oklahoma has averaged about 1,900 tons of coal for each acre of disturbed land.

OKLAHOMA'S UNRECLAIMED MINED LANDS

Prior to passage of the reclamation acts of 1968 and 1971, Oklahoma companies were not obligated to devote any effort toward restoring mined land, and the need for low-cost production of minerals in a highly competitive field caused most companies to minimize their expenditures on land reclamation. About 35,400 acres has been disturbed by surface mining for coal through June 30, 1973; 3,384 acres has been reclaimed, 4,961 acres has been partly reclaimed, and 27,079 acres remains unreclaimed (table 2). These data summarize acreage information presented in detail on accompanying map sheets 1, 2, and 3 and in generalized form in figure 8.

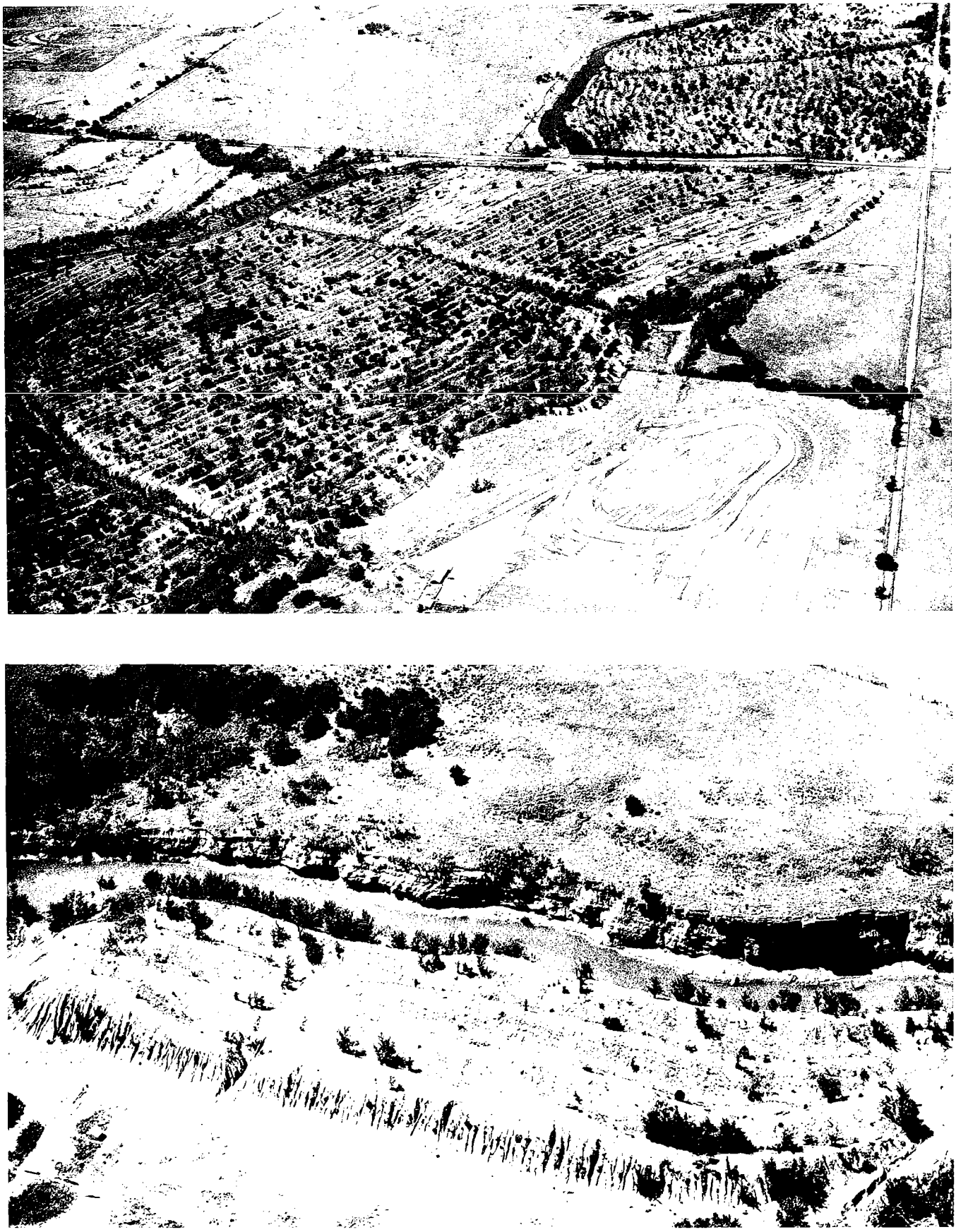

Figure 6. Aerial views of unreclaimed land mined by area-mining method (above) and contour-mining method (below). Upper photograph taken in May 1971 of site in secs. 32 (foreground) and 29 (background), T. 19 N., R. 15 E., Wagoner County; lower photograph taken in May 1971 of site in sec. 29, T. 23 N., R. 17 E., Rogers County.

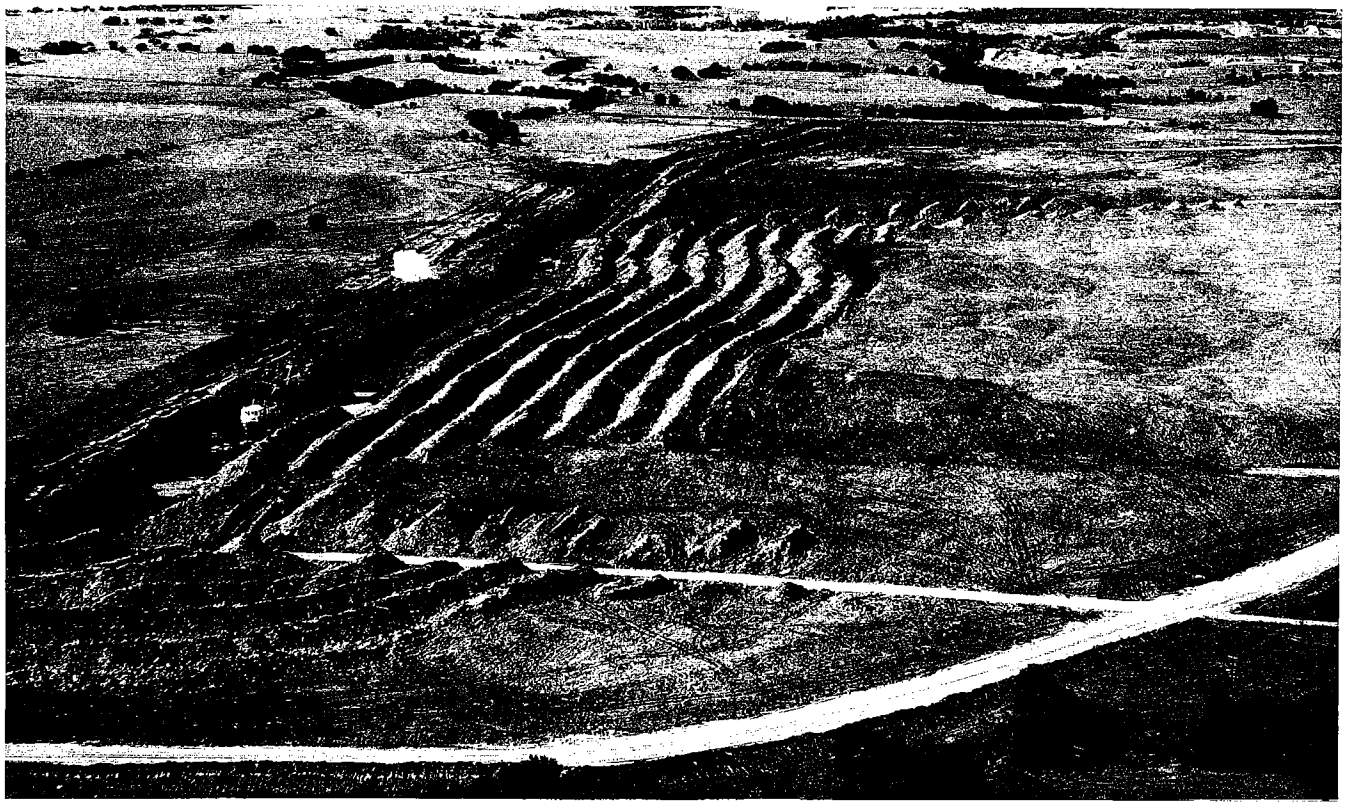

Figure 7. Aerial view of current coal-mining and reclamation operation in Rogers County. Spoil banks in central part of picture are being leveled as mining progresses; all land to right of spoil banks has been mined and leveled. Photograph taken in May 1972, looking north across sec. 11, T. 23 N., R. 16 E. Oologah Reservoir is in background.

Unreclaimed land is distributed in 16 counties, with three-fourths in Rogers, Haskell, Wagoner, Craig, and Le Flore Counties. These areas are commonly marked by ridges and piles of spoil (figs. 5, 6) that consist of unweathered rock and clay heaped upon or thoroughly mixed with a small percentage of original topsoil. Spoil ridges left by mining operations prior to 1960 are generally 20 to 30 feet high (trough to crest) and 40 to 60 feet wide (crest to crest); large, modern shovels and draglines now pile spoil banks up to 60 feet high and 120 feet wide.

In general, soil textures and structures in spoil are inferior to the original topsoil. Spoil commonly is deficient in organic matter and other usable plant nutrients and may be somewhat acidic. No single treatment or vegetative covering is applicable for reclaiming all mined land in Oklahoma. Variations in geology and soil condition as a result of physical and chemical characteristics, different climates, orientation of spoil ridges, steepness of slopes, presence or absence of toxic substances, and seed sources all play a part in determining the rate of revegetation and the type of vegetation that succeeds in a given area (Doerr, 1961, p. 29).

Most of the spoil in old mine areas has been allowed to revegetate on its own. As a result, weeds, grasses, and shrubs commonly have appeared shortly after mining, with trees such as sycamore, cottonwood, and sassafras becoming conspicuous after several years. In most cases, the steep

Table 1.—Reclamation Costs per Ton of Coal for Coal Beds 12 to 60 Inches Thick

THICKNESS OF COAL (INCHES)	ESTIMATED PRODUCTION PER ACRE (TONS)[1]	COST PER TON OF COAL, IF RECLAMATION COST IS:			
		$300 PER ACRE	$500 PER ACRE	$700 PER ACRE	$1,000 PER ACRE
12	1,440	$ 0.21	$ 0.35	$ 0.49	$ 0.69
24	2,880	0.10	0.17	0.24	0.35
36	4,320	0.07	0.12	0.16	0.23
48	5,760	0.05	0.09	0.12	0.17
60	7,200	0.04	0.07	0.10	0.14

[1]Assumed rate of recovery is 80 percent of original coal, or 1,440 tons per acre-foot.

Table 2.—Acreage Disturbed and Reclaimed by Surface Mining in Oklahoma Coal Field Through June 30, 1973[1]

COUNTY	LAND DISTURBED AND UNRECLAIMED[2] (ACRES)	LAND DISTURBED AND PARTLY RECLAIMED[2] (ACRES)	LAND DISTURBED AND RECLAIMED[2] (ACRES)	TOTAL (ACRES)
Atoka	95	–	–	95
Coal	595	–	–	595
Craig	2,744	1,212	529	4,485
Haskell	4,699	434	975	6,108
Latimer	850	–	–	850
Le Flore	2,556	104	11	2,671
Mayes	112	–	–	112
McIntosh	699	–	–	699
Muskogee	996	–	72	1,068
Nowata	129	136	416	681
Okmulgee	1,148	31	114	1,293
Pittsburg	321	–	–	321
Rogers	6,770	2,904	1,140	10,814
Sequoyah	1,321	–	–	1,321
Tulsa	1,380	–	75	1,455
Wagoner	2,664	140	52	2,856
Totals	27,079	4,961	3,384	35,424

[1]These data summarize acreage shown on accompanying map sheets 1, 2, and 3.

[2]See Introduction for descriptions of these terms.

slopes and ridge crests have been less than 50 percent covered 10 years or more after mining (Doerr, 1961, p. 30), and some spoils are so toxic that they do not accept natural revegetation for 20 years or more.

Tracts of disturbed land in Oklahoma are typically long and narrow, particularly where contour mining is necessitated by hilly terrain or by coal beds dipping into the ground at an angle greater than 5°. The average width is less than 0.2 mile, and a length of 1 to several miles is not uncommon.

Ponds are critical for recreational or grasslands development of "orphan" mined lands. In Oklahoma, ponds constitute 5 to 17 percent of the acreage in most tracts of area-mined land and average about 11 percent of the acreage at each site. These figures were determined by measuring total pond area in each of 20 randomly chosen area-mined tracts comprising 65 to 300 acres. Ponds make up a greater percentage of contour-mined tracts, ranging from 10 to 25 percent of the acreage at most sites and averaging about 17 percent (determined using 20 randomly chosen tracts, each of which is only 200 to 500 feet wide and comprises 20 to 100 acres). Of course, some mined sites are without water, while others, such as those at which only one or two cuts were made, may be 40 percent pond area.

The quality of water in Oklahoma mine ponds varies, but at most sites it is nearly neutral (pH 7.0). Doerr (1961, appendix) reports that 21 of 24 water samples from all parts of the coal field had a pH of 6.8 to 8.4, and that the remaining 3 samples (collected at Henryetta, east of Checotah, and west of Vinita) were acidic, with a pH of 3.0 to 4.0.

RECLAMATION PROCEDURES

Minimal effort has been directed to acreage disturbed prior to 1968. Forage grass for animals has sometimes been seeded in tracts, and—occasionally—trees suitable for making fence posts have been planted. Lakes formed in the open pits have been used for watering livestock and, to a certain degree, for recreational purposes. However, dry open pits and other depressions near urban areas should, ideally, be used for refuse disposal in sanitary landfill operations, with subsequent use of the filled land for parks and recreational areas. Such pits should be tested and prepared to assure that ground water will not be contaminated as a result of the landfill.

Data concerning methods and costs of reclaiming "orphan" mined lands are available through a continuing study by the Kansas Mined Land Redevelopment Office (MLRO) at Girard, Kansas. MLRO, through funding from the Ozarks Regional Commission and the State Geological Survey of Kansas, has conducted cost-sharing demonstration projects to encourage the redevelopment of 46,000 acres of mined land in the southeast Kansas coal field (Camin, 1971, 1972; Johnson, 1971). General data from that program can be projected into parts of the Oklahoma coal field because of similarities of geology, spoil-bank materials, mining methods, climate, and agricultural needs and methods.

Reclamation steps followed in preparing Kansas acreage for grassland involves leveling the spoil banks, testing the soil, seedbed preparation, lime application, fertilizer application, and seeding. The results of this program have been highly favorable, and observers have been especially pleased

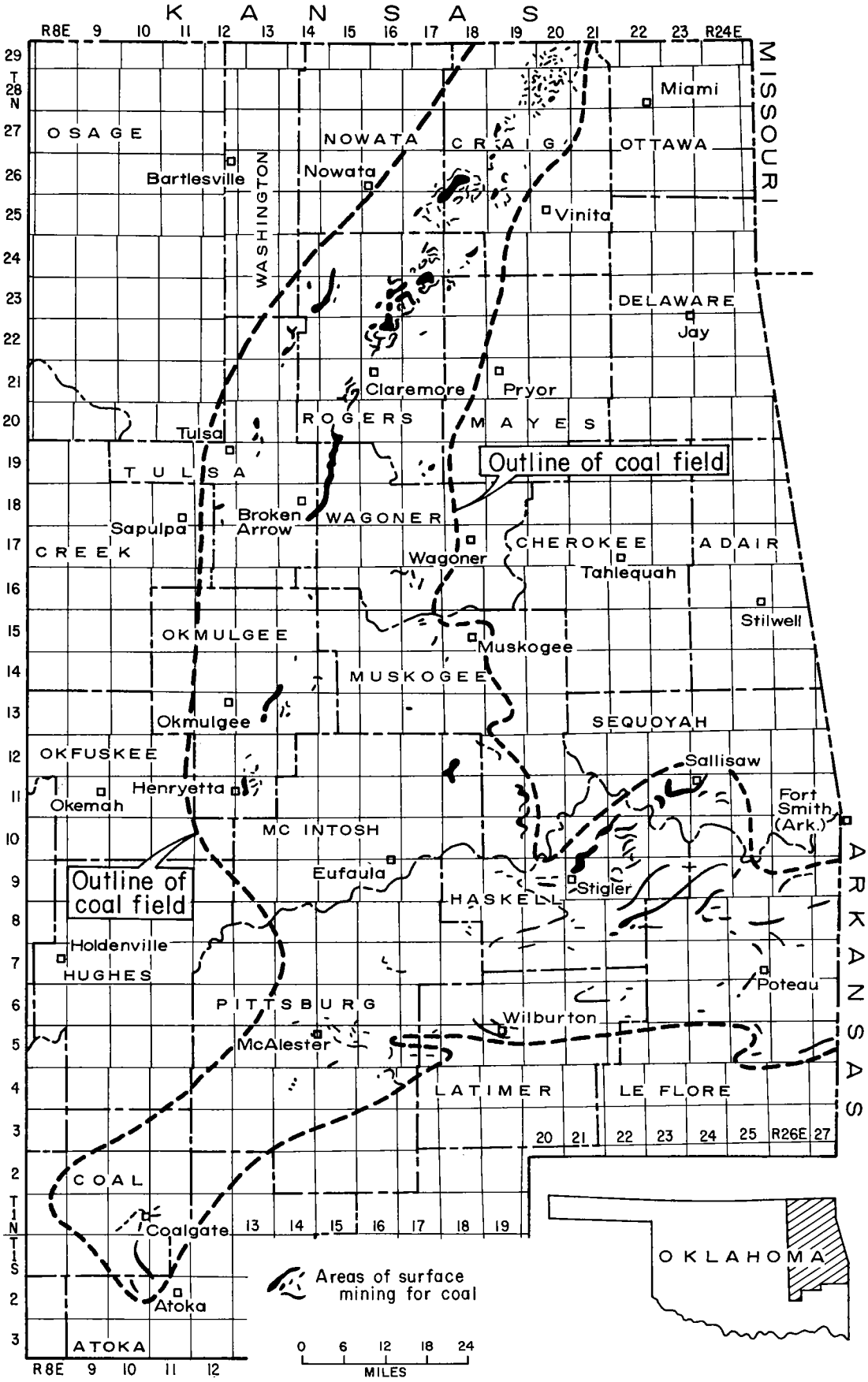

Figure 8. Map showing outline of eastern Oklahoma coal field and areas that have been disturbed by surface mining for coal through June 30, 1973. Generalized from accompanying large-scale map sheets 1, 2, and 3.

Figure 9. Aerial view of reclaimed mined lands in southeastern Kansas. Almost the entire quarter section shown, back to the rows of trees, had been unproductive "orphan" mined land prior to reclamation. Photograph taken in May 1972 of land owned by Maurice Barnes in sec. 35, T. 31 S., R. 22 E., Cherokee County, Kansas.

to see restoration of "orphan" mined lands to a gently rolling topography suited to a variety of sequential uses (fig. 9). The principal step, and the most costly, is leveling and grading the land. This involves bulldozing spoils from the peaks and ridges into the adjacent troughs and shaping the land surface into a gently rolling terrain that allows for proper drainage.

Leveling and grading Kansas sites were estimated initially to cost from $55 to $210 per acre, with an average cost of $156 per acre (Camin, 1972, p. 22); the estimates have been borne out by cost data compiled by MLRO from 68 demonstration sites involving 1,307 acres of land in southeast Kansas, where the cost of leveling most lands was found to range from $120 to $200 per acre and to average $158 per acre (K. Q. Camin and Frank Fox, oral and written communication, 1973). Additional costs for lime, fertilizer, seedbed preparation, and seed average about $40 to $50 per acre, making the total cost for reclaiming most "orphan" spoils to grasslands vary from $150 to $250 and average about $200 per acre.

Unreclaimed coal-mine lands in Oklahoma can be leveled and restored to productivity, and I feel that costs will run about the same as those in Kansas. But for maximum effectiveness, a program of assistance and demonstration must be organized to marshal the expertise of all persons interested in reclamation. A basic program, entailing the following eight elements, has already been suggested (Johnson, 1971, p. 120-122): (1) make a complete inventory, (2) evaluate potential land use, (3) determine grading requirements, (4) determine land-conditioning requirements, (5) evaluate types and methods of revegetation, (6) encourage reclamation by demonstration and assistance programs, (7) adapt machinery and equipment to reclamation needs, and (8) cooperate with neighboring states that have similar problems. The accompanying map sheets 1, 2, and 3 make up an inventory, which is the necessary first step in such a program.

METHODS OF INVESTIGATION

Disturbed mine lands were identified and outlined on detailed topographic maps, which are available for all areas of eastern Oklahoma that have been surface-mined for coal; acreage was measured on these maps by planimeter. Data were compiled on 7½-minute-quadrangle topographic maps

for 95 percent of the area and on 15-minute quadrangles for the remaining 5 percent of the area. Where land was disturbed after publication of a topographic map, acreage was outlined and calculated on recent aerial photographs (flown mostly in March and April 1972) and data were transferred to the topographic map. Acreage calculations are believed accurate within 1 to 3 acres at individual sites; county and state totals are believed accurate within 1 or 2 percent. Original work maps are kept on open file at the Oklahoma Geological Survey and are available for public examination.

Delineation of reclaimed and partly reclaimed lands was accomplished largely through stereoscopic study of recent aerial photographs and examination of topographic maps. It is therefore possible that a small amount of the lands identified on the accompanying maps as "unreclaimed" or "partly reclaimed" were in fact reclaimed as of June 30, 1973, and certainly more of them will have been reclaimed by the time this report is issued (mid-1974). Current data on lands being reclaimed during the 1972-73 fiscal year were obtained from the Oklahoma Department of Mines.

Highway, town, and road information on the accompanying maps was taken from county road maps issued by the Oklahoma Department of Highways.

ACKNOWLEDGMENTS

Topographic maps, aerial photographs, technical assistance, and cartographic work were supplied by the Oklahoma Geological Survey, and data were compiled under a program initiated by the Survey. The report was printed and distributed jointly by the Oklahoma Geological Survey and the Oklahoma Department of Mines. The maps and text were reviewed by Ward Padgett, chief mine inspector, and Robert H. Arndt, U.S. Bureau of Mines liaison officer for Oklahoma. Appreciation is extended to Mr. Padgett and to Edna Havens, secretary, Oklahoma Department of Mines, for their cooperation in compiling data for this report. Thanks are also due the coal-mining companies of Oklahoma for providing information on current mining and reclamation activities, and to Kay Q. Camin and Frank Fox of the Kansas Mined Land Redevelopment Office for information on land reclamation in southeast Kansas.

Special thanks are extended to Lorinda V. Vick and Ronald R. Mercer, geology students and part-time Survey employees, who assisted by making most of the acreage calculations, and to John Langford and Roy D. Davis, cartographers for the Survey, for preparing all maps and illustrations for publication. Appreciation is expressed to William D. Rose and Rosemary Croy for editorial assistance.

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