

Ozarks Regional Commission



Kansas Labor Department



Kansas Geological Survey

Frank W. Wise

MINED-LAND REDEVELOPMENT WORKSHOP

Pittsburg, Kansas

May 26-27, 1971

Woodson	Allen	Bourbon
Wilson	Neosho	Crawford
Montgomery	Labette	PITTSBURG ★ Cherokee

Special Distribution Publication 58

STATE GEOLOGICAL SURVEY OF KANSAS
UNIVERSITY OF KANSAS
LAWRENCE, KANSAS

SEPTEMBER, 1971

STATE OF KANSAS
ROBERT B. DOCKING, *Governor*

BOARD OF REGENTS

JAMES J. BASHAM, *Chairman*
HENRY A. BUBB
CARL L. COURTER
W. F. DANENBARGER

THOMAS J. GRIFFITH
ROBERT W. HELMAN

MAX BICKFORD, *Executive Officer*
ELMER C. JACKSON
JESS STEWART
PAUL R. WUNSCH

MINERAL INDUSTRIES COUNCIL

ROBERT F. WALTERS, *Chairman*
HAROLD J. BORN
RICHARD C. BYRD
HOWARD J. CAREY, JR.
JOHN J. CONARD

RICHARD A. COOK
STUART EURMAN
MORRIS A. KAY

ROLAND LEHR
GEORGE K. MACKIE, JR.
PERRY L. MILLER
CLIFFORD W. STONE

STATE GEOLOGICAL SURVEY OF KANSAS, UNIVERSITY OF KANSAS, LAWRENCE 66044

E. LAURENCE CHALMERS, JR., PhD, *Chancellor of The University and ex officio Director of the Survey*

WILLIAM W. HAMBLETON, PhD, *State Geologist and Director*

ERNEST E. ANGINO, PhD, *Associate State Geologist and Associate Director*

ADMINISTRATIVE SECTION

William R. Hess, BS,
Administrative Geologist
Frank C. Foley, PhD,
Jo Anne Kellogg,
Editors

Lila M. Watkins,
Business Manager
Sharon K. Hagen, *Chief*,
Graphic Arts

Kathy J. Hird, BFA, *Director*,
Information and Education
Diana Coleman,
Secretary

ENVIRONMENTAL GEOLOGY SECTION
Paul L. Hilpman, PhD, *Chief*

GEOCHEMISTRY SECTION
O. KARMIE GALLE, BS, *Acting Chief*

GEOLOGIC RESEARCH SECTION
John C. Davis, PhD, *Chief*

MINERAL RESOURCES SECTION
Ronald G. Hardy, BS, *Chief*

OPERATIONS RESEARCH SECTION
Owen T. Spitz, MS, *Chief*

WATER RESOURCES SECTION
John C. Halepaska, PhD, *Chief*

SUBSURFACE GEOLOGY SECTION
Edwin D. Goebel, PhD,
Senior Geologist and Chief

COOPERATIVE STUDIES WITH THE UNITED STATES GEOLOGICAL SURVEY

WATER RESOURCES DIVISION
Charles W. Lane, BS, *District Chief*

TOPOGRAPHIC DIVISION
A. C. McCutchen, *Regional Engineer*

BRANCH OFFICES

NORTHWEST KANSAS SUBDISTRICT OFFICE
465 North Austin Avenue, Colby 67701
E. D. Jenkins, BS, *Subdistrict Chief*

SOUTHWEST KANSAS SUBDISTRICT OFFICE
1111 Kansas Plaza, Garden City 67846
H. E. McGovern, BA, *Subdistrict Chief*

WELL SAMPLE LIBRARY
4150 Monroe Street, Wichita 67209
R. L. Dilts, MS, *Geologist in Charge*

Mined-Land Redevelopment Workshop, Pittsburg, Kansas

May 26 & 27, 1971

State Geological Survey of Kansas

Kansas Labor Department

Ozarks Regional Commission

Special Distribution Publication 58

State Geological Survey of Kansas

University of Kansas

Lawrence, Kansas

September, 1971

CONTENTS

	Page
Introduction	3
Acknowledgments	3
Program	4
The Geological Context of Mined-Land Redevelopment	5
Dr. William W. Hambleton, Director State Geological Survey of Kansas University of Kansas, Lawrence, Kansas	
An Action Plan for Redeveloping Southeast Kansas Lands Disturbed by Surface Mining	9
Dr. Kay Camin, Project Director Associate Professor, Dept. of Economics Wichita State University, Wichita, Kansas	
Effects of Fly Ash as a Soil Amendment on Strip-Mined Soils	15
Dr. Larry Murphy, Associate Professor Agronomy Department Kansas State University, Manhattan, Kansas	
Agriculture Crops on Mined Lands	21
Alten F. Grandt, General Manager Land Use and Conservation Dept. Peabody Coal Co., Farmington, Illinois	
Mined Land Reclamation	25
Dr. Robert Hyde, Extension Specialist Range and Pasture Management Extension Service Kansas State University, Manhattan, Kansas	
Reclamation of Acid Spoil with Powerplant Fly Ash	29
John P. Capp and Lester M. Adams U. S. Department of the Interior, Bureau of Mines Energy Research Center Morgantown, West Virginia	
Fly Ash Research Test Plots	41
William Kovacic, Research Technician U. S. Department of the Interior Bureau of Mines Denver, Colorado	
Attendance at May 26 & 27, 1971, Workshop	43

INTRODUCTION

The Kansas Geological Survey, the Kansas Labor Department, and the Ozarks Regional Commission are engaged in a joint effort to implement restoration of strip-mined land. The southeast Kansas coal mining area is serving as the laboratory to develop economic data, and to determine proper methods of reclamation by the use of demonstration sites to motivate landowners to reclaim their land.

Believing that an exchange of information and ideas would not only be profitable but would also lead to coordinated efforts, a workshop on studies being carried on throughout the country was convened. In order that others may benefit from the exchange, this publication, containing papers and other pertinent data presented at the Mined-Land Redevelopment Workshop, has been prepared.

ACKNOWLEDGMENTS

Many individuals contributed generously to the structuring and functioning of this workshop. Mr. Patrick Tansey of the Kansas City Power & Light Co. encouraged the idea of a workshop to discuss the use of fly ash. Landowners Herman Kuplen and Maurice Barnes invited the participants in the workshop to tour their farms to observe reclamation. W. J. Fox provided the facilities for the luncheon. The contractors involved in strip-mine spoil-bank leveling were hosts to the workshop participants before the evening dinner.

Finally, to the technical assistance staff, Shirley Buckle, Susan Scott, Cathy Ciardullo, Frank Fox, and William Kovacic, and to the Survey staff, Helen Wolfe, Douglas Beene, Richard Wallace, and Kathy Hird, a very heartfelt thank you for looking after the multitude of major and minor details.

PROGRAM
MINED-LAND REDEVELOPMENT WORKSHOP

Place: Holiday Inn, Pittsburg, Kansas

Dates: May 26 and 27, 1971

May 26

9:00 a.m. Registration and coffee
10:00 a.m. Briefing--Dr. Kay Camin, Project Director
10:15 a.m. Tour
12:00 noon Picnic at Red Fox Area
1:00 p.m. Tour
5:00 p.m. Social Hour
6:30 p.m. Dinner
7:30 p.m. Program
1. The geological context of mined-land redevelopment.
Dr. W. W. Hambleton, Director, State Geological Survey of Kansas.
2. Background of present mined-land reclamation in Kansas.
Fred Weaver, State Representative, Cherokee County.
3. An action plan for redeveloping southeast Kansas lands disturbed
by surface mining. Dr. Kay Camin, Project Director, Associate Pro-
fessor, Dept. of Economics, Wichita State University, Wichita,
Kansas.
4. Effects of fly ash as a soil amendment on strip-mined soils.
Dr. Larry Murphy, Associate Professor of Agronomy, Kansas State
University, Manhattan, Kansas.

May 27

Papers and Discussion
I. Reclamation experience
9:00 a.m. 1. Alten F. Grandt, General Manager, Land Use & Conservation
Dept., Peabody Coal Co., St. Louis, Mo.
9:30 a.m. 2. J. W. Howland, Senior Project Engineer, P & M Coal Mining
Co., Kansas City, Mo.
10:00 a.m. 3. Richard Smith, Dept. of Agronomy, W. Virginia University,
Morgantown, W. Virginia.
10:30 a.m. Coffee
11:00 a.m. 4. Dr. Robert M. Hyde, Extension Specialist, Range & Pasture
Management, Kansas State University, Manhattan, Kansas.
12:00 noon Lunch
1:00 p.m. II. Fly ash application in mined-land reclamation
1. J. P. Capp, Chemical Research Engineer, U.S. Bureau of
Mines, Morgantown, W. Virginia.
2. William Kovacic, Student Research Assistant, U.S. Bureau of
Mines, Denver, Colorado.
3. Patrick Tansey, Asst. Sales Manager, Kansas City Power and
Light Co., Kansas City, Mo.
4. Discussion.

THE GEOLOGICAL CONTEXT OF MINED-LAND REDEVELOPMENT

by

William W. Hambleton, Director
State Geological Survey
The University of Kansas
Lawrence, Kansas

The Earth is a series of approximately concentric shells: the lithosphere, the hydrosphere, the atmosphere, the biosphere, and finally the sociosphere. This last, of course, is the sphere of man and all of his activities, and in our time it increasingly dominates all others for good and ill.

The Earth as a system got along very nicely without a sociosphere for most of about 4 1/2 billion years. It behaved, although it did not know it, generally in a Newtonian manner and according to the second law of thermodynamics. That is to say, it behaved as an order-disorder system, and has cycled throughout its history. From time to time the Earth pushed up mountains, creating a high energy state, then cycled through erosional processes to a state of minimum energy and disorder. At times it concentrated within its crust certain elements such as iron ore, coal, and oil; these concentrations we would now call mineral deposits. However, in its cycling process, the Earth dispersed these resources again. Thus, the Earth throughout its entire history has cycled and recycled through processes of concentration and dispersal of resources. This process continues today, and as William Pecora, former Director of the U. S. Geological Survey and new Undersecretary of the Department of the Interior, noted in a commencement address at George Washington University (1970), natural Earth processes are by far the principal agents in modifying our environment. He further observed that environmental degradation is a natural process on Earth. Some of the Earth's processes are cataclysmic in character; if man caused them they would be termed environmental pollution.

It has been estimated that more than 1 million tons of fixed nitrogen in the form of ammonia and nitrates are deposited annually from the atmosphere to the Earth as part of a natural precipitation process. In the United States alone, more than 4 million tons of table salt, 2 1/2 million tons of sodium sulfate, and 36 million tons of calcium compounds fall upon the land surface--all in rainwater.

Particulate matter and natural gases dispersed from volcanoes is a continuing phenomenon. From three eruptions alone--the Krakatoa eruption in Java (1883), the Mount Katmai eruption in Alaska (1912), and the Hekla eruption in Iceland (1947)--more dust, ash, and combined gases were ejected into the atmosphere than from all of man's activities.

Many have long believed that water issuing from natural springs is pure, and beneficial to health because of its purity. Springs issuing into the Arkansas and Red Rivers carry 17 tons of salt per minute. The Lemonade Springs in New Mexico carry 900 pounds of sulfuric acid per million pounds of water, which is ten times the acid concentration of most acid mine streams in the nation. The Azure Yampa Spring in Colorado contains eight times the radium that the Public Health Service sets as a safe limit. In 1792, Vancouver, who had been Captain Cook's navigator, recorded on passing through Santa Barbara channel:

The surface of the sea, which was perfectly smooth and tranquil, was covered with a slimy substance, which when separated or disturbed by a little agitation, became very luminous, whilst the light breeze, which came principally from the shore, brought with it a strong smell of tar or some other such resinous substance. The next morning the sea had the appearance of dissolved tar floating on its surface, which covered the sea in all directions within the limits of our view...

Certain plants on the Colorado Plateau concentrate selenium, which is toxic to cattle. The smoke of the Great Smoky Mountains is caused by natural emission of turpines from the forests.

Natural landslides--fault scarps and the like--scar the face of the Earth just as certainly as do disfiguring strip mines. The excrement of any animal pollutes the environment for his neighbors. Without man, the Earth then is a cycling machine, concentrating and dispersing its resources.

The introduction of man changed the entire time-frame of this process. His numbers and his capabilities enabled him within a short time to actually accelerate Earth capabilities for concentration and dispersal of resources.

If 50 thousand years represents the history of man, and a lifetime is reckoned at 62 years, man has been on Earth for 800 lifetimes. He spent 650 of these in caves. Only during the last 70 has it been possible for him to communicate; only during the last 6 has the printed word been available; only during the last 4 has it been possible to measure time with precision; only during the last 2 has the electric motor been available. During the last or 800th lifetime, most of the material goods that we know have been developed. The 800th lifetime represents a sharp break with all past human experience and man's relationship to Earth resources has reversed itself. His ability to create toxic substances and trash outstrips the natural processes of the Earth.

Alvin Toffler has described this as a process of acceleration and transience in his book, Future Shock. Peter Druecker has described it as the Age of Discontinuity.

Nevertheless, Earth will win! The question is, will man survive as the Earth at its own rate naturally purges itself through concentration and dispersal? The recent disasters in East Pakistan, ranging from a tidal wave to war, suggest Earth's population control capabilities. The Earth will reconcentrate energy sources, for few of the materials that we use are lost from the Earth's envelope. The carbon compounds from the burning of coal and oil will be reconcentrated in the oceans and new coal and oil will be formed by organisms. Our garbage, and even waste plastics, will be degraded in time. The question is, will man survive as Earth goes about its usual business?

Now let us look a little more closely at the way in which man has attempted to replicate the Earth's natural concentration and dispersal process. Each production or manufacturing process has always resulted in the concentration of some substance toxic or useless to man. Man has attempted to disperse these substances, just as the earth has, by distributing them into the air or into waterways. His numbers eventually made this kind of scheme unworkable. We now must find ways either to recycle or lock up toxic and dangerous substances which are a product of our processing. For example, in the manufacture of detergents we use phosphates. These natural phosphates contain arsenic. The arsenic can be extracted from the phosphate, but as As_2O_3 it is exceedingly toxic and a way must be found to lock it up.

The production and consumption of coal, no less than other production and manufacturing processes, result in environmental degradation and concentration of substances that are toxic or useless to man. Until recent years, we have permitted strip mines to disfigure our land, and have allowed soluble sulfates derived from the oxidation of iron sulfides in coal to enter our rivers, or to accumulate in ponded strip mines. The products of burning coal for heat or power have been dispersed into the atmosphere in the form of fly ash, sulfur compounds, and perhaps other less-recognized elements. As with other production or manufacturing processes, this scheme has become unworkable as our demands for power have increased. Kansas, and especially southeastern Kansas, has proved to be an ideal laboratory for seeking solutions to some of these problems. Coal mining is not so extensive in Kansas that the problem seems overwhelming, and a climate conducive to solution of our problems has existed in public and private sectors of our economy. A good

Mined-Land Reclamation Law now provides for restoration of mined land, and power companies are utilizing new techniques for removing fly ash and other atmospheric pollutants during the combustion process. Major remaining problems include restoration of already-mined land, development of techniques for returning mined land to productive capacity, and utilization of the products of coal combustion.

Thus, with cooperation and funding from the Ozarks Regional Commission, the Kansas Geological Survey undertook a program of mined-land reclamation in southeastern Kansas that might serve as a model for the entire Ozarks region, and at the same time began investigations that might result in the utilization of fly ash from power installations. The mined-land reclamation activities initially involved study of the alternative uses of reclaimed land in terms of economic return, and study of the costs of reclaiming mined land. Initial cooperation of a vigorous Mineral Resources Task Group eventually expanded to include private individuals such as farmers and stockmen; industry groups such as contractors, mining companies and power companies; three State universities including Wichita State University, Kansas State University, and The University of Kansas, and encompassed such areas as economics, agronomy, engineering, and geology; and many public institutions such as the Kansas Labor Department, Kansas Cooperative Extension Service, Soil Conservation Service, Tennessee Valley Authority, Bureau of Mines, and Agricultural Stabilization and Conservation Service. Significant to this effort were the activities of students, who complemented their formal instruction by engaging in solution of significant and practical problems under direction of appropriate faculty and staff members. Most importantly, the southeastern Kansas mined-land reclamation project has demonstrated that concerned and dedicated citizens can affect change in a substantive way, especially if available technical resources are utilized fully. The results of these efforts will be described at this workshop; participants already have seen formerly disfigured land returned to productive and attractive condition. Additional studies will seek to optimize this process, and also to utilize the waste products of combustion in manufacturing to increase soil productivity.

The Kansas Geological Survey serves its role most effectively by stimulating the kind of effort illustrated by this mined-land reclamation project. Furthermore, the approach is consistent with a geological philosophy of Earth concentration, dispersal of resources, and recycling.

AN ACTION PLAN FOR REDEVELOPING SOUTHEAST KANSAS
LANDS DISTURBED BY SURFACE MINING

by

Kay Camin, Project Director
Associate Professor
Dept. of Economics
Wichita State University
Wichita, Kansas

Objective

The objective of the Mineral Resources Task Group is to stimulate, initiate, advise, and in some cases direct the redevelopment of approximately 50,000 acres of mined land in southeast Kansas. Initial focus will be upon the 45,000 acres which were strip-mined for coal prior to January 1, 1969. The plan is to bring maximum acreage back into productive use on a parcel-by-parcel basis as the acreage, funds, and management can be brought together. The redevelopment of these lands will be based on a multiple-use concept.

Mineral Resources Task Group

In order to encourage the redevelopment of the 50,000 acres, a Mineral Resources Task Group was organized in July, 1969. Specifically, this Task Group is to: (1) determine the land ownership and availability for redevelopment of mined land; (2) determine and demonstrate productive land uses; and (3) explore and determine sources of funds for redevelopment projects. In short, this Task Group is an "action" group organized to encourage all practical and legitimate means of restoring strip-mined land to productive use.

The Mineral Resources Task Group is composed of individuals from various professions with interest in reclamation. The Task Group was appointed by the Governor and its members receive neither pay nor expenses. The Task Group is supported by a paid technical assistance staff. The Mineral Resources Section of the Kansas Geological Survey has the responsibility for this technical assistance staff and has received funds from the Ozarks Regional Commission to provide staff and additional necessary non-personal expenses. The project is in its second year of operation. The first year was supported by a \$27,000 grant from the Ozarks Regional Commission and the second year by a \$54,000 grant from the ORC. Each year of the project, the Kansas Geological Survey contributes services estimated at \$23,000.

The Task Group maintains close cooperation with the Kansas Mined-Land Reclamation and Conservation Board since this board sets the standards for reclamation on all land mined after January 1, 1969.

The Task Group has an office run by members of the technical staff. This office is known as the Mined-Land Redevelopment Office and is located on the third floor of the Crawford County Courthouse, Girard, Kansas.

Mineral Resources Task Group

The members of the Mineral Resources Task Group appointed by the Governor of Kansas are:

Mr. R. W. Fowler, Chairman of the Task Group
Banker, Citizens State Bank
Weir, Kansas 66791

Mr. Maurice Barnes, Cattleman & Rancher
Route #2
McCune, Kansas 66753

Dr. Fred W. Boren, Supt. in Charge
SEK Branch Experiment Station
Mound Valley, Kansas 67354

Mr. Delno Bass, Coordinator
Governor's Committee on Manpower Planning
Mills Building, Room 724
Topeka, Kansas 66612

Mr. Ronald G. Hardy, Exec. Project Director
Chief of Mineral Resources Section
State Geological Survey
University of Kansas
Lawrence, Kansas 66044

Mr. John W. Mackie, Jr.
Sec.-Treas., Clemens Coal Co.
320 N. Locust
Pittsburg, Kansas 66762

Mr. George E. Nettels, Jr.
Pres., Midwest Minerals, Inc.
Box 7
Girard, Kansas 66743

Mr. Meade Gibbs, Farmer & Stockman
Route #2
Pittsburg, Kansas 66762

Mr. Fred Weaver, Farmer
Route #1
Baxter Springs, Kansas 66713

Mr. Darrell Carlton
Commissioner of Labor
Department of Labor
410 Topeka Blvd.
Topeka, Kansas 66603

Technical Staff

Members of the technical assistance staff are:

Dr. Kathleen Q. Camin, Project Director
Associate Professor of Economics
Wichita State University
Wichita, Kansas 67208

Mr. Frank Fox
Reclamation Consultant
Mined-Land Redevelopment Office
Courthouse
Girard, Kansas 66743

Mrs. Shirley Buckle, Secretary
Mined-Land Redevelopment Office
Courthouse
Girard, Kansas 66743

Mr. Bill Kovacic, Research Assistant
 Mined-Land Redevelopment Office
 Courthouse
 Girard, Kansas 66743

Mr. Charles Wilson, Technical Assistant
 Mined-Land Redevelopment Office
 Courthouse
 Girard, Kansas 66743

Miss Susan Scott, Research Assistant
 Department of Economics
 Wichita State University
 Wichita, Kansas 67208

Miss Cathy Ciardullo, Graduate Assistant
 Department of Economics
 Wichita State University
 Wichita, Kansas 67208

Location of Mined Land

Approximate surface acreage disturbed by strip-mining of coal prior to January 1, 1969 includes:^{1/}

Bourbon County	3,000 acres
Cherokee County	20,000 acres
Crawford County	22,000 acres
TOTAL	45,000 acres

Land Ownership

	Cherokee Co* Acres	Crawford Co** Acres	Bourbon Co*** Acres	Total Acres	Percent
Individuals	11,250	15,300	2,750	29,300	67%
Mining Companies:				10,950	25%
Clemens Coal Co.		5,300			
Gulf Oil Co.	5,500		150		
State of Kansas	2,100	1,250		3,350	7%
Cherokee County Sportsman Club	350			350	1%
Total	19,200	21,850	2,900	43,950	100%

*Based upon Cherokee County Property Tax Records, March, 1970.

**Conservative estimates, from Crawford County Property Tax Records, June, 1970.

***Based upon 1963 aerial photos and 1971 land-ownership maps.

^{1/}Kansas Geological Survey--1969 Revision of Table A-2, Southeast Kansas Fact Book, Report No. 9, Kansas Department of Economic Development, January, 1967, p. 18.

Reclamation to Date

Individual owners of mined land have failed to redevelop their land for one or more of the following reasons:

- (1) Lack of knowledge as to profitability
- (2) Lack of financial resources to undertake reclamation
- (3) Reluctance to mortgage cropland to finance reclamation work
- (4) Low cost of holding land in an unproductive state (in terms of county property taxes).

Multiple Use

There is really no new concept inherent in the multiple use of mined land. The Task Group is considering the redevelopment of disturbed lands for agricultural, recreational, housing, industrial, and wildlife uses. Each use should be analyzed on the basis of land location, its availability, land quality, amount of reclamation required, and economic feasibility and environmental impact upon the south-east Kansas region.

Redevelopment into Grassland for Cattle Grazing

It is the belief of the Task Group that redevelopment of mined land into grassland for cattle grazing will be both profitable to the individual and beneficial to the region.

At this time grassland for cattle grazing appears to be a natural use of reclaimed land for many reasons: (1) The cattle industry is the largest industry in Kansas as measured by dollar output. (2) Kansas ranks fourth in production of cattle and calves and the Kansas portion of total cattle production is increasing. One explanation is that Kansas is part of the Milo Belt, and cattle production in the Milo Belt is increasing while cattle production in the Corn Belt is decreasing. (3) The demand for beef is increasing. Demand for beef is increasing because the per capita consumption of beef is increasing at the same time that population is growing.

Cattle Grazing on Reclaimed Mined Land - The Maurice Barnes Experience

Maurice Barnes, farmer and rancher from McCune, Kansas, has successfully redeveloped about 1,000 acres of strip-mined land into excellent grazing land.

His usual reclamation plan is to smooth the dumps to a rolling terrain, fertilize and plant to fescue and wheat (with wheat serving as a nurse crop), and then oversow with switchgrass. The first year following reclamation, wheat and fescue seed are harvested with beef and fescue seed being the main crops in all following years.

For Barnes, leveling, fertilizing, and seeding require an investment of \$150 to \$175 per acre. Using Barnes' data on yields, his investment will return 8 percent by the end of five years.

One should not expect such a fast return on other reclamation-to-grassland undertakings. Average leveling costs are higher by \$25 to \$50 than those experienced by Barnes, and his land requires no liming because of the calcareous shale.

Benefits of Reclamation to Region

For each one dollar increase in cattle production, one can expect an increase of about \$3.50 in all types of production in Kansas. Another measure of the

benefits to the region is the impact upon personal income. For each one dollar of cattle production, approximately 14 cents is paid directly to the household sector (primarily in the form of wages).

When all direct, indirect, and induced effects are taken into account, each one dollar in cattle production should result in an additional income to households of 71 cents.

Need for Demonstration and Research

There is great need to demonstrate that reclamation is profitable. There is further need to determine the difference in profitability of reclaiming land strip-mined in the last five years and land strip-mined many years ago.

Mr. Barnes' experience using fescue and switchgrass is the only guide as to seedbed preparation, fertilizing, liming, and seeding. Are soil tests needed? What is the extent and type of soil testing desirable? What combinations of fertilizer and lime should be used? What grasses and/or legumes are best suited for growing on reclaimed mined land? Are there better methods of earthmoving? What slopes are desirable? Better economic data regarding costs of leveling, seedbed preparation, seeding, and yields are needed to determine the profitability of reclamation.

Kansas State Extension Plots

In order to answer some of the above questions, the Mineral Resources Task Group worked with Kansas State University Cooperative Extension to develop a research-demonstration project. This project involved establishing four plots of 40 acres each. The major portion of each 40-acre plot was to be treated uniformly with respect to lime, fertilizer, and seed. Cattle grazing studies of a weigh-in--weigh-out nature will follow after grass stands are established. A small research area (1 acre) was set aside for conventional fertility and grass species adaptability studies. This small research area will also include application of fly ash (the waste product produced when coal is burned to create electricity).

The Ozarks Regional Commission provided \$16,000 to pay approximately one-half the cost of leveling and seeding the four 40-acre plots. The four cooperating landowners paid half of the costs. One of the four plots (Kuplen) was leveled in February, 1971, and seeded in March to oats and fescue. The other three plots will be seeded in the fall of 1971.

Need for Additional Demonstration Plots

The attitude of landowners in the southeast Kansas area has been one of skepticism. When asked about the Barnes experience, the response was often; "It may work for him, but he operates on a large scale and I'm a small farmer," or "It may work on his land, but it won't work on my land because my spoilbanks are different."

For this reason a large scale grant was sought to cost-share the leveling, liming, fertilizing, and seeding of 1,000 acres in a four-county area. Cost-sharing would be provided for sites from 5 to 20 acres in size. This means involvement of 50 to 70 landowners. It is hoped that landowners, upon seeing that reclamation is successful on their land, will undertake to reclaim their remaining mined land on their own. The "thousand acre" cost-sharing project is a joint effort. The leveling portion is made possible by an ORC grant of \$65,500 to SEE-KAN RC&D. The county SCD Board will review applications and the SCS will inspect the leveling.

The ASCS's REAP Program is providing \$20,000 to pay half the cost of liming, fertilizing and seeding. This joint project is referred to as the RC&D-ASCS

Project, or as the "thousand acre" project.

Although the majority of acreage reclaimed under this grant will be for grassland, other productive uses are eligible. Catfish farming, housing, recreation, and solid waste disposal are potential productive uses which could become demonstration projects under this program.

Recreation

The recreational potential of mined land is large. Almost all of the strip pits contain water suitable for fishlife and, indeed, almost all pits are stocked with fish.

Recreational development which will generate income is the type needed. In general, this necessitates attracting visitors from outside the southeast Kansas area. Facilities are needed. Campsites, rental cabins, horseback riding, and motorcycle, walking, and canoeing trails are needed to supplement the fishing opportunities.

EFFECTS OF FLY ASH AS A SOIL AMENDMENT ON STRIP-MINED SOILS

by

Larry Murphy
Associate Professor
Agronomy Department
Kansas State University
Manhattan, Kansas

The use of fly ash as a soil amendment has been reported in literature from several areas where coal has been strip-mined. With an estimated 45,000 acres of strip-mined land in southeast Kansas, the idea of using fly ash to improve the productivity of this land has been posed. As a preliminary study prior to initiation of field research, a greenhouse experiment with fly ash was initiated to study its effect on soil pH and plant growth. This study was carried out as a special problem course by Mr. Larry McAuley, a junior in Agronomy at Kansas State University.

Experimental Procedure

For this study three soils from strip-mined land in southeast Kansas were collected, air dried, pulverized to pass an 8-mesh screen, and placed in pots. Two of the soils were from newly mined land in Crawford County (designated A and B) and the third soil (designated C) was from older mined land but recently leveled. The soil and fly ash chemical and physical characteristics measured are presented in Table 1. The fly ash was obtained from the settling basin of the Kansas Power and Light Plant at Lawrence, Kansas. Fly ash was applied at the rate of 0, 25, 50, 100, 200, 400, 800 tons per acre. In addition, a treatment with lime at the rate recommended by soil test was included for each soil. (The lime requirement on soil B exceeded the soil test limits and the applied rate was estimated.) All pots received a fertilizer application of N, P, and K based on soil-test determinations.

Table 1. Chemical and physical characteristics measured on soil and fly ash used in the study.

Sample Ident.	Organic Matter	pH	Effective CaCO ₃	Avail. P	Exch. K	CEC	Bulk Density	Field Capacity	Texture		
	%		lbs/A	lbs/A	lbs/A	me/100g	g/cc	%	%	%	%
Soil A	1.7	4.8	7500	50	257	12.7	1.18	20.6	28	72	0
B	1.5	3.1	20,000+	190	93	14.1	1.19	27.5	22	74	4
C	2.2	6.3	3000	34	252	14.1	1.18	24.1	22	74	4
Fly Ash	---	7.7	----	42	1000+	----	1.48	17.0	46	52	2

The fly ash was thoroughly incorporated with the soil and the containers brought to field capacity. The pots were allowed to incubate for a period of five weeks with core soil samples taken at weekly intervals for pH determinations. At the end of the five-week incubation, oats were seeded on the pots and allowed to grow for 35 days after planting. Emergence notes were taken on number of seedlings emerged at one and two weeks after planting. The pots were then thinned to 10 plants per pot. At the end of five weeks, the plants were clipped at ground level, weighed, and then dried at 65°C for 24 hours before taking dry-matter yields.

Results and Discussion

The fly ash and lime treatments had a favorable effect on the soil pH (Fig. 1). In a test on the fly ash for its neutralizing capacity, it was found to be 1.5 percent as effective as pure calcium carbonate. This agrees well with the experimental results comparing pH change of fly ash treatments to lime application. On the extremely acid soil (B), no treatment was sufficient to bring the pH to neutrality. The estimated rate of lime (25,000 lbs ECC/A) was too low.

The neutralizing effect of the fly ash and lime were found to occur quite rapidly as noted by the relative small change in pH of the soils over the duration of the study (Fig. 2, 3, 4, & 5). Under field conditions the rate of neutralization would be slower because the fly ash or lime would not be as thoroughly incorporated. The initial soil samples taken one day after mixing of the soil with the fly ash showed a pH close to that of samples pulled after five weeks of incubation. A slight decline in pH over the 10-week period was noted at the 0 and 50 T/A fly ash rates for soil A, but not on the 200 and 800 T/A fly ash rates. Soil C indicated a slight rise in pH during the 10 weeks of the study at all rates of fly ash. Part of this pH change with time is probably due to incomplete equilibration of the soil-fly ash when the initial pH reading was taken.

Oat plant emergence was recorded at the end of one and of two weeks after planting. Good emergence was noted on all pots except those with none or low rates of fly ash on soil B (Table 2). Not only was the number of seedlings reduced on these treatments, but there was several days' delay in emergence.

Table 2. Percent emergence of oats on strip-mined soil treated with various rates of fly ash and lime

Rate of Application	Soil		
	A(pH 4.8)	B(pH 3.1)	C(pH 6.3)
Tons/A	% Emergence*		
Control	91.5	68.5	95.0
25	93.5	50.0	95.0
50	98.5	71.5	95.0
100	91.5	48.5	90.0
200	95.0	85.0	95.0
400	93.5	91.5	98.5
800	91.5	93.5	95.0
Lime**	100	86.5	95.0

*20 seeds planted per pot with a 92% germination.

**According to soil test--7,500, 25,000, 3,000 lbs ECC/A on soil A, B, & C, respectively.

Although seedlings emerged on all pots, there was no growth of the seedlings on the extremely acid soil B until the pH had been brought above 4.0. The pH of the soil was the main factor influencing growth on soil B. Dry matter yields (Fig. 6) show a marked improvement in growth due to fly ash compared to the control. On soil A, part of the difference in growth is related to a pH change, but in addition the fly ash has contributed other factors for increased plant growth. This is evident by comparing fly ash to lime. Similar comparisons can be made for soil C which has a much higher initial pH. The beneficial effect of fly ash cannot be determined without additional soil and plant analyses. The higher rates of fly ash could cause some alteration in physical properties that could contribute to yield increases.

Summary

The addition of fly ash to strip-mined soil in a greenhouse experiment proved to be beneficial in lowering soil acidity and increasing plant growth. The rate of fly ash necessary for neutralizing soil acidity is extremely high in comparison to calcium carbonate. Increased dry-matter yields due to fly ash were in part due to pH changes, but fly ash effects on the chemical and physical properties of the soil also contributed to the increased yields. No toxic effects were noted from this fly ash material, but fly ash material will differ due to source and handling of the fly ash.

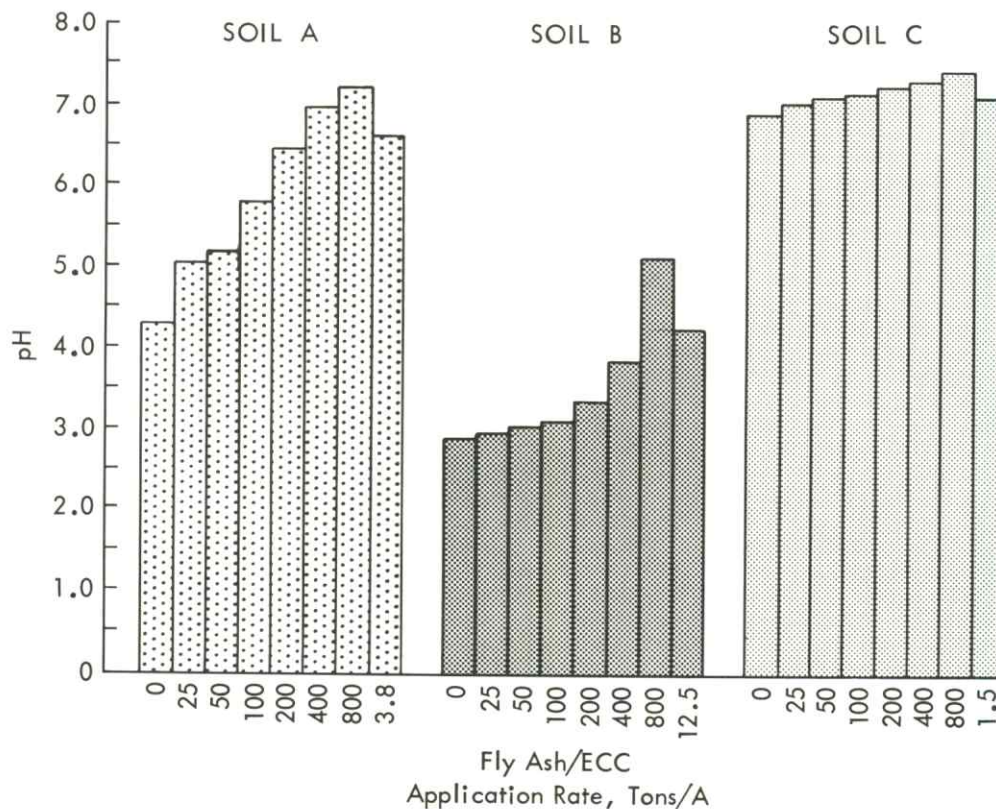


Figure 1.--Effect of fly ash and lime on the pH of strip-mined soils after 10 weeks of reaction.

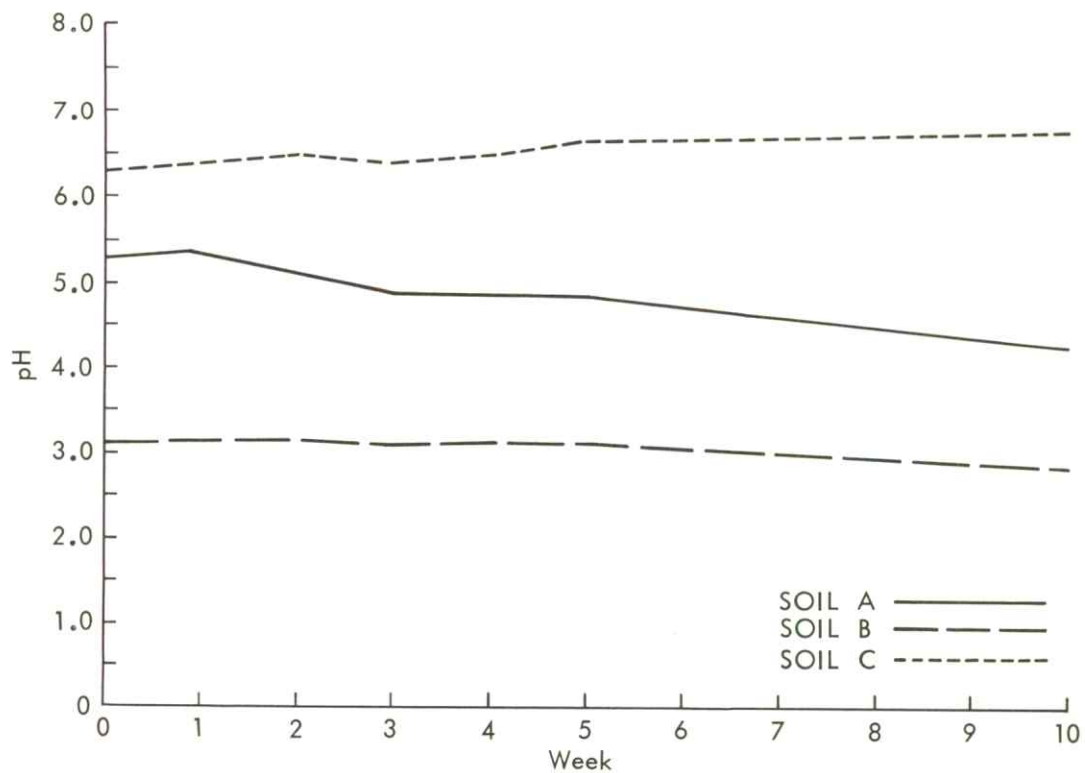


Figure 2.--Change in pH of strip-mined soils with time after addition of fly ash, control samples.

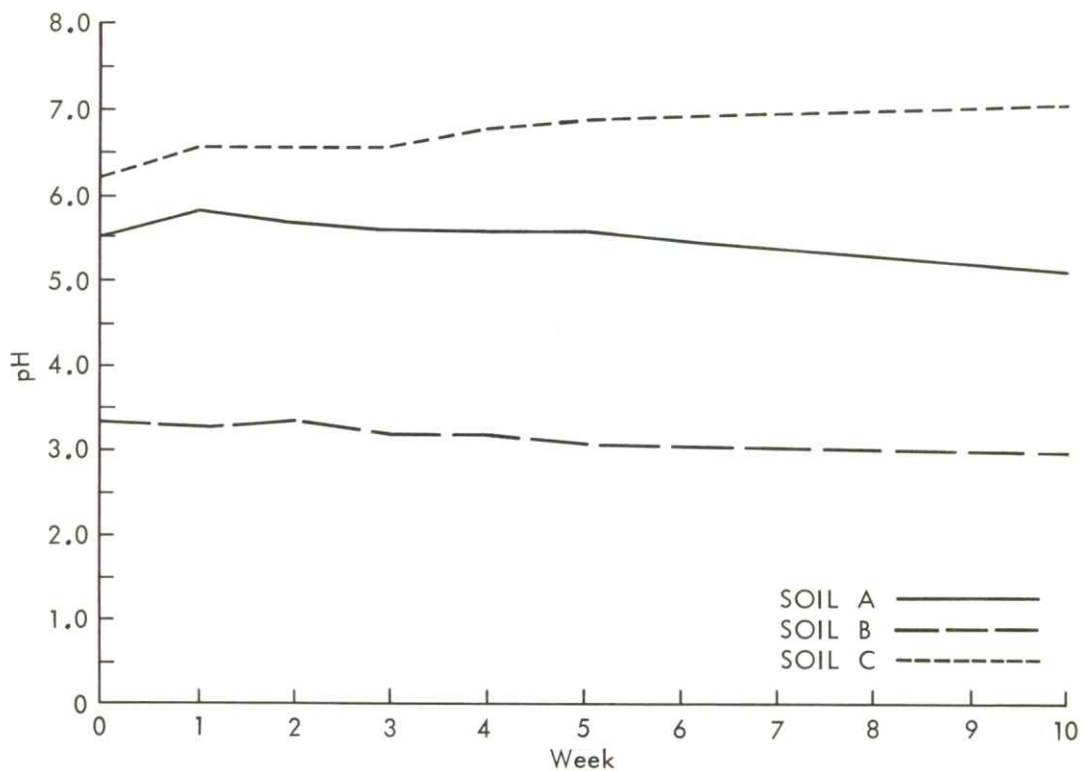


Figure 3.--Change in pH of strip-mined soils with time after addition of fly ash, 50 Tons/A.

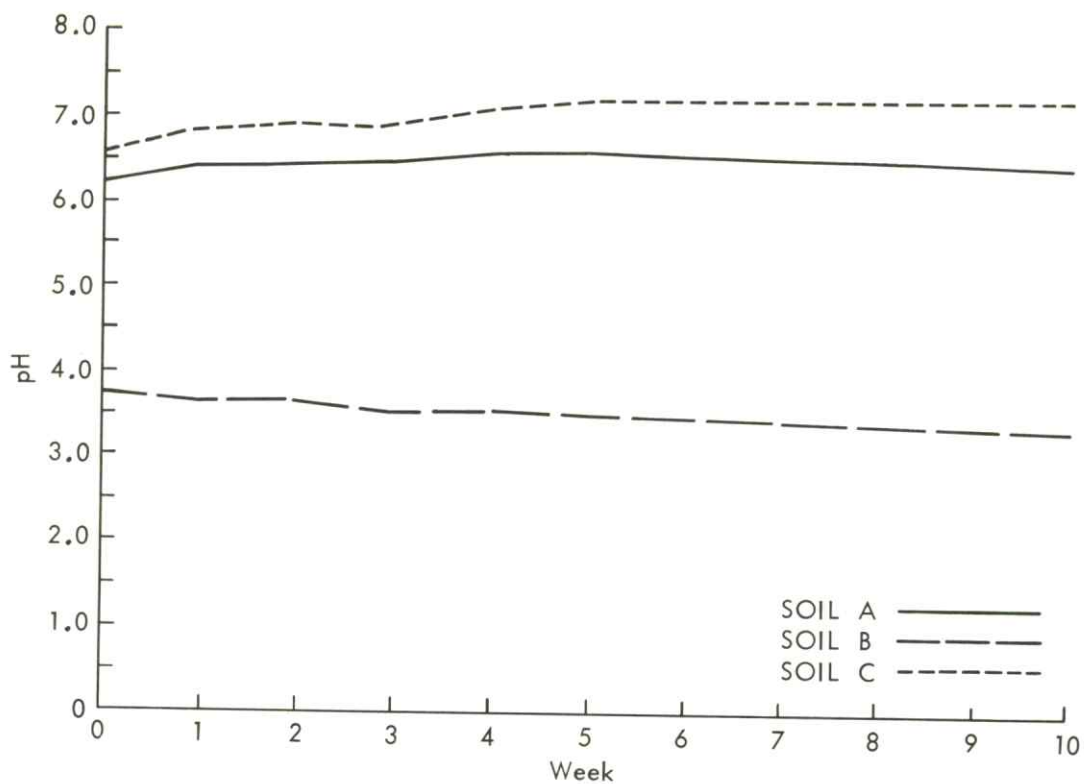


Figure 4.--Change in pH of strip-mined soils with time after addition of fly ash, 200 Tons/A.

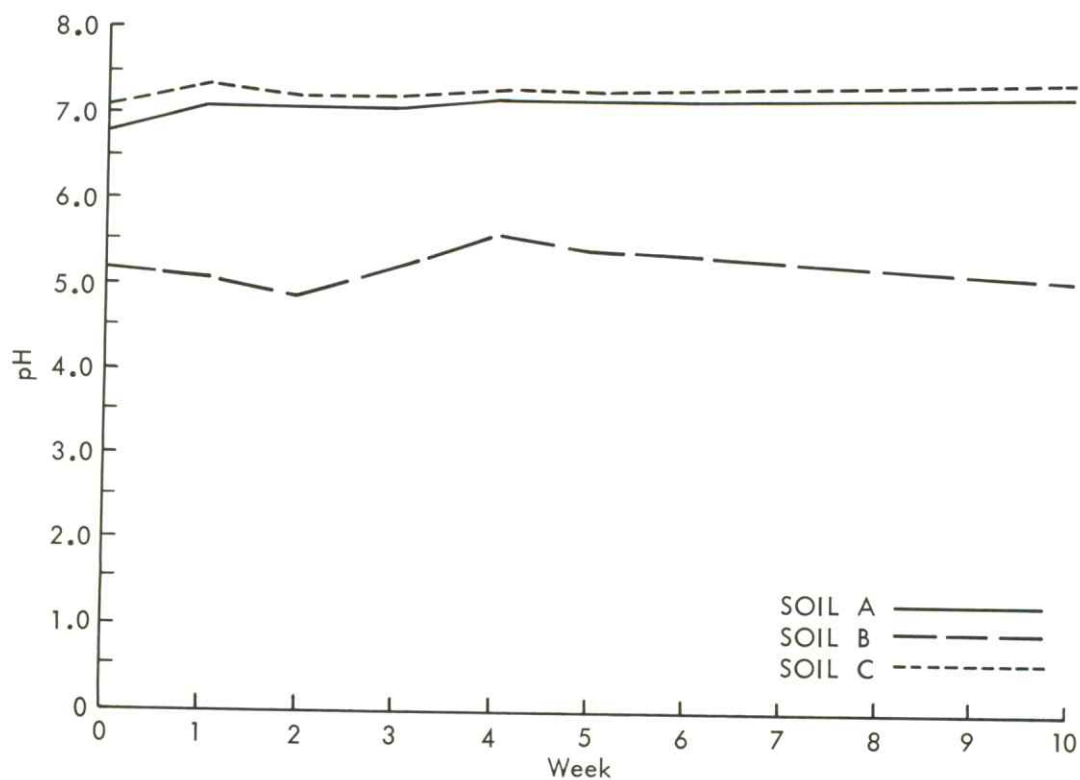


Figure 5.--Change in pH of strip-mined soils with time after addition of fly ash, 800 Tons/A.

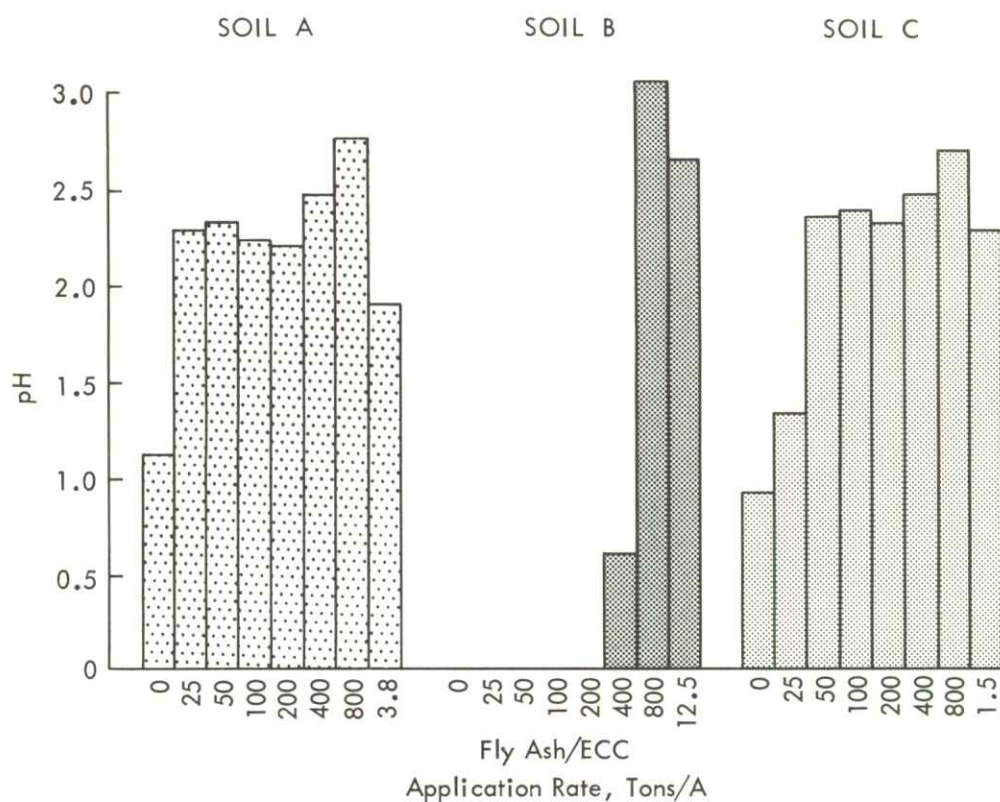


Figure 6.--Effect of fly ash and lime on dry matter yield of oats grown on strip-mined soils (35 days growth in the greenhouse).

AGRICULTURE CROPS ON MINED LANDS*

by

Alten F. Grandt
General Manager
Land Use and Conservation Department
Peabody Coal Company
Farmington, Illinois

In discussing the general topic of agriculture crops on mined lands, it is important to understand (1) the specific types of crops being discussed, as well as (2) the nature and properties of the mined-land soil-material. Basically the chemical, physical, and biological properties of the soil-material determine the specific type of reclamation possible.

The soil characteristics required for the production of the better forage species and grain crops are not adequate in many mined-land areas. Generally the production of grain crops is possible only on a small percentage of mined lands, and this only after a period of time of weathering and after the growing of forage crops, especially the legumes.

Except for climatic conditions, the potential productivity of the soil-material after mining is largely determined by its acidity, as generally measured by pH; by other plant nutrients present and available, such as calcium, phosphorus, potassium, nitrogen, etc.; and by its texture, such as sandy, clayey, rocky, etc. The kind and amount of various geologic strata in the overburden affect the classification of the mined-land soil-material.

Classification of Agricultural Crop Plants

From the agronomic standpoint, crop plants may be classified on the basis of use. Some crops may have several uses. Two broad classifications are forage crops, and cereal or grain crops. Grain crops are primarily grasses grown for their edible seeds. In this discussion forage crops are the two principal botanical families, legumes and grasses, and are used primarily as feed for livestock.

Legumes that have been inoculated with specific cultures of bacteria can fix atmospheric nitrogen in a symbiotic relationship and supply it to plants in the form of nitrogenous products. This fact is of especial economic importance because mined-land soil-material is so lacking in nitrogen and organic matter. For good growth grasses require nitrogen, and by using legumes with grasses the nitrogen is supplied.

Soil Requirements

Every kind of plant is believed to have a most suitable soil reaction or pH range for its optimum growth. Some kinds of plants grow best in a rather narrow pH range while other kinds tolerate a wide pH range.

Generally the growth of legumes is more critical with regard to soil reaction (pH) and plant food nutrients than grasses. For example, sweet clover thrives under a wide range of soil and climatic conditions. It has one important restriction, however, in that it does not tolerate acid soils. It requires a pH of 6.5 or above. It grows well where the available potassium is very low providing the pH is high. In contrast, corn tolerates a soil reaction between pH 5.5 and pH 8.0 for best production. Most legumes require high amounts of calcium, phosphorus, and potassium. Birdsfoot trefoil is particularly sensitive to available phosphorus.

*Paper delivered by Mr. Tom Higgins.

However, it will survive under a wide pH range.

Forage grasses respond to nitrogen fertilizer but in experiments conducted in Illinois gave little or no response when phosphorus and potassium were applied. Wheat responds to additional applications of soluble phosphate fertilizer while corn has a high requirement of potassium.

It is generally recognized by workers in the field that the lespedezas of the legumes and fescue of the grasses are adapted to soil materials that are acid and low in fertility. Fescue is especially adapted to shallow soils that are extremely wet during rainy seasons and dry at other times. Thus, this species is adapted over a wide climatic range. Another favorable factor in the use of fescue is that some of the basal leaves remain green during winter months (low temperatures) and can be used for winter grazing.

All lespedezas are hot weather plants, making very slow early growth. Although lespedezas are drouth resistant, deficient moisture does lessen their growth.

Because of the low pH in some parts of the country, the better forage crops such as alfalfa, the clovers, brome grass, and orchard grass are not recommended.

Establishment of Forage Species

Where the soil conditions are favorable, legume species that have been used include alfalfa, birdsfoot trefoil, clovers, sweet clover, lespedeza, Crown Vetch, and Kudzu. Of the grasses, the tall fescues, orchard grass, brome grass, blue-grasses, timothy, and redtop have been seeded. Some 70 different species have been tested at various times and locations.

Seeding climatically adapted and disease resistant forage varieties is necessary to maintain good stands. This is especially true with alfalfa. Seed having good germination and free of weeds and foreign matter is also highly recommended.

Spring seedings, either broadcast or disced in, are most satisfactory. Seeding can be done by men walking and using a cyclone seeder. Mechanical methods, such as the endgate seeder or the low spreader type seeder, are faster and seed distribution better where the areas are accessible. Aerial seedings have been widely used in the past ten years and perhaps account for the greatest acreage seeded throughout the surface-mining region.

The rate of seeding generally is 20 percent heavier than on farm land. This rate insures quick establishment of a solid stand of forage and aids in controlling volunteer tree and brush growth. Where forage species are adapted, good stands have been obtained by seeding mixtures at the rate of approximately 20 pounds per acre. At least 50 percent of the mixture should be legume, properly inoculated. If a mixture of 12 pounds Korean lespedeza (225,000 seeds per pound unhulled) and 10 pounds of Kentucky 31 Fescue (230,000 seeds per pound) were used, a total of 5,000,000 seeds would be broadcast per acre, or approximately 108 seeds per square foot. Another mixture of 12 pounds alfalfa (200,000 seeds per pound), 5 pounds brome grass (136,000 seeds per pound), and 3 pounds orchard grass (654,000 seeds per pound) gives a total of 5,042,000 seeds per acre, or 115 seeds per square foot. In my opinion this is a heavy seeding rate and allows adequately for an anticipated mortality rate.

Establishment of Cereal or Grain Crops

The establishment of grain-crop species on mined land has been tried in most surface-mining regions. In several areas, corn, wheat, rye and oats have been used. Success has been quite variable. Corn, a member of the grass family, generally shows the greatest economic return potential per acre and therefore much experimental work has been done.

Corn planted on freshly mined lands has not been successful. Several areas have been planted to corn on "raw" spoil very shortly after mining. In almost all cases, when the corn plants were approximately 12 inches tall, the top growth developed symptoms similar to a phosphorus deficiency--a purplish discoloration and stunted growth. When tissues from these stunted plants were analyzed in the laboratory, a high test for phosphorus, potassium, and magnesium was obtained. Some of the corn produced tassels when the stalk was 3 1/2 to 4 feet tall, but there was no yield of grain. Sections of these plots were treated with the minor elements zinc, copper, boron, manganese, iron, and molybdenum. The amounts of these elements needed for plant growth are extremely small. No response was obtained by these applications. No corn was harvested.

Tilling problems are a major hindrance in rocky-textured mined lands. It is difficult to plow with the conventional moldboard plow. The chisel-type plow has been fairly successful.

On the limited areas in the coal-mining region where soil conditions such as fertility and topography are such that cereal or grain crops are potentials on the mined lands, it is advisable to grow legumes and grasses for at least 10 years before attempting to use grain crops. There are several reasons why grasses and legumes have a beneficial effect on newly mined and graded areas. These species provide a good environment for a rapid increase in bacteria. The organic matter formed in the soil by these species increases permeability which allows better drainage and aeration. The root penetration is a means of opening up this soil-material to allow deeper water penetration. The degree of aggregation and stability of the soil particles is improved.

Uses of Adapted Agricultural Crops

In areas of Illinois where soil conditions are favorable to the growth of grasses and legumes, utilization of these forage crops is possible.

A measure of quality is the chemical composition of the forage crop. Some tests were made on samples collected in Illinois. On this basis the quality of the forage species grown on mined lands is excellent. Nitrogen and protein content was high. This is especially true of the grasses that depend mainly on the legumes for their nitrogen. The phosphorus content of the mined-land forage is very high when compared with that grown under normal farm conditions. In calcium, potassium, and magnesium content these forages compare favorably with forages grown on farm land. High protein, phosphorus, and calcium content are necessary to good livestock gains.

Another means of determining the quality of the forage and of determining the value of the mined lands for agricultural production is to measure animal gains through livestock grazing. Lots of 10 steers were grazed on mined-land pastures while the same number were grazed on a regular farm pasture as a check or control group. The 3-year average daily gain for the mined-land pasture was 1.24 pounds and for the control group 1.19 pounds. No significant difference!

Economic Interpretations

One way of utilizing strip-mined land is to organize the mined and unmined land into livestock farm units and rent the acreage as a regular livestock share lease. The unmined lands that do not contain coal, or mineable coal, can be improved and maintained in a high state of fertility and high land use. This land would then produce feed to be fed to the livestock. The mined land is developed progressively each year and utilized as soon as it is ready to produce. This area will furnish the hay for winter feeding and the summer grazing forage. Fences are built and improvements are made. Thus, the mined land and the surrounding farm land can be incorporated into a well-organized farm unit capable of concentrated and continued use. Since the tenant farmer is living in the area, community

life is restored.

Where all the area is mined, another method utilized is to establish a grazing "range-type" lease. This may be done on a share-of-the-gains basis or a fixed-per-head or fixed-per-acre basis.

Summary

Agricultural crops most commonly adapted to mined-land soil-material are the forage species--legumes and grasses. Grain crops are used in very limited areas. The various types of mined lands, classified on the basis of acidity and texture, indicate the kinds of agricultural crops best used.

MINED LAND RECLAMATION

by

Robert M. Hyde, Extension Specialist
Range and Pasture Management
Extension Service
Kansas State University
Manhattan, Kansas

My involvement in vegetative aspects of mined-land reclamation goes back to Kemmerer, Wyoming, and the early 1960's when I helped develop an experimental design to study revegetation of spoil banks in that area. The area under consideration had slopes as steep as 100 percent, average annual rainfall of less than 10 inches, soil pH in the range of 2.2 to 9.8, and very little soil development on the exposed material. Various forms of mulch and netting were used to stabilize the surface and provide a medium for plant growth. (This work was published by Pete W. Jacoby, Jr., 1969, Revegetation Treatments for Stand Establishment on Coal Spoil Banks: Journal of Range Management, Vol. 22, No. 2, pp. 94-97.)

I have been interested in southeast Kansas strip-pit revegetation since coming to Kansas in 1966 and have been involved in an advisory capacity with work that has been done by Robert D. Lippert, Plant Materials Technician, Soil Conservation Service, and Wayne Geyer, Department of Horticulture and Forestry, Kansas State University. Of course, my first love is to plant grass on the strip pits and I am certain this can be justified.

The first meeting, leading to the new plantings viewed yesterday on the Bud Kuplen land, was last summer at an interagency tour in which Kansas State University Cooperative Extension Service, ASCS, SCS, and Mineral Resources Task Group personnel participated. From this and many subsequent meetings, a plan was developed and implemented to develop four 40-acre demonstration pastures in Cherokee and Crawford counties.

Progress to date has been accomplished only through splendid cooperation of the Soil Conservation Service, Rural Environmental Assistance Program, Ozarks Regional Commission, Tennessee Valley Authority, KSU Cooperative Extension Service, and the Mineral Resources Task Force Group.

Farmer cooperators, Herman A. (Bud) Kuplen, Earl McColm, Leon Eppler, and Joe and John Mussa, were selected on February 1, 1971.

The current Kansas State University-Ozarks Regional Contract is for one year (January 1, 1971 to December 31, 1971) with the recommendation that the program be continued at least an additional two years.

There are approximately 45,000 acres of land in Cherokee and Crawford counties which were strip-mined for coal prior to January 1, 1969, the date on which the Kansas Mined-Land Conservation and Reclamation Act went into effect. This land consists of large dumps of mine spoils (such as you saw on the tour). It is unproductive and unsightly. Most of this land can be made productive and the landscape improved by some degree of land shaping and revegetation.

Shaping and revegetation of this land has been attempted only on a very limited basis. Landowners have been hesitant to develop mined land because of costs involved, lack of technical know-how, and concern that such undertakings would not be economically feasible.

Our project was undertaken with the following objectives in mind: (1) to demonstrate the economic feasibility of redeveloping the mined land into grassland; (2) to develop, through research, technical information on better methods of reclaiming mined land to grassland, specifically with respect to land leveling, seedbed preparation, fertilizer and soil amendments, adaptability of various

grass species, time and method of seeding, value of cover and nurse crops, and management of established grass stands; (3) to acquire accurate data on costs and returns; and (4) to demonstrate the redevelopment of strip-mined land in Kansas, Oklahoma, Missouri, and Arkansas by Extension teaching methods.

The major portion of each site is devoted to demonstrating the feasibility of land shaping and reseeding, using presently known methods. Each site will have a relatively small fenced area on which research related to strip-mined land reclamation will be conducted.

County Extension Agents Bill Cox in Crawford County and Ted Wary in Cherokee County were responsible for locating potential cooperators. Cooperators were selected on the basis of having a suitable livestock program to meet the objectives of the demonstration. Cooperators are expected to be enthusiastic and willing to supply the time required for cattle weighing, providing fencing, fertilizing demonstration areas according to plan, and participating in tours and other methods of publicizing results.

Specifications for land shaping were as follows:

(1) Slopes not to exceed 10 percent will be attained on 90 percent of the land, with the remaining 10 percent not to exceed 15-percent slope. Trees will be removed, except on the perimeters. Tree stumps and boulders will be buried.

(2) All slopes to be established to grass will be leveled to the degree needed to permit travel with wheeled tractors and the use of conventional farm machinery for grass establishment and maintenance.

(3) Livestock access at not greater than 4 to 1 slopes will be provided where existing water is available.

(4) Leveling will be planned to maintain or develop livestock water supply.

(5) Needed drainage will be provided as a part of the leveling operation.

Demonstration pastures were treated uniformly with respect to lime and fertilizer. A uniform treatment of 40 pounds N, 70 pounds P_2O_5 , and 70 pounds K_2O per acre was applied to the Kuplen demonstration site before seeding. Annual applications of 100 pounds available nitrogen will be used after grass is established.

Final seedbed preparation included heavy offset discing and dragging with a heavy I-beam. I think some weathering after final seedbed preparation is advantageous, from the grass-establishment standpoint, but this was not done on the Kuplen demonstration.

The Kuplen demonstration site was seeded on March 9 with 20 pounds per acre of K-31 tall fescue and 1 bushel of spring oats as a cover crop.

Fall seeding will be practiced on the other three demonstration sites with winter wheat as the cover crop. It is hoped that Fawn Fescue can be seeded on one of the sites.

Moisture conditions were not good at seeding time and for a considerable time following. I am certain that this had an effect on the present stand, but with moisture, the stand is now adequate. The density of oats cover on Kuplen land appears thin, but is actually ideal for a cover crop. If moisture remains adequate, I am certain that a very satisfactory stand of tall fescue will result.

Grazing of established pastures will be practiced in accordance with guidelines developed by the KSU Extension Service. The demonstration site will be grazed to permit maximum sustained livestock production, and will include a weigh-in--weigh-out program to determine and demonstrate the production potential of reclaimed land. Grass seed production will be included in the demonstration.

Records being kept on each 40-acre demonstration site include the following:

- (1) Itemized costs of shaping and revegetating strip-mined land.
- (2) Soil tests.
- (3) Management practices including fertilizer application.
- (4) Annual costs of grass and livestock production.
- (5) Dates livestock grazed, stocking rate, kind and age of livestock, plus weigh-in--weigh-out information.
- (6) Grass seed yield.
- (7) First year cover crop yield.
- (8) Net returns per acre.
- (9) Benchmark information--costs and returns from similar unreclaimed land.

Sixteen small-plot, pure-stand plantings have been established on the Kuplen demonstration. Species included are: Achenbach Smooth Brome, Fawn Fescue, Garisons Creeping Foxtail, Barton Western Wheatgrass, Kaw Big Bluestem, Aldous Little Bluestem, Kanlow Switchgrass, Blackwell Switchgrass, Cheyenne Indiangrass, Osage Indiangrass, Eastern Gamagrass, El Reno Sideoats Grama, Midland Bermudagrass, W₂F₁ Buffalograss, Emerald Crownvetch, Cicer Milkvetch. Plantings were made on March 9 and March 29. Many of these species have very little possibility of success in strip-pit revegetation. The whole purpose of this study is to determine which ones do have. K-31 tall fescue has been used on the large-scale plantings because it has already been proven satisfactory. The disadvantage of K-31 is that it lacks palatability and production potential, and may cause fescue foot in cattle.

Early small-plot observations on smooth brome are most encouraging. Brome has definite advantages over tall fescue, where adapted, but requires more nitrogen and a higher level of management.

Fawn Fescue also looks good in the observation plots. Fawn Fescue is reportedly considerably more palatable than K-31. If Fawn has the production potential, drought resistance, and winter hardiness that it appears to have, it should be a tremendous grass for tame pasture seedings in Kansas. May 5 clipping yields at Garden City showed Fawn Fescue producing 2,008 pounds dry matter per acre. Achenbach Smooth Brome produced 1,730 pounds by comparison.

El Reno Sideoats Grama and Blackwell Switchgrass have both germinated. Cicer Milkvetch has also germinated and appears to be establishing well. Undoubtedly the establishment and production of grasses and legumes in the pure-stand plantings will provide needed information on species adaptability for strip-pit revegetation.

Fertility studies are being conducted in conjunction with the grass observation plots. Twenty different treatments involving combination of N, P, K and time of application have been established on the Kuplen demonstration site. N rates range up to 300 pounds available P₂O₅; rates of 0, 40, 80, 120, and 240 pounds are being used. K₂O rates are 0, 40, and 80 pounds.

Dr. David Whitney is in charge of the fertility aspects of the demonstration. Verlin Peterson, Kansas State University Area Extension Agronomist for Southeast Kansas, is our local coordinator for the project and has been deeply involved with it.

I think an amazing amount of progress has been made on the project since it was initiated last February. Briefly this progress includes:

1. Bud Kuplen, Earl McColm, Leon Eppler, and Joe and John Mussa were selected as farmer cooperators to participate in the Extension mined-land demonstration research program on a cost-sharing basis.
2. Soil Conservation Service technicians staked and provided technical assistance on all sites.
3. Bids were taken and contracts negotiated with conservation contractors for land shaping. Participating contractors were W. J. "Red" Fox; O'Toole and Sons; John Westhoff; Bob Frome; Jay Jones, Jr.; Gerald Davis; Ada Martin Construction Co.; and Don Zimmerman.
4. Aerial and ground photographs, both color and black and white, were taken on all sites for before-and-after documentation.
5. Work agreements between the KSU Cooperative Extension Service and the farmer cooperators were prepared by the Extension Service and signed by the participating parties.
6. Soil samples of all sites were taken and laboratory tested prior to leveling. Soils on the Kuplen and McColm sites were sampled and tested after leveling.
7. The Cooperative Extension Service completed an agreement with the Tennessee Valley Authority to participate in the fertilizer program on a partial-pay basis.
8. Three of the four 40-acre research-demonstration sites have been leveled. The Eppler site is nearly complete and will be completed in the designated time.
9. Required lime applications have been made on the Kuplen and Mussa sites.
10. Fertilizer at the rate of 40-70-70 pounds per acre was applied on the Kuplen demonstration site on March 9, 1971.
11. K-31 fescue grass seed, with oats as a cover crop, was planted on the Kuplen demonstration site on March 9.
12. Field fertility studies were established on the Kuplen research site on March 9.
13. Species plantings were made on the Kuplen land.
14. Preliminary growth chamber evaluation of fly ash as a soil amendment has been completed. Detailed evaluation studies will begin in July, 1971.
15. Considerable publicity through mass media has been given the program and considerable interest has been aroused.
16. All agencies cooperating in the research-demonstration program are maintaining close communication.

RECLAMATION OF ACID SPOIL WITH POWERPLANT FLY ASH

by

John P. Capp and Lester M. Adams
Morgantown (W. Va.) Energy Research Center
U.S. Department of the Interior
Bureau of Mines

ABSTRACT

Experiments in reclaiming acidic surface-mined coal lands with raw fly ash from bituminous-coal-fired powerplants were conducted at two sites in northern West Virginia. Plots at both sites were treated with varying tonnages of fly ash from three area powerplants and were planted with a variety of grasses, legumes, trees, and shrubs. Eight grasses and seven legumes were investigated. Greatest promise for growth under harsh soil conditions was shown by Kentucky 31 fescue; by rye and red top grasses; and by birdsfoot trefoil, a legume. Survival of trees and shrubs was negligible. Addition of fly ash to the spoil increased the pH to a range tolerable to plant growth, improved the texture of the soil, and increased the water-holding capacity of the mixtures.

INTRODUCTION

Fly ash is a solid waste resulting from the combustion of pulverized coal. Of the more than 30 million tons of fly ash produced annually in the United States by electric generating stations, most is disposed of by dumping. Since the present outlets for fly ash are for construction materials such as concrete, building blocks, and road-bed stabilization, research by the Bureau of Mines has been directed to other possible uses, including the reclamation of acidic spoil resulting from surface mining of coal. Surface mining accounts for large tonnages of coal annually in the United States, but many resultant mined areas are extremely acid following regrading after mining, and it is difficult to establish suitable vegetation that can help prevent erosion and water pollution.

Investigation of fly ash reclamation of spoil was initiated by the Bureau of Mines in cooperation with the West Virginia University Agronomy Department and the Soil Conservation Service, U. S. Department of Agriculture. Specific objectives were to determine (1) if fly ash can sufficiently increase the pH of highly acid spoils to sustain the growth of grasses and legumes; (2) the best proportion of fly ash to spoil; and (3) if fly ash-spoil mixtures can support plants long enough to increase the organic matter in the mixture sufficiently to reduce the toxic potential of the ash. Overlying these objectives was the need to find economical and useful outlets for large tonnages of fly ash.

PHYSICAL AND CHEMICAL CHARACTERISTICS OF SITES

The field experiments were conducted in northern West Virginia on sites that are commonly known as "orphaned" areas because they were not reclaimed after the coal was removed.

The initial site had been surface mined for Sewickley-bed bituminous coal more than 15 years before. It was virtually devoid of vegetation except for scattered brush consisting of black locust (*Robinia pseudoacacia*), wild cherry (*Padus virginiana*), blackberry briars (*Rubus allegheniensis*), and broomsedge (*Andropogon virginicus*) around the perimeter.

Physical and chemical properties of the spoil at the start of the experiment were soil pH, 3.5; nitrogen, phosphorus, potassium, and organic matter, very low; cation exchange capacity (CEC), 12 milli-equivalents per 100 grams; composition of -10 mesh fraction; clay, 21 percent; silt, 23 percent; sand, 56 percent; bulk

density, 1.38 grams per cubic centimeter. The surface was very rocky, with rock sizes ranging from pebbles to boulders weighing several hundred pounds. The chemical analysis is shown in Table 1.

Table 1.--Chemical analysis of spoil at site 1.*

Constituent	Weight-percent
Aluminum (Al_2O_3)	18.0
Silicon (SiO_2)	69.3
Iron (Fe_2O_3)	7.9
Phosphorus (P_2O_5)	.1
Titanium (TiO_2)	.7
Calcium (CaO)	.2
Magnesium (MgO)	.2
Potassium (K_2O)	2.4
Sodium (Na_2O)	.7
Sulfur (S)	.3
Hydrogen (H_2)	.8
Carbon (C)	1.7

*Soil sample cores were taken to a depth of 6 inches and composited for analysis.

The second site was on a spoil area that resulted from the surface mining of the Bakerstown bituminous coal seam. Stripping had been completed in 1956, the area had been backfilled and seeded in 1958, and parts of the area had been re-seeded in 1959. Both seedings were nearly total failures. Adequate ground cover developed on only about 1 percent of the area.

At the start of the study, soil samples from the entire area were obtained to a depth of 6 inches, composited, and analyzed. Results are as follows: bulk density, 1.28 grams per cubic centimeter; nitrogen (very low), approximately 15 pounds per acre; phosphorus (low), 21 pounds per acre; potassium (low), 36 pounds per acre; organic matter, not detectable; pH, 2.6 to 3.3. Iron carbonate, shale, clay, and "acid slicks" were scattered and typified the entire 117 acres.

FLY ASH CHARACTERISTICS

Table 2 shows some of the physical and chemical properties of the fly ashes used in these experiments. Concentrations of the elements are about the same or somewhat higher than those in many natural soils. Many of the major and minor plant nutrients are included. However, fly ash generally contains very little phosphorus and is devoid of nitrogen, both of which are essential to plant growth; thus these elements must be added through fertilization.

FLY ASH APPLICATION

Fly ash application rates ranged from about 150 tons per acre to about 800 tons per acre. All the plots including the controls were plowed and harrowed with ordinary farm machinery to thoroughly mix the fly ash and spoil and to prepare the surface for seeding and fertilization.^{1/} Seed for the plots consisted of a

^{1/} Plots were fertilized at the time of seeding with a granular dry fertilizer at the rate of 1,000 pounds per acre; analysis: 10 percent nitrogen, 10 percent P_2O_5 , and 10 percent K_2O .

Table 2.--Chemical and screen analysis of fly ashes.

	Fly ash 1	Fly ash 2	Fly ash 3
pH	11.4*	9.1-10.6	11.9
Bulk density, g/cc	1.12	0.93	1.15
Chemical analysis, wt pct			
Aluminum (Al_2O_3)	23.9	23.9	23.6
Silicon (SiO_2)	46.3	42.2	47.7
Iron (Fe_2O_3)	22.9	24.0	15.6
Phosphorus (P_2O_5)	.3	.2	.6
Titanium (TiO_2)	.9	.8	2.7
Calcium (CaO)	1.9	4.0	3.5
Magnesium (MgO)	.8	1.2	1.5
Potassium (K_2O)	2.2	2.2	2.2
Sodium (Na_2O)	.6	.6	1.9
Cobalt	.02	.02	ND**
Boron	.008	.02	ND
Manganese	.03	.05	ND
Copper	.02	.02	ND
Molybdenum	.007	NT***	ND
Carbon	5-7	12.4	1.54
Sulfur (total)	.24	.51	.34
Screen analysis, wt pct			
+60 mesh	2	2	1
-60+100 mesh	5	3	2
-100+150 mesh	4	4	2
-150+200 mesh	8	7	4
-200 mesh	81	84	91

*pH of the fly ash used at site 1 was 11.4; when used the next year at site 2 the pH had dropped to the range 4.4-9.5.

**not determined.

***not detected.

mixture of grasses that had grown well in previous experiments. The mixture contained Kentucky 31 fescue (*Festuca arundinacea* Schrebe), perennial rye grass (*Lolium perenne*), orchard grass (*Dactylis glomerata*), red top grass (*Agrostis alba*), and birdsfoot trefoil (*Lotus corniculatus*) and was applied at the rate of 43 pounds per acre. Table 3 gives the breakdown of the mixture.

Table 3.--Percent of various grasses used in seed mixtures for application to fly ash-spoil plots.

Seed Mixture	Wt pct
Kentucky 31 fescue	35
Red top grass	14
Orchard grass	18
Rye grass	28
Birdsfoot trefoil	5
	100

RESULTS AND DISCUSSION

Evaluation of the effect on plant growth of adding raw fly ash to strip-mine spoil necessitates consideration of physical and chemical properties important in soil science and technology. These include bulk density, soil texture, moisture-holding capacity, water infiltration rates, and changes in chemical composition.

Physical Characteristics

Mixing alkaline fly ash with acid surface-mine spoils produced chemical and physical changes that enhanced plant survival and growth. Bulk density of the mixtures was decreased up to 41 percent by addition of the amendment, while the bulk density of a limestone-treated control plot decreased only 5 percent (Table 4). This is to be expected since the bulk density of the fly ash used ranged from 0.92 to 1.15 grams per cubic centimeter. Decreased bulk density values resulted in greater pore volume, greater moisture availability, and higher air capacity--better conditions for root penetration and growth.

Table 4.--Average bulk densities of soils, sites 1 and 2.

Site	Plot	Bulk density, g/cc
1	Untreated control	1.38
	3	1.15
	Limestone	1.31
2	Untreated control	1.55
	6 (1/2 acre)	.92

Soils consist of sand and clay- and silt-sized mineral fractions, with or without rocks. The relative proportion of these various fractions defines a specific soil texture classification. For example, the plow layer (6 inches deep and weighing 1,000 tons per acre) of a typical clay loam has the following analysis per acre: clay, 350 tons; sand, 350 tons; and silt, 300 tons. A typical silt loam has the following per-acre analysis: clay, 150 tons; sand, 200 tons; silt, 650 tons.

Fly ash, which is mostly in the silt size range, was applied at rates of 150 to 800 tons per acre, and this proved to be sufficient ash (particularly the higher rates) to produce a textural change from loam to silt loam. Spoil at site 1 was changed from a sandy clay loam to a silt loam by application of 600 tons of fly ash per acre. This is illustrated by the textural triangle (Fig. 1). At site 2, the texture changed from a clay loam to a silt loam. Although soil scientists consider alteration of texture virtually impossible under ordinary circumstances, this study showed that adding fly ash to surface-mine spoil changed the textural classification.

Moisture Availability and Infiltration

Available Water

It is generally accepted that medium-textured soils (those predominated by the silt fraction) hold more available water than either coarse- (sandy) or fine- (clay) textured soils. Thus, fly-ash-treated spoil should have more water available for plant use. To confirm this, soil moisture tension and gravimetric soil moisture data were obtained, the latter being measured each week at both strip sites from May through October.

To obtain data that would more truly represent the soil in situ, the soil-moisture tension procedure was modified by the use of larger undisturbed core or ring soil samples. Normal procedure calls for the soil to be screened through a 10-mesh or 2-millimeter screen before use on the tension table. Thus, since strip-

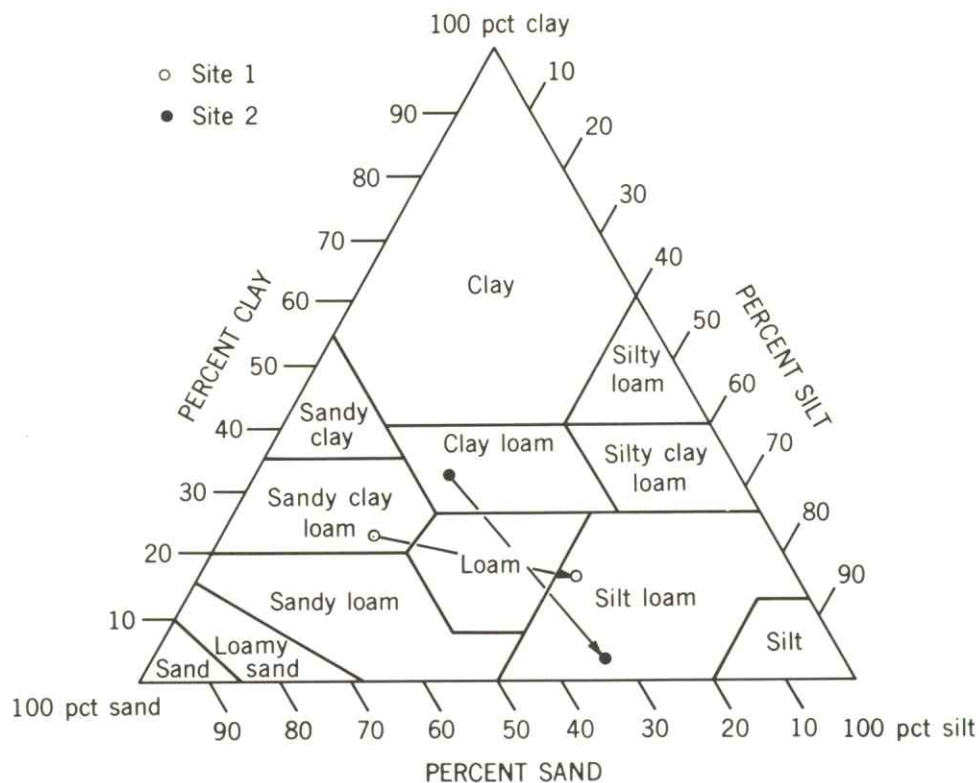


Figure 1.--Addition of 600 tons per acre of fly ash changes spoil to silt loam classification.

mine spoil generally contains platelike pieces of shale and/or other bits of rock, it was hoped that a more realistic moisture picture would be obtained by this modified procedure.

Moisture tension (pressure) values, expressed in atmospheres, were $1/3$, 1, 5, 9, and 15. The $1/3$ -atmosphere value is commonly referred to as the field capacity tension value, and the 15-atmosphere tension value is referred to as the wilt point. Between these pressures is the available water, or water that is generally available to plant usage and growth; that is, water for photosynthesis, respiration, and other physiological and metabolic processes.

Duplicate samples were obtained to minimize errors, and the samples were placed on the pressure membrane and allowed adequate time to absorb moisture and become saturated--at least 24 hours. The appropriate pressure was applied, and the samples were allowed to come to equilibrium. In some cases, samples were left under pressure for as long as four days to obtain equilibrium, after which the samples were weighed and oven-dried and the percentage moisture was calculated. From these data the moisture curves were plotted, of which Figure 2 is typical.

Preliminary results indicate that much water is held at the very low tensions ($1/3$ atmosphere), with the fly-ash-treated spoil holding somewhat more moisture than untreated spoil. It is difficult to explain the very sharp drop in moisture content as the pressure is increased from $1/3$ to 1 atmosphere, but it may be due to the presence in the undisturbed core of roots and of rock and shale particles larger than two millimeters, which, as stated above, are ordinarily removed. Available water values (shown on Fig. 2) for $1/3$ atmosphere and 15 atmospheres (also shown in Figs. 3, 4, and 5) give an indication of the approximate range. Figures 3, 4, and 5 give the gravimetric moisture values for the plots indicated, along with precipitation for the site 2 area for each growing season. Undoubtedly fly ash can affect the moisture content, especially during wet periods (first two

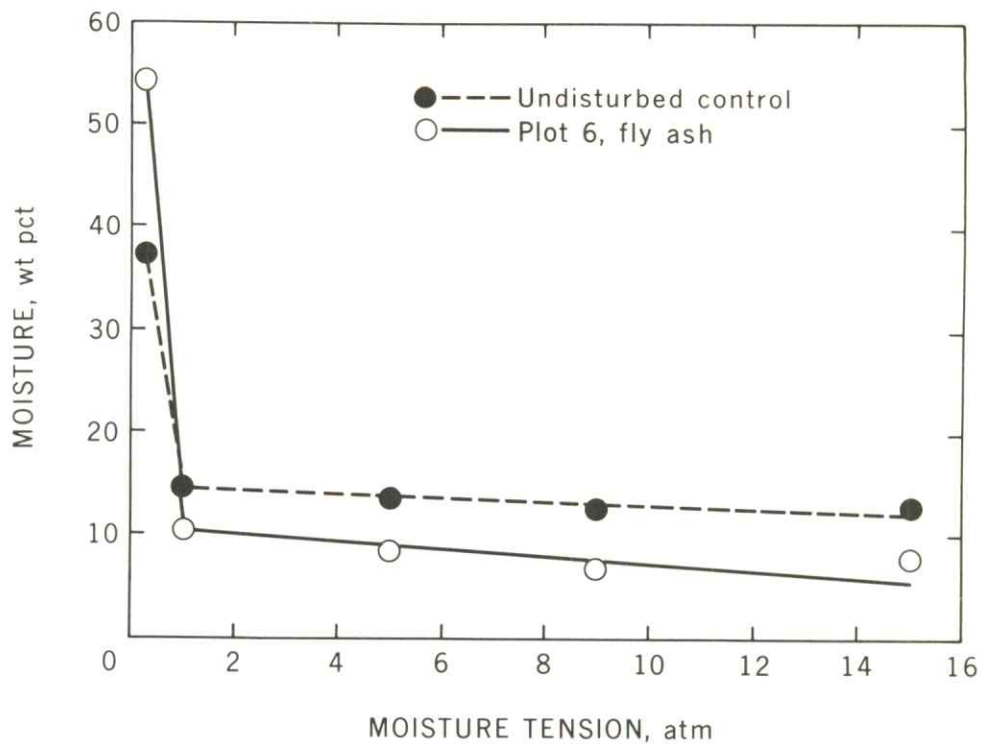


Figure 2.--Moisture curves for undisturbed control and plot 6, site 2, show sharp drop with increase in pressure from 1/3 atmosphere to 1 atmosphere.

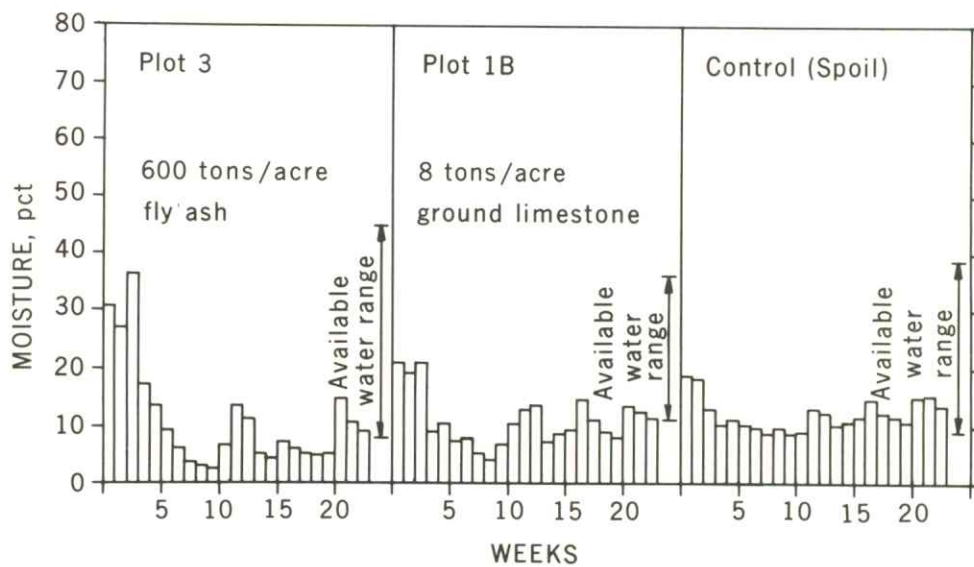


Figure 3.--Moisture content determinations for spoil-ash mixtures (top 6 inches), site 1, 3rd year, reveal fly ash addition increases availability of plant water.

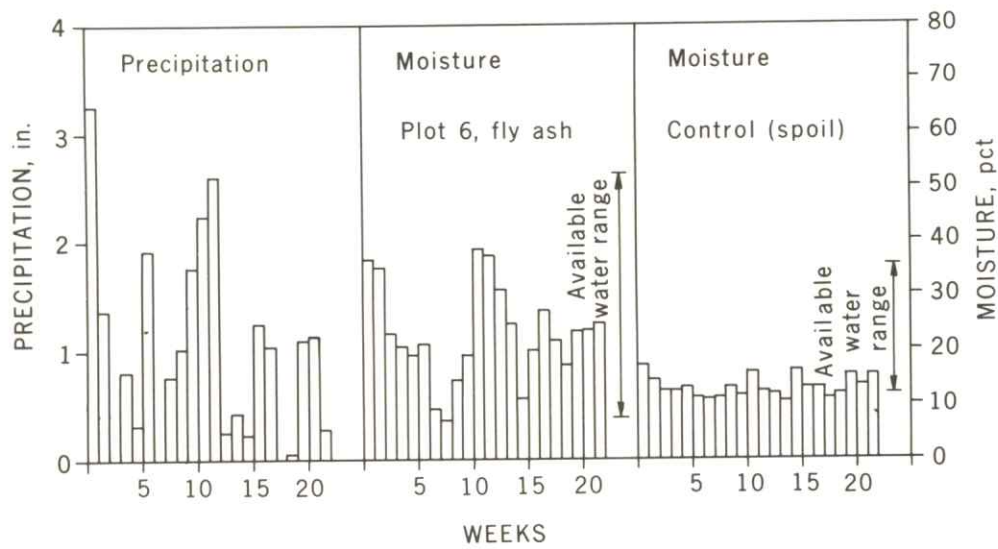


Figure 4.--Moisture content determinations for spoil-ash mixtures (top 6 inches), site 2, 2nd year, reveal fly ash addition increases availability of plant water.

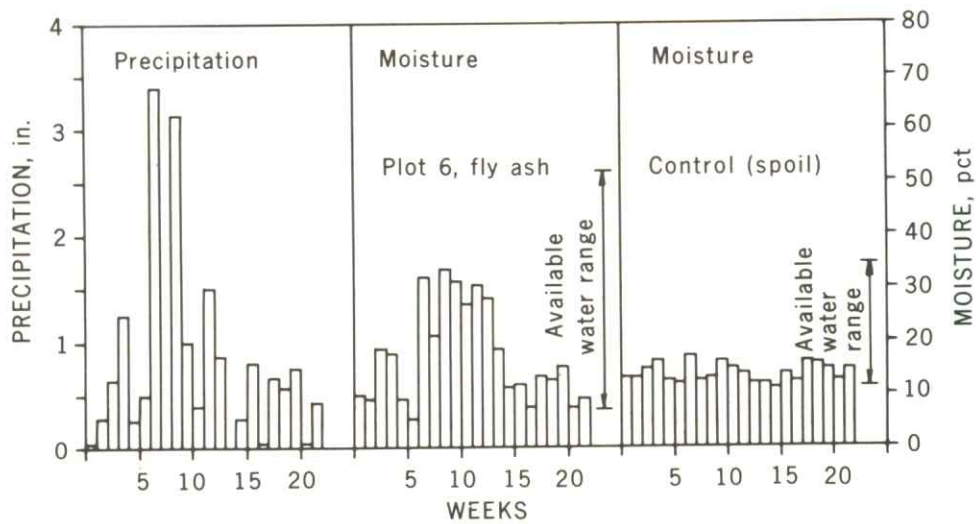


Figure 5.--Moisture content determinations for spoil-ash mixtures (top 6 inches), site 2, 3rd year, reveal fly ash addition increases availability of plant water.

weeks, second growing season; Fig. 4). Furthermore, the available moisture range remains wider well into the dry periods (6th to 8th weeks and again from 20-22 weeks, site 2, third year; Fig. 5).

Water Infiltration

Moisture infiltration rates (determined by double-ring infiltrometer) at site 1 were moderate for one fly ash-treated plot (600 tons per acre) and one limestone-treated plot, while the control plot showed a moderately rapid infiltration rate (Table 5). (A nearby field soil was not available for testing.) At site 2, the undisturbed control had an average intake rate of 1.5 inches per hour compared with the nearby field soil value of 1.7 inches per hour; fly ash-treated plots had values both lesser and greater than these, 0.7 to 3.6 inches per hour (footnote 3, Table 5). Such variable results may have been caused primarily by the shaly nature of the spoil.

Table 5.--Water infiltration at fly ash-reclaimed sites.*

Site and description		Accumulated intake, in	Intake rate, in/hr	Classification**
1	Limestone treated	5.6	1.4	Moderate
	Control	14.0	3.5	Moderately rapid
	Fly ash treated	7.0	1.8	Moderate
2	Field soil	6.6	1.7	Moderate
	Control	5.8	1.5	Moderate
	Fly ash treated	6.7	1.7	***

*Average data at end of 4th hour (flow rate stabilized).

**Very rapid, 10.00 in/hr; rapid, 5.00 to 10.00; moderately rapid, 2.50 to 5.00; moderate 0.80 to 2.50; moderately slow, 0.20 to 0.80; slow, 0.05 to 0.20; very slow, 0.05 in/hr (4).

***Average of 8 plots. Range of accumulated intake after 4 hours, 2.9 to 14.4 inches; range of intake rate after 4 hours, 0.7 to 3.6 in/hr (moderately slow to moderately rapid).

Biological Properties

Evidence was also found that the microbiological environment of spoil-fly ash mixtures was improved. Nodules of active nitrogen-fixing bacteria were observed on the roots of birdsfoot trefoil plants, a legume that appears to thrive in fly ash-spoil mixtures (Fig. 6).

Chemical Properties

Chemical analyses of the fly ashes and spoil show some differences (Tables 1 and 2) in major and minor constituents. Of the major plant nutrients in spoil, nitrogen (N) is negligible and available phosphorus (P) and potassium (K) are low. Although fly ash contains some phosphorus and potassium, it also is low in nitrogen. To assure an adequate and available supply of the major plant nutrients, the plots were treated with a commercial fertilizer containing 100 pounds each of N, P₂O₅, and K₂O.

Calcium and magnesium, also low in quantity, are necessary to sustain plant life. These elements in fly ash range from 1.9 to 4 percent for calcium and 0.8 to 1.5 percent for magnesium. A 600-ton application of fly ash may add as much as 48,000 pounds of calcium and 18,000 pounds of magnesium, which is equivalent to a total of 33 tons of liming material. Undoubtedly this large quantity of liming material accounts for the neutralization of acid in spoil sufficiently to increase

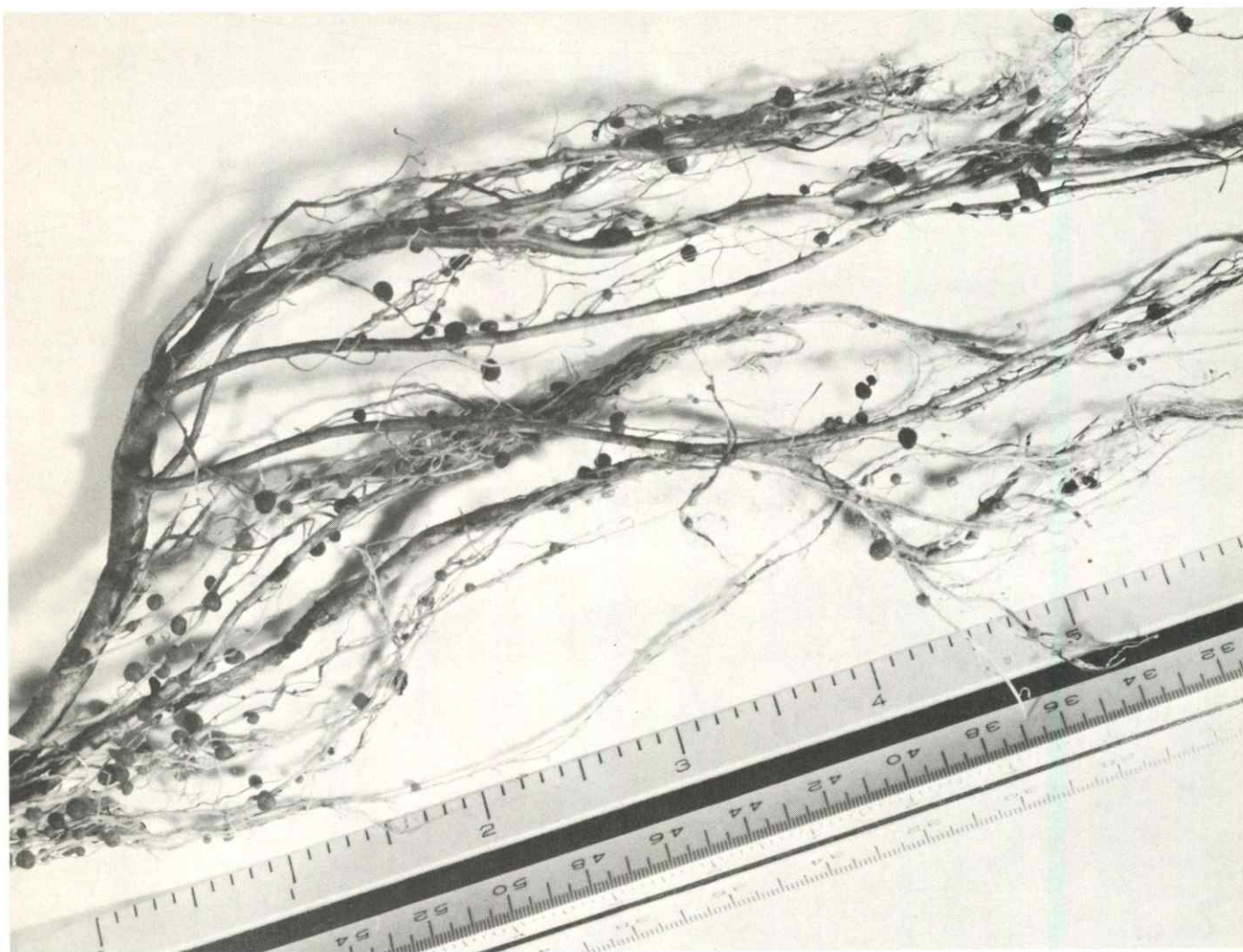


Figure 6.--Nodules on birdsfoot trefoil roots grown in fly ash-reclaimed spoil.
pH to acceptable levels, as illustrated by the curves in Figure 7.

In humid regions or during periods of heavy precipitation, leaching may be as important as crop production in removing exchangeable bases and increasing soil acidity. Studies have shown, for example, that more calcium can be lost in drainage water than is removed in harvested crops. However, it is believed the calcium in fly ash is present in the glassy-spheres portion of the solids, and, as a result, is likely to be released very slowly. Other factors that affect leaching are slope and permeability. Both sites sloped about 3-10 degrees, but infiltration studies showed that precipitation entered the fly ash-treated spoil. This is important because adequate moisture is necessary to rapidly establish a vegetative cover to reduce erosion after fly ash treatment.

Lime Requirement

As can be seen from the pH curves in Figure 7, the pH of the untreated controls remained low throughout the study. The pH of the fly ash plots, initially increased by the addition of fly ash, declined gradually over a 3-year period, though not to a level that was detrimental to growth. Liming materials present in the fly ash or added as limestone either were used by the plants or gradually

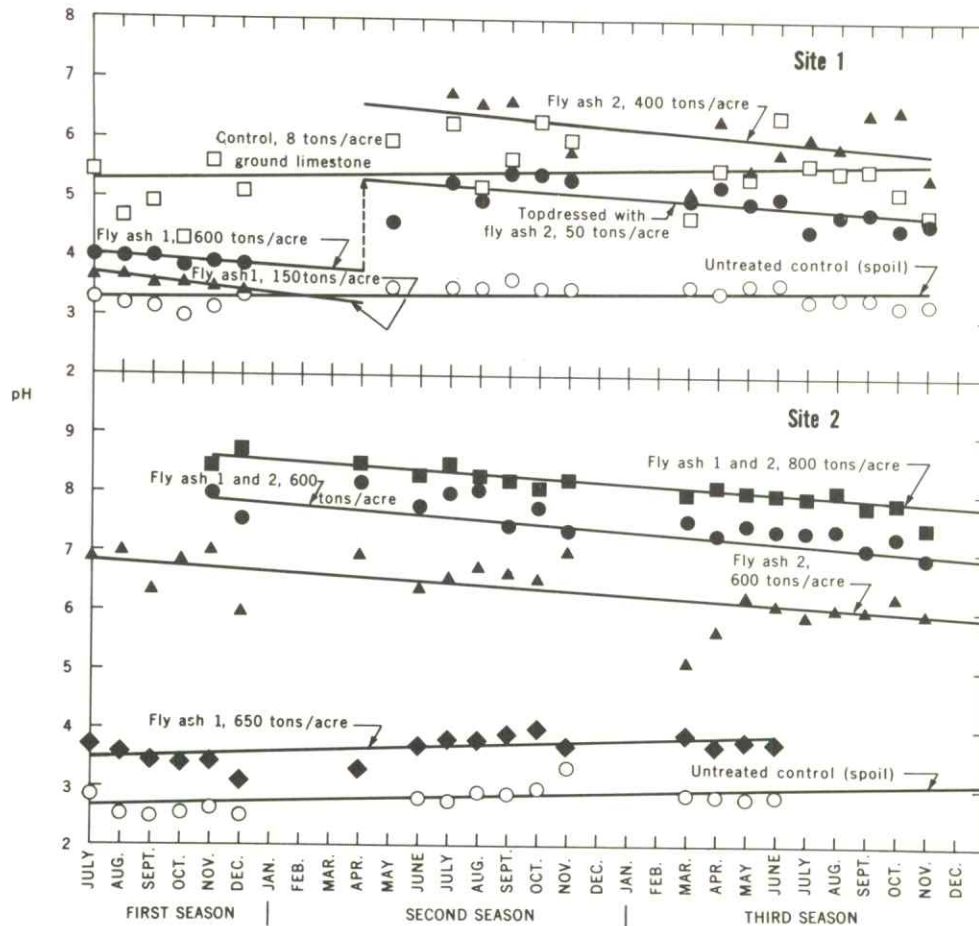


Figure 7.--Untreated spoil remains acidic, pH of spoil-fly ash mixtures remains sufficiently high to maintain plant life.

leached from the soil. This, as expected, gradually lowered the pH. Application of fly ash in tonnage quantities therefore increased the calcium content and raised the pH, thus lowering the lime requirement.

Dry Matter Yields

During the third year at site 2, fertilizer (N, P, and K) rates^{2/} were increased. Since nitrogen is the most easily lost by leaching, it was applied in equal portions of 70 pounds per acre as urea in the spring and after the first two cuttings. Spring applications of P and K were 90 pounds per acre of P (as P_2O_5) and 180 pounds of K (as K_2O) from 0-15-30 analysis granulated fertilizer. This treatment increased yields and permitted three cuttings instead of the usual one or two per year. Average dry-matter yields from all the plots for each cutting are given in Table 6. The overall average yields for the three cuttings are 44, 34, and 22 percent of the season total, which is comparable with those obtained at the West Virginia University Agronomy Farm, Reedsville, W. Va., in high-fertilization-rate experiments. Furthermore, the total average yield of about 4

^{2/} Fertilizer rates and cutting dates were suggested by Dr. G. Jung, formerly assistant professor, Agronomy Dept., West Virginia University, Morgantown, W. Va.; now research agronomist, Regional Pasture Research Lab., U.S. Dept. of Agriculture, University Park, Pa.

tons per acre for the third year at site 2 was typical of the yields obtained during West Virginia University's pasture experiments with perennial tall grasses.

Table 6.--Average dry matter yields, site 2.

Year	Dry Weight, Tons/Acre						Total Yield
	1st Cutting Date	Yield	2nd Cutting Date	Yield	3rd Cutting Date	Yield	
First	June 1	1.6	--	None	--	None	1.6
Second	June 5	1.4	Sept. 5	.9	--	None	2.3
Third	June 2	1.7	July 29	1.2	Sept. 30	.9	3.8

To determine the nutritional value of dry forage taken from the plots, several bales were pulverized and fed to meadow voles, a rodent with the ability to digest forages. A control group of voles were fed pulverized dry forage that had grown on ordinary field soil. No significant differences were noted in weight gain or growth characteristics of the two groups at the end of the 38-day study. In addition, the landowner has fed hay from these plots to his cattle over a 5-year period, with no adverse effects.

FLY ASH RESEARCH TEST PLOTS*

Cooperative Research Effort
by

U. S. Bureau of Mines, Denver, Colorado
State Geological Survey, University of Kansas, Lawrence, Kansas

William Kovacic, Research Technician
Mario Nardelli, Sr., Landowner

Original Soil pH

4.2	3.8	4.1
3.7	3.9	3.8
3.8	3.5	3.6

NORTH PLOT

3.6	3.7	3.4
3.7	3.4	3.4
3.6	3.7	3.9

MIDDLE PLOT

3.5	3.4	3.9
3.4	3.4	3.4
3.9	3.4	3.5

SOUTH PLOT

Application and Seeding

Strip A: $2\frac{1}{2}' \times 25'$			
Strip B: $2\frac{1}{2}' \times 25'$			
Strip C: $2\frac{1}{2}' \times 25'$			

NORTH PLOT (25' x 25')

	Test Plot	Per Acre Rate
Fertilizer	46 oz.	200 lbs.
Strip A		
Flyash	600 lbs.	137 tons
Crownvetch transplants		
Strip B		
No neutralizing agent		
Crownvetch transplants		
Strip C		
Lime	50 lbs.	12 tons
Crownvetch transplants		

*Location: sec. 15, T 28 S, R 25 E, Crawford County, Kansas.

MIDDLE PLOT (25' x 25')

	<u>Test Plot</u>	<u>Per Acre Rate</u>
Lime	500 lbs.	12 tons
Fertilizer	46 oz.	200 lbs.
Fescue seed	7 oz.	30 lbs.

SOUTH PLOT (25' x 25')

	<u>Test Plot</u>	<u>Per Acre Rate</u>
Flyash	3800 lbs.	137 tons
Fertilizer	46 oz.	30 lbs.
Fescue seed	7 oz.	30 lbs.

Acknowledgments

The grass seed, Kentucky 31 tall fescue, was donated by Frank Fox; the fertilizer was 6-24-24, donated by Charlie Snow, Sohigro, Inc., Girard; the lime was 65% ECC and was donated by Midwest Minerals, Inc., Girard; and the flyash was donated by the Kansas City Power and Light Co. from their Montrose Plant at Clinton, Missouri.

ATTENDANCE AT MAY 26 & 27, 1971, WORKSHOP

Mr. Lester Adams
Chemical Engineer
U.S. Bureau of Mines
Morgantown Energy Research Center
P. O. Box 880
Morgantown, West Virginia 26506

Mr. Frank Alexander
Garland Coal & Mining Co.
Box 186
Ft. Smith, Arkansas 72901

Dr. Anneka Allen
Chemistry Department
Wichita State University
Wichita, Kansas 67208

Mr. Thomas Badger
District Conservationist
Cherokee County
Soil Conservation Service
141 East Maple
Columbus, Kansas 66725

Mr. O. Dale Baker
Kansas Liaison Office
Ozarks Regional Commission
Little Rock, Arkansas 72202

Mr. Maurice Barnes
Mineral Resources Task Group
Route 2
McCune, Kansas 66753

Mr. LaVern Becker
State ASC Committee
Russell, Kansas 67665

Mr. Douglas Beene
Systems Analyst
Mineral Resources Section
State Geological Survey
University of Kansas
Lawrence, Kansas 66044

Mr. Bill Bellis
Geochemist
Oklahoma Geological Survey
University of Oklahoma
830 South Oval
Norman, Oklahoma 73069

Mr. Leon Blake
Burgan Trucking
Route 1
Scammon, Kansas 66773

Mr. Earl Bondy
Conservation Agronomist
Soil Conservation Service
Salina, Kansas 67401

Dr. Fred Boren
Mineral Resources Task Group
Superintendent
Agricultural Experiment Station
Mound Valley, Kansas 67354

Mr. Frank Boyd
State ASC Committee
Moran, Kansas 66755

Mr. Lester Branson
Program Specialist
Rural Environmental Assistance Div.
Kansas State ASCS Office
2601 Anderson Avenue
Manhattan, Kansas 66502

Mr. Charles Bredahl
Executive Secretary
State Soil Conservation Comm.
State Office Building
Topeka, Kansas 66612

Mr. Bill Bridwell
Manager
Kansas State Employment Service
1st & Pine
Pittsburg, Kansas 66762

Father Vincent Brown
Chairman
Outdoor Recreation Committee
106 North Western
Girard, Kansas 66743

Mrs. Shirley Buckle
Research Assistant
Mined-Land Redevelopment Office
Box 344
Girard, Kansas 66743

Mr. James Burgan
Burgan Trucking Co.
Columbus, Kansas 66725

Dr. Kay Camin
Project Director
Mined-Land Redevelopment Office
Box 344
Girard, Kansas 66743

Mr. Ben Cannon
Frome Construction Co.
Route 3, Box 55
Pittsburg, Kansas 66762

May 26 & 27 Workshop Attendance Cont.

Mr. John P. Capp
Chemical Engineer
U.S. Bureau of Mines
Morgantown Energy Research Center
P. O. Box 880
Morgantown, West Virginia 26506

Mr. Kenneth Cassidy
Division Engineer
Pittsburg & Midway Coal Mining Co.
103 West 11th
Pittsburg, Kansas 66762

Mr. Donald Chisam
Labette County Agri. Extension Agent
Altamont, Kansas 67330

Miss Cathy Ciardullo
Graduate Assistant
Economics Department
Wichita State University
Wichita, Kansas 67208

Mr. Jerry Cloyed
District Conservationist
Soil Conservation Service
Lamar, Missouri 64759

Mr. Jerry Coalgate
Coal Research Bureau
West Virginia University
Morgantown, West Virginia 26506

Mr. Genio Colasacco
REAP Program Specialist
Oklahoma State ASCS Office
Agricultural Center Office Bldg.
Stillwater, Oklahoma 74074

Dr. John Conard
University Relations
University of Kansas
Lawrence, Kansas 66044

Mr. William E. Cox
Crawford County Extension Agri. Agent
Box 156
Courthouse
Girard, Kansas 66743

Mr. J. Parker Craig
State Mine Inspector
1720 South Joplin
Pittsburg, Kansas 66762

Mr. Joe Cukjati, Chairman
Crawford County ASCS Committee
Route 3
Girard, Kansas 66743

Mr. Carroll Daniels
Rural Route
Moran, Kansas 66755

Mr. Gerald David
Contractor
Route 2
Girard, Kansas 66743

Mr. Parker Davies
Bureau of Land Management
Federal Building
Billings, Montana 59101

Mr. Earl Evans
Public Relations Representative
Gulf Oil Corporation
610 Dwight Building
P. O. Box 8200
Kansas City, Missouri 64105

Mr. John H. Faber
Executive Vice-President
National Ash Association, Inc.
Suite 650, 1819 H. Street, N.W.
Washington, D. C. 20006

Dr. Linda Flueckinger
Geologist
Mineral Resources Section
State Geological Survey
University of Kansas
Lawrence, Kansas 66044

Mr. Frank Fox
Reclamation Consultant
Mined-Land Redevelopment Office
Box 344
Girard, Kansas 66743

Mr. Lawrence Fox
Mined-Land Conservation &
Reclamation Board
Route 1
Walnut, Kansas 66780

Mr. W. J. "Red" Fox
Contractor
110 South Ozark
Girard, Kansas 66743

Mr. Bill Fribley
Special Asst. to the Federal
Co-Chairman
Ozarks Regional Commission
125 Mart Building
Little Rock, Arkansas 72202

May 26 & 27 Workshop Attendance Cont.

Mr. Bob Frome
Contractor
Route 3, Box 55
Pittsburg, Kansas 66762

Mr. Jim Gaskell
Project Director
See-Kan RC&D Committee
Altamont, Kansas 67330

Mr. Meade Gibbs
Mineral Resources Task Group
Route 2
Pittsburg, Kansas 66762

Dr. Paul Griffith
Associate Director of Extension
Division of Extension
Umberger Hall
Kansas State University
Manhattan, Kansas 66502

Dr. James Gunderson
Chairman, Geology Department
Wichita State University
Wichita, Kansas 67208

Mr. J. Max Haden
Asst. Division Manager
KG&E
Box. 111
Ft. Scott, Kansas 66701

Mr. Hardy Hall
Vice-President
Garland Coal & Mining Co.
Box 186
Ft. Smith, Arkansas 72901

Dr. William W. Hambleton
Director
Kansas Geological Survey
University of Kansas
Lawrence, Kansas 66044

Mr. Ron Hardy, Chief
Mineral Resources Section
State Geological Survey
University of Kansas
Lawrence, Kansas 66044

Mr. Tom Higgins
Land Use and Conservation Dept.
Peabody Coal Co.
301 North Memorial Drive
St. Louis, Missouri 63102

Dr. Donald W. Hight
Mined-Land Owner
105 West Quincy
Pittsburg, Kansas 66762

Miss Kathy Hird
State Geological Survey
University of Kansas
Lawrence, Kansas 66044

Mr. Darrell Hite
Mined-Land Owner &
Soil Conservation District Board
Route 2
Pittsburg, Kansas 66762

Mr. C. W. Holle
Balderson Manufacturing Co.
Wamego, Kansas 66547

Mr. David Houser
President, SEKORA
808 West Elm
Columbus, Kansas 66725

Mr. J. W. Howland
Senior Project Engineer
P&M Coal Mining Co.
10 Main Center
Kansas City, Missouri 64105

Mr. Paul Hunter
President, See-Kan RC&D
Route 2
Parsons, Kansas 67357

Dr. Robert Hyde
Range & Pasture Management
Extension Specialist
Waters Hall, Room 206
Kansas State University
Manhattan, Kansas 66502

Mr. Frank J. Iuen, III
Missouri Liaison Officer
Ozarks Regional Commission
P. O. Box 1157
Jefferson City, Missouri 65101

Dr. Ken Johnson
Geologist
Oklahoma Geological Survey
University of Oklahoma
830 South Oval
Norman, Oklahoma 73069

Mr. Jay Jones, Jr.
Contractor
Weir, Kansas 66781

Mr. Leonard Jurgens
Range Conservationist
Soil Conservation Service
Box 548
Emporia, Kansas 66801

May 26 & 27 Workshop Attendance Cont.

Mr. Bill Kovacic
Research Assistant
Bureau of Mines
Mined-Land Redevelopment Office
Box 344
Girard, Kansas 66743

Mr. S. W. Kowal
Manager, Allied Equipment
Construction Machinery Division
Allis Chalmers
3000 West 6th Street
Springfield, Illinois 62703

Mr. Herman Kuplen
Extension Cooperator
40-Acre Demonstration Site
Route 1
Mulberry, Kansas 66756

Mrs. Herman Kuplen
Route 1
Mulberry, Kansas 66756

Mr. George Longerot
County Executive Director
ASCS Office
Girard, Kansas 66743

Mr. J. Bob Lucas
Editorial Department
Tulsa Tribune
Tulsa, Oklahoma

Mr. A. D. McElroy, Head
Process Chemistry Section
Midwest Research Institute
425 Volker Boulevard
Kansas City, Missouri 64110

Mr. John Mackie, Jr.
Secretary-Treas.
Clemens Coal Company
320 North Locust
Pittsburg, Kansas 66762

Mr. Steve Mangan
Occupational Analyst
Kansas State Employment
1st & Pine
Pittsburg, Kansas 66762

Mr. John Masovero
State Representative (R)
Arma, Kansas 66712

Mr. Carl Mercer
Contractor
Route 1
Hallowell, Kansas 66744

Mr. Clark Miller
Photographer
1800 South Pine
Pittsburg, Kansas 66762

Dr. Larry Murphy
Associate Professor of Agronomy
Kansas State University
Manhattan, Kansas 66502

Mr. Jim Myers
Asst. Professor
Geology Department
Wichita State University
Wichita, Kansas 67208

Dr. John Nebgen
Principal Chemist
Midwest Research Institute
425 Volker Boulevard
Kansas City, Missouri 64110

Mr. Glen Neucomer
Bourbon County Extension
Agricultural Agent
210 South Nation
Ft Scott, Kansas 66701

Mr. Sylvester O'Toole
Route 2
Girard, Kansas 66743

Mr. E. R. Patton
State ASC Committee
Scott City, Kansas 67871

Mr. Verlin Peterson
Area Extension Agronomist
20 Highland
Chanute, Kansas 66720

Mr. J. F. Porter, President
Garland Coal & Mining Co.
Ft. Smith, Arkansas 72901

Dr. M. L. Potts
Chemistry Professor
Chemistry Department
Kansas State College
Pittsburg, Kansas 66762

Dr. E. W. Powell
Associate Professor of Geography
Kansas State College
Pittsburg, Kansas 66762

Mr. Harold Reisna
Caterpillar Tractor Company
Peoria, Illinois 61602

May 26 & 27 Workshop Attendance Cont.

Mr. Mike W. Rhea, Sec.
Kansas Conservation Contractors Assn.
Box 145
Yates Center, Kansas 66783

Mr. Gary Rice
State News Desk
The Wichita Eagle
Wichita, Kansas 67208

Mr. Wayne Roberts
Project Engineer
Product & Applied Science Staff
Research Department-Technical Center
Caterpillar Tractor Co.
Peoria, Illinois 61602

Mr. Harry Robertson
U. S. Bureau of Mines
Kansas Liaison Officer
518 Capitol Federal Building
Topeka, Kansas 66603

Mr. Elmer Robinson
International Representative
United Mine Workers of America
District #14
Pittsburg, Kansas 66762

Mr. Paul Russell
KOAM-TV
Pittsburg, Kansas 66762

Mr. Leonard Sammons
Member of State Advisory Council on
Ecology
Sammons Medical Laboratory
Kirkwood Building
Pittsburg, Kansas 66762

Mr. Ted Sanborn
Governor's Office
State Capitol Building
Topeka, Kansas 66612

Miss Susan Scott
Research Assistant
Mined-Land Redevelopment
Economic Department
Wichita State University
Wichita, Kansas 67208

Mr. George Sharp
Chairman, Cherokee County ASCS
Route 4
Columbus, Kansas 66725

Mr. Gerald Sharp
Sharp Brothers Seed Co.
Healy, Kansas 67850

Mr. John Shetlar
District Conservationist
Crawford County SCS
Courthouse
Girard, Kansas 66743

Mr. A. L. Smith
Division Manager
P&M Coal Mining Co.
103 West 11th
Pittsburg, Kansas 66762

Dr. Richard Smith
Department of Agronomy
West Virginia University
Morgantown, West Virginia 26505

Mr. John Spurling
Soil Conservation Board
Route 5
Ft. Scott, Kansas 66701

Mr. E. S. Stephens
Vice President
Garland Coal & Mining Co.
Ft. Smith, Arkansas 72901

Mr. Sam Stranathan
District Conservationist
Bourbon County SCS
210 South National
Ft. Scott, Kansas 66701

Mr. Pat Tansey, Jr.
Asst. to General Sales Manager
Kansas City Power & Light Co.
1330 Baltimore Avenue
Kansas City, Missouri 64141

Mr. Howell Taylor
Kaysinger Basin, RPC
Clinton, Missouri 64735

Mr. Melvin M. Thomson
Area Conservationist
RDI Building
Belcrest & East Trafficway
Springfield, Missouri 65802

Mr. Jay Treat
District Extension Specialist
Farm Management
418 South Sycamore
Iola, Kansas 66749

Mr. Malcolm Turner
Headlight-Sun
Pittsburg, Kansas 66762

May 26 & 27 Workshop Attendance Cont.

Mr. Arthur Wallace
Supt. of Reclamation & Land Use
Hanna Coal Co.
Cadiz, Ohio 43907

Mr. Richard Wallace
Graduate Assistant
State Geological Survey
University of Kansas
Lawrence, Kansas 66044

Mr. Jack Walstrom
Biologist, SCS
P. O. Box 600
760 South Broadway
Salina, Kansas 67401

Mr. Raymond "Ted" Wary
Cherokee County Extension Agricultural
Agent
Courthouse
Columbus, Kansas 66725

Mr. Fred Weaver
State Representative (D)
Mineral Resources Task Group
Route 1
Baxter Springs, Kansas 66713

Mr. Heyward M. Wharton
Geologist, Mineral Resources Section
Div. of Geological Survey &
Water Resources
Buehler Park
Rolla, Missouri 65401

Mr. Doss White
U. S. Bureau of Mines
Denver, Colorado 80225

Dr. David A. Whitney
Soil Testing
Extension Specialist
Waters Hall, Room 146C
Kansas State University
Manhattan, Kansas 66502

Mr. S. R. Widner
604 North Walnut
Pittsburg, Kansas 66762

Mr. Bill Wishart
Farm Manager
P&M Coal Mining Co.
Pittsburg, Kansas 66762

Mrs. Helen Wolfe
Mineral Resources Section
State Geological Survey
University of Kansas
Lawrence, Kansas 66044

Mr. John Wolfe
Lawrence, Kansas 66044

Mr. C. R. Wolford
District Director
ASCS
Erie, Kansas 66733

Mr. Bill Young
Environmental Health Specialist
Pettis County Extension Center
Sedalia, Missouri 65301

Dr. Art Youngman
Assistant Professor of Biology
Wichita State University
Wichita, Kansas 67208

Mr. Don Zimmerman
Contractor
Route 1, Box 116A
Neodesha, Kansas 66757

SOCIAL-HOUR CONTRIBUTORS

1. Jay Jones-Contr.
2. Ada Martin-Contr.
3. Bob Frome-Contr.
4. Donald Zimmerman-Contr.
5. O'Toole & Sons-Contr.
6. Burgan Trucking & Excavating
7. "Red" Fox-Contr.
8. David Construction
9. Carl Mercer-Contr.

